Workshop 7 – Hydropower: Adding Power Plants and Generating Power

Introduction

In this workshop, you will add the power plant to Crazy Mountain Dam with its existing regulating outlet and estimate the power generation available with reservoir simulation. The addition of a power plant will provide new simulation output, including power capability and generation. The workshop consists of three parts.

In Part A, the objective will be to add the physical power plant with no operational power generation requirements and analyze the simulation results with power generation being incidental to operational release requirements.

In Part B, the objective will be to add operational power requirements and analyze the results of the simulation operating to meet a power schedule.

In Part C, the objective will be to add operational outlet allocation to direct all flow through the power plant.

➢ Part A - Add Physical Power Plant and Produce Incidental Power

Problem Description

Part A will focus on the power plant physical features, using the simpler options. Power generated by the power plant will be incidental to the releases derived from non-power releases. The *Crazy Mountain Reservoir Regulation Manual* (Hypothetical Reservoir Manual prepared for this class) contains power plant characteristics in its "*PERTINENT DATA*" section and penstock physical characteristics in Table A-6. You will add the power plant and penstock physical characteristics to the Crazy Mountain reservoir model.

Tasks

1. Open the hydropower workshop watershed: **WS7_Start**
2. Select the **Network** module
3. Open the **Reservoir Network** "***Hydropower Workshop***"
4. Edit the Crazy Mountain reservoir properties
5. Select the **Physical** tab in the Reservoir Editor

- ***<u>Section 1</u> - Adding a Power Plant at Crazy Mountain Dam***

1. Add the Power Plant to the ***Dam*** level of the Crazy Mountain physical tree.

   - Add the penstock rating in the ***Outlet*** tab of the new power plant using the data in Table A-6 of the *Crazy Mountain Regulation Manual* or by copy-paste from the "WS#7 Hydropower" sheet of the *CrazyMountainData.xls* Excel file
   - Fill in the Power Plant parameters on the remaining tab panels with labels **Capacity**, **Efficiency**, **Station Use**, and **Hyd. Losses** using information from the reservoir regulation manual pertinent data or copy-paste from the Excel file

2. Add Tailwater Elevation to the Power Plant by right-clicking on it in the Physical tree

   Enter a constant Tailwater Elevation from information provided in the reservoir regulation manual pertinent data.

3. Examine the existing **Operation** rules in Operation Set named "**Hydropower**". What minimum release will be made when:

   - the pool elevation is within the drought contingency zone? _____
   - the pool elevation is within the conservation zone? _____
   - the pool elevation is at the top of the conservation zone? _____

4. Save the **Hydropower** network.

5. Edit the **Hydropower** alternative.

   - For the configuration named "Existing", select **Hydropower** alternative and then select the **Lookback** tab.
   - The lookback period should have a starting elevation of 662.1 (one tenth foot above drought contingency zone), a constant flow of 1600 cfs through the regulated outlet, and a zero flow through the uncontrolled spillway.
   - Add a constant **zero flow** through the **new power plant**.
   - **Save** the **Hydropower** alternative.
   - **Close** the alternative editor.

6. **Save** the Watershed.

- ***<u>Section 2</u> - Run the reservoir simulation***

1. Select the **Simulation** module.

2. Open the **1997 Spring Freshet** simulation.

3. For the **Hydropower** alternative, select "**Replace From Base Directory …"** to load the reservoir network data into the simulation alternative. Click to add a check in the **Restore Data** box and click **OK** to complete the replace from base.

4. **Compute** the **Hydropower** alternative.

5. When the simulation is complete, review the message output in the compute window to verify that the simulation computed successfully. (If the compute is not successful, ask for assistance before continuing.) Click the **Close** button to continue the workshop.

- ***<u>Section 3</u> - Become familiar with the power output options***

1. Point at the Crazy Mountain reservoir in display area (within the simulation module) and right click to bring up the short cut menu. On the context menu select the **Plot Power** option.

2. Select the **Tabulate** from the plot **File** menu to see the tabulation.

3. From the simulation module **Reports** menu select the **Power Summary**.

4. Using the power output options and other outputs such as the **Release Decision Report** and the Reservoir Summary Report, view and analyze the results…

Questions

I) What were the minimum and maximum pool elevations in the simulation?

II) What was the average power generated?

III) When did the release from the reservoir increase over minimum?

IV) What rule determined the increase above minimum?

V) What is the maximum power that could have been generated when the pool was at the top of the conservation zone?

VI) What was the maximum power actually generated?

VII) Was the power plant flow the same as the total outflow from the reservoir? If not, why was it different?

➢ Part B –Operating Rule: Hydropower - Schedule

Problem Description

In this part, you will add a hydropower energy requirement rule to the reservoir and evaluate the ability to meet this requirement with reservoir simulation. You will specify a scheduled energy rule and run the simulation. Power generated by the power plant in Part B will be based on a monthly energy requirement. The addition of power rules will provide new output for required power generation, which you will observe and analyze in the simulation.

Table 3-1 from the *Crazy Mountain Reservoir Regulation Manual* lists the monthly energy required from the Crazy Mountain power plant to be generated on a schedule of 4 hours per day Monday through Friday, 0600-1000 hours. Your job is to identify the power operation requirements in the regulation manual and add them as a rule to the Crazy Mountain reservoir.

Tasks *(continued from Part A)*

5. Close all plots, tables, and reports you may have opened in the Simulation Module, then go the Network module and open the **Reservoir Network** "***Hydropower Workshop***"

6. Bring up the **Reservoir Editor** for Crazy Mountain reservoir

7. Select the **Operations** tab in Reservoir Editor

8. Select the **Hydropower** Operation Set.

- ***Section 1 - Adding a Scheduled Energy Operation Rule at Crazy Mountain Dam***

9. Add the **Firm Energy** rule to the reservoir's **Conservation Zone**.

    - On the **New Operating Rule** dialog select the ***Crazy Mountain-Power Plant*** from the dropdown list in the **Operates Release from:** field.
    - Select the ***Hydropower - Schedule*** rule from the dropdown list in the **Rule Type:** field.
    - Type ***Scheduled Power*** (or any label meaningful to you) in the **Rule Name** field to name the rule and click **OK**.

10. Add the scheduled energy information shown in the *Table 3-1* in Section III (Water Control Plan) of the *Crazy Mountain Reservoir Regulation Manual*. Optionally, you may copy the same data from the Excel file, *CrazyMountainData.xls* under the worksheet labeled "*WS#7 Hydropower"* and paste them into the ResSim rule tables.

    - Edit the ***Scheduled Power*** rule in the **Conservation Zone**.
    - Select the "**Option…"** button to bring up the **Power Generation Requirement** dialog.
    - As noted in Table 3-1, the energy *Requirement Varies* ***Monthly*** and is specified as ***Monthly Total MWH***. For this workshop, allow the period over which the generation requirement is satisfied to be ***Each Time-Step***.
    - Close the **Power Generation Requirement** dialog by clicking **OK**.
    - Fill in the **Monthly Requirement (MWh)** from *Table 3-1* or by a copy-paste from the table in the Excel file.
    - Click the "**Power Generation Pattern …"** button to bring up the **Power Generation Pattern** dialog.
    - At top of the **Power Generation Pattern** dialog, the **Seasonal Variation** check box should remain unchecked and the label below it should read "**Pattern Applies all Year**" to allow the same pattern to apply throughout the simulation period.
    - Since the regulation manual specifies a Monday through Friday schedule, select the ***Weekdays and Weekend*** pattern in the "**Specify Pattern for"** field.
    - Enter "***1.0***" as the proportional pattern weighting factor for each of the four hours indicated for **Weekdays** in the regulation manual and excel worksheet. The weighting factor could be any number, but must be of equal magnitude for the four hours to indicate an equally weighted pattern. The remainder of weekday hours and the weekend should be zeros to indicate no generation required in those periods. Alternately, the pattern may be entered more conveniently with a copy-paste from the table in the Excel file.
    - Close the **Power Generation Pattern** dialog with an **OK**.
    - Add the new ***Scheduled Power*** rule to the **Drought Contingency** zone by selecting **Use Existing** from the **Rule** menu.

Question

VIII) How much energy will your new scheduled power rule attempt to generate during the month of June? _____

11. Close the reservoir editor and **Save** the **Network**.

12. **Save** the Watershed from the **File** menu.

- ***<u>Section 2</u> - Run the reservoir simulation***

13. Select the **Simulation** module.

14. Open the **1997 Spring Freshet** simulation.

15. For the **Hydropower** alternative, select "**Replace From Base Directory …"** to load the reservoir network data into the simulation alternative. Click to add a check in the **Restore Data** box and click **OK** to complete the replace from base.

16. **Compute** the **Hydropower** alternative.

17. Click **Close** on the **Compute** dialog when the simulation is complete.

- ***<u>Section 3</u> - Analyze the scheduled power simulation by examining the power output options***

18. Examine the plot produced by the reservoir context menu item, **Plot Power**. Note that there is a new variable, **Power-Required**, which indicates how power was scheduled to meet energy requirements.

19. Select the **Tabulate** from the plot **File** menu to see the tabulation.

20. Select the **Release Decision** report to see when the power rule or other rules determined the powerhouse releases.

21. From the simulation module **Reports** menu select the **Power Summary**.

22. View and analyze the results using the power output options and other outputs such as the **Release Decision Report**.

Questions

IX) What dates comprised the weekend in this simulation?

X) Did the power plant generate power only on the required schedule? If not, what other rules cause power generation?

XI) What was the average power generated during the simulation?

XII) What effect did the lower pool elevation at the beginning of the simulation period have on power generation?

XIII) Did the simulation make all releases through the power plant? If not, did these non-power releases occur during scheduled hydropower periods?

➢ Part C – Outlet Allocation

Problem Description

In this part, you will add an outlet allocation to the reservoir to ensure all releases generate power. You will specify the appropriate allocation method and determine the effect on power generation during the simulation.

Tasks (continued from Part B)

23. In the **Simulation module** create a trial of the **Hydropower** alternative and name it ***Outlet Allocation***.

24. Bring up the **Reservoir Editor** for Crazy Mountain reservoir

25. Select the **Operations** tab in Reservoir Editor

26. Select **Hydropower** Operation Set.

- ***Section 1 - Adding outlet allocation to operation rule set***

27. Select the **Rel. Alloc.** tab.

    - At the dam level in the **Rel. Alloc.** dialog, select the ***Sequential*** allocation type.
    - Using the up-down arrow button move the ***Power Plant*** to the top of the list.
    - In this specification, all flow will pass through the power plant up to its capacity. If release beyond the power plant capacity is required, the Regulated Outlet will make the additional release. *(Note: you will need to create a new "allocation set to be able to select sequential).*

28. Close the reservoir editor and **Save** the **Simulation**.

29. **Save** the Watershed.

- ***Section 2 - Run the reservoir simulation trial***

30. **Compute** the **Outlet Allocation** trial.

31. Click **Close** on the **Compute** dialog when the simulation is complete.

- ***<u>Section 3</u> - Analyze the scheduled power simulation by examining the power output options***

32. Using the power output options and others as necessary, view and analyze the results…

Questions

XIV) Did the simulation make all releases through the power plant? Other than the specified flows in the lookback period, did the reservoir make any releases through other outlets?

XV) Did the power plant generate additional incidental power?

XVI) If the average plant factor from the Part C simulation applied to the whole month, how much energy would be generated? Is this the same as the monthly energy requirement? If not, why is it different?

XVII) Check both the alternative and the trial to compare generation. What was the increase in average power generated during the simulation when comparing the results of Part B and Part C?