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USE OF THE MIDDLE ST. JOHNS RIVER EFDC HYDRODYNAMIC MODEL TO SIMULATE THE IMPACTS OF WATER SUPPLY WITHDRAWALS AND DISCHARGE IN THE MIDDLE ST. JOHNS RIVER

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ABSTRACT

The St. Johns River Water Management District's (District's) Middle St. Johns River (MSJR) Environmental Fluid Dynamics Code (EFDC) model was utilized to assess the potential impacts of the operation of Reverse Osmosis (RO) facilities at two locations along the MSJR. The operation of the RO facilities was examined by calculating the changes in the salinity that occur during critical low-flow conditions. Simulations were run with each of the RO plants operating alone and with the two plants operating simultaneously at water production rates of 50 million gallons per/day (MGD), 25 MGD, 12.5 MGD, 6 MGD, and 3 MGD.

1. INTRODUCTION

1.1 Project Background

Ground water supplies have reached their sustainable limit in large areas within Florida, or will reach their limits in the very near future. Water supply utilities in these areas are seeking alternative sources to meet projected future demands. The St. Johns River Water Management District (District) is investigating the use of surface waters, such as the Middle St. Johns River (MSJR), for alternative water supply options. A preliminary evaluation, based on established Minimum Flows and Levels (MFL), indicated that about 155 million gallons per/day (MGD) could be withdrawn from the St. Johns River above DeLand, without violating the established MFL.

The Water Supply Impact Study (WSIS) is evaluating potential surface water withdrawals at two locations in the MSJR between DeLand and Lake Harney: near the mouth of Lake Jesup (Lake Jesup site), and near the mouth of Lake Monroe (the existing Yankee Lake site). Figure 1 shows the two locations. The Lake Jesup and Yankee Lake locations may use an alternative process to remove dissolved salts prior to distribution of the water, and return reject water of higher salt concentration back to the MSJR. From a hydrodynamic perspective, this process has the effect of reducing flushing of the receiving water body without reducing salt mass. This alteration of the

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hydrodynamic conditions in the system has the potential to increase salinity in the vicinity of the discharge points.

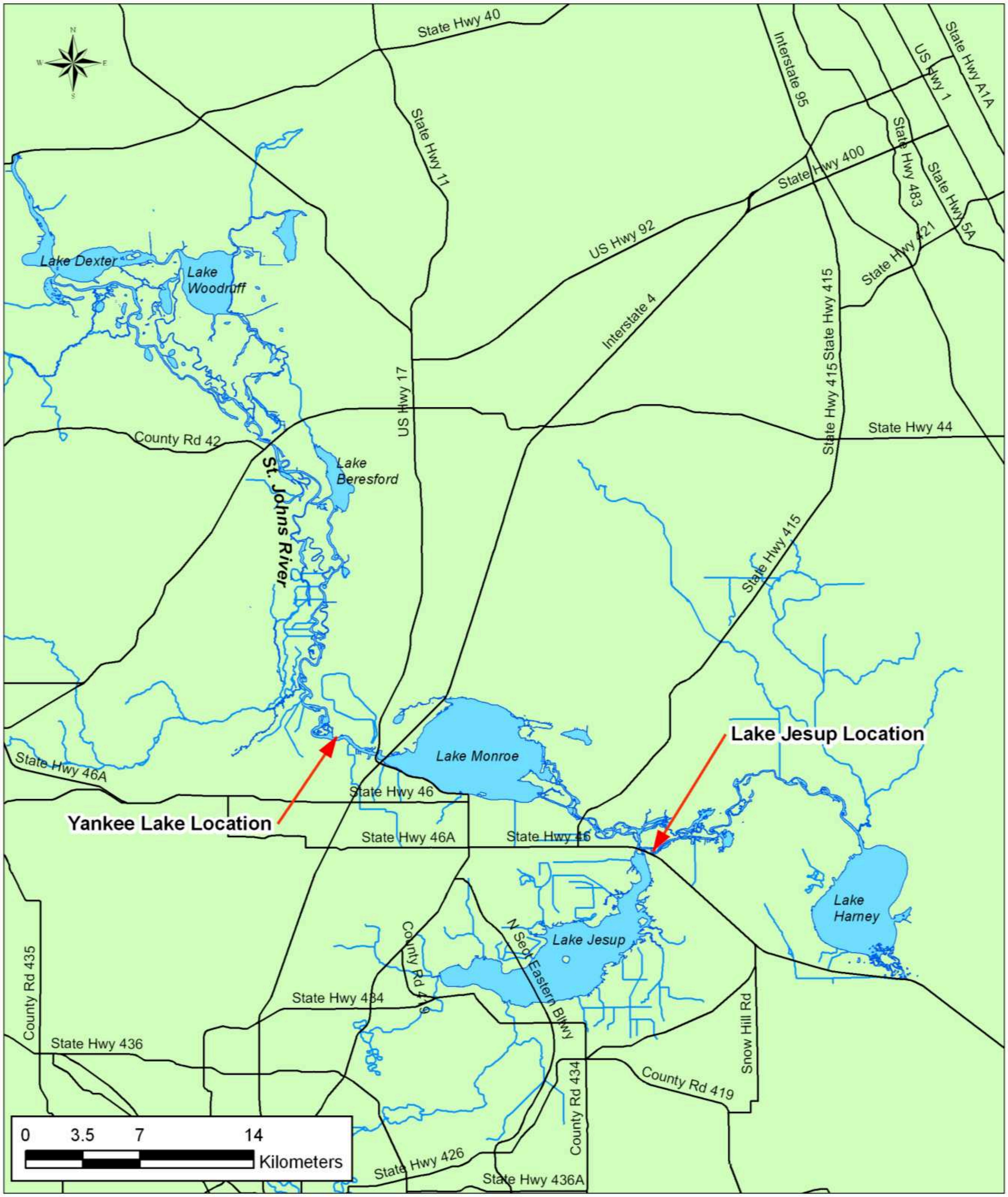

Figure 1 Project area map and withdrawal locations

1.2 Purpose

The District has developed a hydrodynamic model of the MSJR that encompasses the areas where the two sites are located. This model was summarized in a report titled *Phase I – Expert Assistance with St. Johns River Hydrodynamic Model Development and Support for the Cumulative Impact Assessment Project* (SJRWMD, 2009). The goal of the work presented herein was to use the District's existing, calibrated Environmental Fluids Dynamic Code (EFDC) model of the MSJR, as described above, to develop and perform hydrodynamic model simulations to estimate the far-field effect of reject water on chloride concentrations in the MSJR.

The model simulation period was 1996–2005. Using the MSJR model as a base, code modifications were implemented to allow simulation of the withdrawal of water from the MSJR and subsequent return of reject water from the reverse osmosis (RO) process. The results were evaluated to assess impacts within the study area (from Lake Harney to Astor at the entrance to Lake George). The assessments were performed for a range of water production rates with the two withdrawals operating independently and in conjunction. The scenarios presented in this report evaluated water production rates from 50 MGD down to 3 MGD for each facility.

2. PROJECT DESCRIPTION

2.1 Study Area

Figure 1 presents the extents of the study area for the MSJR EFDC model. The model covers from State Road 40 at Astor to upstream of Lake Harney where the MSJR crosses State Road 46. The study area includes Lake Dexter, Lake Woodruff, Lake Beresford, Lake Monroe, Lake Jesup, and Lake Harney.

2.2 Withdrawal Simulations

For this study, a series of constant water production rates were simulated for each site: 50 MGD, 25 MGD, 12.5 MGD, 6 MGD, and 3 MGD. The scenarios included each of the RO plants operating independently (either at the Lake Jesup site or at the Yankee Lake site) as well as the two plants operating simultaneously.

Where the residence time of waterbodies is high, it is necessary to do long-term simulations to assess the cumulative impact of the withdrawals (in particular, the potential for recirculation and salinity build up). For the higher production rate scenario (50 MGD), a long-term 10-year simulation was run (using 1996 to 2005 conditions). This long-term run was then compared to a 2-year simulation that was run under the most critical drought or low-flow conditions. These were compared to determine if the 10-year run showed differing levels of impacts. The results from the high production rate comparisons showed little difference, therefore, all other simulations were conducted using a 2-year simulation period during the critical dry period (9/12/99 to 9/12/01).

3. MSJR EFDC MODEL

3.1 Baseline Model

As discussed previously, a hydrodynamic model for the MSJR was developed under a separate scope of work (SJRWMD, 2009). This model extends from the USGS gage at Astor upstream to immediately above Lake Harney. Figures 2a and 2b present the model grid. This model was utilized as the baseline for the simulations.

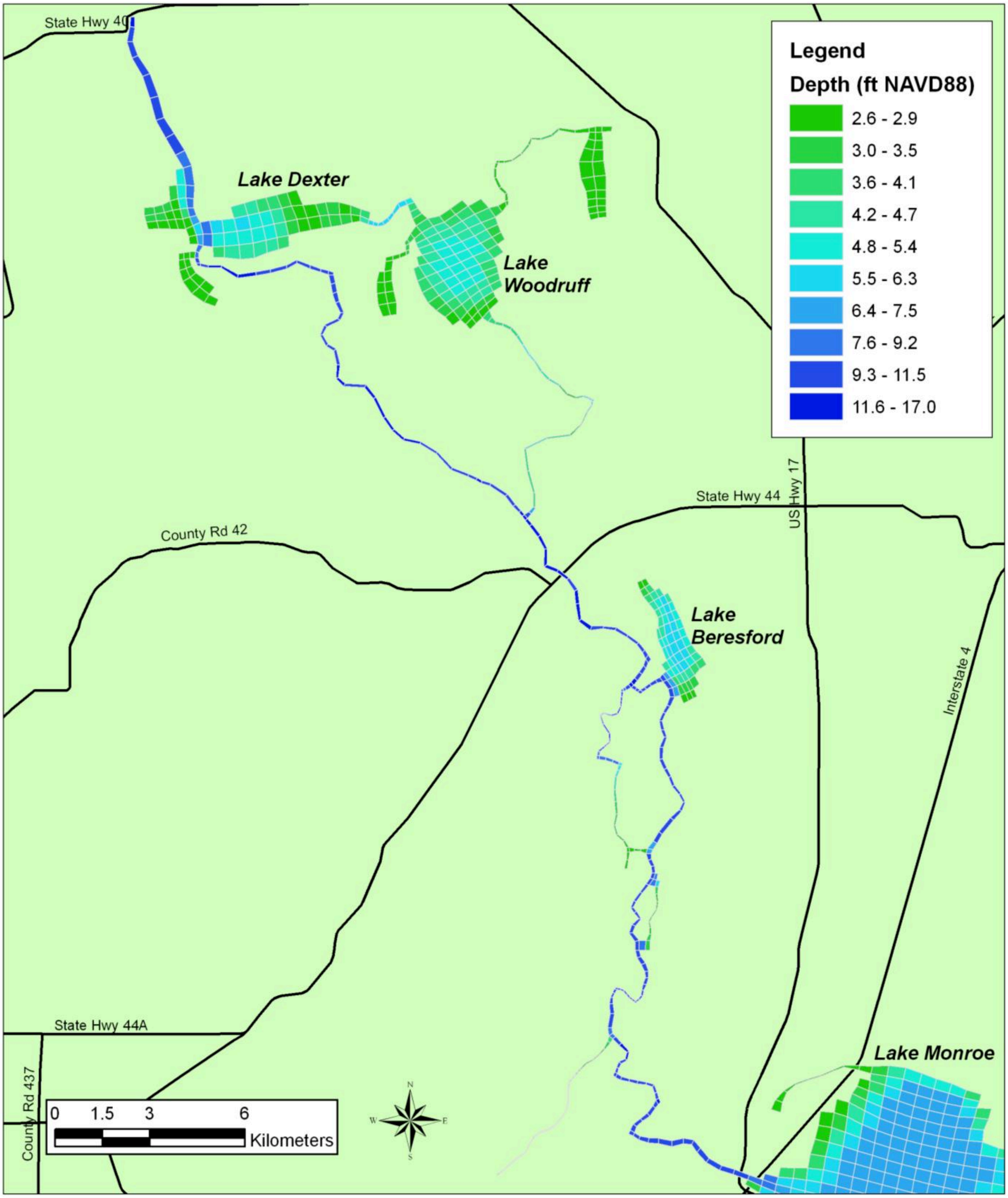

Figure 2a MSJR model grid, northern portion

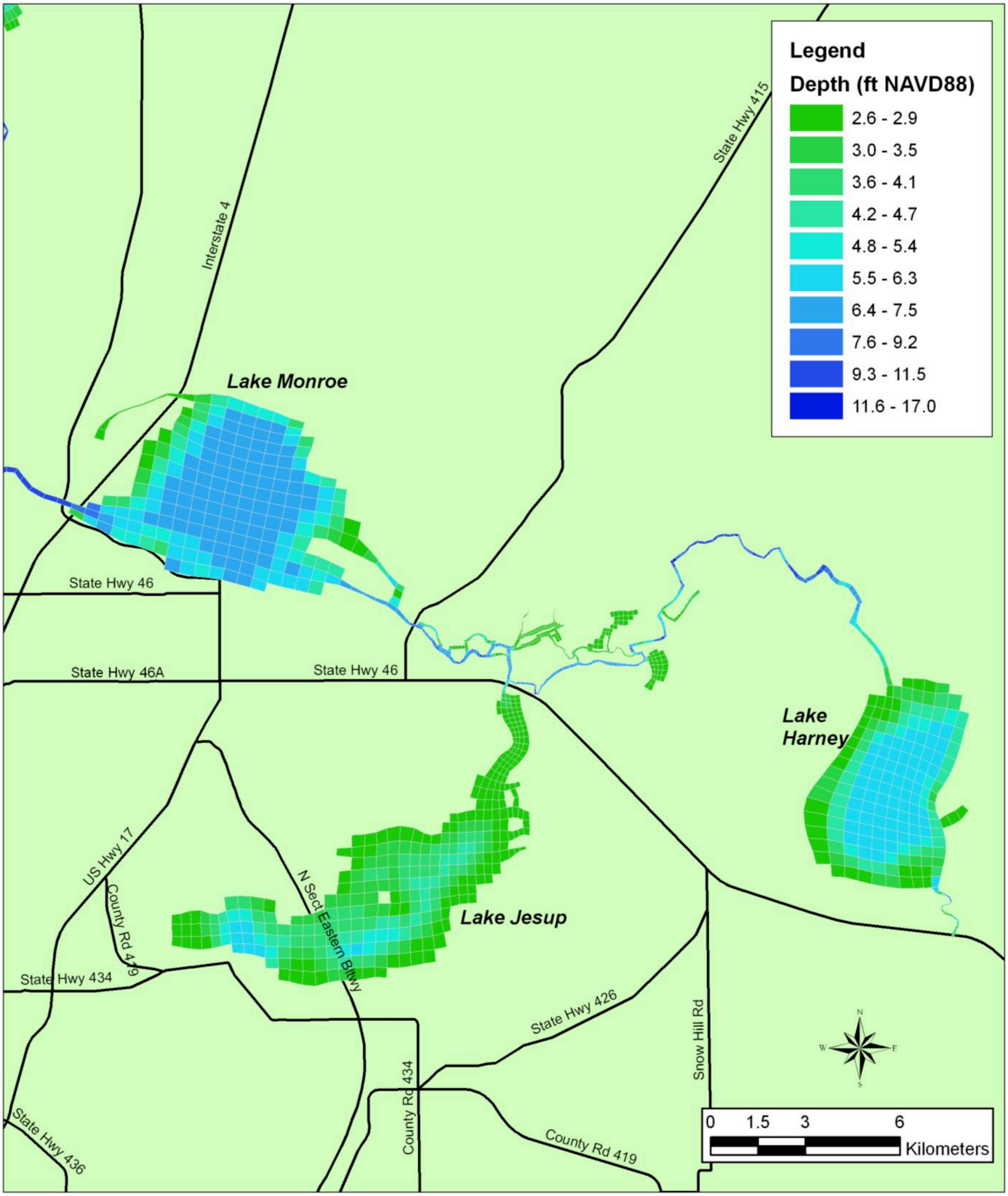

Figure 2b MSJR model grid, southern portion

3.1 Code Modifications for Withdrawal and Discharge Simulation

In order to simulate the withdrawal and discharge from the RO plant operations, code modifications were made to the MSJR EFDC model. The code was revised to allow the user to specify the locations of the intake and discharge, the intake rate, the volume recovery fraction, R, and the salinity rejection fraction, r. This gives the user flexibility in easily testing different RO plant scenarios based on pilot study data or other assumptions for these values.

The reduction in volume discharged back to the river (i.e., the flow into the "downstream" grid cell) is implemented in the "calqvs.for" file. The "calqvs" subroutine updates source and sink volume fluxes. The line in the subroutine that adds the volume flux to the downstream cell multiplies the withdrawal flux by the water volume rejection fraction (1- recovery fraction). The same changes were made to the "calexp" subroutine (which calculates the explicit momentum equation terms), the "cosexp" subroutine (which calculates the explicit momentum equation terms using the COSMIC advection scheme), and the "calphns" subroutine (which calculates quasi-non-hydrostatic pressure). The changes to these last three subroutines are only necessary if the user wants to account for the momentum of the discharge (it is unnecessary for this particular study).

The increase in salinity concentration in the water discharged back to the river is implemented in the "calfqc.for" file. The "calfqc" subroutine calculates mass sources and sinks associated with constant and time series inflows and outflows. The discharged (downstream) mass, M_D, is calculated as a function of the inflow (upstream) mass, M_U, the volume recovery fraction, R, and the constituent rejection fraction, r, as follows:

$$M_D = M_U \times (1 - R * (1 - r)) \tag{1}$$

This yields the same result as the estimates of concentration factor, CF, given by CH2M HILL (2008a) [which references Mickley et al. (1993)]:

$$\text{CF} = \frac{1 - R \times (1 - r)}{1 - R} \tag{2}$$

CH2M HILL (2008b) estimates that the CF for chloride is 3.3 and 6.6 for recovery volumes of 70% and 85%, respectively. This is based on a rejection fraction of 0.99 using the above equation. After the code revisions were completed, the model was set up for a simple two-dimensional test case to confirm that the predictions were consistent with the values estimated by CH2M HILL (2008b).

4. MODEL INPUT CONDITIONS FOR WATER SUPPLY IMPACT ASSESSMENT

4.1 Simulation Time Period and Hydrology

For the evaluation of the impacts of the RO plant operations, the simulation time period corresponds to the simulation period of the original model, 1996 to 2005. Figure 3 presents the measured freshwater inflow at the upstream boundary of the study area (St. Johns River above Lake Harney, USGS 02234000) and at a point within the interior of the study area (St. Johns River at US 17/92, USGS 02234500) downstream of Lake Monroe. As the data show, the flow conditions along the river range from near zero (and negative for the downstream station) during low-flow periods to upwards of 10,000 cubic feet per second (cfs).

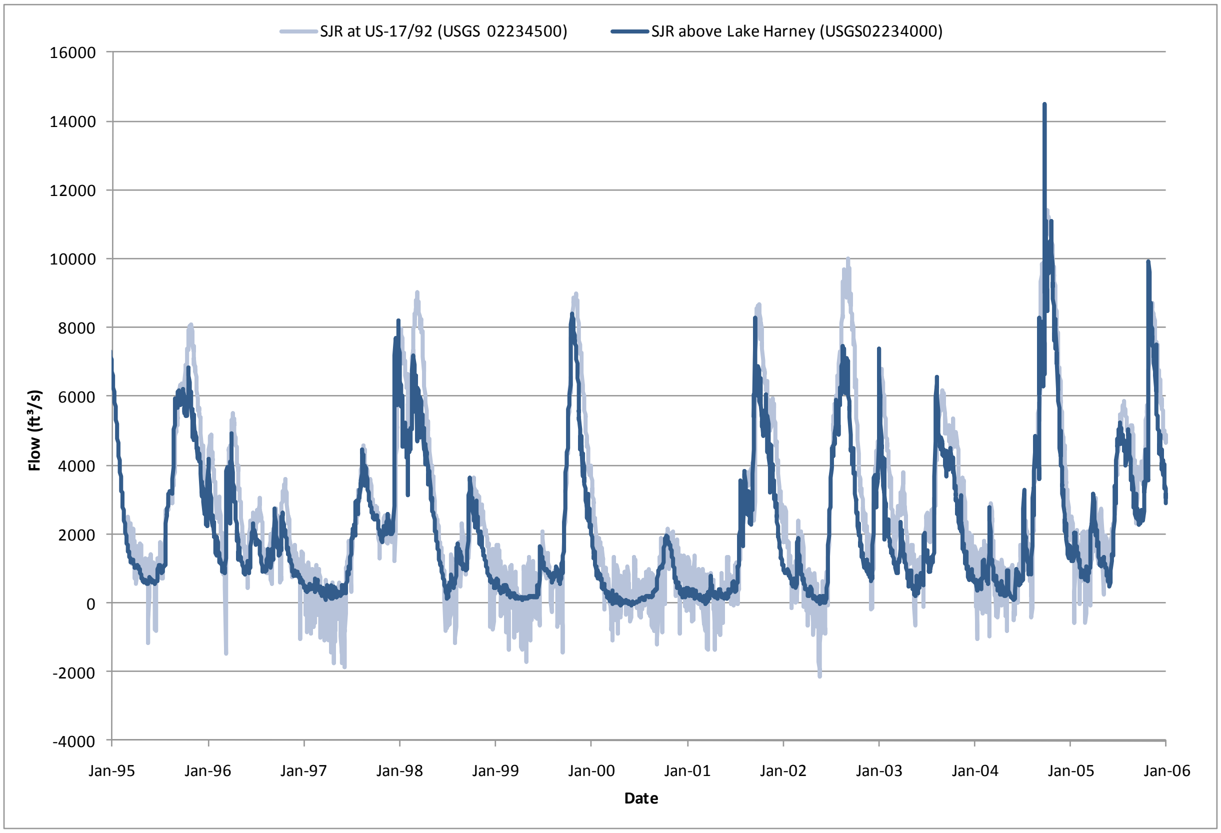

Figure 3 Measured flow for St. Johns River at US-17/92 (USGS 02234500) and St. Johns River at SR 46 above Lake Harney (USGS 02234000)

Given the complexity of the simulations and the number of scenarios to be evaluated, a 2-year critical period was identified to reduce the simulation times. The critical period chosen was from September 12, 1999 to September 12, 2001. Examination of the measured flows during this time frame identifies that this is the lowest overall flow conditions throughout the 10-year period.

4.2 Downstream Boundary

The downstream boundary for the model simulations is located on the St. Johns River at State Road 40 near Astor (USGS 02236125). From this station, the measured water surface elevations and salinities are used as the downstream boundary condition. The District provided the measured values from this station as the input file of the water surface elevation to the EFDC model. The District also supplied the measured salinities at this location.

4.3 Upstream Boundaries and freshwater Inflows

The District provided the upstream flows for the EFDC model. The data file includes the flow time series for the following:

- Upstream flow based on the USGS gage 02234000 at SR46,
- Spring flows,
- Flows based on gaged and ungaged tributaries, and
- Estimates of diffuse groundwater inflow.

The locations of the model input flows are shown in Figure 4. Discharge data for the ungaged flows were based on a Hydrological Simulation Program–Fortran (HSPF) run completed in January 2009 by SJRWMD staff.

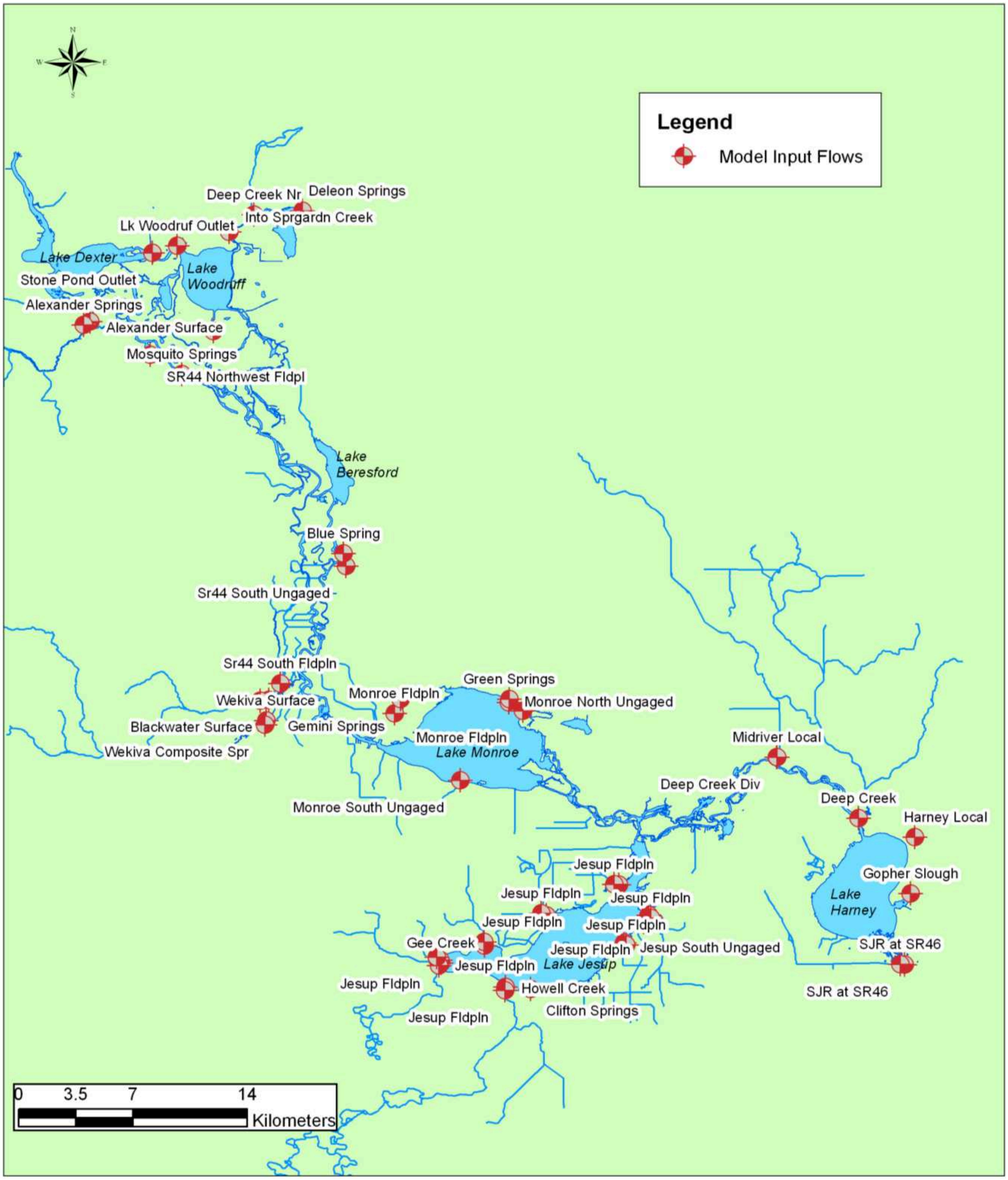

Figure 4 Input flow locations for the EFDC model

4.4 Water Supply Intakes and Discharges

As discussed previously, the Lake Jesup site is located along the main stem of the St. Johns River immediately upstream of where Lake Jesup enters the river. The Yankee Lake site is located along the main stem of the St. Johns River, downstream of Lake Monroe.

Figure 5 shows a close-up view of the Lake Jesup intake and discharge locations overlain on an aerial view (including the model grid and depths). As the figure shows, the intake is located approximately 0.7 mile upstream of the Lake Jesup mouth, while the discharge is located approximately 0.7 mile downstream of the intake, near the location where Lake Jesup flows into the main stem.

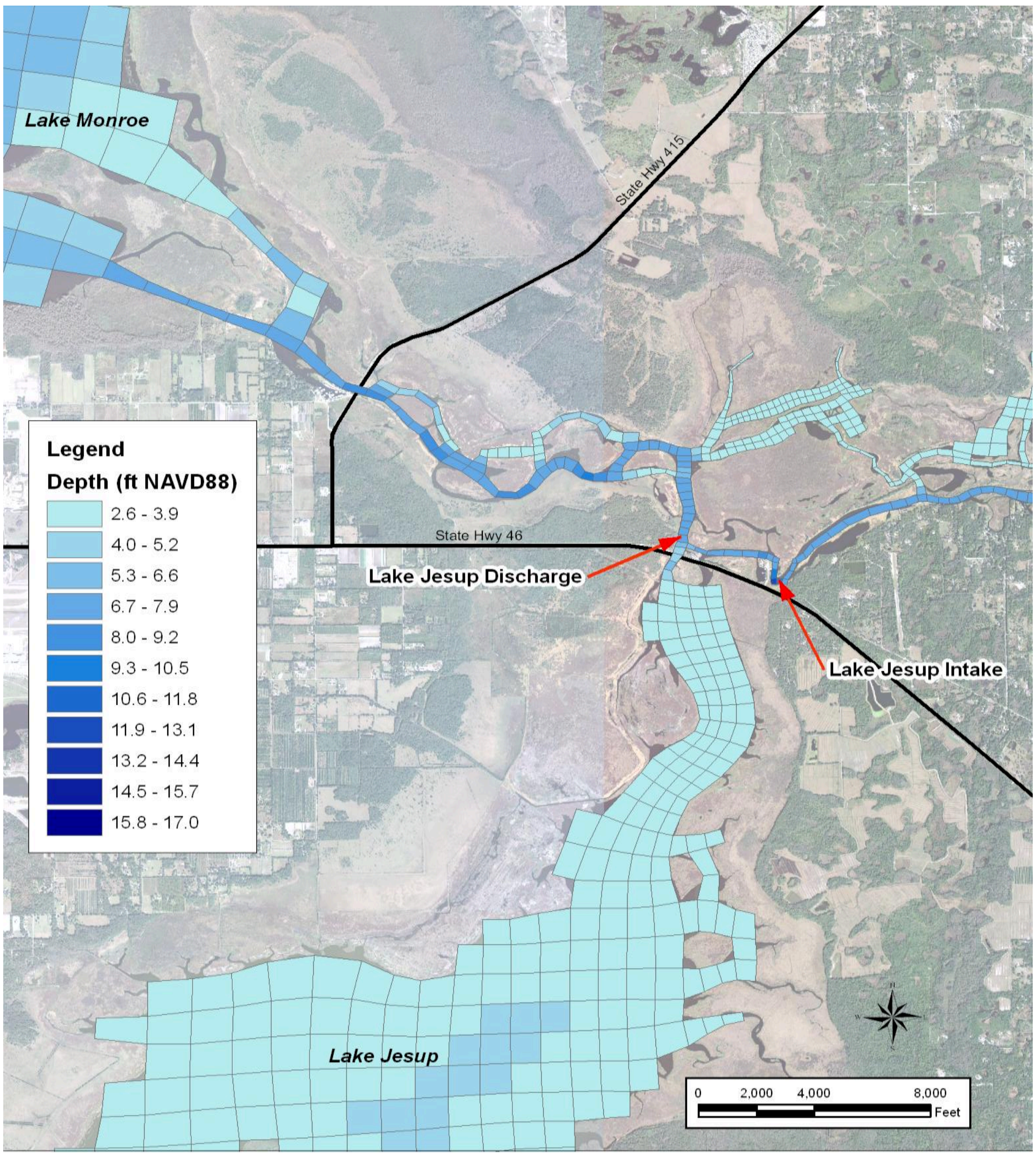

Figure 5 Lake Jesup intake and discharge locations

Figure 6 shows a close up view of the Yankee Lake site intake and discharge. The intake is located approximately 2 miles downstream of the entrance to Lake Monroe along the main stem, with the discharge approximately 0.4 miles downstream of the intake.

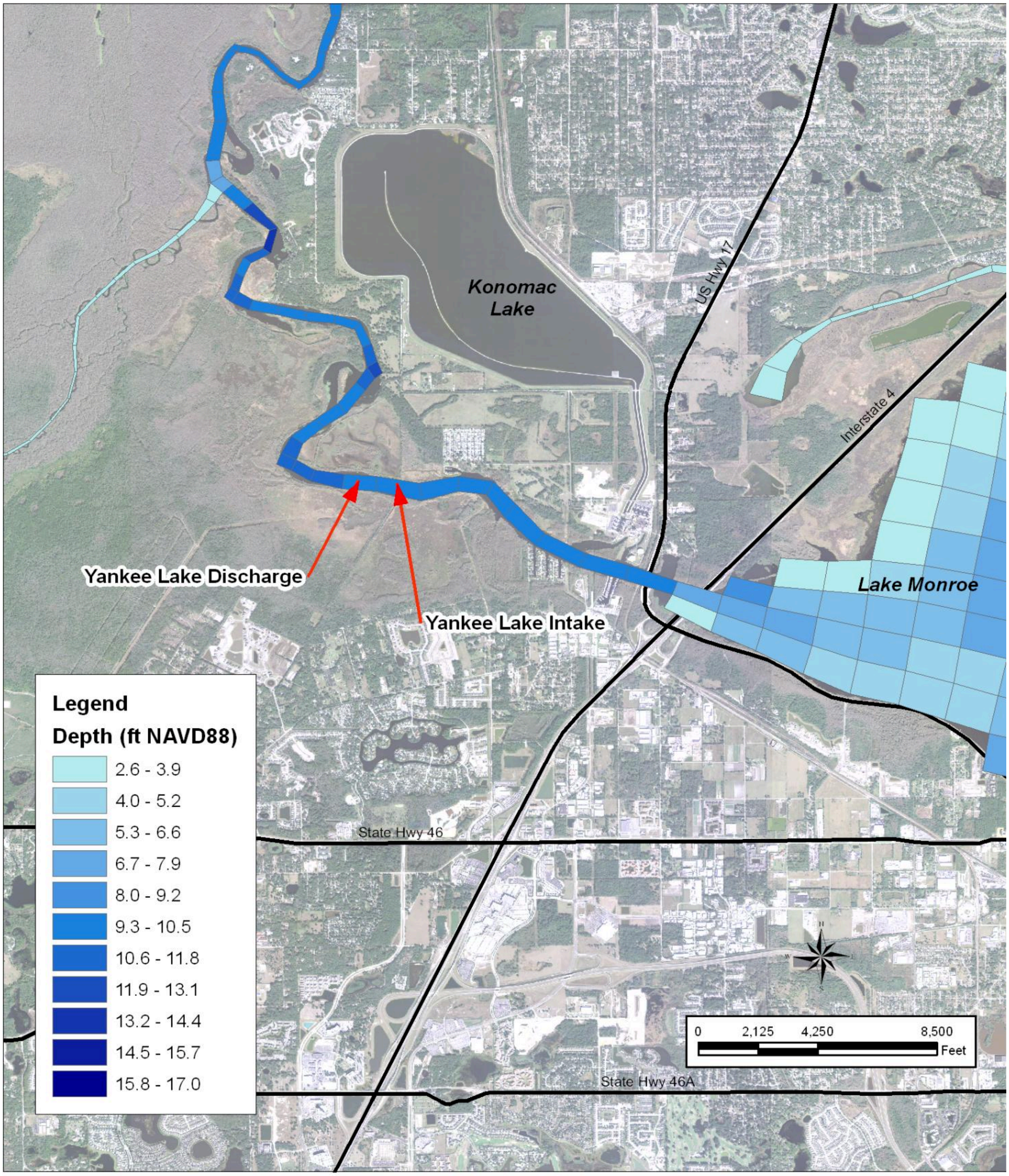

Figure 6 Yankee Lake intake and discharge locations

As discussed in Section 3.2, the EFDC code was modified to allow simulation of the RO plants accounting for potential recirculation affects. The model inputs for each site include the following:

- Location of the intake and discharge;
- Intake flow rate (determined from the desired water production rate and the percent recovery);
- The percent recovery assumed for the RO plant operation; and
- The rejection rate (the rate at which dissolved solids are returned in the discharge).

For the various production rate simulations, the locations, the percent recovery, and the rejection rate were held constant. The intake flow rate was then determined based upon the desired water production rate to be simulated. For the simulations presented, a percent recovery of 85% and a rejection rate of 99% were utilized.

5. MODEL SIMULATION RESULTS

To evaluate the potential impacts of the operation of the RO plants at the two locations, a series of scenarios were run using the EFDC model described in Sections 3 and 4. These scenarios were run for the critical 2-year period identified in Section 4, and for the 10-year period for the 50 MGD scenario. Water production rates of 50 MGD, 25 MGD, 12.5 MGD, 6 MGD, and 3 MGD were simulated.

The scenarios included runs with each of the plants operating individually and with both plants running simultaneously using the same water production rates. Table 1 presents the scenarios simulated. The baseline condition is simply the run without either of the two plants operating. Impacts are presented as salinity changes that occur from the baseline condition.

The results are provided within a summary table (Table 2) that lists the maximum salinity recorded at the model grid cell where the discharge is located, along with the salinity change, the percent change in salinity, and the date on which the maximum delta occurred. Where only one plant is in operation for any scenario, the results at the discharge point for the non-operational plant are listed as N/A. The following sections provide discussion of the findings under the 50 MGD, 25 MGD and 12.5 MGD production rates along with a discussion of the potential for cumulative impacts of salinity increase in Lake Jesup.

5.1 Water Production Rates at 50 MGD

In Table 2, the first two sets of scenarios represent the 2-year versus the 10-year simulations. Examination of the results shows that the differences are nearly identical for all simulations.

For the Lake Jesup site operating at 50 MGD, the percent salinity change at the discharge point is 198%, with salinities increasing from 1.18 ppt to 3.52 ppt. Figure 7 provides a far-field view, showing the maximum salinity delta at each of the cells at *any time during the entire simulation*. The results show that salinity changes occur downstream to Lake Monroe, well into Lake Jesup, and up as far as the downstream end of Lake Harney.

For the Yankee Lake site operating at 50 MGD, the percent salinity change at the discharge point is 90%, with the depth-averaged salinity increasing from 1.05 ppt to 1.99 ppt. Figure 8 provides a far-field view showing the maximum salinity delta at each of the cells at any time. The results show that salinity changes occur upstream into Lake Monroe and downstream all the way to the model boundary.

For both sites operating at 50 MGD simultaneously, the salinity changes at the upstream (Lake Jesup) site are the same as the condition with the Lake Jesup site operating alone. The salinity changes at the Yankee Lake site are increased slightly from the case with it operating alone.

Table 1 Withdrawal rates and discharge locations for production simulations

Scenario Name	Lake Jesup Site Production (MGD)	Lake Jesup Site Withdrawal (MGD)	Yankee Lake Site Production (MGD)	Yankee Lake Site Withdrawal (MGD)
Baseline (10 year)	0	0	0	0
Baseline (2 year)	0	0	0	0
50 MGD Jesup (10 year)	50	58.8	0	0
50 MGD Jesup (2 year)	50	58.8	0	0
25 MGD Jesup (2 year)	25	29.4	0	0
12.5 MGD Jesup (2 year)	12.5	14.7	0	0
6 MGD Jesup (2 year)	6	7.1	0	0
3 MGD Jesup (2 year)	3	3.5	0	0
50 MGD Yankee (10 year)	0	0	50	58.8
50 MGD Yankee (2 year)	0	0	50	58.8
25 MGD Yankee (2 year)	0	0	25	29.4
12.5 MGD Yankee (2 year)	0	0	12.5	14.7
6 MGD Yankee (2 year)	0	0	6	7.1
3 MGD Yankee (2 year)	0	0	3	3.5
50 MGD Both (10 year)	50	58.8	50	58.8
50 MGD Both (2 year)	50	58.8	50	58.8
25 MGD Both (2 year)	25	29.4	25	29.4
12.5 MGD Both (2 year)	12.5	14.7	12.5	14.7
6 MGD Both (2 year)	6	7.1	6	7.1
3 MGD Both (2 year)	3	3.5	3	3.5

Table 2 Peak salinity changes under varying production rates

Scenario Name	Intake Flow Rate (MGD)	Water Production Rate (MGD)	Depth Averaged Salinity when Max Delta Occurs (ppt)		Maximum Depth Averaged Salinity Delta (ppt)		Maximum Depth Averaged Salinity Delta (%)		Date of Maximum Salinity Delta	
			Yankee Lake Discharge Cell	Lake Jesup Discharge Cell	Yankee Lake Discharge Cell	Lake Jesup Discharge Cell	Yankee Lake Discharge Cell	Lake Jesup Discharge Cell	Yankee Lake	Lake Jesup
50 MGD Jesup (10 year)	58.8	50.0	N/A	3.52	N/A	2.34	N/A	198%	N/A	02/23/01
50 MGD Yankee (10 year)	58.8	50.0	1.99	N/A	0.94	N/A	90%	N/A	06/17/01	N/A
50 MGD Both (10 year)	58.8	50.0	2.33	3.51	1.28	2.34	122%	200%	06/14/01	02/23/01
50 MGD Jesup (2 year)	58.8	50.0	N/A	3.51	N/A	2.33	N/A	197%	N/A	02/23/01
50 MGD Yankee (2 year)	58.8	50.0	1.99	N/A	0.94	N/A	90%	N/A	06/17/01	N/A
50 MGD Both (2 year)	58.8	50.0	2.33	3.52	1.28	2.34	122%	198%	06/14/01	02/23/01
25 MGD Jesup (2 year)	29.4	25.0	N/A	2.22	N/A	1.04	N/A	88%	N/A	02/23/01
25 MGD Yankee (2 year)	29.4	25.0	1.51	N/A	0.46	N/A	44%	N/A	06/17/01	N/A
25 MGD Both (2 year)	29.4	25.0	1.66	2.22	0.61	1.05	58%	90%	06/14/01	02/23/01
12.5 MGD Jesup (2 year)	14.7	12.5	N/A	1.68	N/A	0.50	N/A	42%	N/A	02/23/01
12.5 MGD Yankee (2 year)	14.7	12.5	1.28	N/A	0.23	N/A	22%	N/A	06/17/01	N/A
12.5 MGD Both (2 year)	14.7	12.5	1.34	1.68	0.29	0.50	27%	42%	06/17/01	02/23/01
6 MGD Jesup (2 year)	7.1	6.0	N/A	1.45	N/A	0.25	N/A	21%	N/A	03/06/01
6 MGD Yankee (2 year)	7.1	6.0	0.74	N/A	0.13	N/A	21%	N/A	02/27/01	N/A
6 MGD Both (2 year)	7.1	6.0	1.20	1.45	0.14	0.25	13%	21%	06/17/01	03/06/01
3 MGD Jesup (2 year)	3.5	3.0	N/A	1.19	N/A	0.14	N/A	13%	N/A	02/15/01
3 MGD Yankee (2 year)	3.5	3.0	0.67	N/A	0.06	N/A	9%	N/A	02/27/01	N/A
3 MGD Both (2 year)	3.5	3.0	1.12	1.39	0.07	0.14	6%	11%	06/17/01	07/16/00

N/A - For individual discharges the change values at the other location are not relevant

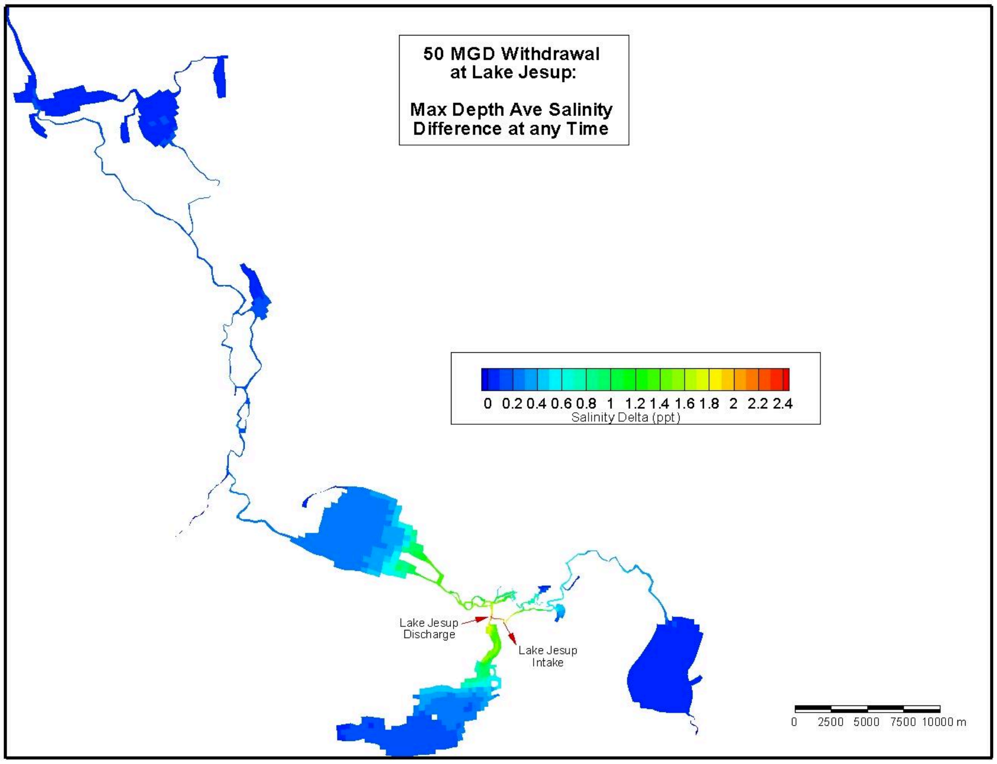

Figure 7 Far-field salinity increases due to Lake Jesup production at 50 MGD

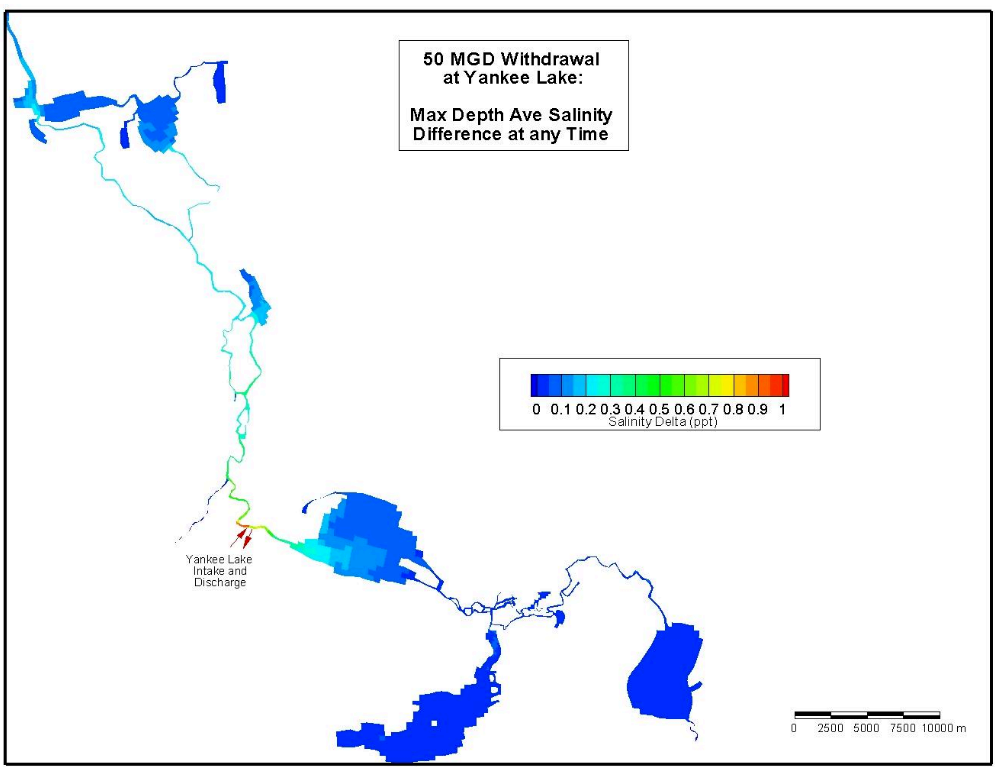

Figure 8 Far-field salinity increases due to Yankee Lake production at 50 MGD

The percent salinity change increases from 90% to 122%. The depth-averaged salinity increases from 1.05 to 2.33 ppt at the discharge point. Figure 9 shows a far-field view of the maximum salinity change at any time. The plots show that the upstream station impacts remain similar to the case with it operating alone, while the downstream site shows greater impact.

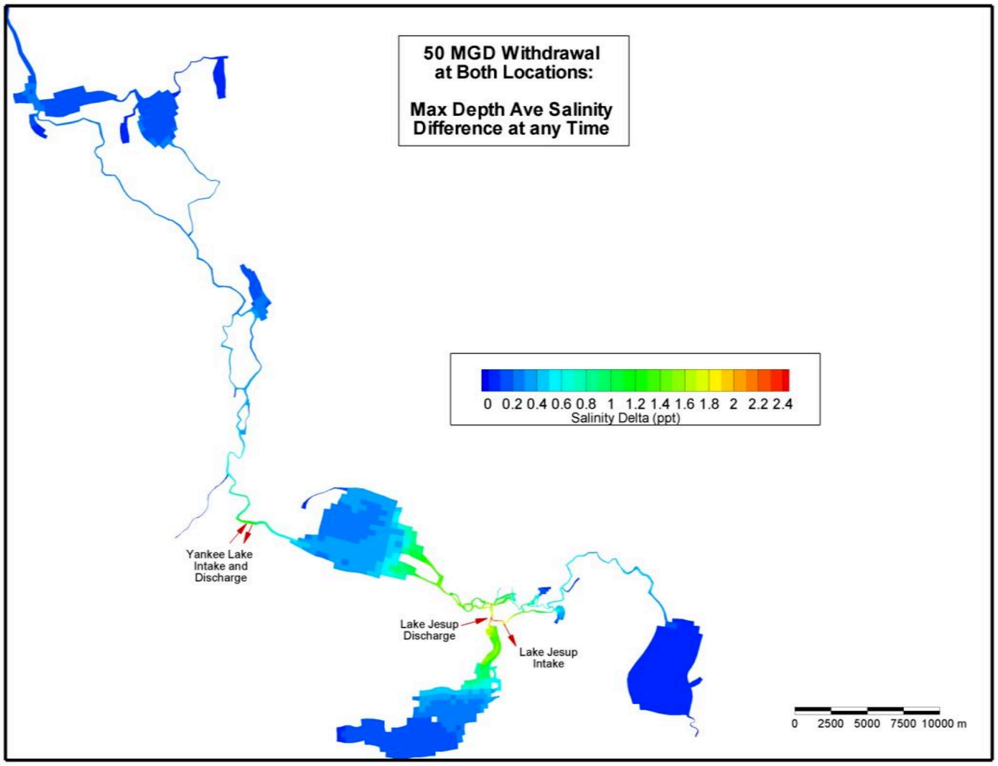

Figure 9 Far-field salinity increases due to Lake Jesup and Yankee Lake production at 50 MGD

5.2 Water Production Rates at 25 MGD

For the Lake Jesup site operating at 25 MGD, the percent salinity increase at the discharge point is 88%, with salinities increasing from 1.18 ppt to 2.22 ppt. Figure 10 provides a far-field view showing the maximum salinity delta at each of the cells at any time. The results show that salinity changes occur downstream to Lake Monroe, into Lake Jesup, and upstream toward Lake Harney.

For the Yankee Lake site operating at 25 MGD, the percent salinity change at the discharge point is 44%, with the depth-averaged salinity increasing from 1.05 ppt to 1.51 ppt. Figure 11 provides a far-field view showing the maximum salinity delta felt at each of the cells at any time. The results show that salinity changes occur upstream into Lake Monroe and downstream all the way to the model boundary.

For both sites operating at 25 MGD simultaneously, the salinity changes at the upstream (Lake Jesup) site are the same as the condition with the Lake Jesup site operating alone. The salinity changes at the Yankee Lake site are increased from the case with it operating alone. The percent salinity change increases from 44% to 58%. The depth-averaged salinity increases from 1.05 ppt to 1.66 ppt at the discharge point. Figure 12 shows a far-field view of the maximum salinity change at any time. The plots show that the upstream station impacts remain similar to the case with it operating alone, while the downstream site shows greater impact.

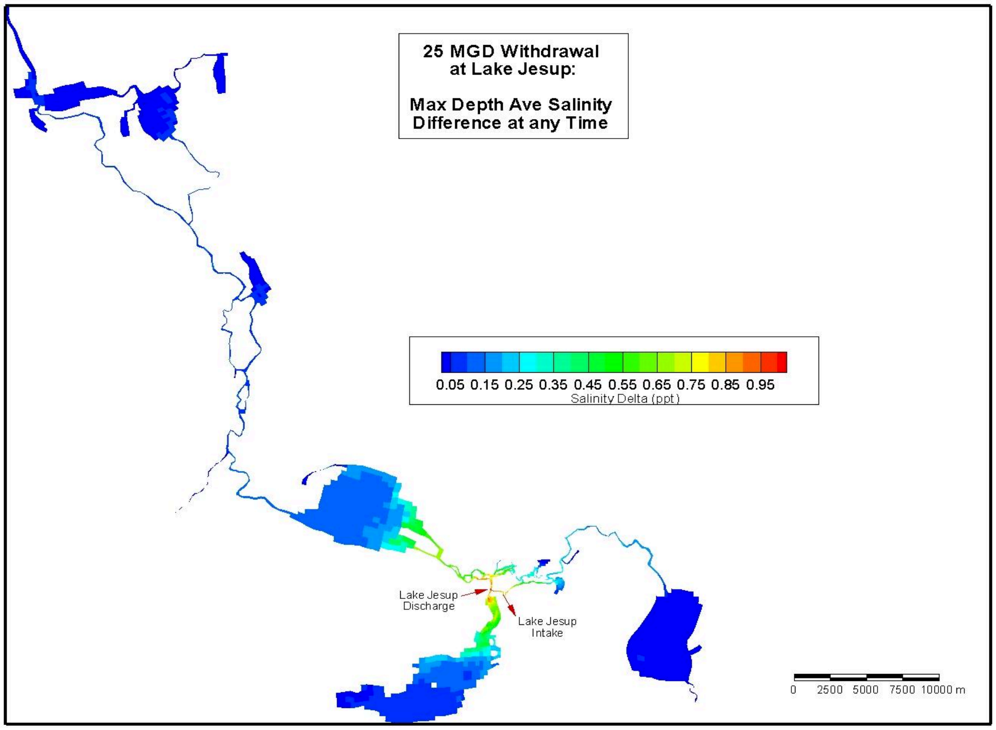

Figure 10 Far-field salinity increases due to Lake Jesup production at 25 MGD

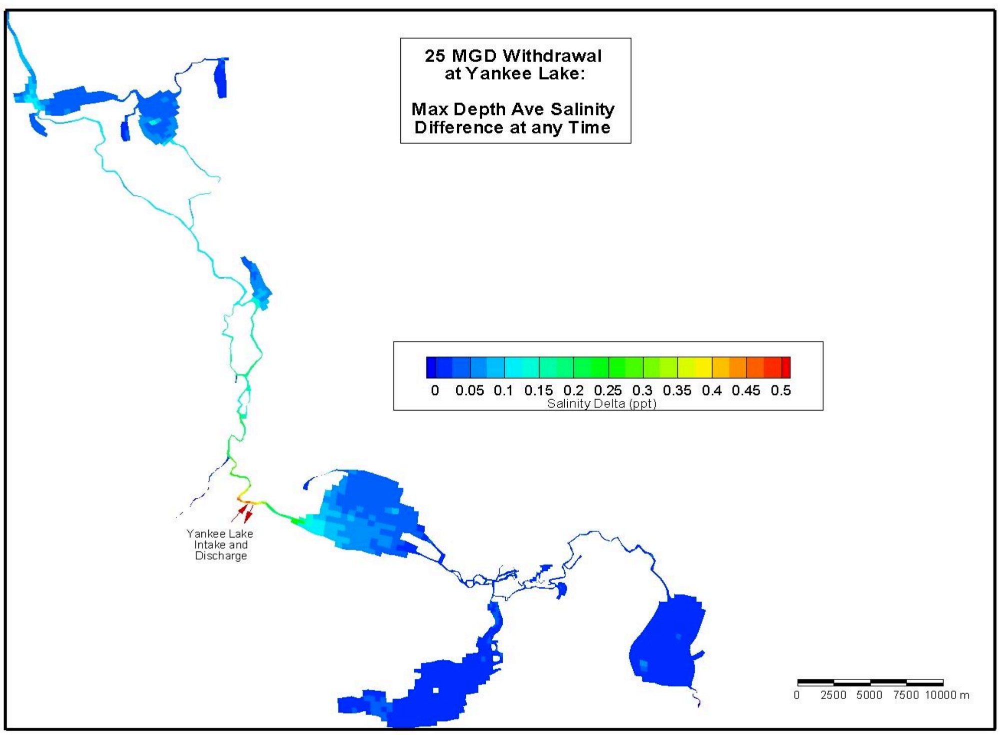

Figure 11 Far-field salinity increases due to Yankee Lake production at 25 MGD

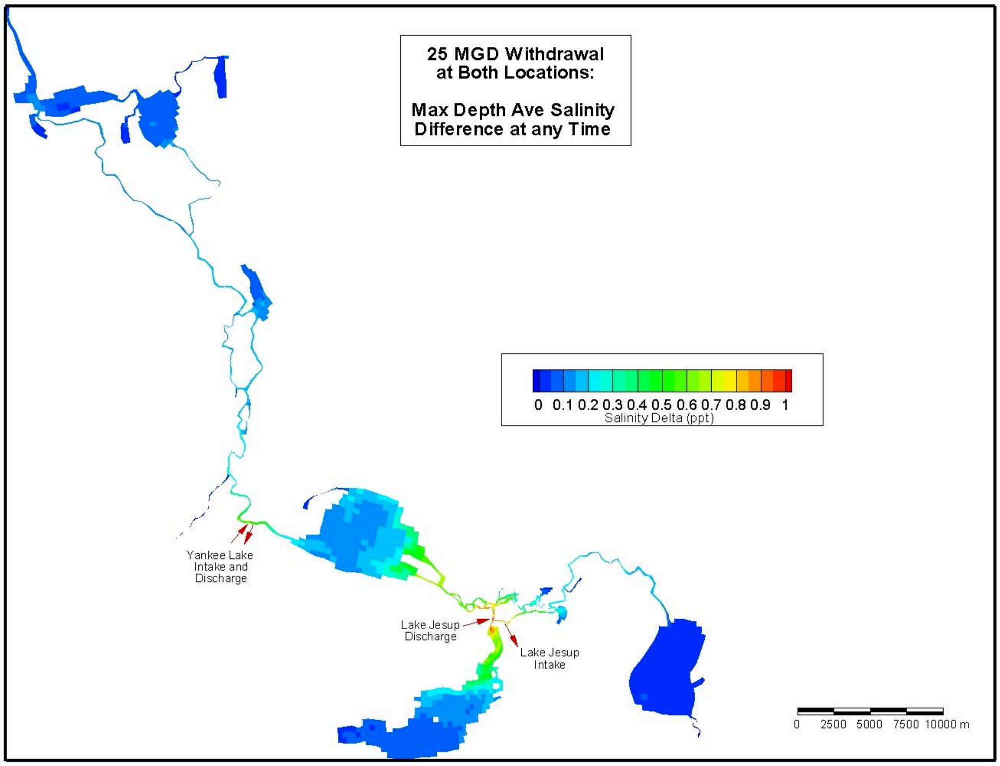

Figure 12 Far-field salinity increases due to Lake Jesup and Yankee Lake production at 25 MGD

5.3 Water Production Rates at 12.5 MGD

For the Lake Jesup site operating at 12.5 MGD, the percent salinity change at the discharge point is 42%, with salinities increasing from 1.18 ppt to 1.68 ppt. Figure 13 provides a far-field view showing the maximum salinity delta felt at each of the cells at any time. The results show that salinity changes occur downstream to Lake Monroe, into Lake Jesup, and upstream toward Lake Harney.

For the Yankee Lake site operating at 12.5 MGD, the percent salinity change at the discharge point is 22%, with the depth-averaged salinity increasing from 1.05 ppt to 1.28 ppt. Figure 14 provides a far-field view showing the maximum salinity delta felt at each of the cells at any time. The results show that salinity changes occur upstream into Lake Monroe and downstream all the way to the model boundary.

For both sites operating at 12.5 MGD simultaneously, the salinity changes at the upstream (Lake Jesup) site are the same as the condition with the Lake Jesup site operating alone. The salinity changes at the Yankee Lake site are increased from the case with it operating alone. The percent salinity change increases from 22% to 27%. The depth-averaged salinity increases from 1.05 ppt to 1.34 ppt at the discharge point. Figure 15 shows a far-field view of the maximum salinity change at any time. The plots show that the upstream station impacts remain similar to the case with it operating alone, while the downstream site shows greater impact.

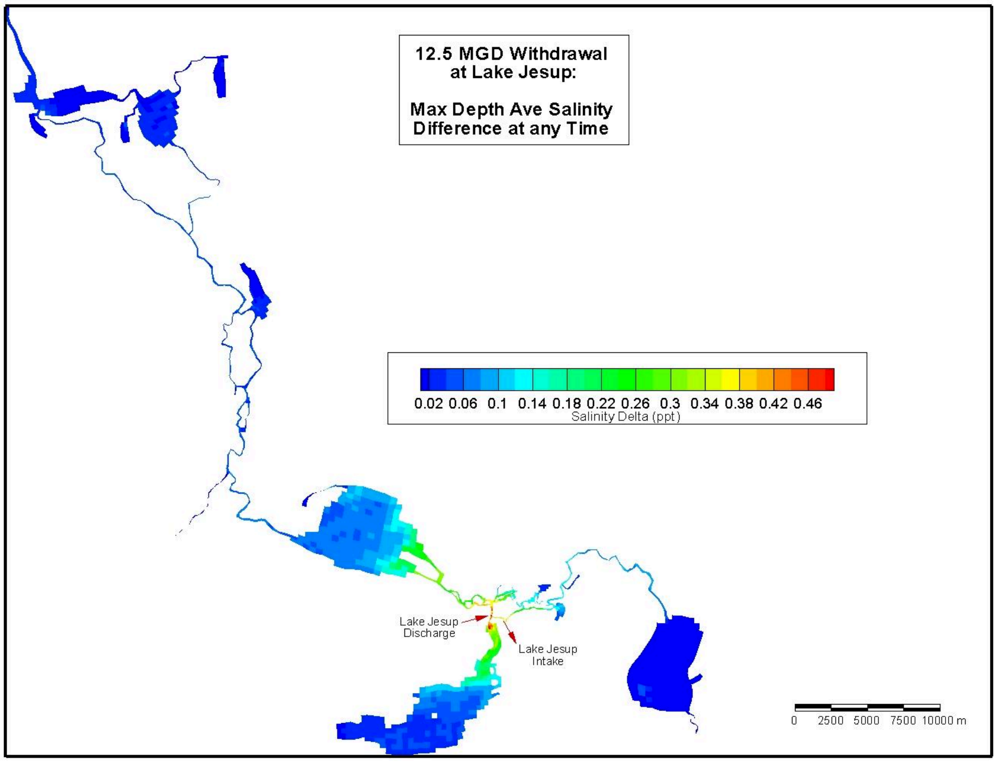

Figure 13 Far-field salinity increases due to Lake Jesup production at 12.5 MGD

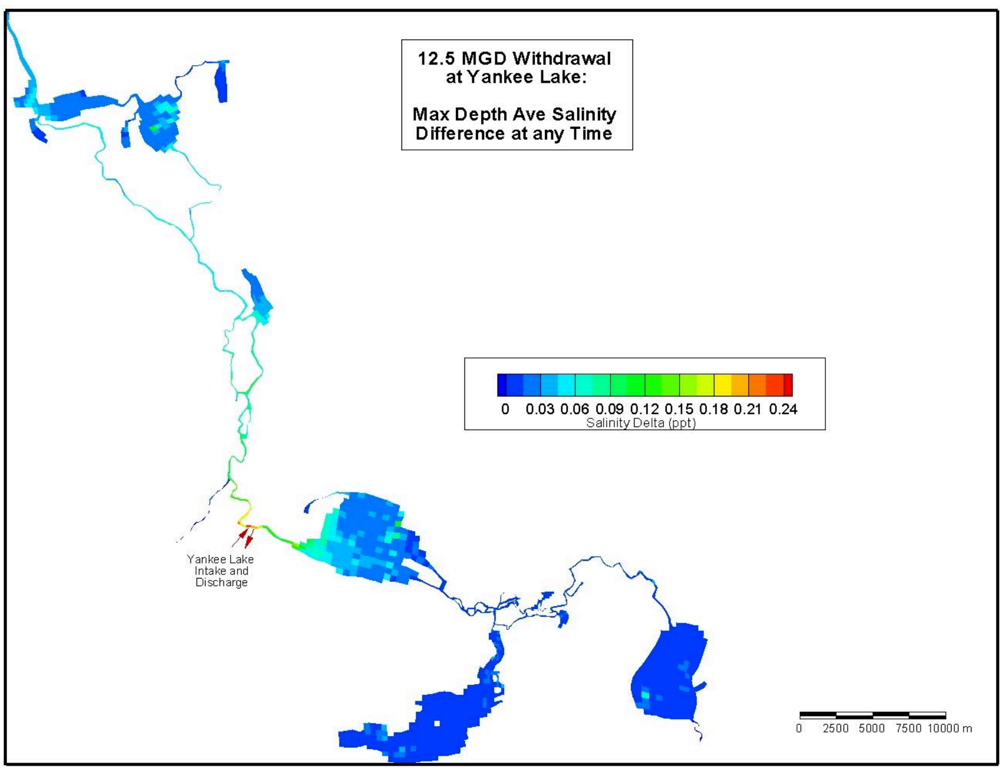

Figure 14 Far-field salinity increases due to Yankee Lake production at 12.5 MGD

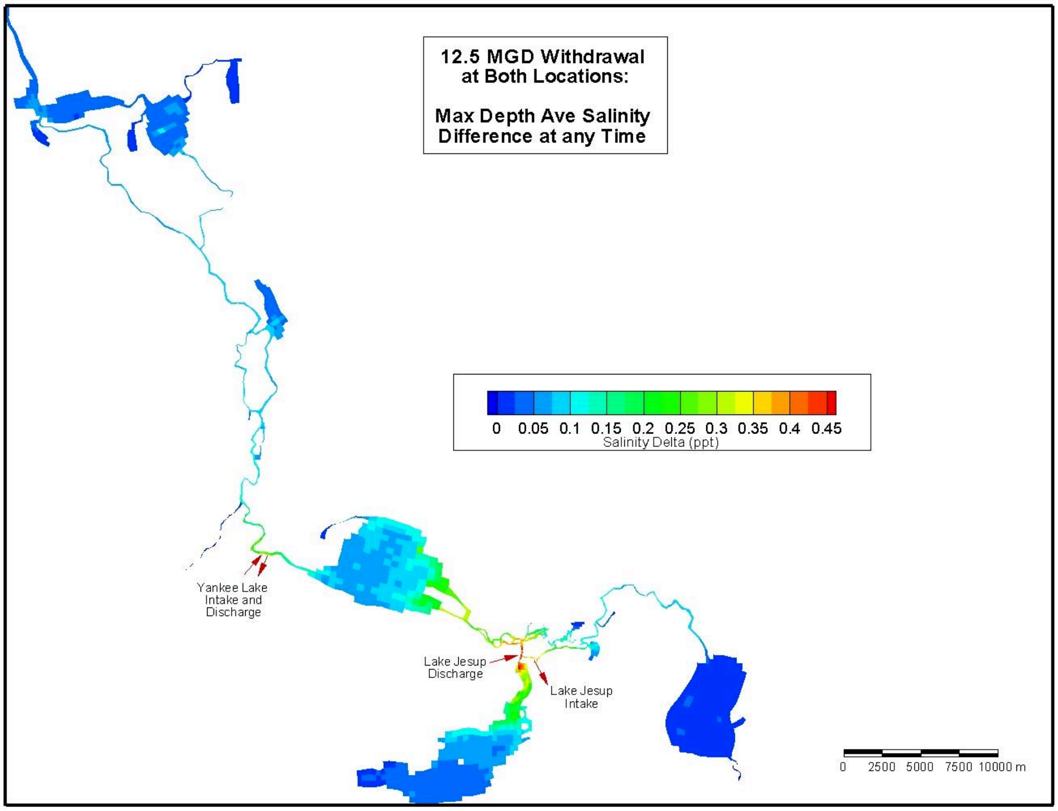

Figure 15 Far-field salinity increases due to Lake Jesup and Yankee Lake production at 12.5 MGD

5.4 Potential for Cumulative Impacts in Lake Jesup

Lake Jesup is a unique situation in that the levels of exchange within the lake are long and, therefore, of all the locations evaluated within the MSJR area, it would be the most susceptible to long-term cumulative impacts. This is due to the fact that the lake is “offline” of the St. Johns River as compared to the other lakes, which have significant direct inflow to and outflow from the St. Johns River. Additionally, the intake and discharges are located at the mouth where the lake enters the system.

The 10-year 50 MGD run with both plants operating was utilized as the worst-case condition, with the assumption that if long-term impacts are not seen under this condition, the other scenarios should not have issues. Points of analysis were chose near the mouth of Lake Jesup (NE Lake Jesup), the middle (Central Lake Jesup), and far side (SW Lake Jesup). Figure 16 presents a plot of the time series of salinity at the three locations. The plot shows the time series of impacts at each of these points, but the plots also show that the system does flush during high-flow conditions and that there is no observable net change or cumulative impact upon the system, i.e., the lake “resets" during high flow events.

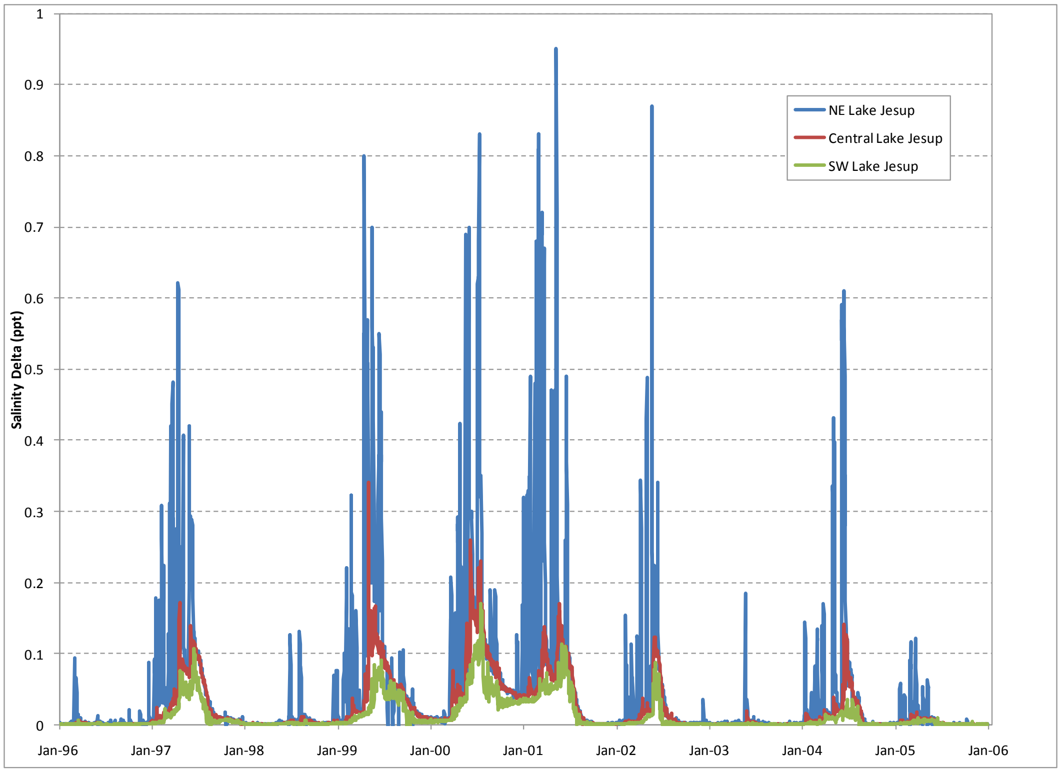

Figure 16 Time series of salinity change in Lake Jesup for 10 year 50 MGD production at Yankee Lake and Lake Jesup sites

6. STATISTICAL EVALUATION OF SALINITY IMPACTS

While maximum changes in salinity provide some indication of the extreme conditions, biological impacts are more closely tied to changes in the magnitude and frequency of changes or changes in the statistical distributions at any location. To identify the frequency of occurrence of the salinity impacts at the point(s) of discharge, statistical analyses were performed on the baseline condition, and the condition(s) with the plants operating. For all of these analyses, the full 10-year 50 MGD simulations were utilized. The following presents discussions of the histograms and cumulative distribution plots for the baseline versus the operating conditions as well as for the salinity impacts (baseline minus operating condition).

Figures 17 through 20 present the histograms and cumulative distribution plots for baseline and operating salinity conditions (frequency of occurrence as percent of total) at the Yankee Lake point of discharge with the Yankee Lake site in operation, the Lake Jesup point of discharge with the Lake Jesup site in operation, and the Yankee Lake and Lake Jesup points of discharge with both sites in operation. The results show, for all cases, the shifting of the frequency of occurrence of salinity out into the higher salinity conditions with the plants in operation.

Figures 21 through 24 present the histograms and cumulative distribution plots (frequency of occurrence as percent of total) of the salinity changes at the Yankee Lake point of discharge with the Yankee Lake site in operation, the Lake Jesup point of discharge with the Lake Jesup site in operation, and the Yankee Lake and Lake Jesup points of discharge with both sites in operation. For all of the conditions, it is evident that the bulk of the salinity impacts are around or below the 0.1 to 0.2 ppt level, with over 60 to 70% of the impacts in this range. For the Yankee Lake site, the influence of the upstream discharge when the two plants are operating simultaneously can be seen with higher percentages in the salinity impacts above 0.2 ppt.

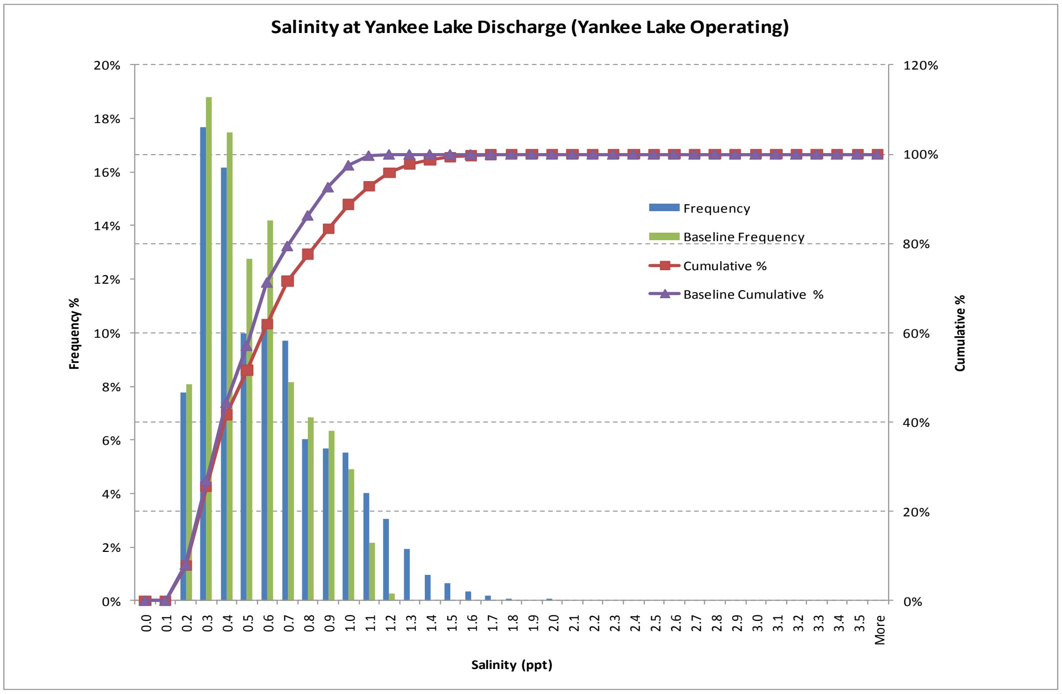

Figure 17 Histogram of baseline salinity condition versus salinity under 50 MGD water production, Yankee Lake site (Yankee Lake discharge cell)

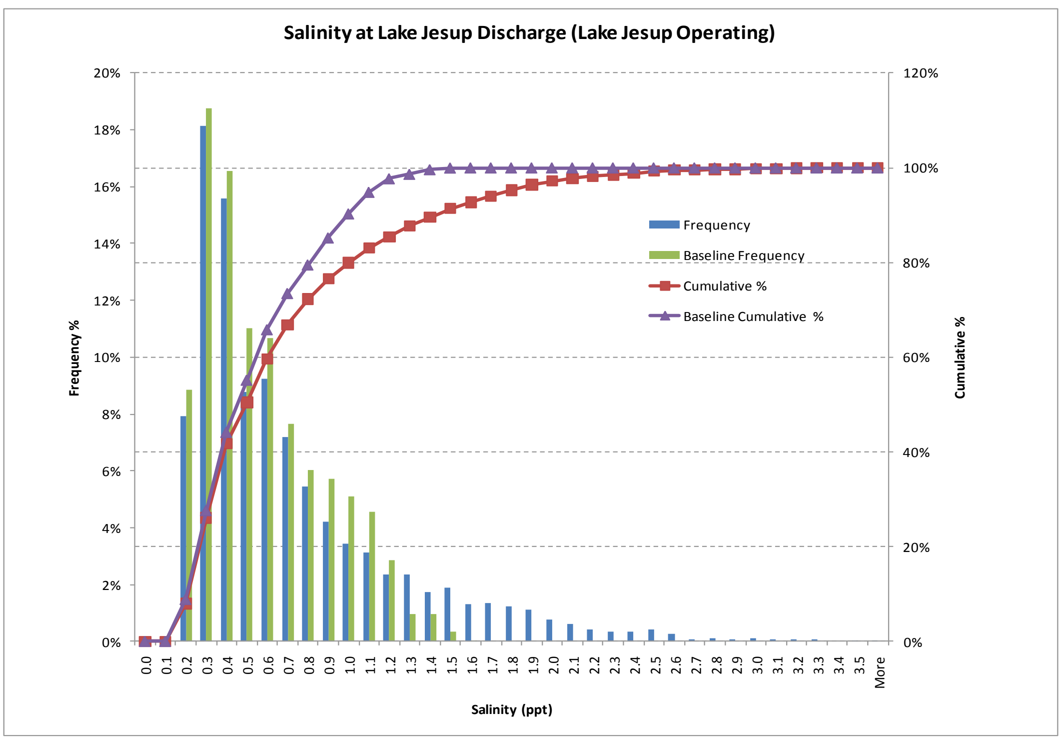

Figure 18 Histogram of Baseline salinity condition versus salinity under 50 MGD water production at Lake Jesup site (Lake Jesup discharge cell)

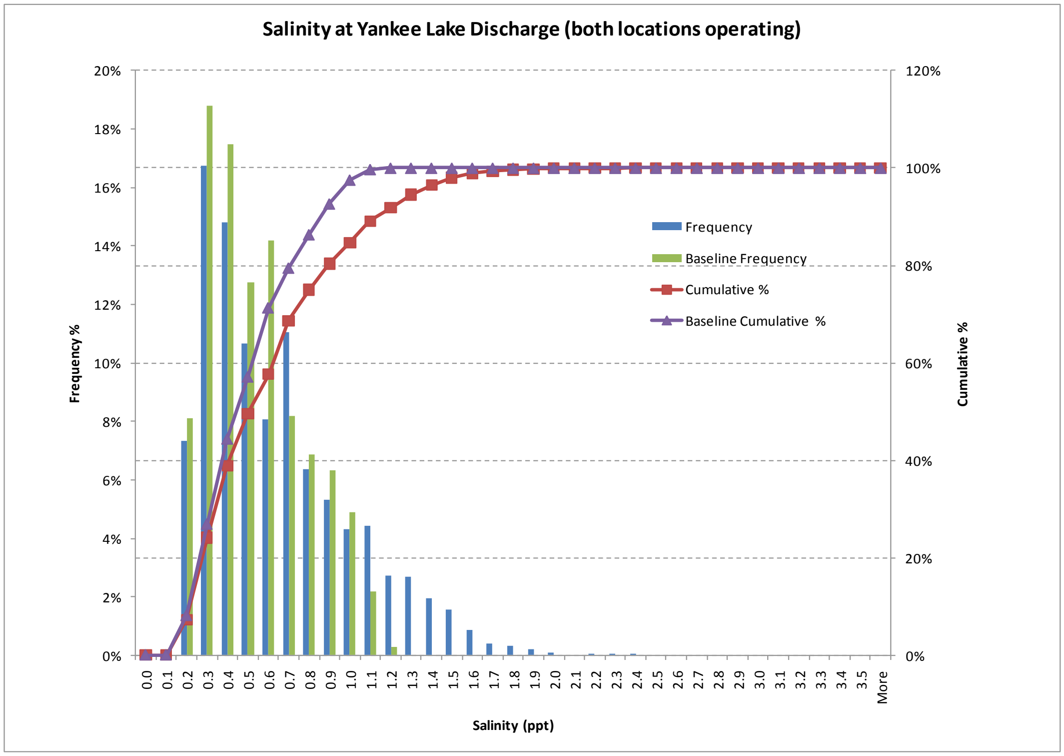

Figure 19 Histogram of baseline salinity condition versus salinity under 50 MGD water production at Yankee Lake and Lake Jesup sites (Yankee Lake discharge cell)

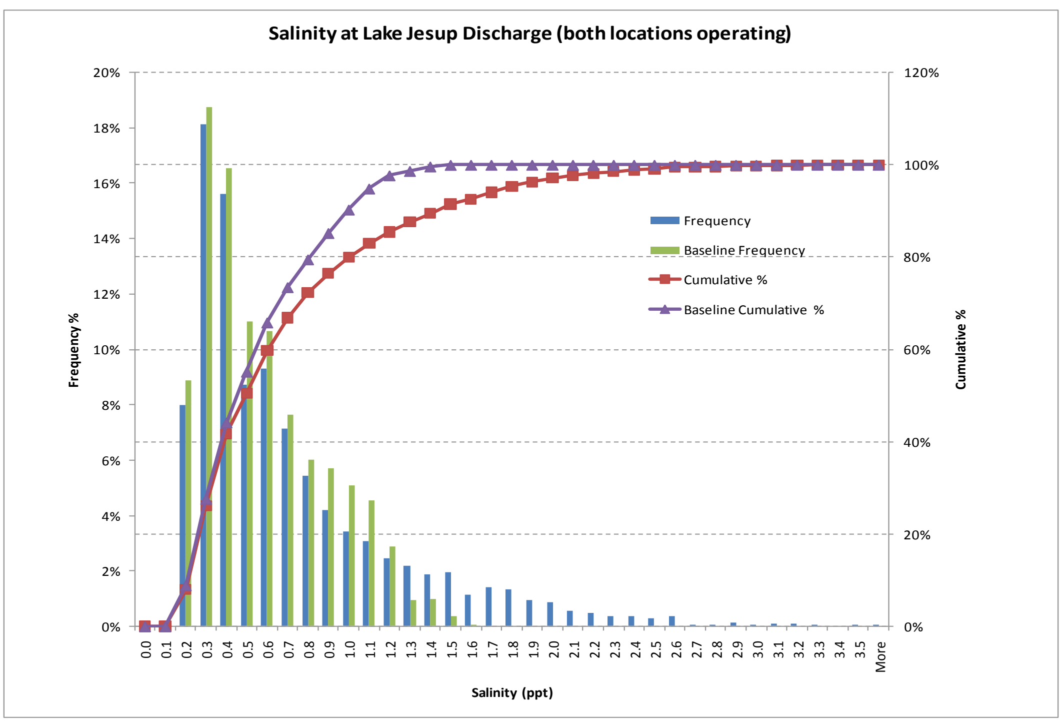

Figure 20 Histogram of baseline salinity condition versus salinity under 50 MGD water production at Yankee Lake and Lake Jesup sites (Lake Jesup discharge cell)

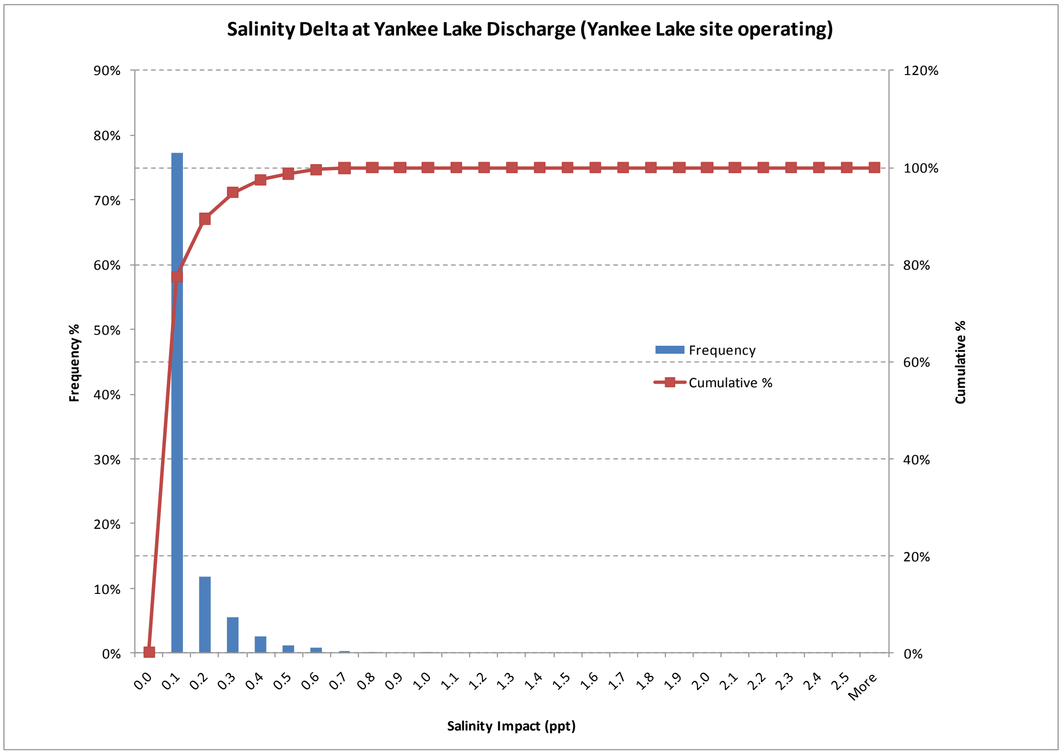

Figure 21 Histogram of salinity delta under 50 MGD water production at Yankee Lake site (Yankee Lake discharge cell)

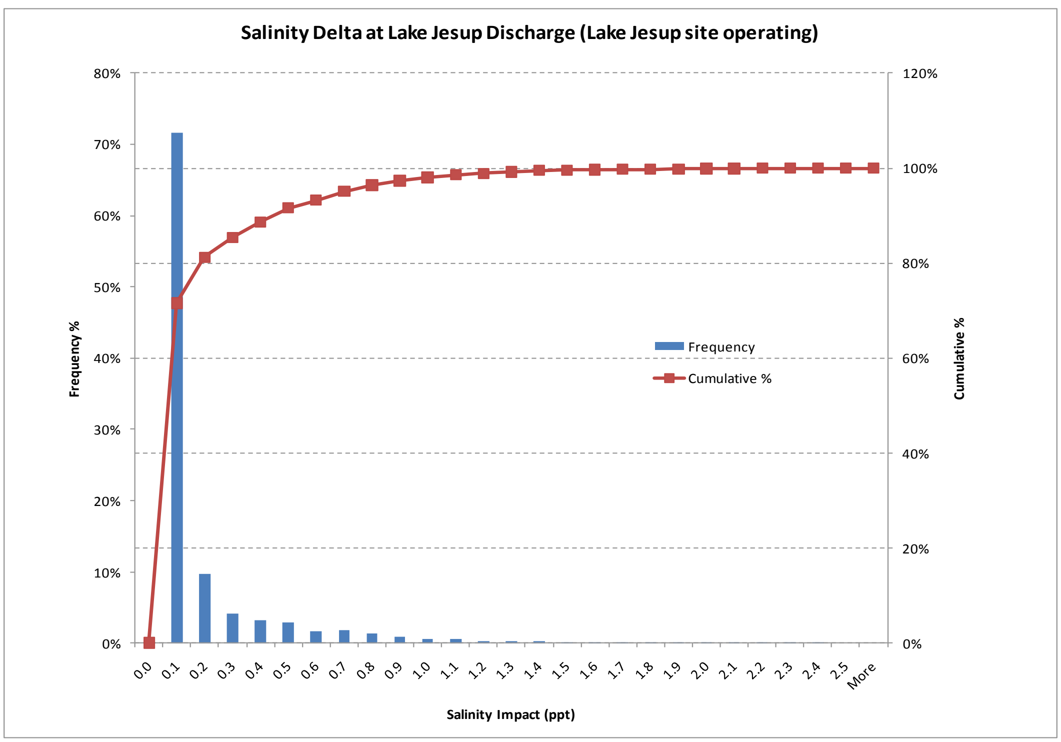

Figure 22 Histogram of salinity delta under 50 MGD water production at Lake Jesup site (Lake Jesup discharge cell)

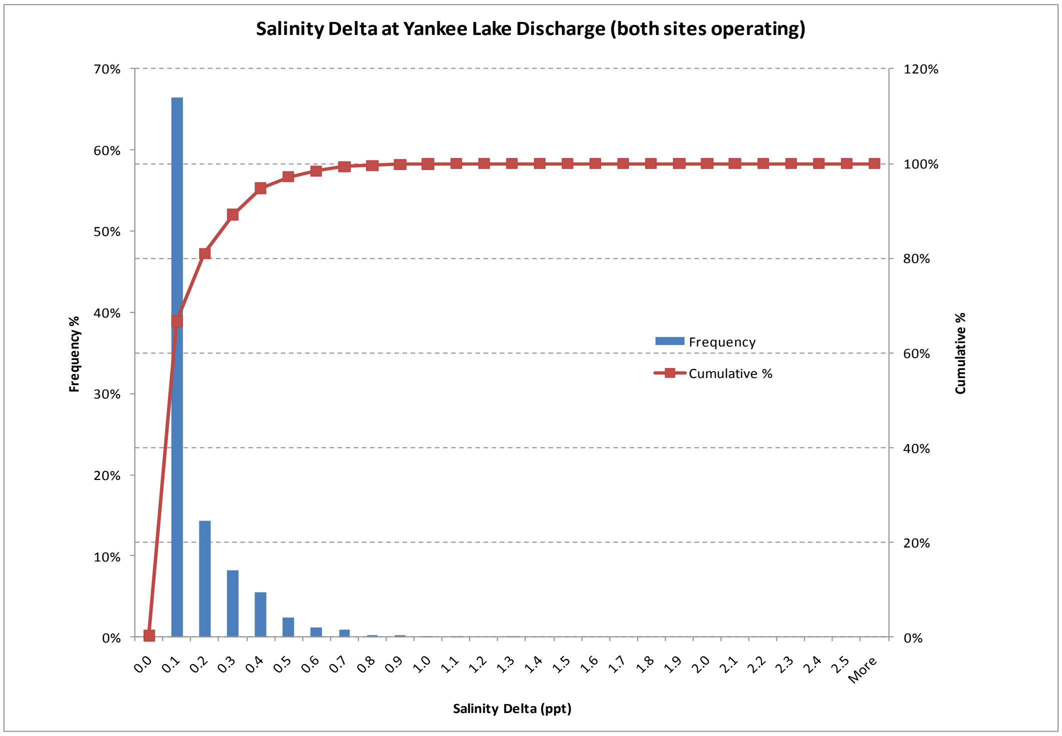

Figure 23 Histogram of salinity delta under 50 MGD water production at Yankee Lake and Lake Jesup sites (Yankee Lake discharge cell)

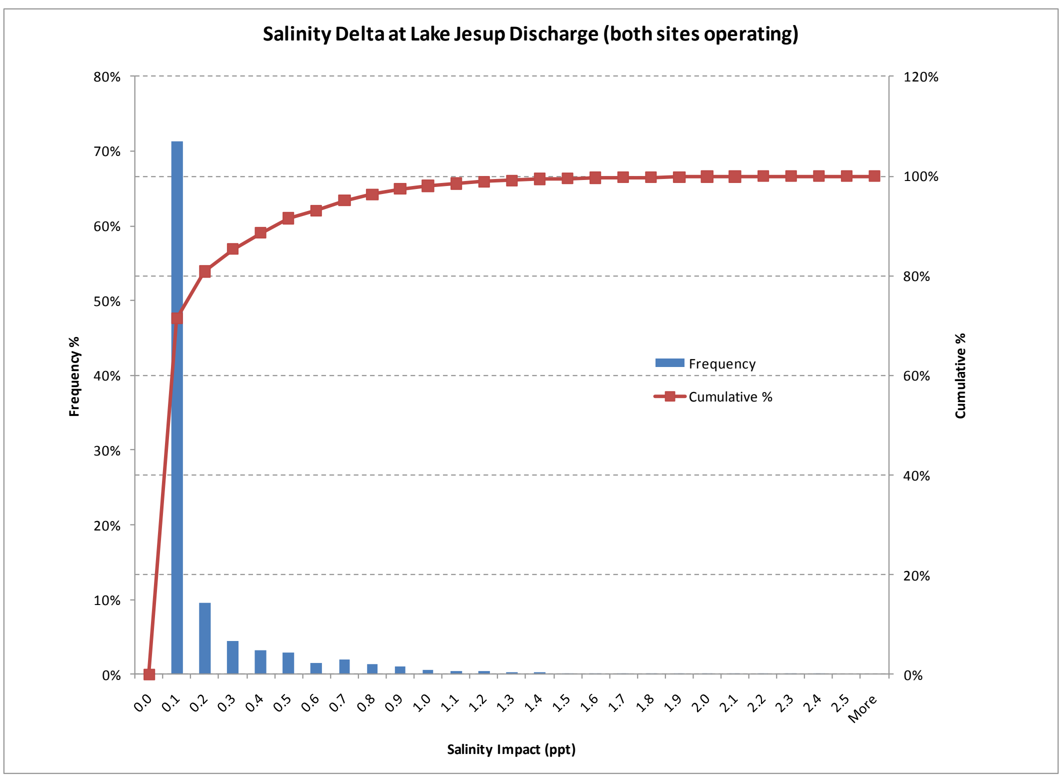

Figure 24 Histogram of salinity delta under 50 MGD water production at Yankee Lake and Lake Jesup sites (Lake Jesup discharge cell)

7. SUMMARY AND CONCLUSIONS

The District's MSJR EFDC model was utilized to assess the potential impacts of the operation of RO facilities at two locations along the MSJR. The first location is along the main stem of the MSJR immediately upstream of the entrance to Lake Jesup (Lake Jesup site). The second location is along the main stem of the MSJR downstream of Lake Monroe (Yankee Lake site).

To allow for the simulation of the RO plant operations, modifications were made to the MSJR EFDC model code to allow for the input of the intake rates, percent recovery for the water production, and the fraction of the salinity returned to the system. These code modifications were tested to demonstrate that they operate properly.

The operation of the RO facilities was examined by calculating the changes in the salinity that occur during critical low-flow conditions. For the simulations presented in this report, that period was September 12, 1999 to September 12, 2001. Additionally, for the 50 MGD scenarios, a 10-year simulation was performed, from 1996 to 2005. The baseline condition inputs were the actual downstream water surface elevation, flows, and meteorologic conditions that occurred during the simulation periods.

Simulations were run with each of the RO plants operating alone and with the two plants operating simultaneously at water production rates of 50 MGD, 25 MGD, 12.5 MGD, 6 MGD, and 3 MGD. For each of the simulations, the absolute salinity changes and the percent salinity changes were determined at the point of discharge and at cells upstream and downstream of the point of discharge.

For the Lake Jesup facility, the absolute salinity changes ranged from greater than 2 ppt at the Lake Jesup site for the 50 MGD scenario down to around 0.1 ppt for the 3 MGD scenario. Due to the low baseline salinity conditions, the percent changes never drop below 10% and range from 200% for the 50 MGD scenario to 11% for the 3 MGD scenario.

For the Yankee Lake facility, the absolute salinity changes range from around 1.3 ppt to below 0.1 ppt. Once again, due to the low baseline salinity conditions, the percent changes range from 122% to 6%, with the percent changes below 10% for the 3 MGD operating condition.

When the two plants are operating simultaneously, the upstream plant (Lake Jesup) does not show any increase in the salinity changes from the case where it is operating alone. The downstream plant (Yankee Lake) does show some change in the impacts when the two facilities are operating simultaneously.

Analyses were also prepared for the 50 MGD water production scenarios with each of the individual plants operating alone and the plants running simultaneously. For these high water production scenarios, statistical analyses were presented along with an analysis of the potential for cumulative impacts within Lake Jesup. The cumulative impact analysis did not show long-term net impacts upon the lake even under the full 50 MGD scenario with both sites operating.

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