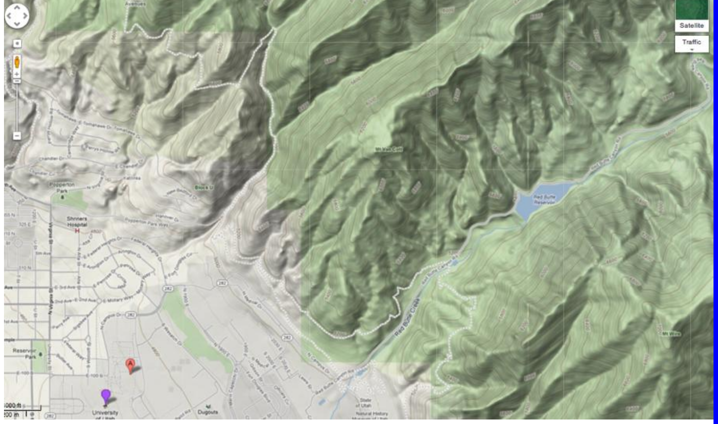
CVEEN 4410: Engineering Hydrology

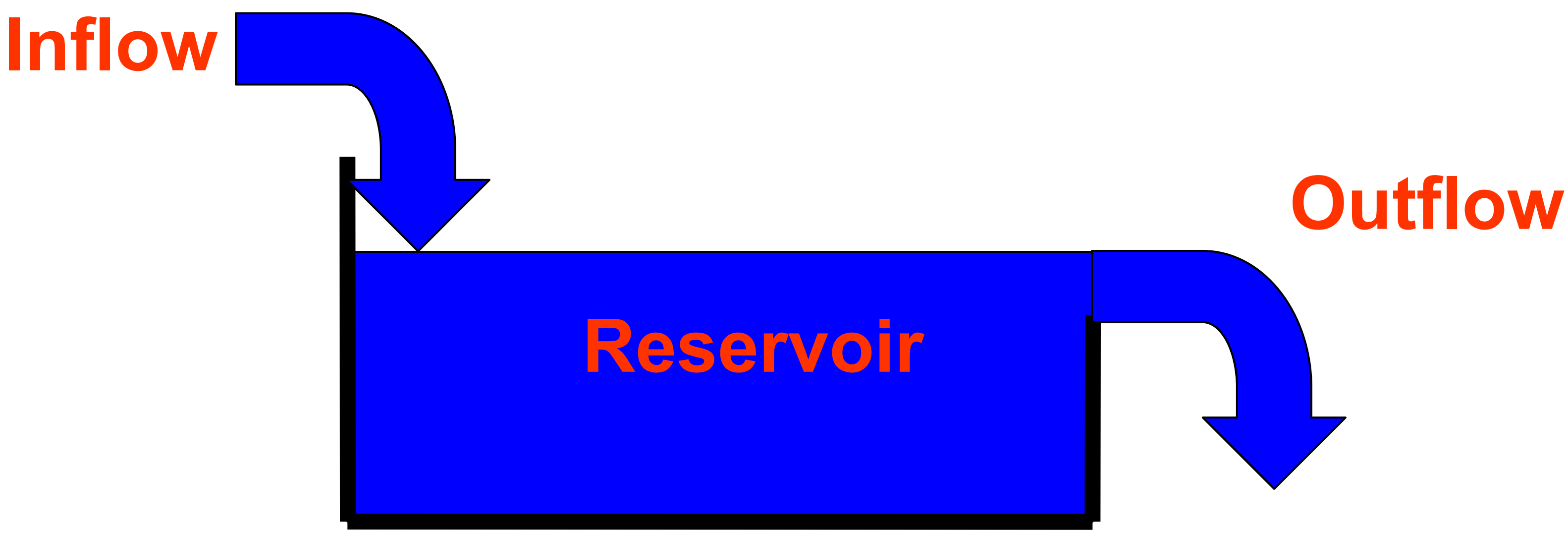
Topic and Goal:
Apply reservoir routing method, to account for stage and storage capacity on discharge from the reservoir.

Objectives

- **Describe continuity approach to reservoir routing**
- **Determine a reservoir stage-storage-discharge function**
- **Route hydrographs through reservoirs using Modified Puls**

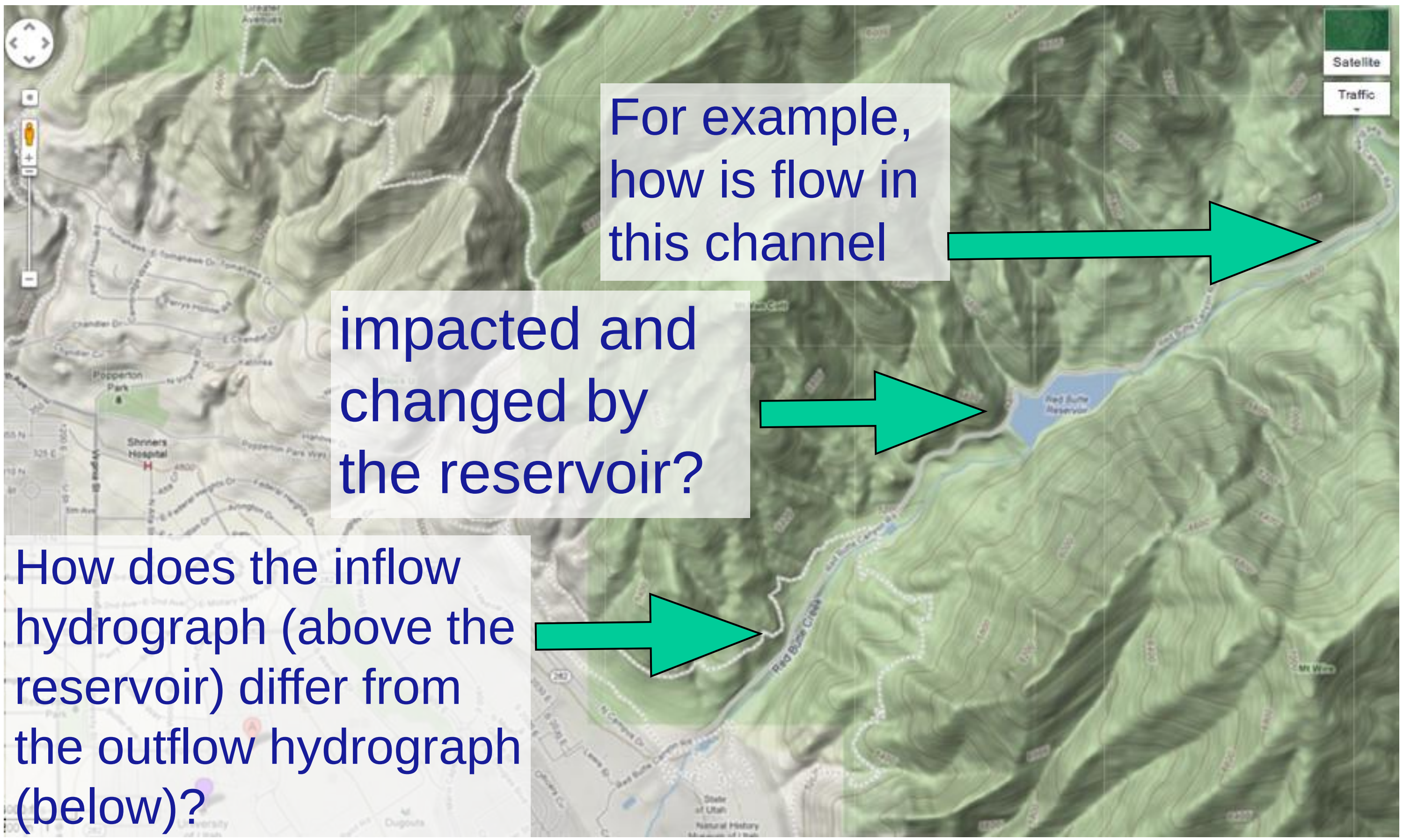
- **Reservoir routing** **describes the methods of computing an outflow hydrograph given an inflow hydrograph and reservoir characteristics**





Reservoir Routing
Objectives
Modified Puls Method
Routing Concept
Mass Balance Approach
Modified Puls Routing Equation

- **Reservoir routing** describes the methods of computing an outflow hydrograph given an inflow hydrograph and reservoir characteristics



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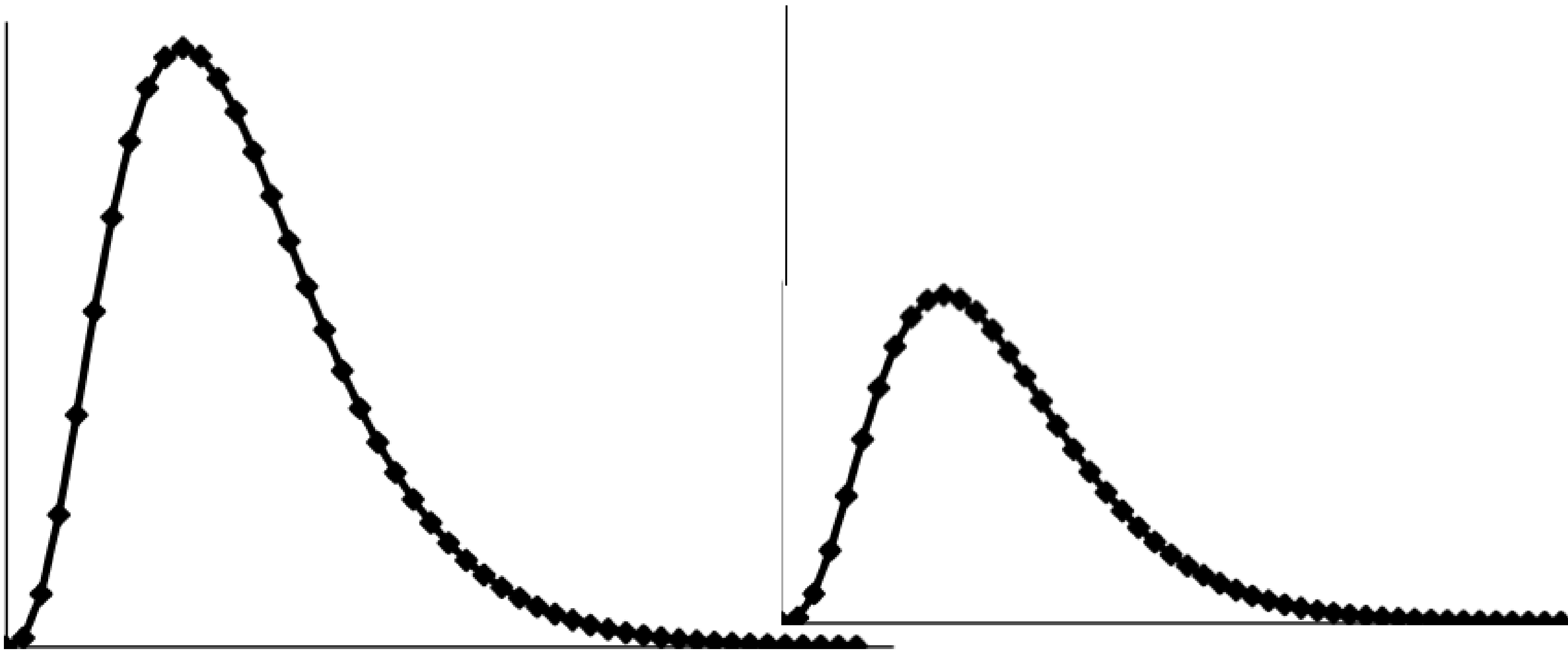

Inflow Hydrograph

Outflow Hydrograph

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Continuity:

$$I - O = \frac{dS}{dt} = \frac{\Delta S}{\Delta t}$$

where *I* and *O* are the inflow and outflow, respectively, during the incremental time *dt* (or ⊗*t*) and *S* is the storage

- **For reservoir routing, *I* and *O* would be the inflow and outflow hydrographs**

A numerical form of this mass balance equation, $I - O = \frac{dS}{dt} = \frac{\Delta S}{\Delta t}$, is:

$$\frac{1}{2}(I_1 + I_2)\Delta t - \frac{1}{2}(O_1 + O_2)\Delta t = S_2 - S_1$$

- Assuming that the inflow hydrograph is known for all *t* and that the initial outflow and storage, O_1 and S_1, are known at t_1, then the above equation contains two unknowns: O_2 and S_2

- Rearrange to put knowns on left hand side…

$$\frac{1}{2}(I_1 + I_2)\Delta t - \frac{1}{2}(O_1 + O_2)\Delta t = S_2 - S_1$$

- **Rearrange to put knowns on left hand side…**

$$\frac{1}{2}(I_1 + I_2)\Delta t + \left(S_1 - \frac{1}{2}O_1\Delta t\right) = \left(S_2 + \frac{1}{2}O_2\Delta t\right)$$

- **One equation and two unknowns. We need another equation**

- **A storage-discharge relationship can be developed given reservoir geometry and outlet characteristics (second equation)**

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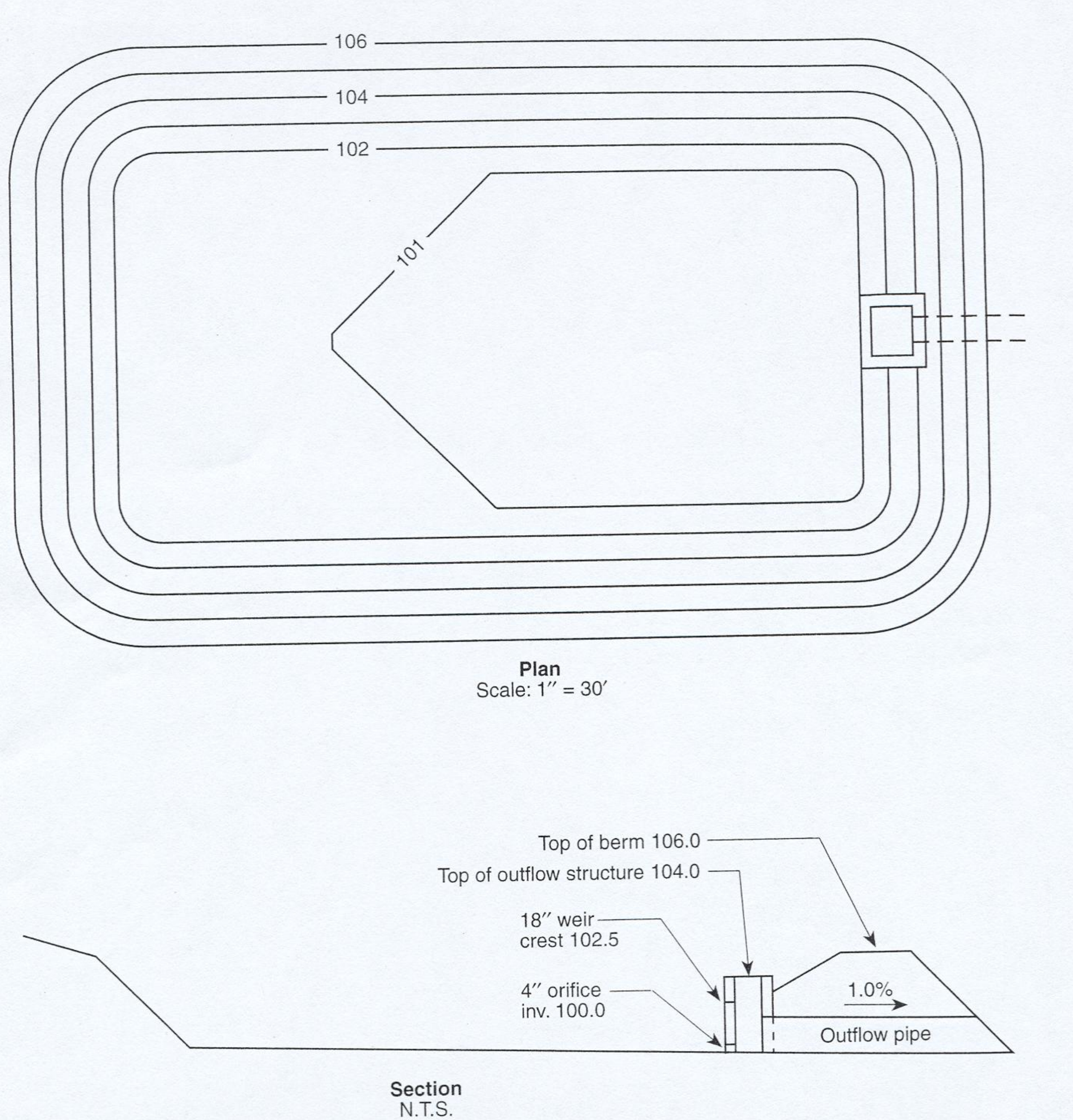
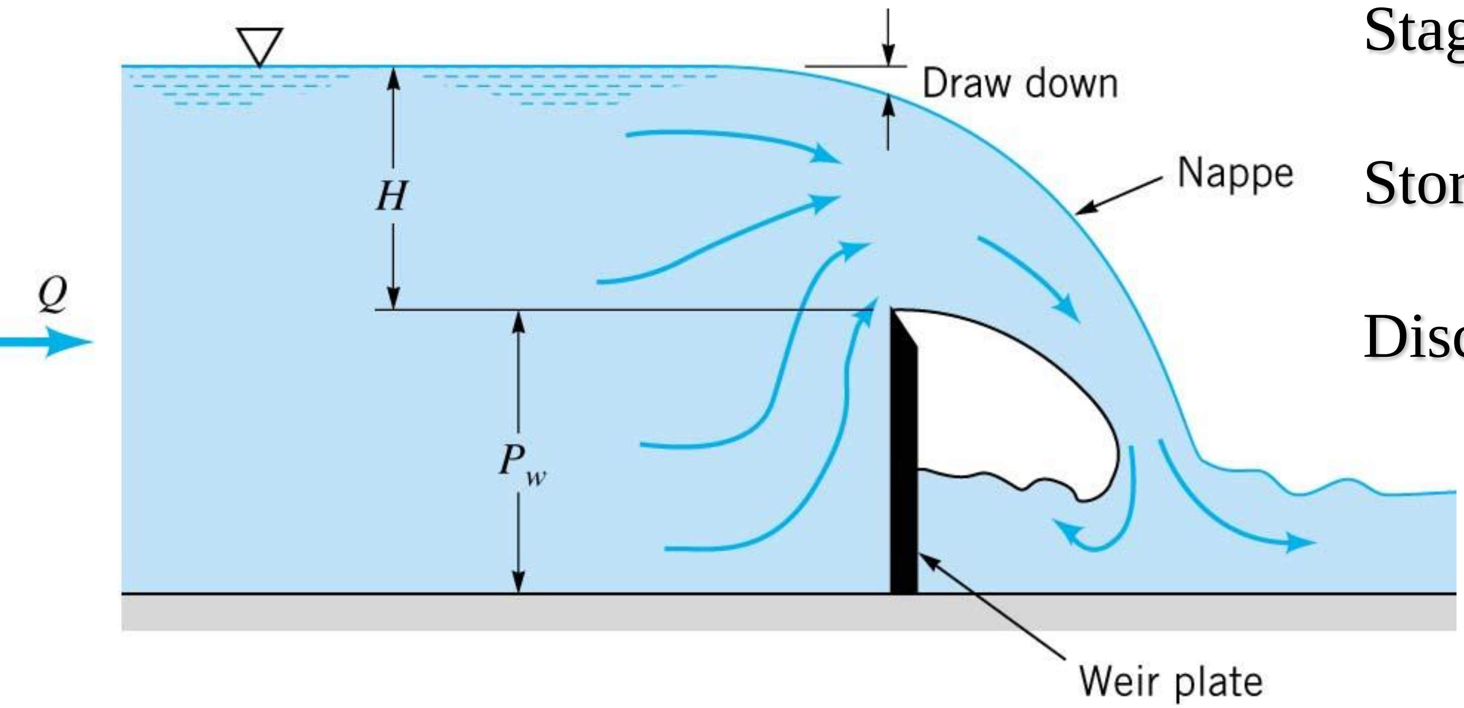
- **One equation and two unknowns. We need another equation**
- **A storage-discharge relationship can be developed given reservoir geometry and outlet characteristics (second equation)**
- **Make a mental note of this equation, for later**



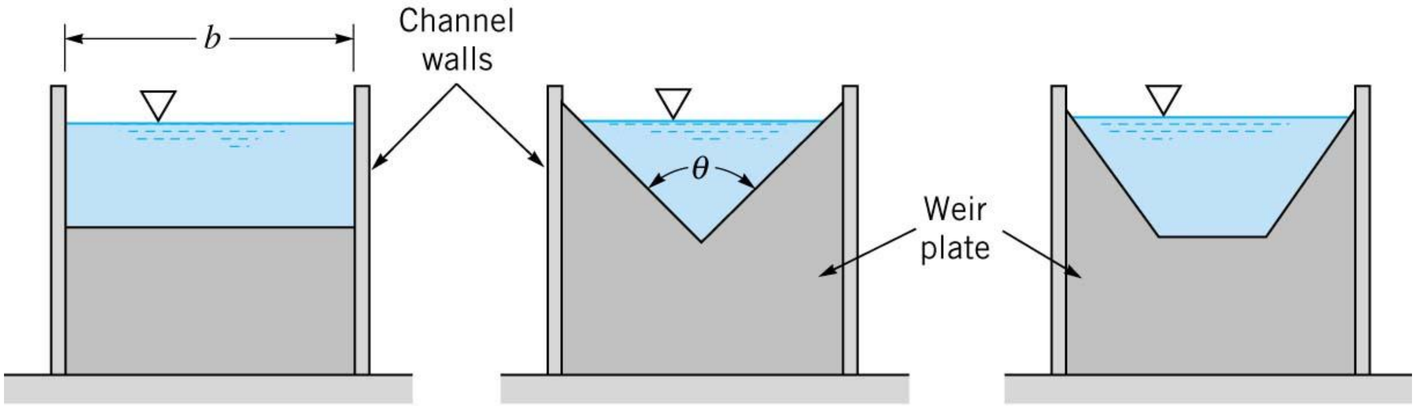
Goal:
Account for effects of reservoir geometry on stage, storage and ultimate discharge from the reservoir (e.g., stage-storage-discharge relationship).



Stage

Storage

Discharge



Stage

Storage

Discharge

Fully submerged weirs:

$$Q = C_w L H^{3/2}$$

Stage

Storage

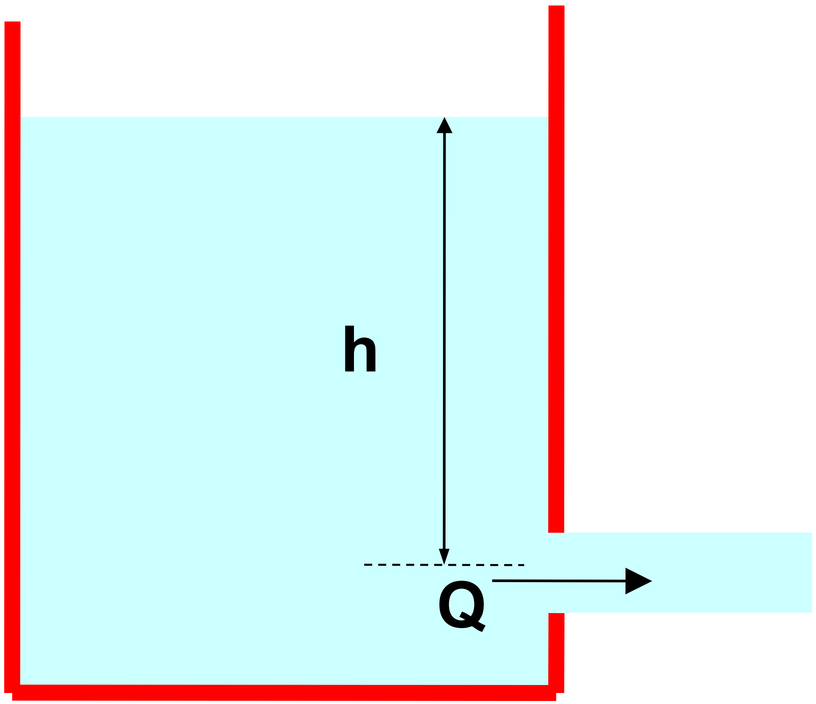
Discharge

V-notch:

$$Q = C_w H^{5/2}$$

[Q is the discharge (cfs)]
[C_w is the weir coefficient]
[L is the weir length (ft)]
[H = head (depth of discharge over weir (ft)]

Orifice Discharging into Atmosphere:



Stage

Storage

Discharge

$$Q = C_d A \sqrt{2gh}$$

C_d is approximately 0.6

Reservoir Routing

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Assumptions:

1) Reservoir water surface is horizontal
2) Outflow is a unique function of storage volume.
3) Outflow rate varies linearly with time during each time period ⊗t.

Recall our mass balance equation from earlier:

$$\frac{1}{2}(I_1 + I_2)\Delta t + \left(S_1 - \frac{1}{2}O_1\Delta t\right) = \left(S_2 + \frac{1}{2}O_2\Delta t\right)$$

Let's multiply this by 2, divide through by Δt, and rearrange just a bit:

$$\left(\frac{2S_2}{\Delta t} + O_2\right) = (I_1 + I_2) + \left(\frac{2S_1}{\Delta t} - O_1\right)$$

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This is the Modified Puls equation for reservoir routing. Much like channel routing, we will use an *iterative* approach!

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This is the Modified Puls equation for reservoir routing. Much like channel routing, we will use an *iterative* approach!

First, though, we will develop a stage-storage-discharge equation, to provide the second equation (e.g., to make *two* equations for the *two* unknowns….).

Please read "routing_methods_reading_assignment.pdf", posted on the website with this presentation, and we'll work a couple of in-class exercises, including:

- calibration (create stage-storage-discharge table)
- basin routing exercise with the Modified Puls method