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.

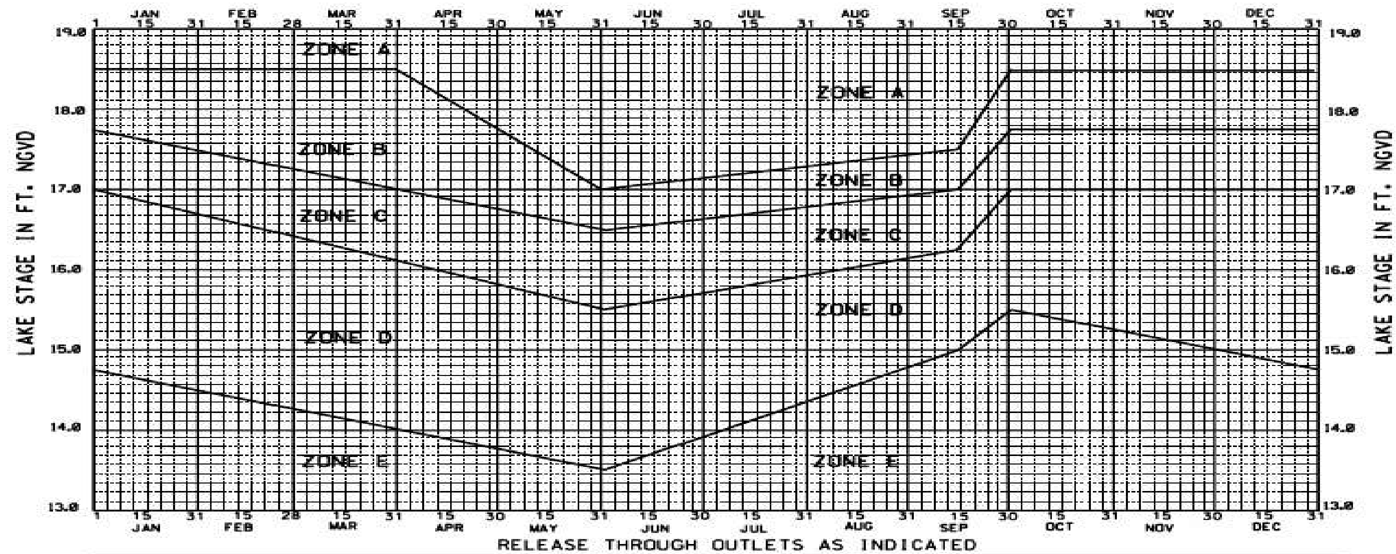
In the actual implementation of the WSE Operational Schedule, it is suggested that additional hydrologic data, and the recent advances in hydro-meteorologic and climatologic forecasting be directly incorporated into the Lake Okeechobee operational guidelines. This report presents the most basic guidelines 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.




RELEASE THROUGH OUTLETS AS INDICATED

| 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

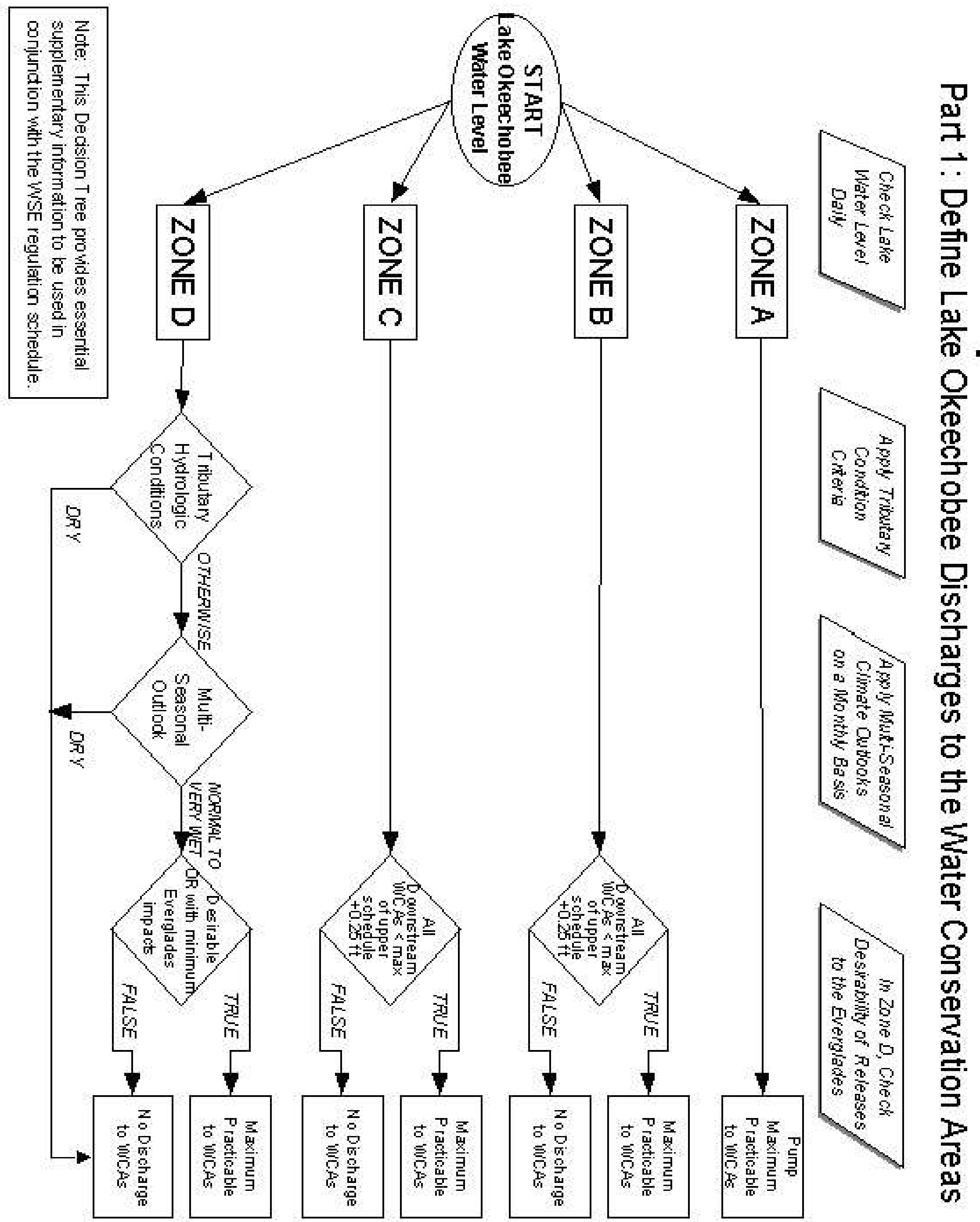
CENTRAL AND SOUTHERN FLORIDA
INTERIM REGULATION SCHEDULE
LAKE OKEECHOBEE

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



# WSE Operational Guidelines Decision Tree

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

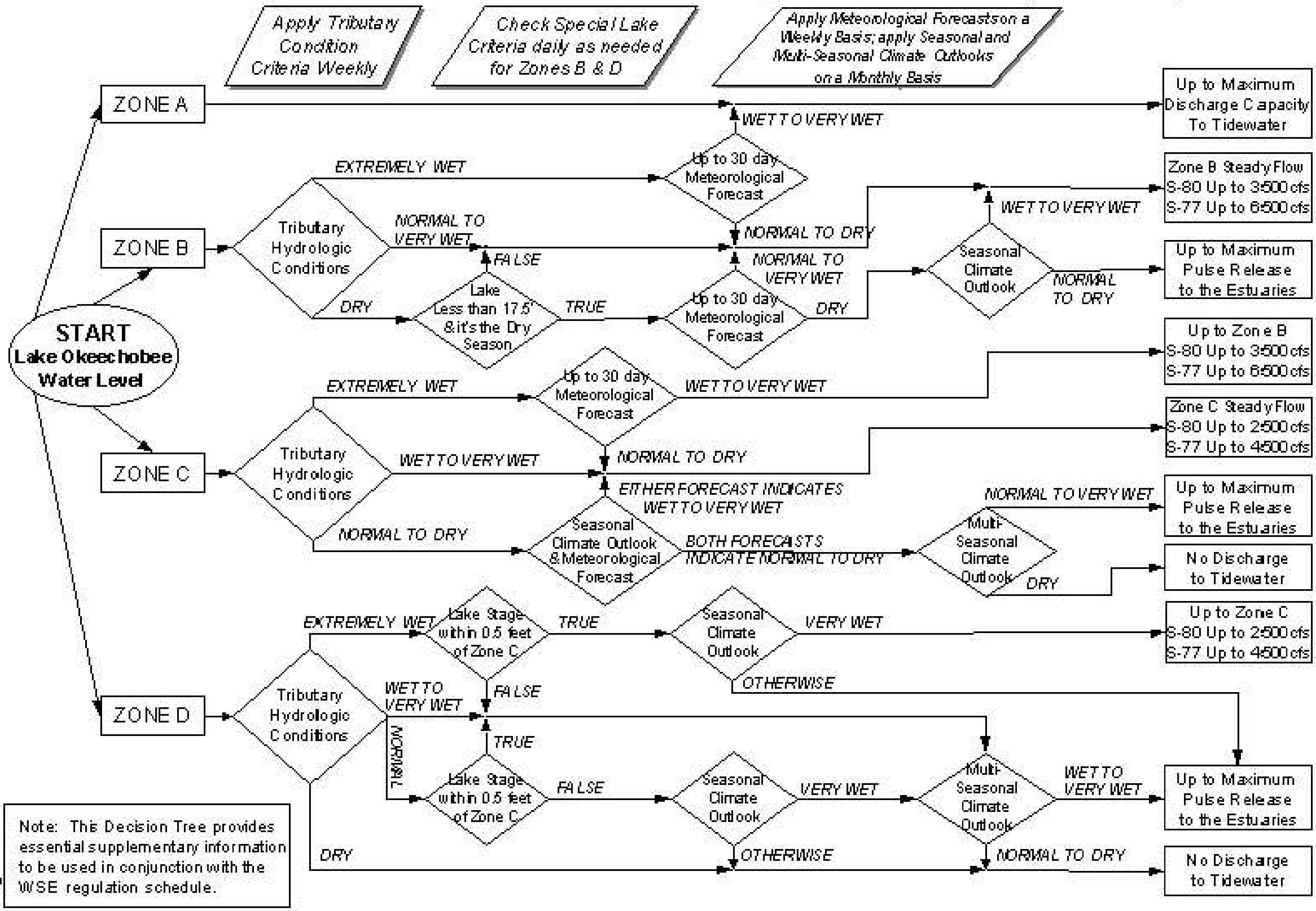



Figure 2b

**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).

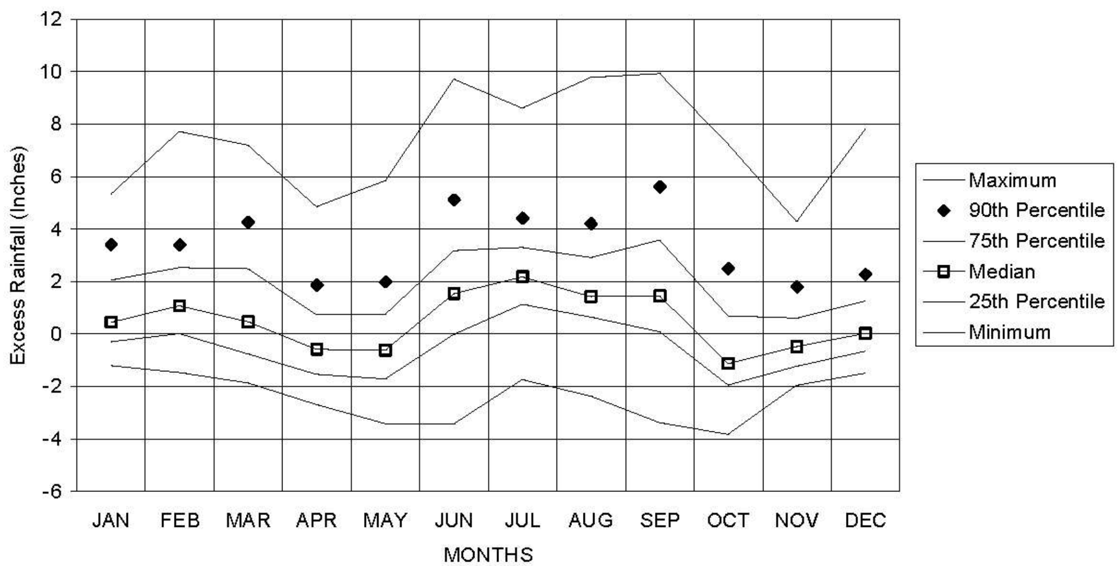
The net rainfall was computed by subtracting the monthly ET from the monthly rainfall for the period 1895 through May of 1998. The maximum, minimum, quartiles and 90th percentile of the net rainfall for each month is illustrated in Figure 3a. Figure 3b delineates the rainfall exceedance curve with all 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



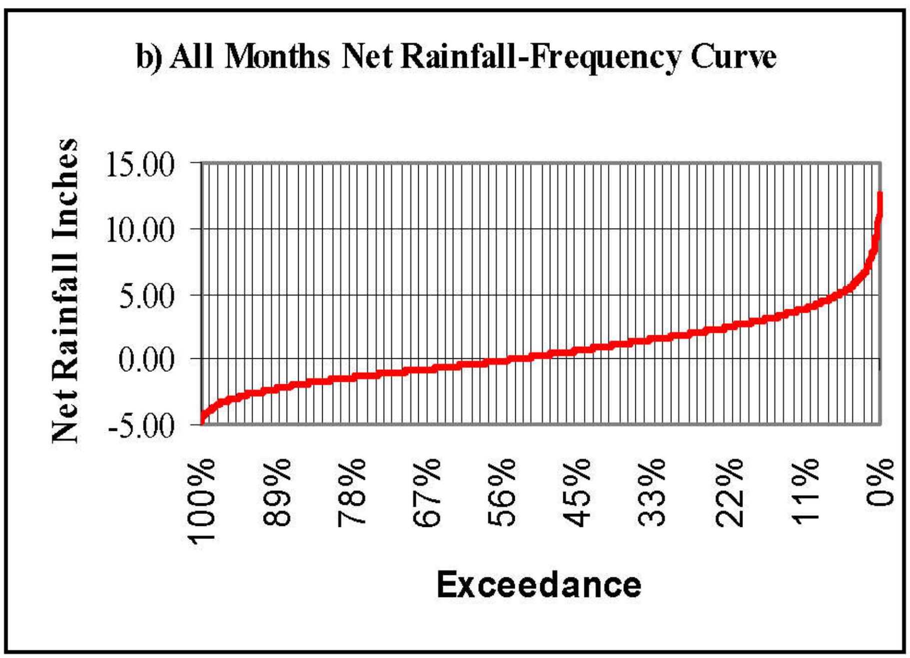
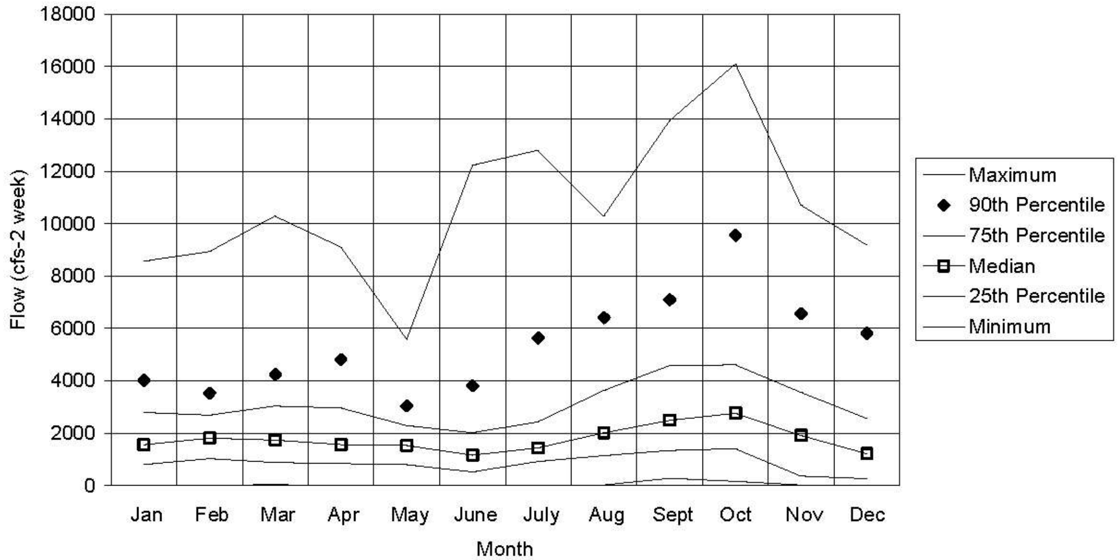
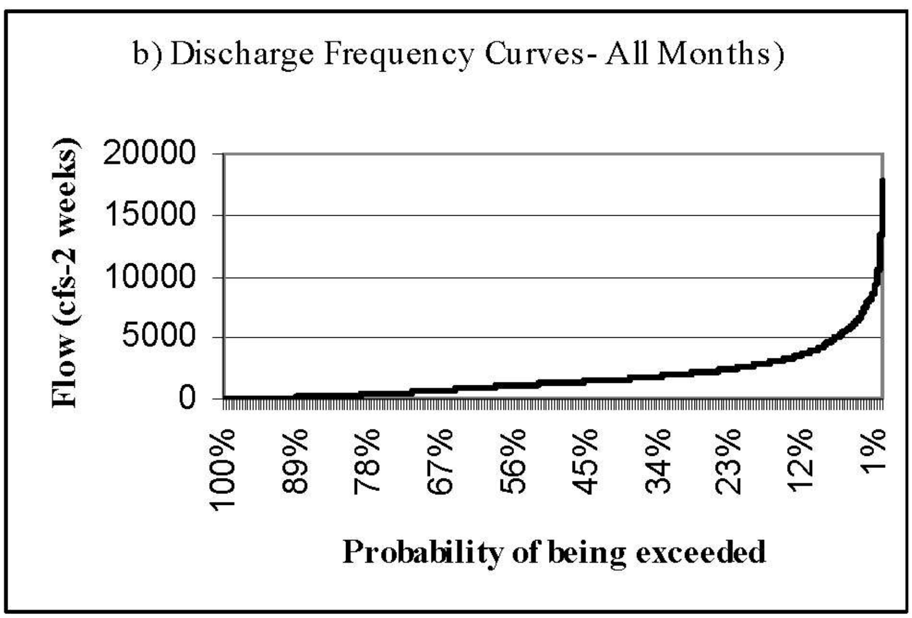



Figure 4. S-65E Maximum Monthly Flow
Period of Analysis January 1930-June 1998

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)**

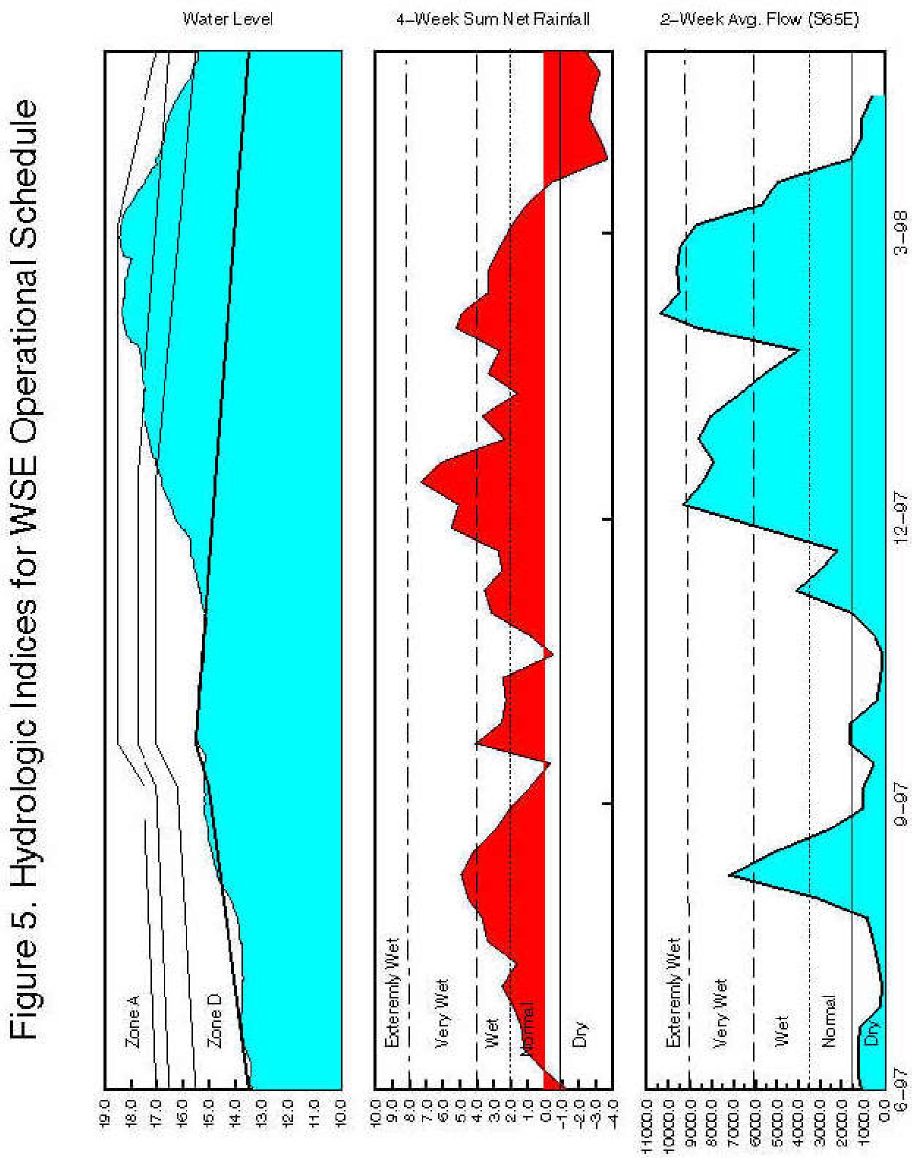
| Tributary Conditions | Percent Occurrence | Average Net Rainfall (inches past 4 weeks) | Average S-65E Flow (cfs - 2 week average) | Average Net Lake Inflow (cfs - 2 week average) |
|---|---|---|---|---|
| Dry | 21% | -2.2 | 580 | 1463 |
| Normal | 47% | 0.1 | 1324 | 3236 |
| Wet | 19% | 2.4 | 2344 | 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<br>Paul Trimble<br>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<br>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.<br>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<br>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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 1950 | -1.21 | 1911 | -1.47 | 1956 | -1.87 | 1981 | -2.69 | 1927 | -3.42 | 1931 | -3.43 | 1932 | -1.74 | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 1939 | -1.36 | 1955 | -0.67 | 1961 | -0.18 |
| 1908 | -1.39 | 1933 | -0.71 | 1899 | -0.19 |
| 1955 | -1.41 | 1943 | -0.72 | 1901 | -0.19 |
| 1970 | -1.44 | 1973 | -0.72 | 1896 | -0.22 |
| 1928 | -1.46 | 1907 | -0.75 | 1903 | -0.25 |
| 1954 | -1.53 | 1938 | -0.77 | 1954 | -0.26 |
| 1914 | -1.54 | 1945 | -0.78 | 1927 | -0.31 |
| 1917 | -1.57 | 1898 | -0.79 | 1951 | -0.34 |
| 1935 | -1.59 | 1948 | -0.83 | 1904 | -0.39 |
| 1966 | -1.60 | 1990 | -0.87 | 1917 | -0.41 |
| 1972 | -1.62 | 1993 | -0.88 | 1924 | -0.41 |
| 1932 | -1.67 | 1935 | -1.04 | 1988 | -0.42 |
| 1929 | -1.75 | 1927 | -1.05 | 1928 | -0.47 |
| 1926 | -1.77 | 1961 | -1.09 | 1960 | -0.47 |
| 1949 | -1.78 | 1965 | -1.09 | 1993 | -0.54 |
| 1934 | -1.79 | 1975 | -1.10 | 1895 | -0.58 |
| 1964 | -1.82 | 1906 | -1.18 | 1952 | -0.59 |
| 1913 | -1.84 | 1913 | -1.18 | 1939 | -0.60 |
| 1930 | -1.84 | 1978 | -1.22 | 1982 | -0.63 |
| 1978 | -1.94 | 1996 | -1.23 | 1966 | -0.66 |
| 1905 | -1.95 | 1964 | -1.23 | 1980 | -0.66 |
| 1967 | -1.96 | 1939 | -1.24 | 1937 | -0.73 |
| 1925 | -2.02 | 1950 | -1.27 | 1992 | -0.76 |
| 1931 | -2.09 | 1970 | -1.27 | 1923 | -0.85 |
| 1906 | -2.17 | 1901 | -1.32 | 1946 | -0.91 |
| 1973 | -2.36 | 1909 | -1.33 | 1970 | -0.91 |
| 1977 | -2.43 | 1929 | -1.38 | 1975 | -0.98 |
| 1919 | -2.49 | 1991 | -1.44 | 1995 | -1.00 |
| 1920 | -2.49 | 1905 | -1.50 | 1934 | -1.04 |
| 1909 | -2.51 | 1928 | -1.50 | 1910 | -1.04 |
| 1901 | -2.53 | 1900 | -1.51 | 1990 | -1.05 |
| 1980 | -2.61 | 1974 | -1.51 | 1991 | -1.16 |
| 1907 | -2.74 | 1944 | -1.54 | 1943 | -1.16 |
| 1976 | -2.75 | 1934 | -1.57 | 1962 | -1.17 |
| 1961 | -2.78 | 1956 | -1.59 | 1906 | -1.19 |
| 1903 | -2.95 | 1966 | -1.60 | 1968 | -1.21 |
| 1981 | -2.96 | 1960 | -1.61 | 1926 | -1.22 |
| 1963 | -3.01 | 1924 | -1.66 | 1908 | -1.23 |
| 1962 | -3.04 | 1942 | -1.69 | 1984 | -1.23 |
| 1988 | -3.14 | 1899 | -1.70 | 1956 | -1.30 |
| 1984 | -3.21 | 1917 | -1.71 | 1987 | -1.30 |
| 1979 | -3.42 | 1967 | -1.71 | 1944 | -1.36 |
| 1974 | -3.61 | 1923 | -1.81 | 1938 | -1.47 |
| 1940 | -3.78 | 1931 | -1.88 | 1932 | -1.48 |
| 1942 | -3.82 | 1940 | -1.96 | 1933 | -1.50 |

**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)**