Analysis of Reservoir Levels and Water Supply Impacts of Proposed Concord Kannapolis Interbasin Transfer

Supplement to the Final Environmental Impact Statement

August 31, 2006

Division of Water Resources
North Carolina Department of Environment and Natural Resources

Summary

1. Computer modeling previously done by the Division of Water Resources for the Final Environmental Impact Statement on the proposed Concord-Kannapolis Interbasin Transfer and for the supplement to the Final Environmental Impact Statement (Final EIS), dated July 7, 2006, is not reliable for two reasons. First, this modeling did not use the final version of the Catawba-Wateree CHEOPS Operations Model of the Catawba basin and the final version of the Low Inflow Protocol (drought management plan) for the Catawba basin, which were not yet available at the time of the Final EIS. Second, the Division of Water Resources made unit conversion and data input errors, which affected the modeling results. The Division of Water Resources regrets and apologizes for these errors. New modeling has been done using the latest version of the computer model and the final version of the Low Inflow Protocol, which are being used for Duke Energy's hydropower license application. The Division of Water Resources has checked its latest modeling by having three engineers review the inputs and also by obtaining an outside review by Devine Tarbell & Associates, the consultant to Duke Energy, which developed the CHEOPS model (Attachments A and B).

2. Four scenarios were modeled using the Catawba-Wateree CHEOPS Operations Model for the purpose of evaluating the impacts of the proposed interbasin transfer (IBT) of water from the Catawba River by Concord and Kannapolis. Each scenario modeled a different quantity of withdrawal. The following IBT quantities were modeled: Zero, an average of 10 millions gallons per day (MGD), an average of 16 MGD, and an average of 22 MGD. All results may be downloaded at the website of the Division of Water Resources at:

   http://www.ncwater.org/Permits_and_Registration/Interbasin_Transfer/Status/Concord/

3. The reservoir level and outflow duration curves included in this report show that, on a large time scale, average daily interbasin transfers of 10, 16, and 22 MGD have little or no noticeable effect on reservoir elevations and reservoir outflows in North and South Carolina over the 75-year period of hydrologic record from 1929-2003.

4. In the future, Duke Energy's reservoirs will be operated under a Low Inflow Protocol (LIP) during periods of low flow. As the stage of the LIP increases from Stage 1 to Stage 4, stricter water use restrictions are applied. Over the 75-year period, the impacts of the proposed IBT on occurrences of the various stages of LIP were evaluated. For a 10 MGD average interbasin transfer, no changes are predicted in the occurrence of Low Inflow Protocol Stages 1 and 2 compared to the Zero transfer scenario. The model predicts one additional month of LIP Stage 1 for a 16 MGD average interbasin transfer. Nine additional months of Stage 1 and one less month of Stage 2 is predicted for an average interbasin transfer of 22 MGD. Stages 3 or 4 are not triggered under any of the modeled scenarios.

5. A closer examination was made of the modeled effects of the proposed interbasin transfer during the most severe drought, specifically in 2000-2002. During this

drought, the model predicts that for the 10 MGD and 16 MGD IBT scenarios, levels in Lake James are reduced by about a quarter of a foot for a period of about two months. For the 22 MGD IBT scenario, the model predicted an increase in the elevation of Lake James, compared to the other scenarios, for about nine months. This is thought to be because of the seven additional months of Stage 1 LIP restrictions predicted for the 22 MGD IBT scenario.

6. Reservoir levels in the system of 11 Duke Energy Reservoirs are significantly affected by reservoir operating policies and by the Low Inflow Protocol. In order to isolate the effect of the interbasin transfer from these other variables, a simple analysis was done, assuming that the entire interbasin transfer would be withdrawn from six of the reservoirs in North Carolina for six months, assuming no inflow to the reservoirs and no withdrawals from them. This simple analysis showed that the effect of withdrawing 10, 16, and 22 MGD from the six reservoir system continuously for six months would lower reservoir elevations by 1 inch to 5 inches. Although this simplified analysis does not match the way the reservoirs are operated, it does provide a way to estimate the magnitude of the impact associated with the proposed transfer.

7. A short summary of portions of the Duke Energy Water Supply Study is presented. During relicensing of the Duke Energy reservoirs in the Catawba-Wateree basin in North and South Carolina, a high priority has been to determine if the basin could withstand the increased demands projected for the future. These demands are expected to include larger water supply withdrawals, increased releases from reservoirs for aquatic habitat, greater consumptive use of cooling water for electric power generation, and maintenance of critical reservoir elevations to assure water supply security. Duke Energy worked with water supply users and other interested parties to project water needs to 2058. The projection show an increase of total withdrawals from 496 MGD in 2008 to 946 MGD and an increase in "net outflows" or consumptive uses from 215 MGD in 2008 to 475 MGD. The Duke Energy Water Supply Study concluded that all of these projected increased water uses for municipalities, industry, power generation, and agriculture could be met past 2048, even during the most severe drought of the 75 years of hydrologic record, without violating the critical reservoir elevations needed to assure the operability of public water supply sources. This analysis included projected increases in interbasin transfers from the basin, including Concord and Kannapolis' proposed transfer, as well as the many other demands on water resources. This independent conclusion by the Duke Energy Water Supply Study shows that all projected future demands on the basin can be met for more than 40 years into the future.

8. A summary of consumptive water use in the Catawba Basin is presented. The Duke Energy Water Supply Study shows that consumptive water use in the Catawba Basin, as a percent of average flow from Lake Wateree, is expected to increase from 2008 to 2038. Consumptive use for power generation is projected to grow from 3.0 % to 5.2 % of average flow by 2038. Consumptive use for public water systems, excluding interbasin transfers, are projected to grow from 1.5% to 4.5% of average flow over the same period. Interbasin transfers are projected to increase from 0.5% to 2.0% of average flow, including 0.8% of average flow for an IBT to Concord and Kannapolis, over the same period.

Purpose

The purpose of this supplement is to provide updated computer modeling results and other analyses to evaluate potential impacts on the Catawba River Basin of the proposed interbasin transfer (IBT) of water by the Cities of Concord and Kannapolis from the Catawba River and Yadkin River Basins to the Rocky River Basin. These updated modeling results pertain only to the Catawba River Basin. The results replace previous modeling results in the Final Environmental Impact Statement (EIS) and the July 7, 2006 supplement to the EIS which contained data input and unit conversion errors.

In addition to the computer modeling analysis, this report includes a simplified analysis of the incremental effects of the proposed IBT on the reservoirs within North Carolina in the Catawba River Basin. This less complex approach evaluates the impacts on reservoir levels of the proposed IBT, assuming no inflows to the system and no other withdrawals over a six-month period. These assumptions were used to isolate the effects of the proposed IBT from other factors, such as reservoir operations.

This report also includes a summary of some of the relevant water supply related information in the Water Supply Study carried out for Duke Energy as a part of its Federal Energy Regulatory Commission (FERC) relicensing process.

Finally, a brief summary is included that compares the proposed IBT to other present and future consumptive water uses in the Catawba River Basin.

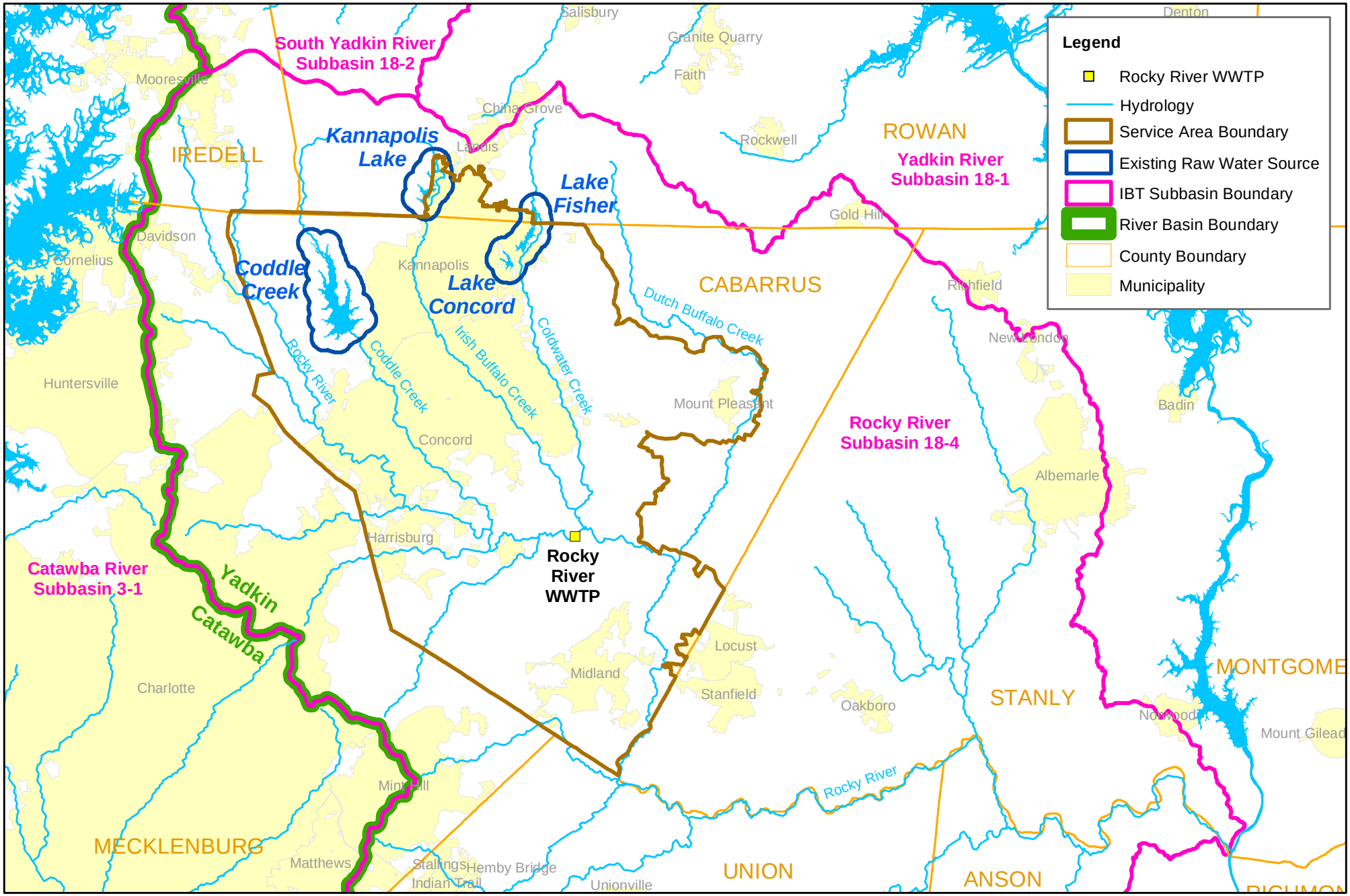
IBT Request

The Cities of Concord and Kannapolis are requesting an IBT certificate to meet their projected water supply shortfall during the next 30 years. The Cities and their service areas in Cabarrus County (Figure S-1) are within the Rocky River Basin.

The Cities are requesting permission to transfer an average of 22 million gallons per day (MGD) from the Catawba River and Yadkin River Basins for use in the Rocky River Basin. The maximum day IBT being requested is up to 36 MGD. The Cities are requesting permission to transfer up to a maximum of 10 MGD from the Yadkin River Basin with the remainder of up to a maximum of 36 MGD to come from the Catawba River Basin. Therefore, if permission is granted to transfer 10 MGD from the Yadkin River Basin, then the requested amount of the transfer from the Catawba River Basin is reduced to a maximum day transfer of up to 26 MGD.

The Cities submitted an IBT petition and supporting EIS. The Draft EIS was reviewed by agencies of the Department of Environment and Natural Resources and the Wildlife Resources Commission. It was then revised by the applicant to address agency comments. A public comment period on the revised Draft EIS and IBT Petition began in May 2005 and ended August 11, 2005. Public hearings were held in Charlotte, NC and Albemarle, NC on June 22 and 23, 2005.

The Final EIS, which addressed comments received on the revised Draft EIS and the IBT Petition, was released for public review on May 26, 2006. Due to modeling errors in the Final EIS, the public review, originally scheduled for 60 days, was extended by the Environmental Management Commission until September 30, 2006.



CH2MHILL

Figure S-1
Existing Raw Water Souces
Concord/Kannapolis IBT Environmental Impact Statement

Public meetings will be held to facilitate further public comment on this project in the Town of Valdese, NC on September 7, 2006 and in the Charlotte area the week of Sept 18 (details not yet available). Details of the September 7 meeting and the Charlotte meeting (when they become available) may be found at the Division of Water Resources (DWR) website: http://www.ncwater.org/Permits_and_Registration/Interbasin_Transfer/Status/Concord/.

It is anticipated that the EMC will act on this request at their November 9, 2006 meeting.

Computer Modeling

Computer modeling results presented in this report have been developed using the most recent version of the Catawba-Wateree CHEOPS Operations Model (Version 8.7 released in March, 2006). This computer model was developed to describe the effects of water quantity related operational changes and physical modifications to the hydropower facilities operated by Duke Energy in the Catawba-Wateree River Basin. Version 8.7 includes the most recent Low Inflow Protocol (LIP) developed for the Catawba-Wateree Project. This version of the model is being used by Duke Energy as the basis for the Federal Energy Regulatory Commission (FERC) license application and for the Final Comprehensive Relicensing Agreement for the Catawba-Wateree Hydro Project filed with FERC in August 2006.

Due to the timing of the request for certification, the modeling that was presented in the Final Environmental Impact Statement (EIS) released in May 2006 had to be done using previous versions of the model and the LIP. This previous modeling, conducted as a part of the Final EIS and a supplement to the EIS distributed on July 7, 2006, is unreliable due to input errors related to the Concord and Kannapolis IBT quantities. DWR apologizes for these data input errors, has corrected the errors, and has taken steps to ensure that results presented in this document are accurate. The inputs to the updated modeling have been reviewed in detail by Devine Tarbell & Associates (DTA), the developers of the Catawba-Wateree CHEOPS Operations Model. The detailed results of the updated modeling presented in Attachment A, *Revised Report: CHEOPS Simulation of Proposed Concord-Kannapolis Interbasin Transfer from the Catawba River Basin.* DTA's review report is found in Attachment B, *Catawba-Wateree CHEOPS™ Model Review of Input Concord Kannapolis, NC Final EIS for IBT Certification.*

Updated CHEOPS Results

Four levels of proposed interbasin transfer were analyzed as follows:

Scenario Name	Concord Kannapolis IBT
Zero MGD IBT	Zero IBT
10 MGD IBT	10 MGD Average IBT withdrawn from Lake Norman
16 MGD IBT	16 MGD Average IBT withdrawn from Lake Norman
22 MGD IBT	22 MGD Average IBT withdrawn from Lake Norman

All IBT scenarios assume that the water is withdrawn from Lake Norman. Apart from the Concord Kannapolis IBT, all other inputs to the model for the four scenarios are the same.

The model uses a 75-year historical record of inflows for the Catawba River system from 1929 to 2003 to simulate the effects of the IBT. The analysis is based on a projection of water supply needs for the year 2035, including municipal water supply, power plant cooling, agricultural, and industrial demands based on the Water Supply Study developed as part of FERC relicensing. These demands include other IBTs that are either certified, grandfathered, or anticipated, but not certified. The model requires that withdrawals be supplied as annual average daily withdrawal values. Since the withdrawal is not the same for every day of the year, the annual average daily values are adjusted to produce monthly use patterns to simulate seasonal water use patterns. In the CHEOPS model, each withdrawal's monthly distribution is based on the historical pattern for that water user. The Concord-Kannapolis proposed IBT withdrawals were distributed according to Concord and Kannapolis' monthly demand patterns reflected in their 2002 local water supply plans. Table S-1 shows the monthly distribution of average demands as a percentage of annual average demand that was used in the CHEOPS model for the Concord Kannapolis withdrawal in all four scenarios.

Table S -1: Monthly Distribution for Concord and Kannapolis Water Demands

Month	% of Average
January	91%
February	90%
March	90%
April	101%
May	108%
June	116%
July	110%
August	111%
September	102%
October	103%
November	91%
December	88%

Results of these simulations have been summarized on a long term time scale using duration curves of reservoir level and reservoir outflow, and using a summary of the occurrences of LIP stages. The effects of the transfer are also examined on a shorter term time scale by examining changes in reservoir elevation and LIP stages during the drought of record. While the whole system of 11 reservoirs was modeled and analyzed, this summary includes results of the modeling for Lakes James, Norman, Wylie and Wateree, chosen as representative reservoirs. Information for additional reservoirs can be found in Attachment A and additional modeling results are available on the DWR website at

http://www.ncwater.org/Permits_and_Registration/Interbasin_Transfer/Status/Concord/

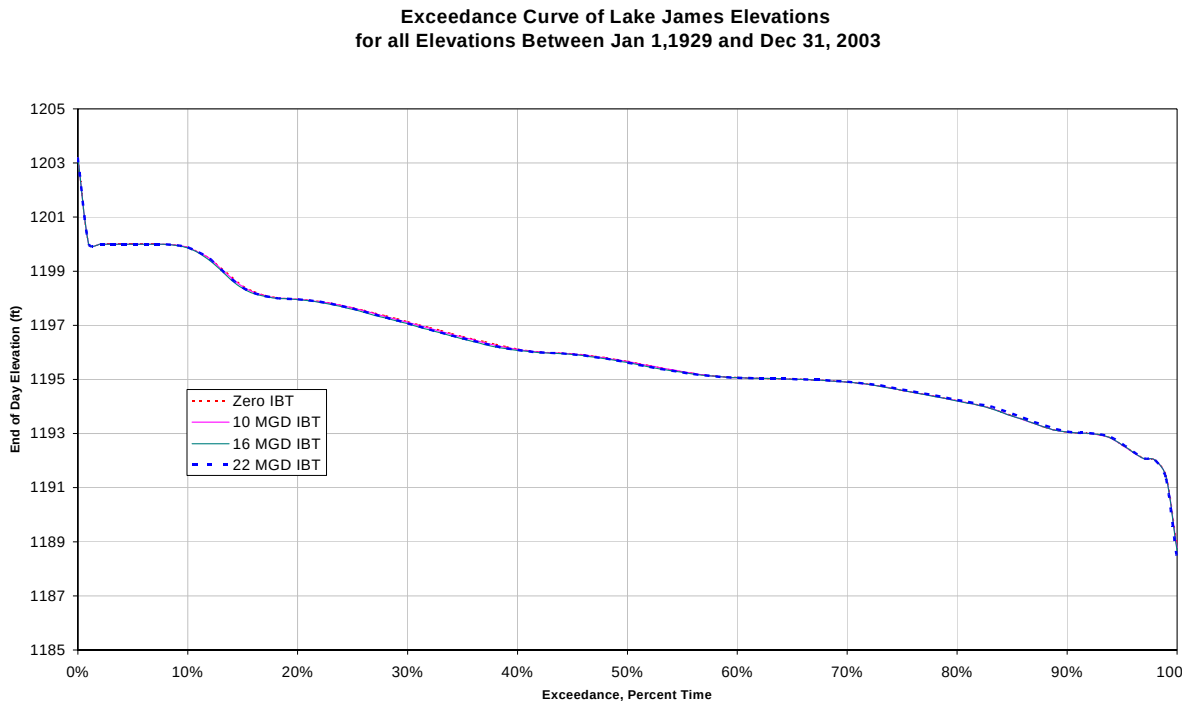
Long Term Analysis

The duration curves presented here are cumulative frequency curves showing the percentage of time over the period of record that a specified reservoir level or outflow is equaled or exceeded. They show in a probabilistic way how the various levels of IBT are predicted to affect reservoir levels and outflows, and provide a means of presenting the impacts of the transfers on a large time scale.

Figures S-2 and S-3 show reservoir elevation duration curves for Lake James and Lake Norman for the four scenarios. Tables S-2 and S-3 show the reservoir elevation duration data for Lake James and Lake Norman. Figures S-4 and S-5 show reservoir outflow duration curves for outflow from Lake James and Lake Wylie. Tables S-4 and S-5 show reservoir outflow duration data for outflow from Lake James and Lake Wylie.

Duration curves are typically used because they provide an easy way to compare results of several different scenarios. In this case the results of the four scenarios are so similar, few differences are noticeable on the graphs. Tables showing the values for selected frequency percentages are included to make it easier to see the differences between the four scenarios. For example, in the case of Lake James elevation shown below, the differences in minimum elevation, the elevation exceeded 100% of the time, is not discernable from the graph. However, the data table shows that the predicted absolute minimum elevation is 0.54 feet lower with a 22 MGD transfer compared to what the model predicts for the zero transfer scenario. The minimum predicted elevations for Lake James for IBT amounts of 10 and 16 MGD are 0.11 and 0.20 feet lower, respectively.

Figure S-2: Lake James Elevation Duration Curve



Exceedance, Percent Time	Lake James Levels Remain above Elevation, FT			
	Zero IBT	10 MGD IBT	16 MGD IBT	22 MGD IBT
0%	1203.2	1203.2	1203.2	1203.2
10%	1199.88	1199.88	1199.86	1199.88
25%	1197.65	1197.64	1197.59	1197.62
50%	1195.67	1195.66	1195.62	1195.62
75%	1194.59	1194.59	1194.59	1194.62
90%	1193.05	1193.05	1193.05	1193.07
95%	1192.57	1192.57	1192.58	1192.61
99%	1192.01	1192.01	1192.01	1192.01
100%	1188.88	1188.77	1188.68	1188.34

Figure S-3 : Lake Norman Elevation Duration Curves

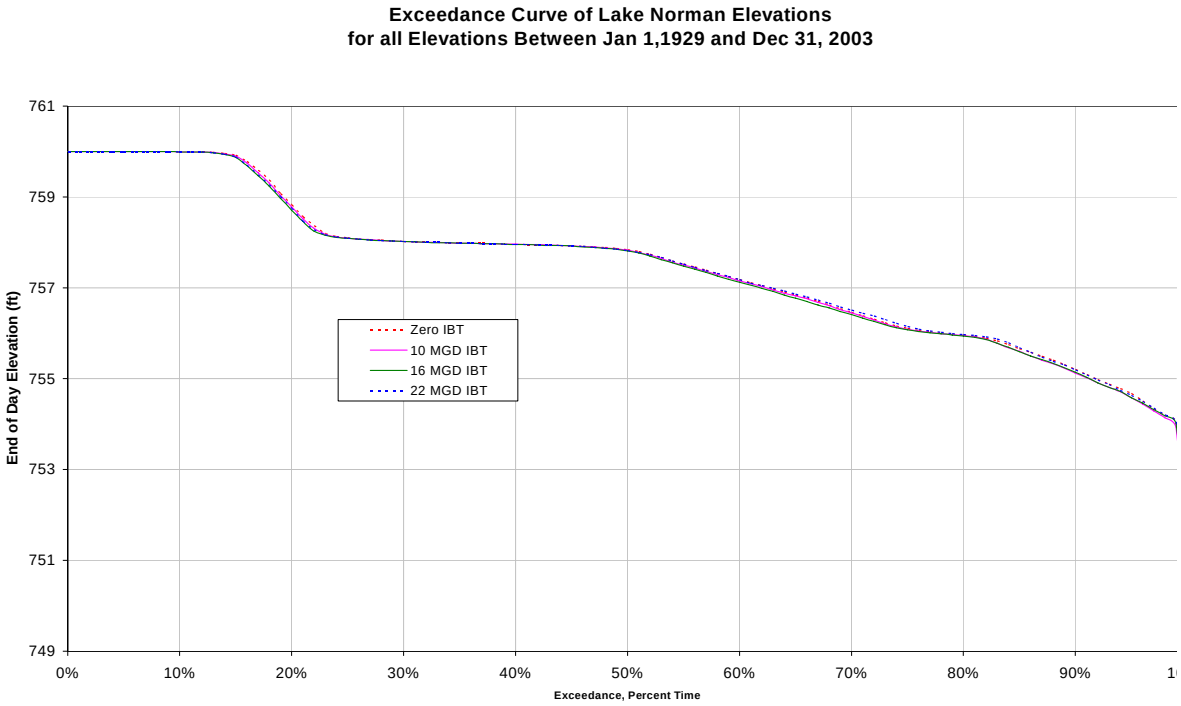


Table S--2: Lake Norman Elevation Duration Data

Exceedance, Percent Time	Lake Norman Levels Remain above Elevation, FT			
	Zero IBT	10 MGD IBT	16 MGD IBT	22 MGD IBT
10%	759.99	759.99	759.99	759.99
25%	758.1	758.09	758.09	758.09
50%	757.84	757.83	757.81	757.82
75%	756.11	756.09	756.08	756.15
90%	755.31	755.23	755.24	755.3
95%	754.78	754.71	754.72	754.74
99%	754.19	754.14	754.18	754.2
100%	751.53	750.65	751.22	752.95

Figure S-4: Lake James Outflow Duration Curves

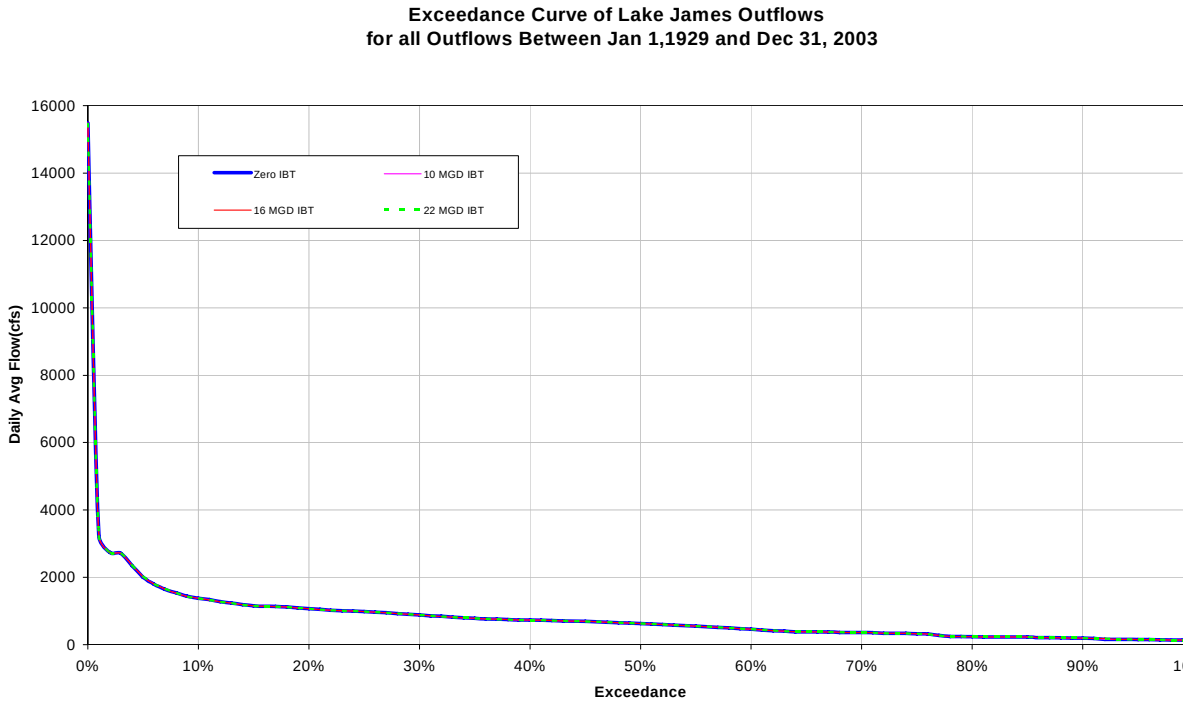


Table S--3: Lake James Outflow Duration Curves

Exceedance, Percent Time	Lake James Flow Remain above, cfs			
	Zero IBT	10 MGD IBT	16 MGD IBT	22 MGD IBT
0%	15,491	15,491	15,491	15,491
10%	1,384	1,382	1,381	1,379
25%	986	985	985	985
50%	627	627	628	627
75%	327	327	327	327
90%	202	202	202	203
95%	159	159	159	159
99%	140	140	140	140
100%	139	139	139	139

Figure S-5: Lake Wylie Outflow Duration Curves

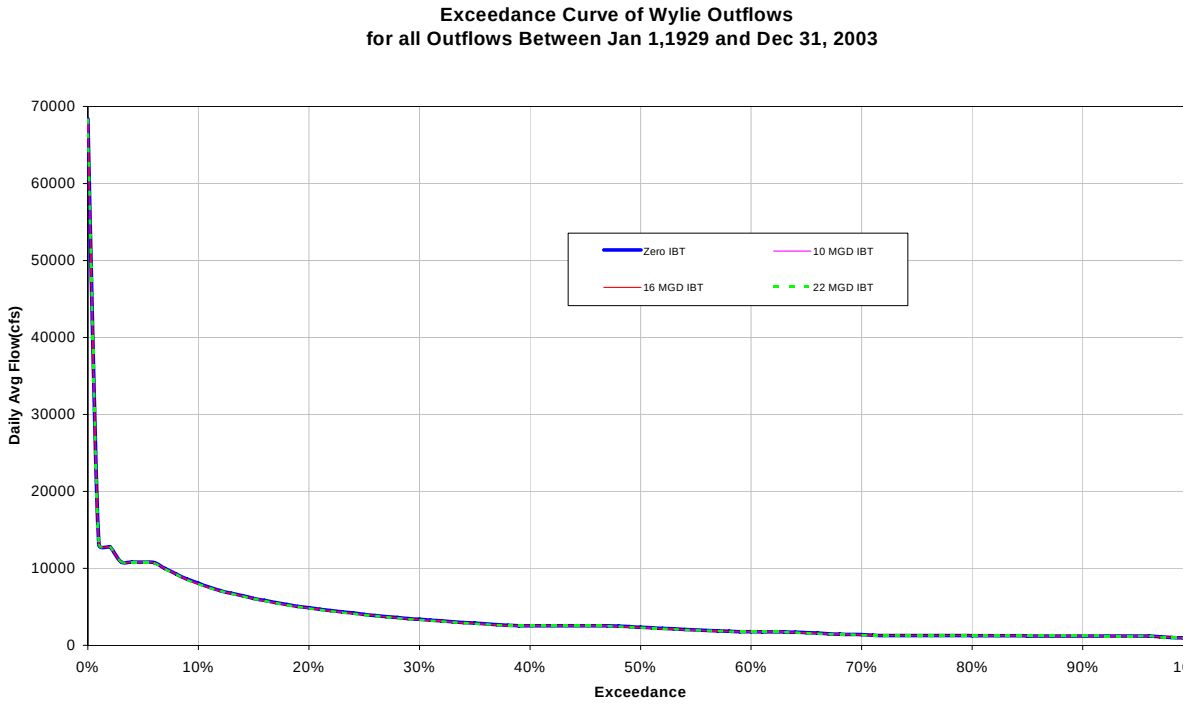


Table S--4 : Lake Wylie Outflow Duration Data

Exceedance, Percent Time	Lake Wylie Flow Remain above, cfs			
	Zero IBT	10 MGD IBT	16 MGD IBT	22 MGD IBT
0%	68,400	68,399	68,392	68,404
10%	8,047	7,997	7,965	7,946
25%	4,027	3,981	3,980	3,953
50%	2,345	2,321	2,314	2,303
75%	1,271	1,270	1,270	1,269
90%	1,221	1,221	1,221	1,221
95%	1,205	1,205	1,205	1,204
99%	1,011	1,011	1,011	995
100%	838	838	838	838

Effects on Low Inflow Protocol Implementation

In the future, Duke Energy's reservoirs will be operated under a Low Inflow Protocol during periods when inflows to the system are not adequate to maintain required water levels in the reservoirs while supplying required downstream releases. As the stage of the LIP increases from Stage 1 to Stage 4, stricter water use restrictions are applied.

Another long term approach to examining the impacts of the IBT is to evaluate changes to the occurrence of Low Inflow Protocol stages for the four levels of transfer modeled. Each LIP stage stipulates water management actions designed to manage project operations and withdrawals during drought conditions. Stage 0 is a watch stage, and Stages 1-4 impose increasing levels of water use reduction measures and changes to outflows from the reservoirs. The Low Inflow Protocol included in the Catawba-Wateree CHEOPS Operations Model Version V8.7 is included with this report as Attachment C.

Table S-6 is a summary of the LIP actions for public water supply systems.

TABLE S- 6
Summary of Catawba River Basin Low Inflow Protocol Stages

Stage	Public Water Supply Actions	Water Use Reduction Goals
-1	Normal Conditions	None
0	Low Inflow Watch – DMAG Meets	None
1	Voluntary Water Use Restrictions	3 to 5 percent
2	Mandatory Use Restrictions	5 to 10 percent
3	Increased Mandatory Use Restrictions	10 to 20 percent
4	Emergency Use Restrictions	20 to 30 percent

DMAG = Drought Management Advisory Group

The Low Inflow Protocol included in the Catawba-Wateree CHEOPS Operations Model Version 8.7 is included with this report as Attachment C.

The model examines the effect of the four scenarios of IBT on the LIP stage over the 75 years of available hydrologic record. Occurrences of Stages 1-4 are particularly important in the evaluation because these stages require water users in the basin to reduce water use and require reductions in normal outflows from the reservoirs. In this analysis, neither Stage 3 nor Stage 4 is triggered by any of the four levels of transfer modeled.

The top part of Table S-7 shows that the model predicts the 10 MGD IBT scenario would produce the same months of Stages 1 and 2 occurrences as the Zero MGD IBT scenario. The 16 MGD IBT scenario has one additional month of Stage 1 compared to the Zero MGD IBT scenario. The model predicts that the 22 MGD IBT scenario would have an additional seven months of Stage 1 restrictions and one less month of Stage 2 restrictions than the Zero MGD IBT scenario. All of the predicted deviations in LIP stage between the four scenarios occurred during the hydrologic conditions experienced in the period 2000-2002.

Further, the lower part of Table S-7 shows that for all four IBT scenarios, the model predicts that Stage 1 voluntary restrictions would be implemented in ten of the 75 years studied and Stage 2 mandatory restrictions would be implemented in one year, the year 2002. Stage 0 watch measures would have been implemented in 55 of 75 years according to the model, one less than for the other three scenarios. This is because more months are spent in Stage 1 voluntary restriction under the 22 MGD IBT scenario.

Table S-7: Occurrence of Low Inflow Protocol Stages

Table S-7: LIP Summary by Stage for a Lake Norman Withdrawal

Model Scenario	Zero MGD IBT		10 MGD IBT		16 MGD IBT		22 MGD IBT	
LIP Stage	**Number of Months**	**Percent of Time**	**Number of Months**	**Percent of Time**	**Number of Months**	**Percent of Time**	**Number of Months**	**Percent of Time**
Monthly Summary								
-1	576	64.0%	574	63.8%	576	64.0%	574	63.8%
0	276	30.7%	278	30.9%	275	30.6%	270	30.0%
1	**43**	**4.8%**	**43**	**4.8%**	**44**	**4.9%**	**52**	**5.8%**
2	**5**	**0.6%**	**5**	**0.6%**	**5**	**0.6%**	**4**	**0.4%**
3	0	0.0%	0	0.0%	0	0.0%	0	0.0%
4	0	0.0%	0	0.0%	0	0.0%	0	0.0%
LIP Stage	**Number of Years**	**Percent of Years**	**Number of Years**	**Percent of Years**	**Number of Years**	**Percent of Years**	**Number of Years**	**Percent of Years**
Annual Summary - Number of years with least 1 month occurrence in the calendar year.								
-1	66	88.0%	66	88.0%	66	88.0%	66	88.0%
0	56	74.7%	56	74.7%	56	74.7%	55	73.3%
1	**10**	13.3%	**10**	13.3%	**10**	13.3%	**10**	13.3%
2	**1**	1.3%	**1**	1.3%	**1**	1.3%	**1**	1.3%
3	0	0.0%	0	0.0%	0	0.0%	0	0.0%
4	0	0.0%	0	0.0%	0	0.0%	0	0.0%

Extreme Case Analysis

To assess impacts on a shorter time scale, the effect of the proposed IBT amounts during significant droughts in the period of record were examined.

The most severe drought during the 75-year period of record in the Catawba Basin occurred during 2001-02. Figures S-6 and S-7 show the period of greatest variation between the four modeled scenarios in reservoir elevations of Lake James and Lake Norman predicted by the model during the 2001-02 droughts. LIP stage levels are indicated in the figures for the four scenarios.

Modeling predicts that for the 75 year record all variations in LIP implementation caused by the IBT would occur during a repeat of the hydrologic conditions experienced from early summer 2000 through the spring of 2003. During this three-year period, under all scenarios, restrictions at the level of Stage 1 and above would be in place by mid-summer of year two (2001 on the graph) and continue through the end of year three (2002 on the graph). Under

the Zero MGD IBT and 10 MGD IBT scenarios, Stage 1 is initiated in July of year two and under the 16 MGD IBT scenario, it is initiated a month earlier in June. Under the 22 MGD IBT scenario, Stage 1 is initiated in November of year one (2000 on the graph), adding an additional eight months of restrictions to the nineteen months predicted under the Zero and 10 MGD scenarios, and seven months to the twenty months predicted for the 16 MGD scenario. In summary, during conditions similar to those experienced during the drought of record, the model predicts that with a 22 MGD IBT, the basin would experience one additional Winter, Spring and early Summer under LIP Stage 1 restrictions, compared to what would occur under the other three scenarios.

As the LIP goes to each higher stage, additional reductions in hydropower production, water withdrawals, and required outflows occur, thereby reducing the volume of water that leaves the reservoirs. The modeling shows that during hydrologic conditions similar to the drought of record, one effect of the 22 MGD IBT is that the LIP would be in Stage 1 for a longer period of time than in the other scenarios. The earlier and longer reduced outflows required under Stage 1 restrictions postpone initiation of Stage 2 restrictions by one month. This reduces Stage 2 restrictions to four consecutive months as opposed to five consecutive months under the other three scenarios. As Figure S-6 shows, the modeling indicates that for Lake James, the reduction in outflows associated with the additional months of Stage 1 restrictions with a 22 MGD transfer, results in an increase in water elevation in the reservoir. Reservoir elevations would be higher than what is predicted for the other scenarios over the additional seven months of Stage 1 restrictions.

Figure S-6: Lake James Elevation during 2001-02 Drought

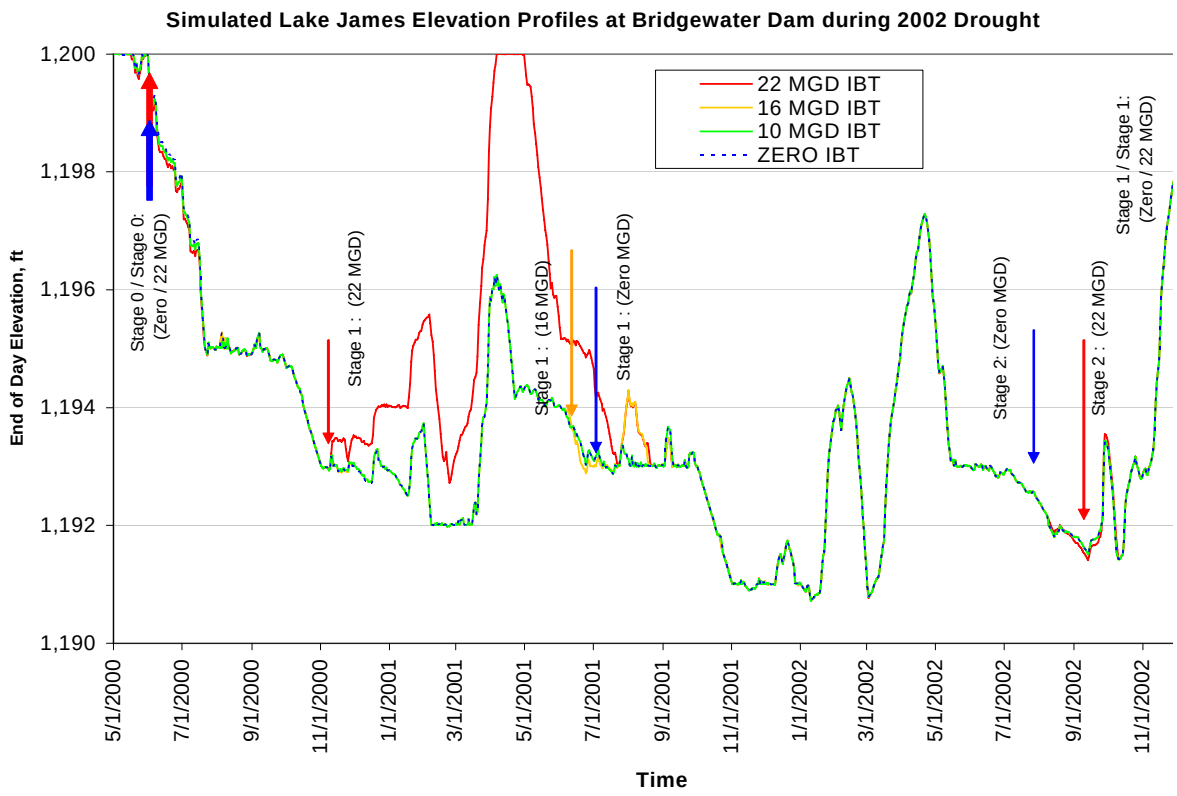
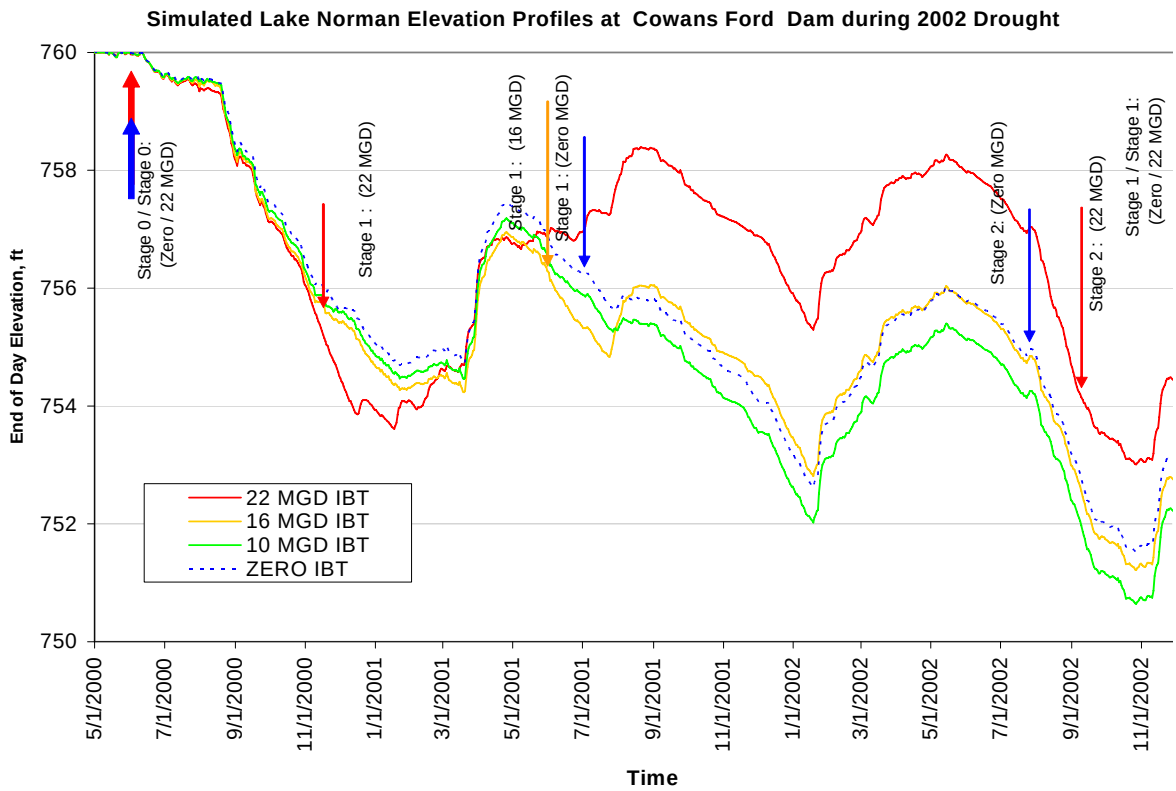


Figure S-6 shows the plot of the predicted reservoir levels of Lake James during the 2001-02 drought. It shows that the Zero, 10 MGD and 16 MGD curves follow each other closely indicating little variation in the reservoir elevation between these scenarios. For the 16 MGD IBT scenario, the LIP stage moves to Stage 1 in June 2001, one month earlier than the Zero and 10 MGD IBT scenarios. The earlier shift to Stage 1 appears to cause the 16 MGD reservoir level curve to drop slightly below the Zero and 10 MGD IBT curves for approximately two months, and then it rises above the Zero and 10 MGD IBT curves from July to August of 2001. From September 2001 through the end of 2003, the water levels for Lake James are almost identical under all four scenarios.

The 22 MGD IBT curve follows the other three curves until November 2000, when the LIP stage shifts to Stage 1, 7 months before the 16 MGD IBT scenarios shifts to Stage 1. This shift in LIP stage has a significant effect on the reservoir level. The model predicts that upon implementation of the LIP Stage 1, the Lake James level would rise above the other three curves before joining the other curves in August 2001 when Stage 1 is in place for all four scenarios.

The reservoir levels predicted by the model for Lake Norman during the hydrologic conditions experienced in 2000-2002 are also significantly affected by LIP restrictions. Figure S-7 shows that all four scenarios closely follow each other until November 2000 when the 22 MGD would trigger LIP Stage 1. This causes the 22 MGD curve to drop to about 1.5 feet below the other three curves over the next four months. Later, however, the 22 MGD curve joins the others and, beginning in about June of 2001, rises up to about 2 feet above the other curves over the following 18 months. This increase in reservoir levels is explained by the extra months of Stage 1 LIP measures predicted in the 22 MGD scenario. These results show that predicted reservoir levels may be significantly affected by the LIP drought stage level and the associated drought response measures built into the model.

Figure S-7: Lake Norman Elevation during 2001-02 Drought



Water Quality Impacts

In the Final EIS, the predicted impacts on reservoir elevation and outflow were used to evaluate potential water quality impacts of the proposed IBT. Since the proposal is to remove water from the basin and not discharge water into the basin, the proposed IBT would not directly increase the inputs of pollutants to the Catawba River Basin. It is necessary to assess whether the transfer of the specified volumes of water out of the river system could influence the ability of the basin to assimilate pollutants.

The modeling results presented in Figures S-2, S-3, S-4 and S-5 show there are little or no noticeable effects of the proposed IBT amounts on the frequency of occurrence of reservoir elevations or reservoir outflows. Some effects of the IBT were noted at the 22 MGD level when focusing specifically on the 2001-0202 drought of record. Hydrologic conditions, stream flow and reservoir volume are major input parameters to the water quality model developed as part of the relicensing effort. Because there were no significant changes to hydrologic conditions, and the proposed withdrawal of water from the basin are not expected to directly increase the pollutant inputs, additional water quality modeling was considered unwarranted in the Final EIS. The updated CHEOPS ™ analysis presented in this report predicts less effects on system hydrology than the analysis in the Final EIS; therefore, additional modeling to evaluate water quality effects in the Catawba River Basin of the IBT is not required.

Simplified Analysis

Another evaluation of the impacts associated with the proposed transfer of water for Concord and Kannapolis was greatly aided by the availability of the complex and powerful Catawba-Wateree CHEOPS Operations Model. However, so that the model not be the only analysis tool for evaluating the impacts of the proposed IBT, a simpler analysis was also conducted to evaluate the effect of the IBT on reservoir levels.

Procedure

An analysis was conducted to show the effects of the proposed IBT on reservoir elevations for reservoirs located in North Carolina over a six-month period. The analysis is designed to answer the following question: How much would the elevation of water in the six reservoirs in North Carolina be changed by the proposed IBT if that was the only withdrawal and no water was flowing in to replace lost water? The no-inflow assumption is chosen in order to evaluate the case of extreme drought, and would not be expected to ever actually occur. During the period of analysis, no downstream releases are made from any of the reservoirs. To help simulate drought conditions, two starting points were used, one with reservoir levels at 90 percent, and one at 75 percent of storage volume. The 10 MGD, 16 MGD and 22 MGD withdrawals were distributed over the six reservoirs proportionally by volume. The share of IBT taken from each reservoir is the ratio for storage in that reservoir to storage in all six reservoirs. In order to isolate the impacts of the IBT, no other withdrawals were included.

To summarize the assumptions for this analysis:

1. No inflows to the system for a six month period.
2. Evaporation neglected.
3. No required releases.
4. Only the six reservoirs in North Carolina are included in the analysis.
5. Reservoirs begin the 6-month period either 75% full or 90% full by volume.
6. The share of the IBT taken from each reservoir is the ratio of storage in that reservoir to storage in all six reservoirs.
7. Other than the IBT, no other water withdrawals from the system are included.

Table S-8 summarizes the results of the analysis. Note that the reductions in elevation in the table are shown in inches.

Table S-8. No Inflow Assumption Analysis

	Reduction in Reservoir Elevations (inches) for Transfers of 10, 16, and 22 MGD					
	10 MGD		16 MGD		22 MGD	
	Initial Storage Conditions					
Reservoir	**90% storage**	**75% storage**	**90% storage**	**75% storage**	**90% storage**	**75% storage**
James	2.1	2.3	2.1	3.7	4.5	5.0
Rhodhiss	1.1	1.2	1.1	1.9	2.4	2.6
Hickory	1.4	1.6	1.4	2.5	3.0	3.5
Lookout Shoals	1.3	1.3	1.3	2.1	2.8	2.9
Norman	1.4	1.7	1.4	2.6	3.1	3.6
Mountain Island	0.9	1.0	0.9	1.6	2.1	2.3

The results show a range of potential reductions in reservoir elevation from 1 to 5 inches.

To reiterate, this is a worst case analysis, since no inflow to the reservoirs is assumed and storage volume is taken only out of the upper six reservoirs in the system. In reality, Duke Energy operates the project as a whole and balances storage throughout the system, which would tend to lessen the impact on reservoir level of each of the six reservoirs considered. Despite these conservative assumptions, this analysis is useful for comparing the magnitude of the IBT to the amount of storage in the Catawba Basin.

Duke Energy Water Supply Study

One of the concerns with the proposed IBT is whether the Catawba River Basin can continue to meet the water supply needs for the growth and development of communities in the basin and for increased power generation for the region without adverse impacts to users and the environment.

This same issue was a top priority during relicensing. Relicensing participants wanted to know if the Catawba-Wateree River Basin could support large projected increases in water use and electric power generation, while providing higher downstream releases for aquatic habitat and meeting critical reservoir elevation targets.

To answer this question, Duke Energy contracted for a Water Supply Study to be conducted, with the participation of major water users in the basin in North and South Carolina, as part of the relicensing process. The Water Supply Study projected future water use to 2058 for industrial, public water supply, power generation and agricultural irrigation water use for the Catawba-Wateree River Basin in North Carolina and South Carolina above Lake Wateree Dam. The projections included grandfathered, permitted, and other potential IBTs, including Concord and Kannapolis. Table S-9 is a summary of these projections by category and shows this projected growth in water use for the watersheds of each of the reservoirs.

Table S-9: Catawba-Wateree River Basin Water Withdrawals (mgd)

Reservoir Watershed	Type	2008	2018	2028	2038	2048	2058
Lake James	Industrial	1.2	1.4	1.7	2.0	2.3	2.7
	Public Water Supply	1.9	2.2	2.5	2.9	3.3	3.8
	Power	0.0	0.0	0.0	0.0	15.3	15.3
	Agricultural/Irrigation	8.9	9.3	9.7	10.2	11.0	12.0
	Total Withdrawals	**12.0**	**12.9**	**13.9**	**15.1**	**31.9**	**33.8**
Lake Rhodhiss	Public Water Supply	23.3	25.3	27.5	29.9	32.5	35.5
	Agricultural/Irrigation	4.7	5.1	5.6	6.2	7.0	7.9
	Total Withdrawals	**28.0**	**30.4**	**33.1**	**36.1**	**39.5**	**43.4**
Lake Hickory	Public Water Supply	15.8	19.1	23.1	28.1	34.1	41.4
	Agricultural/Irrigation	1.3	1.5	1.8	2.1	2.5	2.9
	Total Withdrawals	**17.1**	**20.6**	**24.9**	**30.2**	**36.6**	**44.3**
Lookout Shoals Lake	Public Water Supply	4.5	5.5	6.6	8.0	9.0	9.0
	Agricultural/Irrigation	1.3	1.6	1.9	2.2	2.7	3.2
	Total Withdrawals	**5.8**	**7.1**	**8.5**	**10.2**	**11.7**	**12.2**
Lake Norman	Public Water Supply	26.9	49.4	68.9	83.6	102.1	112.0
	Power	36.4	46.0	46.0	46.0	62.5	62.5
	Agricultural/Irrigation	2.9	3.2	3.5	3.8	4.2	4.6
	Total Withdrawals	**66.2**	**98.6**	**118.4**	**133.4**	**168.8**	**179.1**
Mountain Island Lake	Public Water Supply	127.6	149.8	168.7	188.2	203.6	219.9
	Power	2.5	2.5	2.5	2.5	2.5	2.5
	Agricultural/Irrigation	0.8	0.9	0.9	1.0	1.0	1.1
	Total Withdrawals	**130.9**	**153.2**	**172.1**	**191.7**	**207.1**	**223.5**
Lake Wylie	Industrial	15.0	15.6	16.4	17.2	18.5	20.2
	Public Water Supply	29.0	34.2	40.6	48.1	57.3	68.1
	Power	41.9	41.9	53.0	53.0	53.0	53.0
	Agricultural/Irrigation	8.8	9.6	10.4	11.4	12.6	14.0
	Total Withdrawals	**94.7**	**101.3**	**120.4**	**129.7**	**141.4**	**155.3**
Fishing Creek Reservoir	Industrial	102.1	104.6	107.3	110.4	113.9	117.8
	Public Water Supply	21.4	32.8	42.2	51.3	58.9	66.3
	Agricultural/Irrigation	8.4	8.8	9.3	9.8	10.3	10.9
	Total Withdrawals	**131.9**	**146.2**	**158.8**	**171.5**	**183.1**	**195.0**
Great Falls-Dearborn Reservoir	Agricultural/Irrigation	1.5	1.6	1.7	1.9	2.1	2.3
	Total Withdrawals	**1.5**	**1.6**	**1.7**	**1.9**	**2.1**	**2.3**
Cedar Creek Reservoir	Agricultural/Irrigation	0.6	0.7	0.7	0.8	0.8	0.9
	Total Withdrawals	**0.6**	**0.7**	**0.7**	**0.8**	**0.8**	**0.9**
Lake Wateree	Public Water Supply	6.3	8.0	9.7	11.0	12.7	14.4

	Power	0.0	0.0	0.0	13.1	13.1	39.7
	Agricultural/Irrigation	1.2	1.3	1.4	1.5	1.6	1.7
	Total Withdrawals	**7.5**	**9.3**	**11.1**	**25.6**	**27.4**	**55.8**
		2008	**2018**	**2028**	**2038**	**2048**	**2058**
Total by Category[1]	Industrial	118.3	121.6	125.4	129.6	134.7	140.7
	Public Water Supply	256.7	326.3	389.8	451.1	513.5	570.4
	Power	80.8	90.4	101.5	114.6	146.4	173.0
	Agricultural/Irrigation	40.4	43.6	46.9	50.9	55.8	61.5
	Total Withdrawals	**496.2**	**581.9**	**663.6**	**746.2**	**850.4**	**945.6**

1. Totals represent total withdrawals or demands by category and do not consider whether any portion is returned to the basin.

The public water system estimates from the Water Supply Study show increases in demand for all public water system withdrawals for the period 2008 to 2058. For example, the withdrawal for Valdese is modeled as growing 2.1 MGD from 6.2 MGD to 8.3 MGD and Morganton's withdrawal is modeled to increase 6 MGD from 8.9 MGD to 14.9 MGD. Hickory's withdrawal is modeled as growing from 14.3 MGD to 38.1 MGD an increase of 23.8 MGD this is similar to the increase expected for Gastonia, modeled to grow 24.8 MGD from 15.4 MGD to 40.2 MGD. Further downstream in South Carolina Rock Hill's withdrawal is modeled as increasing 24.1 MGD from 14.3 MGD to 38.4 MGD and the Chester Metro system withdrawal is modeled to grow by 15.9 MGD from 4 MGD to 19.9 MGD. To support growth in the Mecklenburg County area, the Charlotte Mecklenburg Utilities' demand is modeled as increasing 95.2 MGD from 128 MGD to 223.2 MGD. The water withdrawal information tabulated above does not quantify what part of the withdrawal is returned to the basin after use and what part is lost to the basin due to evaporation, incorporation into products, other consumptive uses or transfers out of the basin. The relicensing Water Supply Study also evaluated these losses to the basin (withdrawals minus returns), which were collectively presented as "net outflows" in the final report.

The annual growth rate (AGR) for net outflows for industrial, public water supply, agricultural, and power generation water uses were estimated. These annual growth rates from the study are shown in Table S-10. Continued significant growth in net outflows from the basin is anticipated over the next 50 years, especially for the public water supply category.

Table S-10: Projected Net Outflows and Annual Growth Rates (AGR)

Table S-10			
Water Supply Study - Projected Net Outflows and Annual Growth Rates (AGR)			
Water User Category	**Current MGD**	**2058 MGD**	**AGR**
Industrial	3.7	5.9	0.85%
Public Water Supply	55.0	243.0	2.74%
Agricultural/Irrigation	31.2	53.5	0.99%
Power	80.8	173.0	1.39%
Total Basin	**170.7**	**475.4**	**1.88%**

The Safe Yield analysis developed for the Water Supply Study was evaluated using the Catawba-Wateree CHEOPS ™ Operations Model. The analysis using the final set of operating protocols and the final LIP shows that the projected demands shown in Table S-9, including all anticipated interbasin transfers, can be met beyond 2048. The Duke Energy Water Supply Study concluded that through 2048, with an additional 354 MGD of water withdrawals, and a total of 421 MGD of net outflows, the Catawba-Wateree Basin can meet these demands even during a reoccurrence of drought conditions like 2001-2002 (the worst on record) without any reservoir dropping below critical elevations for the existing water supply intakes. Usable storage was limited for each reservoir by the highest intake elevation in the reservoir. Modifications of intake elevations could further increase the usable storage.

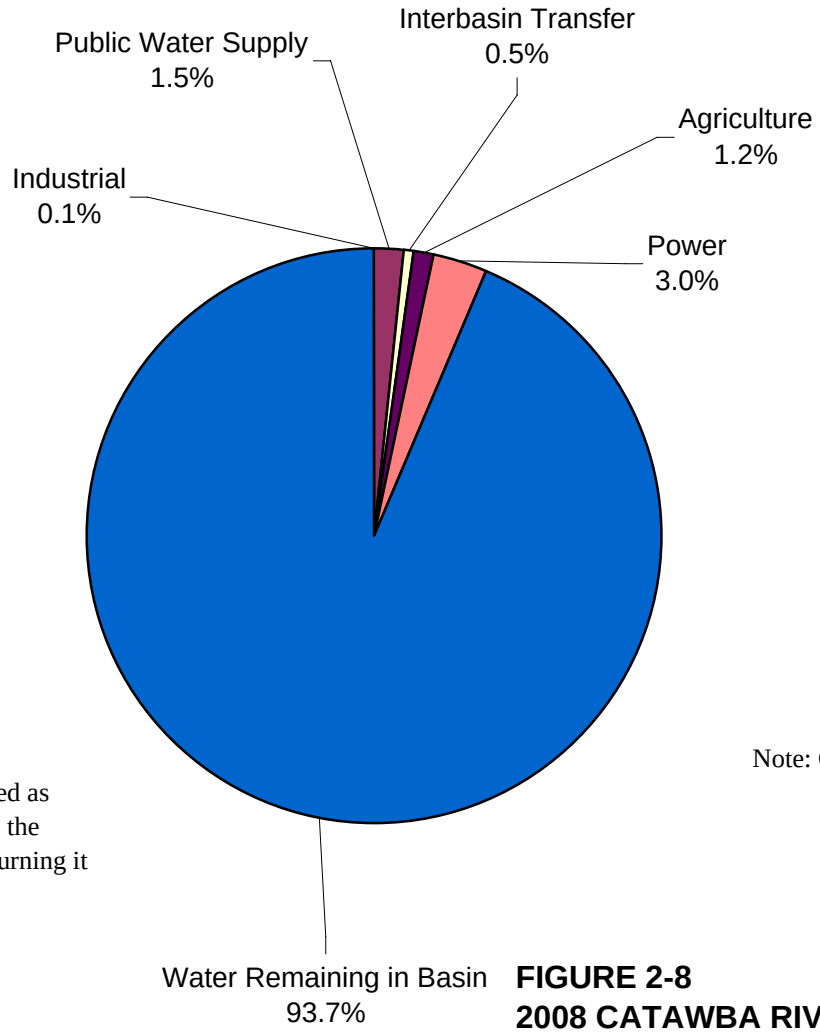
Consumptive Uses in the Catawba Basin

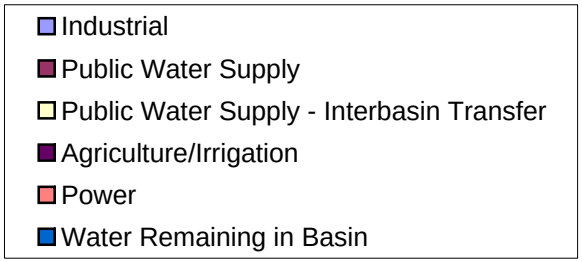
A key factor affecting river basin water supply is the amount of water that is withdrawn and not directly returned to the river system, or "consumptive water use". Consumptive water use for this evaluation refers to the difference between the volume of water withdrawn by water users and the volume of water directly returned to the river system. This is also referred to as "net outflow" in the Duke Energy Water Supply Study. The principal consumptive water users in the Catawba River Basin are public water supply systems, thermal electric power plants (cooling water use), and irrigation. For the Catawba-Wateree River system above Lake Wateree dam, the Water Supply Study projected an average day withdrawal of 747 MGD in 2038. Of this amount, the study projected 355 MGD of consumptive use, or net outflow.

In order to compare the magnitude of present and projected IBTs in the Catawba River Basin to other consumptive uses, IBTs were separated from other public water supply uses in this analysis. Figure S-8 shows consumptive use estimates for 2008. Figure S-9 shows projected consumptive use estimates for the year 2038, near the end of the planning period for the proposed Concord Kannapolis IBT. The IBT amount depicted in the pie chart for Concord and Kannapolis is based on no IBT in 2008 and an average of 22 MGD in 2038.

These charts show that all IBTs are expected to be about 0.5% of the average flow in the Catawba Basin in 2008. In 2038, IBTs are expected to increase to about 2.0% of the average flow, 0.8% of which would be attributed to Concord and Kannapolis if the entire 22 MGD request were certified. Another approach to put into context the impact of the proposed Concord-Kannapolis Interbasin Transfer, relative to all water demands on the basin, is to examine all water uses that remove water from the basin, including consumptive use and interbasin transfer. These water uses that remove water from the basin were compared to the average flow at Lake Wateree in SC.

2008 Catawba River Consumptive Use



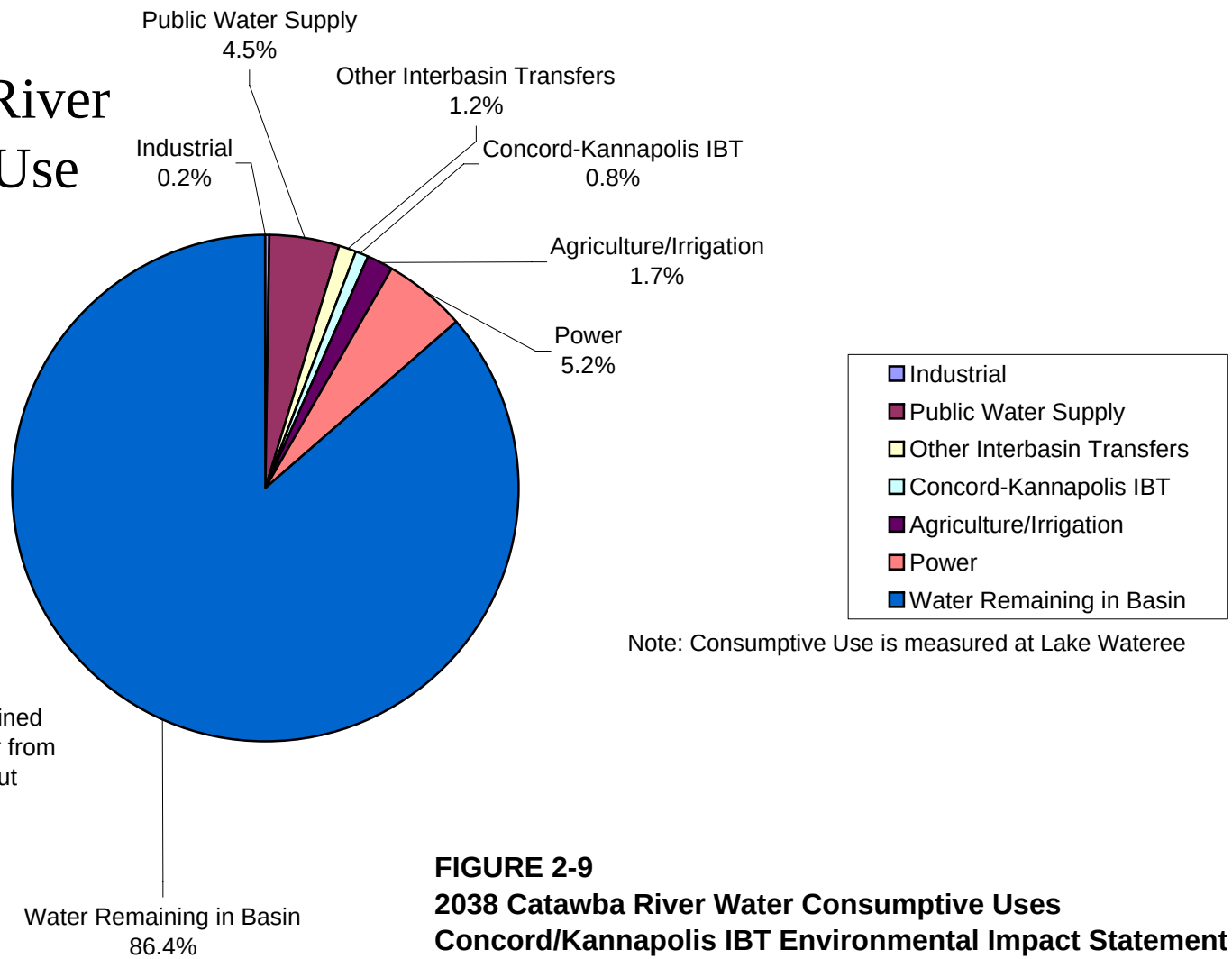


Note: Consumptive Use is measured at Lake Wateree

Note: Consumptive uses are defined as those uses that remove water from the Catawba River system without returning it to the basin.

FIGURE 2-8
2008 CATAWBA RIVER WATER USERS
Concord/Kannapolis IBT Environmental Impact Statement

2038 Catawba River Consumptive Use



Note: Consumptive Use is measured at Lake Wateree

Note: Consumptive uses are defined as those uses that remove water from the Catawba River system without returning it to the basin.

FIGURE 2-9
2038 Catawba River Water Consumptive Uses
Concord/Kannapolis IBT Environmental Impact Statement

Attachment A

CHEOPS Simulation of Proposed Concord - Kannapolis Interbasin Transfer from the Catawba River Basin

August 31, 2006

Division of Water Resources
North Carolina Department of Environment and Natural Resources

Introduction

The revised modeling analysis in this report was prepared to replace previous modeling analysis performed to assess the impacts on the Catawba River Basin of a proposed interbasin transfer (IBT) by the Cities of Concord and Kannapolis from the Catawba and Yadkin River Basins to the Rocky River Basin. Input errors were found in previous modeling work, first in the May 2006 Final Environmental Impact Statement (EIS) and later in a July 2006 supplement to the Final EIS. For this reason, the inputs developed by the Division of Water Resources to perform the model runs presented in this report were reviewed and verified as accurate by Devine, Tarbell, & Associates, Inc. (DTA), the consulting firm hired by Duke Energy to develop the model.

Modeling presented in this report was performed using the Catawba-Wateree CHEOPS™ Operations Model Version 8.7. This model was developed as a study tool during the ongoing Federal Energy Regulatory Commission (FERC) relicensing of Duke Energy's hydropower projects in the Catawba-Wateree River Basin. A detailed description of the model along with the findings of DTA's review can be found in the attached report titled *Catawba-Wateree CHEOPS™ Model, Review of Input, Concord-Kannapolis, NC Final EIS for IBT Certification*.

The model incorporates operational strategies that were developed during the lengthy process of negotiations between stakeholders during the FERC hydropower relicensing process. A component of these operational strategies is the Low Inflow Protocol (LIP), which establishes procedures for reductions in water use and outflows during periods of low inflow. A purpose of the LIP is that all parties with interests in water quantity would share responsibility to establish priorities and conserve the limited water supply.

The latest version of the model, and the version used in the analysis presented in this report is Version 8.7. Version 8.7 incorporates the operational strategies in the final negotiated settlement agreement from FERC relicensing, including the final LIP. This version of the model was used to analyze the set of operational strategies that were included in the final settlement agreement. Previous modeling in the Final EIS and the July 2006 supplement was performed using a previous of the model, Version V8.3.

Model Inputs

The intent of the modeling is to evaluate the impacts of varying levels of the Concord Kannapolis IBT amount. For this reason, four scenarios were modeled, each with a different IBT amount. All inputs for the four scenarios are identical, except for the Concord and Kannapolis IBT amount. The four scenarios are as follows:

Scenario Name	Concord Kannapolis IBT
Zero IBT	No IBT
10 MGD IBT	10 million gallons per day IBT average day from Lake Norman
16 MGD IBT	16 million gallons per day IBT average day from Lake Norman
22 MGD IBT	22 million gallons per day IBT average day from Lake Norman

Inflows

Streamflow and climate data is available for a 75 year period of record in the Catawba Basin. This data was summarized into a set of historical streamflows from 1929-2003. The model then evaluates how the system would behave during the 75 year period of record under the set of assumptions represented in each of the four scenarios to be studied.

Withdrawals

Because the modeling analysis is intended to assess impacts over a 30-year planning period, 2035 projected withdrawals were used for all model runs. Withdrawals for the four scenarios were developed by modifying the projected water withdrawals in the year 2035 derived from the Duke Energy Water Supply Study developed during the FERC relicensing process. Withdrawals include all projected water uses in the basin including public water supply, industrial use, agricultural use, and power generation. The withdrawals in the study were modified to reflect the various levels of IBT by the Cities of Concord and Kannapolis to be studied.

The model does not assume the IBT is withdrawn equally for every day of the year. Rather, the average annual daily withdrawal is converted to a monthly average daily withdrawal using a distribution factor multiplier to approximate the monthly pattern of water use for all water withdrawals. Distribution factors are specific to each withdrawal. Tables 1 - 4 show the distribution multipliers used for the Concord-Kannapolis IBT and the resulting monthly average daily withdrawals that were modeled for each of the four scenarios.

All of the IBT by Concord and Kannapolis is assumed by the model to come from Lake Norman. The actual withdrawals used as inputs to the model from Lake Norman for the four modeling scenarios are summarized in the following four tables:

Table 1: Withdrawals for Zero IBT Scenario

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2035 Original Wtihdrawal, cfs	189	184	169	209	216	233	229	217	195	191	172	183	199
Concord Kannapolis Distribution Pattern	91%	90%	90%	101%	108%	116%	110%	111%	102%	103%	91%	88%	
2035 IBT amount, cfs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2035 IBT amount, MGD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mod 2035 Total Withdrawal, cfs	170.49	165.58	150.08	187.95	193.61	208.64	205.74	194.29	173.56	169.49	152.61	165.04	178.09

Table 2: Withdrawals for 10 MGD IBT Scenario

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2035 Original Wtihdrawal, cfs	189	184	169	209	216	233	229	217	195	191	172	183	199
Concord Kannapolis Distribution Pattern	91%	90%	90%	101%	108%	116%	110%	111%	102%	103%	91%	88%	
2035 IBT amount, cfs	14.1	13.8	13.9	15.5	16.7	17.9	16.9	17.2	15.8	15.8	14.0	13.6	15.4
2035 IBT amount, MGD	9.11	8.96	9.00	10.07	10.82	11.58	10.99	11.12	10.22	10.25	9.07	8.82	10.00
Mod 2035 Total Withdrawal, cfs	184.55	179.40	163.96	203.48	210.30	226.50	222.69	211.44	189.33	185.31	166.60	178.65	193.52

Table 3: Withdrawals for 16 MGD IBT Scenario

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2035 Original Wtihdrawal, cfs	189	184	169	209	216	233	229	217	195	191	172	183	199
Concord Kannapolis Distribution Pattern	91%	90%	90%	101%	108%	116%	110%	111%	102%	103%	91%	88%	
2035 IBT amount, cfs	22.5	22.1	22.2	24.9	26.7	28.6	27.1	27.4	25.2	25.3	22.4	21.8	24.7
2035 IBT amount, MGD	14.58	14.33	14.39	16.11	17.31	18.53	17.58	17.79	16.36	16.40	14.51	14.11	16.00
Mod 2035 Total Withdrawal, cfs	192.98	187.69	172.29	212.80	220.31	237.23	232.86	221.73	198.79	194.80	175.00	186.81	202.77

Table 4: Withdrawals for 22 MGD IBT Scenario

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2035 Original Wtihdrawal, cfs	189	184	169	209	216	233	229	217	195	191	172	183	199
Concord Kannapolis Distribution Pattern	91%	90%	90%	101%	108%	116%	110%	111%	102%	103%	91%	88%	
2035 IBT amount, cfs	30.9	30.4	30.5	34.2	36.7	39.3	37.3	37.7	34.7	34.8	30.8	29.9	33.9
2035 IBT amount, MGD	20.05	19.70	19.79	22.15	23.80	25.48	24.17	24.46	22.49	22.55	19.95	19.41	22.00
Mod 2035 Total Withdrawal, cfs	201.41	195.98	180.61	222.12	230.32	247.95	243.02	232.02	208.26	204.29	183.39	194.98	212.03

Modeling Results

The model was run for each of the four scenarios over the entire 75-year record. As the model runs on a 15-minute time step, a large volume of output data was generated for each run. This output was then analyzed and summarized into tables and plots that are useful in interpreting the large volume of data. The tables and plots depict in different ways the impacts of the proposed IBT and are presented in the remainder of this report.

Low Inflow Protocol Impacts

The Catawba LIP includes the following five stages of water use restriction:

Stage 0: Low Inflow Watch
Stage 1: Voluntary Restrictions
Stage 2: Mandatory Restrictions
Stage 3: Mandatory Restrictions
Stage 4: Mandatory Restrictions

Each increasing level of restriction involves an increasing degree of water use restriction and reductions in required downstream releases as indicated by the LIP agreement. A table is included totaling the number of months the model predicts that each of the five levels of LIP would be invoked. This information is depicted graphically in chronological order.

It is important, therefore, to evaluate how the proposed IBT is predicted to affect the frequency of the different levels of restriction that would be implemented.

Table and plots are presented indicating the predicted impacts of the IBT on LIP stage under the four IBT scenarios, both for the overall period of record and during the extreme drought period of 2001-02.

Table 5: Comparison of LIP Stage Durations by Month during 2001-2002 Drought

Date	Zero IBT LIP Stage	10 MGD LIP Stage	16 MGD LIP Stage	22 MGD IBT LIP Stage
06/01/2000	0	0	0	0
07/01/2000	0	0	0	0
08/01/2000	0	0	0	0
09/01/2000	0	0	0	0
10/01/2000	0	0	0	0
11/01/2000	0	0	0	1
12/01/2000	0	0	0	1
01/01/2001	0	0	0	1
02/01/2001	0	0	0	1
03/01/2001	0	0	0	1
04/01/2001	0	0	0	1
05/01/2001	0	0	0	1
06/01/2001	0	0	1	1
07/01/2001	1	1	1	1
08/01/2001	1	1	1	1
09/01/2001	1	1	1	1
10/01/2001	1	1	1	1
11/01/2001	1	1	1	1
12/01/2001	1	1	1	1
01/01/2002	1	1	1	1
02/01/2002	1	1	1	1
03/01/2002	1	1	1	1
04/01/2002	1	1	1	1
05/01/2002	1	1	1	1
06/01/2002	1	1	1	1
07/01/2002	1	1	1	1
08/01/2002	2	2	2	1
09/01/2002	2	2	2	2
10/01/2002	2	2	2	2
11/01/2002	2	2	2	2
12/01/2002	2	2	2	2
01/01/2003	1	1	1	1
02/01/2003	0	0	0	0

Figure 1: LIP Stages for IBT Runs

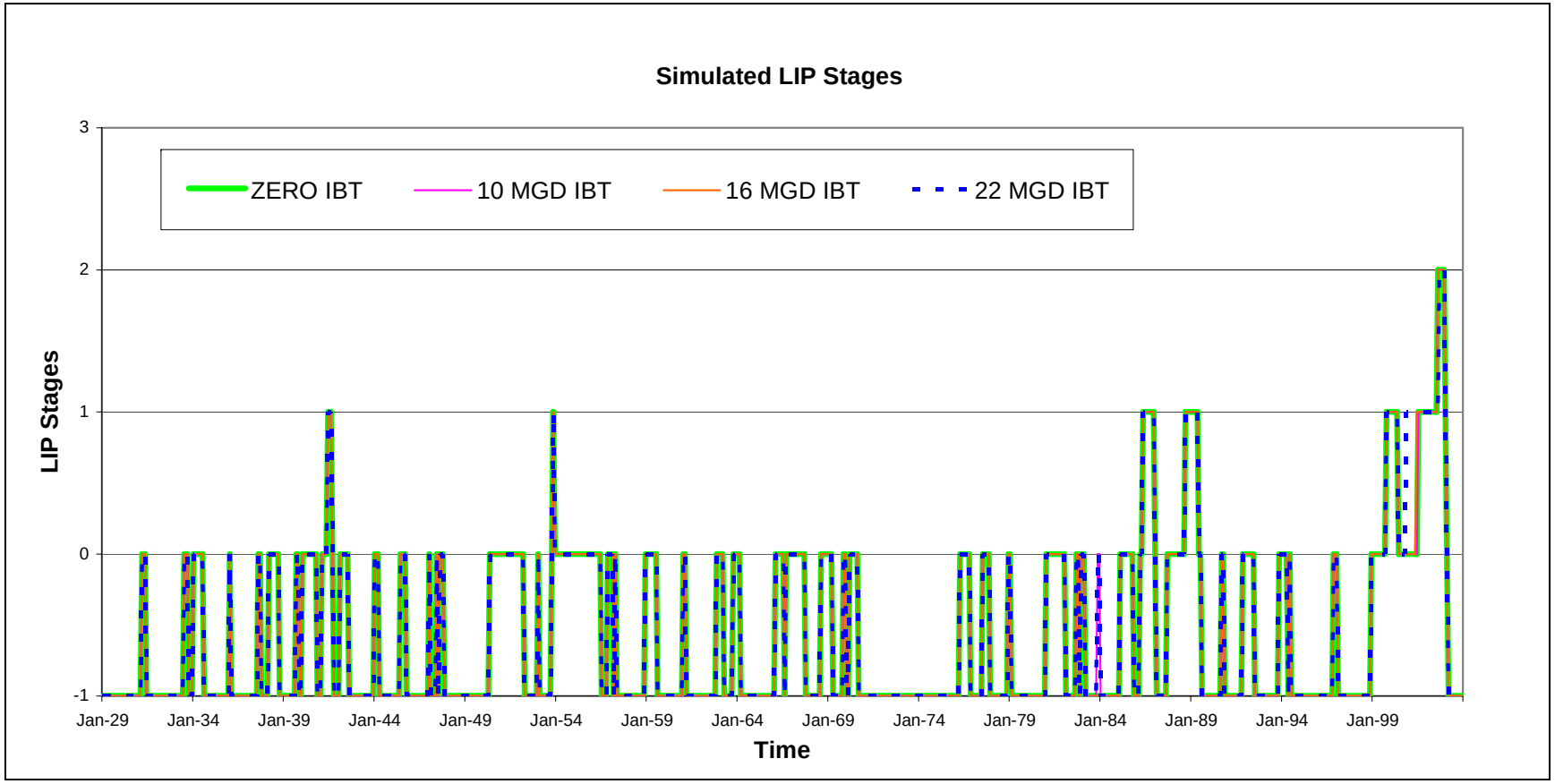


Table 6: LIP Summary for Scenario Zero IBT

LIP Stage Summary for ZERO IBT from Lake Norman 1/1/1929 to 12/1/2003		
LIP Stage	**Number of Months**	**Percent of Time**
-1	576	64%
0	276	31%
1	43	5%
2	5	1%
3	0	0%
4	0	0%

Monthly LIP Stage Summary for ZERO IBT from Lake Norman 1/1/1929 to 12/1/2003						
LIP Stage	**-1**	**0**	**1**	**2**	**3**	**4**
Total Number of Months	576	276	43	5	0	0
January	42	29	4	0	0	0
February	45	27	3	0	0	0
March	46	26	3	0	0	0
April	48	24	3	0	0	0
May	49	22	4	0	0	0
June	47	25	3	0	0	0
July	49	22	4	0	0	0
August	51	20	3	1	0	0
September	47	24	3	1	0	0
October	51	19	4	1	0	0
November	52	17	5	1	0	0
December	49	21	4	1	0	0

Table 7: LIP Summary for Scenario 10 MGD IBT

LIP Stage Summary for 10 MGD IBT from Lake Norman 1/1/1929 to 12/1/2003		
LIP Stage	**Number of Months**	**Percent of Time**
-1	574	64%
0	278	31%
1	43	5%
2	5	1%
3	0	0%
4	0	0%

Monthly LIP Stage Summary for 10 MGD IBT from Lake Norman 1/1/1929 to 12/1/2003						
LIP Stage	**-1**	**0**	**1**	**2**	**3**	**4**
Total Number of Months	574	278	43	5	0	0
January	42	29	4	0	0	0
February	45	27	3	0	0	0
March	46	26	3	0	0	0
April	48	24	3	0	0	0
May	49	22	4	0	0	0
June	47	25	3	0	0	0
July	49	22	4	0	0	0
August	51	20	3	1	0	0
September	47	24	3	1	0	0
October	51	19	4	1	0	0
November	51	18	5	1	0	0
December	48	22	4	1	0	0

Table 8: LIP Summary for Scenario 16 MGD IBT

LIP Stage Summary for 16 MGD IBT from Lake Norman 1/1/1929 to 12/1/2003		
LIP Stage	**Number of Months**	**Percent of Time**
-1	576	64%
0	275	31%
1	44	5%
2	5	1%
3	0	0%
4	0	0%

Monthly LIP Stage Summary for 16 MGD IBT from Lake Norman 1/1/1929 to 12/1/2003						
LIP Stage	**-1**	**0**	**1**	**2**	**3**	**4**
Total Number of Months	576	275	44	5	0	0
January	42	29	4	0	0	0
February	45	27	3	0	0	0
March	46	26	3	0	0	0
April	48	24	3	0	0	0
May	49	22	4	0	0	0
June	47	24	4	0	0	0
July	49	22	4	0	0	0
August	51	20	3	1	0	0
September	47	24	3	1	0	0
October	51	19	4	1	0	0
November	52	17	5	1	0	0
December	49	21	4	1	0	0

Table 9: LIP Summary for Scenario 22 MGD IBT

LIP Stage Summary for 22 MGD IBT from Lake Norman 1/1/1929 to 12/1/2003		
LIP Stage	**Number of Months**	**Percent of Time**
-1	574	64%
0	270	30%
1	52	6%
2	4	<1%
3	0	0%
4	0	0%

Monthly LIP Stage Summary for 22 MGD IBT from Lake Norman 1/1/1929 to 12/1/2003						
LIP Stage	**-1**	**0**	**1**	**2**	**3**	**4**
Total Number of Months	574	270	52	4	0	0
January	42	28	5	0	0	0
February	45	26	4	0	0	0
March	46	25	4	0	0	0
April	48	23	4	0	0	0
May	49	21	5	0	0	0
June	47	24	4	0	0	0
July	49	22	4	0	0	0
August	51	20	4	0	0	0
September	47	24	3	1	0	0
October	51	19	4	1	0	0
November	51	17	6	1	0	0
December	48	21	5	1	0	0

Impacts on Reservoir Levels

Lakes James, Norman, Wylie, and Wateree were identified as representative reservoirs for evaluating impacts in the basin. Therefore the following sets of plots are included for each of these four reservoirs. Each plot contains four curves, one for each of the four IBT scenarios.

I. Elevation Duration Curves

Reservoir elevation duration curves are cumulative frequency curves showing the percentage of time over the period of record that specified daily average reservoir levels are equaled or exceeded. Elevation duration curves are useful for evaluating large impacts on reservoir elevation over a long period of time.

II. Outflow Duration Curves

Outflow duration curves are cumulative frequency curves showing the percentage of time over the period of record that specified daily average reservoir outflows are equaled or exceeded. Outflow duration curves are useful for evaluating large impacts on reservoir outflow over a long period of time.

III. Elevation Profiles

An elevation profile shows the predicted reservoir elevation over the period of interest. Plots are presented both for the entire period of record and for droughts of interest. For the extreme drought of 2001-02, the plots also show when the LIP stages were invoked for each of the scenarios. Elevation profiles are useful for examining the shorter term impacts on reservoir elevation.

Reservoirs and Power Generation Plants

References are made in the following results to both reservoir names and the names of the power generation plants corresponding to the reservoirs. Here is a list of reservoirs and their corresponding power generation plants:

	Reservoir	Plant Names Used [Abbrev]
01.	Lake James	Bridgewater [BW]
02.	Lake Rhodhiss	Rhodhiss [RH]
03.	Lake Hickory	Oxford [OX]
04.	Lookout Shoals	Lookout Shoals [LS]
05.	Lake Norman	Cowan Ford [CF]
06.	Lake Mountain Island	Mountain Island [MI]
07.	Lake Wylie	Wylie [WY]
08.	Fishing Creek Reservoir	Fishing Creek [FC]
09.	Great Falls Reservoir	Great Falls [GF]
10.	Rocky Creek Reservoir	Rocky Creek [RC]
11.	Lake Wateree	Wateree [WA]

Figure 2: Elevation Duration Curve for Lake James

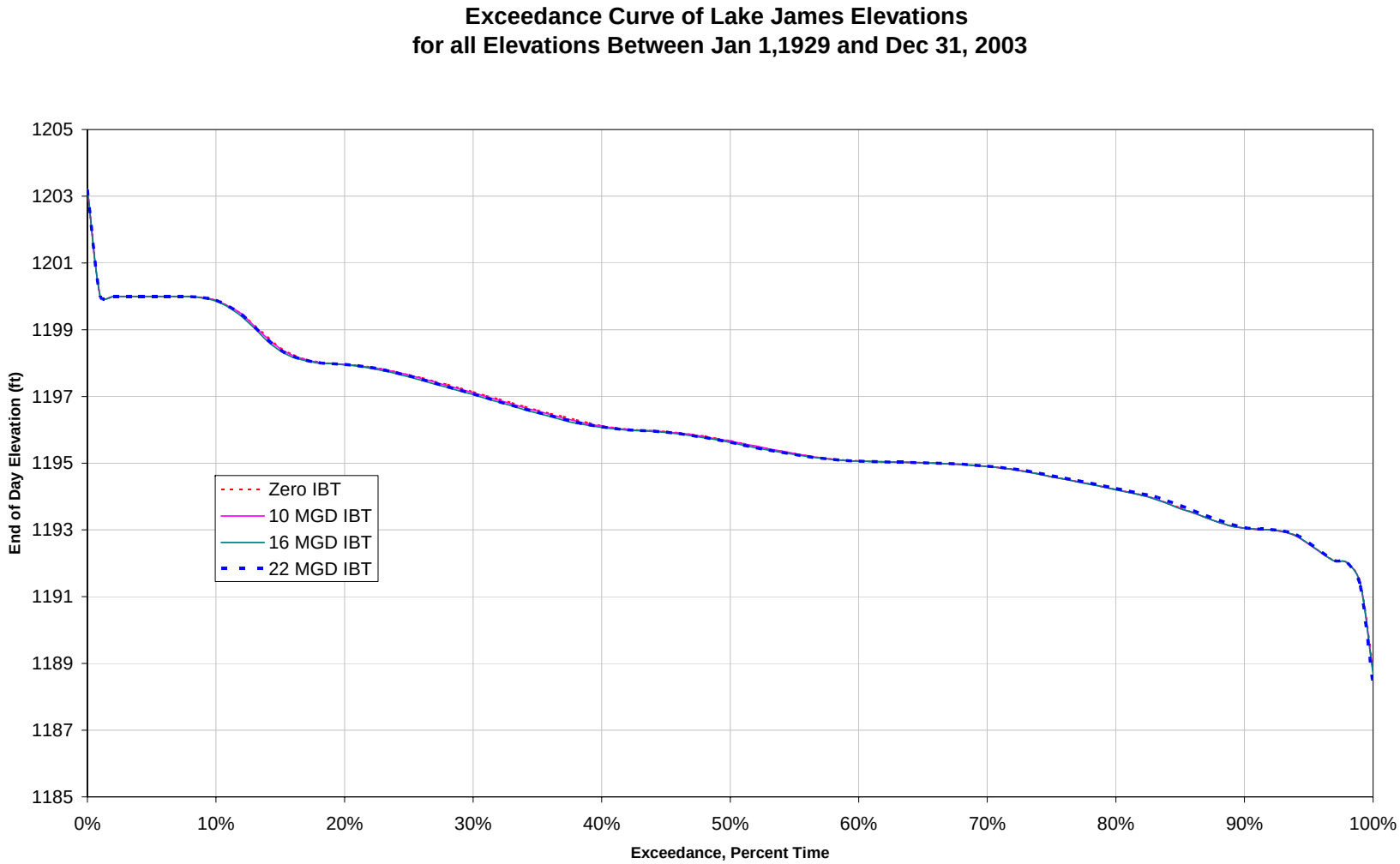


Table 10: Lake James Elevation Exceedance Data, FT

Exceedance, Percent Time	Lake James Levels Remain above Elevation, FT			
	Zero IBT	10 MGD IBT	16 MGD IBT	22 MGD IBT
0%	1203.2	1203.2	1203.2	1203.2
1%	1200	1200	1200	1200
2%	1200	1200	1200	1200
5%	1200	1200	1200	1200
10%	1199.88	1199.88	1199.86	1199.88
20%	1197.96	1197.96	1197.95	1197.96
30%	1197.14	1197.11	1197.06	1197.07
40%	1196.12	1196.11	1196.07	1196.09
50%	1195.67	1195.66	1195.62	1195.62
60%	1195.07	1195.06	1195.06	1195.06
70%	1194.9	1194.9	1194.9	1194.91
80%	1194.21	1194.21	1194.2	1194.24
90%	1193.12	1193.11	1193.11	1193.16
95%	1192.83	1192.82	1192.83	1192.86
98%	1192.08	1192.07	1192.07	1192.08
99%	1192.01	1192.01	1192.01	1192.01
100%	1188.88	1188.77	1188.68	1188.34

Figure 3: Elevation Duration Curve for Lake Norman

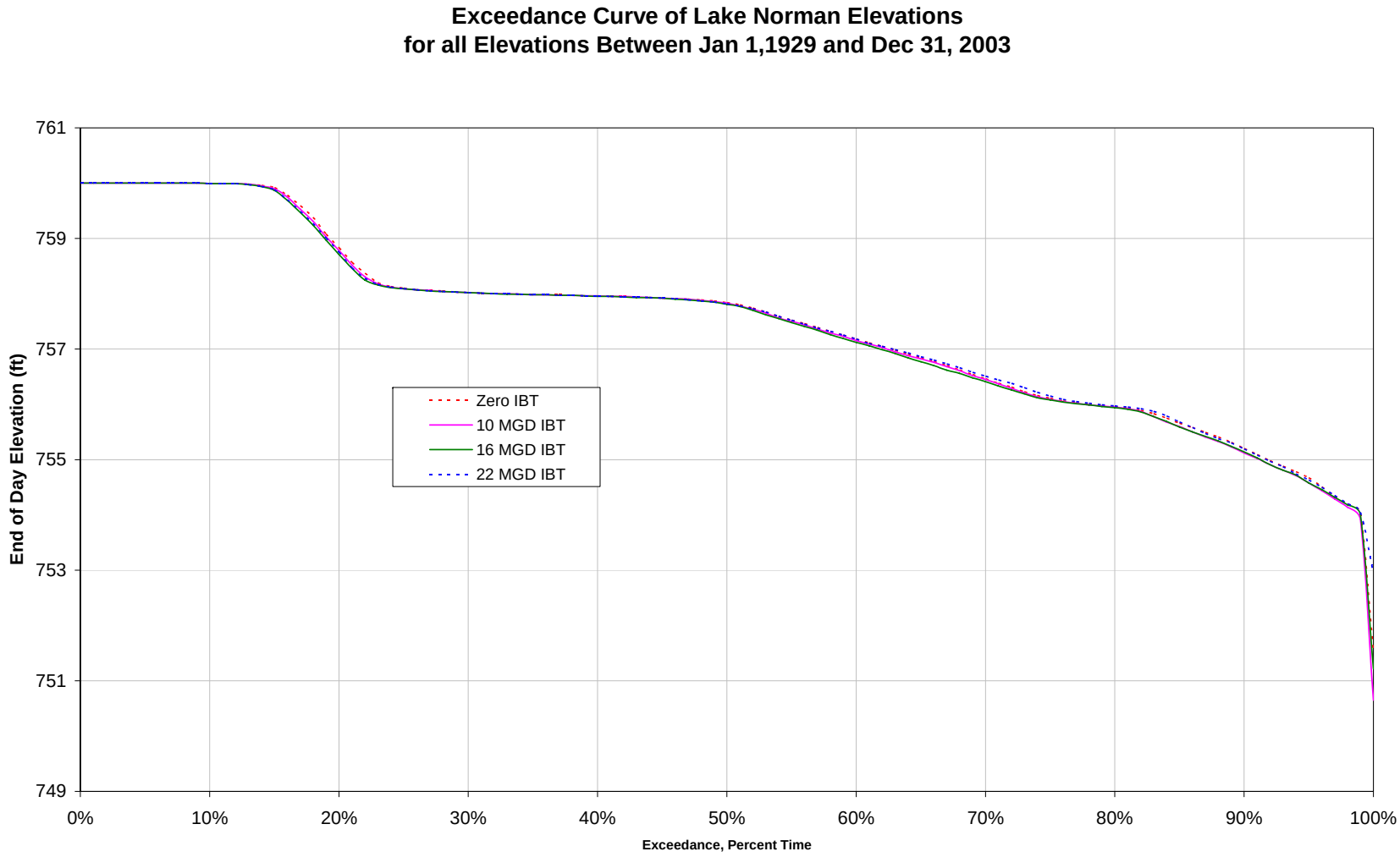


Table 11: Lake Norman Elevation Exceedance Data, FT

Exceedance, Percent Time	Lake Norman Levels Remain above Elevation, FT			
	Zero IBT	10 MGD IBT	16 MGD IBT	22 MGD IBT
0%	760	760	760	760
1%	760	760	760	760
2%	760	760	760	760
5%	760	760	760	760
10%	759.99	759.99	759.99	759.99
20%	758.83	758.78	758.71	758.75
30%	758.02	758.02	758.02	758.02
40%	757.96	757.96	757.95	757.96
50%	757.84	757.83	757.81	757.82
60%	757.18	757.15	757.12	757.18
70%	756.46	756.45	756.41	756.51
80%	755.96	755.95	755.94	755.97
90%	755.2	755.12	755.14	755.19
95%	754.78	754.71	754.72	754.74
98%	754.34	754.29	754.32	754.35
99%	754.19	754.14	754.18	754.2
100%	751.53	750.65	751.22	752.95

Figure 4: Elevation Duration Curve for Lake Wylie

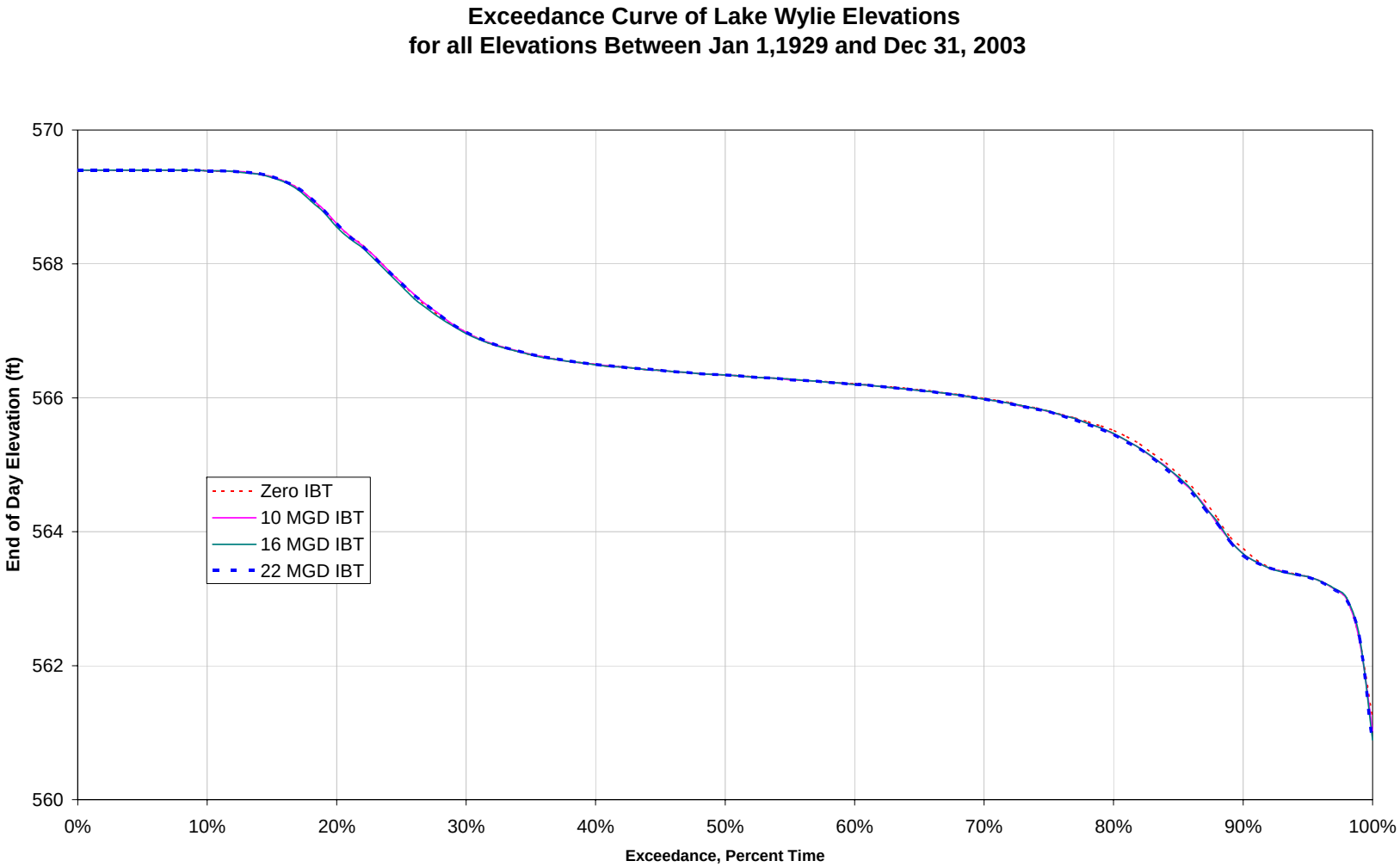


Table 12: Lake Wylie Elevation Exceedance Data, FT

Exceedance, Percent Time	Lake Wylie Levels Remain above Elevation, FT			
	Zero IBT	10 MGD IBT	16 MGD IBT	22 MGD IBT
0%	569.4	569.4	569.4	569.4
1%	569.4	569.4	569.4	569.4
2%	569.4	569.4	569.4	569.4
5%	569.4	569.4	569.4	569.4
10%	569.39	569.39	569.39	569.39
20%	568.58	568.6	568.55	568.6
30%	566.98	566.98	566.96	566.98
40%	566.5	566.5	566.49	566.5
50%	566.34	566.34	566.34	566.34
60%	566.21	566.2	566.2	566.2
70%	565.99	565.98	565.98	565.98
80%	565.51	565.46	565.47	565.45
90%	563.92	563.87	563.87	563.85
95%	563.37	563.36	563.36	563.37
98%	563.15	563.15	563.16	563.14
99%	562.99	562.99	563.01	562.98
100%	561.21	561.03	560.89	560.83

Figure 5: Elevation Duration Curve for Lake Wateree

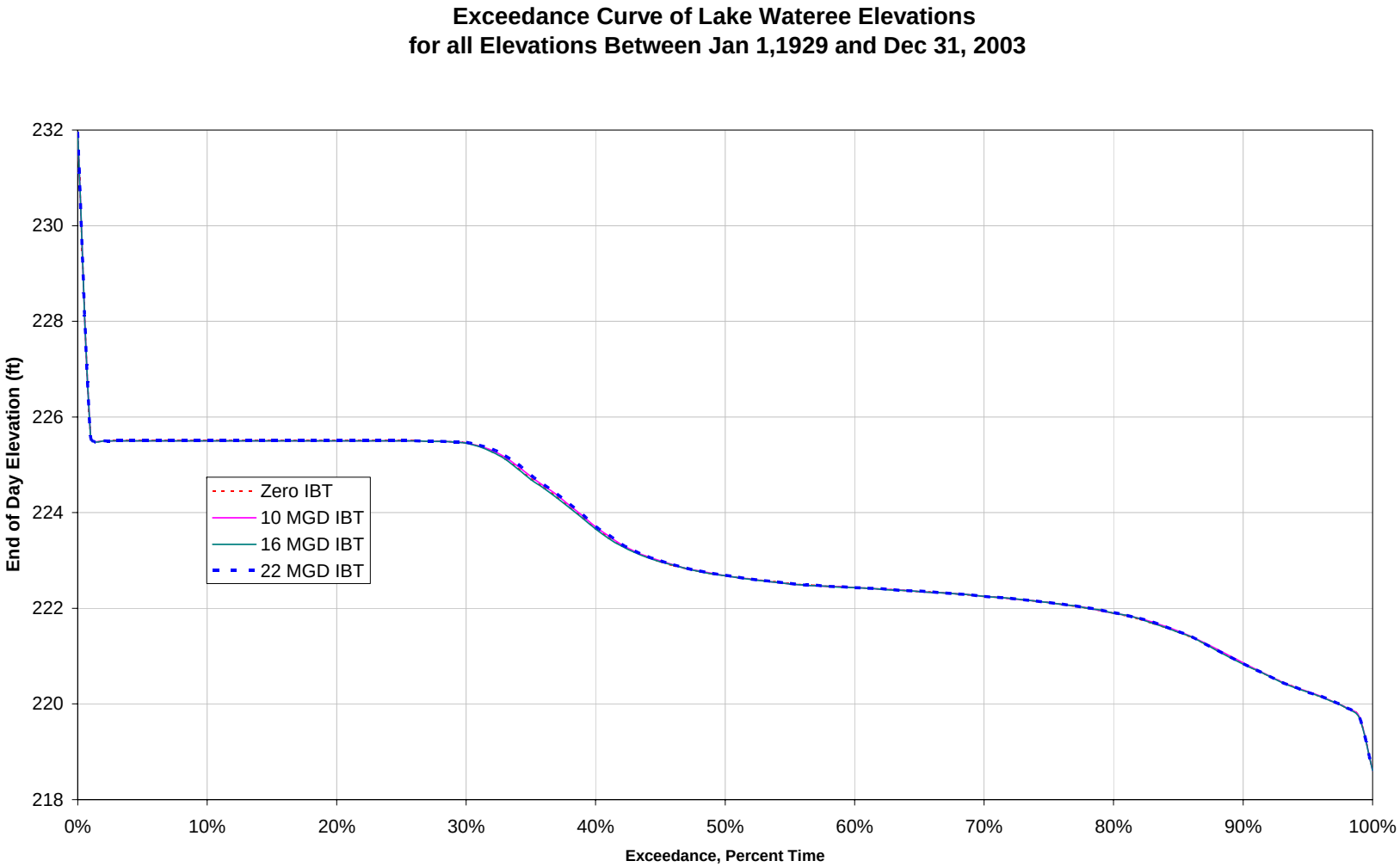


Table 13: Lake Wateree Elevation Exceedance Data, FT

Exceedance, Percent Time	Lake Wateree Levels Remain above Elevation, FT			
	Zero IBT	10 MGD IBT	16 MGD IBT	22 MGD IBT
0%	231.95	231.94	231.95	231.96
1%	225.56	225.56	225.55	225.56
2%	225.5	225.5	225.5	225.5
5%	225.5	225.5	225.5	225.5
10%	225.5	225.5	225.5	225.5
20%	225.5	225.5	225.5	225.5
30%	225.46	225.46	225.45	225.47
40%	223.67	223.7	223.66	223.71
50%	222.68	222.68	222.68	222.69
60%	222.43	222.43	222.43	222.43
70%	222.25	222.25	222.25	222.25
80%	221.9	221.9	221.9	221.91
90%	220.99	221	220.97	220.98
95%	220.35	220.35	220.34	220.35
98%	220.04	220.04	220.04	220.05
99%	219.91	219.92	219.91	219.92
100%	218.61	218.61	218.61	218.61

Figure 6: Outflow Duration Curve for Lake James

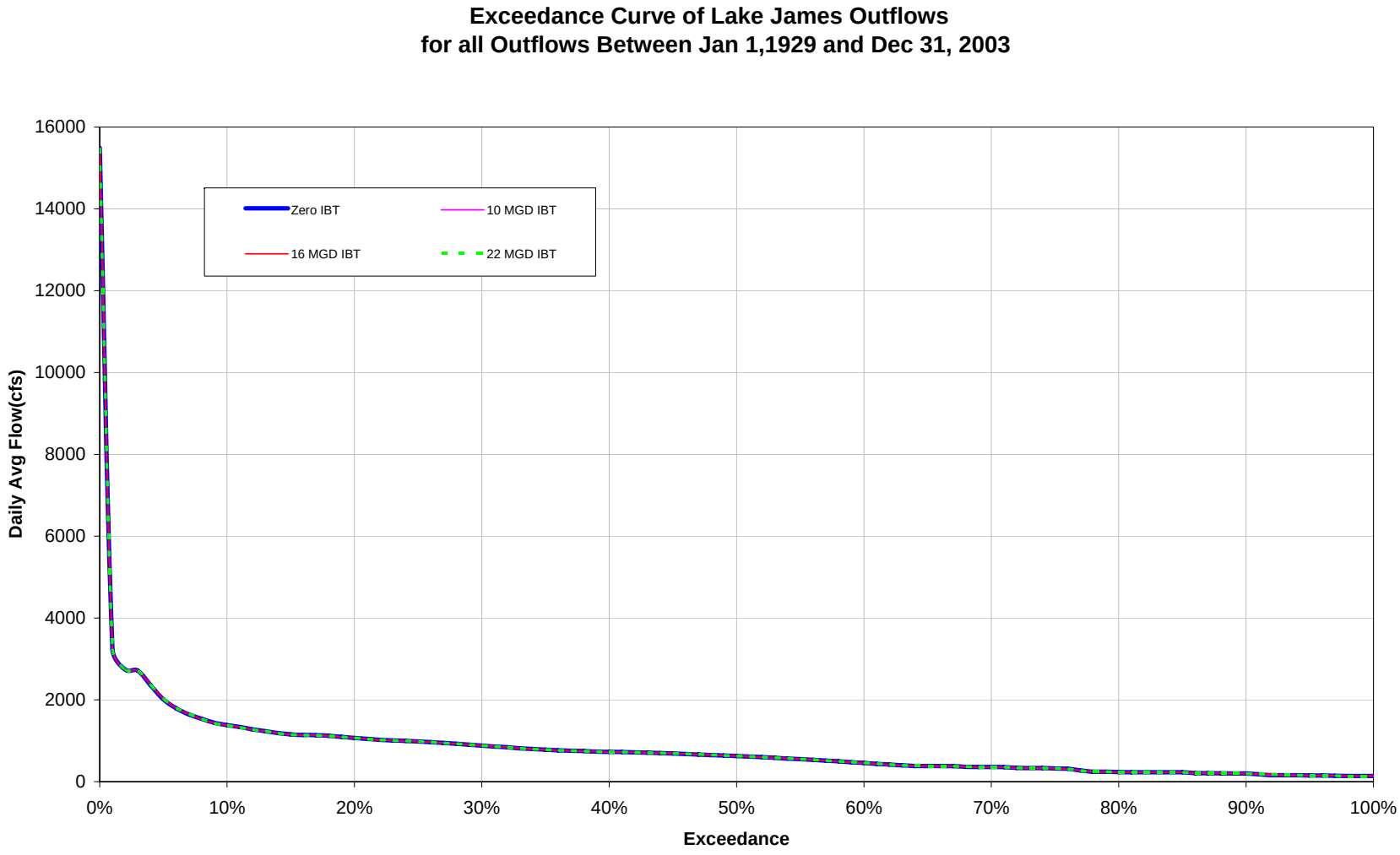


Table 14: Lake James Outflow Exceedance Data, FT

Exceedance, Percent Time	Lake James Flow Remain above, cfs			
	Zero IBT	10 MGD IBT	16 MGD IBT	22 MGD IBT
0%	15,491	15,491	15,491	15,491
1%	3,238	3,246	3,232	3,246
2%	2,744	2,744	2,744	2,744
5%	2,011	2,026	2,025	2,029
10%	1,384	1,382	1,381	1,379
20%	1,071	1,070	1,069	1,069
30%	884	883	884	882
40%	729	729	730	729
50%	627	627	628	627
60%	458	457	460	462
70%	360	360	360	360
80%	237	237	237	237
90%	202	202	202	203
95%	159	159	159	159
98%	146	146	146	146
99%	140	140	140	140
100%	139	139	139	139

Figure 7: Outflow Duration Curve for Lake Wylie

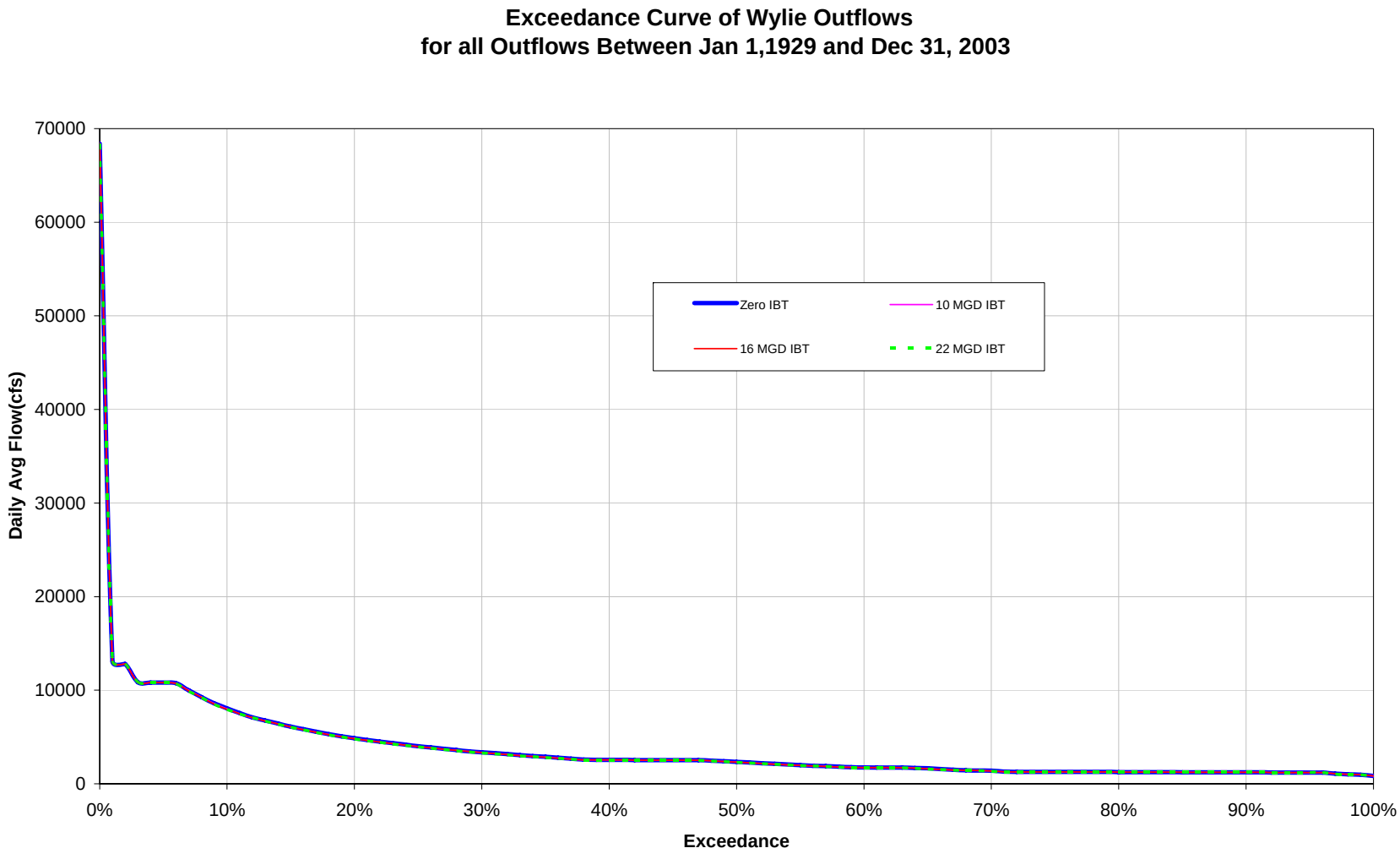


Table 15: Lake Wylie Outflow Exceedance Data, CFS

Exceedance, Percent Time	Lake Wylie Flow Remain above, cfs			
	Zero IBT	10 MGD IBT	16 MGD IBT	22 MGD IBT
0%	68,400	68,399	68,392	68,404
1%	13,093	13,094	13,073	13,100
2%	12,810	12,810	12,810	12,810
5%	10,819	10,819	10,807	10,807
10%	8,047	7,997	7,965	7,946
20%	4,870	4,837	4,818	4,803
30%	3,373	3,338	3,337	3,306
40%	2,550	2,549	2,549	2,549
50%	2,345	2,321	2,314	2,303
60%	1,761	1,745	1,743	1,743
70%	1,400	1,377	1,374	1,341
80%	1,258	1,256	1,256	1,256
90%	1,221	1,221	1,221	1,221
95%	1,205	1,205	1,205	1,204
98%	1,096	1,096	1,095	1,034
99%	1,011	1,011	1,011	995
100%	838	838	838	838

Figure 8: Outflow Duration Curve for Lake Wateree

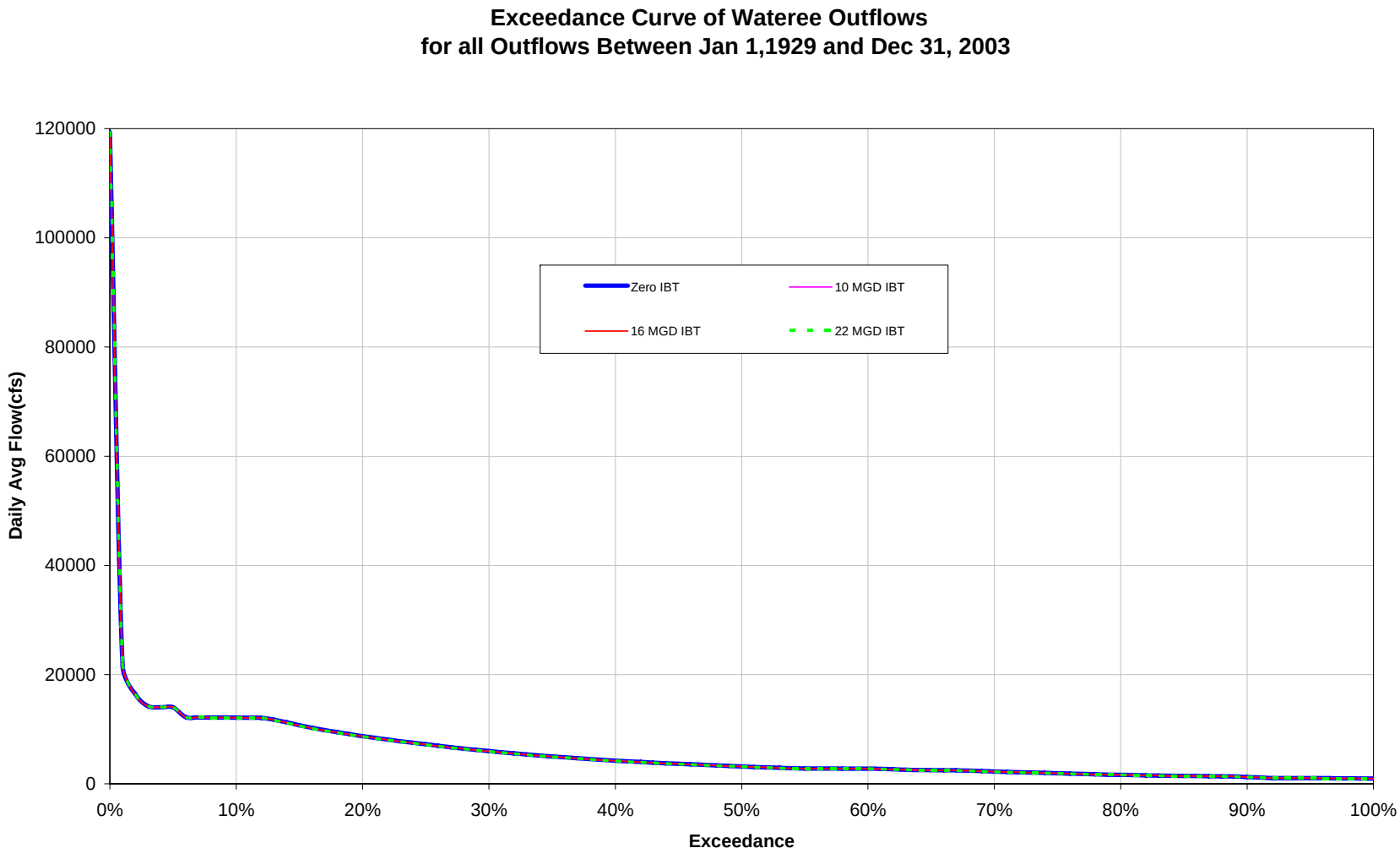


Table 16: Lake Wateree Outflow Exceedance Data, CFS

Exceedance, Percent Time	Lake Wateree Flow Remain above, cfs			
	Zero IBT	10 MGD IBT	16 MGD IBT	22 MGD IBT
0%	119,380	119,332	119,379	119,578
1%	21,755	22,059	21,878	22,115
2%	16,489	16,418	16,355	16,405
5%	14,001	14,002	14,001	14,001
10%	12,112	12,113	12,110	12,110
20%	8,735	8,707	8,678	8,649
30%	5,992	5,974	5,955	5,935
40%	4,258	4,212	4,212	4,200
50%	3,177	3,164	3,157	3,135
60%	2,777	2,776	2,776	2,766
70%	2,248	2,233	2,239	2,209
80%	1,654	1,641	1,640	1,629
90%	1,343	1,327	1,333	1,318
95%	1,038	1,037	1,037	1,037
98%	1,005	1,005	1,005	994
99%	991	991	991	991
100%	963	963	963	963

Figure 9: Lake James Elevation Profiles

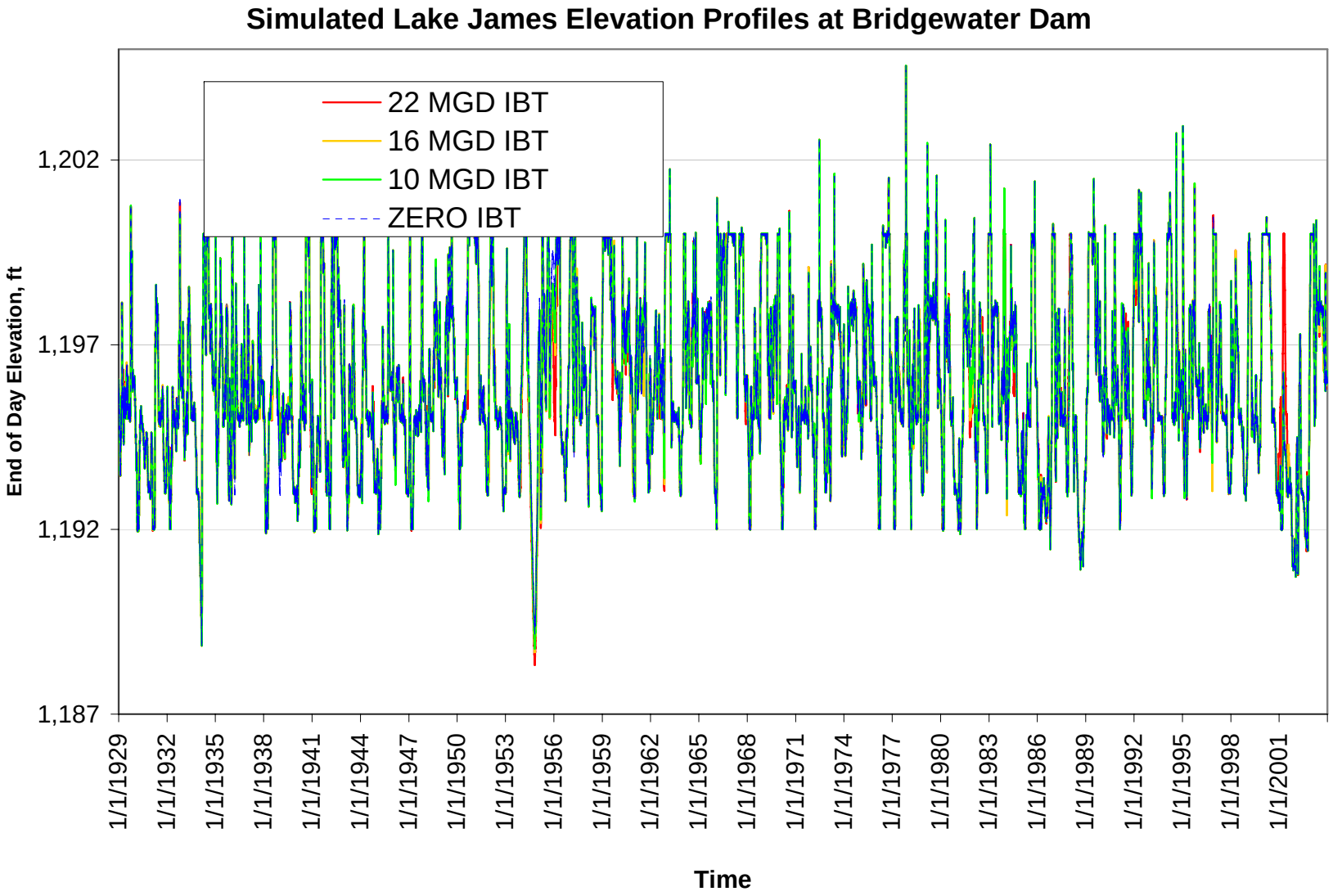


Figure 10: Lake James Elevation Profiles during 1950's Drought

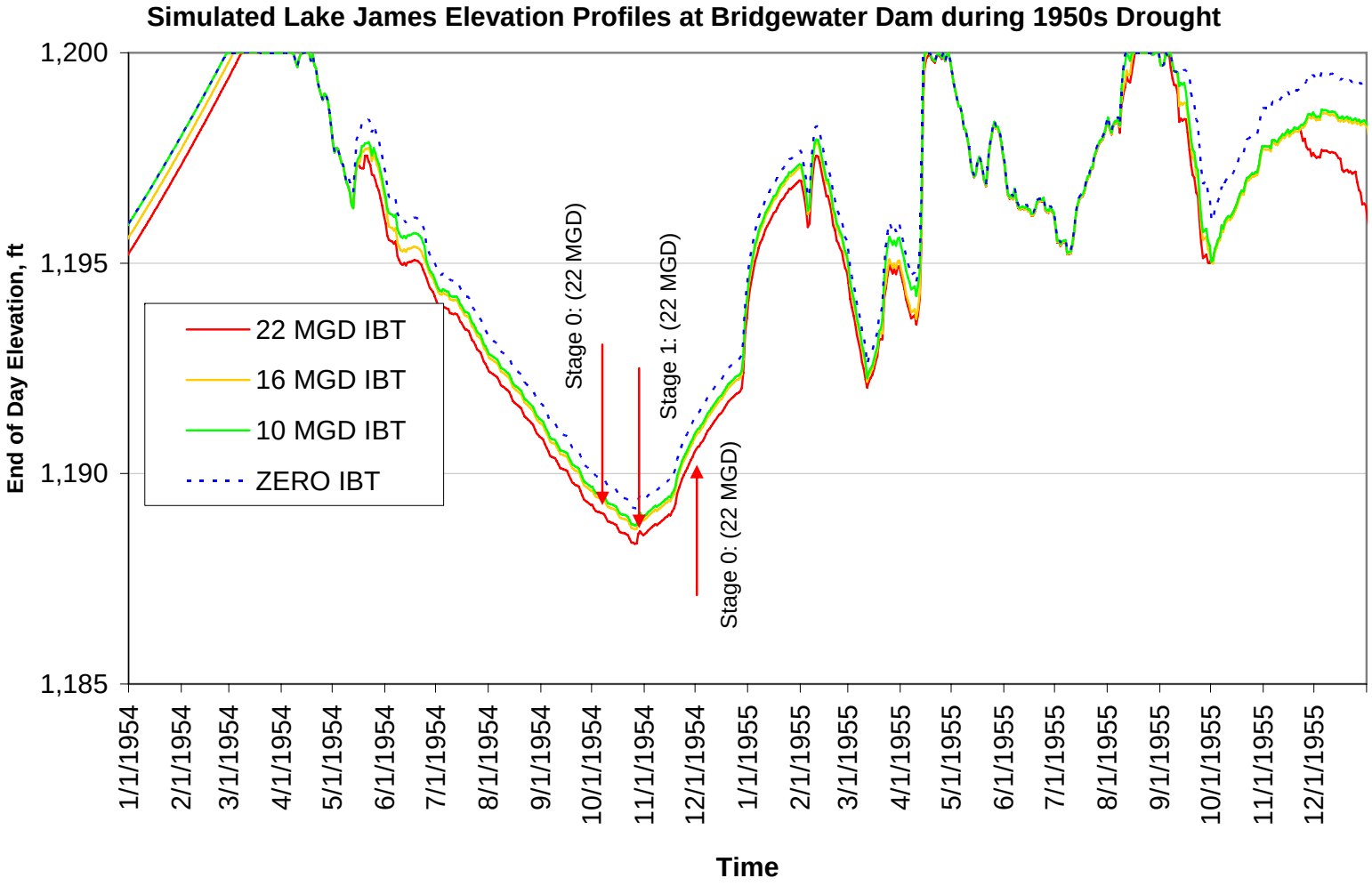


Figure 11: Lake James Elevation Profiles during 1980's Drought

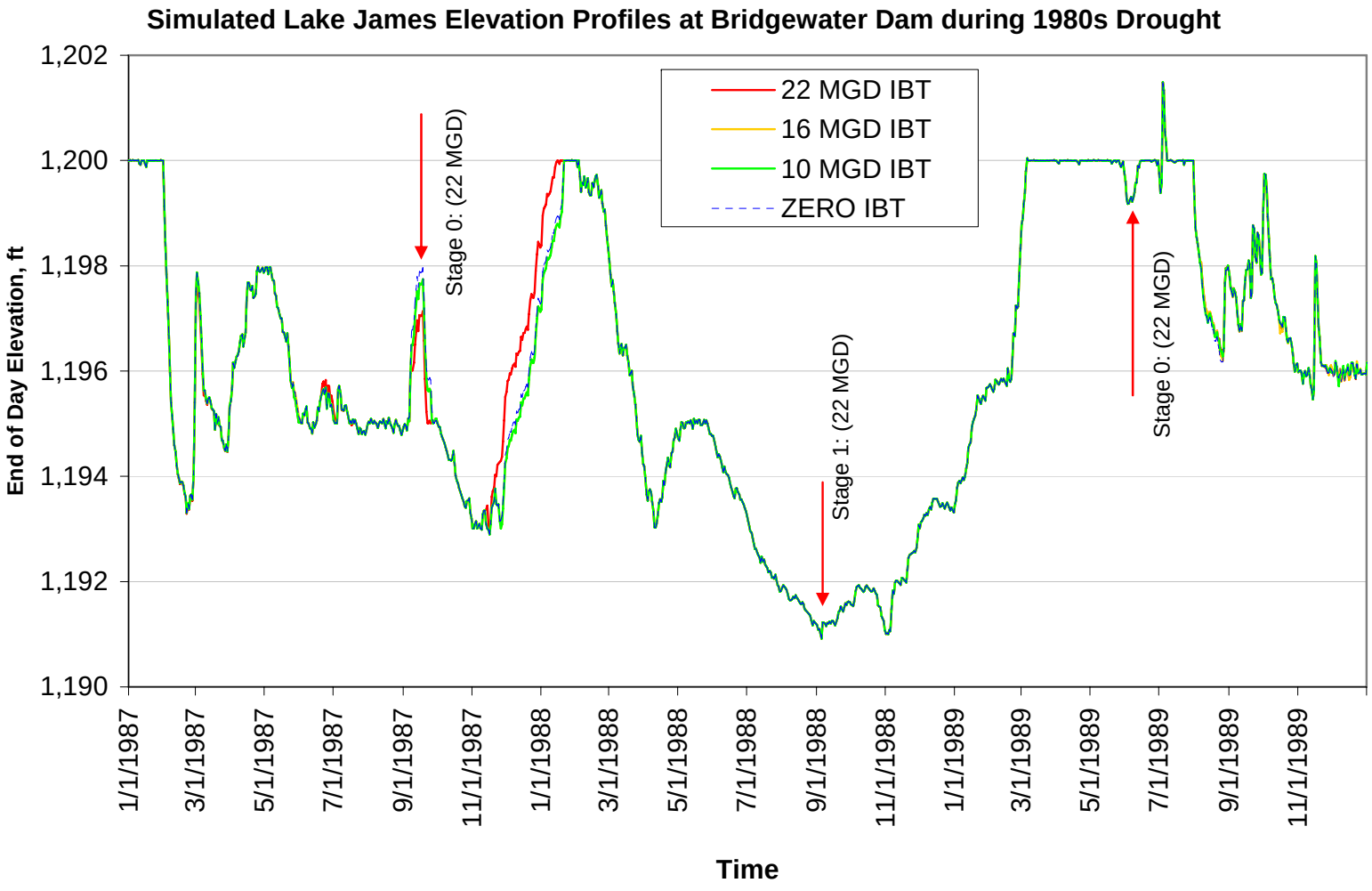


Figure 12: Lake James Elevation Profiles during 2002 Drought

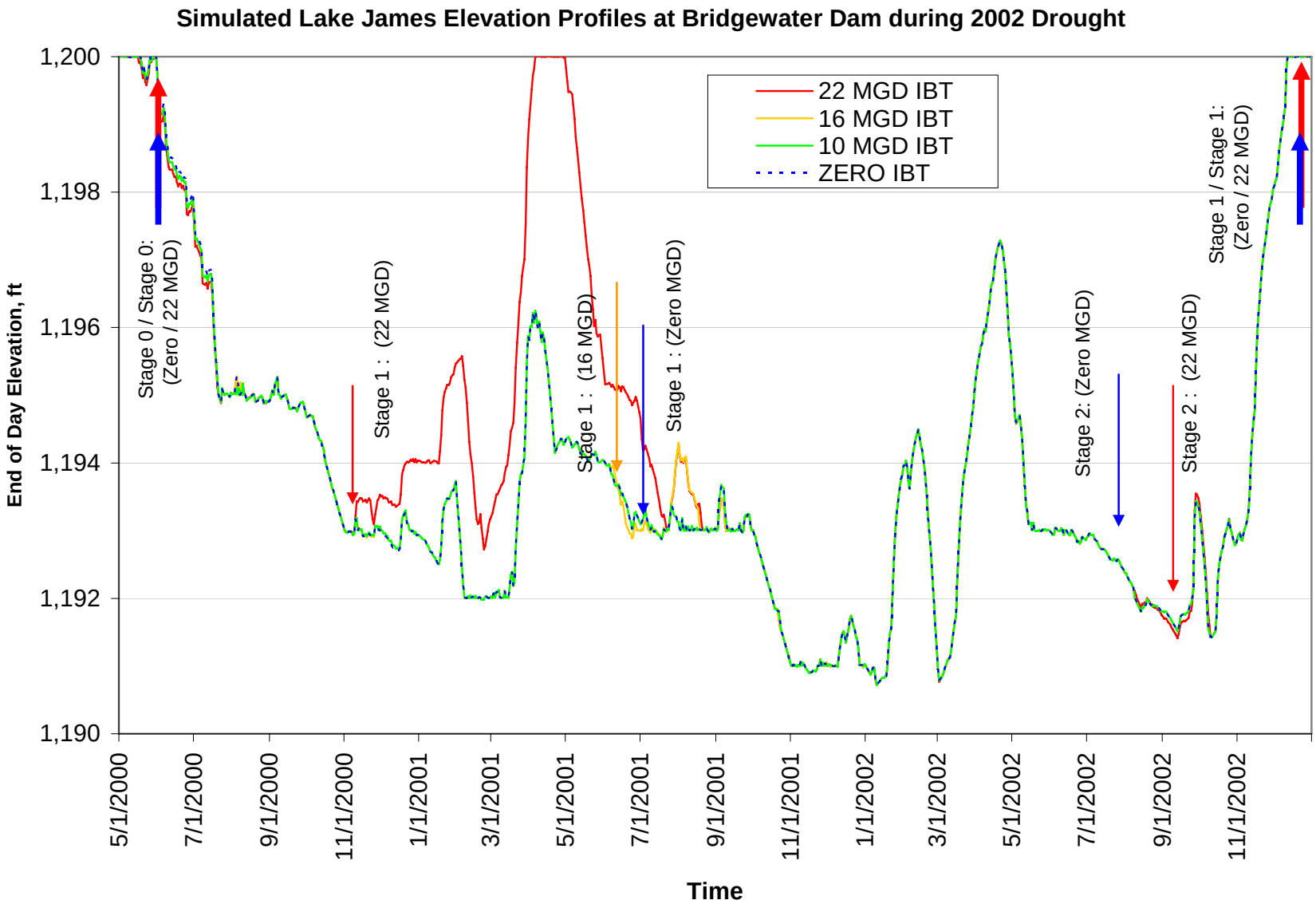


Figure 13 Lake Norman Elevation Profiles

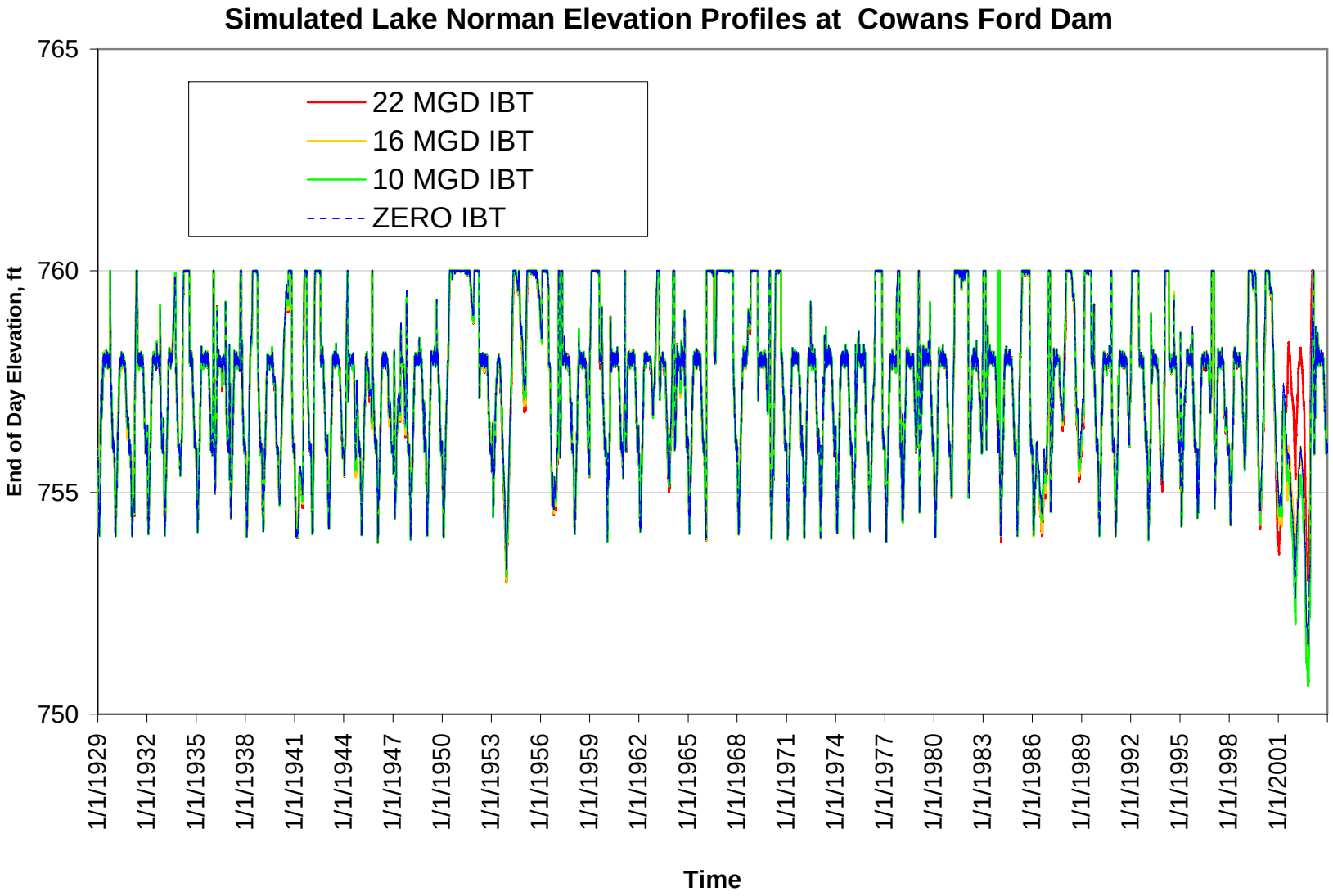


Figure 14: Lake Norman Elevation Profiles during 1950s Drought

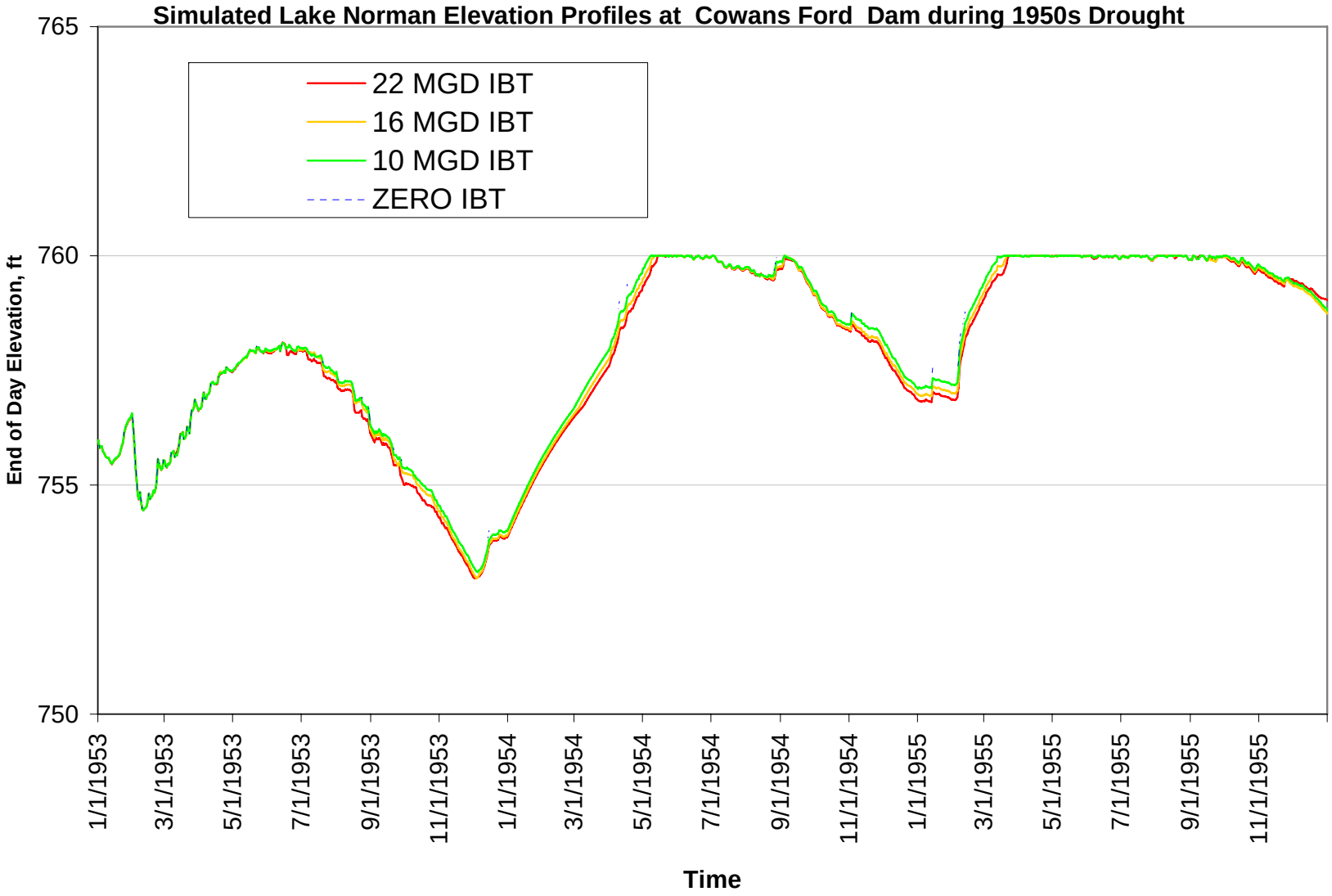


Figure 15: Lake Norman Elevation Profiles during 1980s Drought

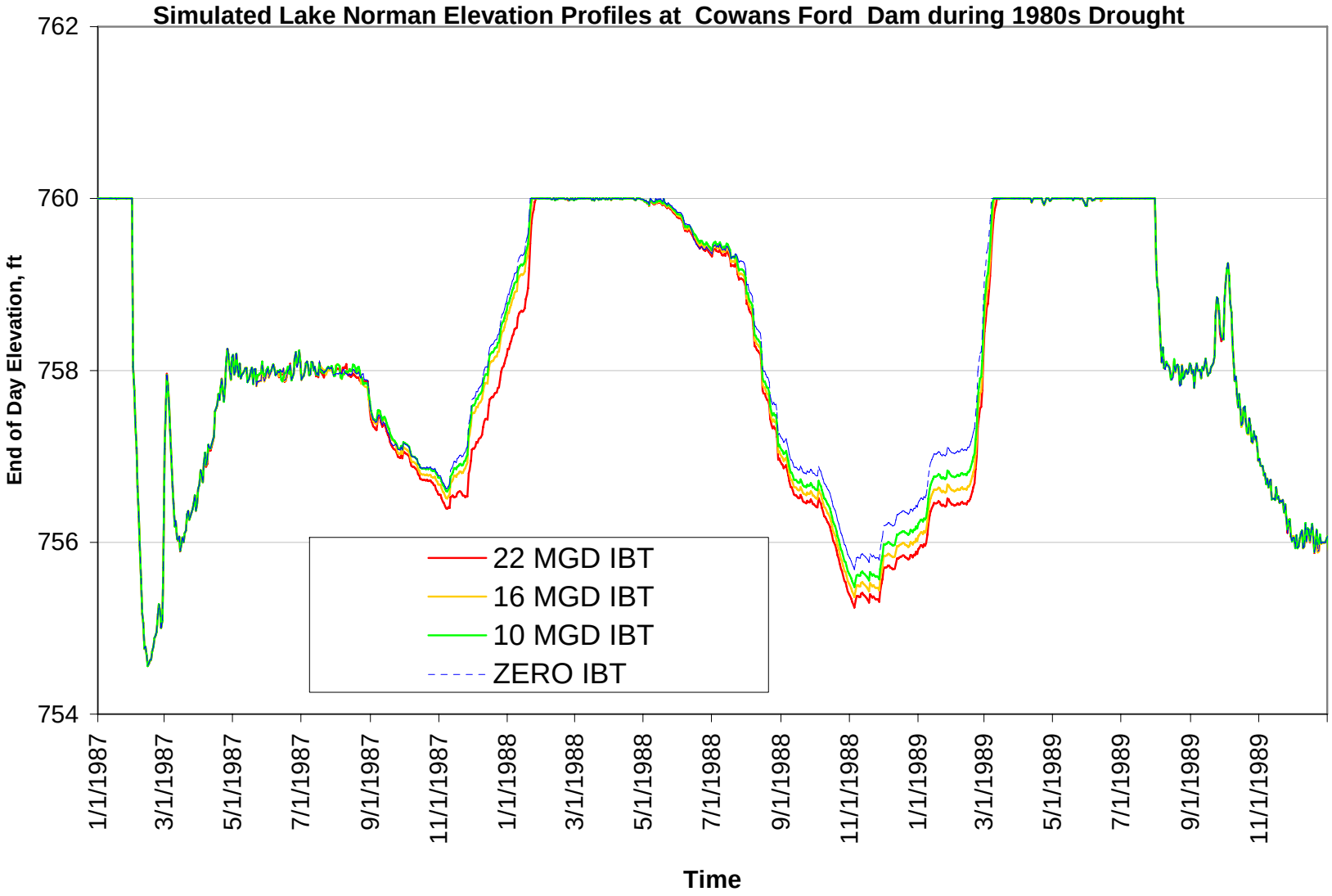


Figure 16: Lake Norman Elevation Profiles during 2002 Drought

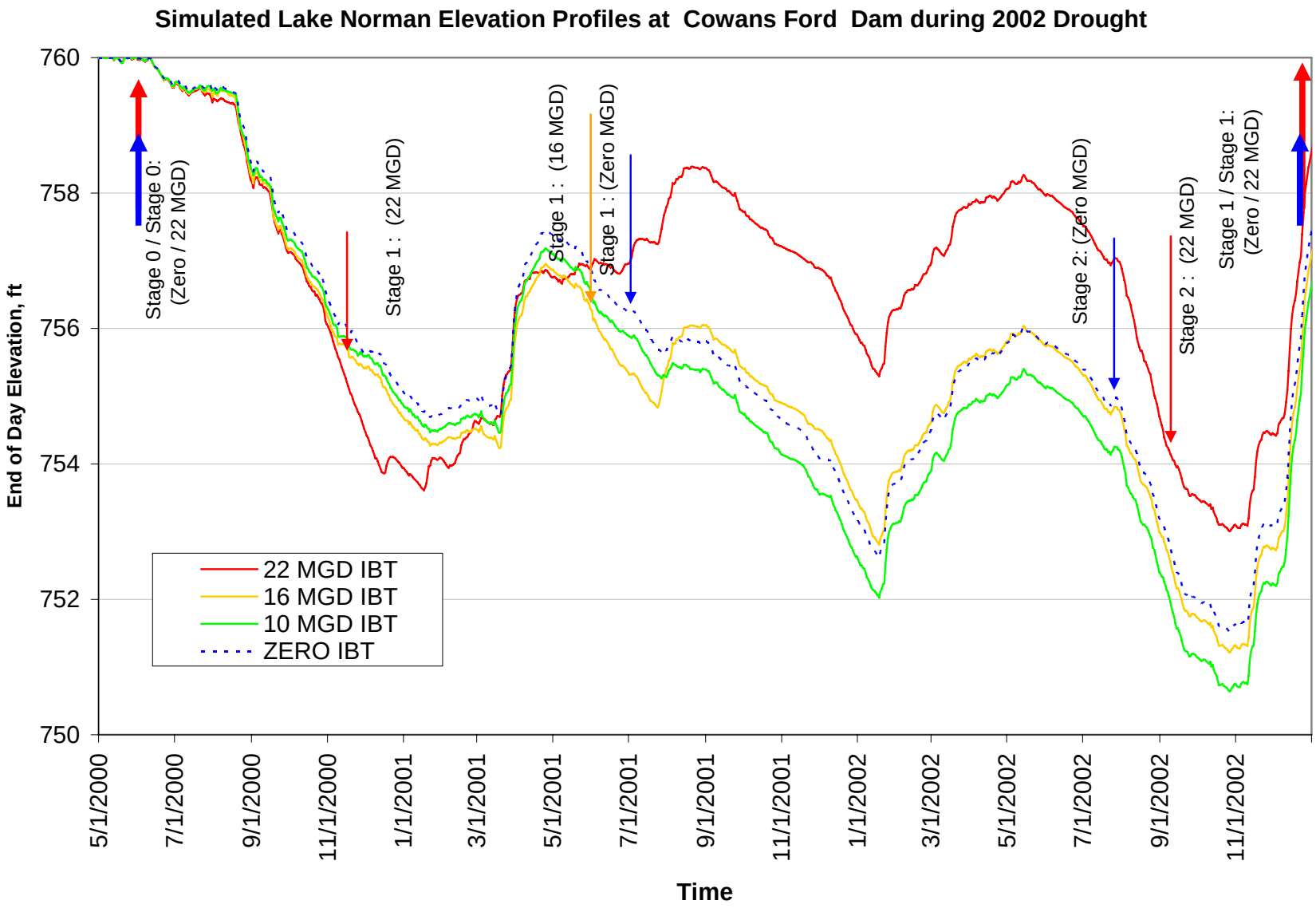


Figure 17: Lake Wylie Elevation Profiles

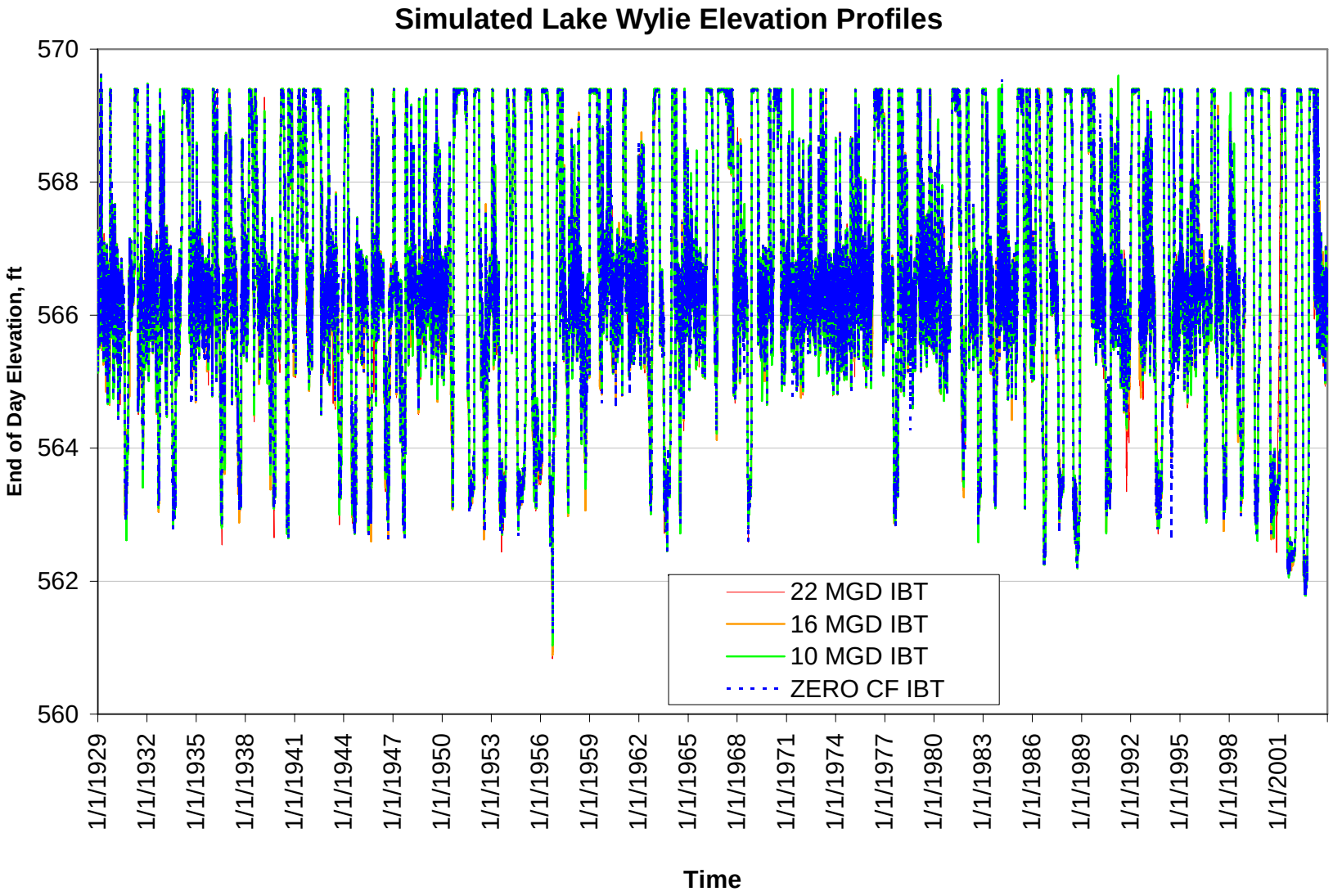


Figure 18: Lake Wylie Elevation Profiles during 1950s Drought

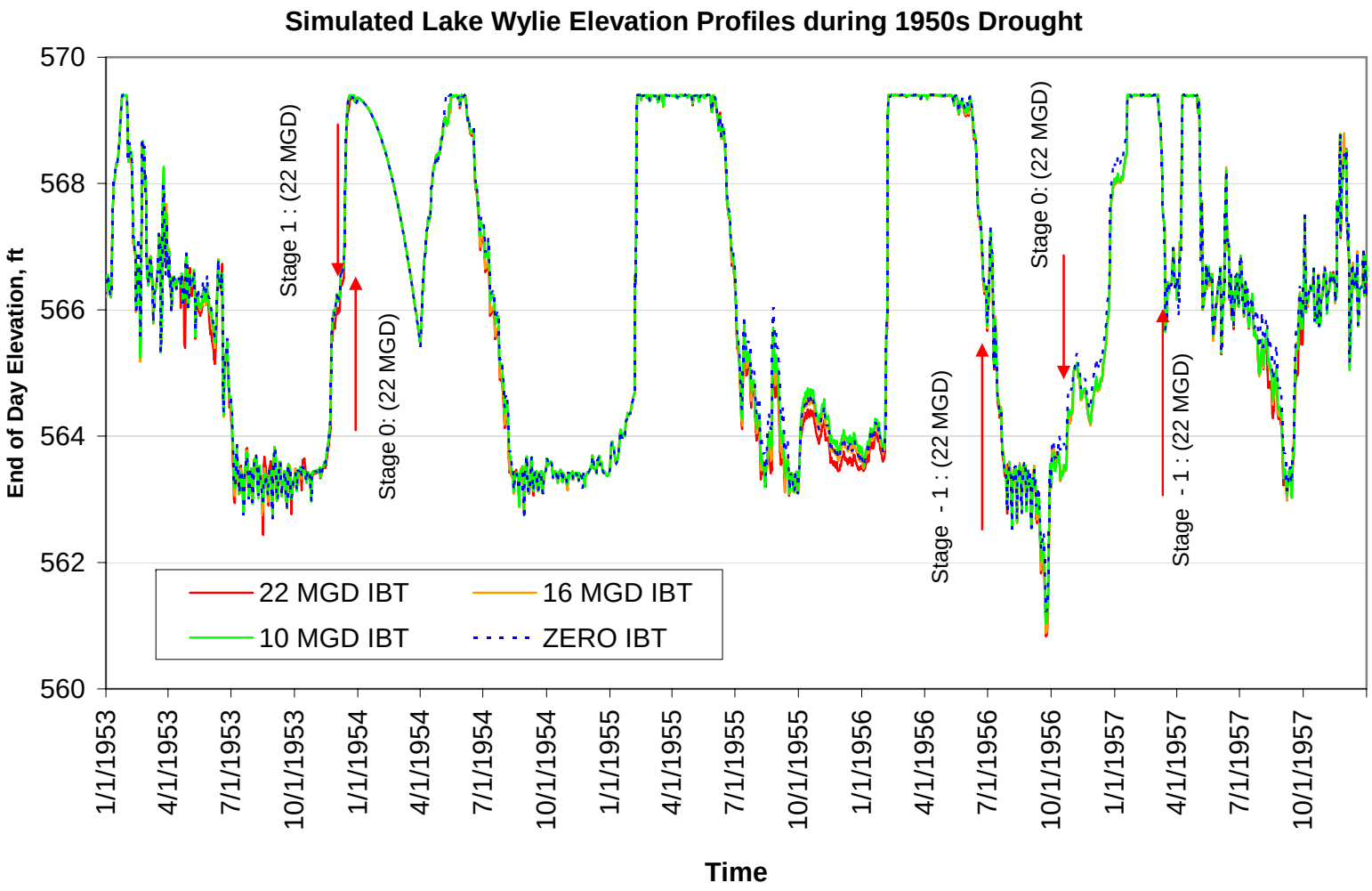


Figure 19: Lake Wylie Elevation Profiles during 1980s Drought

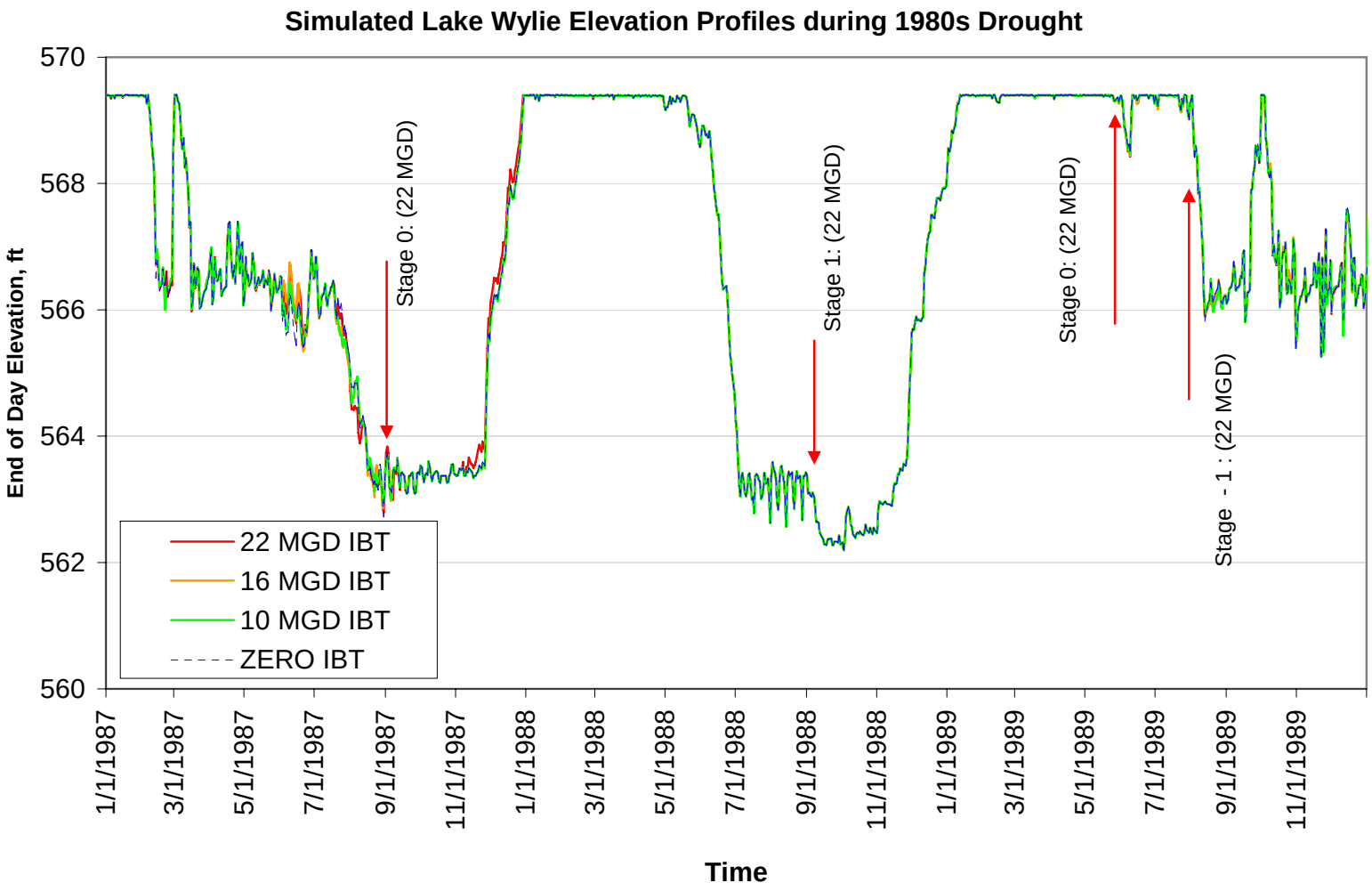


Figure 20: Lake Wylie Elevation Profiles during 2002 Drought

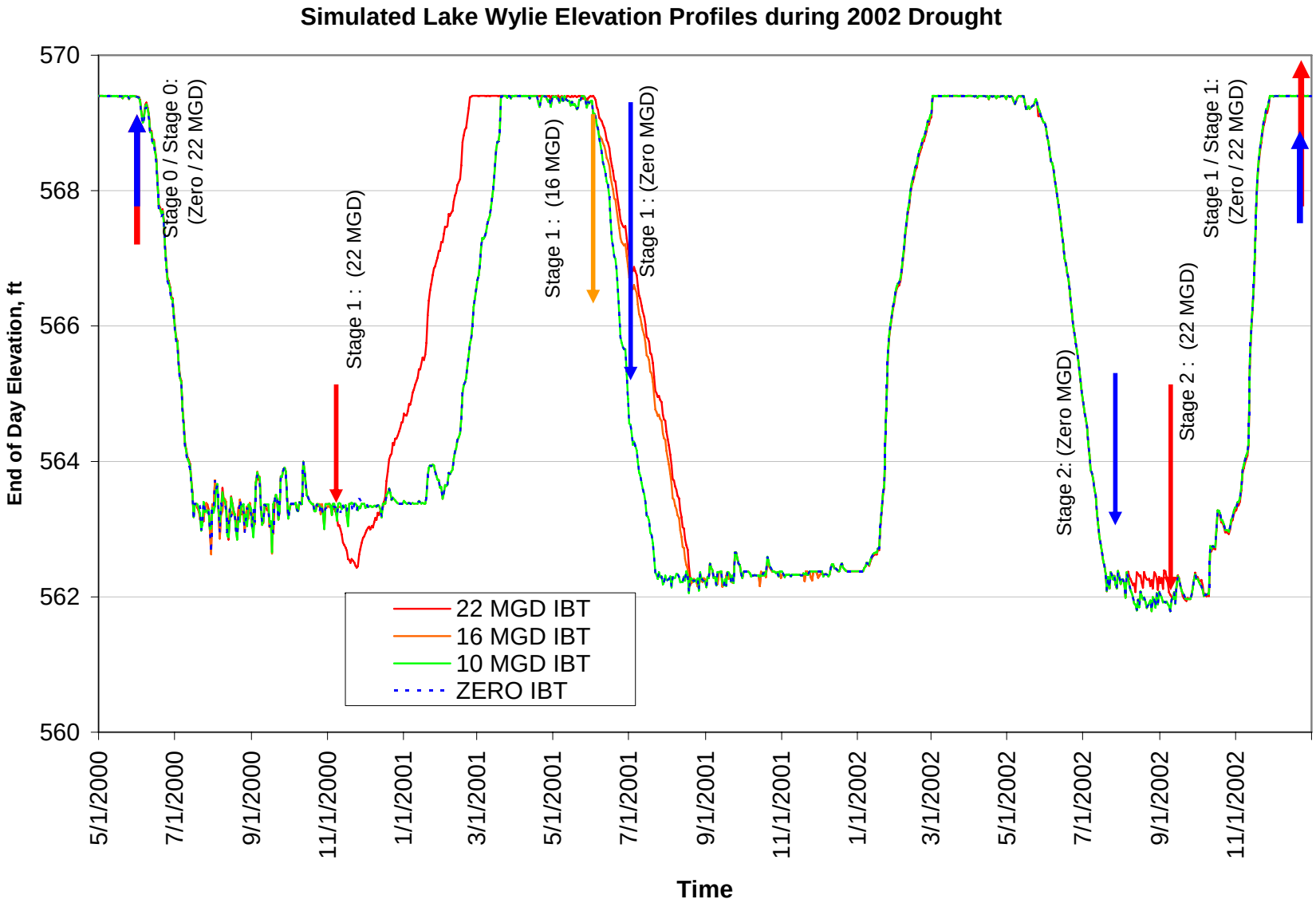


Figure 21: Lake Wateree Elevation Profiles

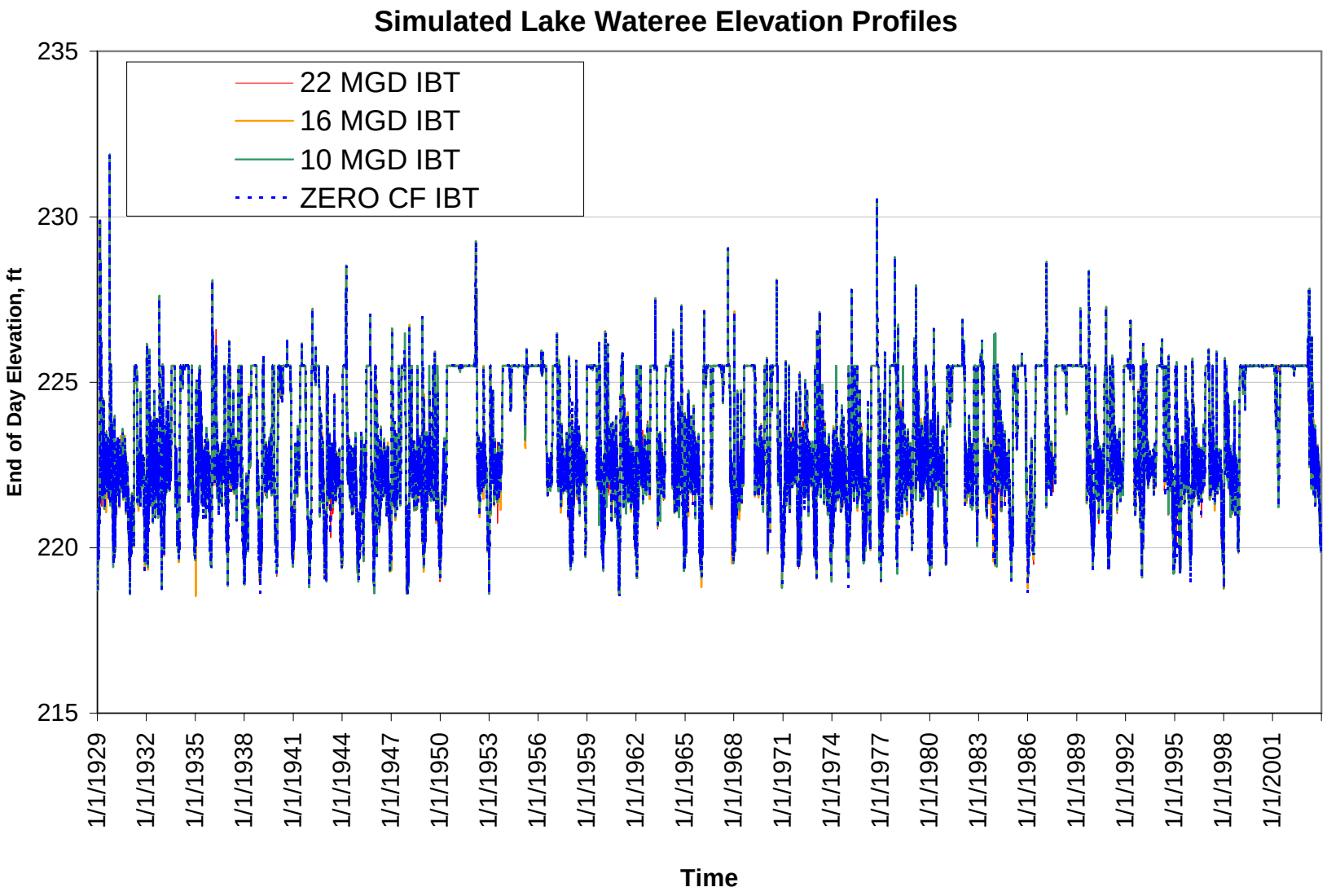


Figure 22: Lake Wateree Elevation Profiles during 1950s Drought

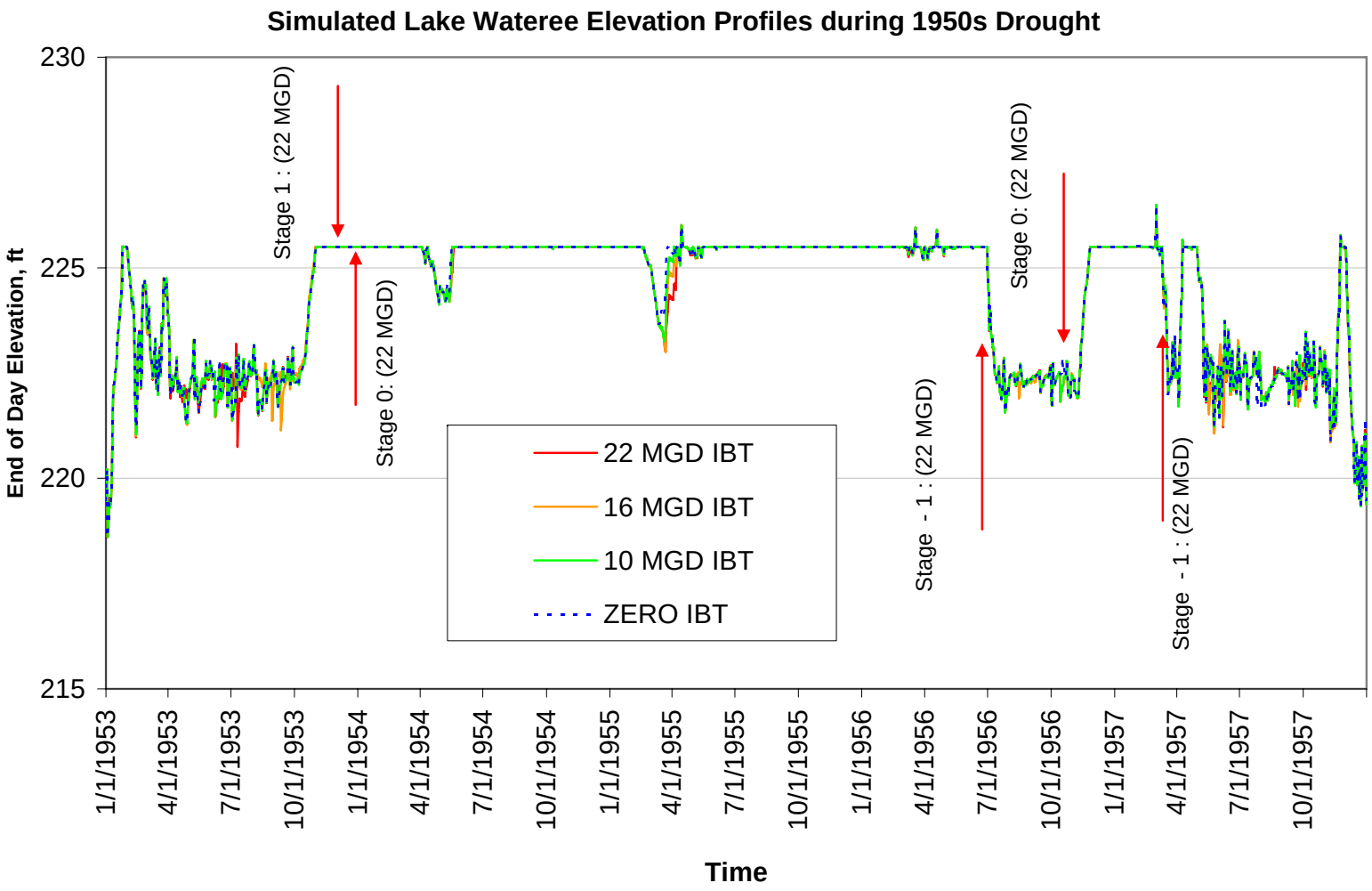


Figure 23: Lake Wateree Elevation Profiles during 1980s Drought

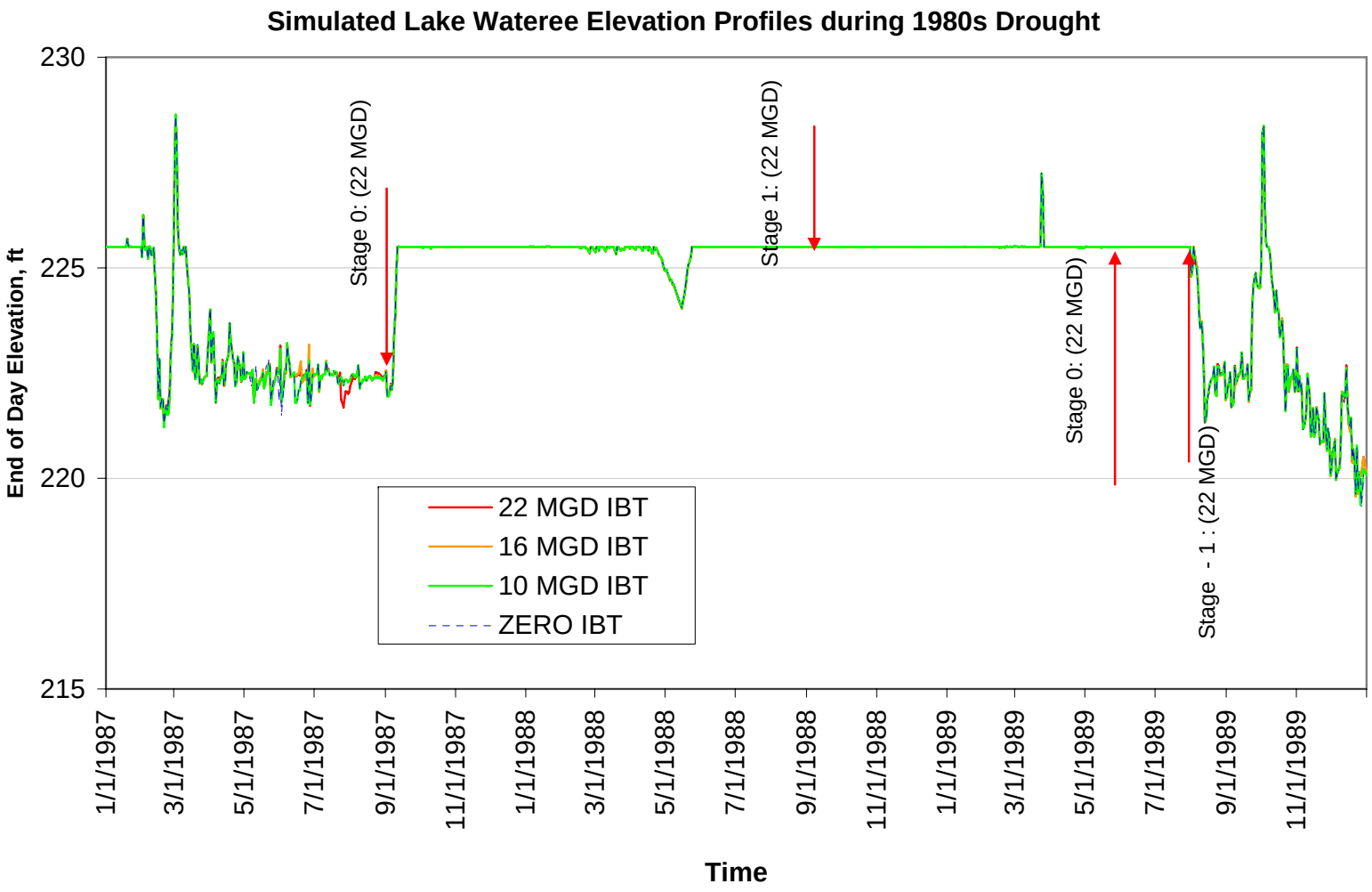
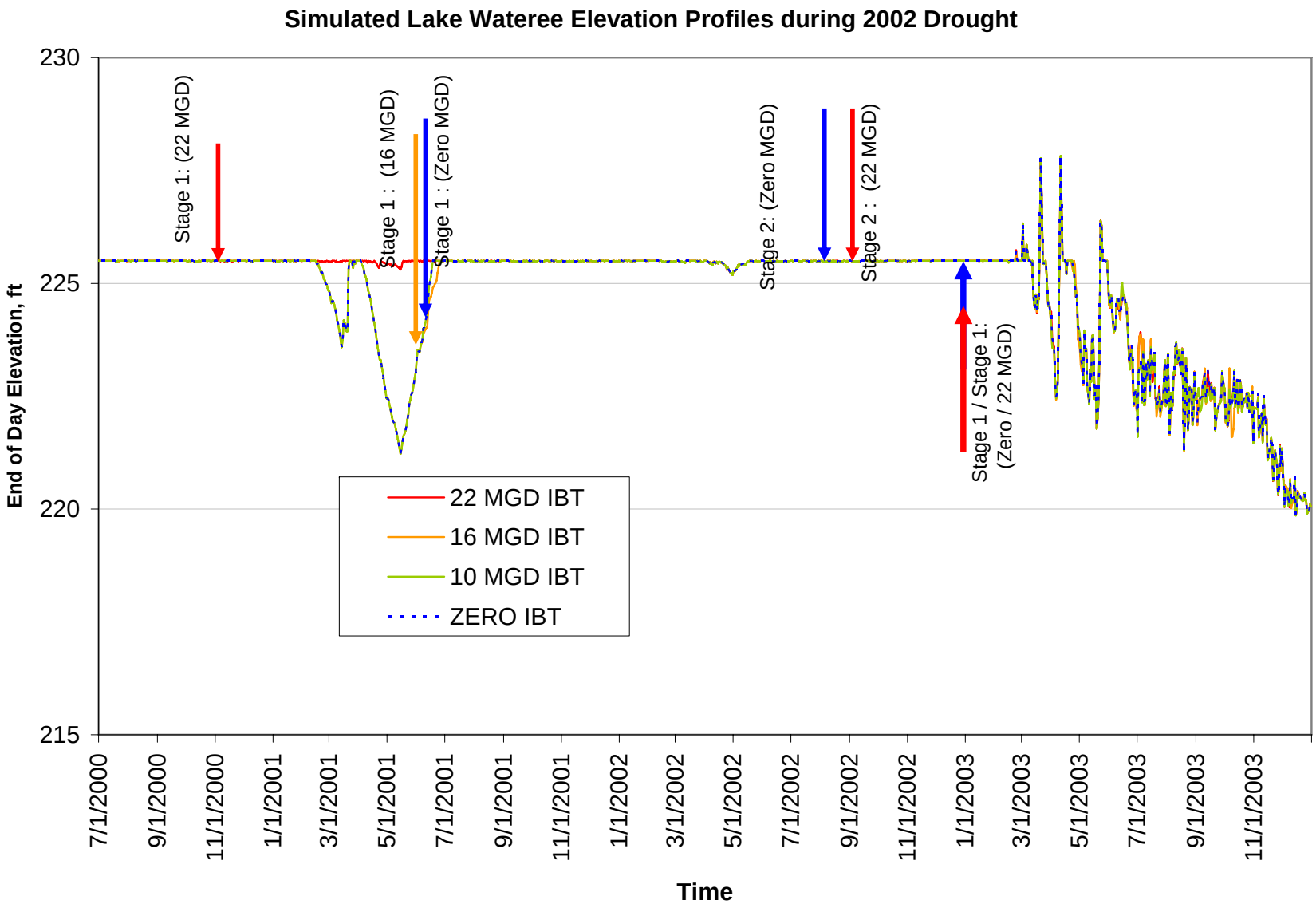


Figure 24: Lake Wateree Elevation Profiles during 2002 Drought



Attachment B

CATAWBA-WATEREE CHEOPS™ MODEL
REVIEW OF INPUT
CONCORD-KANNAPOLIS, NC
FINAL EIS FOR IBT CERTIFICATION

Prepared for:
CH2M HILL, Inc.
Charlotte, North Carolina

Prepared by:
DEVINE TARBELL & ASSOCIATES, INC.
Charlotte, North Carolina

August 2006

Devine Tarbell & Associates, Inc.
Consulting Engineers, Scientists, & Regulatory Specialists

CATAWBA-WATEREE CHEOPS™ MODEL
REVIEW OF INPUT
CONCORD-KANNAPOLIS, NC
FINAL EIS FOR IBT CERTIFICATION

TABLE OF CONTENTS

Section	Title	Page No.
SECTION 1	MODEL BACKGROUND	1-1
SECTION 2	WORK PERFORMED	2-1
SECTION 3	FINDINGS	3-1

Devine Tarbell & Associates, Inc.

REPORT VERIFICATION

Project: Concord – Kannapolis IBT

Title of Report: REVIEW OF INPUT CONCORD-KANNAPOLIS, NC FINAL EIS FOR IBT CERTIFICATION

This document has been reviewed for accuracy and quality commensurate with the intended application.

Approved by: J. Christopher Ey, PE	Date: 08/18/06

Seal: NORTH CAROLINA PROFESSIONAL SEAL 12572 ENGINEER J. CHRISTOPHER EY 8/28/06

Devine Tarbell & Associates, Inc.
400 South Tryon Street
Charlotte, NC 28285

© Copyright 2006 by: Devine Tarbell & Associates, Inc.

Section 1
Model Background

The Catawba-Wateree CHEOPS™ Operations Model was developed for the FERC relicensing of the Catawba-Wateree Project (FERC No. 2232) using CHEOPS (Computer Hydro Electric Operations and Planning Software), a computer modeling software package developed by Devine Tarbell & Associates, Inc. (DTA) to characterize current conditions and operations of the Catawba-Wateree Hydro Project (Project). CHEOPS is specifically designed to evaluate the effects of water quantity operational changes (e.g., habitat, industrial and major water supply withdrawal and returns and recreational flow releases) and physical modifications at multi-development hydroelectric projects.

Because of the large amount of data involved in defining a hydro-system, the method of data storage and retrieval in the CHEOPS model is somewhat involved. A CHEOPS model run is called a Scenario. A Scenario is made up of a particular set of data that defines a combination of physical attributes and operational requirements that make up one specific system configuration. A Scenario is a collection of Settings. Each Scenario has a System Setting and a Physical, Operational, and Generation setting for each plant in the model. Each Setting is a collection of Conditions. The Conditions hold the actual input data that the model uses to simulate the system. A schematic of the CHEOPS Scenario Object is shown in Figure 1.

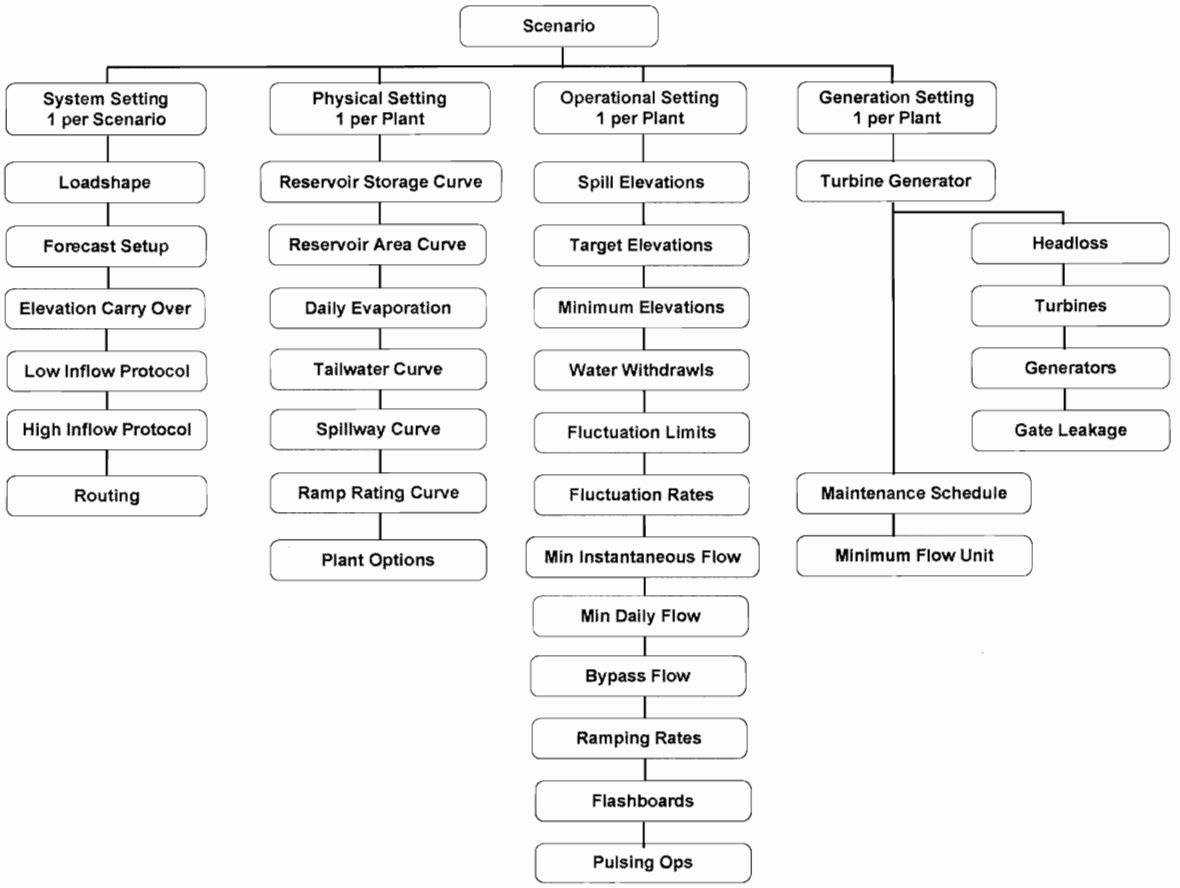
The System Setting consists of the Conditions that refer to data applicable to each plant in the system, or unique data solely applicable to one plant in the system.

Each Scenario contains a unique Physical Setting for each plant. The Physical Setting contains the Conditions that can be categorized as physical attributes of the system (ref. Figure 1).

Similar to the Physical Settings, the Operation Settings are plant specific. Each scenario contains one Operation Setting for each plant. The Operation Setting contains conditions that control how the

plant is operated: reservoir elevation constraints, and required flow releases. All elevations are in units of "feet" and should be based on the same datum as the Physical Settings.

Figure 1 Graphical Representation of the CHEOPS Scenario Object



Generation Settings are plant specific and contain the data necessary to simulate power generation. The data includes turbine performance, generator performance, headloss data, gate leakage, unit outages, and low-level outlet generating units. This data, combined with the physical and operational data, allows the model to estimate generation on a 15-minute schedule.

The primary CHEOPS output is a 15-minute schedule of plant releases and generation. An intermediate step in producing the 15-minute schedule is calculating the daily inflows, releases, and elevation targets for each plant in the system. The following sections detail the method used to calculate the daily average plant releases.

Retrieval of Constraint Data

The first step in the plant loop is to retrieve the constraints for each plant for that day. The model calculates the target elevation, minimum flows, bypass flow, water withdrawals, etc. All settings for each plant for the specific day is calculated and loaded into the model logic.

Sum of Inflows

With all the daily constraint data loaded into the model, the model then retrieves the upstream plant's releases for the day, local accretions, and any other bypass flows and/or spill flows that will arrive at that plant. The model sums these inflows and calculates a detailed 15-Minute Inflow Profile for each plant.

Daily Release Calculation

After the model determines the inflow volume for the plant it calculates a daily average release. The daily average release is a function of the total daily inflow, forecasted project inflows, target elevations, plant capacity, and minimum release requirements.

With the daily release calculated, the model checks the release against daily constraints such as minimum daily average flows, minimum instantaneous flows, downstream requirements, and minimum and spill elevations. Adjustments are made to the daily average release as necessary to meet the plant constraints.

15-Minute Time Step

Once the daily average flows have been set, the model develops the plant's 15-minute release schedule. The first priority is to meet the Minimum Instantaneous Flow for the plant. This Minimum Instantaneous Flow volume is removed from the volume available for peaking purposes. All daily constraint flows are accounted for in the derivation of the daily release volume. The primary guide for the 15-minute schedule is the utility's Loadshape.

Release Priorities Based on Loadshape

The Loadshape contains the period durations for each month for both weekdays and weekends. The model uses this data to create the 15-Minute Schedule along with the plant's peak unit capacities. The model allocates the peaking volume of water into the peak periods first, the period between peaks, the secondary peak periods, and finally the off-peak periods. The model attempts to operate the units at peak efficiency in order to maximize the generation for the period.

Constraint Checking

After the peaking volume has been scheduled, the model calculates 15-minute reservoir elevations based on the 15-minute inflows and releases. With the calculated elevations the model will check for reservoir constraint violations. If violations are found, the model will incrementally shift water either at the current plant or the upstream plant to remove reservoir violations. When the violations are eliminated to the best of the models ability (within set tolerance), the model proceeds to the next downstream plant.

Model Logic Flow Chart

Figures 2 and 3 give an overview of the model logic in sequence.

Figure 2 CHEOPS MODEL EXECUTION FLOW CHART

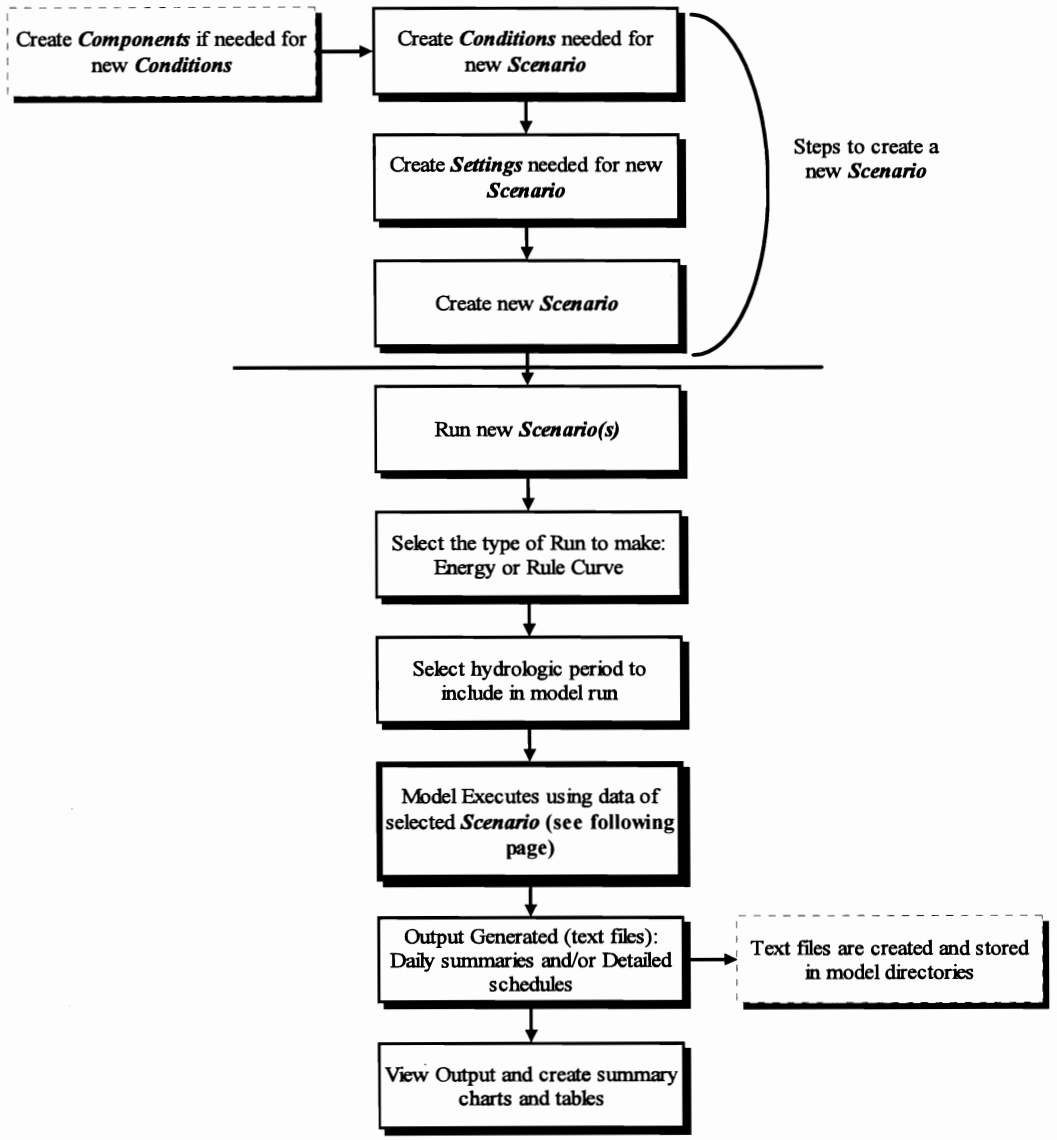
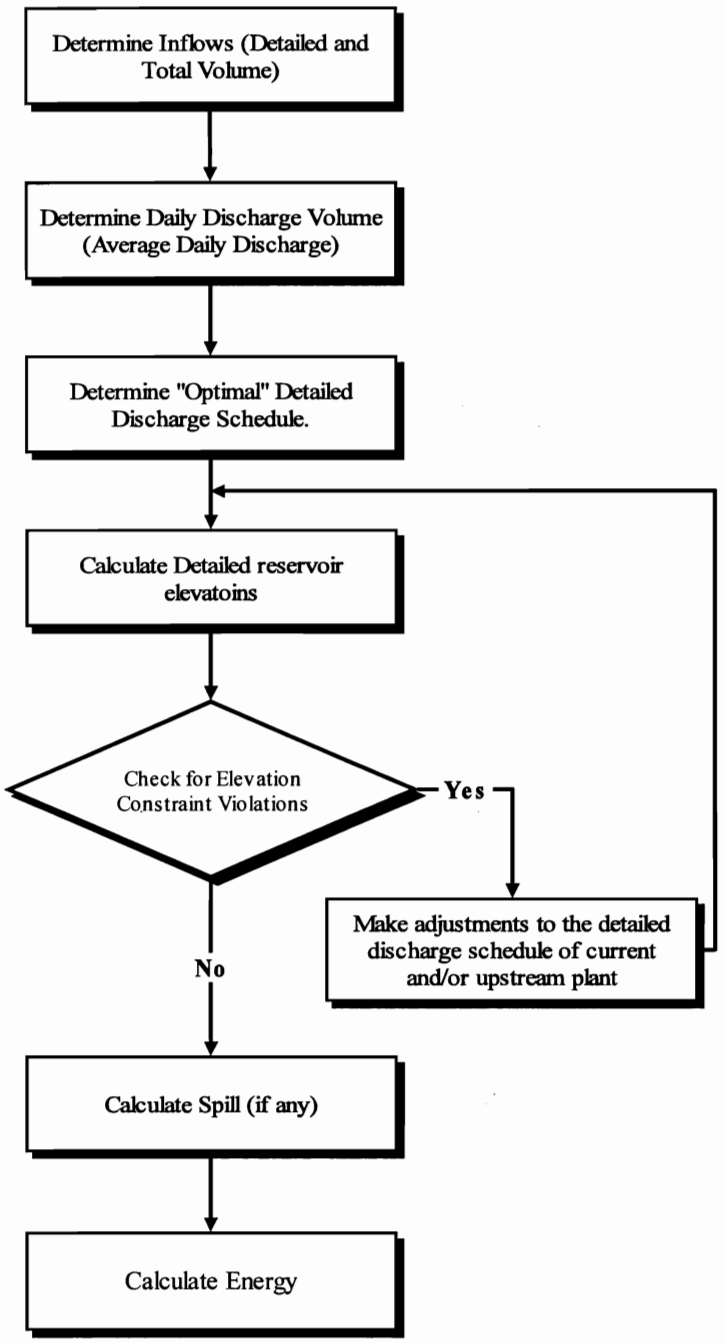


Figure 3 CHEOPS Scheduling Flow Chart



The Catawba-Wateree CHEOPS model is capable of simulating the hydro development specific hydraulic relationships based on an average daily inflow series to each of the individual development incremental drainages beginning upstream of Lake James and ending at Lake Wateree. Prior to being used in the Federal Energy Regulatory Commission (FERC) relicensing process, the model was verified to demonstrate that it is capable of providing realistic results associated with the cumulative effects of project operations on the natural flow regimen and historic operational. The verification of the model is documented in the Operations 01 relicensing study report that is part of the application for new license being prepared by Duke Energy (August 2006).

DTA created the CHEOPS™ hydro electric system simulation model as an accurate and easy-to-use tool for evaluating a wide range of physical changes (e.g., turbine upgrades) and operational constraints (e.g., minimum flows) associated with relicensing or upgrading single and multiple-development hydro systems. One of the many strengths of the CHEOPS model is the degree of customization each individual model contains. The model is tailored to meet the demands of the particular system being modeled. The unique CHEOPS program architecture provides a platform for investigating each project-specific feature under scrutiny. The Catawba-Wateree Operations Model was custom configured for the Project based on the specific Project constraints, such as environmental and recreational releases, target reservoir elevations, municipal and industrial water withdrawals and powerhouse equipment constraints. The model was designed to be capable of simulating the complex interaction between the hydrology, hydraulics, reservoir elevation operating limits, minimum flows, turbine unit variable efficiencies, and the cumulative effects of project operations on the natural flow regimen and proposed operational alternatives associated with the requirements of 18CFR4.51, Exhibit E.

The period of analysis that can be used in any CHEOPS model is based on the physical description of the plant being modeled and on the inflow to the reservoir. The Catawba-Wateree CHEOPS model is capable of analyzing from one to 75 years of inflow data for any single scenario. The 75 year time increment was based on the period of historical generation records currently available in digital format (1991 to 2003) and reconstruction of original operating records from hardcopy data

sheets stored on microfilm (1929 to 1990) in the Licensee's archives vault. It is typical to use historic inflow data to test future operating conditions because the historic inflow is a reasonable assumption of the amount of runoff that can be expected to occur in the same river basin in the future.

The Catawba-Wateree Operations Model uses mean daily unimpaired flow data as the hydrology inputs (i.e., the source of water to the Project) for simulations of a given scenario. "Unimpaired flows" are defined as synthesized mean daily stream flows that would have occurred in Project reaches in the absence of flow regulation. The hydrologic period of record is water year 1929 through 2003.

As shown in Figures 1, 2 & 3, CHEOPS utilizes daily flows, plant generating characteristics, and operating criteria of the project to simulate operation of the project and calculate energy production. The energy production module simulates operation of the plant to maximize energy production during user defined periods and meet all regulatory and physical operational constraints. The model calculates headwater elevation, headlosses, net head, turbine discharge and spill, and power generation in 15-minute increments. The 15-minute time step used in the CHEOPS model is important to the accurate modeling of energy production and water releases but is not intended to be used for instantaneous release analyses or dispatch of power turbines. CHEOPS is designed for long-term analysis of the effects of operational and physical changes made to the modeled hydro-system.

As part of the relicensing process a series of model scenarios were developed by the stakeholders including Duke Energy, state agencies, municipal and industrial water users and non-governmental organizations. The final scenario that was developed to reflect the variety of interests involved in the relicensing was called Modified Mutual Gains 02.22.06 referencing the date of the scenario and the interest group that it represented.

Section 2
Work Performed

DTA was contracted by CH2M HILL, Inc. on behalf of the cities of Concord and Kannapolis to review modified model inputs to the CHEOPS model (Version 8.7) for a proposed interbasin transfer (IBT) that would withdrawal water from Lake Norman. The modeling that was provided for review was performed by North Carolina Division of Water Resources (NCDWR).

A total of four new scenarios based on the Modified Mutual Gains 02.22.06 (MMG022206) FERC relicensing scenario were developed by NCDWR to study the impacts of the proposed Concord – Kannapolis IBT from the Catawba River Basin. Each of the four scenarios was developed to test the impact of the proposed withdrawal of up to 22 MGD from Lake Norman in the year 2035. Since the MMG022206 model included a projection of the Concord – Kannapolis IBT, the four scenarios developed were designed to add to or subtract water withdrawal from Lake Norman to simulate the following conditions:

Scenario Names	Assumption / Conditions
Zero CF IBT	Net 0 MGD IBT for Concord-Kannapolis from Lake Norman
10 MGD CF IBT	Net 10 MGD IBT for Con-Kan from Lake Norman
16 MGD CF IBT	Net 16 MGD IBT for Con-Kan from Lake Norman
22 MGD CF IBT	Net 22 MGD IBT for Con-Kan from Lake Norman

Interpreting the output information provided by these four model scenarios as documented in the NCDWR July 28, 2006 revised report titled "CHEOPS Simulation of Proposed Concord – Kannapolis Interbasin Transfer from the Catawba River Basin" is beyond the scope of work of the project. DTA's reviewed was limited to the CHEOPS model functions and format of model inputs and is not an affirmation of the process or presentation of the results of the modeling.

In order to perform a review of the model inputs, NCDWR was requested to provide the following information that facilitated DTA's review:

- A copy of the NCDWR CHEOPS database file: Master.mdb
- A copy of the NCDWR complete CHEOPS Hydrology Files Folder
- A copy of the NCDWR Output Folder containing results of CHEOPS scenarios
- A text file containing an explanation/description of each CHEOPS scenario

Since each CHEOPS scenario is very complex with many combinations of variable settings it was important to start the review with the same files that were used for the study. NCDWR provided all the files that were requested. The following process was used by DTA to review the data and each of the four scenarios.

Review Process	Passed	Failed
Review of data and files provided by two experienced CHEOPS users including a check of the modifications to the withdrawals and returns file (one file for each scenario) and the conversion of the withdrawals from million gallons per day (MGD) to cubic feet per second (cfs) which CHEOPS requires for input of flows.	X	
Reviewed the database to confirm the results with the output files provided.	X	
Reviewed the database to confirm that the NCDWR inputs corresponded with the descriptions for each scenario.	X	
Reviewed the MMG022206 scenario for modifications from the original.	X	
Executed the MMG022206 scenario on one of the DTA CHEOPS computers using 1929 hydrology and the withdrawals set to 2035 and compared to output from a separate execution using the database provided by NCDWR for 1929 to confirm that the results matched.	X	
Reviewed the copies of the Low Inflow Protocol and High Inflow Protocol files provided by NCDWR against the final copies produced for the Duke Energy relicensing.	X	
Reviewed the LIP summaries in the NCDWR report.	X	
Review of the changes to the MMG022206 scenario to account for no future sedimentation.	X	

Section 3
Findings

Based on the files and documentation provided by NCDWR, it appears that the input modifications made to develop the four new IBT scenarios using the Modified Mutual Gains 02.22.06 scenario were performed correctly. Changes to the withdrawals and returns file appear to be performed using the appropriate conversion factors (MGD to cfs) based on review of the supplied tables and explanation of addition or subtraction of specific withdrawal factors. Changes to model settings to remove future sedimentation appear to be performed correctly.

Attachment C

APPENDIX C: LOW INFLOW PROTOCOL (LIP) FOR THE CATAWBA-WATEREE PROJECT

PURPOSE

The purpose of this Low Inflow Protocol (LIP) is to establish procedures for reductions in water use during periods of low inflow to the Catawba-Wateree Project (the Project). The LIP was developed on the basis that all parties with interests in water quantity will share the responsibility to establish priorities and to conserve the limited water supply.

OVERVIEW

This Low Inflow Protocol provides trigger points and procedures for how the Catawba-Wateree Project will be operated by the Licensee, as well as water withdrawal reduction measures and goals for other water users during periods of low inflow (i.e., periods when there is not enough water flowing into the Project reservoirs to meet the normal water demands while maintaining Remaining Usable Storage in the reservoir system at or above a seasonal target level).

The Licensee will provide flow from hydro generation and other means to support electric customer needs and the instream flow needs of the Project. During periods of normal inflow, reservoir levels will be maintained within prescribed Normal Operating Ranges. During times that inflow is not adequate to meet all of the normal demands for water and maintain reservoir levels as normally targeted the Licensee will progressively reduce hydro generation. If hydrologic conditions worsen until trigger points outlined herein are reached, the Licensee will declare a Stage 0 - Low Inflow Watch and begin meeting with the applicable agencies and water users to discuss this LIP. If hydrologic conditions continue to worsen, the Licensee will declare various stages of a Low Inflow Condition (LIC) as defined in the Procedure section of this document. Each progressive stage of the LIC will call for greater reductions in hydro station releases and water withdrawals, and allow additional use of the available water storage inventory.

The goal of this staged LIP is to take the actions needed in the Catawba-Wateree River Basin to delay the point at which the Project's usable water storage inventory is fully depleted. While there are no human actions that can guarantee that the Catawba-Wateree River Basin will never experience operability limitations at water intake structures due to low reservoir levels or low streamflows, this LIP is intended to provide additional time to allow precipitation to restore streamflow, reservoir levels, and groundwater levels to normal ranges. The amount of additional time that is gained during the LIP depends primarily on the diagnostic accuracy of the trigger points, the amount of regulatory flexibility the Licensee has to operate the Project, and the effectiveness of the Licensee and other water users in working together to implement their required actions and achieve significant water use reductions in a timely manner.

To ensure continuous improvement regarding the LIP and its implementation throughout the term of the New License, the LIP will be re-evaluated and modified periodically. These re-evaluations and modifications will be as determined by the Catawba-Wateree Drought Management Advisory Group (CW-DMAG).

KEY FACTS AND DEFINITIONS

1. Human Health and Safety and the Integrity of the Public Water Supply and Electric Systems are of Utmost Importance – Nothing in this protocol will limit the Licensee's ability to take any and all lawful actions necessary at the Project to protect human health and safety, protect its equipment from major damage, protect the equipment of the Large Water Intake Owners from major damage, and ensure the stability of the regional electric grid and public water supply systems. It is recognized that the Licensee may take the steps that are necessary to protect these things without prior consultation or notification. Likewise, nothing in this LIP will limit the States of North Carolina and South Carolina from taking any and all lawful actions necessary within their jurisdictions to protect human health and safety. It is recognized that North Carolina and South Carolina may also take the steps necessary to protect these things without prior consultation or notification.

2. No Abrogation of Statutory Authority – It is understood that the South Carolina Department of Natural Resources (SCDNR) must operate under the statutory authority of its drought response statutes, and nothing in this LIP will require the SCDNR to take any action that exceeds its authority under their drought response statute.

3. Normal Full Pond Elevation – Also referred to simply as "full pond," this is the level of a reservoir that corresponds to the point at which water would first begin to spill from the reservoir's dam(s) if the Licensee took no action. This level corresponds to the lowest point along the top of the spillway (including flashboards) for reservoirs without floodgates and to the lowest point along the top of the floodgates for reservoirs that have floodgates. To avoid confusion among the many reservoirs the Licensee operates, it has adopted the practice of referring to the Full Pond Elevation for all of its reservoirs as equal to 100.0 ft. relative. The Full Pond Elevations for the Catawba-Wateree Project reservoirs are as follows:

Reservoir	Full Pond Elevation (ft. above Mean Sea Level)
Lake James	1200.0
Lake Rhodhiss	995.1
Lake Hickory	935.0
Lookout Shoals Lake	838.1
Lake Norman	760.0
Mountain Island Lake	647.5
Lake Wylie	569.4
Fishing Creek Reservoir	417.2
Great Falls Reservoir	355.8
Cedar Creek Reservoir	284.4
Lake Wateree	225.5

4. Net Inflow – The cumulative inflow into a reservoir, expressed in acre-feet (ac-ft) per month. Net inflow is the sum of tributary stream flow, inflow from upstream hydro development releases (where applicable), groundwater inflow, precipitation falling on the reservoir surface, land surface runoff, and on-reservoir point-source return flows, less the sum of on-reservoir water withdrawals, groundwater recharge, hydro development flow releases, evaporation, and other factors.

5. Normal Minimum Elevation – The level of a reservoir (measured in feet above Mean Sea Level (MSL) or feet relative to the full pond contour with 100.0 ft. corresponding to full pond) that defines the bottom of the reservoir's Normal Operating Range for a given day of the year. If inflows and outflows to the reservoir are kept within some reasonable range of the average or expected amounts, hydroelectric project equipment is operating properly and no protocols for abnormal conditions have been implemented, reservoir level excursions below the Normal Minimum Elevation should not occur.

6. Normal Maximum Elevation – The level of a reservoir (measured in feet above Mean Sea Level (MSL) or feet relative to the full pond contour with 100.0 ft. corresponding to full pond) that defines the top of the reservoir's Normal Operating Range for a given day of the year. If inflows and outflows to the reservoir are kept within some reasonable range of the average or expected amounts, hydroelectric project equipment is operating properly, and no protocols for abnormal conditions have been implemented, reservoir level excursions above the Normal Maximum Elevation should not occur.

7. Normal Target Elevation – The level of a reservoir (measured in feet above Mean Sea Level (msl) or feet relative to the full pond contour with 100.0 ft corresponding to full pond) that the Licensee will endeavor in good faith to achieve, unless operating in this Low Inflow Protocol, the Maintenance and Emergency Protocol, the Spring Reservoir Level Stabilization Program (Lakes James, Norman, Wylie and Wateree only), a Spring Stable Flow Period (Lake Wateree only) or a Floodplain Inundation Period (Lake Wateree only). Since inflows vary significantly and outflow demands also vary, the Licensee will not always be able to maintain actual reservoir level at the Normal Target Elevation. The Normal Target Elevation falls within the Normal Operating Range, but it is not always the average of the Normal Minimum and Normal Maximum Elevations.

8. Normal Operating Range for Reservoir Levels – The band of reservoir levels within which the Licensee normally attempts to maintain a given reservoir that it operates on a given day. Each reservoir has its own specific Normal Operating Range, and that range is bounded by a Normal Maximum Elevation and a Normal Minimum Elevation. If inflows and outflows to the reservoir are kept within some reasonable range of the average or expected amounts, hydro project equipment is operating properly and no protocols for abnormal conditions have been implemented, reservoir level excursions outside of the Normal Operating Range should not occur.

9. Large Water Intake – Any water intake (e.g., public water supply, industrial, agricultural, power plant, etc.) having a maximum instantaneous capacity greater than or equal to one Million Gallons per Day (MGD) that withdraws water from the Catawba-Wateree River Basin.

10. Public Water Supply (PWS) – Any water delivery system owned and/or operated by any governmental or private entity that utilizes waters from the Catawba-Wateree

River Basin for the public interest including drinking water; residential, commercial, industrial, and institutional uses; irrigation, and/or other public uses.

11. Critical Reservoir Elevation – Unless it is otherwise stated as applying only to a specific intake or type of intake, the Critical Reservoir Elevation is the highest level of water in a reservoir (measured in feet above Mean Sea Level (mls) or feet relative to the full pond contour with 100.0 ft. corresponding to full pond) below which any Large Water Intake used for Public Water Supply or industrial uses, or any regional power plant intake located on the reservoir will not operate at its Licensee-approved capacity. The Critical Reservoir Elevations, as of June 1, 2006, are defined below:

Reservoir	Critical Reservoir Elevation (ft. relative to local datum) (100 ft = Full Pond)	Type of Limit
Lake James	61.0	Power Production
Lake Rhodhiss	89.4	Municipal Intake
Lake Hickory	94.0	Municipal Intake
Lookout Shoals Lake	74.9	Municipal Intake
Lake Norman	90.0	Power Production
Mountain Island Lake	94.3	Power Production
Lake Wylie	92.6	Industrial Intake
Fishing Creek Reservoir	95.0	Municipal Intake
Great Falls Reservoir	87.2	Power Production
Cedar Creek Reservoir	80.3	Power Production
Lake Wateree	92.5	Municipal Intake

12. Total Usable Storage (TUS) – The sum of the Project's volume of water expressed in acre-feet (ac-ft) contained between each reservoir's Critical Reservoir Elevation and the Full Pond Elevation.

13. Remaining Usable Storage (RUS) – The sum of the Project's volume of water expressed in acre-feet (ac-ft) contained between each reservoir's Critical Reservoir Elevation and the actual reservoir elevation at any given point in time.

14. Storage Index (SI) – The ratio, expressed in percent, of Remaining Usable Storage to Total Usable Storage at any given point in time.

15. Target Storage Index (TSI) – The ratio of Remaining Usable Storage to Total Usable Storage based on the Project reservoirs being at their Normal Target Elevations. The following table lists the Target Storage Index for the first day of each month:

Month	Target Storage Index For 1st Day of Month (%)*
Jan	61
Feb	51
Mar	61
Apr	66

Month	Target Storage Index For 1st Day of Month (%)*
May	75
Jun	75
Jul	75
Aug	75
Sep	75
Oct	75
Nov	69
Dec	62

* Target Storage Indices for other days of the month are determined by linear interpolation.

16. U.S. Drought Monitor – A synthesis of multiple indices, outlooks, and news accounts that represents a consensus of federal and academic scientists concerning the drought status of all parts of the United States. Typically, the U.S. Drought Monitor indicates intensity of drought as D0-Abnormally Dry, D1-Moderate, D2-Severe, D3-Extreme, and D4-Exceptional. The website address is http://www.drought.unl.edu/dm/monitor.html. The following federal agencies are responsible for maintaining the U.S. Drought Monitor:
    - Joint Agricultural Weather Facility (U.S. Department of Agriculture and Department of Commerce/National Oceanic and Atmospheric Administration)
    - Climate Prediction Center (U.S. Department of Commerce/NOAA/National Weather Service)
    - National Climatic Data Center (DOC/NOAA)
17. U.S. Drought Monitor Three-Month Numeric Average – If the U.S. Drought Monitor has a reading of D0-D4 as of the last day of the previous month for any part of the Catawba-Wateree River Basin that drains to Lake Wateree, the Basin will be assigned a numeric value for the current month. The numeric value will equal the highest Drought Monitor designation (e.g., D0 = 0, D4 = 4) as of the last day of the previous month that existed for any part of the Catawba-Wateree River Basin that drains to Lake Wateree. A normal condition in the Basin, defined as the absence of a Drought Monitor designation, would be assigned a numeric value of negative one (-1). A running average numeric value of the current month and the previous two months will be monitored and designated as the U.S. Drought Monitor Three-Month Numeric Average.
18. Critical Flows – The minimum flow releases from the hydro developments that may be necessary to:
    a. prevent long-term or irreversible damage to aquatic communities consistent with the resource management goals and objectives for the affected stream reaches;
    b. provide some basic level of operability for Large Water Intakes located on the affected stream reaches; and,

c. provide some basic level of water quality maintenance in the affected stream reaches.

For the purposes of this LIP, the Critical Flows are as follows:

a. Linville River, below the Bridgewater Development: 75 cubic feet per second (cfs).

b. Catawba River Bypassed Reach below the Bridgewater Development: 25 cfs.

c. Oxford Regulated River Reach below the Oxford Development: 100 cfs.

d. Lookout Shoals Regulated River Reach below the Lookout Shoals Development: 80 cfs.

e. Wylie Regulated River Reach below the Wylie Development: 700 cfs.

f. Great Falls Bypassed Reaches (Long and Short) at the Great Falls-Dearborn Development: 450 cfs and 80 cfs respectively.

g. Wateree Regulated River Reach below the Wateree Development: 800 cfs.

h. Leakage flows at the remaining Project structures. Leakage flows are defined as the flow of water through wicket gates when the hydro units are not operating and seepage through the Project structures at each development.

19. Recreation Flow Reductions – Since all recreation flow releases must be made by either releasing water through hydroelectric generation or through flow releases that bypass hydro generation equipment, reductions in Project Flow Requirements will impact recreation flow releases.

20. Organizational Abbreviations – Organizational abbreviations include the North Carolina Department of Environment and Natural Resources (NCDENR), North Carolina Wildlife Resources Commission (NCWRC), South Carolina Department of Natural Resources (SCDNR), South Carolina Department of Health and Environmental Control (SCDHEC), and the United States Geological Survey (USGS).

21. Catawba-Wateree Drought Management Advisory Group (CW-DMAG) – The CW-DMAG will be tasked with working with the Licensee when the LIP is initiated. This team will also meet as necessary to foster a basin-wide response to a Low Inflow Condition (see Procedure section of this LIP). Members of the CW-DMAG agree to comply with the conditions of this LIP. Membership on the CW-DMAG is open to the following organizations, of which each organization may have up to two members:

a. NCDENR (including Division of Water Resources and the Division of Water Quality)
b. NCWRC
c. SCDNR
d. SCDHEC
e. USGS
f. Each Owner of a Large Water Intake located on one of the Catawba-Wateree Project reservoirs or the main stem of the Catawba-Wateree River
g. Each Owner of a Large Water Intake located on any tributary stream within the Catawba-Wateree River Basin that ultimately drains to Lake Wateree
h. Licensee (CW-DMAG Coordinator)

The CW-DMAG will meet at least annually (typically during the month of May) beginning in 2007 and continuing throughout the term of the New License, regardless of the Low Inflow Condition status, to review prior year activities, discuss data input from Large Water Intake Owners, and discuss other issues relevant to the LIP. The Licensee will maintain an active roster of the CW-DMAG and update the roster as needed. The Licensee will prepare meeting summaries of all CW-DMAG meetings and will make these meeting summaries available to the public by posting on its Web site.

22. Revising the LIP – During the term of the New License, the CW-DMAG will review and update the LIP periodically to ensure continuous improvement of the LIP and its implementation. These evaluations and modifications will be considered at least once every five (5) years during the New License term. Modifications must be approved by a consensus of the participating CW-DMAG members. If the participating members cannot reach consensus, then the dispute resolution procedures set forth in Section 31.0 of the relicensing Final Agreement will apply. Approved modifications will be incorporated through revision of the LIP and the Licensee will file the revised LIP with the FERC. If any modifications of the LIP require amendment of the New License, the Licensee will: (i) provide notice to all Parties to the relicensing Final Agreement advising them of the proposed license article amendment and the Licensee's intent to file it with the FERC; (ii) submit the modification request to the North Carolina Division of Water Quality (NCDWQ) and/or the South Carolina Department of Health and Environmental Control (SCDHEC) for formal review and approval as may be required by any reopener conditions of the respective state's 401 Water Quality Certification for the Project; and (iii) file a license amendment request for FERC approval. During this process, the CW-DMAG may appoint an ad hoc committee to address issues and revisions relevant to the LIP. The filing of a revised LIP by the Licensee will not constitute or require modification to the relicensing Final Agreement and any Party to the relicensing Final Agreement may be involved in the FERC's public process for assessing the revised LIP. Issues such as sediment fill impact on reservoir storage volume calculations, revising the groundwater monitoring plan and substitution of a regional drought monitor for the U.S. Drought Monitor, if developed in the future, are examples of items that may be addressed.

23. Water Withdrawal Data Collection and Reporting – The Licensee will maintain information on cumulative water use from Project reservoirs beginning in 2006 and continuing throughout the term of the New License and will make the information available to water intake owners and governmental agencies upon their request. The Licensee will require all owners of Large Water Intakes located within the FERC Project Boundaries to report to the Licensee, on an annual basis in MGD, their average monthly water withdrawals from and flow returns to the Project or its tributary streams that drain to Lake Wateree. The Licensee will maintain a database of this information including the Licensee's own non-hydro water use records (i.e., water uses due to thermal power generation). These annual withdrawal summaries will be in writing, certified for accuracy by a professional engineer or other appropriate official, and will be provided to the Licensee by January 31 of each year for the preceding calendar year beginning in 2007. This information may be used to determine if future increased water withdrawals would be within the projections of the Water Supply Study conducted during the relicensing process and filed with the FERC as part of the Licensee's Application for New License for the Project.

24. Reclaimed Water – Wastewater that has been treated to reclaimed water standards and is re-used for a designated purpose (e.g. industrial process, irrigation). Reclaimed Water will not be subject to the water use restrictions outlined in this LIP.
25. Drought Response Plan Updates – All Large Water Intake Owners will review and update their Drought Response Plans or Ordinances (or develop a plan or ordinance if they do not have one) by June 30, 2007 and within 180 days following the acceptance by the FERC of any future LIP revisions during the term of the New License to ensure compliance and coordination with the LIP, including the authority to enforce the provisions outlined herein, provided that the requirements of the LIP are consistent with state law.
26. Relationship Between the LIP and the Maintenance & Emergency Protocol (MEP) – The MEP outlines the response the Licensee will take under certain emergency and equipment failure and maintenance situations to continue practical and safe operation of the Project, to mitigate any related impacts to license conditions, and to communicate with resource agencies and the affected parties. Under the MEP, temporary modifications of prescribed flow releases and the reservoir level Normal Operating Ranges are allowed. Lowering levels of Project reservoirs caused by situations addressed under the MEP will not invoke implementation of this Low Inflow Protocol (LIP). Also, if the LIP has already been implemented at the time that a situation covered by the MEP is initiated, the Licensee will typically suspend implementation of the LIP until the MEP situation has been eliminated. The Licensee may, however, choose to continue with the LIP if desirable.
27. Consensus – Consensus is reached when all CW-DMAG members in attendance can 'live with' the outcome or proposal being made. The concept of consensus is more fully described in the Catawba – Wateree Hydroelectric Project Relicensing – Stakeholder Teams Charter (dated October, 2005).
28. Monitored USGS Streamflow Gages – The Monitored USGS Streamflow Gages are identified as USGS streamflow gage #'s 02145000 (South Fork Catawba River at Lowell, NC), 02137727 (Catawba River near Pleasant Gardens, NC), 02140991 (Johns River at Arney's Store, NC), and 02147500 (Rocky Creek at Great Falls, SC).

ASSUMPTIONS

1. Instream Flows for Recreation – The New License for the Catawba-Wateree Project includes recreational flow releases as listed in the proposed Recreational Flows License Article.
2. Minimum Flows – The New License for the Catawba-Wateree Project includes the minimum flow requirements as listed in the proposed Minimum Flows License Article, the proposed Wylie High Inflow Protocol License Article, and the proposed Flows Supporting Public Water Supply and Industrial Processes License Article.
3. Project Flow Requirements – These flow requirements include the Minimum Flows and the portion of the Recreational Flows that is greater than the Minimum Flows for normal conditions (i.e., conditions outside of this LIP or Maintenance and Emergency Protocol).
4. Public Information System – The New License for the Catawba-Wateree Project includes the requirement to provide information to the public as specified in the proposed Public Information License Article.

5. Normal Operating Ranges for Reservoir Levels – The New License for the Catawba-Wateree Project includes the Normal Operating Ranges for reservoir levels (i.e., Normal Minimum, Normal Maximum, and Normal Target Elevations) as listed in the proposed Reservoir Elevations License Article.
6. Spring Reservoir Level Stabilization Program – The New License for the Catawba-Wateree Project includes the reservoir level requirements in the proposed Spring Reservoir Level Stabilization Program License Article.

PROCEDURE

During periods of normal inflow, reservoir levels will be maintained within prescribed Normal Operating Ranges. During times that inflow is not adequate to meet all of the normal demands for water and maintain reservoir levels as normally targeted, the Licensee will progressively reduce hydro generation while meeting Project Flow Requirements. During a Low Inflow Watch or a Low Inflow Condition (LIC) (as defined below), the Licensee and other water users will follow the protocol set forth below for the Catawba-Wateree Project regarding communications and adjustments to hydro station flow releases, bypassed flow releases, minimum reservoir elevations, and other water demands. The adjustments set forth below will be made on a monthly basis and are designed to equitably allocate the impacts of reduced water availability in accordance with the purpose statement of this LIP.

Trigger points that demonstrate worsening hydrologic conditions will define various stages of the Low Inflow Condition. A summary of trigger points for various stages is provided in the table below. The specific triggers required to enter successive stages are defined in the procedure for each stage.

Summary of LIP Trigger Points

Stage	Storage Index [1]		Drought Monitor [2] (3-month average)		Monitored USGS [3] Streamflow Gages
0[4]	90% < SI < 100% TSI		3mo Ave DM ≥ 0		AVG ≤ 85% LT 6mo Ave
1	75% TSI < SI ≤ 90% TSI	**and**	3mo Ave DM ≥ 1	**or**	AVG ≤ 78% LT 6mo Ave
2	57% TSI < SI ≤ 75% TSI	**and**	3mo Ave DM ≥ 2	**or**	AVG ≤ 65% LT 6mo Ave
3	42% TSI < SI ≤ 57% TSI	**and**	3mo Ave DM ≥ 3	**or**	AVG ≤ 55% LT 6mo Ave
4	SI ≤ 42% TSI	**and**	3mo Ave DM = 4	**or**	AVG ≤ 40% LT 6mo Ave

[1] The ratio of Remaining Useable Storage to Total Usable Storage at a given point in time.

[2] The three-month numeric average of the published U.S. Drought Monitor.

[3] The sum of the rolling sixth-month average for the Monitored USGS Streamflow Gages as a percentage of the period of record rolling average for the same six-month period for the Monitored USGS Streamflow Gages.

[4] Stage 0 is triggered when any two of the three trigger points are reached.

Stage 0 Actions

The Licensee will monitor the Storage Index, the U.S. Drought Monitor, and the Monitored USGS Streamflow Gages on at least a monthly basis and will declare a Stage 0 Low Inflow Watch if any two of the following conditions occur:

a. On the first day of the month, Storage Index is below the Target Storage Index, but greater than 90% of the Target Storage Index, while providing the Project Flow Requirements for the previous month.

b. The U.S. Drought Monitor Three-Month Numeric Average has a value greater than or equal to 0.

c. The sum of the actual rolling six-month average streamflows at the Monitored USGS Streamflow Gages is equal to or less than 85% of the sum of the period of record rolling average streamflows for the same six-month period.

When a Low Inflow Watch has been declared:

a. The Licensee will activate the CW-DMAG, including the initiation of monthly meetings or conference calls to occur on the second Tuesday of each month. These monthly discussions will focus on:

- Proper communication channels between the CW-DMAG members.
- Information reporting consistency for CW-DMAG members, including a storage index history and forecast (at least a 90-day look back and look ahead) from the Licensee, a water use history and forecast (at least a 90-day look back and look ahead) from each water user on the CW-DMAG, streamflow gage and groundwater monitoring status from the state agencies and USGS, and state-wide drought response status from the state agencies.
- Refresher training on this LIP.
- Overview discussions from each CW-DMAG member concerning their role and plans for responding if a Stage 1 or higher Low Inflow Condition is subsequently declared.

b. The Licensee will reduce the prescribed recreation flow releases at the Wylie Development from 6,000 cfs to 3,000 cfs.

Stage 1 Actions

1. The Licensee will declare a Stage 1 Low Inflow Condition (LIC) and notify the CW-DMAG if:

   a. On the first day of the month, the Storage Index is at or below 90% of the Target Storage Index, but greater than 75% of the Target Storage Index, while providing the Project Flow Requirements for the previous month.

   and either of the following conditions exists:

   b. The U.S. Drought Monitor Three-Month Numeric Average has a value greater than or equal to 1.

   c. The sum of the actual rolling six-month average streamflows at the Monitored USGS Streamflow Gages is equal to or less than 78% of the sum of the period of record rolling average streamflows for the same six-month period.

2. The Licensee will complete the following activities within 5 days after the Stage 1 LIC declaration:
    a. Reduce the Project Flow Requirements by 60% of the difference between the normal Project Flow Requirements and the Critical Flows. These reduced Project Flow Requirements are referred to as Stage 1 Minimum Project Flows.
    b. Reduce the Normal Minimum Elevations by two feet at Lake James and Lake Norman and by one foot at each of the other Project reservoirs, but not to levels at any reservoir below the applicable Critical Reservoir Elevation. These elevations are referred to as the Stage 1 Minimum Elevations.
    c. Update its Web site and Interactive Voice Response (IVR) messages to account for the impacts of the LIP on reservoir levels, usability of the Licensee's public access areas, and recreation flow schedules.
    d. Notify the Federal Energy Regulatory Commission (FERC), the United States Fish and Wildlife Service (USFWS), the United States Bureau of Indian Affairs (USBIA), National Marine Fisheries Service (NMFS), and the Catawba Indian Nation of the Stage 1 LIC declaration.
    e. Provide bi-weekly (once every two weeks) information updates to owners of Large Water Intakes about reservoir levels, meteorological forecasts, and inflow of water into the system.
    f. In addition the Licensee may, at its sole discretion, modify or suspend its use of selected operating procedures that are designed for periods of normal or above normal inflow to optimize the water storage capabilities of the Project, including the Normal Maximum Elevations and Normal Target Elevations for reservoir levels; the Spring Reservoir Level Stabilization Program; the Wylie High Inflow Protocol and at Lake Wateree, the Spring Stable Flow Periods and Floodplain Inundation Periods. These modifications and suspensions may be used at the Licensee's sole discretion in any Low Inflow Condition (Stages 1 through 4).
3. Owners of Public Water Supply intakes and owners of intakes used for irrigation with a capacity greater than 100,000 gallons per day will complete the following activities within 14 days after the Stage 1 LIC declaration:
    a. Notify their water customers and employees of the Low Inflow Condition through public outreach and communication efforts.
    b. Request that their water customers and employees implement <u>voluntary</u> water use restrictions, in accordance with their drought response plans, which may include:
        - Reduction of lawn and landscape irrigation to no more than <u>two days</u> per week (i.e. residential, multi-family, parks, streetscapes, schools, etc).
        - Reduction of residential vehicle washing.

        At this stage, the goal is to reduce water usage by 3-5% (or more) from the amount that would otherwise be expected. The baseline for this comparison will be generated by each entity and will be based on existing conditions (i.e. drought conditions). For the purposes of determining 'the amount that would

otherwise be expected', each entity may give consideration to one or more of the following:

- Historical maximum daily, weekly, and monthly flows during drought conditions.
- Increased customer base (e.g. population growth, service area expansion) since the historical flow comparison.
- Changes in major water users (e.g. industrial shifts) since the historical flow comparison.
- Climatic conditions for the comparison period.
- Changes in water use since the historical flow comparison.
- Other system specific considerations.

c. Provide a status update to the CW-DMAG on actual water withdrawal trends. Discuss plans for moving to mandatory restrictions, if required.

4. Owners of Large Water Intakes, other than those referenced in item 3 above, will complete the following activities within 14 days after the Stage 1 LIC declaration:

   a. Notify their customers and employees of the Low Inflow Condition through public outreach and communication efforts.

   b. Request that their customers and employees conserve water through reduction of water use, electric power consumption, and other means.

   c. Provide a status update to the CW-DMAG on actual water withdrawal trends.

<u>Stage 2 Actions</u>

1. The Licensee will declare a Stage 2 Low Inflow Condition (LIC) and notify the CW-DMAG if:

   a. On the first day of the month, the Storage Index is at or below 75% of the Target Storage Index, but greater than 57% of the Target Storage Index, while providing the Stage 1 Minimum Project Flows during the previous month.

   and either of the following conditions exists:

   b. The U.S. Drought Monitor Three-Month Numeric Average has a value greater than or equal to 2.

   c. The sum of the actual rolling six-month average streamflows at the Monitored USGS Streamflow Gages is equal to or less than 65% of the sum of the period of record rolling average streamflows for the same six-month period.

2. The Licensee will complete the following activities within 5 days after the Stage 2 LIC declaration:

   a. Eliminate prescribed recreation flow releases at this stage and all subsequent stages. Reduce the Project Flow Requirements by 95% of the difference between the normal Project Flow Requirements and Critical Flows. These reduced flows are referred to as Stage 2 Minimum Project Flows.

   b. Reduce the Stage 1 Minimum Elevations by one additional foot at Lake James (three feet total below Normal Minimum Elevation) and two additional

feet at Lake Norman (four feet total below Normal Minimum Elevation) and by one additional foot (two feet total below Normal Minimum Elevations) at each of the other Project reservoirs but not to levels at any reservoir below the applicable Critical Reservoir Elevation. These elevations are referred to as the Stage 2 Minimum Elevations.

c. Update its Web site and IVR messages to account for the impacts of the LIP on reservoir levels, usability of the Licensee's public access areas, and recreation flow schedules.

d. Notify the FERC, the USFWS, the USBIA, NMFS, and the Catawba Indian Nation of the Stage 2 LIC declaration.

e. Provide bi-weekly information updates to owners of Large Water Intakes about reservoir levels, meteorological forecasts, and inflow of water into the system.

f. In addition the Licensee may, at its sole discretion, modify or suspend its use of selected operating procedures that are designed for periods of normal or above normal inflow to optimize the water storage capabilities of the Project, including the Normal Maximum Elevations and Normal Target Elevations for reservoir levels; the Spring Reservoir Level Stabilization Program; the Wylie High Inflow Protocol; and at Lake Wateree, the Spring Stable Flow Periods and Floodplain Inundation Periods. These modifications and suspensions may be used at the Licensee's sole discretion in any Low Inflow Condition (Stages 1 through 4).

3. Owners of Public Water Supply intakes and owners of intakes used for irrigation with a capacity greater than 100,000 gallons per day will complete the following activities within 14 days after the Stage 2 LIC declaration:

   a. Notify their water customers and employees of the continued Low Inflow Condition and movement to mandatory water use restrictions through public outreach and communication efforts.

   b. Require that their water customers and employees implement <u>mandatory</u> water use restrictions, in accordance with their drought response plans, which may include:

      - Limiting lawn and landscape irrigation to no more than <u>two days</u> per week (i.e. residential, multi-family, parks, streetscapes, schools, etc).
      - Eliminating residential vehicle washing.
      - Limiting public building, sidewalk, and street washing activities except as required for safety and/or to maintain regulatory compliance.

      At this stage, the goal is to reduce water usage by 5-10% (or more) from the amount that would otherwise be expected (as discussed in Stage 1 above).

   c. Enforce mandatory water use restrictions through the assessment of penalties.

   d. Provide a status update to the CW-DMAG on actual water withdrawal trends.

4. Owners of Large Water Intakes, other than those referenced in item 3 above, will complete the following activities within 14 days after the Stage 2 LIC declaration:

a. Continue informing their customers and employees of the Low Inflow Condition through public outreach and communication efforts.

b. Request that their customers and employees conserve water through reduction of water use, electric power consumption, and other means.

c. Provide a status update to the CW-DMAG on actual water withdrawal trends.

Stage 3 Actions

1. The Licensee will declare a Stage 3 Low Inflow Condition (LIC) and notify the CW-DMAG if:

   a. On the first day of the month, the Storage Index is at or below 57% of the Target Storage Index, but greater than 42% of the Target Storage Index, while providing the Stage 2 Minimum Project Flows during the previous month.

   and either of the following conditions exists:

   b. The U.S. Drought Monitor Three-Month Numeric Average has a value greater than or equal to 3.

   c. The sum of the actual rolling six-month average streamflows at the Monitored USGS Streamflow Gages is equal to or less than 55% of the sum of the period of record rolling average streamflows for the same six-month period.

2. The Licensee will complete the following activities within 5 days after the Stage 3 LIC declaration:

   a. Reduce the Project Flow Requirements to Critical Flows. These reduced flows are referred to as Stage 3 Minimum Project Flows.

   b. Reduce the Stage 2 Minimum Elevations by seven additional feet at Lake James (ten feet total below Normal Minimum Elevation) and one additional foot at Lake Norman (five feet total below Normal Minimum Elevation) and by one additional foot (three feet total below Normal Minimum Elevations) at each of the other Project reservoirs but not to levels at any reservoir below the applicable Critical Reservoir Elevation. These elevations are referred to as the Stage 3 Minimum Elevations.

   c. Update its Web site and IVR messages to account for the impacts of the LIP on reservoir levels, usability of the Licensee's public access areas, and recreation flow schedules.

   d. Notify the FERC, the USFWS, the USBIA, NMFS, and the Catawba Indian Nation of the Stage 3 LIC declaration.

   e. Provide bi-weekly information updates to owners of Large Water Intakes about reservoir levels, meteorological forecasts, and inflow of water into the system.

   f. In addition the Licensee may, at its sole discretion, modify or suspend its use of selected operating procedures that are designed for periods of normal or above normal inflow to optimize the water storage capabilities of the Project, including the Normal Maximum Elevations and Normal Target Elevations for reservoir levels; the Spring Reservoir Level Stabilization Program; the Wylie High Inflow Protocol; and at Lake Wateree, the Spring Stable Flow Periods

and Floodplain Inundation Periods. These modifications and suspensions may be used at the Licensee's sole discretion in any Low Inflow Condition (Stages 1 through 4).

3. Owners of Public Water Supply intakes and owners of intakes used for irrigation with a capacity greater than 100,000 gallons per day will complete the following activities within 14 days after the Stage 3 LIC declaration:

    a. Notify their water customers and employees of the continued Low Inflow Condition and movement to more stringent mandatory water use restrictions through public outreach and communication efforts.

    b. Require that their water customers and employees implement <u>increased mandatory</u> water use restrictions, in accordance with their drought response plans, which may include:

        - Limiting lawn and landscape irrigation to no more than <u>one day</u> per week (i.e. residential, multi-family, parks, streetscapes, schools, etc).
        - Eliminating residential vehicle washing.
        - Limiting public building, sidewalk, and street washing activities except as required for safety and/or to maintain regulatory compliance.
        - Limiting construction uses of water such as dust control.
        - Limiting flushing and hydrant testing programs, except to maintain water quality or other special circumstances.
        - Eliminating the filling of new swimming pools.

        At this stage, the goal is to reduce water usage by 10-20% (or more) from the amount that would otherwise be expected (as discussed in Stage 1 above).

    c. Enforce mandatory water use restrictions through the assessment of penalties.

    d. Encourage industrial/manufacturing process changes that reduce water consumption.

    e. Provide a status update to the CW-DMAG on actual water withdrawal trends.

4. Owners of Large Water Intakes, other than those referenced in item 3 above, will complete the following activities within 14 days after the Stage 3 LIC declaration:

    a. Continue informing their customers and employees of the Low Inflow Condition through public outreach and communication efforts.

    b. Request that their customers and employees conserve water through reduction of water use, electric power consumption, and other means.

    c. Encourage industrial/manufacturing process changes that reduce water consumption.

    d. Provide a status update to the CW-DMAG on actual water withdrawal trends.

<u>Stage 4 Actions</u>

1. The Licensee will declare a Stage 4 Low Inflow Condition (LIC) and notify the CW-DMAG if:

a. On the first day of the month, the Storage Index is at or below 42% of the Target Storage Index, while providing the Stage 3 Minimum Project Flows during the previous month.

and either of the following conditions exists:

b. The U.S. Drought Monitor Three-Month Numeric Average has a value of 4.

c. The sum of the actual rolling six-month average streamflows at the Monitored USGS Streamflow Gages is equal to or less than 40% of the sum of the period of record rolling six-month average streamflows for the same six-month period.

2. The Licensee will:

a. Continue to provide Critical Flows as long as possible.

b. Reduce the Stage 3 Minimum Elevations to the Critical Reservoir Elevations.

c. Establish a meeting date and notify the CW-DMAG within 1 day following the Stage 4 LIC declaration.

d. Notify the FERC, the USFWS, the USBIA, NMFS, and the Catawba Indian Nation of the Stage 4 LIC declaration.

e. Continue to update its Web site and IVR messages to account for the impacts of the LIP on reservoir levels, usability of the Licensee's public access areas, and recreation flow schedules.

f. Provide bi-weekly information updates to owners of Large Water Intakes about reservoir levels, meteorological forecasts, and inflow of water into the system.

g. In addition the Licensee may, at its sole discretion, modify or suspend its use of selected operating procedures that are designed for periods of normal or above normal inflow to optimize the water storage capabilities of the Project, including the Normal Maximum Elevations and Normal Target Elevations for reservoir levels; the Spring Reservoir Level Stabilization Program; the Wylie High Inflow Protocol, and at Lake Wateree, the Spring Stable Flow Periods and Floodplain Inundation Periods. These modifications and suspensions may be used at the Licensee's sole discretion in any Low Inflow Condition (Stages 1 through 4).

Note: Once a Stage 4 LIC is declared, the Remaining Usable Storage in the reservoir system is small and can be fully depleted in a matter of weeks or months. Groundwater recharge may also contribute to declining reservoir levels. For these reasons in the Stage 4 LIC, the Licensee may not be able to ensure that flow releases from its hydro developments will meet or exceed Critical Flows or that reservoir elevations will be greater than or equal to the Critical Reservoir Elevations.

3. Owners of Public Water Supply intakes and owners of intakes used for irrigation with a capacity greater than 100,000 gallons per day will complete the following activities within 14 days after the Stage 4 LIC declaration:

a. Notify their water customers and employees of the continued Low Inflow Condition and movement to **emergency** water use restrictions through public outreach and communication efforts.

b. Restrict all outdoor water use.

c. Implement emergency water use restrictions in accordance with their drought response plans, including enforcement of these restrictions and assessment of penalties.

d. Prioritize and meet with their commercial and industrial large water customers to discuss strategies for water reduction measures including development of an activity schedule and contingency plans.

e. Prepare to implement emergency plans to respond to water outages.

At this level, the goal is to reduce water usage by 20-30% (or more) from the amount that would otherwise be expected (as discussed in Stage 1 above).

4. Owners of Large Water Intakes on the CW-DMAG, other than those referenced in item 3 above, will complete the following activities within 14 days after the Stage 4 LIC declaration:

   a. Continue informing their customers and employees of the Low Inflow Condition through public outreach and communication efforts.

   b. Request that their customers and employees conserve water through reduction of water use, electric power consumption, and other means.

   c. Encourage industrial/manufacturing process changes that reduce water consumption.

   d. Provide a status update to the CW-DMAG on actual water withdrawal trends.

5. The CW-DMAG will:

   a. Meet within 5 days after the declaration of the Stage 4 LIC and determine if there are any additional measures that can be implemented to:

      (1) reduce water withdrawals without creating more severe regional problems;

      (2) reduce water releases from the Project without creating more severe regional problems; or

      (3) use additional reservoir storage without creating more severe regional problems.

   b. Work together to develop plans and implement any additional measures identified above.

<u>Recovery from the Low Inflow Protocol</u>

1. Recovery under the LIP as conditions improve will be accomplished by reversing the staged approach outlined above, except that:

   a. <u>All three</u> of the trigger points identified above for declaring the lower numbered stage must be met or exceeded before returning reservoir minimum elevations and Project flows to levels specified in that LIC stage, Low Inflow Watch, or Normal Conditions.

   b. The following groundwater level trigger points must also be attained before returning reservoir minimum elevations and Project flows to the levels specified in that LIC stage, Low Inflow Watch, or Normal Conditions:

USGS has reviewed available well records and has determined that there are existing wells with an adequate period that can be used for this process and has also determined that additional wells are advised in order to include groundwater data as part of the recovery. The CW-DMAG and the Catawba-Wateree Water Management Group (WMG) will work together to revise the plan for groundwater monitoring by December 31, 2007 and will update the table below.

Groundwater Trigger Points (depth below land surface (feet)) for Returning to the Indicated Stage					
Groundwater Monitor [Reg.=regolith; BR=bedrock]	**Stage 3 (a)**	**Stage 2 (b)**	**Stage 1 (c)**	**Stage 0 (d)**	**Normal (d)**
#1 Future Well Placeholder					
#2 Future Well Placeholder					
#3 Future Well Placeholder					
#4 Future Well Placeholder					
#5 Future Well Placeholder					
#6 USGS Langtree Peninsula RS Reg. well MW-2 & BR well MW-2D	24.91	23.61	22.21	18.21	18.21
#7 USGS Linville RS NC-220 BR well	2.74	2.19	2.11	2.04	2.04
#8 NC DWR Glen Alpine BR well L 76G2	10.01	9.03	8.32	7.69	7.69
#9 Future Well Placeholder					
#10 Future Well Placeholder					

Note: USGS groundwater levels calculated from daily mean data. North Carolina Division of Water Resources (NCDWR) water levels calculated from hourly data. All trigger levels calculated from water levels collected through the 2005 Water Year. Trigger groundwater levels may be updated on a yearly or water-year basis.
Footnotes:
(a) Stage 3: Period of record low water level
(b) Stage 2: 10th percentile
(c) Stage 1: 25th percentile
(d) Stage 0 and Normal: 50th percentile

2. The NCDENR, SCDNR, SCDHEC, USGS and the Licensee will determine when attainment of the groundwater trigger points for recovery is reached.
3. The Licensee will directly notify the CW-DMAG members within 5 days following attainment of all the trigger points necessary to recover to a lower stage of the LIC, Low Inflow Watch, or Normal Conditions.
4. The Licensee will update its Web site and IVR messages to account for the impacts of the LIP on reservoir levels, usability of the Licensee's public access areas, and recreation flow schedules.