Gavin's Point Dam, NE/SD

Problem: Design a sediment management strategy to maximize reservoir life and allow for continued hydropower and irrigation water supply. The plan should include:

1. Method of sediment management
2. Necessary changes to dam
3. Frequency and approximate timing of the activity
4. Estimated impacts to water supply, hydropower, and other reservoir uses
5. Description of other downstream impacts or other ancillary impacts
6. Estimate of costs and benefits of sediment management activities
7. Description of impacts associated with not performing sediment management.

Background: Gavin's Point Dam is an earthen fill gravity dam constructed from 1952-1955, located on the Missouri River above Yankton, South Dakota, and is the border between the states of South Dakota and Nebraska. The full pool at 369 m was 696M m^3 when closed. As of the 2011 survey, remaining storage was 521M m^3, which is a loss of nearly 30%. The majority of the storage loss is in the multipurpose pool from 357 m to 366 m.

The reservoir primarily provides hydropower, flow regulation for downstream navigation, recreation, and public water supply. It also provide a small amount of flood reduction, irrigation, fish and wildlife habitat, and water quality benefits.

The reservoir has been filling with sediment since closure primarily due to the Niobrara River, which enters the Missouri River about 25 km above the reservoir pool. At closure the open pool extended past Springfield, SD, and has lost 11 km of open water. Sedimentation has been high due to the elimination of high flood flows on the Missouri which in pre-dam time effectively transported Niobrara River sediment down the Missouri.

The Missouri River is an alluvial bed river, with an annual flow of 2.9×10^{10} m^3. The average slope of the river and bed of the reservoir is 0.18 m/km.

Figure 1. Aerial View of Lewis and Clark Lake at Gavin's Point Dam 2015

Figure 2. Gavin's Point Dam Discharging 4530 cms from Spillway Gates

Purpose: Gavin's Point Dam is authorized by the United States Congress to provide:

1. Flood Risk Reduction
2. Hydropower
3. Recreation
4. Fish and Wildlife
5. Navigation
6. Water Supply
7. Water Quality
8. Irrigation

All of these purposes are intended to be provided through a compromise of existing water storage, available flood storage, and variable management

Watershed: Flows into Gavin's Point Dam are regulated by Fort Randall Dam, approximately 150km upstream. The Missouri provides approximately 85% of inflow, the remainder coming from the Niobrara River (10%), smaller tributaries and overland flow (5%).

Sediment Sources: Sediment inflow from the watershed is:

Table 1. Sediment Sources to Gavin's Point Dam

Sediment Source	Percent of Total
Niobrara River	55%
Missouri River above Ponca Creek, Ponca Creek, Bazile Creek, and areas draining directly to the lake	35%
Choteau Creek, Emanuel Creek and minor drainages	10%

Source: Eng. & Hydrosystems (2002)

The sediment delivery from Fort Randall dam is essentially zero. All Missouri River sediment delivered is due to bed and bank erosion.

Reservoir Sedimentation Rate: The long term average sedimentation rate below the maximum pool of the dam (369 m) is 3.2M m^3. An additional 0.7M m^3 deposits in the river channel above the reservoir pool.

Sediment Particle Size Distribution: The incoming sediment load to Gavin's Point Dam is 20% FS, 40% VFS, 30% Silt, 10% Clays. The sand deposits in the visible delta and river channel above, and the fines deposit evenly over the lower 25km of the reservoir to approximately 1m deep.

Reservoir Pool:

Table 2. Reservoir Elevations for Gavin's Point Dam

Parameter	Value
Spillway Elevation	360 m
Penstock Centerline Elevation	357 m
Normal Pool	367 m
Original Reservoir bottom elevation	352 m
Current Sediment Elevation at Dam	353 m
Spillway Capacity	9000 cms @ elevation 369 m
Low Level Capacity	none
Turbine Capacity	850 cms @ elevation 369 m

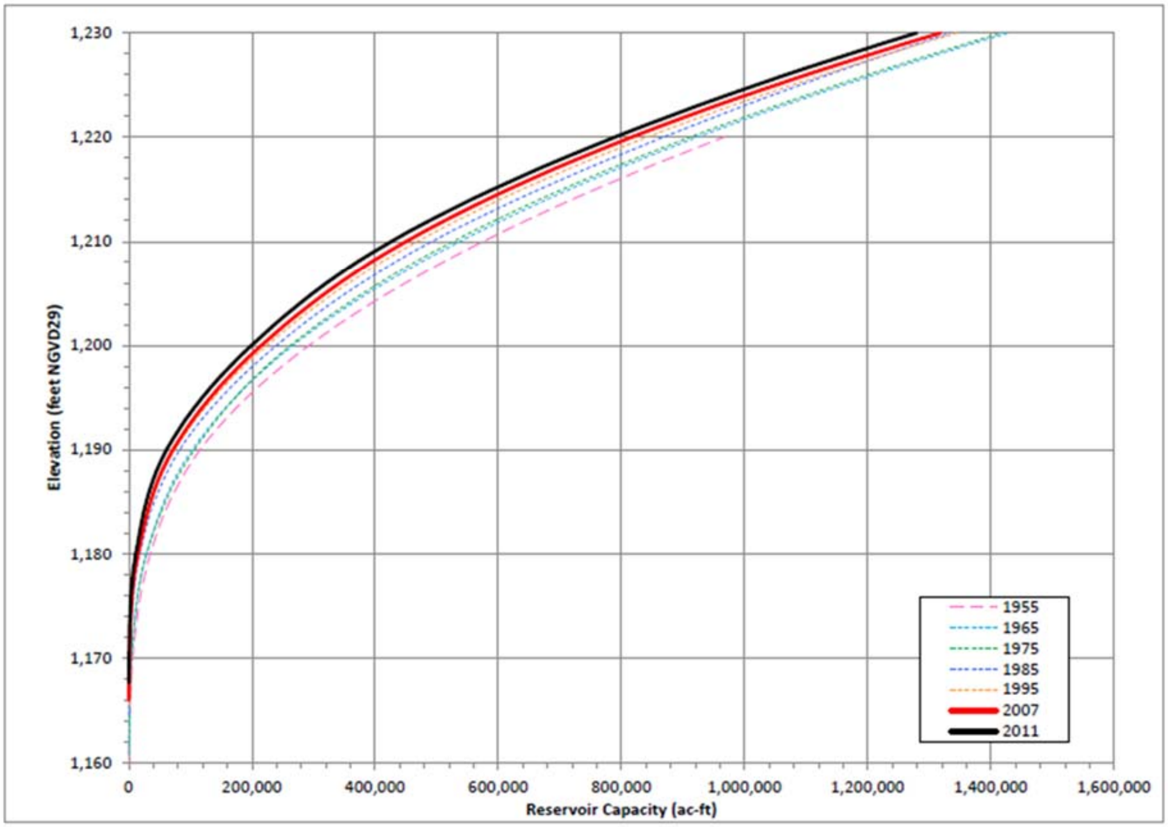


Figure 3. Capacity vs. Elevation Curves for Gavins Point Dam

Table 8-2 (Cont'd). Lewis and Clark Lake – Reservoir Capacity by Storage Zone

Storage Pool	Reservoir Capacity (acre-feet)			Change in Reservoir Capacity (acre-feet)			Rate of Change (acre-feet/yr)	Percent Change per Year
	1995	2007	2011	1995-2007	2007-2011	1955-2011	1955-2011	1955-2011
Exclusive Flood Control 1210.0-1208.0	58,528	56,825	55,469	-1,703	-1,356	-9,648	-172	-0.26%
Flood Control & Multipurpose 1208.0-1204.5	89,095	85,780	82,691	-3,315	-3,089	-20,719	-370	-0.36%
Permanent 1204.5-1160.0	320,379	307,441	287,670	-12,938	-19,771	-118,515	-2,116	-0.52%
Gross Storage 1210.0-1160.0	468,001	450,046	425,829	-17,956	-24,216	-148,883	-2,659	-0.46%

Figure 4. Annual Storage Loss for Lewis and Clark Lake at Gavin's Point Dam

Operations: The dam normally operates a three turbine powerhouse at 285 cms for each turbine for a maximum powerhouse discharge of 850 cms. The dam has 14 tainter gates that have a combined maximum discharge of over 9000 cms. The reservoir is held at 367 m pool elevation all year, and can increase to 369 m for flood storage. No seasonal drawdown is done. The dam serves primarily as a reregulation dam for a downstream navigation channel. Under a normal summer flow of 850 cms,the residence time is approximately seven days.

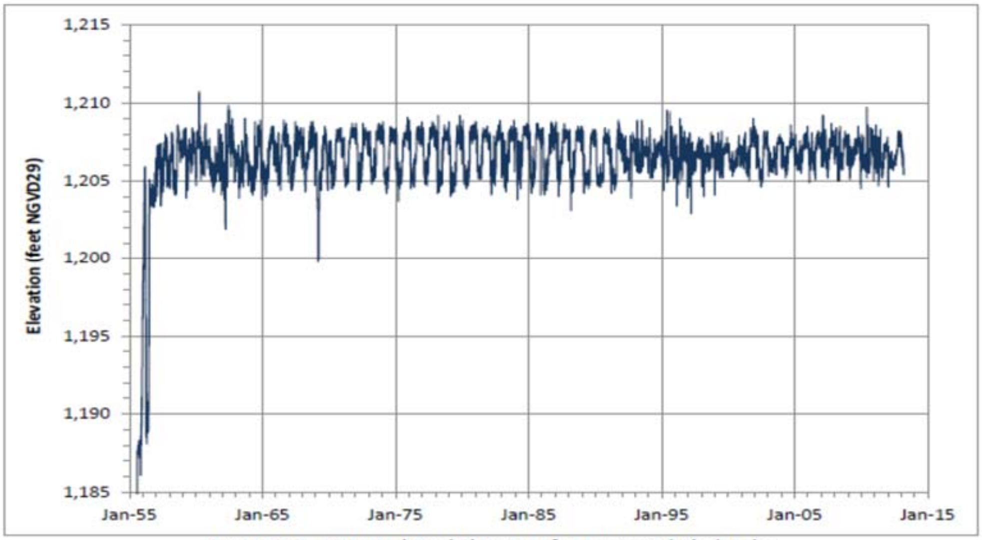


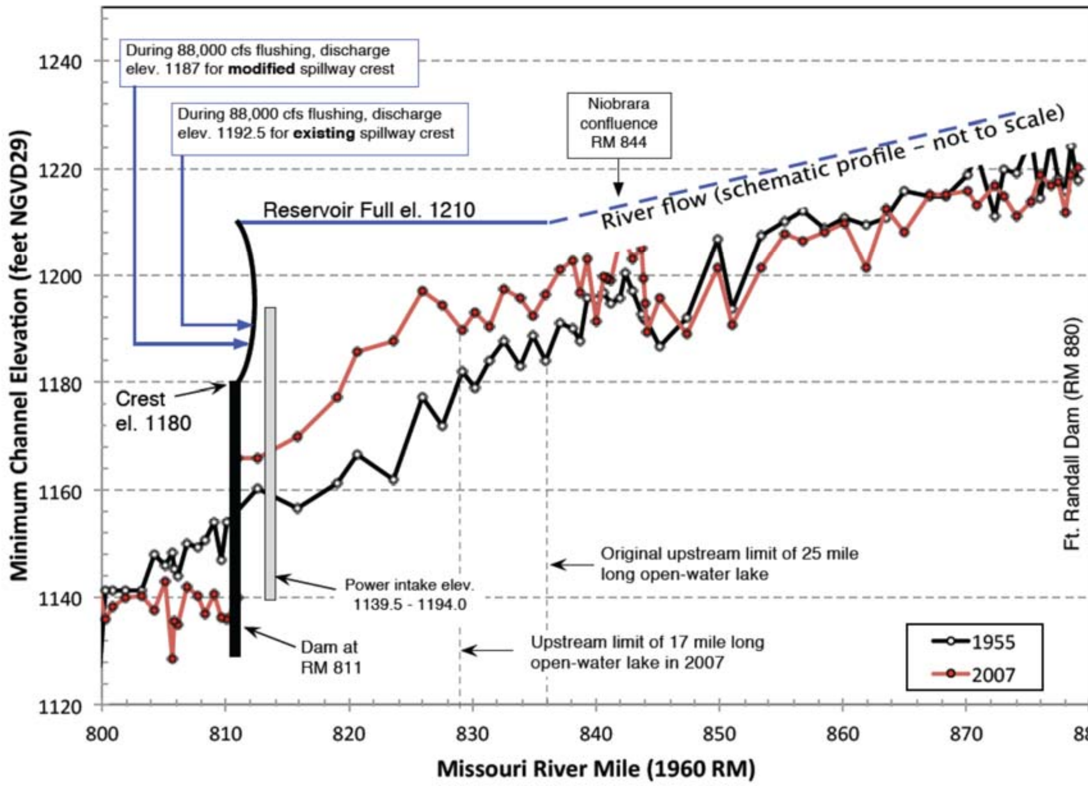
Figure 2-2. Historical Pool Elevation for Lewis and Clark Lake

Figure 5. Pool Elevations for Lewis and Clark Lake at Gavin's Point Dam

Transport Rates: For the purposes of this class, the rate of sediment transport from the reservoir will be greatly simplified and can be estimated as suggested by Atkinson (1996):

$$Q_s = K\frac{Q^{1.6}S^{1.2}}{W^{0.6}}$$

Q_s = sediment transport capacity (metric tons/s)
Q = flow (m^3/s)
S = Slope of reservoir water surface for drawdown condition (-)
W = erosion width (m)
K = constant, which is a function of sediment grain size and erodibility; assumed 100 for this study



From G. Morris, unpublished.

These costs are only for the class room exercise and are only approximately average costs of these activities. Actual costs can vary based upon local conditions. The unit costs of dredging can vary substantially based the volume of material, type of material and grain size of material, Location of material in reservoir, disposal location and distance. In addition, the costs of hydroelectricity, water, etc. also vary based upon geographic location, season, drought etc…

For the purposes of the class, we give the following unit cost in US Dollar amounts.

Item	**Unit Cost or Revenue**
Sediment Removal by Hydraulic Dredging	$ 25/m^3
Mechanical Sediment Removal	$ 20/m^3
Daily Hydropower Revenue	$7,000
Daily Lost benefits at Run of River condition (water supply, recreation, navigation)	$30,000
Treatment of Watershed	Not Applicable