Lake Drought Analysis Description

Introduction

A drought analysis was conducted to estimate the amount of cooling water available from Clinton Lake for the additional power plant operations. The drought analysis was conducted following the theoretical procedure outlined in the Clinton Power Station (CPS) Updated Safety Analysis Report (USAR) Section 2.4.11.1 (Illinois Power 2001) for the CPS. Two design droughts were established, a 50-year and a 100-year recurrence interval drought, each with a 5-year duration. Low flow runoff data for both design droughts were obtained from the CPS USAR, which cited *Low Flows of Illinois Stream for Impounding Reservoir Design* published as Bulletin 51 by the Illinois State Water Authority (Stall 1964). Note that the 5-year drought durations are not actual time periods. They have been derived based on an evaluation of historic drought conditions.

This memorandum describes the source of data and calculation performed in the analysis. Each worksheet in the spreadsheet file (NRC RAI E5.2-1&-2 Att C – Lake Drought Analysis) represents different combinations of plant type and drought conditions.

Data and Calculation Descriptions

Column A

Column A contains the name of the month for each of the monthly time-steps for the 5-year period.

Column B

Column B contains the numeric month (1 through 60) for each of monthly time-steps for the 5-year period.

Column C

Column C contains the calculation estimating the Lake elevation for each month. The elevation is calculated using the lake volume (in Column D) to solve a regression equation developed from elevation-volume data presented in CPS Environmental Report – Operating License Stage (ER-OLS) Figure 2.4-6. The elevation volume relationship is based on the normal lake volume of 74,200 ac-ft at normal lake level of 690.0 NGVD 1929 (Illinois Power 1982). The normal lake level is the level at the crest of the Clinton Dam Ogee Spillway and was used as the starting water surface level. The development of the regression equation is presented under the worksheet entitled "Elevation-Volume Curve" of the spreadsheet (NRC RAI E5.2-1&-2 Att C – Lake Drought Analysis).

Column D

Column D contains a running total of Lake volume. The calculation adds the net gain or loss in volume of Clinton Lake for the previous month (Column R) to the volume of Clinton Lake for the previous month (Column D). The volume was not allowed to exceed the normal pool volume of 74,200 acre feet. If the volume is exceeded, then the volume is reset at the normal volume using an "if-then" statement. This has the conservative effect of discharging any attenuated volume at the end of each monthly time step.

Column E

Column E contains a calculation that estimates the Lake area. This calculation is based on the lake volume (Column D) and a regression equation to predict the area of Clinton Lake. The regression equation is included in Column E and was developed within worksheet "Elevation-Volume Curve" within the spreadsheet. This regression equation was developed from data found in CPS ER-OLS Figure 2.4-6 based on the normal lake volume of 74,200 ac-ft at normal lake level of 690.0 (Illinois Power 1982).

Column F

Column F contains monthly average net lake water loss in inches (total of evaporation and precipitation) at the Clinton Lake water surface. Negative numbers represent the case in which monthly direct precipitation on the lake exceeds lake evaporation. The data were taken directly from CPS USAR Table 2.4-21 that were derived from data found within "Lake Evaporation in Illinois" by W. J. Roberts and J. B. Stall (1967) (Illinois Power 2001).

Column G

Column G contains a calculation to determine net lake evaporation minus precipitation volume loss in acre-feet. The monthly average net lake water loss in inches (Column F) are multiplied by the area of the lake in acres (Column E) and divided by 12 to convert inches into feet.

Column H

Column H contains forced evaporation loss due to the originally planned two 992 MWe plants at a 70% LF as originally proposed. The data were taken directly from CPS USAR Table 2.4-22 (Illinois Power 2001). This factor accounts for the total evaporative loss occurring along the cooling loop that results from dissipation of the heat rejected to the lake from the two plants. The term "forced evaporation" is used because the rejected heat and associated increase in lake temperature will "force" an increase in the rate of evaporation over ambient levels to dissipate the rejected heat. The increase in lake temperature is not considered in this drought model. Temperature changes through the Clinton Lake cooling loop were previously simulated by Edinger Associates Incorporated in 1989, Document No. 89-15-R (Edinger 1989). That study simulated mean lake temperature for similar heat rejection rates (single 992 MWe @100%) from the CPS into two lake volumes. One at normal pool and one at a drought pool set at 4.5 feet below normal pool. The simulated results indicate higher lake mean temperatures at the point of discharge with the drought pool volume compared to normal volume. Mean temperatures at the plant intake were essentially unchanged from normal to drought pool volume. The mean temperature increase (Table 5.1 and 5.2) at the lake surface (Layer 5) varied from 1.2 degrees C at the point of discharge (Seg. 16) to 0.1 degrees C at the plant intake (Seg. 5). Near the lake bottom (Layer 10) the simulated mean temperature increase varied from 1.3 degrees C at the point of discharge (Seg. 16) to 0.0 degrees C at the plant intake (Seg. 5).

Column I

Column I is used to convert the forced evaporation losses established for the original proposed two 992 MWe plants to the current single 992 MWe plant that was uprated to 1138 MWe. Because there is a linear relationship between power produced and heat rejected, Column H was divided by two to account for the one plant versus the two, then multiplied by 1.15 to account for the uprate from 992 MWe to 1138 MWe. The loading factor was also changed from 70% to 100% by dividing the data by a factor of 0.70. The net effect of this is equivalent to multiplying Column H by a factor of 0.82. This column contains blank cells in the worksheet containing analysis of the two originally planned plants without the uprate.

Column J

Column J contains the maximum additional loss due to a new plant that would maintain a minimum lake surface elevation of 677.0 feet. This column is only used in the “Max Add’l Loss” analysis, and contains blank cells in other worksheets. The value represents the maximum amount of withdrawal available for a new plant. This loss is considered a direct evaporative loss through a plant cooling process. No significant water volume is return from the cooling process to the lake. Although the actual operation of the new plant may have some seasonally variations, this model represents the loss as constant value over the 5-year duration.

Column K

Column K contains the amount of minimum downstream discharge (298 acre-feet/month which is equivalent to the required minimum lake discharge of 5 cfs) (Illinois Power 2001)

Column L

Column L contains the amount of water lost through the bottom of the lake via seepage. According to the CPS USAR (page 2.4-29), this value is equal to 5% of the volume, so this column contains a calculation which multiplies the lake volume (Column D) by 0.05. (Illinois Power 2001).

Column M

Column M contains a calculation to compute total loss by adding net lake evaporation loss (Column G), forced loss due to two 992 MWe plants (Column H) or uprated plant forced evaporation loss (Column I), additional loss for new plant (Column J), minimum downstream discharge (Column K), and assumed seepage of 5% of lake volume (Column L).

Column N

Column N contains a calculation of the watershed area minus the area of the lake (Column E). This is done because precipitation on the lake itself is accounted for in Columns F and G, and runoff calculations should then account for precipitation within the watershed area minus the lake area.

Column O

Column O contains runoff data in inches for the appropriate drought scenario (50-year or 100-year drought events). The data were taken directly from CPS USAR Table 2.4-20 (100-year drought) and CPS USAR Table 2.4-24 (50-year drought) (Illinois Power 2001). The drought runoff data for Salt Creek at the Rowell gauging station were derived from the low flow recurrence curves in the Illinois State Water Survey publication, “Low Flows of Illinois Stream for Impounding Reservoir Design” (Stall 1964).

Column P

Column P contains inflow due to runoff. This is calculated by dividing Column O by 12 to convert inches to feet and multiplying by the watershed area minus the lake area (Column N) to get acre feet of runoff.

Column Q

Column Q contains no data or calculations.

Column R

Column R calculates the net gain or loss in volume of water for the month by subtracting total loss (Column M) from inflow (Column P).

References

Roberts, Wyndham and J.B. Stall. *Lake Evaporation in Illinois*, Illinois State Water Survey Report of Investigation 57, 1967.

Stall, J.B. *Low Flows of Illinois Stream for Impounding Reservoir Design*, Illinois State Water Authority Bulletin 51, 1964.

Illinois Power. *Clinton Power Station Environmental Report – Operating License Stage*. Supplement 3. April 1982.

Illinois Power. *Clinton Power Station Updated Safety Analysis Report*. Revision 9. January 2001.

J.E. Edinger & Associates, Inc., Probabilistic Hydrothermal Modeling Study of Clinton Lake, Document 89-15-R, February 1989.