Hydrologic Engineering Center

Training course on

# Reservoir Systems Analysis with HEC-ResSim

**06-10 February, 2023**

The Reservoir System Analysis course is intended for water resource professionals who are involved in various aspects of reservoir studies. A primary objective of the course is to provide participants with the capability to perform reservoir system studies using the HEC-ResSim reservoir operations simulation software. After completing the course, students will be able to use HEC-ResSim to build, modify, and run reservoir models and analyze results.

The pre-release version 3.5 of ResSim will be used during this course.

## Prerequisites

A basic understanding in hydrology, hydraulics and reservoir regulation is required. Three or more years of professional work experience in hydrology and hydraulics or in water resource planning with emphasis in hydrologic studies meets this level of understanding.

HEC Instructors (in alphabetical order)

- Russell Errett
- Beth Faber
- Fauwaz Hanbali
- Evan Heisman
- Joan Klipsch
- Sara O'Connell
- Leila Ostadrahimi

Guest Lecturer

- John DeGeorge

## References

Reference materials related to the course include manuals for the HEC-ResSim software.

1) The 3.3 *HEC-ResSim Quick Start Guide*
2) The 3.3 *HEC-ResSim User's Manual*

These documents can be downloaded from the HEC website: www.hec.usace.army.mil
Simply follow the HEC-ResSim link from the Software menu of the home page.

Day 1: Monday, 6 Feb

8:00 – 8:45 INTRODUCTION

Class and staff introductions, administrative details, pre-test.

8:45 – 9:30 Lecture 1: **SIMULATING RESERVOIR SYSTEMS (Klipsch)**

The basic principles for simulating reservoir systems: Authorized purposes, operational goals, physical data requirements, operational data; flow data, simulation considerations and analysis procedure.

9:30 – 10:00 Lecture 2: **INTRODUCTION TO HEC-ResSim (O'Connell)**

An overview of the capabilities of HEC-ResSim, "*Reservoir Evaluation System-Simulation"*. Includes a brief description of ResSim data structures.

10:00 – 10:15 Break

10:15 – 10:45 Lecture 3: **DEVELOPING A WATERSHED SCHEMATIC (Ostadrahimi)**

Development of a stream alignment, configurations, and the various schematic elements.

10:45 – 11:30 Lecture 4: **RESERVOIR NETWORK (Klipsch)**

What is a Reservoir Network? Network relationship to configuration. Network connectivity (reaches). Reach properties. Reservoir data and sub-elements. Losses.

11:30 – 12:30 Lunch

12:30 – 1:45 Workshop 1: **WATERSHED SETUP AND RESERVOIR NETWORK DEVELOPMENT (Klipsch, Ostadrahimi)**

Create a reservoir network. Add reaches to complete connectivity. Entering reach properties, reservoir pool and dam definition, and outlets and define outlet properties. Creating an operation set.

1:45 – 2:15 Lecture 5: **BASIC GUIDE CURVE OPERATIONS (O'Connell)**

What are Reservoir Operations, a Guide Curve, Zones, and Rules? How are they defined in HEC-ResSim? What is Guide Curve Operation?

2:15 – 3:00 Lecture 6: **ALTERNATIVES AND SIMULATIONS (Errett)**

Concepts, development, and editing of alternatives and simulations.

3:00 – 3:15 Break

3:15 – 4:00 Lecture 7: **ANALYSIS OF RESULTS (O'Connell)**

Evaluating simulation performance, overview of available output options, pre- and user-defined plots and tables; summary reports; performance indices and methods to develop them.

4:00 – 5:00 Workshop 2: **BASIC GUIDE CURVE OPERATIONS (Klipsch)**

Create a simple operation set and define its zones – Guide Curve definition. Create alternatives and simulations. Perform both high and low flow simulations. Gain understanding of guide curve operation.

Day 2: Tuesday, 7 Feb

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| 8:00 – 8:30 | | **REVIEW (Klipsch)** |
| 8:30 – 9:00 | Lecture 8: | **Routing Methods (Errett)**<br>Overview of routing methods available in HEC-ResSim. Covers the data required and various parameters associated with the different methods. Also, a look at the pros/cons and use-cases for each method. |
| 9:00 – 9:15 | Break | |
| 9:15 – 10:15 | Lecture 9: | **BASIC RULE-BASED RESERVOIR OPERATION (Errett)**<br>Developing rule-based operations. Review of guide curve operations and the impact of operation rules. Walk through the release decision logic. Analyzing decision results. |
| 10:15 – 11:00 | Lecture 10: | **IMPLEMENTING RELEASE RULES (Errett)**<br>Overview of operation sets, zones, and rules. Creating "at-site" Release Function, Rate of Change rules based on Flow or Elevation. |
| 11:00 – 12:00 | Workshop 3: | **CREATING AT-SITE OPERATING RULES (Hanbali, Errett)**<br>Develop an operation set and its associated alternative for each rule type. Gain familiarity with the Release Function editor and each type of "at-site" rule. |
| 12:00 – 1:00 | Lunch | |
| 1:00 – 2:15 | Workshop 3: | **CREATING AT-SITE OPERATING RULES**<br>(continued) |
| 2:15 – 2:30 | Break | |
| 2:30 – 3:30 | Lecture 11: | **OPERATION FOR DOWNSTREAM OBJECTIVES (DeGeorge)**<br>Implementing operation rules to meet downstream flow objectives. Prioritizing rules in complex operation sets. |
| 3:30 – 5:00 | Workshop 4: | **MULTIPLE RULES OPERATION (DeGeorge, Klipsch)**<br>Add a downstream control rule to an existing operation set. Prioritize the rules in the operation set. Understand how downstream operation and rule prioritization influence release decisions. |

Day 3: Wednesday, 8 Feb

8:00 – 9:15 Lecture 12: **EMERGENCY GATE OPERATION – INDUCED SURCHARGE (Faber)**

Role and assumptions of emergency operation. Definition of induced surcharge. Application of Induced Surcharge rule in ResSim.

9:15 – 11:00 4.4 Workshop 5: **INDUCED SURCHARGE OPERATION (Klipsch, Errett)**

Duplicate existing operation set. Add emergency operation zone to new operation set. Add induced surcharge rule. Duplicate alternative. Change operation set to new set in a new alternative. Edit simulation, adding new alternative. Update from base. Analyze difference in operation.

11:00 – 11:15 Break

11:15 – 11:45 Lecture 13: **DEVELOPING INFLOWS (Errett)**

Sources of local inflow data, methods for computing local inflows from observed flows, connecting to HMS results

11:45 – 12:00 **REVIEW (Klipsch)**

12:00 – 1:00 Lunch

1:00 – 2:00 Lecture 14: **REALTIME vs STUDY MODELING APPROACH (Hanbali)**

2:00 – 3:00 Lecture 15: **SYSTEM OPERATION (Hanbali)**

Multiple reservoir operation for flood control and conservation purposes. Use of system “balance” rules.

3:00 – 3:15 Break

3:15 – 5:15 Workshop 6: **SYSTEM OPERATION (Hanbali, Errett)**

Part A – review Guide Curve operations. Part B – add an implicit, parallel reservoir system. Part C – add an implicit, tandem reservoir system. Part D – add an explicit reservoir system and define the storage balance scheme. Analyze operations, changes in reservoir storage management and downstream regulation.

Day 4: Thursday 9 Feb

8:00 – 9:00 Lecture 16: **HYDROPOWER CONCEPTS (Heisman)**

Role and impact of hydropower in multipurpose development; definition of terms; demand for power, computing hydropower releases, reservoir operations and power benefits.

9:00 – 9:45 Lecture 17: **HYDROPOWER SIMULATION (Ostadrahimi)**

Defining hydropower facilities: penstocks, power plants, plant efficiencies, and headwater and tailwater considerations. Concepts of "run-of-river" power production. ResSim hydropower operations: scheduled energy options, Power Guide curve, and defined time series data.

9:45 – 9:55 Break

9:55 – 11:25 Workshop 7 **HYDROPOWER (Heisman, Ostadrahimi)**

Add a power plant and analyze standard operations without energy demand (secondary power production). Add a scheduled energy requirement to the operations and analyze impact of power requirement on results. Become familiar with hydropower output options.

11:25 – 12:00 Lecture 19*: **STATE VARIABLES (O'Connell)**

Adding complex logic to standard prioritized rule list of a zone in an operation set.

12:00 – 1:00 Lunch

1:00 – 1:30 Lecture 18*: **IF-THEN-ELSE RULE BLOCKS (Ostadrahimi)**

Creating your own variables for use within the conditional logic of your If-Then-Else blocks. We will introduce the concept here and the basics of the editor.

1:30 – 2:45 Workshop 8: **IF-THEN-ELSE RULE BLOCKS AND STATE VARIABLES (Errett, Ostadrahimi)**

Creating If-Then-Else rules. We will start with a watershed that already has a state variable defined. We will use that state variable within the condition of an If block. We will analyze the behavior and influence of the If block on the release decision logic/determination.

2:45 – 3:00 Break

3:00 – 4:00 Lecture 20: **COMPUTE BLOCKING & MODELING TECHNIQUES (Heisman)**

Modeling techniques to help ResSim manage dependencies. Also includes a brief discussion on linking to HMS flows.

4:00 – 5:00 Lecture 21: **MODELING CHALLENGES (Klipsch)**

Modeling challenges in real case studies.

*(Lecture 19 switched with Lecture 18 time slot).

Day 5: Friday, 10 Feb

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| 8:00 - 8:30 | POST COURSE TEST |
| 8:30 – 10:00 | Workshop 9: **TYING IT ALL TOGETHER (Hanbali, Ostadrahimi)**<br>Run and analyze different ResSim model exercises, then solve modeling issues and answer questions presented in the problem statement. |
| 10:00 – 11:00 | Lecture 22: **PREVIEW of ADVANCED ResSim FEATURES (Heisman)**<br>A selection of advanced ResSim features. |
| 11:00 – 11:30 | CRITIQUE AND CLOSING |