SIMULATING THE EFFECT OF WATER REGIME RESTORATION MEASURES ON WILDLIFE POPULATIONS AND HABITAT WITHIN THE PEACE-ATHABASCA DELTA

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EXECUTIVE SUMMARY

Simulation modelling was used to assess effectiveness of water regime control measures on the Peace-Athabasca delta. Two weirs were constructed in 1975 on the outlet channels of Lake Athabasca in order to offset undesirable changes in the flow regime of the Peace River that were caused by the Bennett Dam in British Columbia. A computer model developed during the Peace-Athabasca Delta Project study was used to translate effects of this regulated weir regime and two others (natural, Bennett Dam) into wildlife numbers and habitat changes, so that productivity comparisons could be made between regimes.

Plant succession, which was accelerating under the Bennett Dam regime, will be slowed under the weir regime to become closer to that of the natural regime. The weirs will prevent a major vegetation shift downward along lake margins. The weirs increase perched basin shoreline compared to the Bennett Dam regime, but the net amount will be at least 15 percent short of complete restoration. Waterfowl production is expected to be almost completely restored, but waterfowl staging habitat is expected to decline beyond that predicted for the Bennett Dam regime. Muskrat production should be improved over conditions resulting from the Bennett Dam alone, but will not approach numbers reached under the natural regime. In summary, the weir regime improves overall conditions on the Peace-Athabasca delta, but falls short of complete restoration.

RÉSUMÉ

Pour évaluer l'efficacité des mesures de régularieation du régime des eaux du delta des rivières de la Paix et Athabasca, on a eu recours à la modélisation par simulation. En 1975, deux déversoirs ont été construits sur les canaux de sortie du lac Athabasca pour contrebalancer les effets négatifs de la fluctuation du régime d'écoulement de la rivière de la Paix, causés par le barrage Bennett en Colombie-Britannique. À l'aide d'un modèle informatique mis au point pendant l'étude du projet du delta des rivières de la Paix et Athabasca, on a analysé les effets du régime régularisé par un déversoir et de deux autres situations (régime naturel et régime influencé par le barrage Bennett) sur les fluctuations de l'habitat et du nombre de sujets des espèces fauniques. Cette analyse a servi à faire des comparaisons des taux de productivité selon les régimes.

L'alternance végétale, en accélération sous le régime du barrage Bennett, sera ralentie sous le régime des déversoirs et se rapprochera du taux d'alternance sous le régime naturel. Les déversoirs empêcheront les grands bouleversements végétaux en aval, en bordure des rives du lac. Comparativement au régime du barrage Bennett, les déversoirs font augmenter l'étendue des nappes suspendues du rivage, mais la superficie totale sera d'au moins 15 p. 100 inférieure au rétablissement intégral. Il est prévu que la population d'oiseaux aquatiques se rétablira à peu près complètement. On s'attend toutefois à ce que les aires de repos des oiseaux aquatiques se détérioreront au-delà de ce qu'il était prévu sous le

régime du barrage Bennett. Il est en outre prévu que la population de rats musqués s'améliorera comparativement à ce qui aurait été le cas sous le régime du seul barrage Bennett, sans toutefois atteindre les proportions dans les conditions du régime naturel. Pour conclure, le régime du déversoir améliore la situation globale du delta des rivières de la Paix et Athabasca, mais n'entraîne pas un rétablissement intégral de l'écosystème.

INTRODUCTION

The purpose of this report is to evaluate, using simulation modelling, the effectiveness of water regime control measures aimed at restoring wildlife populations and vegetation communities on the Peace-Athabasca delta. Changes in the flow regime of the Peace River brought about by the Bennett Dam on the upper Peace were shown to have lowered Lake Athabasca levels and caused substantial reductions in wildlife populations on the delta (PADP Tech. Rept. 1973). In 1975, two weirs were constructed by government on outlet channels of Lake Athabasca in an effort to offset these undesirable effects. The task of evaluating the success of these remedial measures is being undertaken by the Peace-Athabasca Delta Implementation Committee and this report has been prepared to assist in that endeavor.

Water levels of Lake Athabasca and those in the Peace-Athabasca delta have varied greatly from year to year. Annual and seasonal variability has played a large part in the evolution of the Delta and in developing the richness of its plant and animal communities. Seemingly subtle changes to the water regime, such as slightly reducing peak lake levels, or changing average growing season levels by as little as one foot, can bring about a gradual shift in the location and abundance of individual plant communities over time. Deltas are especially sensitive to these changes because the terrain is usually very flat and the vegetation types present are those that commonly inhabit the littoral zone.

Because the annual variability in Lake Athabasca levels is considerable, small permanent changes to lake levels can be difficult to demonstrate statistically without a lengthy series of water records that include both pre and post-regulation conditions. But only nine years of record (1976-1984) is available for the regulated weir regime with which to make comparisons with the pre-1968 natural regime. Consequently, the technique of simulation modelling has been used to generate water levels for each of three conditions--the natural regime, the regulated regime with the Bennett Dam in full operation, and the regulated regime with weirs on the outlets of Lake Athabasca (PAD Hydrology Subcommittee 1985). The three scenarios of simulated levels span the 25 year period 1960-1984, and were produced using a mathematical flow simulation model of the Lake Athabasca and Peace-Athabasca delta system developed jointly by Inland Waters Directorate and Alberta Environment (Sydor, DeBoer, Cheng 1979).

Simulation modelling can also be used to assess how a specified water regime can change the vegetation communities and animal populations on the delta. A wildlife model to accomplish this was developed during the Peace-Athabasca Delta Project study (Townsend 1972), and it has been run using the simulated results from the hydrology model as input. This provides one estimate of the effectiveness of the remedial action taken to restore ecological conditions on the delta to the pre-Bennett Dam range of productivity and abundance. This report discusses the results of these experiments.

METHODS

General Description of Wildlife Model

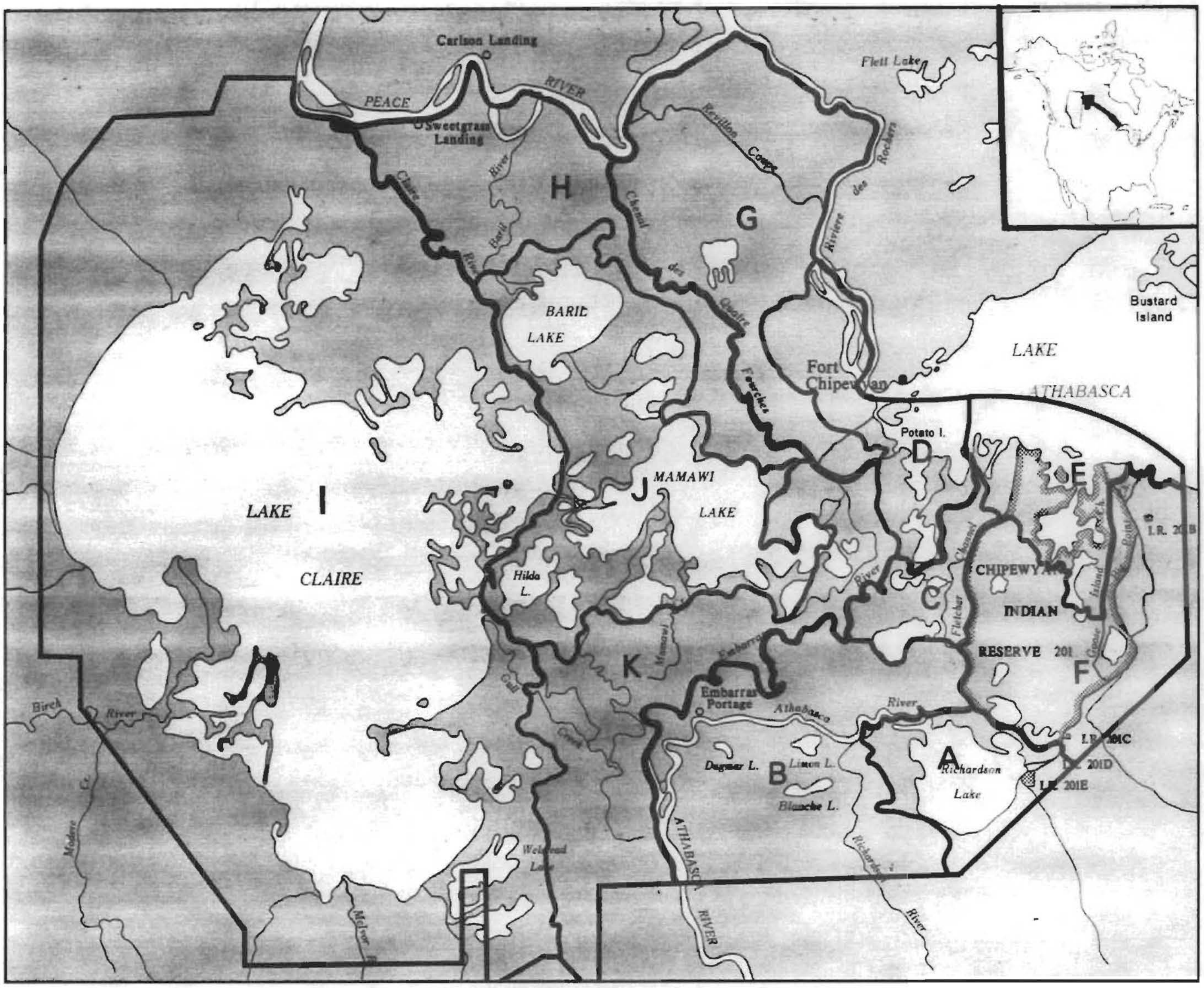
The wildlife computer model was designed to translate effects of water level regimes into wildlife numbers and habitat changes. The model contains as a starting point a topographical representation of the delta, including acreages and shorelengths of eleven major vegetation types distributed vertically within contour intervals, among ten geographical subdivisions and among open and perched basins. These topographical data were derived from measurements of 1970 aerial photographs and from engineering surveys conducted across the delta in 1970 and 1971. It also contains starting populations of muskrats and optimum densities of waterfowl, derived from population censuses conducted during the Delta Project study. Rules of change are built into the model to simulate effects of Lake Athabasca water levels on the process of plant succession, the filling and receding of perched basins, the fluctuations in open drainage basins, and the resultant increases or decreases in wildlife populations and habitats.

The computer model accepts five water levels for each year simulated. Each entry represents the water level for a specified time period during the year that is critical to one or more biological species. Maximum and minimum levels are also supplied for each time period. These water levels operate on the rules of change to update water levels in each open and perched basin, to update plant succession, and to cause wildlife numbers to grow or decline for each year simulated. The program prints the results from each year simulated, including numbers of acres of each habitat type, total miles of perched basin shoreline, wildlife numbers and carrying capacities for selected animals. Finally, once all simulated years have been processed, average values for the entire simulated period are tabulated. A much more detailed description of the wildlife model can be found in Townsend (1972).

Major Assumptions Within the Model

The delta was divided into ten subdivisions (Figure 1, with sub-

FIGURE 1. Subdivisions of the Peace-Athabasca Delta. (From PADP 1973)



divisions I and J being grouped into one). The program executes a solution for each subdivision as an entire unit.

The five time periods were chosen based on ecological significance: 1=May, 2=June, 3=July 1 to August 14, 4=August 15 to October 14, and 5= October 15 to April 30. The major activities of animals under consideration and the vegetation growing season coincide with one or more of these seasonal categories; therefore, it was important to have water level information for each.

The available topographical data was used to construct a mathematical contour map. Each subdivision contains a portion of its total acreage in open drainage, and the rest is allocated across five to seven perched basins. The Lake Athabasca levels entered for each simulated year are adjusted by a constant specified for each subdivision to account for the slope of the delta in relation to rivers adjacent to the subdivision. These constants, in feet, are as follows: A=3.2, B=4.6, C=1.7, D=E=0.0, F=1.9, G=H=IJ=0.0, K=3.2. The converted levels become the open drainage levels for the subdivision.

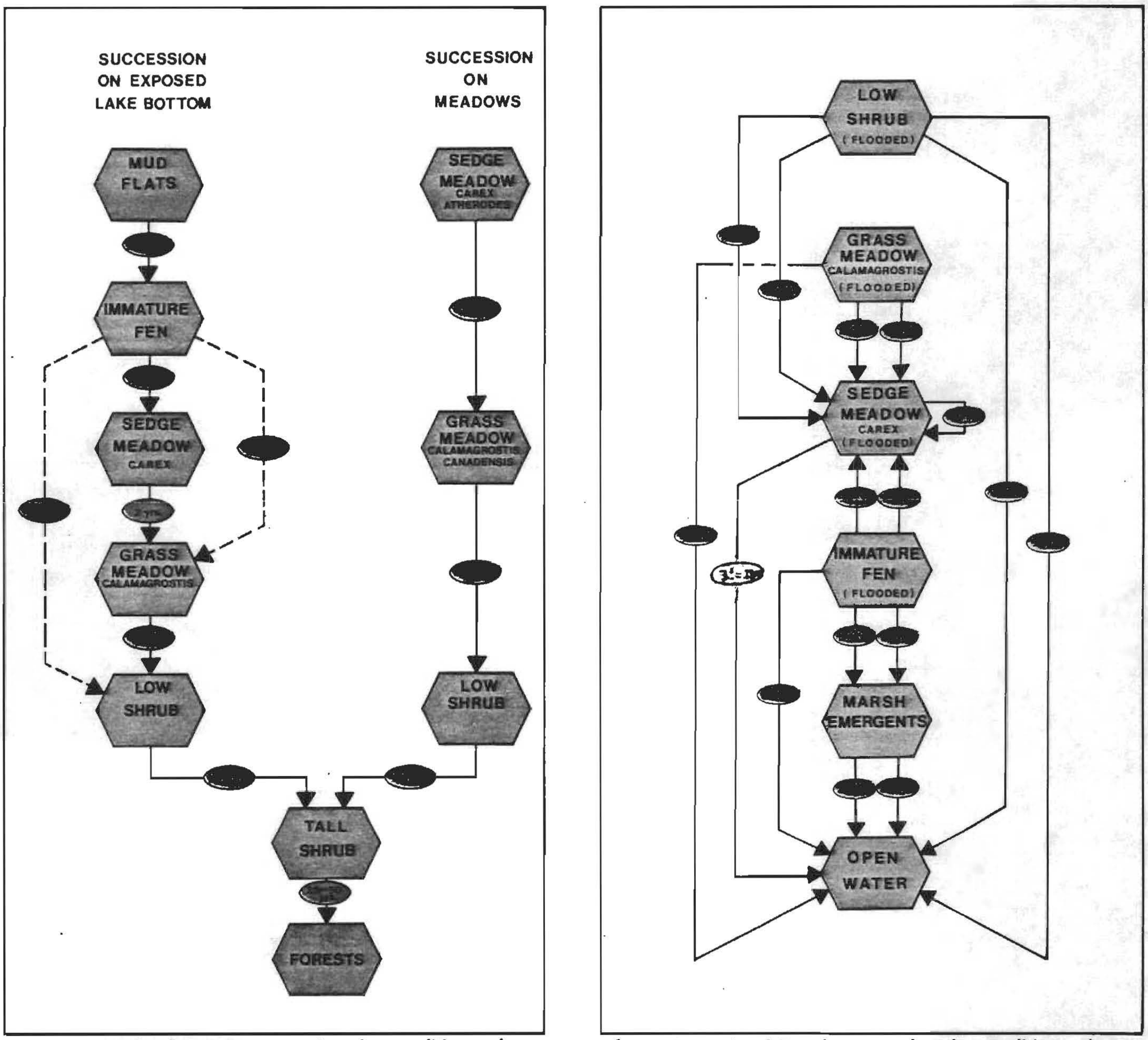
Each perched basin in the model has a defined "spill" elevation, "full" elevation, and basin bottom. If the open drainage water level exceeds the "spill" elevation, the perched basin is assumed to be flooded to that water level. During a later time period, if the open drainage water level becomes less than the perched basin "spill" level, the water in the perched basin is lowered to the defined "full" level. Subsequent years of "no flooding" cause the water level in the perched basin to decline by a constant percentage of acres flooded and basin shorelengths and it is considered to represent loss by evaporation and seepage: A=8%, B=7%, C=D=E=12%, F=10%, G=H=7%, IJ=12%, K=7%.

Within each time period, water levels are considered to fluctuate within the open drainage basin according to the values read into the model. There are no water level fluctuations within the time period in perched basins unless the basin is flooded, because fluctuations on small perched basins are negligible for ecological purposes.

Following the initial allocation of vegetation types to various contour levels, the program updates in each simulated year the habitat present on each of the contours of open drainage and perched basin portions of a subdivision. Thus plant succession advances, is retarded or remains the same depending on the depth or absence of water on each contour level during time periods 2 and 3, according to rules defined in Figure 2. These succession rules represent, in a much simplified way, an extremely complex ecological process that is continually under way within the Peace-Athabasca Delta.

The muskrat is an important mammal of the delta and its populations are modelled within the program. Starting numbers are defined for each subdivision based on 1971 surveys and estimates: A=1000, B=9200, C=1500, D=400, E=200, F=15000, G=2300, H=1800, IJ=1700, K=3200. The sex ratio is assumed to be 1 to 1. Optimum production from spring to fall is 14 young per female. Rising water levels during time periods 1, 2 and 3 reduce the optimum by the following percentages: <1'=0%, 1'=7.5%, 2'=15%, 3'=30%, 4'+=50%. Spring and summer mortality of adults is 5% and is taken just prior to the breeding season. The fall population size equals adults plus young. The surviving winter population is determined by the number of acres of emergent vegetation flooded to various depths. Muskrats assume a maximum density of 10 per acre of emergents, with deepest emergents being allocated first, and shallowest last. The percentage surviving

FIGURE 2. Plant succession trends in the Peace-Athabasca Delta. (From PADP 1973)



a. Successional Trends expected under conditions of declining water levels

b. Successional Trends expected under conditions of prolonged flooding the winter varies as follows: < 0.6'=0%, 0.6-1.0'=30%, 1'=40%, 2'=50%, 3'+=70%. Spring trapping is simulated to take 50% of the population surviving the winter.

Waterfowl production is also simulated within the model and is a function of both shoreline habitat available during time period 1 and water level fluctuations occurring during time periods 1 and 2. Optimum production per mile of shoreline for both dabblers and divers are defined as follows:

Shoreline Type	Dabblers	Divers
Mud flats	24.9	0.0
Immature fen	27.9	8.3
Meadow	48.9	19.3
Low Shrub	27.9	31.9
Tall Shrub	36.0	42.4
Deciduous	16.8	38.5
Coniferous	9.9	34.1
Rock Outcrop	2.7	0.0

Increasing water levels during nesting affects optimum survival values as follows: < 0.5'=100%, 0.5-0.9'=75%, 1.0-1.9'=50%, >1.9'=0%. Decreasing water levels have the following effect on survival: < 1.0'=100%, >1.0'=75%.

Waterfowl fall staging habitat was simulated by summing the number of acres of mud flat and first-year immature fen available during time period 4.

A more complete and detailed description of the assumptions made in defining the model can be found in Townsend (1972).

Major Assumptions External to the Model

An underlying assumption to using water levels that represent historical conditions is that past water levels are also representative of what can reasonably be expected to occur in the future. This does not imply that past sequences of water level fluctuations will be faithfully repeated, but they form one plausible set of an infinite number of possible conditions that could occur. Since the wildlife model requires every water level in a set to be exactly defined, the three scenarios of 25 years reconstructed from past flows and levels satisfy that exact requirement.

For each of the conditions -- simulated natural, simulated Bennett Dam, and simulated Bennett Dam plus weirs -- two sequences of water level data were assembled for input to the model. The Delta 1 scenario comprises the string of water levels from 1960 through 1984, repeated twice, to provide input for a 50 year run. The Delta 2 scenario begins the series with 1971, continues through 1984, is followed by 1960 through 1984, and then repeats 1960 through 1970, to also provide a 50 year run. Different sequences of the same water data provide different results when running the wildlife model, because many of the ecological parameters being simulated are serially related to water level events spanning more than one year.

The hydrology model developed in 1979 produces water levels not only for Lake Athabasca, but for the major delta lakes as well (Sydor, DeBoer, Cheng 1979). However, the wildlife model was developed earlier and accepts only Lake Athabasca levels, adjusting these where necessary by a constant to provide the open drainage basin levels for each of the ten subdivisions. To take advantage of the available simulated Lake Claire levels, the wildlife model was also run using these levels for just subdivisions H and IJ, representing the Claire-Mamawi area.

All water level data used as input were derived from the magnetic tape files of simulated daily levels provided by the PAD Hydrology Subcommittee. Lake Athabasca water levels used are from reach 150, and Lake Claire levels used are from reach 550 (PAD Hydrology Subcommittee 1985). The daily levels were averaged for each ecological time period, and the maximum and minimum levels for each period were expressed as departures from the mean, and also supplied to the wildlife model. The departure values represent water level fluctuations within a time period, and the use of each pair of values for each time period in every year differed from the approach taken for earlier runs (Townsend 1972). Previous runs were made using average fluctuations calculated from summing the respective values for all years.

Plots of the daily lake levels from 1960 through 1984 which form the basis of water level input are presented in the Appendix. These include graphs of Lake Athabasca levels comparing the weir regime with the natural regime, and those comparing the weir regime with the Bennett Dam regime. Similar comparative graphs are presented for Lake Claire levels.

RESULTS AND DISCUSSION

Comparisons Using Only Lake Athabasca Levels

Results of the three treatment runs using the Delta 1 and Delta 2 sequences of water levels have been expressed in terms of deviations from the average annual production of the simulated natural regime (Table 1, 2). If the weirs had not been constructed, the process of plant succession

Table 1. Results of Delta 1 Scenario of 50 years, using Lake Athabasca levels throughout.

	Average Annual Production	Average Annual Deviation from Natural	
Habitat Acres	Natural	Regulated, Weirs	Regulated, Bennett
Open Water	487035	+15%	-20%
Productive Habitats*	383322	-19%	-11%
Shrubs and Forests	603902	0%	+23%
Fall Waterfowl Staging Habitat	60264	-49%	+ 3%
Shoreline Miles			
Perched Basin	6000	-14%	-48%
Animal Numbers			
Dabblers	223946	- 5%	-33%
Divers	93513	- 1%	-18%
Ducks	317460	- 4%	-28%
Muskrats (Spring)	50719	-55%	-76%
Muskrats (Fall)	165307	-51%	-74%
Carrying Capacity Muskrats	84131	-43%	-34%

* Includes emergents, mud flat, immature fen, and meadows, all of which are early successional habitat types.

Table 2. Results of Delta 2 Scenario of 50 years, using Lake Athabasca levels throughout.

	Average Annual Production	Average Annual Deviation from Natural	
Habitat Acres	Natural	Regulated, Weirs	Regulated, Bennett
Open Water	480439	+16%	-20%
Productive Habitats*	381627	-19%	-11%
Shrubs and Forests	612192	0%	+23%
Fall Waterfowl Staging Habitat	59664	-47%	+ 2%
Shoreline Miles			
Perched Basin	5931	-14%	-48%
Animal Numbers			
Dabblers	216587	- 3%	-28%
Divers	94995	- 3%	-19%
Ducks	311581	- 3%	-26%
Muskrats (Spring)	51487	-58%	-86%
Muskrats (Fall)	168905	-54%	-85%
Carrying Capacity Muskrats	98399	-54%	-35%

* Includes emergents, mud flat, immature fen, and meadows, all of which are early successional habitat types.

would have accelerated under the simulated Bennett Dam regime, advancing towards shrubs and forest over a fifty year period to create 23% more acreage than under the simulated natural regime. It would appear that under the simulated weir regime, succession towards the shrub and forest group over a 50 year period has been restored to natural. However, the simulated weir regime would appear to create more open water (+15%, +16%) at the expense of the more productive habitats (-19%), especially emergents and mud flats. This is probably due to reduced annual variability in water levels during the plant growing season, and higher June levels (0.7') under the simulated weir regime. The evidence suggests that the weirs may have been built slightly higher than required to provide the best conditions for the more productive habitats.

The simulated Bennett Dam regime shows a slight increase (+3%) in fall staging habitat, due to the general drying out of the delta, thereby creating abundant mud flat and immature fen. On the other hand, the simulated weir regime operates to hold water levels higher in late summer and fall, thereby keeping shorelines flooded that would ordinarily become exposed under the natural regime.

The average number of miles of shoreline within the perched basins appears to have been greatly improved compared to what was forecasted for the Bennett Dam regime (-48%). The waterfowl production estimates for the weir regime reflect this, and coupled with less fluctuation in water levels during the nesting season than the simulated natural regime, total duck production would appear to be almost entirely restored over a 50 year period.

The muskrat data present an entirely opposite result, however. Only a little improvement is seen under the simulated weir regime compared to the Bennett Dam regime. The low populations from the model run is caused by the reduced acreages of emergent vegetation, as explained above, and the reduced probability of the higher perched basins becoming filled, when compared to the simulated natural regime.

Comparisons Within Claire-Mamawi Subdivision

The Claire-Mamawi (IJ) subdivision accounts for 56% of the entire Peace-Athabasca delta and therefore is a major region to examine by itself. Biological comparisons have been made between the three treatments that result from using the simulated Lake Claire water levels (Table 3). These results differ considerably from those derived when using the simulated Lake Athabasca levels for the Claire-Mamawi area (Table 4). The new hydrology model has obviously added greatly to our understanding of the differences between Lake Athabasca levels and Claire-Mamawi levels, an understanding that was not available in a quantitative way during the Delta Project study. The discussion will focus mainly on Table 3 data derived from Lake Claire simulated levels.

If the weirs had not been constructed, the process of plant succession would have accelerated under the simulated Bennett Dam regime, advancing towards shrubs and forest over a 50 year period to create 24% more acreage than under the simulated natural regime. The simulated weir also produces accelerated plant succession, but to only 7% more shrub and forest acreage over a 50 year period than under the simulated natural regime. This is a definite improvement. Plant succession within the productive habitats group seems to be almost completely restored (-1%) compared to what is simulated for the Bennett Dam regime (-6%).

The fall staging habitat for waterfowl, which includes the exposed mud flats and immature fen, is greatly reduced under the simulated weir

Table 3. Results of Delta 1 Scenario for Claire- Mamawi only, using Lake Claire levels.

	Average Annual Production	Average Annual Deviation from Natural	
Habitat Acres	Natural	Regulated, Weirs	Regulated, Bennett
Open Water	422001	- 4%	-11%
Productive Habitats*	201502	- 1%	- 6%
Shrubs and Forests	239514	+ 7%	+24%
Fall Waterfowl Staging Habitat	17944	-36%	-13%
Shoreline Miles			
Perched Basin	3270	-14%	-39%
Animal Numbers			
Dabblers	124001	- 2%	-28%
Divers	51358	+ 4%	-10%
Ducks	175359	0%	-23%
Muskrats (Spring)	10172	+53%	- 5%
Muskrats (Fall)	34019	+65%	+ 3%
Carrying Capacity Muskrats	45356	+24%	+ 1%

* Includes emergents, mud flat, immature fen, and meadows, all of which are early successional habitat types.

Table 4. Results of Delta 1 Scenario for Claire- Mamawi only, using Lake Athabasca levels.

	Average Annual Production	Average Annual Deviation from Natural	
Habitat Acres	Natural	Regulated, Weirs	Regulated, Bennett
Open Water	364845	+11%	-16%
Productive Habitats*	247138	-15%	- 8%
Shrubs and Forests	251040	- 1%	+31%
Fall Waterfowl Staging Habitat	34166	-56%	+19%
Shoreline Miles			
Perched Basin	3441	-10%	-50%
Animal Numbers			
Dabblers	136176	- 9%	-44%
Divers	51895	- 7%	-30%
Ducks	188071	- 8%	-40%
Muskrats (Spring)	40416	-51%	-84%
Muskrats (Fall)	132330	-46%	-82%
Carrying Capacity Muskrats	63025	-38%	-29%

* Includes emergents, mud flat, immature fen, and meadows, all of which are early successional habitat types.

regime, and this is because the water levels under that regime decline slower from summer maximums than do those under the simulated natural regime. Migrating waterfowl will be faced with less suitable conditions and may congregate onto the fewer available acres of good staging habitat.

The average number of miles of shoreline within the perched basins appears to have been improved considerably (-14%) under the simulated weir regime compared to what was forecasted for the Bennett Dam regime (-39%). High waterfowl production estimates for the simulated weir regime (-2%, +4%, 0) are because of the improved shoreline picture and a slight reduction in flooding during nesting, when compared to the simulated natural regime.

The large positive percentage difference for muskrat production under the simulated weir regime, when compared to the natural regime, is misleading because muskrat production under the simulated natural regime is probably underestimated. This is because overland flooding during spring breakup (including ice jams) has played a considerable role in filling the higher perched basins in the delta under the natural regime. This effect is not included in the simulated hydrographs. The relative differences in modelling results (+53%, +65%, +24%) between simulated weir and natural is due to slower recession from midsummer peaks under the weir regime, resulting in higher fall and winter levels than those of the simulated natural regime.

Comparisons Using Lake Athabasca and Lake Claire Levels

Results of the three treatment runs using the Delta 1 and Delta 2 sequences of water levels have been expressed in terms of deviations from the average annual production of the simulated natural regime (Table 5, 6). If the weirs had not been constructed, the process of plant succession would have accelerated under the simulated Bennett Dam regime, advancing towards shrubs and forest over a 50 year period to create 20% more acreage than under the simulated natural regime. It would appear that under the simulated weir regime, succession towards the shrub and forest group over a 50 year period has been slowed somewhat (+4%). But it is likely that the compressed summer amplitude and reduced annual variability in water levels during the plant growing season of the simulated weir regime leads to an overall reduction of productive habitat types (-11%) by creating more open water (+2%) and more shrub and forest (+4%).

The simulated Bennett Dam regime showed a decrease in fall staging area (-17%), but the simulated weir regime seems to have made conditions much worse (-38%). This is because the water levels under the weir regime decline slower in the fall than do those under the simulated natural regime. Migrating waterfowl will be faced with less suitable conditions and may congregate onto the fewer available acres of good staging habitat.

The average number of miles of shoreline within the perched basins appears to have been considerably improved (-17%) compared to what was forecasted for the Bennett Dam regime (-41%). The waterfowl production estimates for the weir regime reflect this, and coupled with less fluctuation in water levels during the nesting season than under the simulated natural regime, total duck production would appear to be almost entirely restored over a 50 year period.

Muskrat production over the 50 year period would seem to be greatly improved under the simulated weir regime (-8%, 0, -1%) relative to simulated natural, when compared to figures for the simulated Bennett Dam (-26%, -18%, -15%). The Delta 2 scenario does not show as good a result. But, as described earlier when discussing the Claire-Mamawi region separ-

Table 5. Results of Delta 1 Scenario of 50 years, using Lake Claire levels for subdivisions H and IJ, and Lake Athabasca levels for remaining subdivisions.

	Average Annual Production	Average Annual Deviation from Natural	
Habitat Acres	Natural	Regulated, Weirs	Regulated, Bennett
Open Water	547350	+ 2%	-15%
Productive Habitats*	335514	-11%	-10%
Shrubs and Forests	591387	+ 4%	+20%
Fall Waterfowl Staging Habitat	43045	-38%	-17%
Shoreline Miles			
Perched Basin	5824	-17%	-41%
Animal Numbers			
Dabblers	210632	- 1%	-23%
Divers	91827	+ 6%	- 6%
Ducks	302461	+ 1%	-17%
Muskrats (Spring)	20485	- 8%	-26%
Muskrats (Fall)	67011	0	-18%
Carrying Capacity Muskrats	67372	- 1%	-15%

* Includes emergents, mud flat, immature fen, and meadows, all of which are early successional habitat types.

Table 6. Results of Delta 2 Scenario of 50 years, using Lake Claire levels for subdivisions H and IJ, and Lake Athabasca levels for remaining subdivisions.

	Average Annual Production	Average Annual Deviation from Natural	
Habitat Acres	Natural	Regulated, Weirs	Regulated, Bennett
Open Water	558157	+ 1%	-16%
Productive Habitats*	324122	-10%	- 8%
Shrubs and Forests	591972	+ 4%	+20%
Fall Waterfowl Staging Habitat	42898	-39%	-18%
Shoreline Miles			
Perched Basin	5719	-17%	-41%
Animal Numbers			
Dabblers	207629	- 2%	-21%
Divers	91044	+ 7%	- 7%
Ducks	298672	+ 1%	-17%
Muskrats (Spring)	10852	-19%	+18%
Muskrats (Fall)	36214	-13%	+27%
Carrying Capacity Muskrats	56436	0	- 8%

* Includes emergents, mud flat, immature fen, and meadows, all of which are early successional habitat types.

ately, this may be misleading because muskrat production under the simulated natural regime is probably underestimated, and especially so for the Delta 2 scenario. The reason for this underestimate is because overland flooding during spring breakup (including ice jams) has played a considerable role in the recorded natural regime, and this effect is not included in the simulated hydrographs.

CONCLUSIONS

Simulation modelling was used to evaluate the effectiveness of water regime control measures on the Peace-Athabasca delta. Hydrographs spanning a 25 year period that simulate the natural regime, the Bennett Dam regime, and the Bennett Dam regime plus weirs were used as input to the wildlife simulation model to determine differences in productivity of important biological components of the delta ecosystem. The model runs provide one example of changes that could occur over a 50 year period if the simulated water levels and modelling assumptions can be considered representative of future conditions.

Plant succession, which was shown to be accelerating under the Bennett Dam regime, will be slowed down under the weir regime to become closer to that of the natural regime. The weirs cannot restore the net loss of productive habitats brought about by the Bennett Dam because they cannot restore the amplitude of summer growing season water levels. But the weirs are effective in preventing a major shift in vegetation types downward along the lake and marsh contours.

Perched basin shoreline should show a major improvement over the Bennett Dam regime, although it will fall at least 15 percent short of complete restoration to the natural condition. Waterfowl production can be expected to be almost completely restored, because of the increased shoreline available and because of less frequent flooding during the nesting season. Waterfowl staging habitat in the fall will decrease even more so than under the Bennett Dam regime because of higher water levels anticipated in the fall during the migration period.

Muskrat production is expected to be improved over the Bennett Dam regime, but is not expected to approach conditions reached during the existence of the natural regime. This is because the perched basins that are higher along the contour are important muskrat producers, yet they will be filled at a less frequent rate under the weir regime than during the past.

The wildlife simulation modelling using the simulated hydrographs produced some inconsistencies that suggest that something major is missing from the overall equation. I believe that factor is the overland flooding into the higher perched basins. This was known to occur under the natural regime, but its frequency has not been determined, nor has the new frequency under the Bennett-Weir regime been estimated. A better knowledge of this factor might lead to a much different conclusion as to the effectiveness of the weirs in restoring the delta ecosystem.

Based on the evidence at hand, it appears that the weirs will greatly improve overall conditions on the Peace-Athabasca delta over what would have been expected under the Bennett Dam regime. But they fall short of complete restoration. This was known prior to construction, and a number of factors were considered in the eventual decision to select the Rochers weir option in 1973 (see PADP Technical Report, page 152-154, 1973).

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Sydor, M., A. DeBoer, and T. Cheng. 1979. Developing a mathematical flow simulation model for the Peace-Athabasca Delta. Environment Canada, Ottawa and Alberta Environment, Edmonton. 23 p. + 5 Appendices.

Townsend, G.H. 1972. Simulation of habitat succession and wildlife populations. Section O *in* Ecological Investigations, Peace-Athabasca Delta Project, Tech. Rept. App., Vol. 2, 1973, Edmonton.

APPENDIX

Plots of simulated lake levels derived from the one-dimensional hydrodynamic model (Sydor, DeBoer, Cheng 1979) and reproduced from the Peace-Athabasca Delta Implementation Committee Hydrology Subcommittee report (1985).

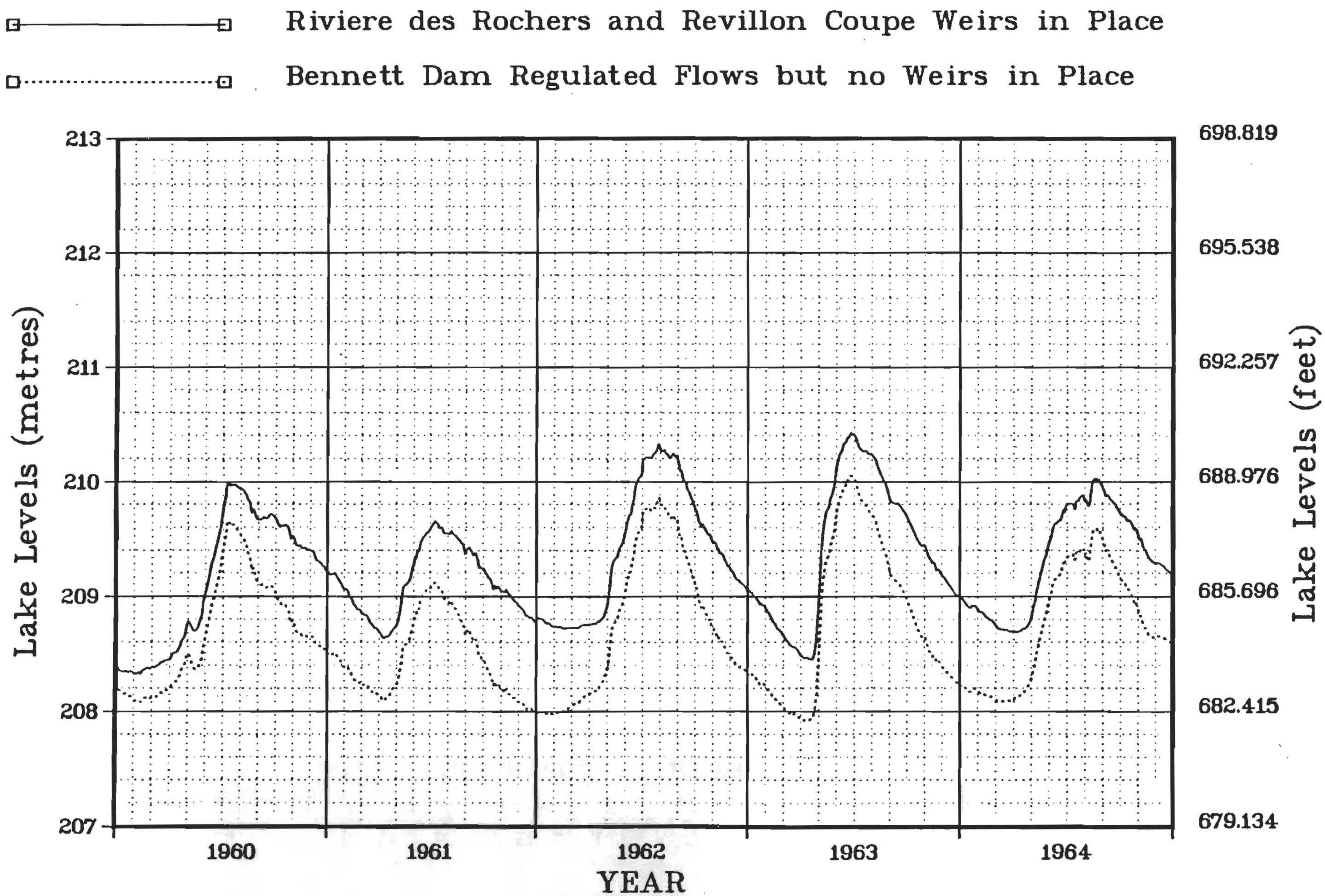
Simulated Lake Athabasca levels (1960-1984),
weirs vs. Bennett Dam regulated - 5 pages

Simulated Lake Athabasca levels (1960-1984),
weirs vs. natural - 5 pages

Simulated Lake Claire levels (1960-1984),
weirs vs. Bennett Dam regulated - 5 pages

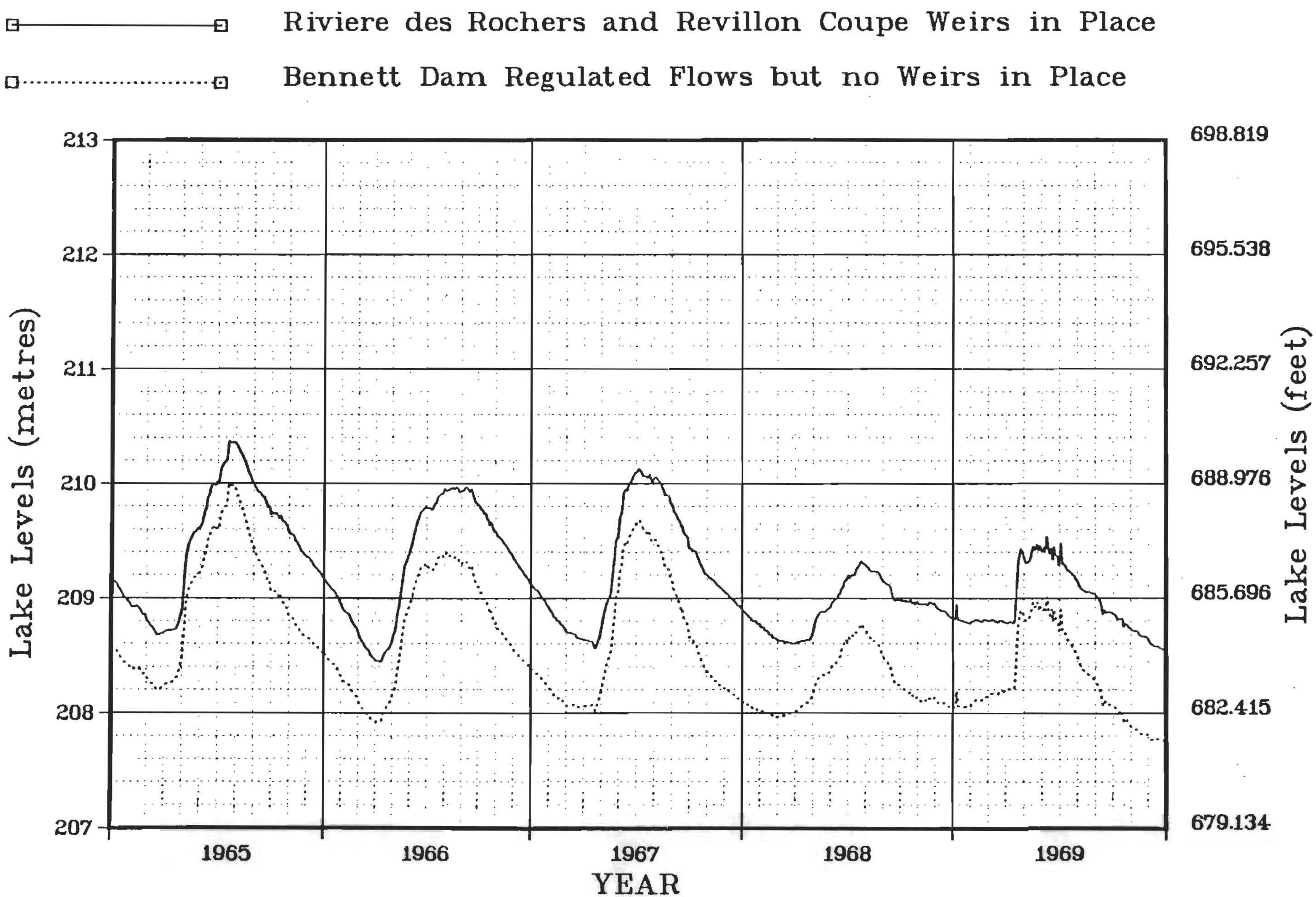
Simulated Lake Claire levels (1960-1984),
weirs vs. natural - 5 pages

LAKE ATHABASCA LEVELS



24/07/84

LAKE ATHABASCA LEVELS



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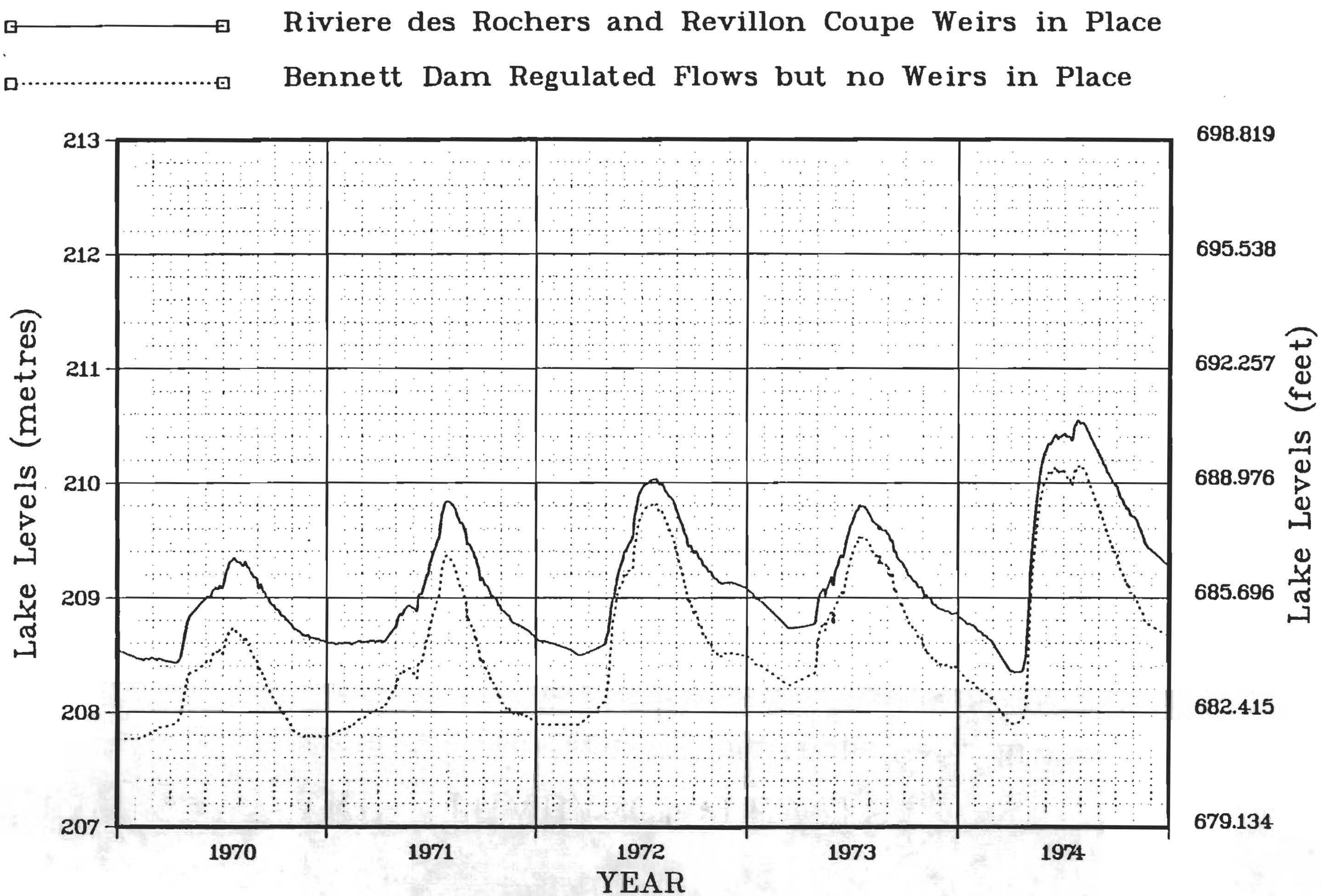
LAKE ATHABASCA LEVELS



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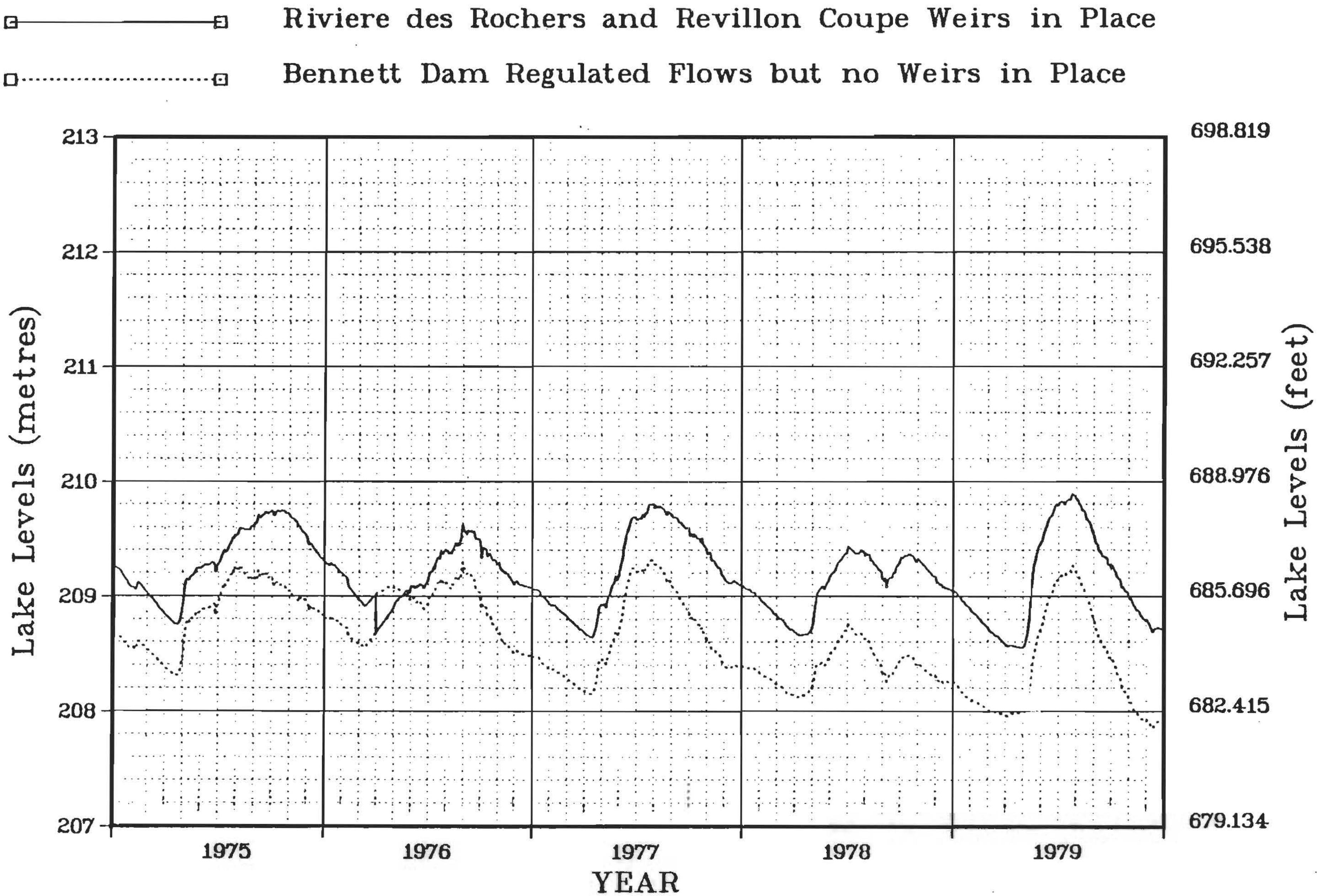

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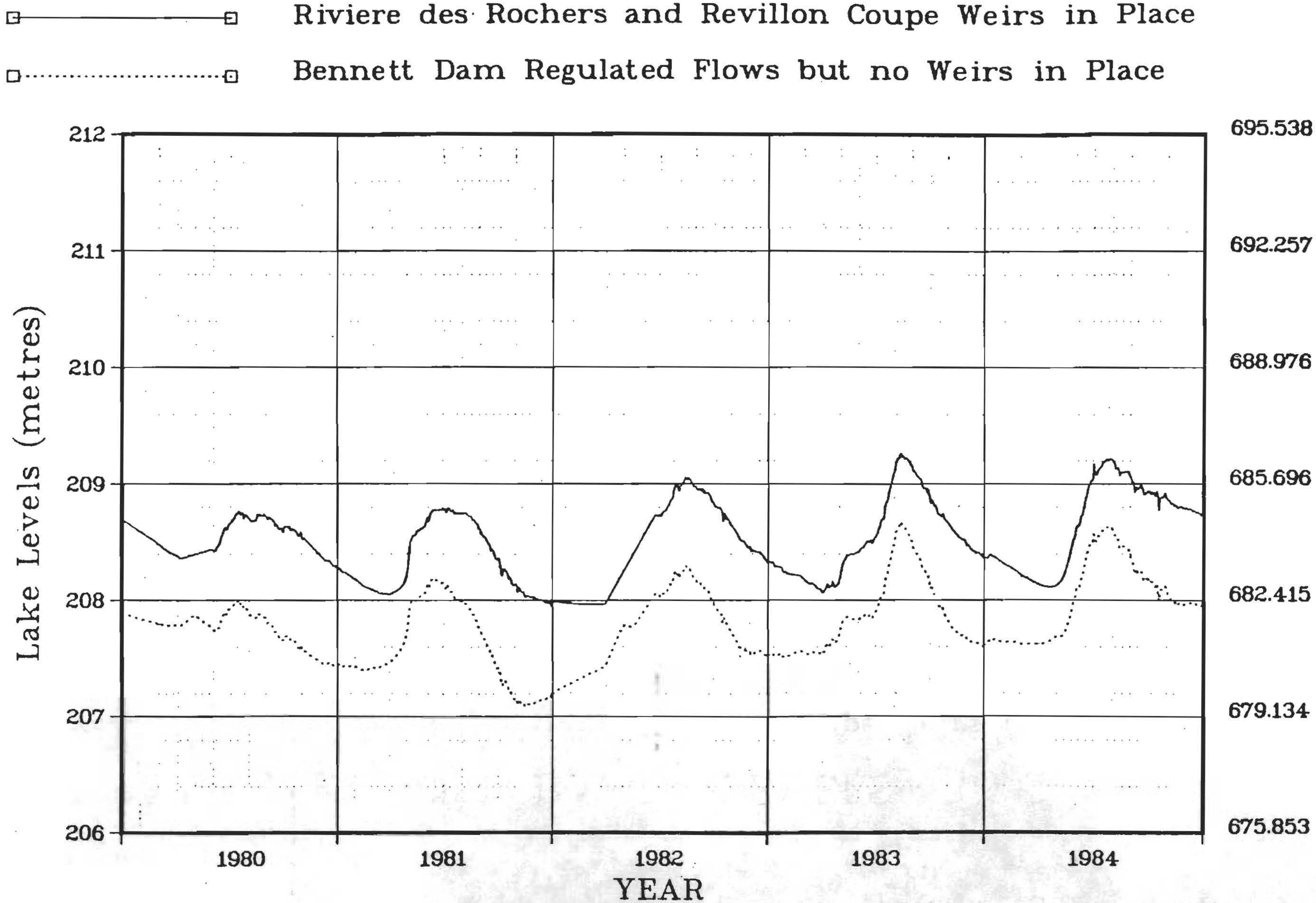

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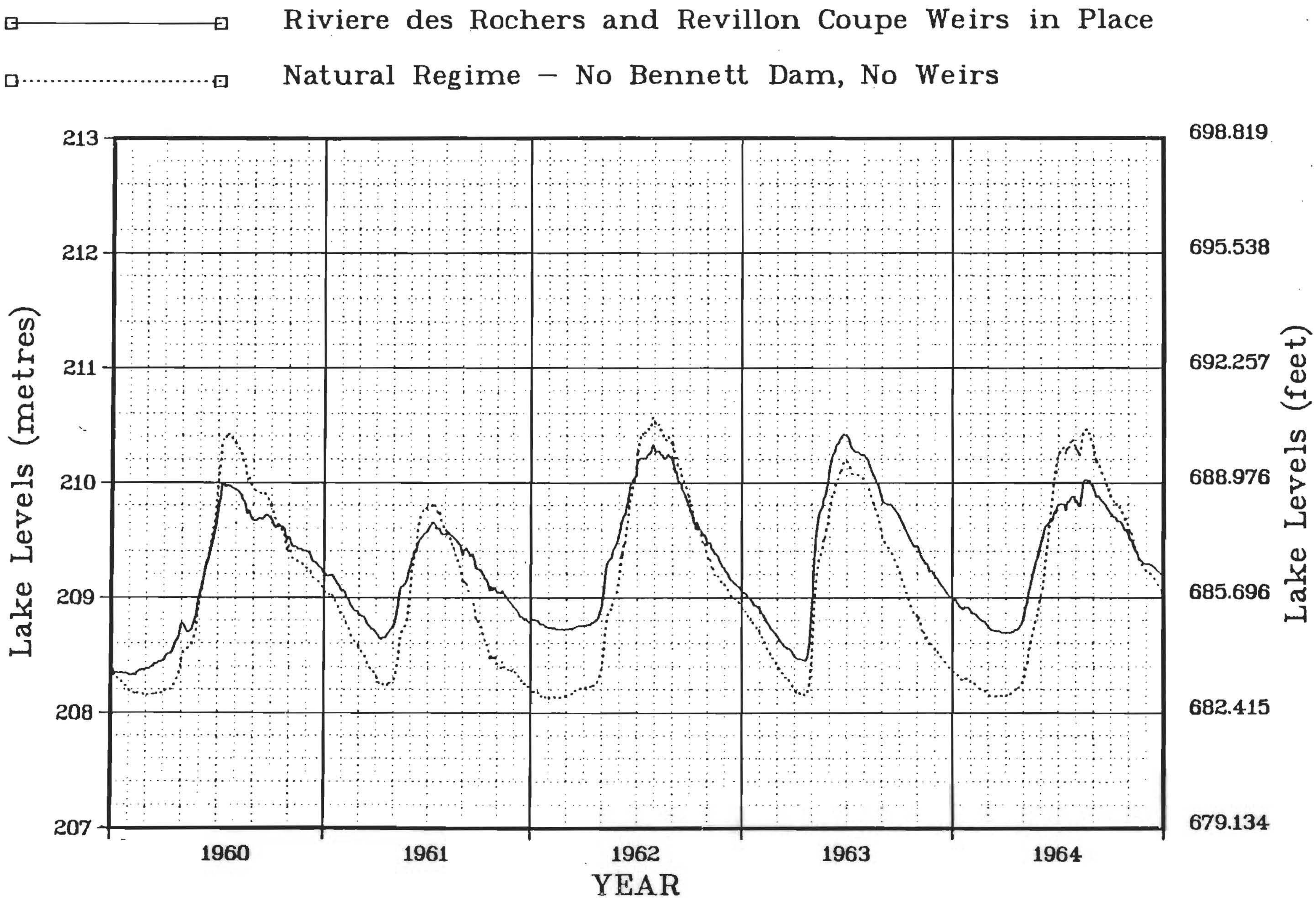

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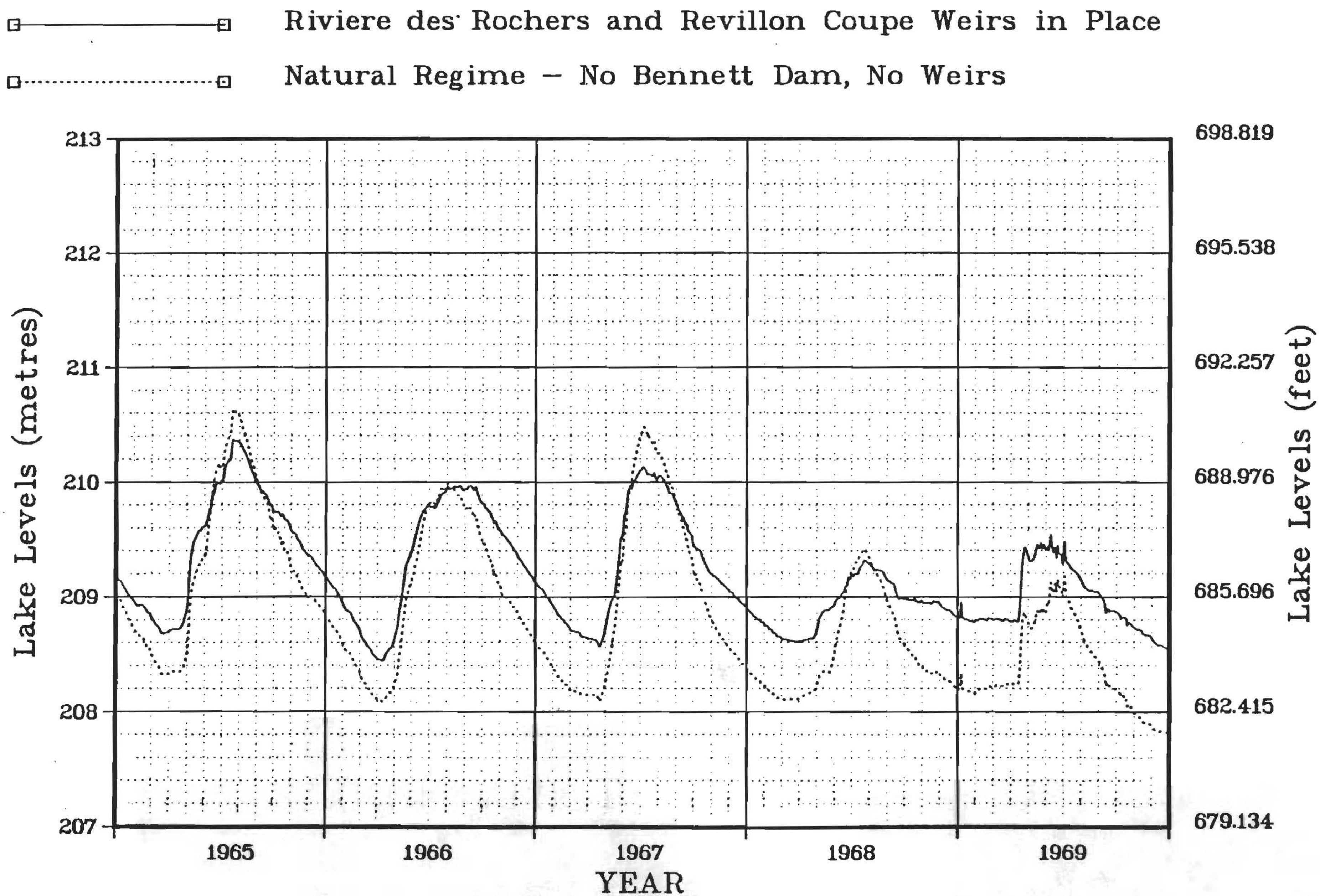

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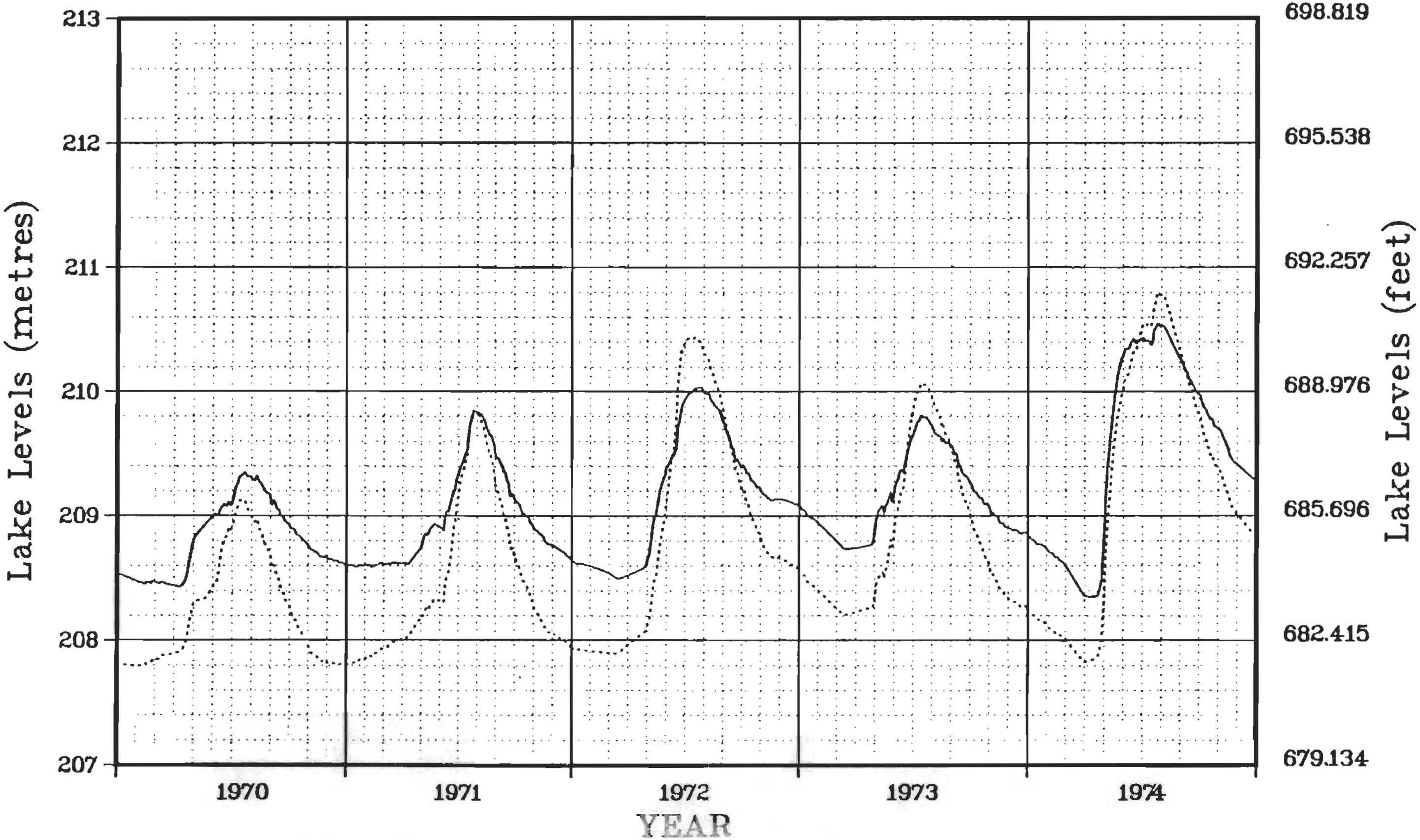
LAKE ATHABASCA LEVELS

Riviere des Rochers and Revillon Coupe Weirs in Place

Natural Regime – No Bennett Dam, No Weirs



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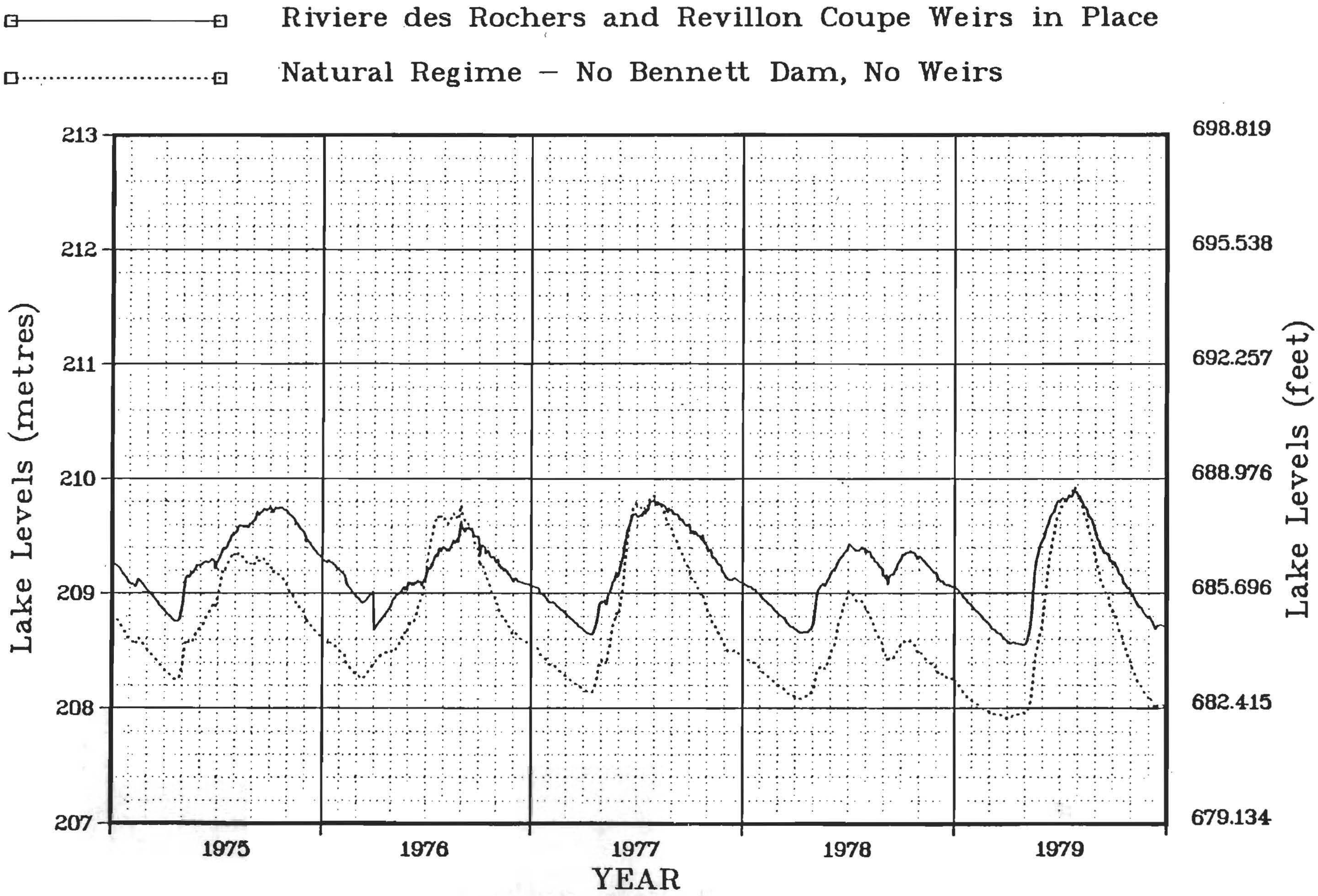

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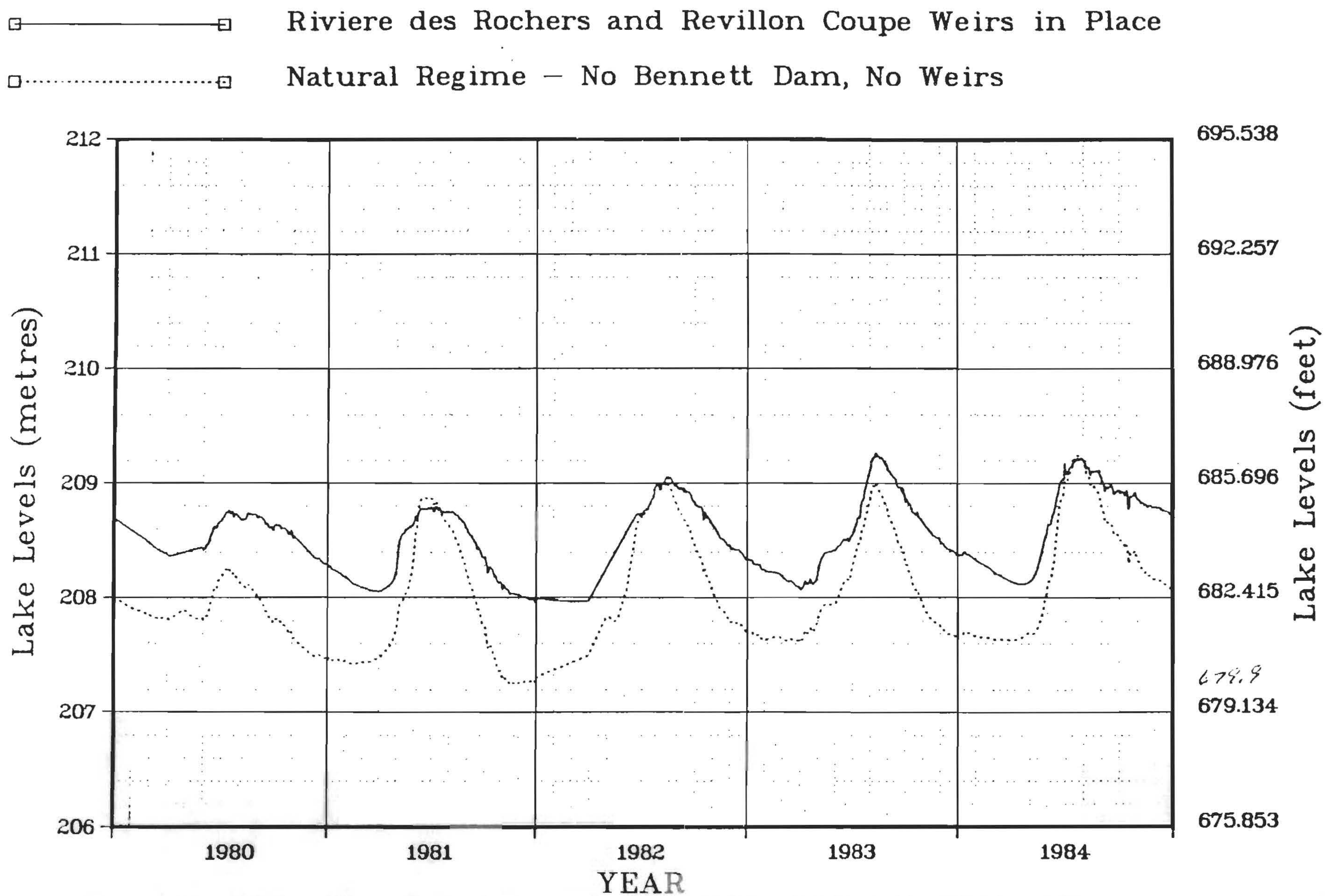
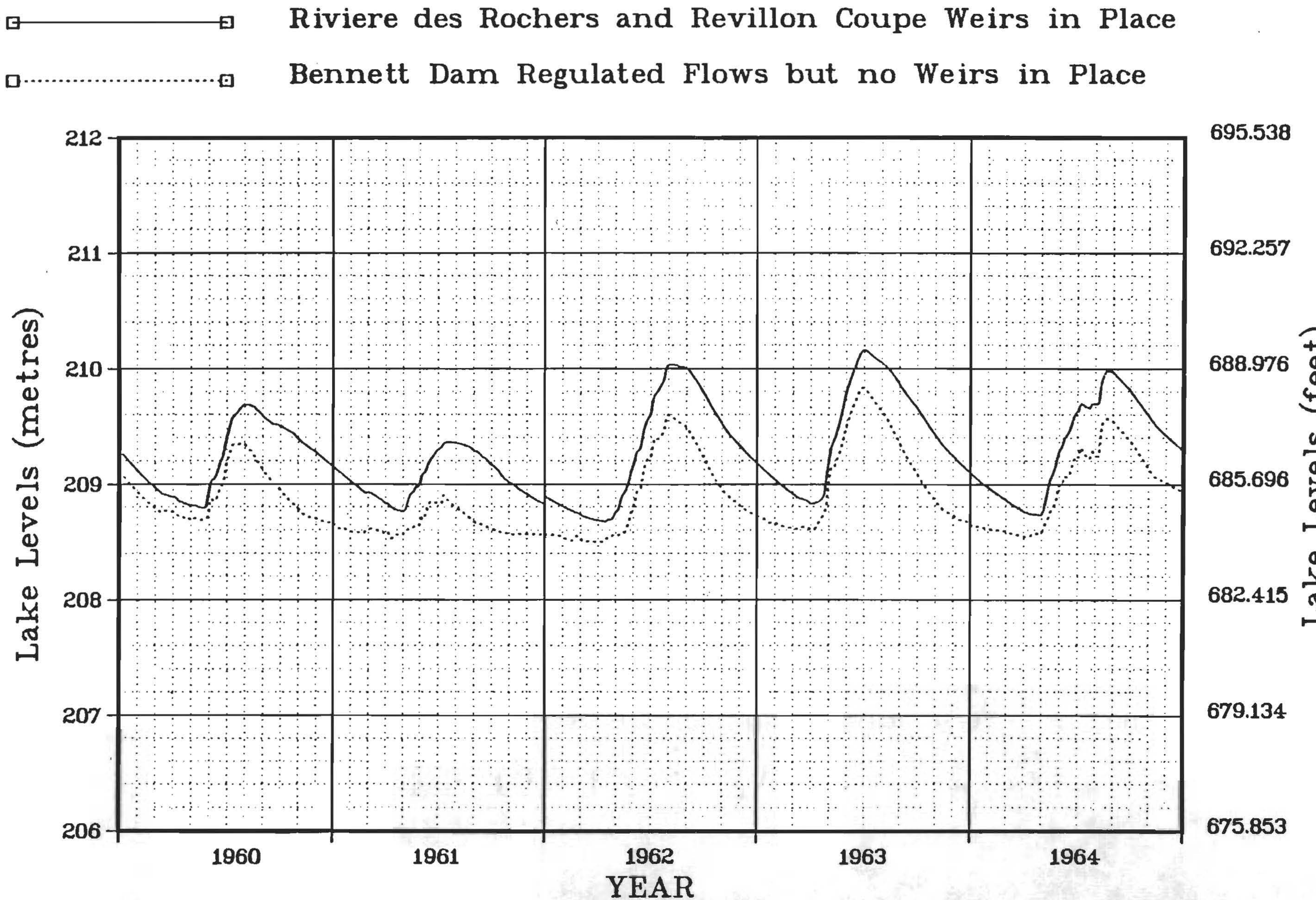
LAKE ATHABASCA LEVELS



LAKE CLAIRE LEVELS



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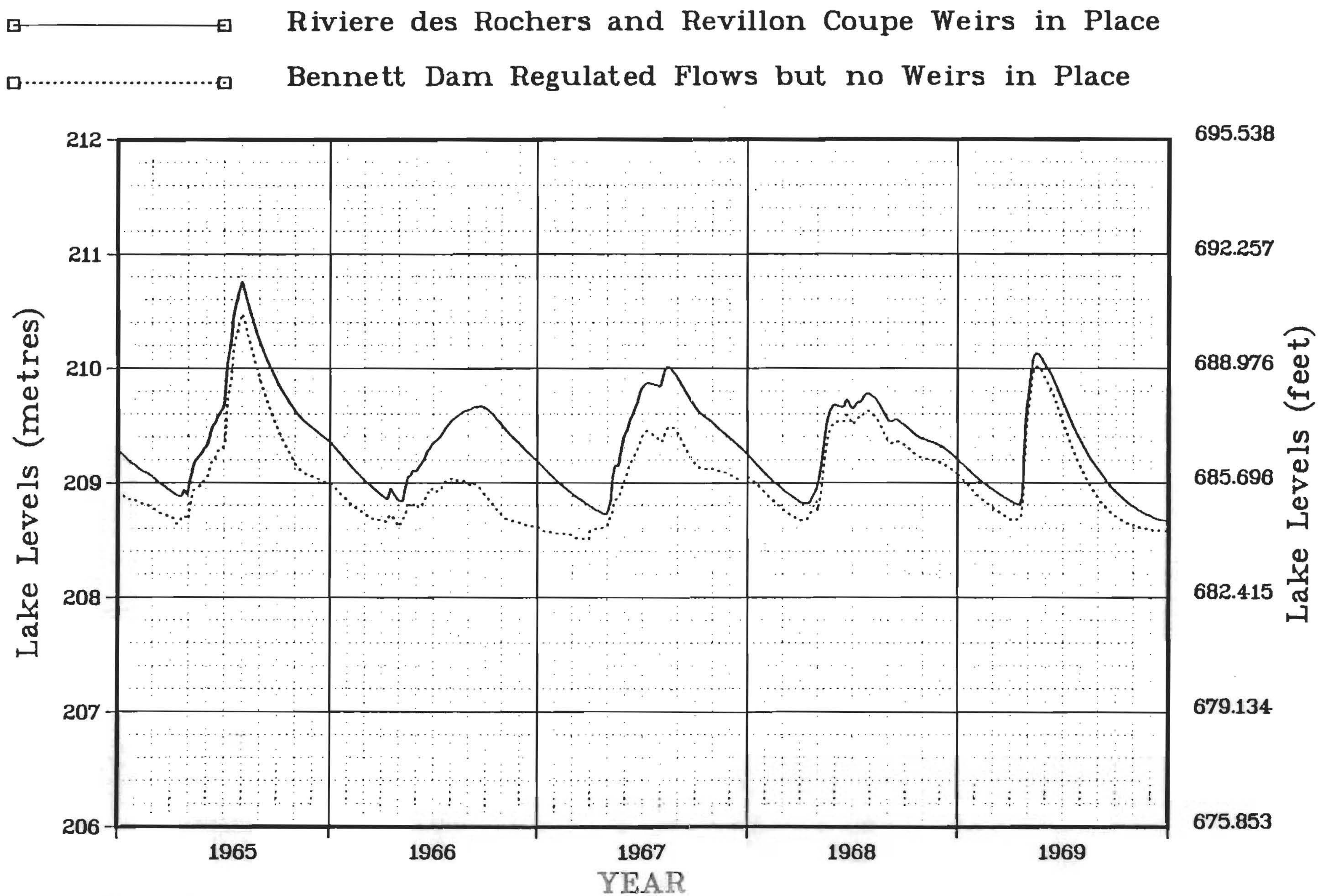

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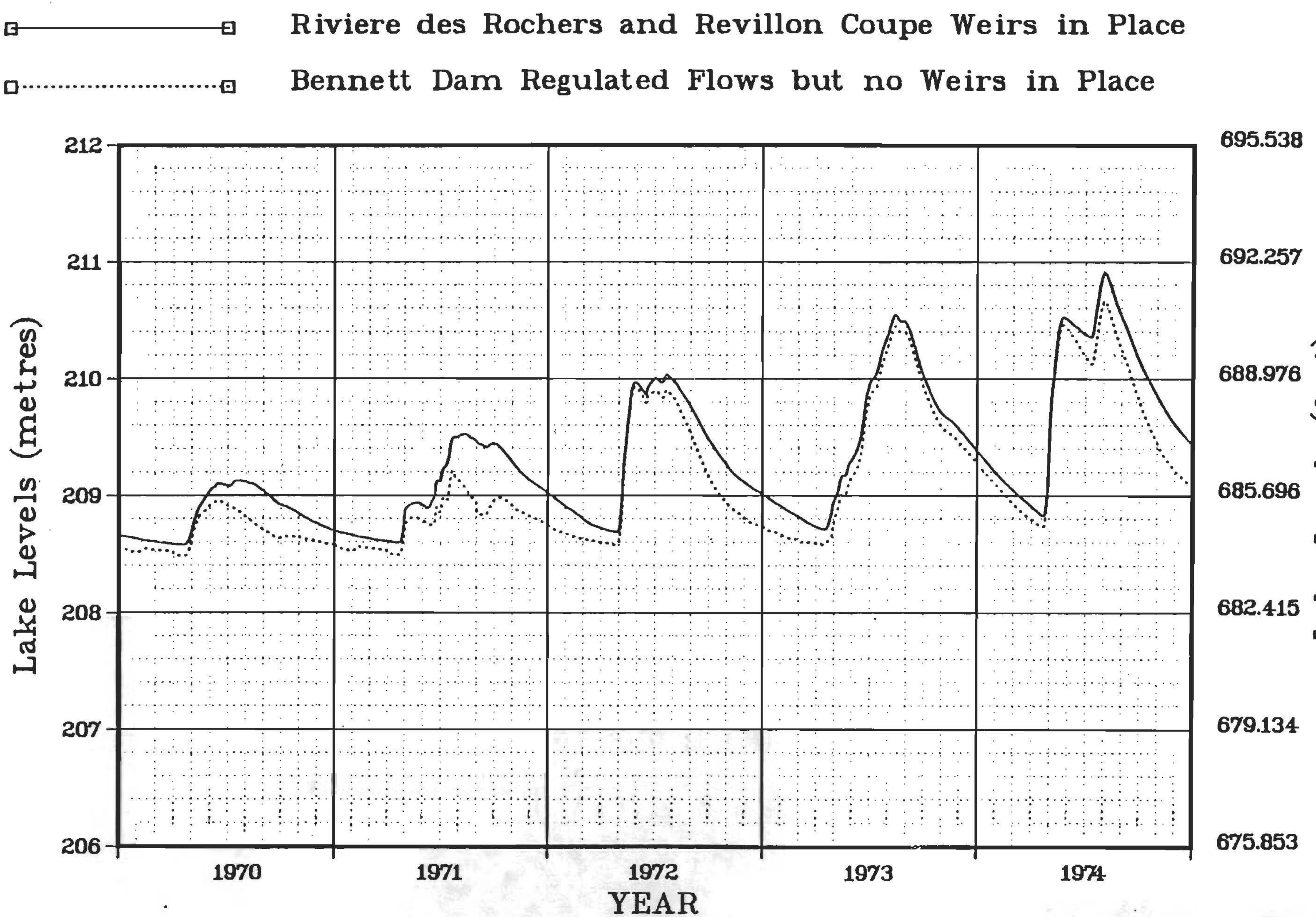
LAKE CLAIRE LEVELS



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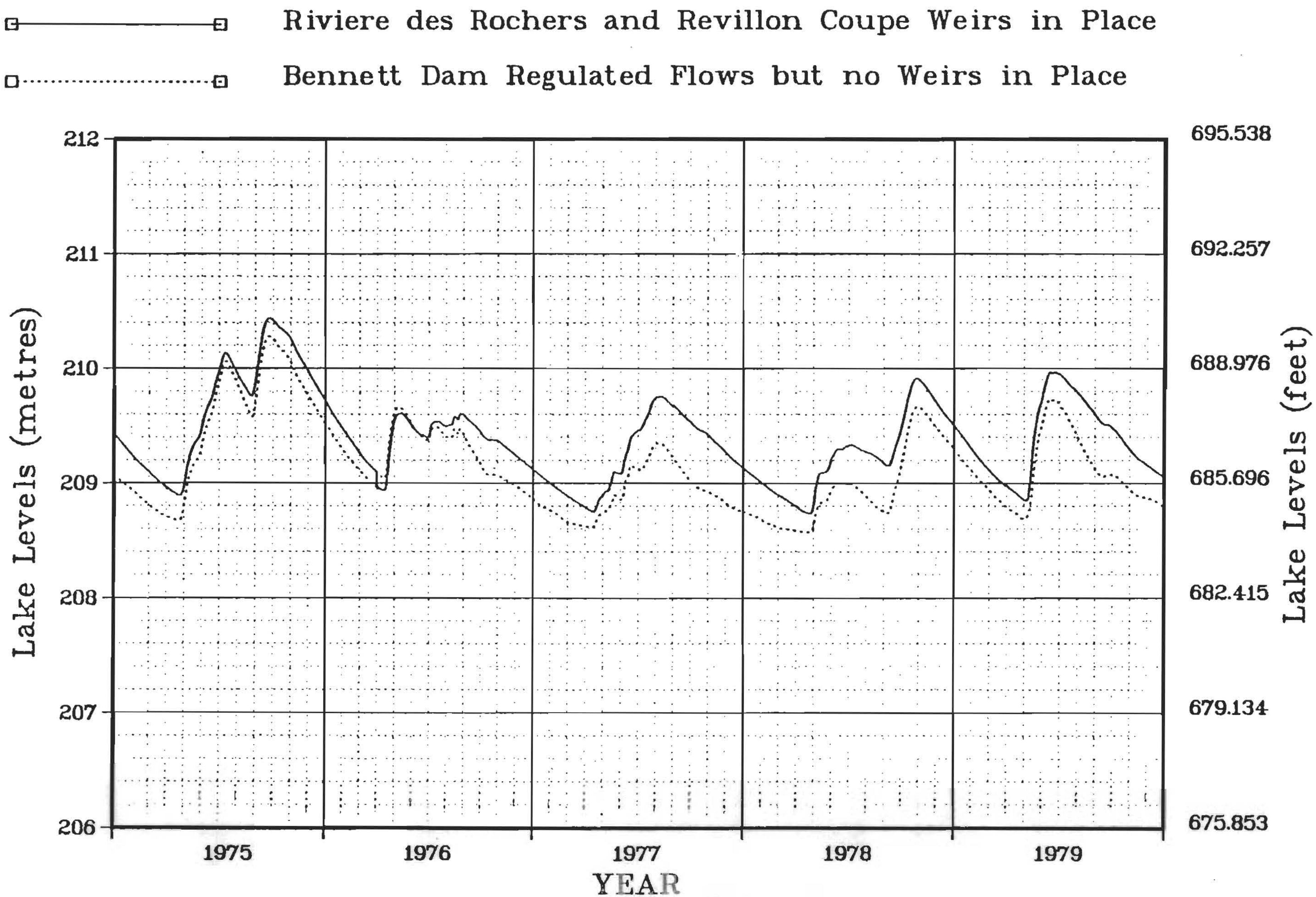
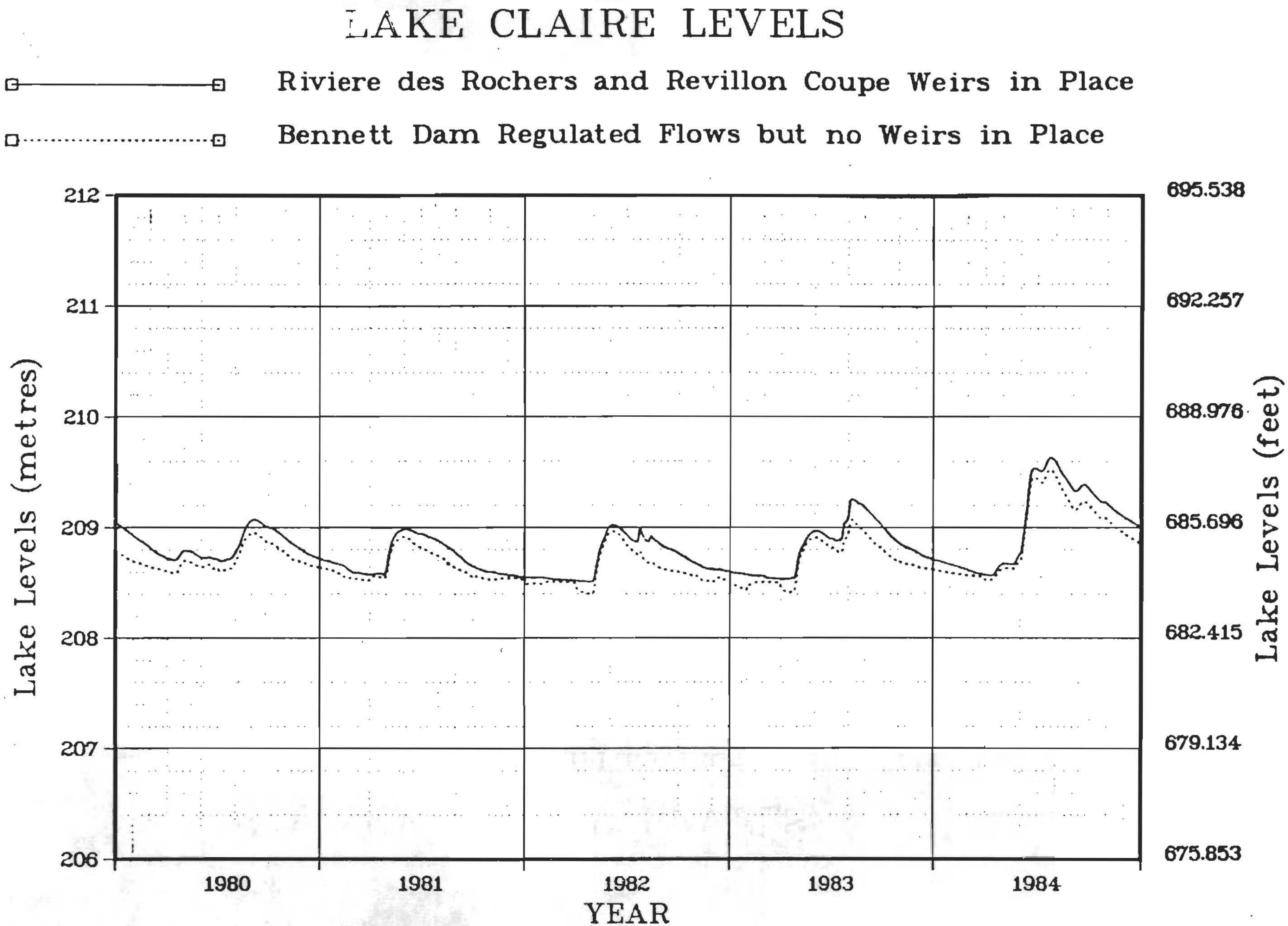
LAKE CLAIRE LEVELS



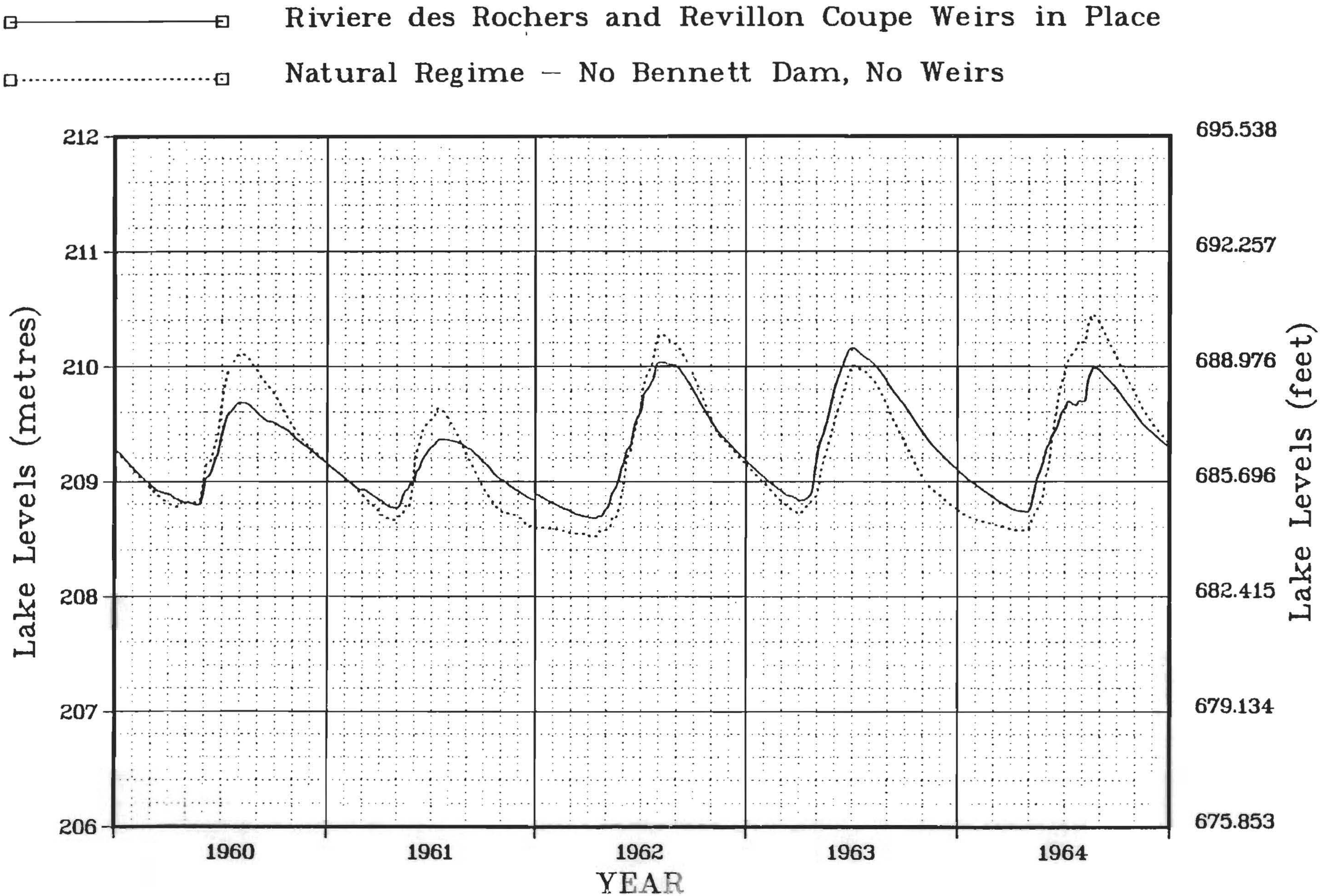


LAKE CLAIRE LEVELS
Riviere des Rochers and Revillon Coupe Weirs in Place
Bennett Dam Regulated Flows but no Weirs in Place
Lake Levels (metres)
Lake Levels (feet)
212
211
210
209
208
207
206
695.538
692.257
688.976
685.696
682.415
679.134
675.853
1980
1981
1982
1983
1984
YEAR

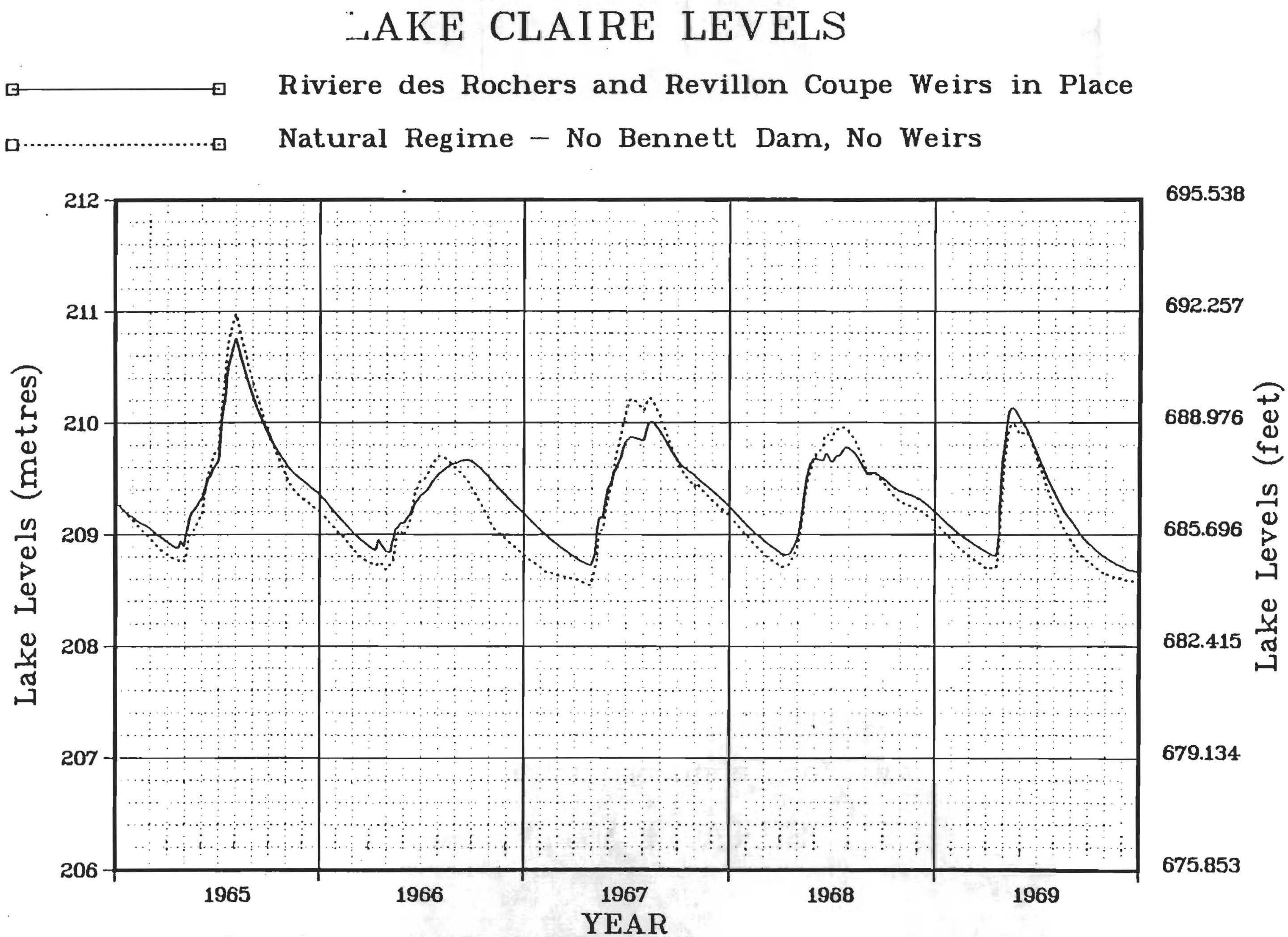
(39)

29/08/8

LAKE CLAIRE LEVELS



25/07


LAKE CLAIRE LEVELS
Riviere des Rochers and Revillon Coupe Weirs in Place
Natural Regime – No Bennett Dam, No Weirs
Lake Levels (metres)
212
211
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208
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206
Lake Levels (feet)
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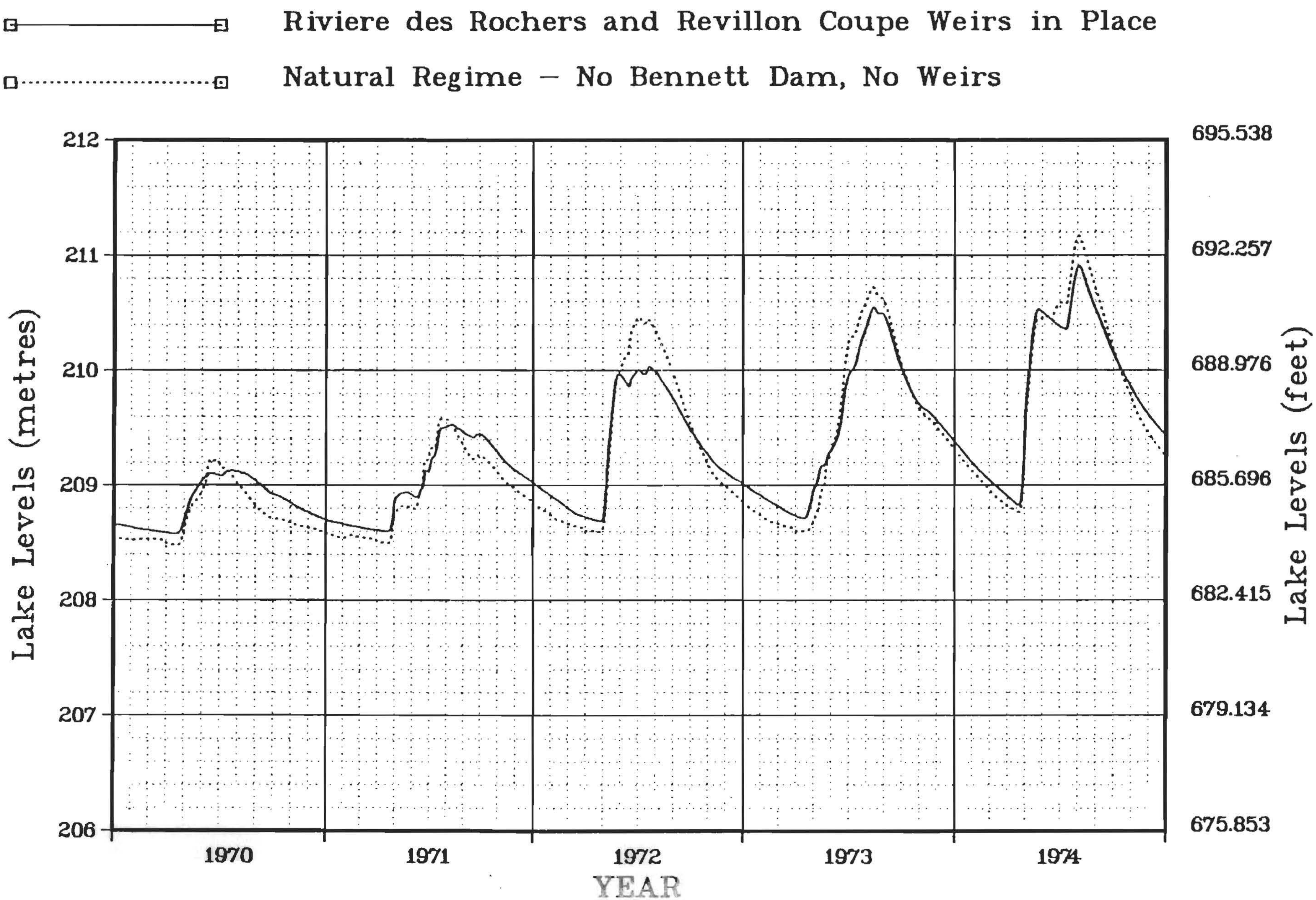
692.257
688.976
685.696
682.415
679.134
675.853
1965
1966
1967
1968
1969
YEAR

LAKE CLAIRE LEVELS



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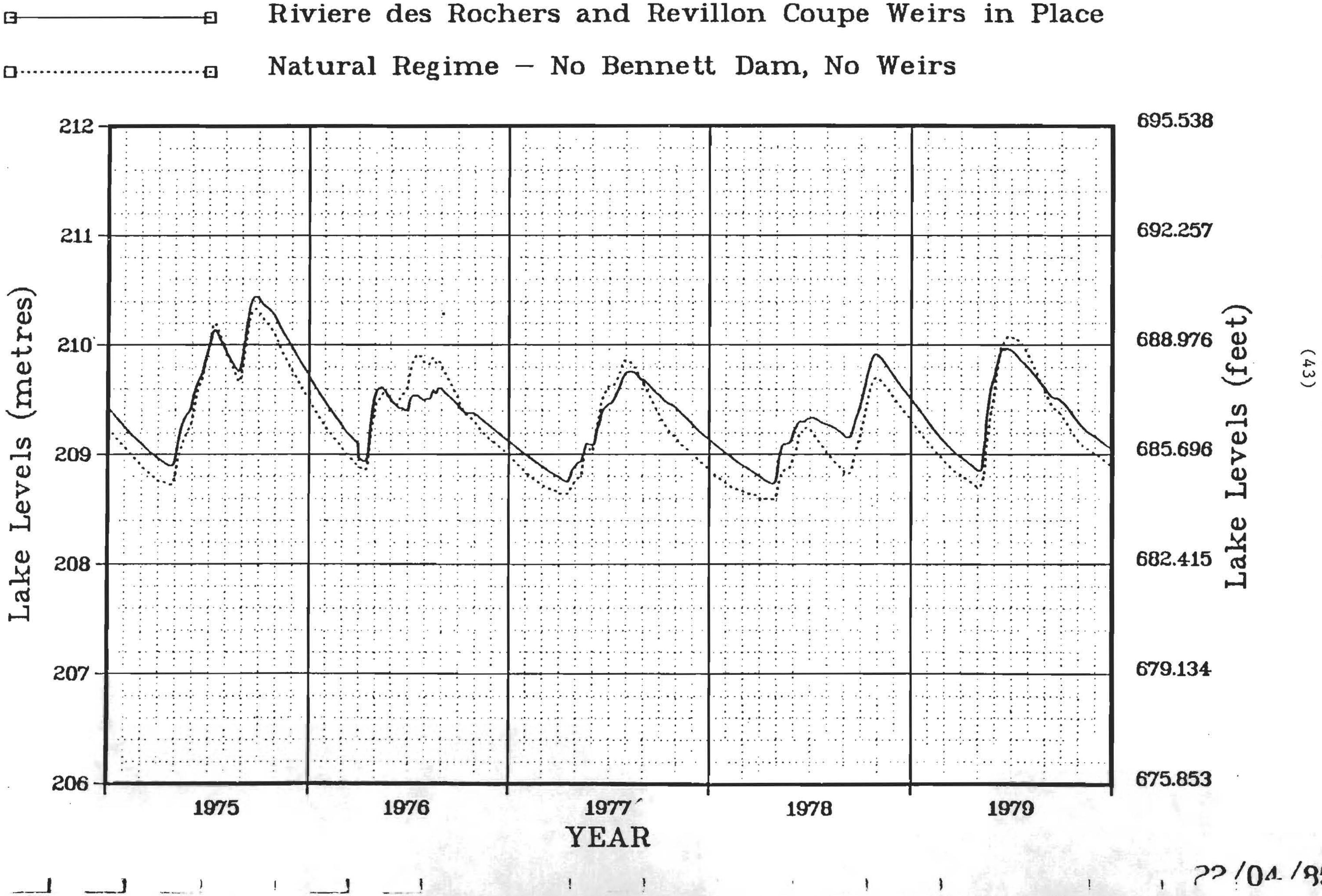

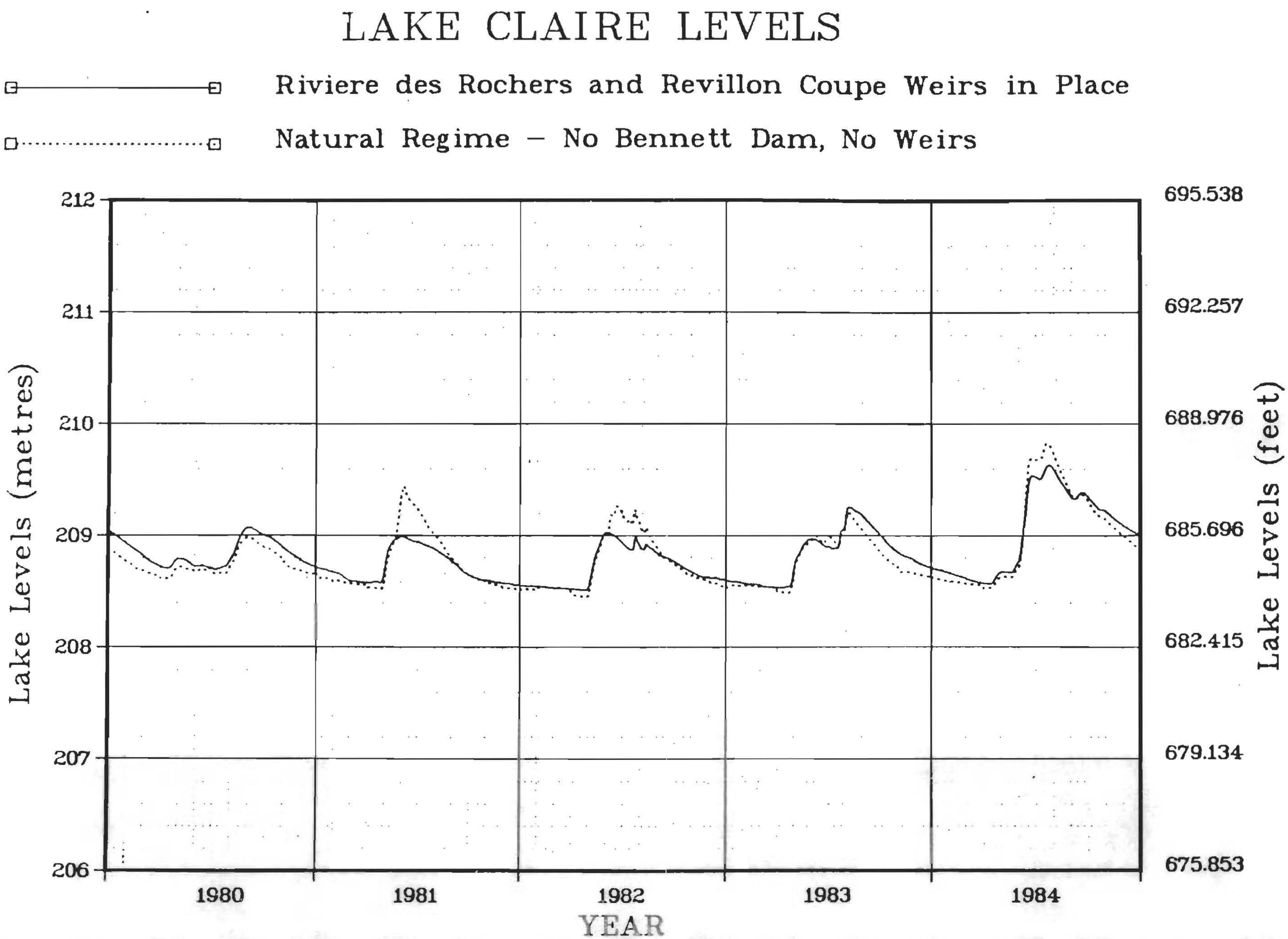

LAKE CLAIRE LEVELS
Riviere des Rochers and Revillon Coupe Weirs in Place
Natural Regime – No Bennett Dam, No Weirs
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1983
1984
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