Flood Routing,

Lecture 9, 04/30/2013

Arturo Leon, Oregon State University (Spring 2013)
Adapted from textbook and notes of Philip B. Bedient

Flood routing

2

Videos

- Morning Glory Spillway (http://www.youtube.com/watch?v=UVI7XZ-HRVE) Reservoir
- Dual spillway gate test at Roosevelt Dam (http://www.youtube.com/watch?v=vaYPCUO4QFw) Reservoir

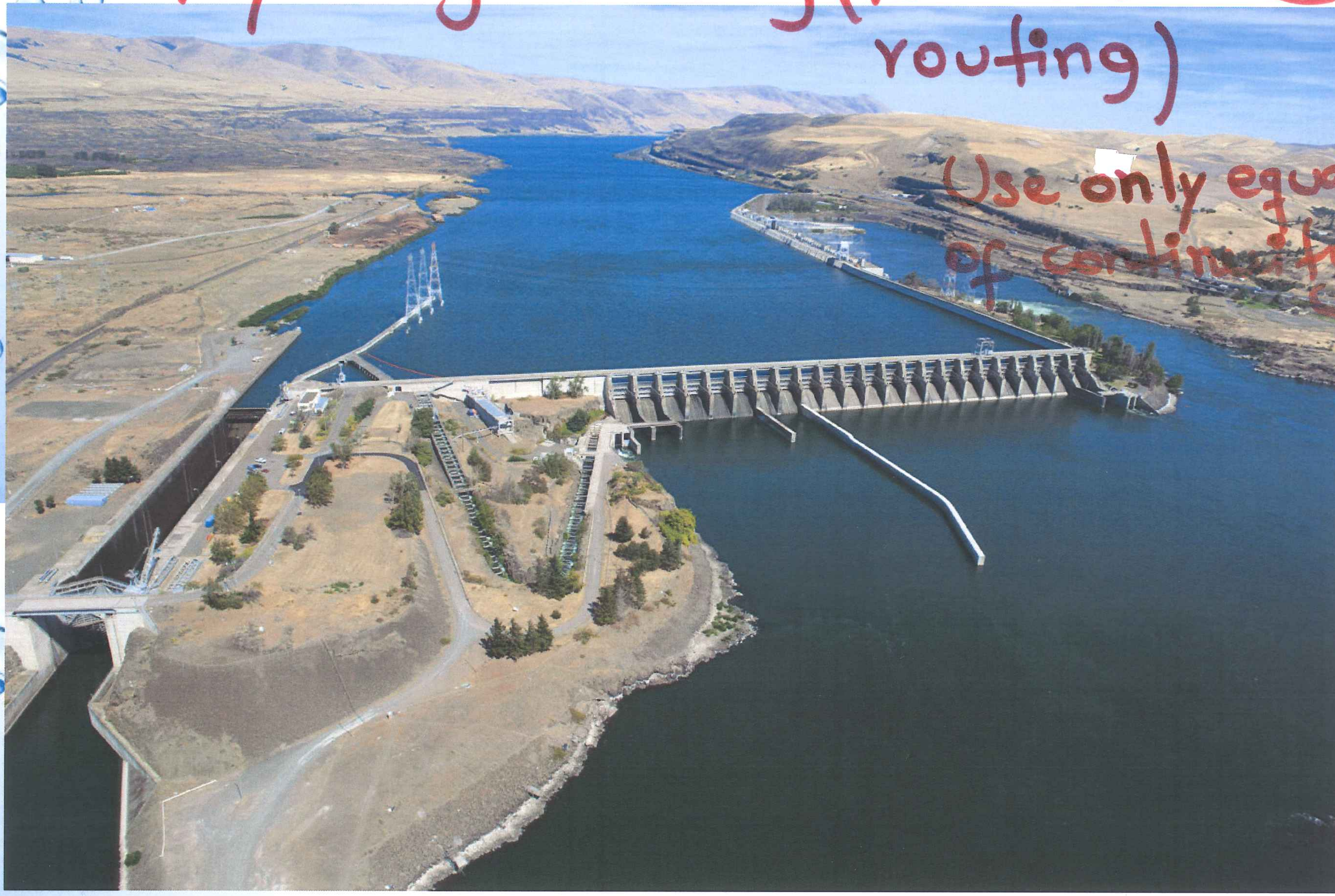
Hydrologic

- Flash floods cascade through western Nepal h floods cascade through western Nepal (http://www.youtube.com/watch?v=yC00cd2TzzU) River

hydraulic routing

Hydrologic routing (Reservoir routing) ③

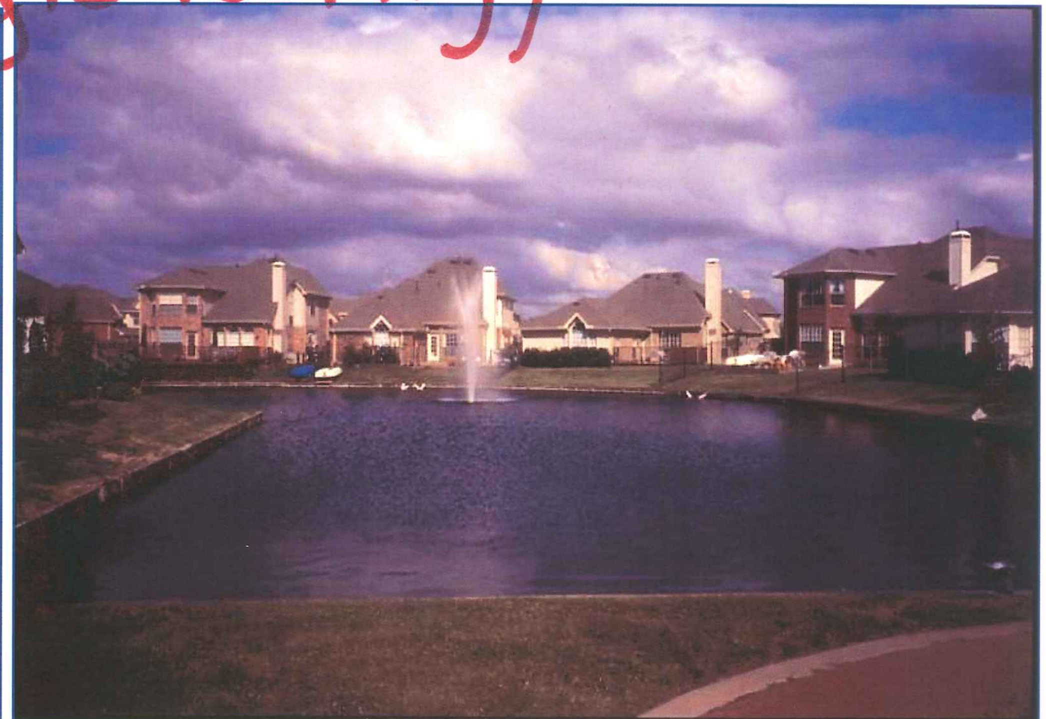
(Use only equation of continuity)



The Dalles Dam, Oregon

4

Detention Ponds
(Hydrologic routing)



Use only eq. of continuity ($\Sigma I - \Sigma O = \frac{\Delta S}{\Delta t}$)

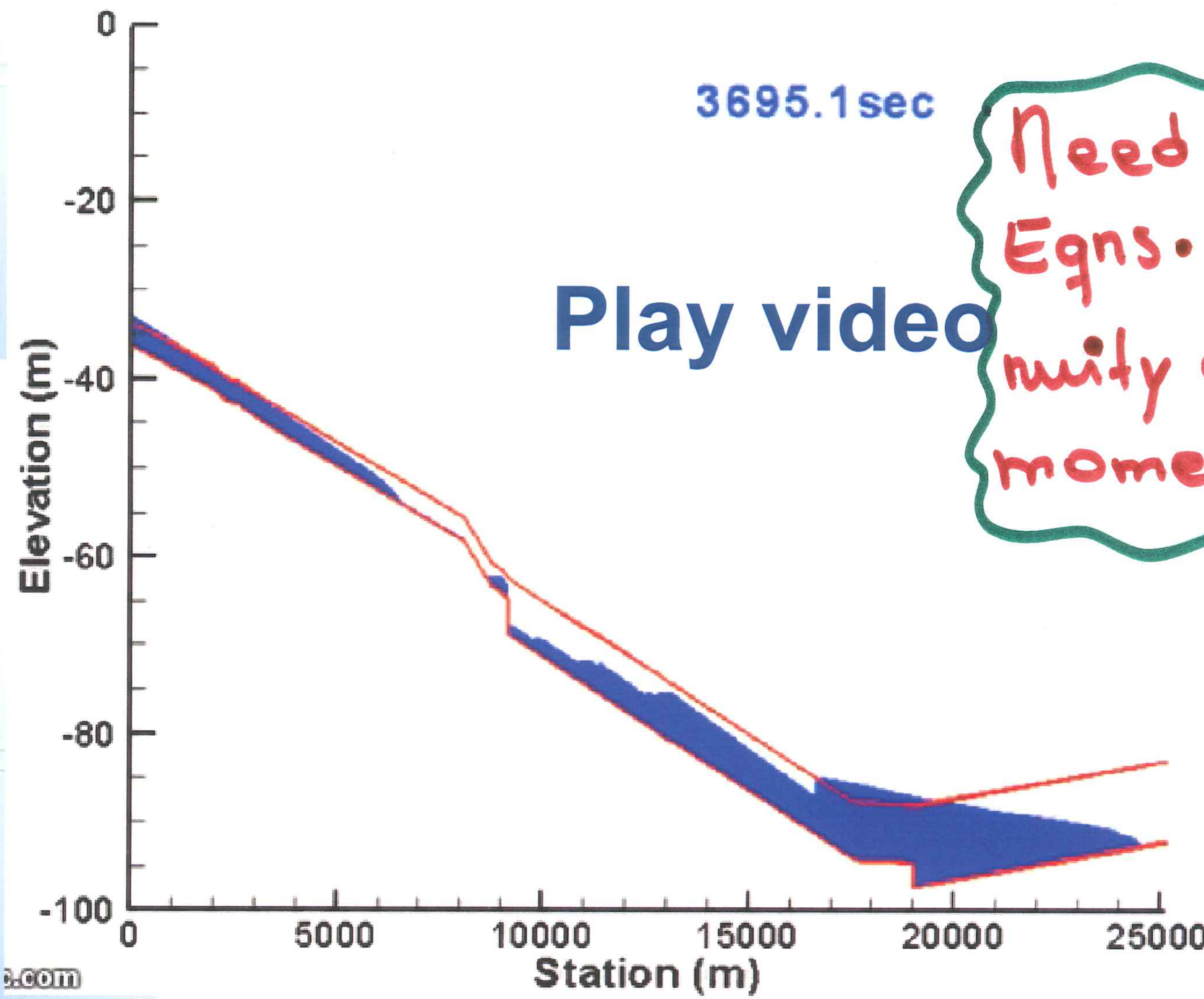
- These ponds store and treat urban runoff and also provide flood control for the overall development.
- Ponds constructed as amenities for the golf course and other community centers that were built up around them.

Hydraulic Routing

5

Example: **Illinois Transient Model (ITM)**

(Being developed at Oregon State University)



Play video

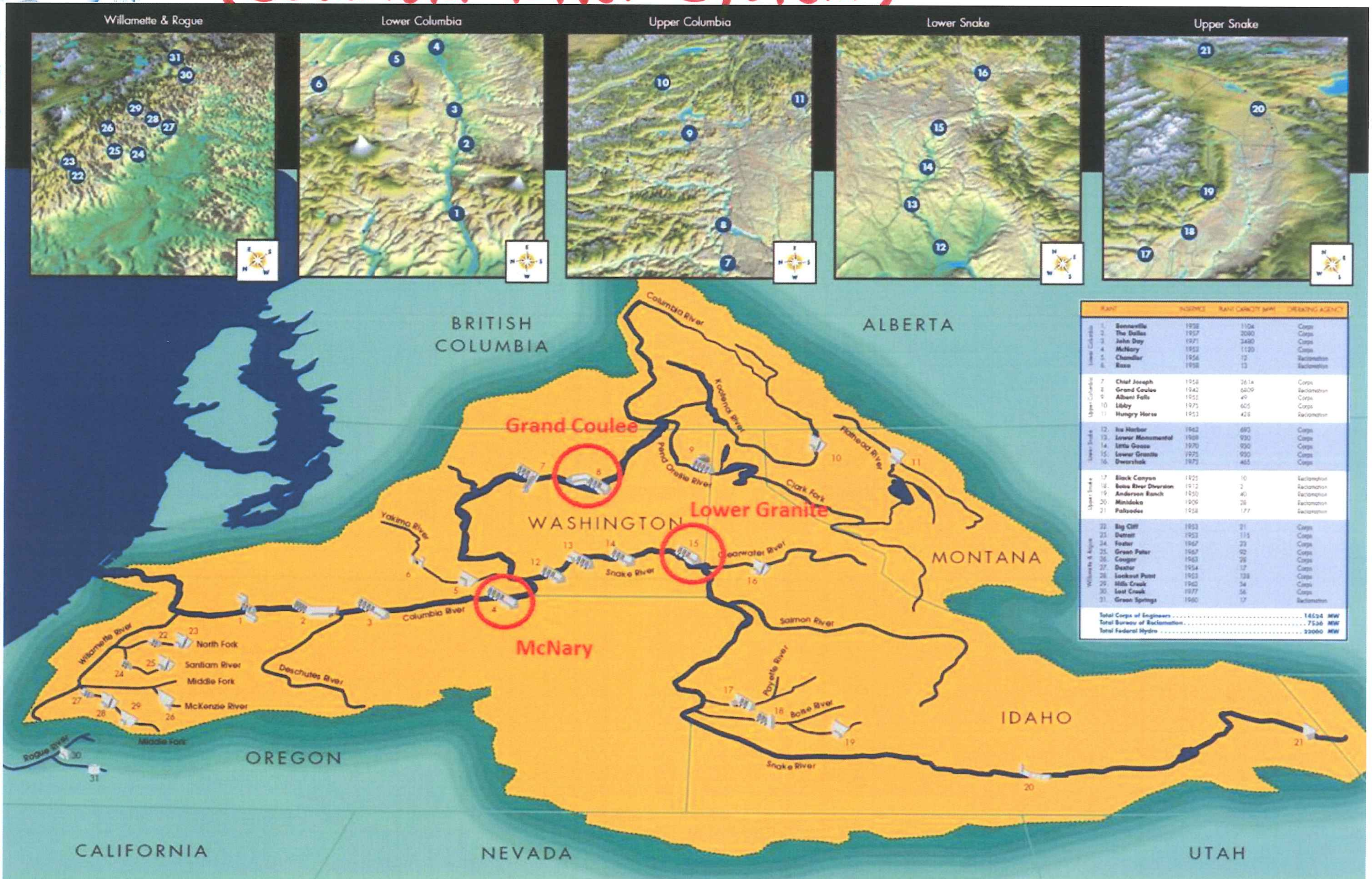
Need to use Eqns. of conti- nuity and momentum

(Combined approach) ⑥

Hydrologic-Hydraulic Routing – Columbia River

Optimization of a multiple reservoir system

(Columbia River System)

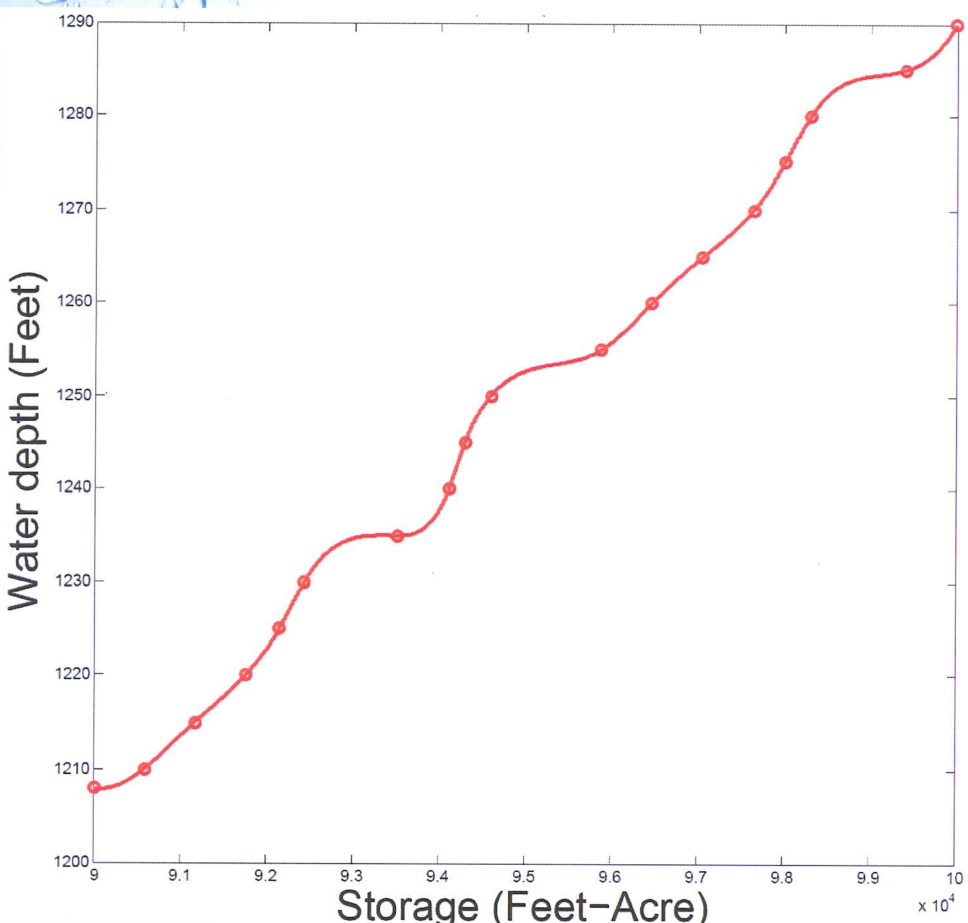


		PLANT	IN SERVICE	PLANT CAPACITY (MW)	OPERATING AGENCY
Lower Columbia	1.	Bonneville	1938	1106	Corps
	2.	The Dalles	1957	2080	Corps
	3.	John Day	1971	2480	Corps
	4.	McNary	1953	1120	Corps
	5.	Chandler	1956	12	Reclamation
	6.	Roza	1958	13	Reclamation
Upper Columbia	7.	Chief Joseph	1958	2614	Corps
	8.	Grand Coulee	1942	6809	Reclamation
	9.	Albeni Falls	1955	49	Corps
	10.	Libby	1975	605	Corps
	11.	Hungry Horse	1953	428	Reclamation
Lower Snake	12.	Ice Harbor	1962	693	Corps
	13.	Lower Monumental	1969	930	Corps
	14.	Little Goose	1970	930	Corps
	15.	Lower Granite	1975	930	Corps
	16.	Dworshak	1973	465	Corps
Upper Snake	17.	Black Canyon	1925	10	Reclamation
	18.	Boise River Diversion	1912	2	Reclamation
	19.	Anderson Ranch	1950	40	Reclamation
	20.	Minidoka	1909	28	Reclamation
	21.	Palisades	1958	177	Reclamation
Willamette & Rogue	22.	Big Cliff	1953	21	Corps
	23.	Detroit	1953	115	Corps
	24.	Foster	1967	23	Corps
	25.	Green Peter	1967	92	Corps
	26.	Cougar	1963	28	Corps
	27.	Dexter	1954	17	Corps
	28.	Lookout Point	1953	128	Corps
	29.	Hills Creek	1962	34	Corps
	30.	Lost Creek	1977	56	Corps
	31.	Green Springs	1960	17	Reclamation

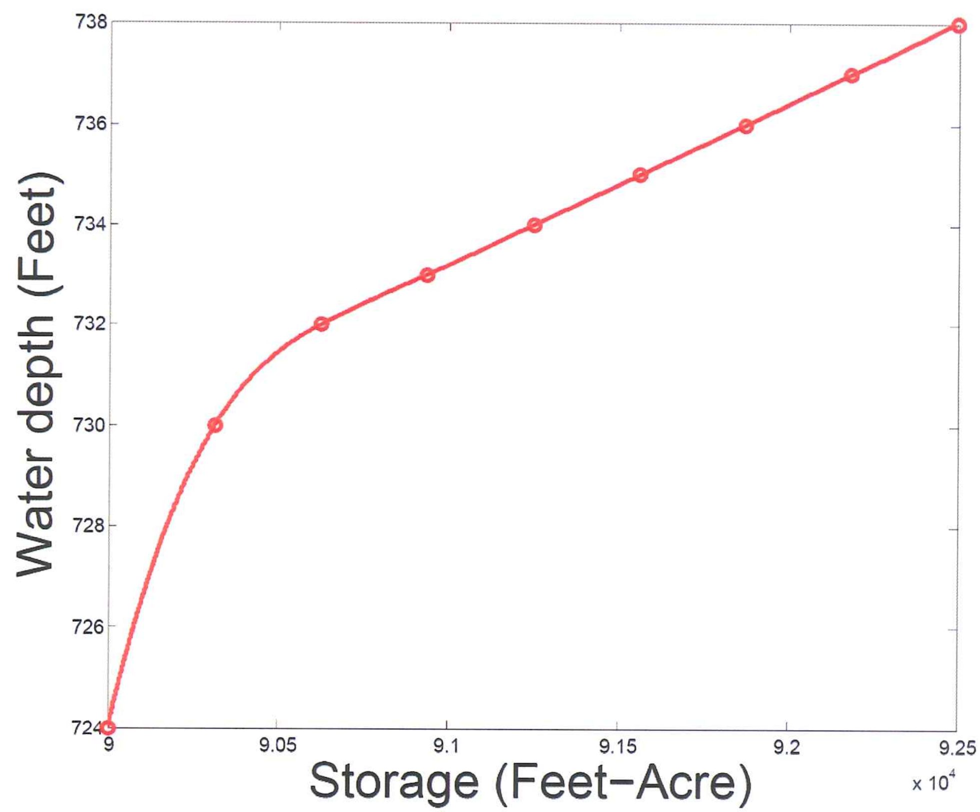
Total Corps of Engineers .... 14524 MW
Total Bureau of Reclamation .... 7536 MW
Total Federal Hydro .... 22060 MW

Stage-Storage Curves of Grand Coulee and Lower Granite, Columbia River System

(Oregon State University, Research group of Arturo Leon)

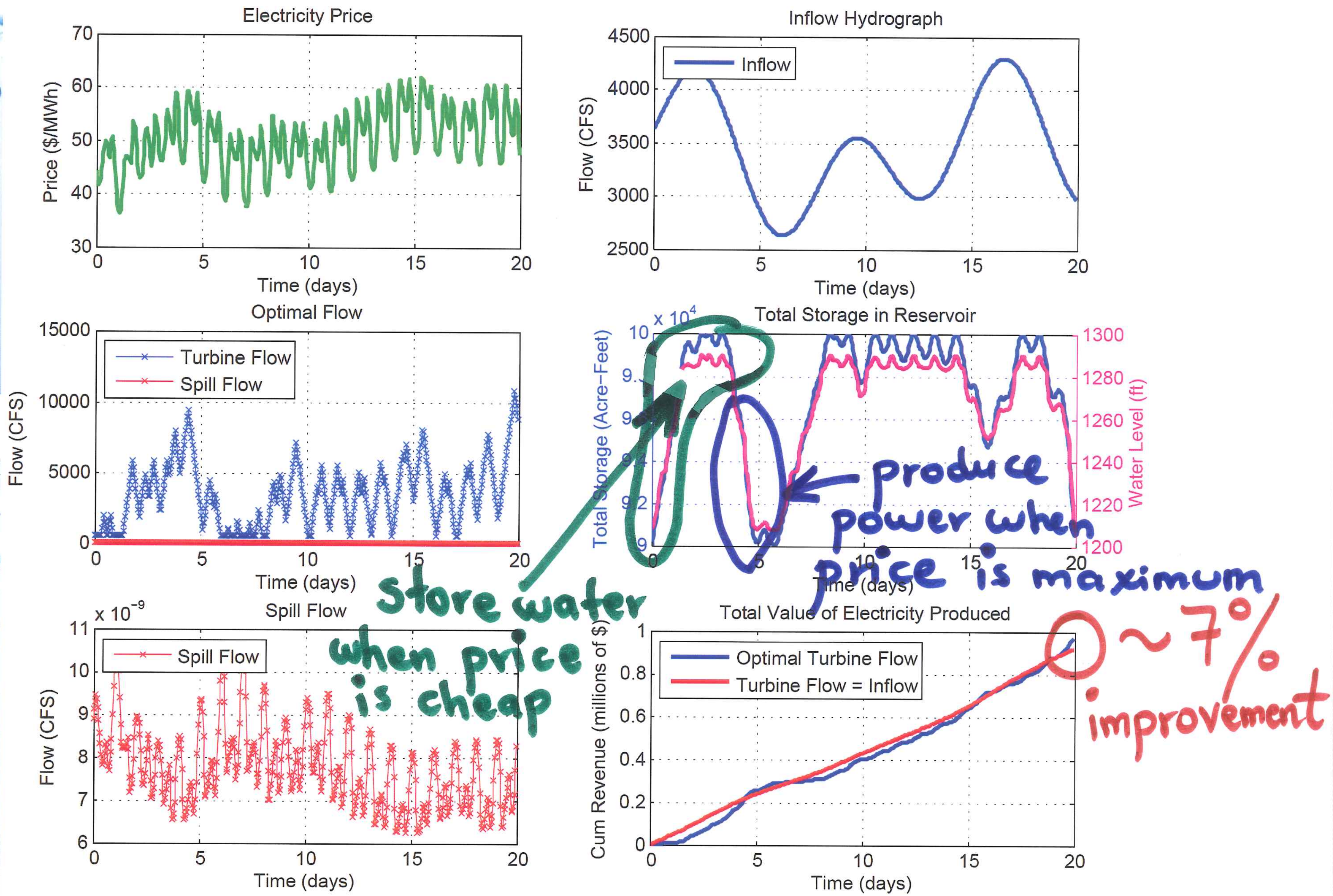


Grand Coulee



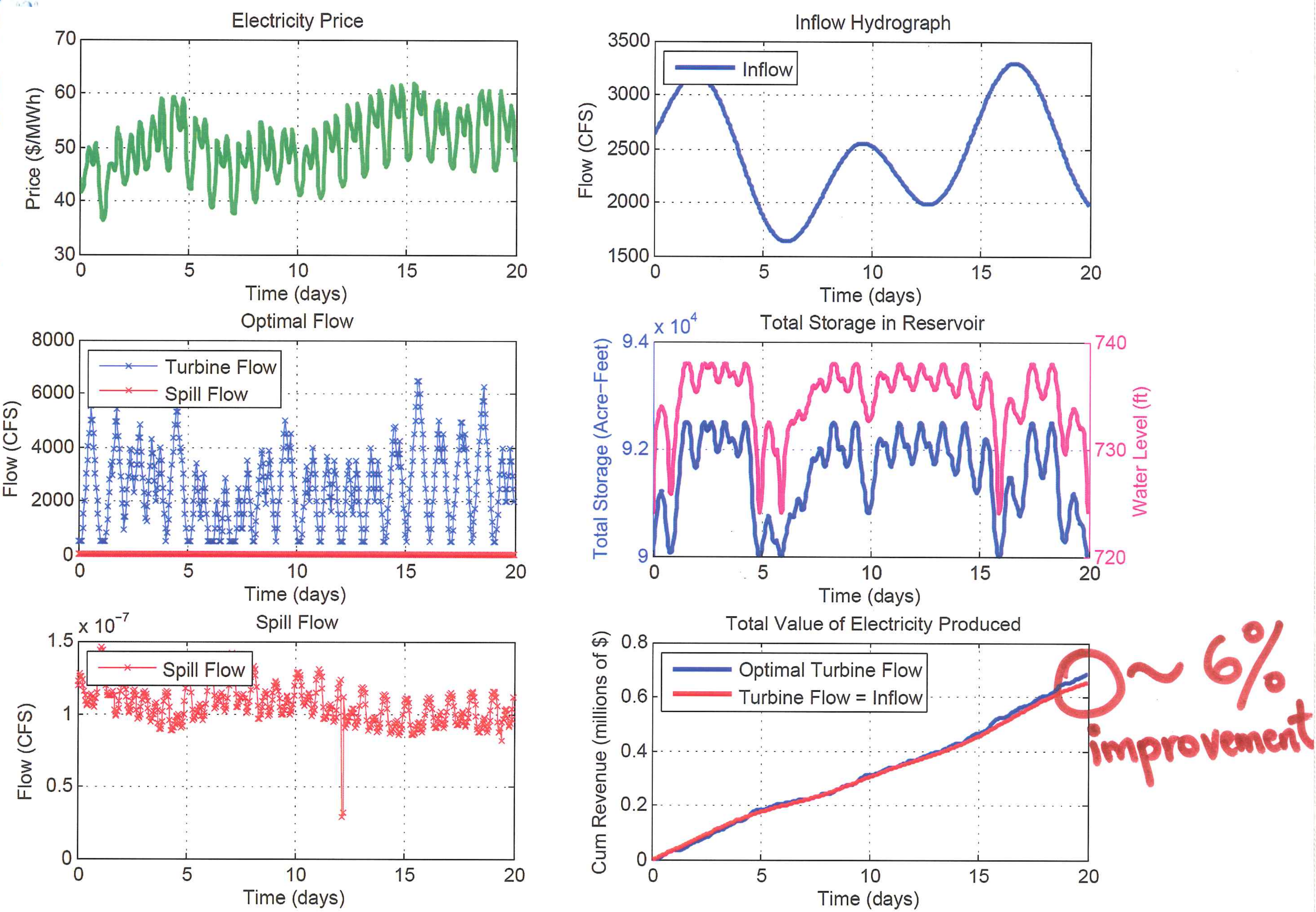
Lower Granite

Grand Coulee optimization
(Oregon State University, Research group of Arturo Leon)



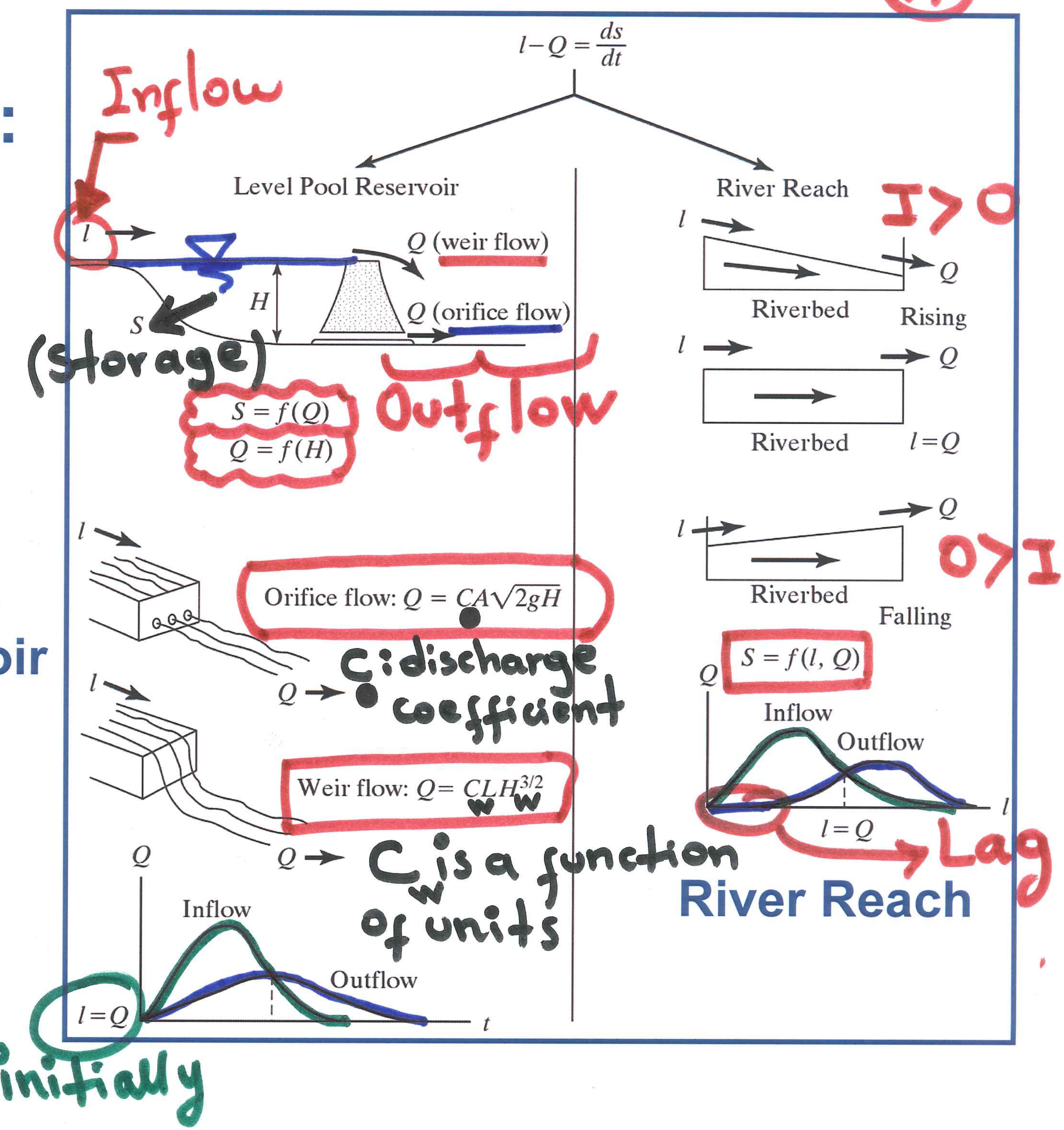
Lower Granite optimization
(Oregon State University, Research group of Arturo Leon)

10



Comparisons: River vs. Reservoir Routing

Level pool reservoir



River Reach

Reservoir Routing

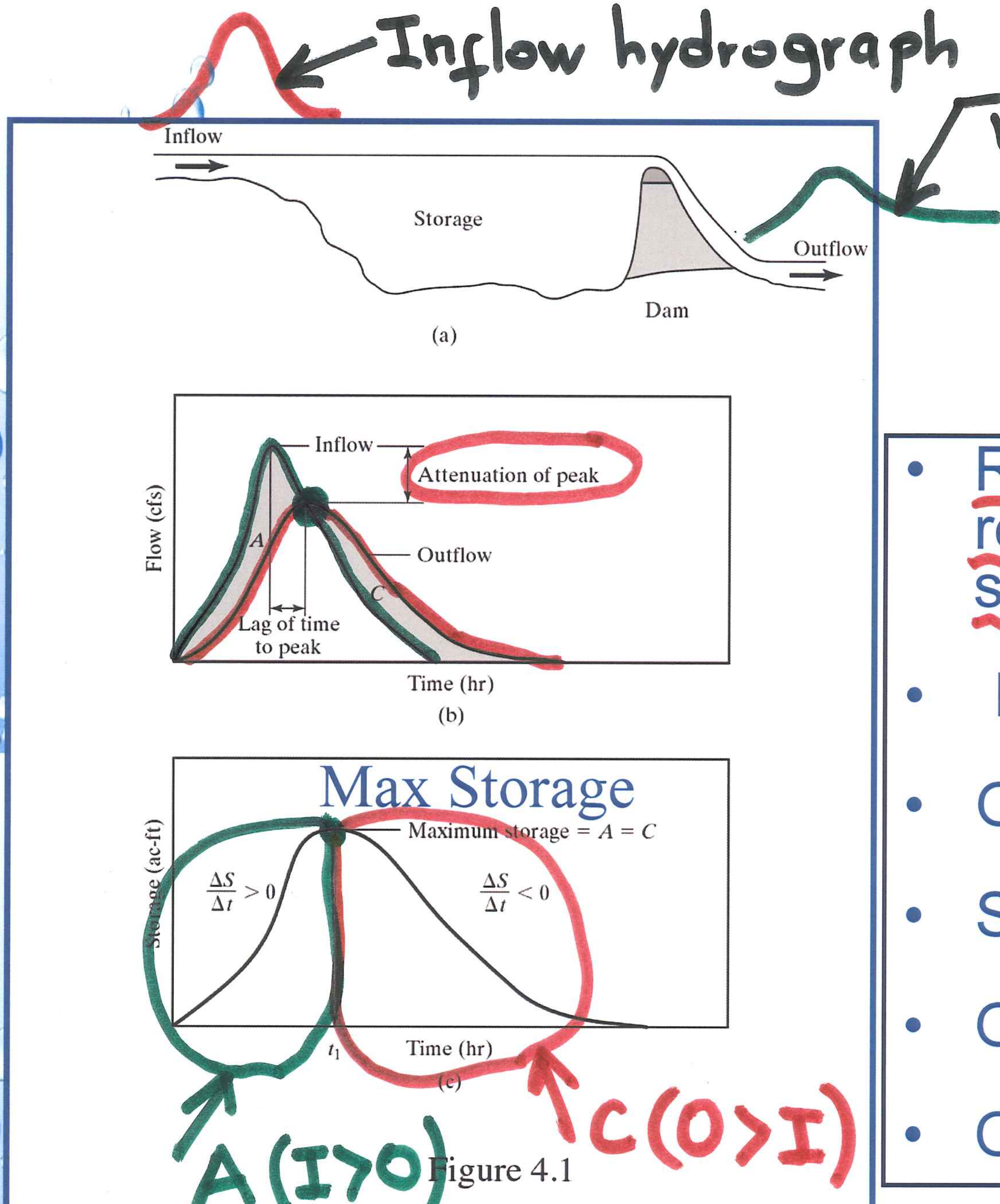
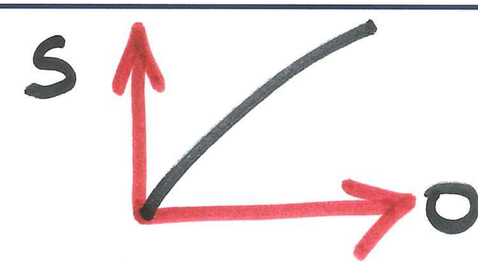


Figure 4.1

Reservoir concepts. (a) Reservoir storage. (b) Inflow to and outflow from the reservoir. (c) Storage in the reservoir.

- Reservoir stores water and release through control structure later.
- Inflow hydrograph
- Outflow hydrograph
- S - Q Relationship
- Outflow peaks are reduced
- Outflow timing is delayed



Inflow and Outflow

$$\sum I - \sum Q = \frac{dS}{dt}$$

Eq. of conservation of mass

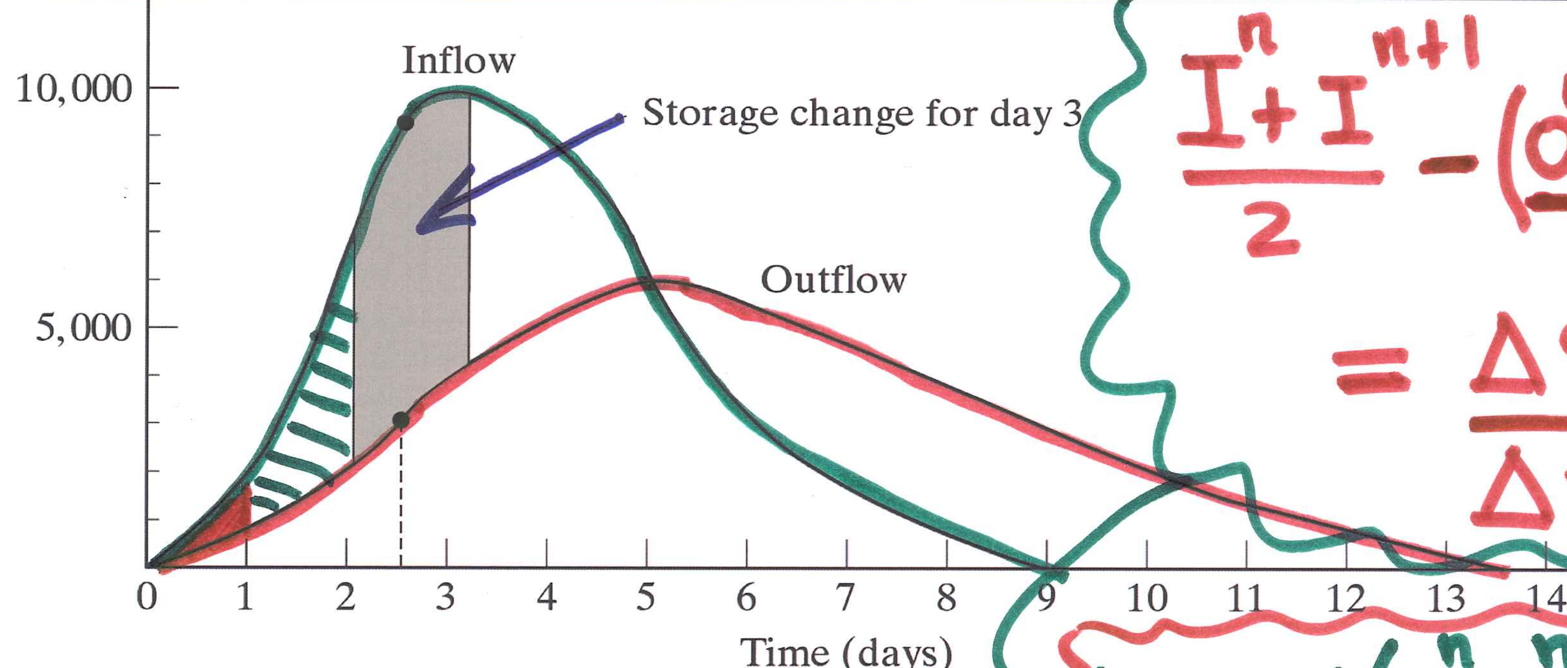


Figure E4.1(a)

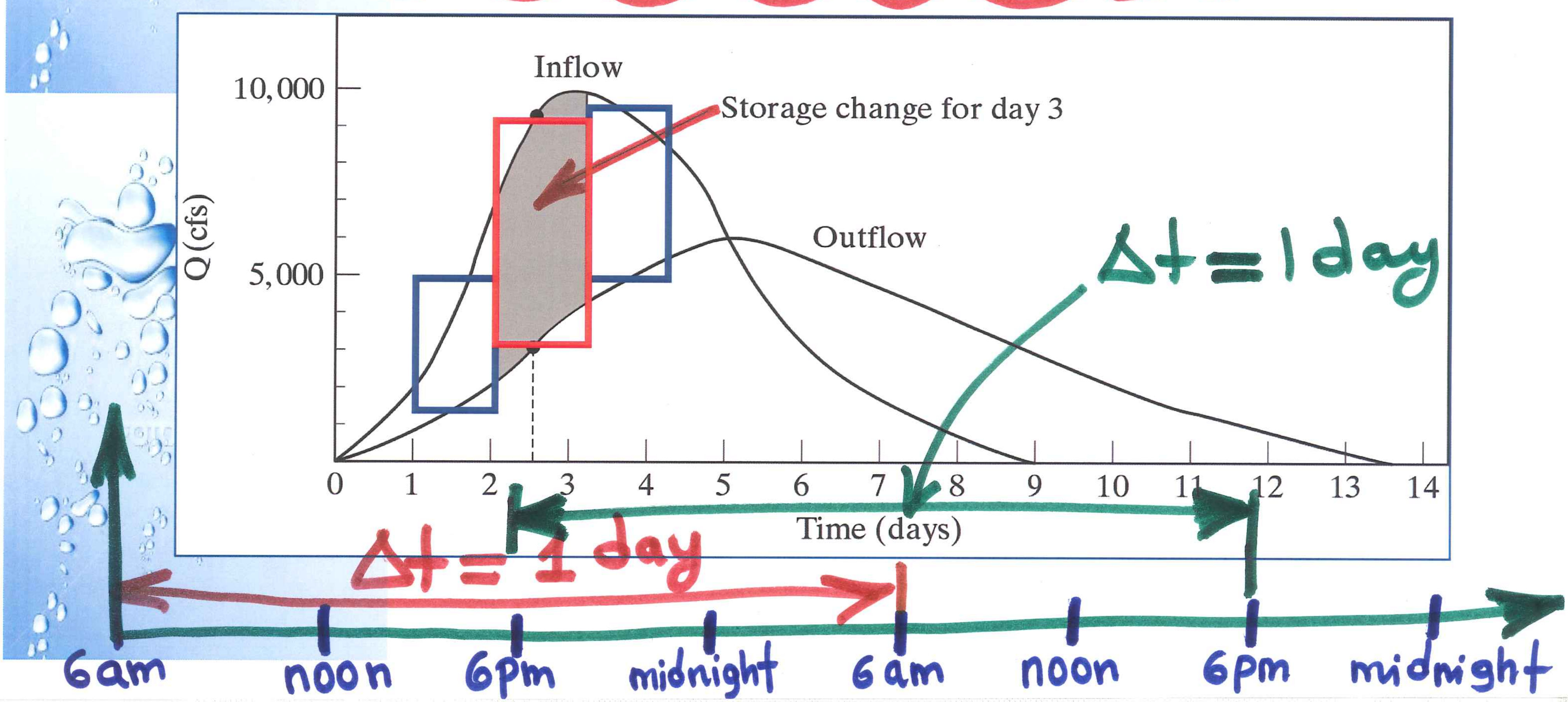
$$\frac{I^n + I^{n+1}}{2} - \left(\frac{O^n + O^{n+1}}{2}\right) = \frac{\Delta S}{\Delta t}$$

$$\Delta S = \Delta t \left(\frac{I^n + I^{n+1}}{2} - \left(\frac{O^n + O^{n+1}}{2}\right)\right)$$

14

Numerical Equivalent
Assume I1 = Q1 initially

$$\frac{I_1 + I_2}{2} - \frac{Q_1 + Q_2}{2} = \frac{S_2 - S_1}{\Delta t}$$



Numerical Progression

15

1. $$\frac{I_1 + I_2}{2} - \frac{Q_1 + Q_2}{2} = \frac{S_2 - S_1}{\Delta t}$$ DAY 1 (hour 1) (any time step)

2. $$\frac{I_2 + I_3}{2} - \frac{Q_2 + Q_3}{2} = \frac{S_3 - S_2}{\Delta t}$$ DAY 2 (or hour 2)

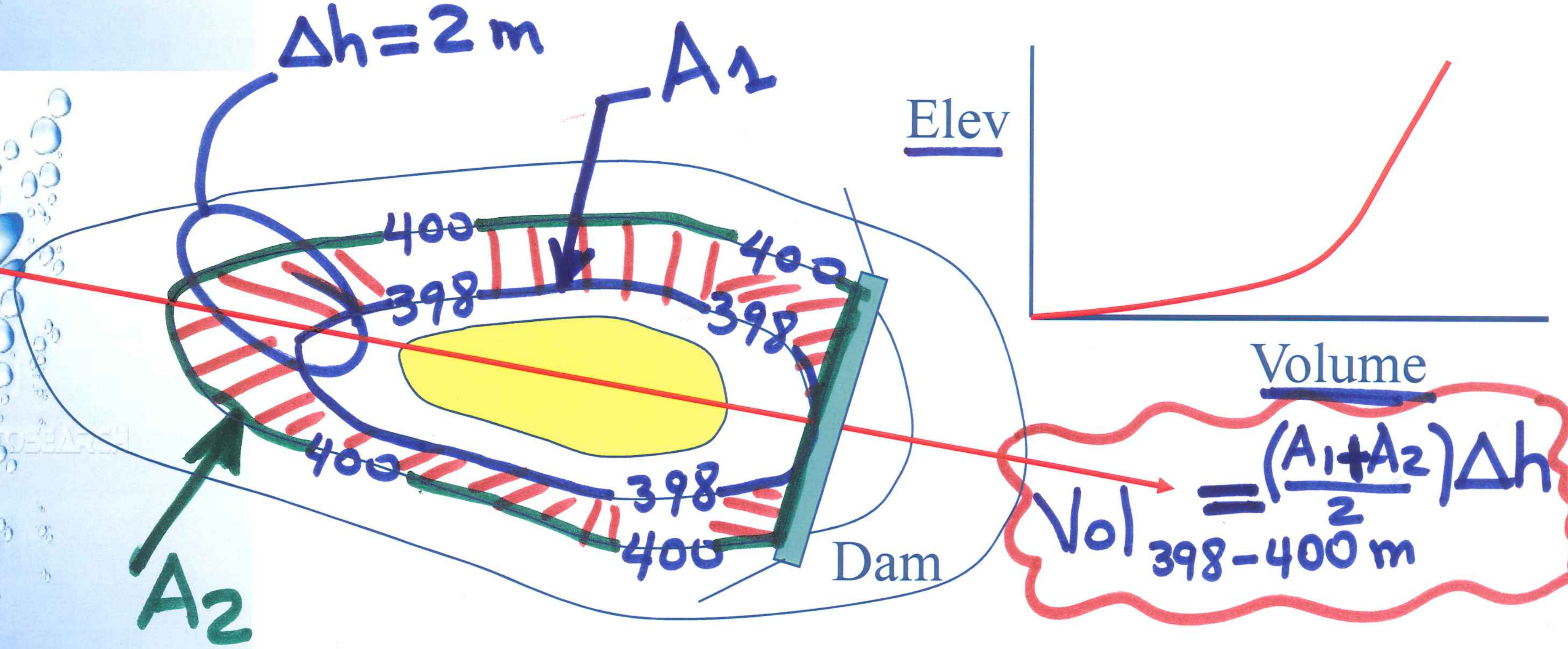
3. $$\frac{I_3 + I_4}{2} - \frac{Q_3 + Q_4}{2} = \frac{S_4 - S_3}{\Delta t}$$ DAY 3 (or hour 3)

Σ 1 year (365 days)

$$\frac{I_1 + I_{365}}{2} + I_2 + I_3 + \dots + I_{364} - \left(\frac{O_1 + O_{365}}{2}\right) - \left(O_2 + O_3 + \dots + O_{364}\right) = \frac{S_{365} - S_1}{\Delta t}$$

Determining Storage

- Evaluate surface area at several different depths
- Use available topographic maps or GIS based DEM sources (digital elevation map)
- Storage and area vary directly with depth of pond

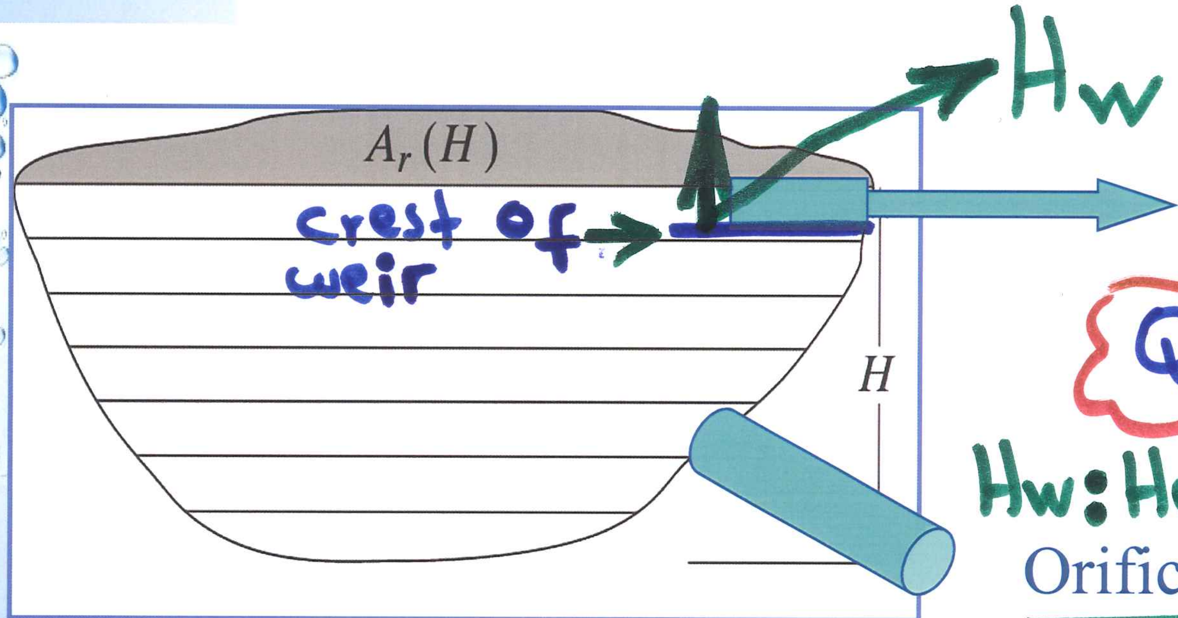


$$Vol_{398-400\,m} = \left(\frac{A_1 + A_2}{2}\right)\Delta h$$

Determining Outflow

Outflow Q can be computed as function of depth for

- Pipes - Manning's Eqn
- Orifices - Orifice Eqn
- Weirs - Weir Eqn



Weir Flow

$$Q_w = C_w L H_w^{3/2}$$

H_w: Height over weir crest to water surface

Orifice/pipe

$$Q_o = C_o A \sqrt{2gH}$$

18

Determining Outflow

$$Q = C_o A\sqrt{2gH} \quad \text{for orifice flow}$$

$$Q = C_w L H_w^{3/2} \quad \text{for weir flow}$$

C_w is a function of units used (Metric or English)

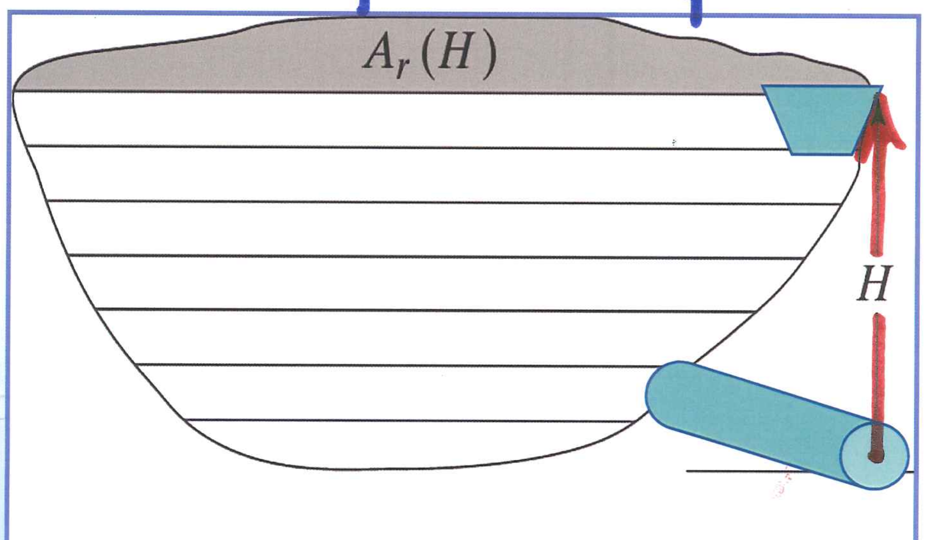
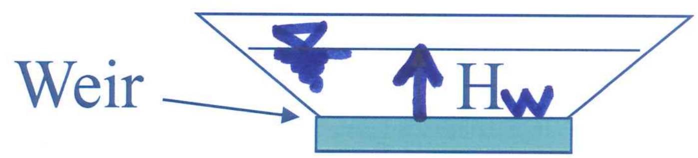


Figure E4.2(b)



Orifice H measured above center of the orifice/pipe up to water surface

19

Typical Storage - Outflow

- Plot of Storage in acre-ft vs. Outflow in cfs
- Storage is largely a function of topography
- Outflows can be computed as function of elevation for either orifices or weirs