Final Report

Implementation Strategies Towards The Most Efficient Water Management:

The Lake Okeechobee WSE Operational Guidelines

The Operational Planning Core Team
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Overview

In the original documentation of the simulations of alternative operational schedules for Lake Okeechobee (Neidrauer, Trimble, and Santee, 1998), the climate-based operational guidelines as incorporated in the WSE operation schedule emerged as a highly desirable approach to Lake Okeechobee water management. However, even in recognizing its apparent advantages, many questions and concerns were raised by the operational staffs of the South Florida Water Management District and the United States Army Corps of Engineers on the details of how such a schedule could be implemented. It has always been the intent of the WSE Operational Schedule developers that the entire spectrum of hydrologic, meteorologic and climatic data and forecasts be considered when implementing the WSE Operational Schedule. However, for simplicity sake and resource limitations that existed at the time of development, only the current water level and a six-month inflow forecast were used in the initial simulation of the WSE Operational Schedule. Since the time of the original documentation entitled *Simulation of Alternative Operational Schedules for Lake Okecchobee* was published, the Planning Department staff has met on a regular basis with the operational staff of the Operations and Maintenance Department and that of the United States Army Corp of Engineers to develop a detailed operational plan that could be safely implemented. This report is the product of these meeting.

The purpose of this report is to lay out the more specific operational guidelines that will allow for the successful implementation of the WSE Operational Schedule. These guidelines are quite explicit as we enter this new era of 'flexible' operations and climate based operational strategies. However, the enormous responsibility associated with Lake Okeechobee water management is clearly recognized such that this new era must be entered with the appropriate amount of caution. Therefore, it is the intent of this report to lay out clear guidelines for day to day operations while realizing that it may be appropriate to 'hedge' from these guidelines when unique environmental and hydrologic conditions present themselves. This shifting or 'hedging' should be done only after careful hydrologic analysis which demonstrates that such actions are truly desirable. Although emphasis has been placed on the water supply and environmental objectives in the development of the WSE schedule, the design and implementation of this operational schedule was completed in such a manner that it will also be a more proficient flood protection schedule. This is accomplished by including the hydrology of the vast tributary basin as an integral part of the decision making process and defining windows of opportunity that climate forecasts may be applied for substantial benefits and with minimum risk if a forecasted climate regime fails to materialize.

Introduction

It has been illustrated with the application of the South Florida Water Management Model (SFWMM; South Florida Water Management District, 1998) that flexible climate-based operational rules can facilitate a higher degree of proficiency for satisfying Lake Okeechobee water management objectives. (Neidrauer, Trimble,and Santee, 1998). These results were derived by integrating climate-based six-month inflow forecasts within the operational guidelines of the Water Supply and Environmental (WSE) Operational Schedule. This Operational Schedule allows for the water supply requirements to be satisfied at least as effectively as the current operational schedule (aka Run 25) while reducing the stress of prolonged high water levels on the littoral zone. The health of the littoral zone was originally the foremost reason for the revaluation of Lake Okeechobee Regulation Schedule. However, the 1997-1998 El Nino event illustrated that further refinements of the current operational schedule were desirable to minimize the adverse impacts to the estuaries. By incorporating the climate-based hydrologic forecasts, in addition to relieving the stress on the littoral zone, the simulated number of discharge events that adversely impact the St. Lucie and Caloosahatchee estuaries collectively were decreased while hydroperiods for the Everglades were enhanced.

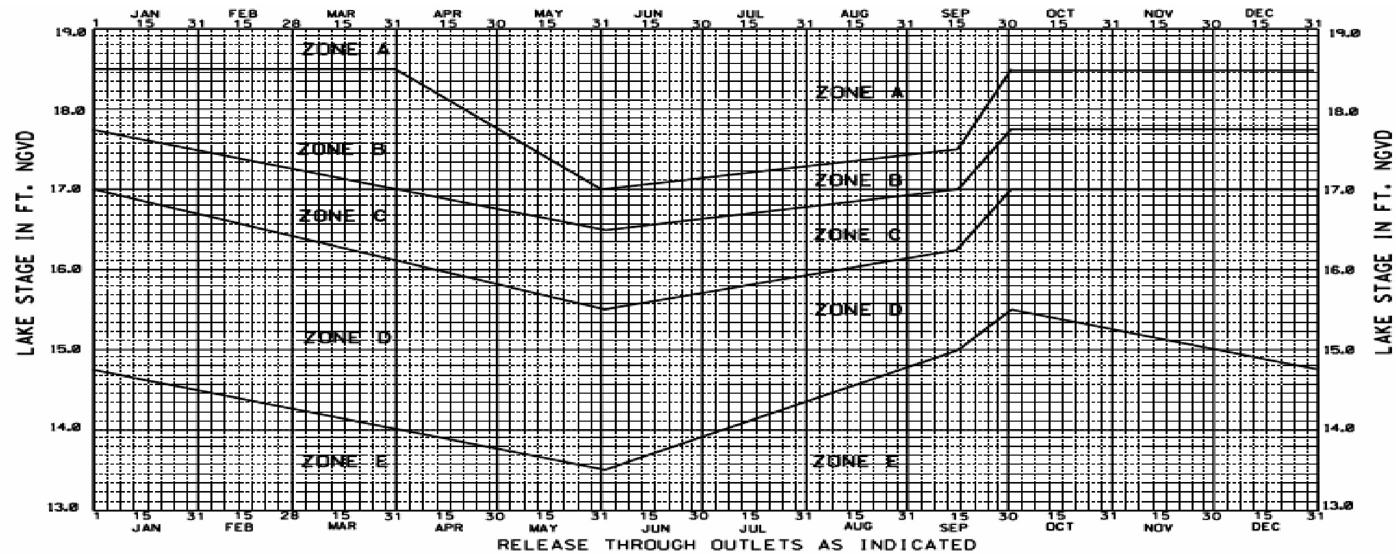
In the actual implementation of the WSE Operational Schedule, it is suggested that additional hydrologic data, and the recent advances in hydro-meteorologic and climatologic forecasting be directly incorporated into the Lake Okeechobee operational guidelines. This report presents the most basic guidelines for implementation of the WSE Operational Schedule. It is expected, as new advances in hydrologic forecasting, modeling and analysis become available, innovative strategies should be investigated to apply these tools within the realm of the WSE Operational Guidelines.

Essential WSE Operational Guidelines

Figure 1 illustrates the WSE Operational Schedule. This schedule promotes the amalgamation of our knowledge of the south Florida regional hydrologic system with that of the state and trends of the current global climate for operational proficiency. Figure 2a and 2b delineate detailed operational decision trees that will enable the successful implementation of the WSE schedule. Due to the approximate nature of extended climate forecasts, the extent of their application is proposed to be constrained by hydrologic conditions existing within the vast tributary basins. For example, it would not usually be deemed appropriate to only make minimum pulse releases in Zone B of the WSE Operational Schedule based on extended dry climate forecasts while very wet conditions exist in tributary basins and large inflows to the Lake are occurring. There will be times for 'hedging' from the basic WSE Operational Schedule implementation guidelines as unique hydrologic and/or environmental conditions present themselves in the future. However, even if no such hedging occurred, the WSE Operational Schedule is designed to lead to an advancement in operational proficiency by directly incorporating tributary hydrologic conditions and climate forecasts into the operational guidelines. In the following sub-sections the decision criteria (diamonds in the decision tree; Figure 2a and Figure 2b) are discussed in detail. These criteria may be considered the starting point from which to 'hedge' our operational decisions as unique hydrologic or environmental events present themselves.

Lake Okeechobee Water Level Criteria

Lake Okeechobee water levels should continue to be checked with a similar regularity as is procedure with the current operational schedule and at least as often as necessary to determine changes in the operational zone.



ZONE	AGRICULTURAL CANALS To WCAs (1.2)	CALOOSAHATCHEE RIVER AT S-77 (1.2.4)	ST. LUCIE CANAL AT S-80 (1.2.4)
A	PUMP MAXIMUM PRACTICABLE	UP TO MAXIMUM CAPACITY	UP TO MAXIMUM CAPACITY
B (3)	MAXIMUM PRACTICABLE RELEASES	RELEASES PER DECISION TREE (THESE CAN RANGE FROM MAXIMUM PULSE RELEASE UP TO MAXIMUM CAPACITY)	RELEASES PER DECISION TREE (THESE CAN RANGE FROM MAXIMUM PULSE RELEASE UP TO MAXIMUM CAPACITY)
C (3)	MAXIMUM PRACTICABLE RELEASES	RELEASES PER DECISION TREE (THESE CAN RANGE FROM NO DISCHARGE UP TO 6500 CFS)	RELEASES PER DECISION TREE (THESE CAN RANGE FROM NO DISCHARGE UP TO 3500 CFS)
D (3.5)	AS NEEDED TO MINIMIZE ADVERSE IMPACTS TO THE LITTORAL ZONE WHILE NOT ADVERSELY IMPACTING THE EVERGLADES. (SEE NOTE 5.)	RELEASES PER DECISION TREE (THESE CAN RANGE FROM NO DISCHARGE UP TO 4500 CFS)	RELEASES PER DECISION TREE (THESE CAN RANGE FROM NO DISCHARGE UP TO 2500 CFS)
E	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE

NOTES:
(1) SUBJECT TO FIRST REMOVAL OF RUNOFF FROM DOWNSTREAM BASINS
(2) GUIDELINES FOR WET, DRY AND NORMAL CONDITIONS ARE BASED ON: 1) SELECTED CLIMATIC INDICES AND TROPICAL FORECASTS AND 2) PROJECTED INFLOW CONDITIONS. RELEASES ARE SUBJECT TO THE GUIDELINES IN THE WSE OPERATIONAL DECISION TREE, PARTS 1 AND 2.
(3) RELEASES THROUGH VARIOUS OUTLETS MAY BE MODIFIED TO MINIMIZE DAMAGES OR OBTAIN ADDITIONAL BENEFITS. CONSULTATION WITH EVERGLADES AND ESTUARINE BIOLOGISTS IS ENCOURAGED TO MINIMIZE ADVERSE EFFECTS TO DOWNSTREAM ECOSYSTEMS.
(4) PULSE RELEASES ARE MADE TO MINIMIZE ADVERSE IMPACTS TO THE ESTUARIES
(5) ONLY WHEN THE WCAs ARE BELOW THEIR RESPECTIVE SCHEDULES

CENTRAL AND SOUTHERN FLORIDA
INTERIM REGULATION SCHEDULE
LAKE OKEECHOBEE

DEPARTMENT OF THE ARMY, JACKSONVILLE DISTRICT
CORPS OF ENGINEERS, JACKSONVILLE, FLORIDA
DATED: 5 NOVEMBER 1999

WSE (WITH CLIMATE OUTLOOK)

Figure 1. Proposed Regulation Schedule

Figure 2A. Operational Decision Tree

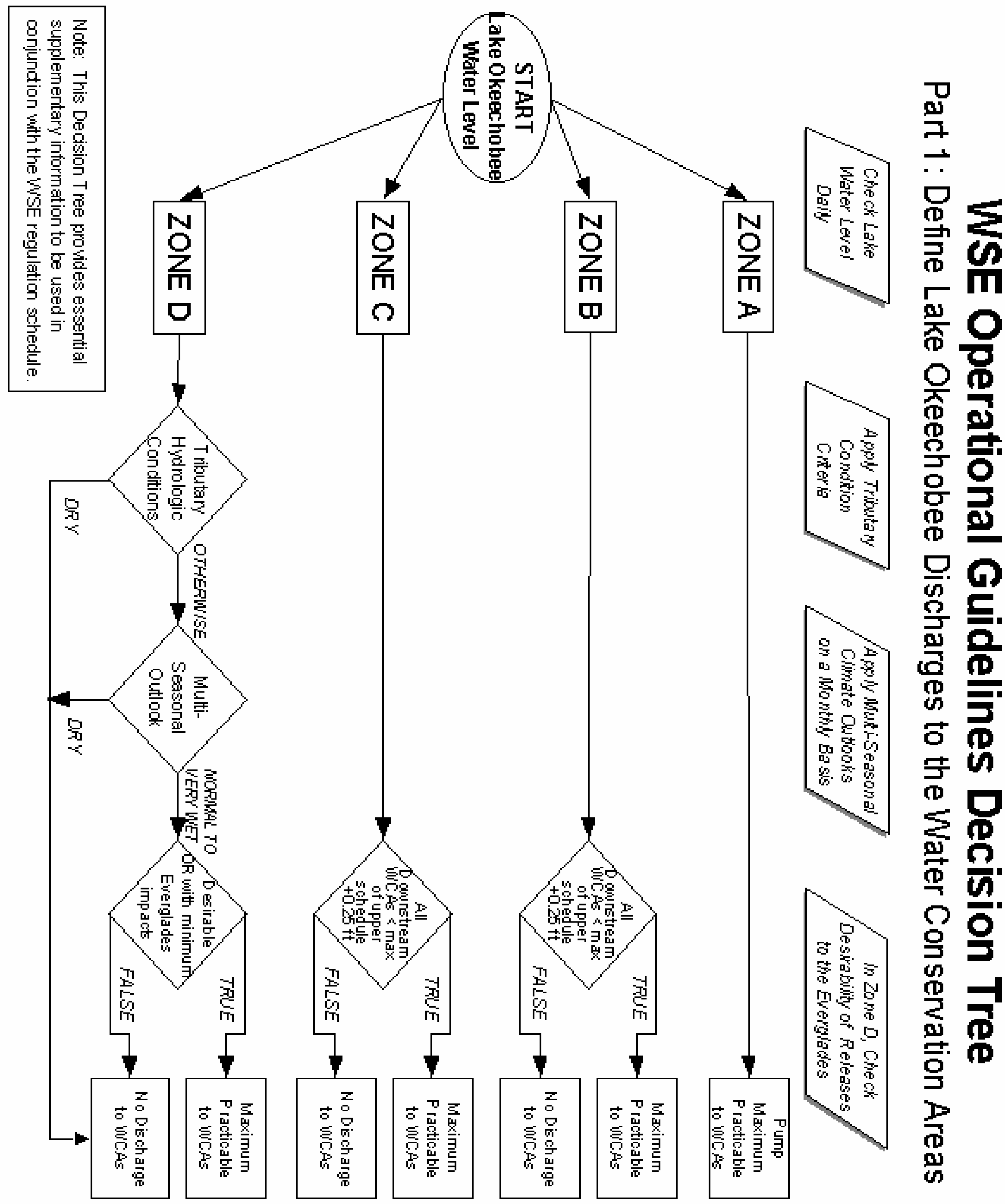
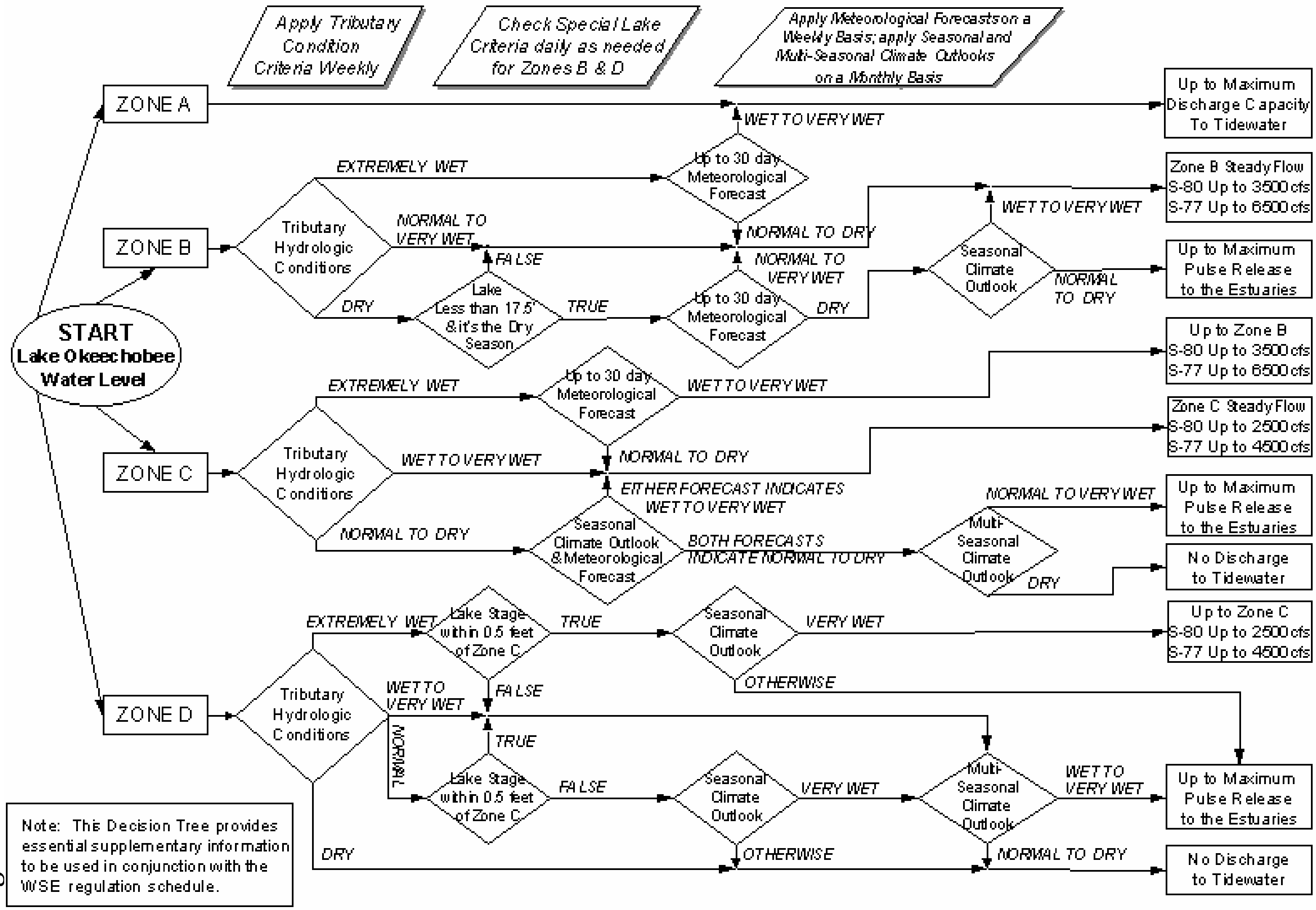


Figure 2b

WSE Operational Guidelines Decision Tree

Part 2: Define Lake Okeechobee Discharges to Tidewater (Estuaries)



Tributary Hydrologic Conditions

The majority of the Lake Okeechobee regulatory schedules prior to 1978 (USACE, Rules and Operating Criteria Master Regulation Manuals, 1978) included operational flexibility. This allowed for adjustments to be made in the timing and magnitude of Lake Okeechobee regulatory discharges based on conditions in the Lake tributary basins and extended meteorological outlooks. The implementation of the WSE Operational Schedule suggest that such considerations be re-emphasized. These conditions will be especially valuable for determining whether the appropriate window of opportunity exists to 'hedge' water management practices in order to take advantage of the recent advances in climate forecasting. Two measures of the tributary hydrologic conditions are included within the design of the operational decision tree: 1) regional excess or deficit of net rainfall (rainfall minus evapotranspiration) during the past four weeks and, 2) the average S-65E inflow for the past two weeks. Each measure should be updated each week.

Thirty-Day Net Rainfall

The merit of the regional net rainfall may be derived from the following data sets:

1. the monthly rainfall record from the National Climatic Data Center (NCDC) for the period 1895-1998, and
2. the monthly evapotranspiration which was estimated as being 75% of the standard project storm ET for the Kissimme River Basin (USACE, 1978).

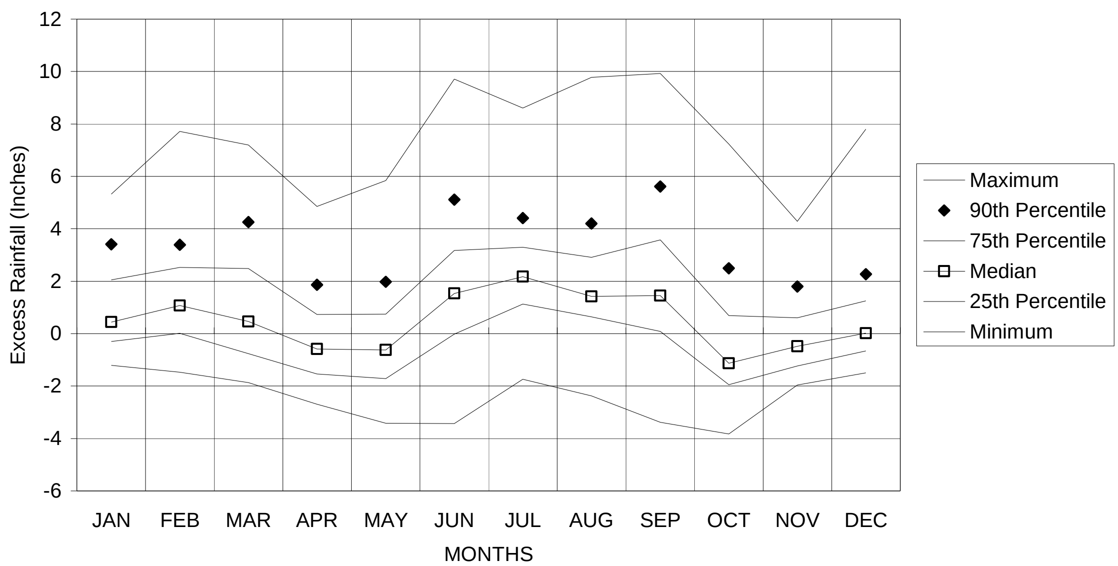
The net rainfall was computed by subtracting the monthly ET from the monthly rainfall for the period 1895 through May of 1998. The maximum, minimum, quartiles and 90th percentile of the net rainfall for each month is illustrated in Figure 3a. Figure 3b delineates the rainfall exceedance curve with all the months of the year being considered collectively. In the implementation of WSE schedule, it is recommended that the tributary rainfall data may be represented by averaging the upper and lower Kissimmee basins for the previous 30-day rainfall as made available in the South Florida Water Management District's (SFWMDs) daily weather report. The tributary basin ET may be represented as 60% of the long term daily average pan evaporation estimated at the Lake Alfred experimental station (on an annual average basis 60% of Lake Alfred Pan evaporation is equivalent to 75% of the standard project storm or about 44 inches per year). The net rainfall provides a valuable indicator of the regional hydrologic trends within the tributary basin during the past four weeks.

Two-Week Average S-65E Flow

The S-65E flow factors in the rainfall excesses or deficits that have accumulated within the Kissimmee tributary basins over periods of the past few days to periods for as long as several months. On average, S-65E flow represents between 35 to 50 percent of the structural inflows to Lake Okeechobee and thus is an additional effective regional hydrologic indicator of conditions in the tributary basin. Figure 4a and 4b summarize the statistics for the 14-day running average S-65E flow (the summary statistics consist of the maximum 14-day flow that occurred within each month) with a similar convention as was used for net rainfall. The period of record included in this analysis extends from 1930 through June of 1998. Sequential and ranked net rainfall and S-65E flows as computed for Figure 3 and Figure 4 are included in Appendices A, B, C and D, respectively.

Figure 3 Lake Okeechobee Tributary Net Rainfall Summary
Period of Analysis 1895-June 1998

a) Monthly Quartiles and 90th Percentile



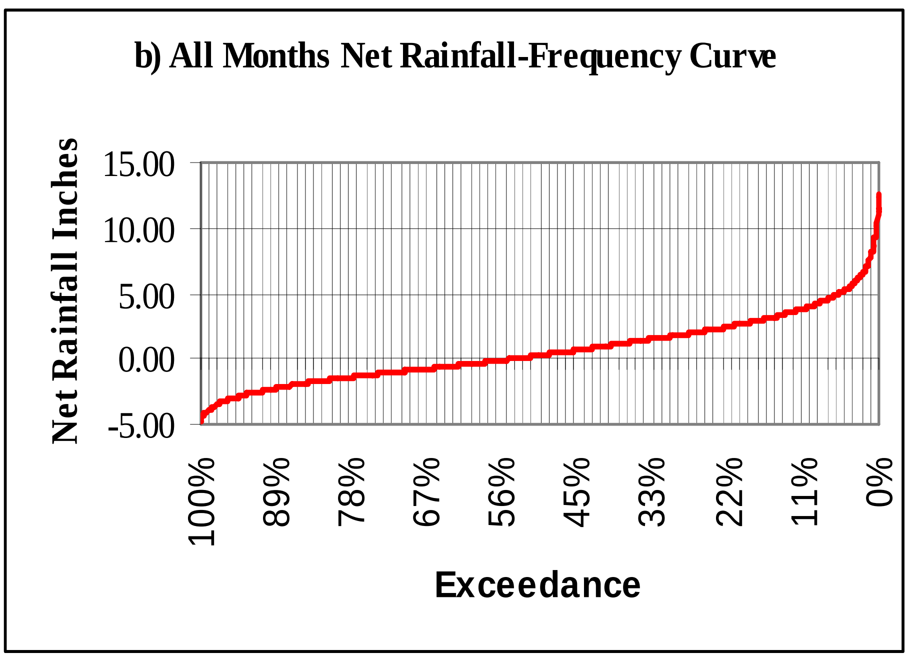
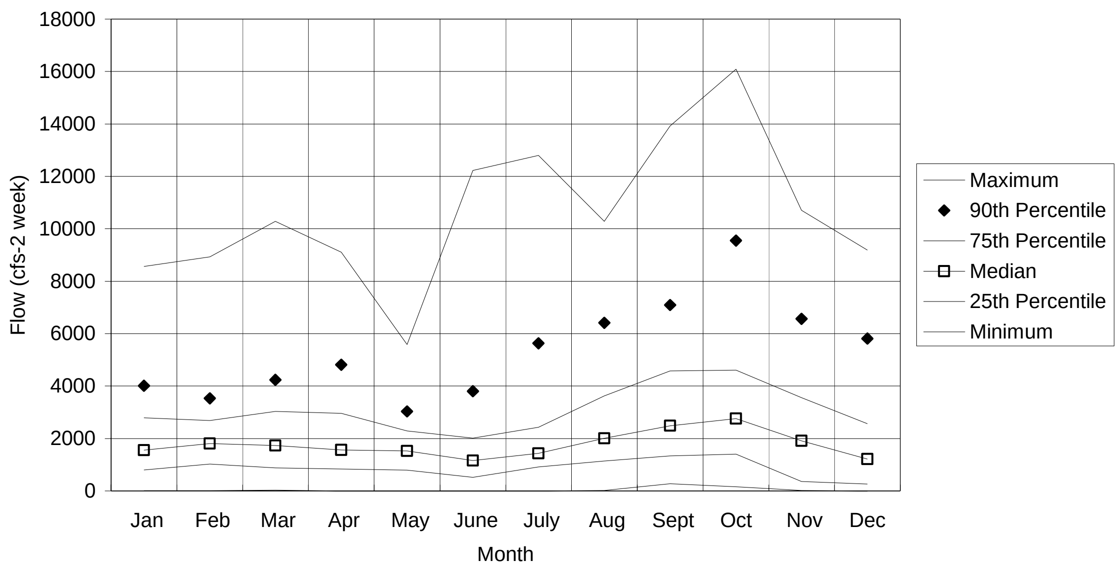
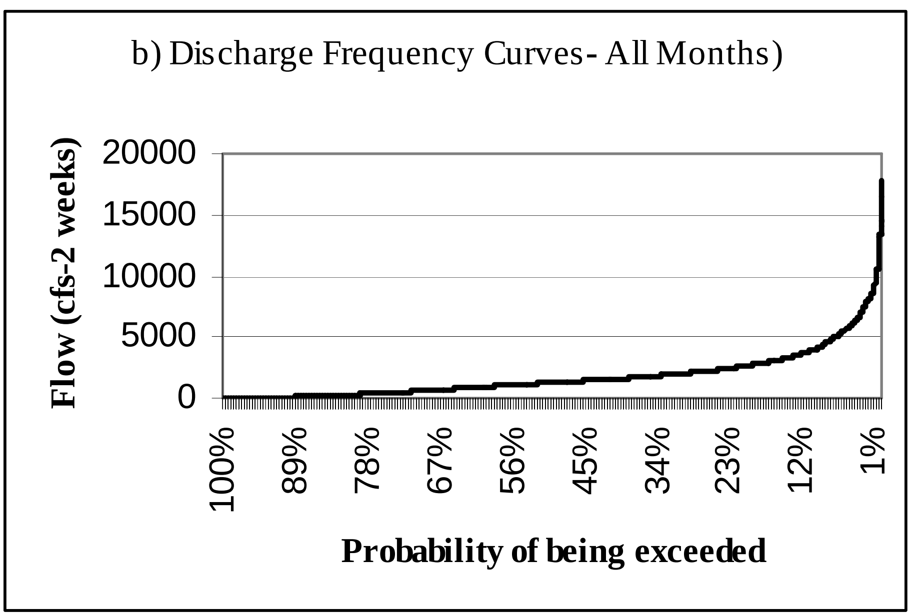


Figure 4. S-65E Maximum Monthly Flow
Period of Analysis January 1930-June 1998

a) Monthly Quartiles and 90th Percentile





Identifying Various Hydrologic Regimes

Table 1 summarizes the ranges of the net rainfall and two-week average flow as they were selected to represent the various hydrologic regimes. These ranges were based on: 1. an extensive review of the available hydrologic record for the period beginning in 1930 and extending through the El Nino period of 1997-1998 and 2. testing with the application of the South Florida Water Management Model to determine the best threshold values for meeting the regional hydrologic performance measures. In this respect, each hydrologic classification are not specifically related to the mean or variances of the regional hydrologic indicator.

The wettest classification of the two regional hydrologic indicators is selected to represent the hydrologic conditions in the tributary basin to ensure that flood protection criteria are being met. Therefore, if net rainfall indicates wet conditions but S-65E flow indicates normal conditions, the operational condition will be taken to be 'wet'. During extreme wet conditions it is desirable to check regional hydrologic conditions every day. When conditions become extremely wet, there may be significant advantages for flood protection and environmental considerations to increase flows above the maximum flows rates defined for a given zone. This type of action should be taken only after the appropriate consideration has been given to all the primary water management objectives. When considering drier than normal conditions, both measures of tributary moisture should indicate dry conditions before tributary hydrologic conditions are defined to be 'dry'. The tributary hydrologic indicators should be updated weekly with a new value being computed for net rainfall and for average S-65E inflow each week.

Table 1. Classification of Tributary Hydrologic Regimes (Check weekly)[1]

Tributary Condition	Net Rainfall (inches past 4 weeks)	S-65E Flows (cfs-2 week average)
Very Dry	less than -3.00	less than 500
Dry	-3.00 - -1.01	500 - 1499
Normal	-1.00 - 1.99	1500 - 3499
Wet	2.00 - 3.99	3500 - 5999
Very Wet	4.00 - 7.99	6000 - 8999
Extremely Wet	greater than 8.0	greater than 9000

[1] Wet conditions are defined by the wettest of these two indicators.

Summary of Historical Rankings

Table 2 provides supporting hydrologic data for the classifications selected in Table 1. This data includes the percentage of weeks a particular hydrologic regime occurs and the average tributary basin net rainfall, S-65E flow and Lake net inflow for each regime. From this table, it can be recognized that under normal to dry tributary conditions, the Lake water levels can most often be successfully regulated with releases southward to the Everglades and/or low impact pulse releases to tidewater. For wet to very wet tributary conditions, normally larger steady flow discharges to tidewater will be required to control the Lake level. While for extremely wet conditions, larger flows, up to maximum capacity, may be required to control the Lake water levels. The exact magnitude of discharge required to tidewater is dependent on the Lake water level, whether the seasonal Lake operational schedule is rising or falling, the conveyance capacity for delivering excess water to the WCAs, the desirability or impact such releases would have on the Everglades, and finally the temporal and spatial distribution of the rainfall.

Hydrologic Conditions during the 1997-1998 El Nino

The WSE operational guidelines were designed in part based on the events of the 1997-1998 El Nino. This period includes by far the wettest dry season in the 103 years of record available for the Lake tributary basin. Areal average net rainfall of about 22 inches occurred over the Lake's vast tributary basin during the period of November 1, 1997 through March 31, 1998. This excess rainfall was more than twice as large as the second largest event that occurred during the 1982-1983 El Nino (November-March period). The 1982-1983 event had a net rainfall which was equivalent to about 10 inches of rain averaged over the Lake tributary basin. The current operational schedule (Run 25) was designed to lessen the impacts of an El Nino event such as that which occurred during the dry season of 1982-1983 with the tools available at that time but not a dry season rainfall as extreme as the 1997-1998 event. Complicating matters for

Table 2. Percentage of weeks that fall within each of the hydrologic regimes (based on the period of January 1930 through June 1998)

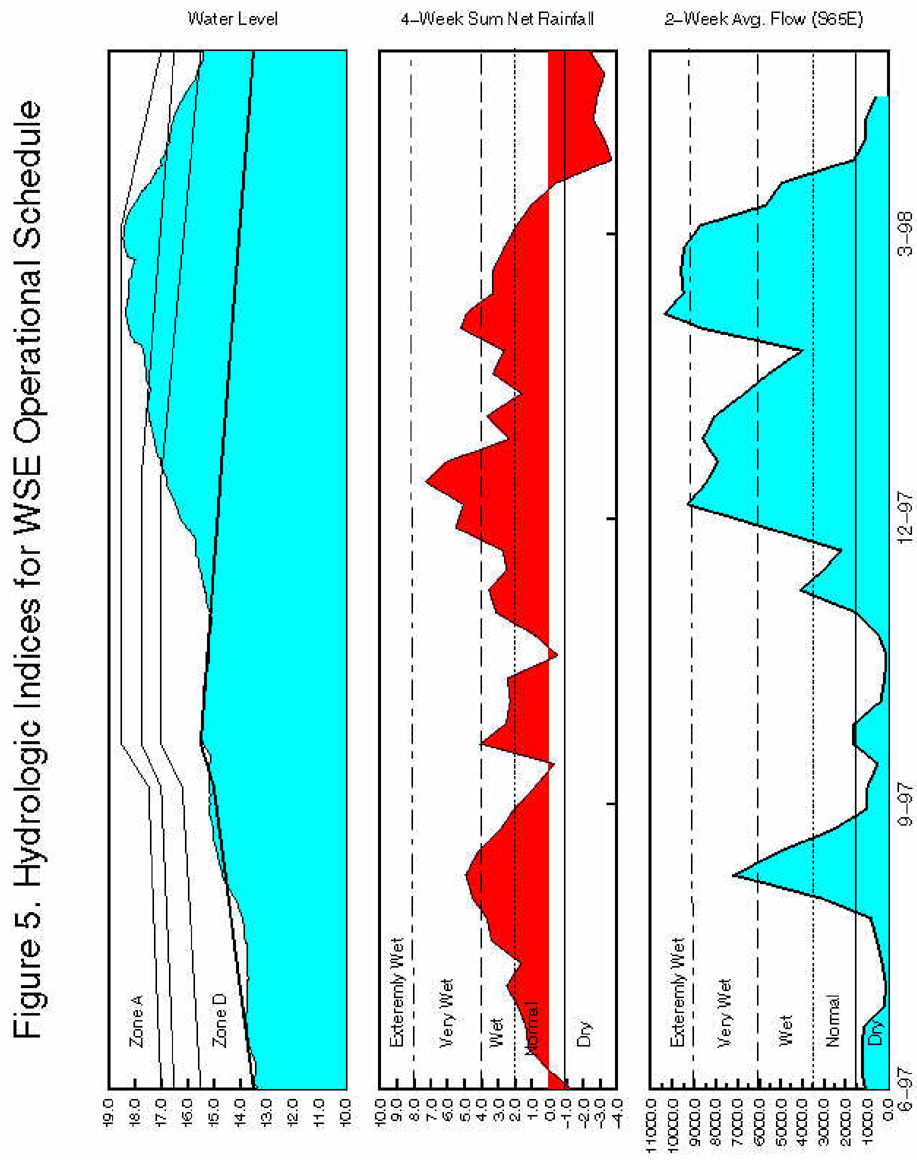
Tributary Conditions	Percent Occurrence	Average Net Rainfall (inches past 4 weeks)	Average S-65E Flow (cfs - 2 week average)	Average Net Lake Inflow (cfs - 2 week average)
Dry	21%	-2.2	580	1463
Normal	47%	0.1	1324	3236
Wet	19%	2.4	2344	5952
Very Wet	11%	4.7	3664	10007
Extremely Wet	2%	8.1	7929	16427

water management in south Florida was the fact that the last moderately strong El Nino (1991-1992) did not produce greater than normal rainfall. The WSE Operational Schedule would not recommend discharges during the 1991-1992 El Nino condition since the tributary basin remained relatively dry during this period. It does, however, allow for an earlier response at lower Lake levels during the 1997-1998 El Nino as the tributary conditions met the criteria of being 'very wet' by December 1997.

Figure 5 illustrates the Lake water levels relative to the WSE Operational Schedule during the 1997-1998 El Nino event. As the water levels in the Lake rose above the lowest line of the schedule in late November, net rainfall conditions already indicated the tributary basins were 'wet' and quickly becoming 'very wet'. This information, when combined with the Climate Prediction Center forecast for the likelihood of above normal rainfall, would have recommended the initiation of pulse releases to tidewater. Within the month of December of 1997, both net rainfall and S-65E flow conditions were indicative of 'extremely wet' conditions. During this period, while Lake water levels were in Zone D, it would have been desirable to initiate steady flow releases. Hydrologic conditions in the tributary basins remained extremely wet until the end of March. These conditions suggest that larger than the standard discharges in both Zones C and B would have been desirable in an attempt to decrease the duration of Zone A discharges. By mid-April, the tributary basins were in a drying state so that steady flow discharges were allowed to be reduced to pulse releases during the remainder of the dry season. A forecast of below normal rainfall for June of 1998 by the Climate Prediction Center and an increased potential for dry climate conditions for the 1998-1999 dry season suggested that it may be advantages to discontinue releases to tidewater during May, 1998. However, the passing of tropical storm Mitch in early November of 1998 eliminated potential advantages gained from this last action.

Another useful example of combining tributary hydrology with climate forecasts is the case of the spring and summer prior to a forecasted La Nina Year. During wet seasons months, based on the net rainfall computations for the tributary basins, conditions are normally classified as approaching or being wet during the period of June through September. However, during certain years the wet season may get a late start and/or never reach the normal wet conditions as defined in Table 1. Such combination of factors may lead to increased potential for drought especially if the following dry season is a La Nina year. Therefore, it may, at times, be desirable to discontinue or reduce regulatory discharges during the late spring months until the selected indicators suggest that a normal rainy season has begun. If conditions stay dry in the tributary basins, the Lake will decline to the desired levels by ET and water demands alone as the tropical season approaches. This will minimize impacts to the estuaries during a period of the year when large freshwater inflow are not normally desirable. This type of operational action should only be implemented in a way that ensures that Lake water levels does not exceed critical water levels during the peak of the hurricane season.

Figure 5. WSE Operational Schedule, Lake Level and Hydrologic Indices
1997-1998 El Nino



Special Lake Okeechobee Water Level Criteria

Three special Lake Okeechobee water level criteria are included in the operational decision tree. These criteria are as follows:

1. Pulse releases are only permitted to replace steady flow releases during the dry season and when the Lake is below 17.5 feet.

2. When the Lake water levels are in the upper portion of Zone D, within .5 feet of Zone C, and normal conditions exist in the tributary basin, the decision to make pulse releases should be based on multi-seasonal forecasts,

3. While water levels are in Zone D, steady flow discharges due to extremely wet tributary basins are only suggested if the Lake water levels are within .5 feet of Zone C.

Higher than desirable water levels in the WCAs should allow pulse releases to be made to tidewater at lower Lake levels while lower than desired water levels in the WCAs may preclude or lessen regulatory discharges being made to tidewater. This is particularly true while water levels are in Zone D.

Seasonal Climatic and Meteorologic Outlooks

Changnon (1982) discussed possible uses of long range climate forecasts in water resources at the International Symposium on Hydro-meteorology sponsored by the American Water Resources Division. Although at the time of his presentation, climate forecasts may not have reached the point where they could be generally applied in water resources, his insights towards desired lead times and accuracy of forecasts needed for particular water resources applications still appear valid today. Changnon's paper has been included in Appendix E for ease of reference. With the recent advances in climate forecasting, it appears, with the appropriate caution, that the time for including these forecasts in the framework of the operational guidelines has arrived.

Due to the intricate and vast nature of the C&SF Flood Control Project and the complex interactions of tropical and extra-tropical weather system that effect Florida's weather, it should not be expected that extended forecasts can be made to a very precise level of accuracy. However, with recent advances in climate prediction, it is now possible to predict with some level of confidence whether the upcoming season is likely to have above, below or near normal rainfall. Changnon indicated that certain longer term regional water resources operational planning decisions can be enhanced by applying climate forecasts that are classified into three such terciles. It is at this level of detail at which the official seasonal forecasts[2] from the National

[2]http://nic.fb4.noaa.gov:80/products/predictions/multi_season/13_seasonal_outlooks /color/index.html)

Center of Environmental Predictions, Climate Prediction Center (CPC) are to be referenced in this application.

The year is partitioned into two seasons:

1. wet season (May-October) and
2. dry season (November-April)

The 3 to 6 month climate forecasts should be applied to make probabilistic hydrologic forecasts for the for the remainder of the current season. In addition to climate forecasts, when lake water levels are in Zone C or higher, one to two week meteorologic forecasts should also be considered.

Multi-seasonal Climate Outlooks
Multi-seasonal outlooks are applied to determine when an increased possibility of extended periods of abnormal rainfall may occur either in the form of large inflows to the Lake or increased potential for drought. When applying multi-seasonal climate forecasts for operational planning, it is important that the cumulative hydrologic effects be considered.

Tables of Additional Tools and Measures for WSE Implementation

There are several useful measures and tools that are currently available for Lake Okeechobee operational decisions. One of the most valuable sets of tools may be the regional hydrologic models that are available within the Hydrologic Systems Modeling Division of the Planning Department. These models are summarized in Table 3. Table 4 list additional meteorological and climate forecasts that may be considered.

Table 3. Regional Hydrologic Models

Models	Description	Contact
Object-Oriented Routing Model (ORM).	This model is initialized with current water levels and simulates water levels for a period of several months up to two years into the future considering climatological events that have occurred in the past. It is most useful in making probabilistic forecasts of expectation and setting confidence levels for these hydrologic projections when the climatology of the current year can be identified with a select class of past climatological years. For example, the 1998-1999 projected La Nina conditions may suggest that only the past La Nina years be considered when determining the expected value and confidence levels of these projection. This type of application is often referred to as '**position analysis'**.	Cary White, Dr. Luis Cadavid, Dr. Jayantha Obeysekera and Randy Vanzee
South Florida Water Management Model (SFWMM)	This is the most well known regional hydrologic model. It's model domain includes from Lake Okeechobee, the Caloosahatchee River, and the St Lucie River Basins, southward through the Everglades and includes the Lower east Coast Developed Region. Currently this model is only applied for continuous simulation but may also be valuable tool if applied in the framework of position analysis	Dr. Luis Cadavid Paul Trimble Ray Santee
South Florida Regional Simulation Model (SFSRM)	This is the newest of the regional models that currently may be applied for the Everglades.	Randy Vanzee
Upper Kissimmee Lakes Model (UKISS)	This model simulates the Upper Kissimmee Lakes and may be useful for projecting flows through S-65 that will make their way through the Kissimmee River Basin to the Lake	Randy Vanzee

Table 4. Additional Climate Based Tools

Climate Tool	Description	Contact
Converting NOAAs Climate Forecasts to Statistical Hydrologic Forecasts	Thomas Croley (1996) presents an approach that applies historical hydrologic data together with the new long-lead climate forecasts, for making statistical hydrologic forecasts. The potential use of this methodology is currently under investigation by the Hydrologic Systems Modeling Division. Croley's paper appears in Appendix F.	Dr. Luis Cadavid Dr. Jayantha Obeysekera
Atlantic Ocean Thermohaline Current	Ongoing research of Colorado State University and the Atlantic Oceanographic and Meteorological Laboratory, have reported on cyclic decadal shifts of the Atlantic Ocean currents that significantly effect Climate regimes. within the Atlantic Ocean Basin. The most recent indicators of the phase of this ocean current indicates that Florida may expect much wetter conditions from June through October during the next few decades similar to those that were experienced during the decades of the 1930s, 1940s, 1950s and the 1960s.	Paul Trimble
Meteorological and Climatological Forecasts	SFWMD's Meteorological Forecasts	Geoff Shaughnessy, Eric P. Swartz
Solar Eruptive Activity and Secular Trends	Rainfall Activity seasonal to multi-seasonal prediction of shifts	Paul Trimble
Artificial Neural Networks, Intelligent Systems and other pattern recognition technology	Pattern recognition technology such as neural networks have provided another valuable tool for forecasting regional climate shifts for Florida that may best be explained by considering the state of El Nino, the Atlantic Ocean Thermohaline and solar activity together	Beheen Trimble Paul Trimble

Simulation of the WSE Implementation Plan

As a final step to this process, it is essential the detailed operational guidelines that were developed from this process are adequately tested. This is to ensure that they meet the regional water management objectives to a similar or greater level of proficiency as the original documented WSE simulation. This was accomplished with the application of the South Florida Water Management Model which was modified to incorporate the more detailed operational guidelines that are illustrated in Figure 2.

Baseline assumptions for this evaluation include:

1. Operation Schedule 25 (also referred to as Run 25),

2. 1995 infrastructure and water use levels,

3. Best Management Practices (BMPs) for the EAA,

4. BMP Replacement Water Rule is being applied,

5. 1995 Operational Schedules for the Water Conservation Areas,

6. Additional constraints put on discharging regulatory releases to the WCAs when the Lake water levels are Zone B or C,

In the original simulations of the alternative operational schedules it was assumed that discharges to a particular WCA were discontinued when that WCA exceeded the maximum of its upper most schedule by more than .25 feet. This rule has been refined to discontinue the discharges if a particular WCA or any of the WCAs downstream the WCA under consideration are more than .25 feet above their schedule. For WCA2A, the maximum of the current drawdown schedule replaced the WCA2A regulatory schedule when making the operational decision whether regulatory discharges should be made from the Lake to the WCAs.

Simulated Results

A complete set of the performance measures, as presented in the original documentation of the alternative Lake Okeechobee Operational Schedule evaluation, are including in Appendix G. These performance measures are limited to comparing the 1995 base condition to that of the proposed WSE operational schedule. Figure 6 illustrates a similar trade-off analysis as was presented in the original report. The WSE operational schedule illustrates similar favorable performance measure trends as was previously documented. These include: 1) a decrease by 3 in the undesirable Lake Okeechobee water level events for the Lake littoral zone, 2) an increase by approximately 4 percent of the Lake Okeechobee Service Area water supply needs being met during drought years, 3) improved hydro-pattern matches to the Natural System Figure 6

Model simulations within the WCAs, 4) a decrease in the number of times high discharge criteria were exceeded for the estuaries and 5) the simulated benefits for the estuaries and Everglades Hydroperiod. The benefits for the Everglades Hydroperiod appear to be reduced slightly due to the additional constraints that were discussed in the previous section for making regulatory releases to the WCAs. Finally, a crucial performance measure criterion is that for flood protection during the peak of the hurricane season. The number of days greater than 16.5 feet during the peak of the hurricane season (August 1-September 15th) was reduced from 47 days in the base condition to 6 days with the WSE Operational Schedule guidelines incorporated. The maximum water level for this same critical period of the year was reduced from 17.46 feet in the base condition to 16.91 feet with the WSE operational guidelines.

References

Neidrauer C.J., P.J. Trimble, E.R. Santee, Simulation of Alternative Operational Schedules for Lake Okeechobee, Hydrologic Systems Modeling Division, South Florida Water Management District, 1998

South Florida Water Management District, South Florida Water Management Model (SFWMM), 1998

Appendix A

Sequential Net Tributary Basin Rainfall
(inches)

Sequential Net Rainfall

1895	0.00	1.74	-0.40	1.41	0.00	-1.72	2.42	-0.30	0.41	-0.82	0.50	-0.58
1896	2.32	0.97	0.18	-2.48	-1.52	8.41	2.75	0.69	-0.09	-1.16	0.49	-0.22
1897	-0.05	4.11	-1.19	1.28	-1.67	0.51	2.04	1.25	8.41	-0.18	-0.43	0.49
1898	-1.13	0.65	-0.86	-2.16	-2.46	-2.71	3.41	7.86	0.04	0.18	-0.79	1.51
1899	2.64	4.09	-0.79	0.65	-3.16	1.55	4.37	1.25	1.31	1.39	-1.70	-0.19
1900	1.80	2.03	4.39	0.45	-0.03	2.62	2.50	-1.03	-0.43	0.69	-1.51	1.49
1901	0.10	2.64	2.80	-1.29	-0.48	6.99	1.62	5.13	3.58	-2.53	-1.32	-0.19
1902	-0.97	2.72	1.22	-1.37	-1.82	2.04	0.26	-0.99	4.92	0.71	0.50	1.04
1903	3.98	3.39	2.95	-2.67	0.15	1.15	1.79	1.34	3.73	-2.95	0.39	-0.25
1904	3.70	1.26	-0.55	-1.01	-1.68	2.47	1.29	1.56	0.26	1.20	0.44	-0.39
1905	-0.10	1.07	1.73	-0.58	1.13	-0.33	3.18	7.82	3.58	-1.95	-1.50	3.68
1906	2.05	1.29	0.06	-1.33	2.81	2.89	4.00	2.12	-2.00	-2.17	-1.18	-1.19
1907	-0.77	-0.64	-1.50	-0.32	0.18	1.58	2.79	0.65	3.04	-2.74	-0.75	2.68
1908	1.11	-0.04	-1.73	-0.69	-1.85	1.97	1.46	1.42	5.67	-1.39	-0.30	-1.23
1909	0.08	-0.63	-0.34	-0.78	-0.44	0.28	6.90	2.80	-0.82	-2.51	-1.33	0.35
1910	-0.70	1.54	0.18	-2.01	-2.05	4.96	2.34	4.24	-1.78	5.01	-0.43	-1.04
1911	-0.36	-1.47	0.23	-1.71	0.60	-0.30	0.90	3.86	-0.83	-0.32	1.49	1.40
1912	3.46	1.09	0.69	-0.05	1.63	8.66	0.29	0.04	5.14	-0.51	0.49	0.05
1913	0.15	3.14	2.34	-0.70	-1.06	-0.14	-0.01	1.82	-0.53	-1.84	-1.18	1.07
1914	3.05	3.34	-0.62	-0.67	-2.23	-1.26	0.95	-0.46	2.13	-1.54	-0.07	1.75
1915	3.48	2.20	0.55	-1.16	1.38	0.01	2.38	1.43	-0.53	1.54	0.23	0.01
1916	-0.36	-0.93	-1.17	-0.55	-0.41	1.66	0.27	0.97	0.40	-0.41	1.52	2.38
1917	-1.05	-0.42	-1.24	-1.61	-1.61	0.51	1.34	2.47	1.78	-1.57	-1.71	-0.41
1918	0.73	-1.01	0.87	1.89	-1.72	-0.21	0.43	0.34	1.23	0.81	0.58	0.68
1919	-0.02	2.89	2.74	-0.56	2.11	2.05	3.24	1.12	0.86	-2.49	1.12	0.11
1920	0.40	3.97	-1.65	2.13	0.60	1.37	1.98	0.40	3.63	-2.49	1.39	0.61
1921	-0.63	-0.33	-0.34	-1.47	1.65	-1.43	3.30	-1.60	-3.16	5.15	-0.11	0.28
1922	0.16	0.72	-0.94	-2.42	2.81	1.23	1.80	3.52	3.81	3.63	-0.58	0.23
1923	-0.44	-0.48	-0.51	-1.09	4.14	5.12	2.08	1.20	0.42	-0.38	-1.81	-0.85
1924	2.12	1.61	3.98	-0.49	-1.32	1.00	5.26	-1.25	4.29	7.24	-1.66	-0.41
1925	1.25	0.56	-0.17	-1.19	2.02	2.20	2.46	2.18	-2.80	-2.02	1.23	3.18
1926	3.35	0.31	1.70	1.87	-1.41	3.78	4.38	3.19	2.55	-1.77	0.50	-1.22
1927	-1.09	1.77	0.05	-1.53	-3.42	1.89	1.88	1.00	-0.41	-0.67	-1.05	-0.31
1928	-0.91	1.18	1.79	3.41	-0.81	-0.06	2.16	3.98	7.98	-1.46	-1.50	-0.47
1929	1.09	-0.71	-0.87	0.28	0.23	3.13	3.69	1.46	5.78	-1.75	-1.38	0.57
1930	1.46	1.77	5.06	0.56	-0.20	8.61	-0.90	-1.04	3.02	-1.84	0.57	1.74
1931	1.79	0.20	3.28	3.30	-0.50	-3.43	1.08	0.69	1.98	-2.09	-1.88	0.02
1932	-0.30	-0.99	0.64	-1.99	1.42	2.72	-1.74	4.83	0.52	-1.67	0.92	-1.48
1933	-0.12	1.54	0.76	3.42	-1.25	1.76	6.00	0.94	7.04	-0.94	-0.71	-1.50
1934	0.25	2.04	0.67	1.94	1.98	7.93	2.18	-0.85	1.08	-1.79	-1.57	-1.04
1935	-0.73	0.03	-1.67	1.12	-1.14	0.17	3.04	2.67	5.62	-1.59	-1.04	1.39
1936	2.71	6.45	1.17	-1.30	0.04	2.89	1.10	0.51	1.64	0.49	-0.28	-0.03
1937	-0.34	4.52	1.71	1.50	-0.82	0.91	3.10	2.59	-0.54	0.98	2.54	-0.73
1938	0.09	0.01	-0.80	-2.20	-0.61	1.54	3.69	-2.38	0.94	2.71	-0.77	-1.47
1939	-0.34	-0.77	-0.82	1.32	1.97	6.41	2.86	7.34	0.81	-1.36	-1.24	-0.60
1940	2.16	2.64	1.59	-0.76	-2.36	0.97	1.73	1.84	2.50	-3.78	-1.96	2.61
1941	2.83	2.07	0.87	2.70	-3.02	1.95	4.97	-0.43	1.13	-0.44	1.80	2.55
1942	1.45	2.65	3.06	0.10	-0.62	4.61	0.02	-0.11	0.54	-3.82	-1.69	1.25
1943	-0.45	-0.57	2.49	-1.11	0.44	4.65	4.94	3.34	1.04	-0.84	-0.72	-1.16
1944	0.02	-0.99	2.29	-0.14	-1.40	1.40	2.04	1.11	-1.15	2.56	-1.54	-1.36
1945	1.70	-1.17	-1.83	-1.10	-3.02	8.25	6.37	2.20	3.90	0.21	-0.78	1.23
1946	0.44	2.05	-0.53	-2.44	1.96	1.61	3.55	0.96	1.46	-1.22	-0.58	-0.91
1947	-0.16	2.65	4.37	1.45	0.23	4.10	4.24	2.54	8.13	-0.09	1.41	-0.07
1948	4.83	-0.60	0.54	1.02	-1.42	-2.52	4.77	3.17	6.40	-1.28	-0.83	0.07
1949	-0.98	-0.63	-1.31	0.09	-2.24	3.18	1.13	9.78	3.86	-1.78	-0.53	0.55
1950	-1.21	-0.97	1.09	-0.71	-1.80	-0.92	2.40	1.03	3.31	2.33	-1.27	1.59
1951	-0.92	0.85	-0.73	4.85	-2.51	-0.86	2.84	1.10	2.83	-0.16	1.91	-0.34
1952	-0.10	3.21	2.90	-1.72	-0.62	-1.83	2.13	1.80	0.48	5.15	-0.49	-0.59
1953	1.49	1.33	1.36	1.82	-3.03	4.67	1.90	3.69	6.15	1.69	3.19	2.14
1954	0.04	0.41	-0.66	1.14	1.70	2.42	2.71	-0.03	2.03	-1.53	1.48	-0.26

1955	1.07	0.17	0.12	-0.85	-1.75	0.55	2.25	1.11	0.90	-1.41	-0.67	-0.12
1956	-0.27	-0.17	-1.87	-0.03	-0.74	-1.12	0.37	1.48	1.58	3.29	-1.59	-1.30
1957	0.87	2.53	2.68	3.76	3.38	1.40	3.22	3.65	4.17	-1.12	-0.45	0.76
1958	5.32	1.78	3.75	0.56	-0.14	-0.00	0.29	0.30	-0.63	0.41	-0.48	2.24
1959	1.99	1.39	7.20	0.79	2.37	4.79	2.60	3.75	3.60	3.72	-0.31	0.30
1960	-0.27	3.39	5.82	0.61	-1.34	1.00	8.61	0.65	9.93	-0.84	-1.61	-0.47
1961	1.21	0.99	0.07	-0.53	-0.04	-0.66	-0.16	2.07	-2.07	-2.78	-1.09	-0.18
1962	-0.06	-0.38	1.21	-0.29	-1.31	4.36	0.79	4.21	4.73	-3.04	0.52	-1.17
1963	0.77	5.55	-0.36	-2.48	1.39	1.07	1.58	-0.25	3.28	-3.01	3.34	1.47
1964	2.56	3.57	0.88	-1.14	-0.93	-0.95	1.73	2.10	1.35	-1.82	-1.23	0.37
1965	-0.12	2.30	0.75	-1.21	-3.33	2.95	5.37	1.12	0.97	-0.28	-1.09	0.42
1966	3.86	2.87	-0.77	-0.46	-0.13	4.03	1.32	1.57	1.09	-1.60	-1.60	-0.66
1967	-0.26	2.34	-1.45	-2.68	-2.97	2.52	2.87	4.82	-0.26	-1.96	-1.71	0.64
1968	-0.83	0.48	-1.20	-2.09	1.56	9.04	3.16	0.61	0.65	0.66	0.75	-1.21
1969	1.21	0.24	4.59	-1.54	0.64	1.07	1.45	3.84	2.42	2.50	0.61	2.33
1970	2.07	1.38	4.24	-2.38	0.55	-0.48	0.77	0.65	0.67	-1.44	-1.27	-0.91
1971	-0.78	2.52	-0.84	-1.96	-0.87	0.07	2.41	2.92	1.87	1.19	-0.20	-0.08
1972	-0.22	3.49	0.47	-1.05	-0.20	2.79	-1.44	1.87	-3.39	-1.62	1.98	0.82
1973	4.12	0.77	1.15	0.65	-1.30	-0.02	4.05	1.87	2.72	-2.36	-0.72	1.23
1974	-0.76	-0.12	-0.98	-1.68	-0.71	8.53	3.76	1.71	0.81	-3.61	-1.51	0.70
1975	-0.47	0.78	-1.00	-1.89	1.37	1.09	3.05	0.93	2.64	1.15	-1.10	-0.98
1976	-0.73	-0.81	-1.09	-0.92	4.51	2.77	0.48	1.04	1.91	-2.75	0.08	0.61
1977	0.95	0.41	-1.42	-2.24	-1.27	-0.11	2.00	2.11	2.00	-2.43	0.98	2.51
1978	1.48	2.49	0.60	-2.26	0.81	2.27	4.25	0.42	-1.00	-1.94	-1.22	2.21
1979	5.07	0.13	-0.13	-1.36	5.84	-1.39	0.71	3.13	9.05	-3.42	-0.40	0.35
1980	1.55	1.07	0.04	0.74	0.65	-1.12	0.96	0.17	-0.18	-2.61	1.83	-0.66
1981	-0.80	2.19	-1.02	-2.69	-1.79	1.97	-0.42	6.18	0.47	-2.96	-0.35	0.06
1982	0.28	0.99	4.26	1.07	1.92	5.07	2.42	1.32	3.96	-0.89	0.21	-0.63
1983	1.51	7.71	4.60	-0.47	-1.90	1.70	1.14	2.39	1.65	1.09	0.61	4.03
1984	-0.07	1.84	0.67	-0.49	0.74	-1.13	3.70	0.54	0.09	-3.21	1.76	-1.23
1985	-0.08	-0.55	0.24	-0.30	-2.16	1.02	1.68	2.40	2.91	-1.15	-0.34	-0.06
1986	1.64	0.42	2.20	-2.25	-2.17	4.16	1.38	1.89	-0.52	2.16	-0.54	1.67
1987	1.47	0.34	6.94	-2.41	0.26	0.17	1.60	-0.60	1.05	-0.20	4.29	-1.30
1988	1.84	0.80	2.89	-1.57	-1.20	-1.22	2.83	3.17	3.20	-3.14	2.81	-0.42
1989	1.12	-1.05	0.42	-0.48	-2.46	0.86	1.39	0.86	2.61	-1.13	-0.60	2.27
1990	-0.67	2.17	-1.12	-1.12	-1.22	1.23	3.65	1.90	-0.49	-0.30	-0.87	-1.05
1991	2.49	0.31	2.64	1.83	3.18	1.40	5.26	1.16	-1.14	-1.17	-1.44	-1.16
1992	0.05	2.73	-0.41	1.01	-2.73	9.71	-1.10	3.71	1.05	-1.28	1.47	-0.76
1993	4.96	1.04	3.31	0.70	-1.25	-1.73	-0.01	0.93	1.03	1.23	-0.88	-0.54
1994	2.69	0.98	-0.11	0.70	-1.85	3.65	1.92	2.74	5.03	-0.08	1.98	1.96
1995	1.34	0.77	-0.01	0.50	-1.93	4.50	4.41	5.84	2.30	3.68	-0.19	-1.00
1996	3.41	0.34	4.70	-0.66	0.44	2.64	-0.93	-0.04	-0.19	0.20	-1.23	0.66
1997	0.58	-0.07	-0.08	4.33	-0.95	0.92	2.53	1.10	2.91	-1.13	3.68	7.80
1998	1.30	4.93	2.35	-3.15	-2.06	-1.12	-999	-999	-999	-999	-999	-999

Appendix B

Ranked Net Tributary Basin Rainfall
(inches)

Ranked Net Rainfall

January		February		March		April		May		June		July		August		September		October		November		December	
1958	5.32	1983	7.71	1959	7.20	1951	4.85	1979	5.84	1992	9.71	1960	8.61	1949	9.78	1960	9.93	1924	7.24	1987	4.29	1997	7.80
1979	5.07	1936	6.45	1987	6.94	1997	4.33	1976	4.51	1968	9.04	1909	6.90	1898	7.86	1979	9.05	1921	5.15	1997	3.68	1983	4.03
1993	4.96	1998	6.40	1960	5.82	1957	3.76	1923	4.14	1912	8.66	1945	6.37	1905	7.82	1897	8.41	1952	5.15	1963	3.34	1905	3.68
1948	4.83	1963	5.55	1930	5.06	1933	3.42	1957	3.38	1930	8.61	1933	6.00	1939	7.34	1947	8.13	1910	5.01	1953	3.19	1925	3.18
1973	4.12	1937	4.52	1996	4.70	1928	3.41	1991	3.18	1974	8.53	1965	5.37	1981	6.18	1928	7.98	1959	3.72	1988	2.81	1907	2.68
1903	3.98	1897	4.11	1983	4.60	1931	3.30	1906	2.81	1896	8.41	1924	5.26	1995	5.84	1933	7.04	1995	3.68	1937	2.54	1940	2.61
1966	3.86	1899	4.09	1969	4.59	1941	2.70	1922	2.81	1945	8.25	1991	5.26	1901	5.13	1948	6.40	1922	3.63	1972	1.98	1941	2.55
1904	3.70	1920	3.97	1900	4.39	1920	2.13	1959	2.37	1934	7.93	1941	4.97	1932	4.83	1953	6.15	1956	3.29	1994	1.98	1977	2.51
1915	3.48	1964	3.57	1947	4.37	1934	1.94	1919	2.11	1901	6.99	1943	4.94	1967	4.82	1929	5.78	1938	2.71	1951	1.91	1916	2.38
1912	3.46	1972	3.49	1998	4.27	1918	1.89	1925	2.02	1939	6.41	1948	4.77	1910	4.24	1908	5.67	1944	2.56	1980	1.83	1969	2.33
1996	3.41	1903	3.39	1982	4.26	1926	1.87	1934	1.98	1923	5.12	1995	4.41	1962	4.21	1935	5.62	1969	2.50	1941	1.80	1989	2.27
1926	3.35	1960	3.39	1970	4.24	1991	1.83	1939	1.97	1982	5.07	1926	4.38	1928	3.98	1912	5.14	1950	2.33	1984	1.76	1958	2.24
1998	3.26	1914	3.34	1924	3.98	1953	1.82	1946	1.96	1910	4.96	1899	4.37	1911	3.86	1994	5.03	1986	2.16	1916	1.52	1978	2.21
1914	3.05	1952	3.21	1958	3.75	1937	1.50	1982	1.92	1959	4.79	1978	4.25	1969	3.84	1902	4.92	1953	1.69	1911	1.49	1953	2.14
1941	2.83	1913	3.14	1993	3.31	1947	1.45	1954	1.70	1953	4.67	1947	4.24	1959	3.75	1962	4.73	1915	1.54	1954	1.48	1994	1.96
1936	2.71	1919	2.89	1931	3.28	1895	1.41	1921	1.65	1943	4.65	1973	4.05	1992	3.71	1924	4.29	1899	1.39	1992	1.47	1914	1.75
1994	2.69	1966	2.87	1942	3.06	1939	1.32	1912	1.63	1942	4.61	1906	4.00	1953	3.69	1957	4.17	1993	1.23	1947	1.41	1930	1.74
1899	2.64	1992	2.73	1903	2.95	1897	1.28	1968	1.56	1995	4.50	1974	3.76	1957	3.65	1982	3.96	1904	1.20	1920	1.39	1986	1.67
1964	2.56	1902	2.72	1952	2.90	1954	1.14	1932	1.42	1962	4.36	1984	3.70	1922	3.52	1945	3.90	1971	1.19	1925	1.23	1950	1.59
1991	2.49	1942	2.65	1988	2.89	1935	1.12	1963	1.39	1986	4.16	1938	3.69	1943	3.34	1949	3.86	1975	1.15	1919	1.12	1898	1.51
1896	2.32	1947	2.65	1901	2.80	1982	1.07	1915	1.38	1947	4.10	1929	3.69	1926	3.19	1922	3.81	1983	1.09	1977	0.98	1900	1.49
1940	2.16	1901	2.64	1919	2.74	1948	1.02	1975	1.37	1966	4.03	1990	3.65	1988	3.17	1903	3.73	1937	0.98	1932	0.92	1963	1.47
1924	2.12	1940	2.64	1957	2.68	1992	1.01	1905	1.13	1926	3.78	1946	3.55	1948	3.17	1920	3.63	1918	0.81	1968	0.75	1911	1.40
1970	2.07	1957	2.53	1991	2.64	1959	0.79	1978	0.81	1994	3.65	1898	3.41	1979	3.13	1959	3.60	1902	0.71	1969	0.61	1935	1.39
1906	2.05	1971	2.52	1943	2.49	1980	0.74	1984	0.74	1949	3.18	1921	3.30	1971	2.92	1901	3.58	1900	0.69	1983	0.61	1942	1.25
1959	1.99	1978	2.49	1913	2.34	1994	0.70	1980	0.65	1929	3.13	1919	3.24	1909	2.80	1905	3.58	1968	0.66	1918	0.58	1945	1.23
1988	1.84	1967	2.34	1944	2.29	1993	0.70	1969	0.64	1965	2.95	1957	3.22	1994	2.74	1950	3.31	1936	0.49	1930	0.57	1973	1.23
1900	1.80	1965	2.30	1986	2.20	1899	0.65	1911	0.60	1936	2.89	1905	3.18	1935	2.67	1963	3.28	1958	0.41	1962	0.52	1913	1.07
1931	1.79	1915	2.20	1928	1.79	1973	0.65	1920	0.60	1906	2.89	1968	3.16	1937	2.59	1988	3.20	1945	0.21	1926	0.50	1902	1.04
1945	1.70	1981	2.19	1905	1.73	1960	0.61	1970	0.55	1972	2.79	1937	3.10	1947	2.54	1907	3.04	1996	0.20	1895	0.50	1972	0.82
1986	1.64	1990	2.17	1937	1.71	1930	0.56	1943	0.44	1976	2.77	1975	3.05	1917	2.47	1930	3.02	1898	0.18	1902	0.50	1957	0.76
1980	1.55	1941	2.07	1926	1.70	1958	0.56	1996	0.44	1932	2.72	1935	3.04	1985	2.40	1997	2.91	1994	-0.08	1912	0.49	1974	0.70
1983	1.51	1946	2.05	1940	1.59	1995	0.50	1987	0.26	1996	2.64	1967	2.87	1983	2.39	1985	2.91	1947	-0.09	1896	0.49	1918	0.68
1953	1.49	1934	2.04	1953	1.36	1900	0.45	1947	0.23	1900	2.62	1939	2.86	1945	2.20	1951	2.83	1951	-0.16	1904	0.44	1996	0.66
1978	1.48	1900	2.03	1902	1.22	1929	0.28	1929	0.23	1967	2.52	1951	2.84	1925	2.18	1973	2.72	1897	-0.18	1903	0.39	1967	0.64
1987	1.47	1984	1.84	1962	1.21	1942	0.10	1907	0.18	1904	2.47	1988	2.83	1906	2.12	1975	2.64	1987	-0.20	1915	0.23	1976	0.61
1930	1.46	1958	1.78	1936	1.17	1949	0.09	1903	0.15	1954	2.42	1907	2.79	1977	2.11	1989	2.61	1965	-0.28	1982	0.21	1920	0.61
1942	1.45	1930	1.77	1973	1.15	1956	-0.03	1936	0.04	1978	2.27	1998	2.77	1964	2.10	1926	2.55	1990	-0.30	1976	0.08	1929	0.57
1995	1.34	1927	1.77	1950	1.09	1912	-0.05	1895	0.00	1925	2.20	1896	2.75	1961	2.07	1940	2.50	1911	-0.32	1914	-0.07	1949	0.55
1925	1.25	1895	1.74	1964	0.88	1944	-0.14	1900	-0.03	1919	2.05	1954	2.71	1990	1.90	1969	2.42	1923	-0.38	1921	-0.11	1897	0.49
1961	1.21	1924	1.61	1941	0.87	1962	-0.29	1961	-0.04	1902	2.04	1959	2.60	1986	1.89	1995	2.30	1916	-0.41	1995	-0.19	1965	0.42
1969	1.21	1933	1.54	1918	0.87	1985	-0.30	1966	-0.13	1908	1.97	1997	2.53	1973	1.87	1914	2.13	1941	-0.44	1971	-0.20	1964	0.37
1989	1.12	1910	1.54	1933	0.76	1907	-0.32	1958	-0.14	1981	1.97	1900	2.50	1972	1.87	1954	2.03	1912	-0.51	1936	-0.28	1979	0.35
1908	1.11	1959	1.39	1965	0.75	1966	-0.46	1930	-0.20	1941	1.95	1925	2.46	1940	1.84	1977	2.00	1927	-0.67	1908	-0.30	1909	0.35
1929	1.09	1970	1.38	1912	0.69	1983	-0.47	1972	-0.20	1927	1.89	1982	2.42	1913	1.82	1931	1.98	1895	-0.82	1959	-0.31	1959	0.30
1955	1.07	1953	1.33	1934	0.67	1989	-0.48	1916	-0.41	1933	1.76	1895	2.42	1952	1.80	1976	1.91	1943	-0.84	1985	-0.34	1921	0.28
1977	0.95	1906	1.29	1984	0.67	1924	-0.49	1909	-0.44	1983	1.70	1971	2.41	1974	1.71	1971	1.87	1960	-0.84	1981	-0.35	1922	0.23
1957	0.87	1904	1.26	1932	0.64	1984	-0.49	1901	-0.48	1916	1.66	1950	2.40	1966	1.57	1917	1.78	1982	-0.89	1979	-0.40	1919	0.11
1963	0.77	1928	1.18	1978	0.60	1961	-0.53	1931	-0.50	1946	1.61	1915	2.38	1904	1.56	1983	1.65	1933	-0.94	1897	-0.43	1948	0.07
1918	0.73	1912	1.09	1915	0.55	1916	-0.55	1938	-0.61	1907	1.58	1910	2.34	1956	1.48	1936	1.64	1957	-1.12	1910	-0.43	1981	0.06
1997	0.58	1980	1.07	1948	0.54	1919	-0.56	1942	-0.62	1899	1.55	1955	2.25	1929	1.46	1956	1.58	1989	-1.13	1957	-0.45	1912	0.05
1946	0.44	1905	1.07	1972	0.47	1905	-0.58	1952	-0.62	1938	1.54	1934	2.18	1915	1.43	1946	1.46	1997	-1.13	1958	-0.48	1931	0.02
1920	0.40	1993	1.04	1989	0.42	1996	-0.66	1974	-0.71	1957	1.40	1928	2.16	1908	1.42	1964	1.35	1985	-1.15	1952	-0.49	1915	0.01
1982	0.28	1961	0.99	1985	0.24	1914	-0.67	1956	-0.74	1944	1.40	1952	2.13	1903	1.34	1899	1.31	1896	-1.16	1949	-0.53	1936	-0.03
1934	0.25	1982	0.99	1911	0.23	1908	-0.69	1928	-0.81	1991	1.40	1923	2.08	1982	1.32	1918	1.23	1991	-1.17	1986	-0.54	1985	-0.06
1922	0.16	1994	0.98	1910	0.18	1913	-0.70	1937	-0.82	1920	1.37	1944	2.04	1897	1.25	1941	1.13	1946	-1.22	1922	-0.58	1947	-0.07
1913	0.15	1896	0.97	1896	0.18	1950	-0.71	1971	-0.87	1922	1.23	1897	2.04	1899	1.25	1966	1.09	1992	-1.28	1946	-0.58	1971	-0.08
1901	0.10	1951	0.85	1955	0.12	1940	-0.76	1964	-0.93	1990	1.23	1977	2.00	1923	1.20	1934	1.08	1948	-1.28	1989	-0.60	1955	-0.12

1938	0.09	1988	0.80	1961	0.07	1909	-0.78	1997	-0.95	1903	1.15	1920	1.98	1991	1.16	1992	1.05	1939	-1.36	1955	-0.67	1961	-0.18
1909	0.08	1975	0.78	1906	0.06	1955	-0.85	1913	-1.06	1975	1.09	1994	1.92	1919	1.12	1987	1.05	1908	-1.39	1933	-0.71	1899	-0.19
1992	0.05	1973	0.77	1927	0.05	1976	-0.92	1935	-1.14	1969	1.07	1953	1.90	1965	1.12	1943	1.04	1955	-1.41	1943	-0.72	1901	-0.19
1954	0.04	1995	0.77	1980	0.04	1904	-1.01	1988	-1.20	1963	1.07	1927	1.88	1944	1.11	1993	1.03	1970	-1.44	1973	-0.72	1896	-0.22
1944	0.02	1922	0.72	1995	-0.01	1972	-1.05	1990	-1.22	1985	1.02	1922	1.80	1955	1.11	1965	0.97	1928	-1.46	1907	-0.75	1903	-0.25
1895	0.00	1898	0.65	1997	-0.08	1923	-1.09	1993	-1.25	1960	1.00	1903	1.79	1997	1.10	1938	0.94	1954	-1.53	1938	-0.77	1954	-0.26
1919	-0.02	1925	0.56	1994	-0.11	1945	-1.10	1933	-1.25	1924	1.00	1940	1.73	1951	1.10	1955	0.90	1914	-1.54	1945	-0.78	1927	-0.31
1897	-0.05	1968	0.48	1979	-0.13	1943	-1.11	1977	-1.27	1940	0.97	1964	1.73	1976	1.04	1919	0.86	1917	-1.57	1898	-0.79	1951	-0.34
1962	-0.06	1986	0.42	1925	-0.17	1990	-1.12	1973	-1.30	1997	0.92	1985	1.68	1950	1.03	1974	0.81	1935	-1.59	1948	-0.83	1904	-0.39
1984	-0.07	1977	0.41	1909	-0.34	1964	-1.14	1962	-1.31	1937	0.91	1901	1.62	1927	1.00	1939	0.81	1966	-1.60	1990	-0.87	1917	-0.41
1985	-0.08	1954	0.41	1921	-0.34	1915	-1.16	1924	-1.32	1989	0.86	1987	1.60	1916	0.97	1970	0.67	1972	-1.62	1993	-0.88	1924	-0.41
1905	-0.10	1996	0.34	1963	-0.36	1925	-1.19	1960	-1.34	1955	0.55	1963	1.58	1946	0.96	1968	0.65	1932	-1.67	1935	-1.04	1988	-0.42
1952	-0.10	1987	0.34	1895	-0.40	1965	-1.21	1944	-1.40	1917	0.51	1908	1.46	1933	0.94	1942	0.54	1929	-1.75	1927	-1.05	1928	-0.47
1933	-0.12	1926	0.31	1992	-0.41	1901	-1.29	1926	-1.41	1897	0.51	1969	1.45	1975	0.93	1932	0.52	1926	-1.77	1961	-1.09	1960	-0.47
1965	-0.12	1991	0.31	1923	-0.51	1936	-1.30	1948	-1.42	1909	0.28	1989	1.39	1993	0.93	1952	0.48	1949	-1.78	1965	-1.09	1993	-0.54
1947	-0.16	1969	0.24	1946	-0.53	1906	-1.33	1896	-1.52	1935	0.17	1986	1.38	1989	0.86	1981	0.47	1934	-1.79	1975	-1.10	1895	-0.58
1972	-0.22	1931	0.20	1904	-0.55	1979	-1.36	1998	-1.54	1987	0.17	1917	1.34	1931	0.69	1923	0.42	1964	-1.82	1906	-1.18	1952	-0.59
1967	-0.26	1955	0.17	1914	-0.62	1998	-1.36	1917	-1.61	1971	0.07	1966	1.32	1896	0.69	1895	0.41	1913	-1.84	1913	-1.18	1939	-0.60
1956	-0.27	1979	0.13	1954	-0.66	1902	-1.37	1897	-1.67	1915	0.01	1904	1.29	1960	0.65	1916	0.40	1930	-1.84	1978	-1.22	1982	-0.63
1960	-0.27	1935	0.03	1951	-0.73	1921	-1.47	1904	-1.68	1958	-0.00	1983	1.14	1970	0.65	1904	0.26	1978	-1.94	1996	-1.23	1966	-0.66
1932	-0.30	1938	0.01	1966	-0.77	1927	-1.53	1918	-1.72	1973	-0.02	1949	1.13	1907	0.65	1984	0.09	1905	-1.95	1964	-1.23	1980	-0.66
1939	-0.34	1908	-0.04	1899	-0.79	1969	-1.54	1955	-1.75	1928	-0.06	1936	1.10	1968	0.61	1898	0.04	1967	-1.96	1939	-1.24	1937	-0.73
1937	-0.34	1997	-0.07	1938	-0.80	1988	-1.57	1981	-1.79	1977	-0.11	1931	1.08	1984	0.54	1896	-0.09	1925	-2.02	1950	-1.27	1992	-0.76
1911	-0.36	1974	-0.12	1939	-0.82	1917	-1.61	1950	-1.80	1913	-0.14	1980	0.96	1936	0.51	1980	-0.18	1931	-2.09	1970	-1.27	1923	-0.85
1916	-0.36	1956	-0.17	1971	-0.84	1974	-1.68	1902	-1.82	1918	-0.21	1914	0.95	1978	0.42	1996	-0.19	1906	-2.17	1901	-1.32	1946	-0.91
1923	-0.44	1921	-0.33	1898	-0.86	1911	-1.71	1908	-1.85	1911	-0.30	1911	0.90	1920	0.40	1967	-0.26	1973	-2.36	1909	-1.33	1970	-0.91
1943	-0.45	1962	-0.38	1929	-0.87	1952	-1.72	1994	-1.85	1905	-0.33	1962	0.79	1918	0.34	1927	-0.41	1977	-2.43	1929	-1.38	1975	-0.98
1975	-0.47	1917	-0.42	1922	-0.94	1975	-1.89	1983	-1.90	1970	-0.48	1970	0.77	1958	0.30	1900	-0.43	1919	-2.49	1991	-1.44	1995	-1.00
1921	-0.63	1923	-0.48	1974	-0.98	1971	-1.96	1995	-1.93	1961	-0.66	1979	0.71	1980	0.17	1990	-0.49	1920	-2.49	1905	-1.50	1934	-1.04
1990	-0.67	1985	-0.55	1975	-1.00	1932	-1.99	1910	-2.05	1951	-0.86	1976	0.48	1912	0.04	1986	-0.52	1909	-2.51	1928	-1.50	1910	-1.04
1910	-0.70	1943	-0.57	1981	-1.02	1910	-2.01	1985	-2.16	1950	-0.92	1918	0.43	1954	-0.03	1913	-0.53	1901	-2.53	1900	-1.51	1990	-1.05
1935	-0.73	1948	-0.60	1976	-1.09	1968	-2.09	1986	-2.17	1964	-0.95	1956	0.37	1996	-0.04	1915	-0.53	1980	-2.61	1974	-1.51	1991	-1.16
1976	-0.73	1949	-0.63	1990	-1.12	1898	-2.16	1914	-2.23	1956	-1.12	1912	0.29	1942	-0.11	1937	-0.54	1907	-2.74	1944	-1.54	1943	-1.16
1974	-0.76	1909	-0.63	1916	-1.17	1938	-2.20	1949	-2.24	1980	-1.12	1958	0.29	1963	-0.25	1958	-0.63	1976	-2.75	1934	-1.57	1962	-1.17
1907	-0.77	1907	-0.64	1897	-1.19	1977	-2.24	1940	-2.36	1984	-1.13	1916	0.27	1895	-0.30	1909	-0.82	1961	-2.78	1956	-1.59	1906	-1.19
1971	-0.78	1929	-0.71	1968	-1.20	1986	-2.25	1898	-2.46	1988	-1.22	1902	0.26	1941	-0.43	1911	-0.83	1903	-2.95	1966	-1.60	1968	-1.21
1981	-0.80	1939	-0.77	1917	-1.24	1978	-2.26	1989	-2.46	1914	-1.26	1942	0.02	1914	-0.46	1978	-1.00	1981	-2.96	1960	-1.61	1926	-1.22
1968	-0.83	1976	-0.81	1949	-1.31	1970	-2.38	1951	-2.51	1979	-1.39	1913	-0.01	1987	-0.60	1991	-1.14	1963	-3.01	1924	-1.66	1908	-1.23
1928	-0.91	1916	-0.93	1977	-1.42	1987	-2.41	1992	-2.73	1921	-1.43	1993	-0.01	1934	-0.85	1944	-1.15	1962	-3.04	1942	-1.69	1984	-1.23
1951	-0.92	1950	-0.97	1967	-1.45	1922	-2.42	1967	-2.97	1895	-1.72	1961	-0.16	1902	-0.99	1910	-1.78	1988	-3.14	1899	-1.70	1956	-1.30
1902	-0.97	1932	-0.99	1907	-1.50	1946	-2.44	1941	-3.02	1993	-1.73	1981	-0.42	1900	-1.03	1906	-2.00	1984	-3.21	1917	-1.71	1987	-1.30
1949	-0.98	1944	-0.99	1920	-1.65	1963	-2.48	1945	-3.02	1952	-1.83	1930	-0.90	1930	-1.04	1961	-2.07	1979	-3.42	1967	-1.71	1944	-1.36
1917	-1.05	1918	-1.01	1935	-1.67	1896	-2.48	1953	-3.03	1998	-1.90	1996	-0.93	1924	-1.25	1925	-2.80	1974	-3.61	1923	-1.81	1938	-1.47
1927	-1.09	1989	-1.05	1908	-1.73	1903	-2.67	1899	-3.16	1948	-2.52	1992	-1.10	1921	-1.60	1921	-3.16	1940	-3.78	1931	-1.88	1932	-1.48
1898	-1.13	1945	-1.17	1945	-1.83	1967	-2.68	1965	-3.33	1898	-2.71	1972	-1.44	1938	-2.38	1972	-3.39	1942	-3.82	1940	-1.96	1933	-1.50
1950	-1.21	1911	-1.47	1956	-1.87	1981	-2.69	1927	-3.42	1931	-3.43	1932	-1.74										

Appendix C

Maximum Averaged S-65E Flow (cfs-14 day)
Estimated for each Month

Maximum Averaged S-65E Flow (cfs- 14 day)

1930	2009	1868	1974	2906	3369	10023	7765	4704	4240	4501	3347	2625
1931	2845	2671	3109	2832	2364	1671	1274	1142	1285	1171	1028	872
1932	737	598	502	381	328	802	549	851	2122	1266	1123	875
1933	715	586	539	544	378	335	991	2478	7726	5000	3034	2172
1934	1648	1372	1258	1304	1293	3966	7195	5179	4192	2949	2097	1494
1935	1185	907	706	575	431	314	462	524	1288	3000	1735	1349
1936	1234	1847	2929	2076	1516	1678	1760	1916	2123	2298	2135	1748
1937	1464	1300	1264	1396	1081	980	1005	957	1045	2339	2645	3522
1938	2148	1662	1364	999	674	761	1059	1544	1220	1356	1342	1005
1939	815	645	489	415	376	319	1018	1977	3535	3148	2397	1807
1940	1605	1497	1468	1496	1118	1042	1392	1783	2707	2654	1551	1219
1941	1496	1678	1556	1847	1908	1470	2878	3399	2440	2975	2916	2397
1942	2838	2503	3799	2534	1802	2616	2412	2227	2139	1783	1329	1098
1943	900	728	748	562	445	482	1025	1355	1719	3066	1722	1382
1944	1162	945	734	976	644	536	613	952	1237	1349	1741	1598
1945	1464	1264	1070	792	552	469	1800	3209	6145	6116	4368	3291
1946	2504	1771	1624	1170	998	1003	949	1340	2059	2168	1778	1521
1947	1259	1040	1579	1646	1291	2762	5213	5593	8965	9124	6230	4670
1948	4105	3826	2685	2083	1688	1396	1443	1673	5822	11489	5374	3539
1949	2436	1774	1310	943	683	596	997	1879	4839	6869	4128	2448
1950	1793	1468	1184	869	701	741	744	558	620	1427	1693	1147
1951	1080	1067	917	1452	1681	939	1510	1975	1581	3939	2733	2286
1952	1804	1527	1335	1394	1469	1580	1566	1716	1938	3579	3813	2397
1953	1817	1546	1456	1523	1475	1419	1648	2508	7453	11768	7668	6974
1954	5399	3587	2769	1941	1632	3424	3253	2344	2321	2619	1950	1616
1955	1336	1191	925	745	492	470	1130	1126	1124	802	547	467
1956	395	326	263	171	116	99	125	140	465	3398	2289	1375
1957	1151	984	1402	1667	2229	1905	2461	3468	4554	4247	2671	1786
1958	2315	2857	3111	3097	2626	1951	2072	1915	1812	1330	834	710
1959	728	773	1703	2715	2223	4474	5887	5341	6118	8108	6678	4507
1960	3049	2973	3773	5982	3856	2840	3980	9283	11850	11475	7056	4239
1961	2891	2241	1834	1519	1037	772	937	1131	1068	537	378	283
1962	217	165	135	114	72	258	1122	1251	2830	-999	-999	-999
1963	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
1964	-999	-999	-999	-999	-999	-999	-999	-999	-999	2539	839	395
1965	735	911	1705	1147	449	405	1031	1880	1983	2056	1615	656
1966	1040	2130	3994	2903	1769	1909	1963	3321	2700	2765	907	246
1967	195	250	171	102	389	493	540	1700	2451	1669	258	247
1968	217	195	161	94	189	3515	6741	3718	2968	2021	661	305
1969	1449	489	3554	2761	1727	1617	362	1408	1992	9991	2962	3702
1970	4390	2653	3535	2664	326	389	794	334	189	501	122	254
1971	803	2324	333	13	2	362	748	721	1584	929	186	62
1972	15	195	78	380	721	2057	1402	469	508	36	109	188
1973	583	1862	1931	3525	2150	583	1310	2678	4217	1210	163	68
1974	71	814	297	373	675	984	9670	7421	3300	761	95	85
1975	61	63	122	914	1234	714	614	1685	2284	1761	1215	140
1976	104	1460	1878	814	1339	1398	1057	4355	2404	452	88	1301
1977	2337	1570	1973	223	1	29	17	13	457	118	192	766
1978	1695	2324	2631	596	932	1286	2866	5952	1337	579	190	442
1979	3607	2830	864	58	1748	242	464	828	6412	3618	480	1186
1980	1582	1833	1892	1198	1424	78	249	359	500	64	88	94
1981	62	101	35	4	2	1	1	43	1012	44	11	3
1982	7	9	109	680	1229	4675	4800	4062	3012	3319	565	260
1983	809	5939	6953	4662	1205	228	1316	2165	1116	172	54	1636
1984	1808	2323	1150	2890	2362	651	2129	2329	264	72	112	76
1985	0	30	0	51	754	94	228	910	2025	645	91	77
1986	1825	1931	1163	758	723	504	1038	1278	1437	75	248	133
1987	3273	2540	1384	3601	941	1	232	152	407	1563	4099	2298

1988	1051	1926	4231	2540	1173	55	235	736	2230	47	6	0
1989	530	961	1030	1524	1107	15	132	214	471	827	49	90
1990	1409	2097	753	586	253	218	922	808	443	1195	72	17
1991	117	48	328	1131	2156	956	2694	6200	2333	1949	168	97
1992	73	1333	280	2023	1463	962	1049	2794	2061	631	331	443
1993	4043	1217	2066	4962	210	104	67	97	628	262	63	24
1994	84	182	1401	713	137	2802	3365	2351	4204	4360	5386	3380
1995	1881	2037	1948	2136	740	443	1449	6478	6548	4548	1277	1410
1996	2950	1333	1398	2874	607	1021	596	1157	454	561	21	20
1997	451	1102	88	742	2258	974	452	4546	1010	527	2301	6539
1998	7800	6863	9326	3322	422							

Appendix D

Monthly Ranked S-65E Flow (cfs-14 day)

January	February	March	April	May	June	July	August	September	October	November	December
1998 7800	1998 6863	1983 6953	1960 5982	1960 3856	1930 10023	1974 9670	1960 9283	1960 11850	1953 11768	1953 7668	1953 6974
1954 5399	1983 5939	1998 6199	1993 4962	1930 3369	1982 4675	1930 7765	1974 7421	1947 8965	1948 11489	1960 7056	1997 6539
1970 4390	1948 3826	1988 4231	1983 4662	1958 2626	1959 4474	1934 7195	1995 6478	1933 7726	1960 11475	1959 6678	1947 4670
1948 4105	1954 3587	1966 3994	1987 3601	1931 2364	1934 3966	1968 6741	1991 6200	1953 7453	1969 9991	1947 6230	1959 4507
1993 4043	1960 2973	1942 3799	1973 3525	1984 2362	1968 3515	1959 5887	1978 5952	1995 6548	1947 9124	1994 5386	1960 4239
1979 3607	1958 2857	1960 3773	1998 3322	1997 2258	1954 3424	1947 5213	1947 5593	1979 6412	1959 8108	1948 5374	1969 3702
1987 3273	1979 2830	1969 3554	1958 3097	1957 2229	1960 2840	1982 4800	1959 5341	1945 6145	1949 6869	1945 4368	1948 3539
1960 3049	1931 2671	1970 3535	1930 2906	1959 2223	1994 2802	1960 3980	1934 5179	1959 6118	1945 6116	1949 4128	1937 3522
1996 2950	1970 2653	1958 3111	1966 2903	1991 2156	1947 2762	1994 3365	1930 4704	1948 5822	1933 5000	1987 4099	1994 3380
1961 2891	1987 2540	1931 3109	1984 2890	1973 2150	1942 2616	1954 3253	1997 4546	1949 4839	1995 4548	1952 3813	1945 3291
1931 2845	1942 2503	1936 2929	1996 2874	1941 1908	1972 2057	1941 2878	1976 4355	1957 4554	1930 4501	1930 3347	1930 2625
1942 2838	1971 2324	1954 2769	1931 2832	1942 1802	1958 1951	1978 2866	1982 4062	1930 4240	1994 4360	1933 3034	1949 2448
1946 2504	1978 2324	1948 2685	1969 2761	1966 1769	1966 1909	1991 2694	1968 3718	1973 4217	1957 4247	1969 2962	1941 2397
1949 2436	1984 2323	1978 2631	1959 2715	1979 1748	1957 1905	1957 2461	1957 3468	1994 4204	1951 3939	1941 2916	1952 2397
1977 2337	1961 2241	1993 2066	1970 2664	1969 1727	1936 1678	1942 2412	1941 3399	1934 4192	1979 3618	1951 2733	1987 2298
1958 2315	1966 2130	1930 1974	1988 2540	1948 1688	1931 1671	1984 2129	1966 3321	1939 3535	1952 3579	1957 2671	1951 2286
1938 2148	1990 2097	1977 1973	1942 2534	1951 1681	1969 1617	1958 2072	1945 3209	1974 3300	1956 3398	1937 2645	1933 2172
1930 2009	1995 2037	1995 1948	1995 2136	1954 1632	1952 1580	1966 1963	1992 2794	1982 3012	1982 3319	1939 2397	1939 1807
1995 1881	1986 1931	1973 1931	1948 2083	1936 1516	1941 1470	1945 1800	1973 2678	1968 2968	1939 3148	1997 2301	1957 1786
1986 1825	1988 1926	1980 1892	1936 2076	1953 1475	1953 1419	1936 1760	1953 2508	1962 2830	1943 3066	1956 2289	1936 1748
1953 1817	1930 1868	1976 1878	1992 2023	1952 1469	1976 1398	1953 1648	1933 2478	1940 2707	1935 3000	1936 2135	1983 1636
1984 1808	1973 1862	1961 1834	1954 1941	1992 1463	1948 1396	1952 1566	1994 2351	1966 2700	1941 2975	1934 2097	1954 1616
1952 1804	1936 1847	1965 1705	1941 1847	1980 1424	1978 1286	1951 1510	1954 2344	1967 2451	1934 2949	1954 1950	1944 1598
1950 1793	1980 1833	1959 1703	1957 1667	1976 1339	1940 1042	1995 1449	1984 2329	1941 2440	1966 2765	1946 1778	1946 1521
1978 1695	1949 1774	1946 1624	1947 1646	1934 1293	1996 1021	1948 1443	1942 2227	1976 2404	1940 2654	1944 1741	1934 1494
1934 1648	1946 1771	1947 1579	1989 1524	1947 1291	1946 1003	1972 1402	1983 2165	1991 2333	1954 2619	1935 1735	1995 1410
1940 1605	1941 1678	1941 1556	1953 1523	1975 1234	1974 984	1940 1392	1939 1977	1954 2321	1964 2539	1943 1722	1943 1382
1980 1582	1938 1662	1940 1468	1961 1519	1982 1229	1937 980	1983 1316	1951 1975	1975 2284	1937 2339	1950 1693	1956 1375
1941 1496	1977 1570	1953 1456	1940 1496	1983 1205	1997 974	1973 1310	1936 1916	1988 2230	1936 2298	1965 1615	1935 1349
1937 1464	1953 1546	1957 1402	1951 1452	1988 1173	1992 962	1931 1274	1958 1915	1942 2139	1946 2168	1940 1551	1976 1301
1945 1464	1952 1527	1994 1401	1937 1396	1940 1118	1991 956	1955 1130	1965 1880	1936 2123	1965 2056	1938 1342	1940 1219
1969 1449	1940 1497	1996 1398	1952 1394	1989 1107	1951 939	1962 1122	1949 1879	1932 2122	1968 2021	1942 1329	1979 1186
1990 1409	1950 1468	1987 1384	1934 1304	1937 1081	1932 802	1938 1059	1940 1783	1992 2061	1991 1949	1995 1277	1950 1147
1955 1336	1976 1460	1938 1364	1980 1198	1961 1037	1961 772	1976 1057	1952 1716	1946 2059	1942 1783	1975 1215	1942 1098
1947 1259	1934 1372	1952 1335	1946 1170	1946 998	1938 761	1992 1049	1967 1700	1985 2025	1975 1761	1932 1123	1938 1005
1936 1234	1996 1333	1949 1310	1965 1147	1987 941	1950 741	1986 1038	1975 1685	1969 1992	1967 1669	1931 1028	1932 875
1935 1185	1992 1333	1937 1264	1991 1131	1978 932	1975 714	1965 1031	1948 1673	1965 1983	1987 1563	1966 907	1931 872
1944 1162	1937 1300	1934 1258	1938 999	1985 754	1984 651	1943 1025	1938 1544	1952 1938	1950 1427	1964 839	1977 766
1957 1151	1945 1264	1950 1184	1944 976	1995 740	1949 596	1939 1018	1969 1408	1958 1812	1938 1356	1958 834	1958 710
1951 1080	1993 1217	1986 1163	1949 943	1986 723	1973 583	1937 1005	1943 1355	1943 1719	1944 1349	1968 661	1965 656
1988 1051	1955 1191	1984 1150	1975 914	1972 721	1944 536	1949 997	1946 1340	1971 1584	1958 1330	1982 565	1955 467
1966 1040	1997 1102	1945 1070	1950 869	1950 701	1986 504	1933 991	1986 1278	1951 1581	1932 1266	1955 547	1992 443
1943 900	1951 1067	1989 1030	1976 814	1949 683	1967 493	1946 949	1962 1251	1986 1437	1973 1210	1979 480	1978 442
1939 815	1947 1040	1955 925	1945 792	1974 675	1943 482	1961 937	1996 1157	1978 1337	1990 1195	1961 378	1964 395
1983 809	1957 984	1951 917	1986 758	1938 674	1955 470	1990 922	1931 1142	1935 1288	1931 1171	1992 331	1968 305
1971 803	1989 961	1979 864	1955 745	1944 644	1945 469	1970 794	1961 1131	1931 1285	1971 929	1967 258	1961 283
1932 737	1944 945	1990 753	1997 742	1996 607	1995 443	1971 748	1955 1126	1944 1237	1989 827	1986 248	1982 260
1965 735	1965 911	1943 748	1994 713	1945 552	1965 405	1950 744	1937 957	1938 1220	1955 802	1977 192	1970 254
1959 728	1935 907	1944 734	1982 680	1955 492	1970 389	1975 614	1944 952	1955 1124	1974 761	1978 190	1967 247
1933 715	1974 814	1935 706	1978 596	1965 449	1971 362	1944 613	1985 910	1983 1116	1985 645	1971 186	1966 246
1973 583	1959 773	1933 539	1990 586	1943 445	1933 335	1996 596	1932 851	1961 1068	1992 631	1991 168	1972 188
1989 530	1943 728	1932 502	1935 575	1935 431	1939 319	1932 549	1979 828	1937 1045	1978 579	1973 163	1975 140
1997 451	1939 645	1939 489	1943 562	1998 421	1935 314	1967 540	1990 808	1981 1012	1996 561	1970 122	1986 133
1956 395	1932 598	1971 333	1933 544	1967 389	1962 258	1979 464	1988 736	1997 1010	1961 537	1984 112	1991 97
1968 217	1933 586	1991 328	1939 415	1933 378	1979 242	1935 462	1971 721	1993 628	1997 527	1972 109	1980 94

1962 217	1969 489	1974 297	1932 381	1939 376	1983 228	1997 452	1950 558	1950 620	1970 501	1974 95	1989 90
1967 195	1956 326	1992 280	1972 380	1932 328	1990 218	1969 362	1935 524	1972 508	1976 452	1985 91	1974 85
1991 117	1967 250	1956 263	1974 373	1970 326	1993 104	1980 249	1972 469	1980 500	1993 262	1980 88	1985 77
1976 104	1968 195	1967 171	1977 223	1990 253	1956 99	1988 235	1980 359	1989 471	1983 172	1976 88	1984 76
1994 84	1972 195	1968 161	1956 171	1993 210	1985 94	1987 232	1970 334	1956 465	1977 118	1990 72	1973 68
1992 73	1994 182	1962 135	1962 114	1968 189	1980 78	1985 228	1989 214	1977 457	1986 75	199 63	1971 62
1974 71	1962 165	1975 122	1967 102	1994 137	1988 55	1989 132	1987 152	1996 454	1984 72	1983 54	1993 24
1981 62	1981 101	1982 109	1968 94	1956 116	1977 29	1956 125	1956 140	1990 443	1980 64	1989 49	1996 20
1975 61	1975 63	1997 88	1979 58	1962 72	1989 15	1993 67	1993 97	1987 407	1988 47	1996 21	1990 17
1972 15	1991 48	1972 78	1985 51	1971 2	1981 1	1977 17	1981 43	1984 264	1981 44	1981 11	1981 3
1982 7	1985 30	1981 35	1971 13	1981 2	1987 1	1981 1	1977 13	1970 189	1972 36	1988 6	1988 0
1985 0	1982 9	1985 0	1981 4	1977 1							

Appendix E

Possible Uses of Long-Range Weather outlooks in Water Resources (S. A. Changnon,Jr.)

Appendix F

Using NOAA's New Climate Outlooks In Operational Hydrology

Thomas E. Croley II

Journal of Hydrologic Engineering (1996)

Appendix G

Performance Measures Graphics
for the WSE Implementation Guidelines
(1995 Infrastructure and Water Use Levels)