Port of Portland

SMITH-BYBEE LAKES CONTROL STRUCTURE

September 1990

PROJECT INTENT

The intent of this analysis is to propose a conceptual design for a structure to control Smith and Bybee Lakes at various adjustable water surface elevations. The location of the structure is at the earthen plug at the east end of the North Slough just north of St. Johns Landfill. (See Figure 1, Vicinity Map)

AUTHORIZATION AND ORGANIZATION

Preparation of this report was authorized by the Port of Portland. Brian Campbell, Planning Manager for the Port, was the client project manager and Donald Oakley, P.E. was the consultant project manager for David J. Newton Associates, Inc. Paul Fishman of Fishman Environmental Services provided input on fish migration design elements.

KEY DESIGN ELEVATIONS

Smith Lake has a minimum bottom elevation of about 3.7' MSL, with the lowest desirable water elevation considered to be approximately 6.5' MSL. The top of the dam is at elevation 14' MSL approximately, but a spillway around the south end of the dam is at elevation 10.5' MSL. Rainfall and groundwater inflow cause a net outflow from the lakes to the slough. There is an existing 60" diameter corrugated metal pipe (CMP) through the dam which allows water from the lakes to be released to the slough. The water surface in the slough is controlled by the Columbia River and can vary from 2' MSL during Summer months to over 20' MSL during peak events in the Columbia River.

Therefore, the water surface in the lakes will normally vary between about 6.5' and 10.5' in elevation unless high slough levels cause flow back into the lakes. Higher lake levels caused by peak local rainfall events are essentially unrelated to the occurrence of peak river stages.

DESIGN CRITERIA

The proposed design for the structure should function under all of the following conditions:

1. Water surface in lakes higher than water surface in slough and lake level held steady, i.e., the normal desired winter condition.

2. Water surface in lakes higher than water surface in slough and lakes levels gradually drawn down to minimum, so as to simulate Summer drying.

tidal gate

3. Water surface in slough higher than water surface in lakes, but less than 10.5', and water flows into lake backwards through the control structure.

4. Water surface in slough is higher than 10.5' and water flows into lake through spillway.

   NOTE: Water will flow into the lake when the slough level is rising and out of the lake when the slough is receding. The amount of lag in lake elevation is controlled by the size of the spillway and the rate at which the slough level rises or falls. When the slough level exceeds the level of the top of the dam, the slough and the lake function as the same body of water.

HYDROLOGY

why is this considered full'?

The purpose of evaluating lake hydrology is to provide for a major rainfall event when the lakes are nearly full, i.e., nearly 10.5 feet in elevation. Based on observations of the existing earthen dam, it is recommended that the water level in the lakes be managed to prevent discharge from the lakes through the spillway. A high rate of discharge cascading down the downstream face of the spillway embankment to the slough could cause the type of severe erosion that caused the dam to fail in 1982. Therefore, the structure should be designed to contain and discharge a major local rainfall event without lake levels exceeding 10.5 feet in elevation.

The overall drainage basin for the lakes is about 1,600 acres (Fishman, 1987). The surface area of the lakes for water surface elevations of just under 10.5 feet are about 1,000 acres. See Figure 2, "Elevation/Area/Volume Relationships", Smith and Bybee Lakes".

Several types of rainfall statistics were evaluated to select a design rainfall event. Detention capacity of the lakes is large relative to the rate of flow out through the control structure. Therefore, it is not particularly important whether the peak event occurs in 24 hours or over a 2 week time period, as long as the lakes are generally kept at a level which allows for detention of this design peak event below the 10.5' level.

Figure 3, "Precipitation Information", shows historical rainfall data extracted from 30 years of information.

Several facts can be taken from this data:

1. The greatest monthly rainfall total recorded over the 30 year period was 12.83" with several other occurrences between 10" and 12". If slightly more than half of this amount occurred in half the time, then about 8" of rain within two weeks is a reasonable maximum figure for a two week period.

2. With the exception of one occurrence of 9.34" of rain within a 5 day period, the greatest 5 day rainfall events on record over a 30 year period are just under 6".

3. The 24 hour, 100-year rainfall event for the Portland area is about 4.8".

These different measurements of historical and theoretical peak events indicate that we should allow for about a 6" design storm. This level of design storm selection is consistent with the sensitivity of the results. For example, if 7" of rainfall occurred in a short period of time, the difference would only result in an extra 1.5" rise in the lake level even if no water was released from the lake during this period. Given this lack of sensitivity, additional statistical analysis is not warranted.

Assuming that the ground was frozen or saturated when the design rainfall event occurred and that all the rainfall over the 1,600 acre watershed was discharged immediately into the 1,000 acre lake, then the lake would rise (6" x 1600/1000 =) 9.6 inches. Allowing for about 3 inches of residual height of flow over an outlet control weir, the maximum weir height should be set at (10.5' - 9.6" - 3" =) 9.4 feet in elevation.

HYDRAULICS

Figures 4a, 4b, and 4c, "Weir Analysis", for 8', 12' and 16' weirs respectively shows drawdown time in days to discharge the design storm event through the weir. A rectangular weir was assumed and Bernoulli's equation for flow was used in the spreadsheet. Figures 4a, 4b, and 4c show the following results:

	Time to Drain Lake Back to Normal
8' Weir Length	14 Days
12' Weir Length	9 Days
16' Weir Length	7 Days

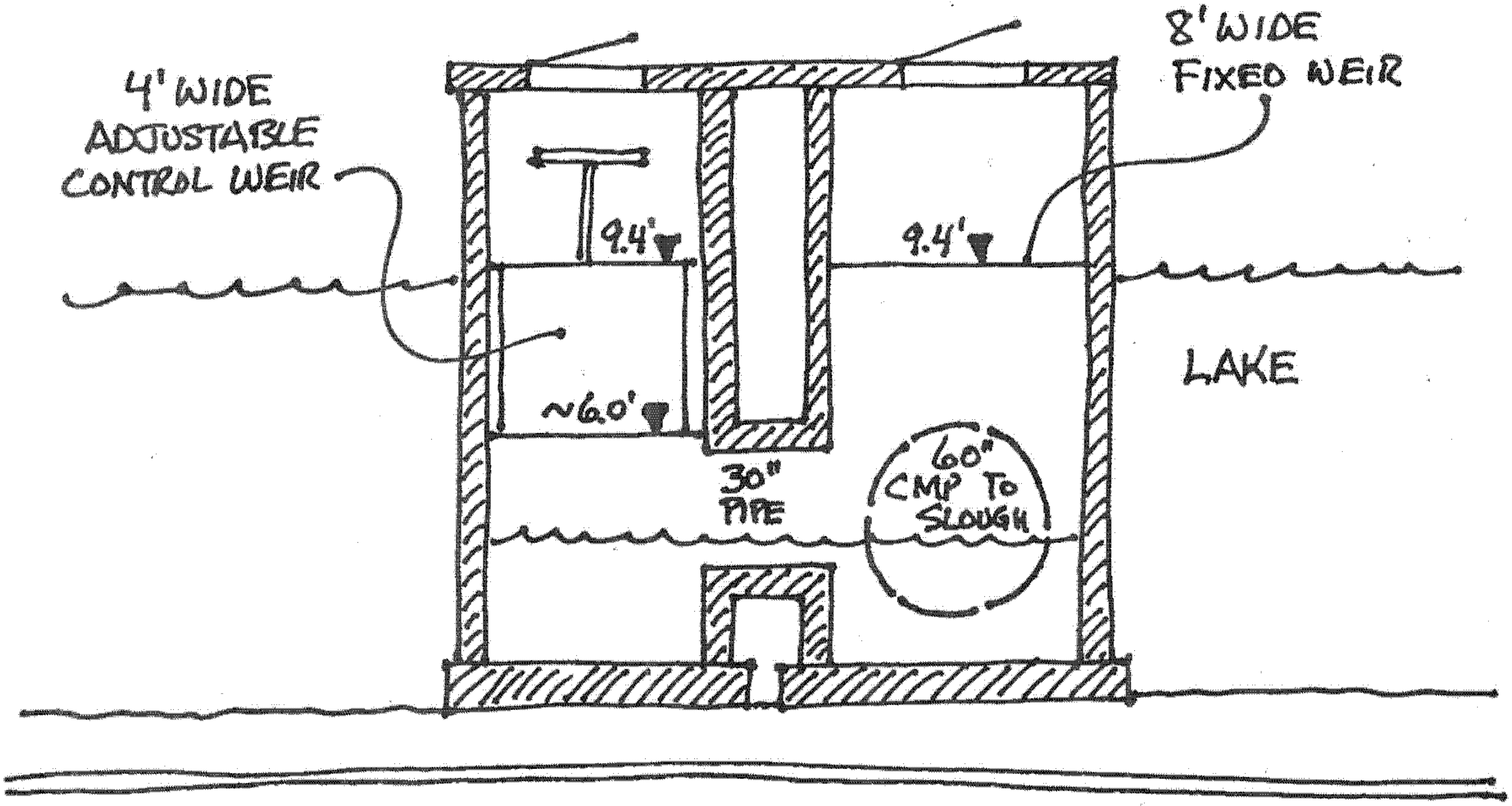
A 12' weir length is recommended because of the limited benefit of the extra 4 feet in weir length. For the 12' weir set at elevation 9.4 feet, the maximum outflow from the lake is about 40 CFS. The capacity of the existing 60" CMP at an assumed slope of 2% is approximately 109 CFS. Therefore, the culvert would flow only partially full during maximum flow out of the lakes.

For Summer drawdown, the starting water surface elevation is assumed to be 9.4' MSL with the goal of lowering the surface to 6.5 feet within about 60 days. A spreadsheet was developed and shown as Figure 5, "Weir Analysis - Summer Drawdown", to determine drawdown time for various weir widths and weir elevations. The spreadsheet computes flow out by a look-up function which translates volume remaining in the lakes to a water surface elevation and then calculates flow over the weir. Precipitation and evaporation averages for July and August are included. Seepage into the lakes is the most difficult variable to estimate. The Fishman report estimated seepage as the remaining variable in a water balance equation. The results were inconclusive but do indicate that maximum inflow probably does not exceed 30 CFS. The in-seepage factor used in Figure 5 of this report was based on the maximum values appearing in the Fishman report and on knowledge of seepage rates in other areas of the Columbia River remnant sloughs. Seepage assumptions are shown in Figure 6.

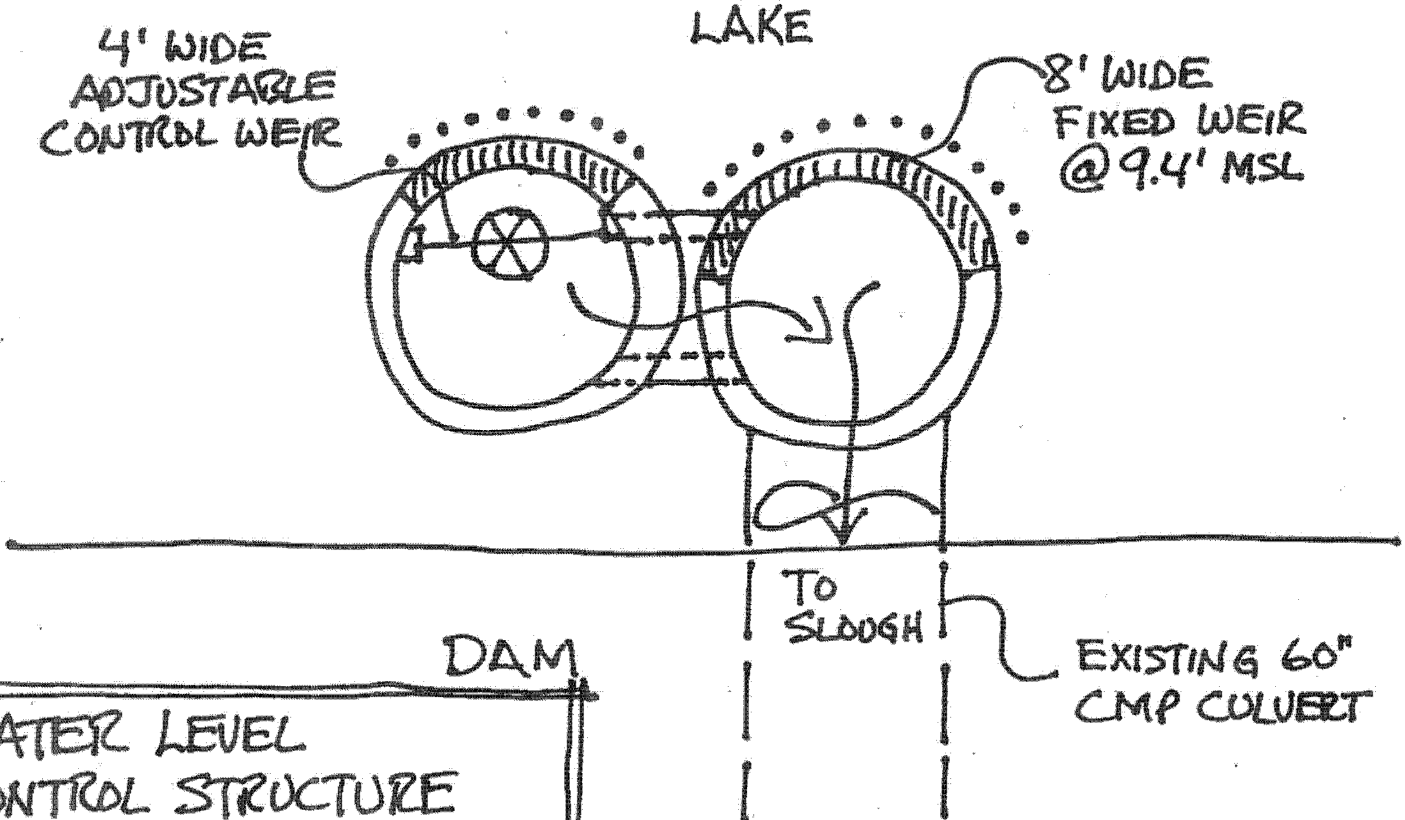
The spreadsheet shown in Figure 5 was run with various weir widths and weir elevations and the resulting drawdown curves are shown on Figure 7, "Summer Drawdown". From these curves it is apparent that a 3' weir is too narrow to accomplish drawdown and that a 5' weir causes drawdown to occur too rapidly after adjustment of the weir. The 4' weir adjusted two or three times over the Summer causes the drawdown rate to approach a constant rate of drawdown. Therefore, a 4' adjustable weir is recommended. Since the recommended high flow weir was previously shown to require a total of 12' in width, a fixed height overflow weir of 8' and an adjustable control weir of 4' will provide for both high flow discharge and Summer drawdown.

Designer: Don Oakley

SECTION



PLAN VIEW



WATER LEVEL CONTROL STRUCTURE
SCHEMATIC DESIGN
SMITH & BYBEE LAKES