WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Periodic Dam Safety Inspection Report

West Seattle Reservoir
King County, Washington

January 2007

Publication No. 07-11-002

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WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Periodic Dam Safety Inspection Report

West Seattle Reservoir
King County, Washington

by
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Water Resources Program
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PO Box 47600
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West Seattle Reservoir
Periodic Inspection Report

Water Resources Program

The dam safety inspection of the West Seattle Reservoir, and the engineering analyses and technical material presented in this report were prepared under the supervision and direction of the undersigned professional engineers, in accordance with RCW 43.21A.064(2).

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Summary

This report summarizes the results of an inspection conducted on July 6, 2005, and a subsequent evaluation of the West Seattle Reservoir performed by the Dam Safety Office (DSO) of the Department of Ecology. It presents the findings from the inspection, engineering evaluation and analyses of the facility, and required remedial actions to correct deficiencies.

Findings & Recommendations

In general, the West Seattle Reservoir is well maintained and operated. The results of the field inspections and engineering analyses indicate that most elements of the facility meet current engineering standards for dam design. The recommendations and required remedial actions presented in this report are similar and/or complement those presented in previous inspection reports.

Embankment, Foundation, and Abutments

The embankment did not show surficial signs of slope instability. A review of previous engineering analyses was conducted as part of this inspection. This review indicated that the methodology used in the analysis is still the standard procedure used by the DSO; and that the assumptions as to the properties of the embankment and foundation soils and the loading conditions made for those analyses are still acceptable.

Static stability – The West Seattle Reservoir embankment meets current engineering standards.

Seismic Stability – In response to the 2001 DSO report, the City of Seattle retained PanGEO, Inc. to evaluate the seismic stability of the West Seattle Reservoir. The results of this evaluation indicated that the embankment is stable under the seismic loading conditions considered.

- The vegetation on the embankment slopes is being properly controlled, which allowed for a thorough visual inspection of the slopes. A few animal burrows were noted along the southeast corner of the reservoir. It is recommended that these burrows be filled, and that steps be taken to control the animal population to prevent further burrowing activity. There were no other visible signs of distress on the embankment slopes or the crest.

- The West Seattle Reservoir has adequate spillway capacity to accommodate the Probable Maximum Flood (PMF) and the maximum system inflow.

- Liner: Visual examination of the liner during the July 6, 2005 inspection revealed that in general, the geomembrane appeared to be in good condition. However, there were a number of areas around the former chlorination structure along the eastern side where the hypalon liner has pulled away from the battens that attach the liner to the structure. According to the City of Seattle, this action has been ongoing for a number of cleaning cycles, and there were signs of past repairs in the liner. The area around the torn liner was inspected closely for any signs of settlement or cracking in the concrete structures

but no signs of movement or distress were observed. The Seattle Public Utilities maintenance staff had already begun the repair process for the liner but we did not observe it in a completed state.

- Outlet Works: The interior of the inlet and outlet conduits were last inspected by the City of Seattle on March 19, 1994. The Dam Safety Office recommends an inspection interval for critical conduit interiors equal to every other periodic inspection. This project feature therefore should be scheduled for an inspection at the City's convenience. The resulting video should then be forwarded to the DSO. Additionally, the outlet conduit should be provided with backup, manual controls for the valve installed on the embankment crest.

- Project Operation and Maintenance: An Operation & Maintenance (O&M) Manual has been prepared for the West Seattle Reservoir. A review of the O&M Manual, dated February 2000, was done as part of this inspection. The O&M plan was found to provide detailed written procedures for dam and reservoir operation, maintenance, monitoring, and inspection of the West Seattle Reservoir.

- Emergency Preparedness: An Emergency Action Plan (EAP) for the West Seattle Reservoir has been developed. A review of the EAP, dated March 2005, was done as part of this inspection. This document meets the minimum requirements for an EAP as recommended in the Dam Safety Guidelines.

Introduction

In accordance with RCW 43.21A.064(2), the Department of Ecology (Ecology) has responsibility and authority to inspect the construction of all dams and other works related to the use of water, and to require necessary changes in construction or maintenance to reasonably secure safety to life and property. This report has been prepared in accordance with the above mentioned statute.

The purpose of this memo is to present the results of the inspection and subsequent safety evaluation of the West Seattle Reservoir. The report provides background information and a description of the project; results of the July 6, 2005 inspection; safety evaluation and analysis of the design of the project; and required remedial actions based on the findings.

West Seattle Reservoir is located in the Highland Park District of the City of Seattle, Washington. The west side of the reservoir is bordered by 8th Avenue SW, the north side by SW Cloverdale Street, and the east and south sides by West Creek Park.

General Background

The facility was built in 1931 to create an offstream reservoir for residential and commercial water use. Construction plans, contract documents, construction inspection reports, and records of project performance are available in the files of the Seattle Public Utilities.

The reservoir has performed adequately through its service life, under normal operating conditions. Further, the facility safely withstood major earthquakes in 1949, 1965 and 2001 with no damage reported.

Construction History

West Seattle Reservoir was constructed with earthfill embankments along the east and west sides, and by excavation of native soils in the reservoir area. A 6-inch thick, non-reinforced concrete liner was originally placed on the entire reservoir area. The joints of the concrete panels were filled with asphalt material. A parapet wall, approximately 1.5 feet high, was built around the reservoir at the upstream edge of the embankment crest. The construction plans and inspection reports do not indicate that a subdrain system was installed in the reservoir. A chlorine chamber was built on the southwest end of the reservoir. In 1994, the reservoir was lined with a Hypalon geomembrane. In addition, cracked concrete slabs were replaced, concrete damage repaired, cracks resealed, and new washout piping was installed.

The reservoir is filled through a 42-inch diameter, steel pipe located at the southwest corner of the reservoir. Water is drained from the reservoir by means of a 24-inch diameter steel pipe located under the northeast embankment section.

The reservoir has a normal storage capacity of 208.0 acre-feet at spillway crest (El. 439.7 feet, North American Vertical datum), a maximum normal operating pool elevation of 439.7 feet. The reservoir is trapezoidal in shape, with approximate dimensions of 900 feet long, 550 feet

wide at the northern end, and 720 feet wide at the southern end.

West Seattle Reservoir was formed in part by construction of earthfill embankments along the east and west boundaries, and on sections of the north and south sides. The maximum height of the embankment is approximately 62 feet at the northern half of the east embankment. Past inspection reports indicate that the downstream slope of the east embankment is 3H:1V, the upstream slope is 2H:1V, and the crest width is 30 feet.

Reservoir Leakage

Seattle Public Utilities attempts to measure reservoir leakage in their open reservoirs once per year. To accomplish this, the reservoir is taken out of service, and changes in water level, precipitation and flow due to leaking valves are measured or recorded. Losses to evaporation are taken from research performed by the U.S. Department of Agriculture in 1968. The latest leakage test was conducted between December 6 and 12 of 2005, and indicated that the daily leakage rate was approximately 0.14 gallons per minute per million gallons. This is an average that results in a total calculated leakage rate of about 10 gpm. This is an acceptable level of leakage given the size of the reservoir and valves at this facility.

Past Inspections

February 1980 - The project was inspected by representatives of the City of Seattle Water Department, International Engineering Company, NTL Geotechnics, and Ecology as part of the National Dam Inspection Program.

> Findings – 1) Insufficient information was available to properly assess embankment stability, 2) the reservoir had adequate storage and discharge capacities to pass the Probable Maximum Flood (PMF), 3) the outlet works appeared to be adequately designed, and 4) the operation and maintenance of the facility were acceptable.
>
> Recommendations - 1) A geotechnical investigation should be performed to determine embankment stability, 2) vegetation that may affect embankment stability should be removed, and the remaining vegetation should be pruned to facilitate visual inspection of the downstream slope, 3) rodent hole damage should be repaired, and the rodent population removed or controlled, 4) practice drills of the disaster plan should be conducted, 5) protective liners in the inlet and outlet conduits should be installed, and 6) the inlet and outlet conduits be provided with valves, and valve controls.

December 1980 - The Seattle Water Department retained Converse Ward Davis Dixon (CWDD) to perform a geotechnical study to evaluate the seismic slope stability of the reservoir, as recommended by the previous inspection report. CWDD conducted the geotechnical study, installed piezometers in the east embankment, and prepared a report summarizing the results of the investigation. The findings of this study indicated that:

> Findings – 1) The pseudostatic slope stability of the embankment was acceptable, 2) seepage was not observed on the downstream embankment slopes, 3) rodent holes were

found on the embankment, and 4) vegetation on the downstream slope of the east embankment may affect embankment stability.

Recommendations – 1) the new piezometers should be periodically monitored, 2) the concrete liner should be periodically inspected, 3) the rodent holes should be repaired and the rodent population controlled, and 4) some of the vegetation should be pruned to facilitate inspection of the embankments.

In 1992, the Seattle Public Utilities (SPU) provided the piezometers with automatic water sensors. These sensors automatically send a signal to the operations center in the event of high piezometric levels.

March 1992 - The DSO conducted a periodic inspection of the reservoir in 1992.

Findings - The results of the inspection indicated that the reservoir was well maintained and that most elements of the facility met current engineering standards for dam design.

Recommendations – 1) vegetation on the embankment slopes needs to be properly maintained to allow visual inspection, 2) the outlet works should be visually inspected and provided with manual backups, and 3) an inundation map for the reservoir be developed, with Emergency Action and Operation and Maintenance Plans prepared for the facility.

April 1999 - The DSO conducted a periodic inspection of the reservoir in April 7, 1999 with an additional site visit on May 11, 1999.

Findings - The results of the inspection indicated that the reservoir was well maintained and that most elements of the facility met current engineering standards for dam design. 1) Static stability of the embankment meets current engineering standards, and shows no surficial signs of slope instability, and 2) vegetation on the embankment slopes is being properly maintained, 3) a few animal burrows were noted along the southeast corner of the reservoir, 4) the hypalon liner had a few areas with cuts and/or unglued seams, likely caused by the machine used to clean the liner during the annual cleanup operations.

Recommendations – 1) The interior of the inlet and outlet conduits should be inspected to evaluate their condition, 2) The animal burrows should be backfilled, and that steps be taken to control the animal population to prevent further burrowing activity, 3) an alternative way of cleaning the reservoir hypalon liner should be considered for future cleaning operations, 4) the EAP needs some phone numbers updated and exercises should be performed to familiarize staff with the procedures required by its implementation, 5) The City of Seattle should consider the establishment of an automatic telephone notification system to inform downstream residents in the event of an emergency at the reservoir.

Project Description and Field Inspection

The field inspection of the West Seattle Reservoir was performed on July 6, 2005. The Dam Safety inspection team for the inspection consisted of the following personnel:

Name	Aspects Covered
Gustavo A. Ordonez, P.E.	Coordinator, Geotechnical
David Cummings, P.E.	Structural Features

Mr. Carlos A. Albarracin, engineer for Seattle Public Utilities, was the owner's representative during the inspection.

At the time of the inspection, the reservoir was empty except for about 8-12 inches of wash water in the SW corner from cleaning operations underway. As a result, about one fourth of the liner surface on the reservoir bottom could not be inspected.

Hypalon Liner

Visual examination of the liner during the July 6, 2005 inspection, revealed that in general, the geomembrane appeared to be in good condition. However, there were a number of areas around the former chlorination structure along the east side where the hypalon liner has pulled away from the battens that attach the liner to the structure. According to Mr. Albarracin, this action has been ongoing for a number of cleaning cycles, and there were signs of past repairs in the liner. The area around the torn liner was inspected closely for any signs of settlement or cracking in the concrete structures but no signs of movement or distress were observed.

The liner damage that occurred during past cleaning actvities did not occur during this cleanup cycle. According to Mr. Albarracin, damage in the past was occuring when the machine was started at a standstill position and the damage happened while the machine was achieving its operating speed and water pressure. The damage is prevented by starting up on protective covers such as tarps or plywood.

Parapet Wall

The parapet wall along the upstream edge of the embankment crest appeared to be in acceptable condition. Cracking on the top and upstream base of the wall, and spalling of the concrete were observed, however. The wall sections were sighted along their lengths and were in acceptable alignment.

Embankment, Abutments, and Foundation

A visual inspection of the embankment crest revealed no evidence of surface cracking, settlement, horizontal misalignment, or any other sign of distress. The embankment crest, re-paved in 1994, did not show signs of recent cracking or obvious settlement of embankment soils.

A survey of the embankment crest included in the appendix, indicates that there are no significant changes in crest elevation along the surveyed section.

The field inspection revealed that the visible sections of the downstream face did not show signs of slumps, scarps, erosion, or unusual movement. The vegetation on the slopes has been properly maintained since our last inspection, which facilitated the visual inspection of the downstream face. No evidence of seepage was observed during the inspection. SWD personnel indicated that slumps, slides, or abnormal seepage have not been observed or reported during the life of the reservoir. A small number of animal burrows were observed on the southeast corner of the embankment. It is recommended that these burrows be backfilled, and that the animal population be controlled to prevent an increase on the burrowing activity.

An examination of the visible foundation and abutment sections, and cut slopes did not reveal any signs of seepage, slides, scarps, or movement. It is recommended that as part of the periodic inspections by the city staff, the area downstream from the wire fence be also inspected.

Reservoir Overflow (Service Spillway)

The overflow drain for the West Seattle Reservoir is located on the north side, and consists of a 40-foot long concrete weir, with a crest elevation of 439.7 feet. Water flowing over the weir discharges to a 24-inch steel pipe that connects to the city's storm sewer system. The entrance to the weir is protected with a screen cage to prevent debris from entering. Visual inspection of the spillway revealed that the concrete appeared to be in good condition. There is no emergency spillway at West Seattle Reservoir.

Instrumentation

The piezometers installed during the 1980 CWDD geotechnical investigation are measured monthly by city staff. The water elevation is measured by city staff, and the data stored on a 4 to 5 year moving time frame. An alarm system installed in the summer of 1992 detects water levels at or above a warning elevation on the piezometers, and automatically sends a signal to the operations center.

Piezometer WS-1 is located on the crest of the north end of the east embankment. The tip of the piezometer is approximately at elevation 398.0 feet (City of Seattle datum, CSd), and located on the lower section of the embankment fill. A review of the piezometer data indicates that there are no significant changes in phreatic elevation with time for the period between February 1996 through July 2005. A warning water elevation of 401.0 feet CSd has been established for piezometer WS-1.

A second piezometer, WS-3, is located on the south end of the east embankment crest. The piezometer tip elevation is approximately 393.0 feet CSd, and is located in the outwash foundation zone. The data for WS-3 indicate that no significant changes in piezometric readings have occurred for the period between February 1996 through July 2005. The warning elevation for WS-3 has been set at 395.0 feet CSd.

The third piezometer, WS-4, is located at the downstream toe of the east embankment, approximately halfway along the embankment length. The piezometer tip was located in the outwash layer of the foundation, at an approximate elevation of 345.0 feet CSd. A review of the water elevation data shows that there has not been a significant change in piezometric readings for the period between February 1996 through July 2005. The warning elevation for WS-4 has been set at 347.0 feet CSd.

The fourth piezometer, WS-5, was installed at the toe of the south end of the east embankment. The piezometer tip elevation is approximately 389.0 feet CSd, and was placed in the outwash soil deposit of the foundation. A review of the piezometric data does not indicate any significant changes in water elevation for the period between February 1996 through July 2005. A warning elevation of 391.0 feet CSd was established for WS-5.

Other instrumentation in the reservoir consists of a high water sensor installed to warn the operator in the event the reservoir rises to unacceptable levels. A flow gauge is used to measure the outflow but not the inflow to the reservoir.

Outlet Works

The inlet for West Seattle Reservoir consists of a 42-inch diameter, steel pipe located at the southwest corner of the reservoir, and connected to the chlorination chamber. A valve is provided at the gate house located near the downstream slope of the southwest embankment section. The valve was not operated during the inspection. Both the inlet and outlet pipes were inspected by the City of Seattle on March 19, 1994. The conduits were not inspected by the DSO during this inspection. The DSO recommends that conduits through earthen embankments should have an interior inspection at every other periodic inspection. The DSO therefore recommends that the City of Seattle have the pipe inspected and the resulting video be forwarded to the DSO.

A 24-inch diameter steel pipe forms the outlet conduit for West Seattle Reservoir. A screen cage installed in the inlet section of the pipe prevents debris from entering the conduit. The pipe is provided with a 12-inch throttled gate valve, which is remotely controlled. However, the valve cannot be manually operated. Thus, it is recommended that backup manual controls for the valve be provided, and installed on the embankment crest.

Evaluation and Analyses

Downstream Hazard Classification

The primary consequences of any dam failure are the potential for loss of life and damage to property downstream of the dam. It is common practice to use a classification system to describe the general level of development downstream from a dam and to use the classification for establishing acceptable design levels.

As part of the inspection, the downstream hazard potential in the event of a dam failure was re-assessed by a visual inspection of the area downstream of the dam. West Seattle Reservoir is located in a populated residential area in Seattle. A failure of the reservoir embankment could release high velocity flows and threaten residential areas and several businesses. Based on these findings the downstream hazard classification for the West Seattle Reservoir should remain Hazard Class 1B, High.

Hydrology and Spillway Adequacy

As part of the inspection, the DSO performed a hydrologic analysis to determine the response of the reservoir to extreme hydrologic and hydraulic operating conditions. For reservoirs that have parapet walls and no tributary drainage area, this entails determining the system's ability to withstand extreme precipitation events, or excessive inflow from the supply system. The results of these analyses are summarized below.

Extreme Storm Analysis

A major consideration in the assessment of spillway adequacy is the selection of an appropriate design storm for evaluating the response of the reservoir water surface elevations. It is standard engineering practice to select the magnitude of the design storm dependent upon the level and type of development downstream from the dam. As the potential for loss of life and/or property damage resulting from an upstream dam failure increases, the design criteria become increasingly more stringent.

The DSO utilizes design storm selection criteria that have an eight-step format. Design storms range from a minimum of a 500-year storm (Step 1) to Probable Maximum Precipitation (PMP, Step 8). Based on the potential for damage in the event of a storm-induced dam failure, it was determined that the West Seattle Reservoir should be capable of accommodating a design storm event corresponding to Step 8 of the eight-step criteria. Step 8 corresponds to the Probable Maximum Precipitation which is an estimate of the maximum rainfall that the atmosphere could physically deliver to a given site over a period of time. The PMP used to analyze the reservoir was derived from the National Weather Service Hydrometeorological Report 57. The storm had a total duration of 72 hours with a 24-hour depth of 12.0 inches, and a total 72-hour depth of 16.2 inches.

The PMP storm was applied to the reservoir to determine if the current freeboard is sufficient. The tributary area to the reservoir has been effectively cut off by the parapet wall that surrounds the reservoir. Thus, the volume contributed by precipitation is that which falls directly on the reservoir alone. The initial water surface elevation was set equal to the elevation of the crest of the overflow weir (elevation 430.0 feet). Water system inflows were assumed to equal outflows during the simulation and conservatively, the overflow drain was assumed to be completely blocked. The resulting increase in the reservoir water surface elevation from the IDF would be 16.2 inches to elevation 431.35 feet. The elevation of the top of the parapet wall is 433.5 feet and the available freeboard is, therefore, 2.15 feet. Thus, even with the overflow drain completely blocked, the reservoir has ample freeboard to contain the PMP.

Overflow Drain

The overflow drain consists of a 40 foot long concrete weir that discharges to a 30 inch steel pipe. Based on the available head between the 30 inch outlet pipe (elevation 426.0 feet), and the top of the parapet wall (elevation 433.5 feet), the maximum discharge from the overflow drain is approximately 65 cubic feet per second (cfs). The capacity may be less depending on backwater effects from the downstream storm drain system. The maximum inlet capacity was reported by SPU personnel to be 50 cfs. Provided that the storm sewer does not limit the overflow capacity, it is unlikely that misoperation could result in the reservoir filling and overtopping the parapet wall. In addition, a high water sensor is installed to warn the operator in the event the reservoir rises to unacceptable levels. Based on the foregoing, the West Seattle Reservoir has adequate spillway capacity to accommodate the PMF and the maximum system inflow.

Embankment Stability

A review of the stability analysis performed for the 1992 periodic inspection was conducted as part of this inspection. This review indicated that the methodology used in the analysis is still the standard procedure used by the DSO; and, that the assumptions as to the properties of the embankment and foundation soils and loading conditions made for the analysis are still acceptable. Accordingly, the static stability of the embankment meets current engineering standards.

Seismic Stability – In response to the 2001 DSO report, the City of Seattle retained PanGEO, Inc. to evaluate the seismic stability of the West Seattle Reservoir. A review of the report prepared by PanGEO indicates that the seismic evaluation of the reservoir considered those fault sources and seismogenic zones that may have a significant effect on the determination of the seismic loading used in the evaluation of the seismic stability. For these earthquake sources, a conservative approach of selecting the median plus one standard deviation peak rock accelerations at the site was used. An “analysis” event was then selected based on the largest level of peak “rock” accelerations. For the analysis event, a target response spectrum was developed using an attenuation relation appropriate for the region. Representative time histories of ground motion from similar tectonic environments that approximately matched the target response spectrum were selected for input in the 1-D equivalent linear analysis of the structure. The results from the ground response analyses were then used to evaluate the slope stability of the embankment and the liquefaction potential of the site under seismic loading. The results of

this evaluation indicated that the soils at the site are unlikely to liquefy and that the embankment is stable under the seismic loading conditions considered.

Project Operation and Maintenance

Operation of the West Seattle Reservoir is performed by the Water Supply Section of the Seattle Public Utilities (SPU). Staff is present in the Water Operations Control Center 24 hours per day. The procedures for reservoir operation were originally summarized on a written document developed in 1975, and updated in the Operation & Maintenance Manual for the facility in February, 2000. In summary, the O&M Manual provides information on reservoir operation, and provides information on maintenance, inspection and monitoring activities to be conducted at the reservoir. A review of this document indicates that the O&M Manual meets the minimum requirements of the Dam Safety Guidelines.

The West Seattle Reservoir is used the entire year. The normal reservoir pool elevation is between 428.0 feet and 430.0 feet CSd. Water is pumped into the reservoir through the 42-inch steel pipe, and discharged under gravity flow through the 24-inch steel pipe. The operation of the gate valve on the outlet pipe is remotely controlled. Information on reservoir operation is telemetered to the Operations Control Center. Records of reservoir levels are stored on a computer for 5 years. Paper copies are available for periods prior to the last 5 years. Inflow/pumping records are available for the last 30 years.

The reservoir is visited daily by water quality personnel, who do not perform an inspection, but are present to observe any unusual or extreme condition at the reservoir. Ground crews visit the facility approximately once a week, and would observe any unusual or extreme conditions at the site. Inspection of the embankment is conducted on a monthly basis.

Emergency Action Plan

As recommended in our 1992 inspection report, an Emergency Action Plan (EAP) for the West Seattle Reservoir was developed. A review of the EAP, dated March 2005, was done as part of this inspection. This document meets the minimum requirements for an EAP as recommended in the Dam Safety Guidelines.

An inundation map is included in the EAP. This map delineates the inundated area assuming that the failure could occur at any point along the embankment section.

Recommendations

In general, the West Seattle Reservoir is well maintained and operated. The results of the field inspections and engineering analyses indicate that most elements of the facility meet current engineering standards for dam design.

- The animal burrows along the southeast corner of the reservoir should be backfilled, and steps be taken to control the animal population to prevent further burrowing activity.

- The Dam Safety Office recommends an inspection interval for critical conduit interiors equal to every other periodic inspection. This project feature therefore should be

scheduled for an inspection at the City's convenience. The resulting video should then be forwarded to the DSO. Additionally, the outlet conduit should be provided with backup, manual controls for the valve installed on the embankment crest.

Appendix A - References

1. Converse Ward Davis Dixon, Seismic Slope Stability Evaluation for West Seattle Reservoir, Seattle, Washington; Converse Ward Davis Dixon, Geotechnical Consultants, Project No. 79-5220-07, Seattle, Washington, December 16, 1980.

2. International Engineering Company, Inc., Phase I Inspection Report, National Dam Safety Program; Volunteer Park Reservoir, WA-210; Maple Leaf Reservoir, WA -211; Green Lake Reservoir, WA -212; Bitter Lake Reservoir, WA-213; Beacon Hill South Reservoir, WA-214; Beacon Hill North Reservoir, WA-215, West Seattle Reservoir, WA-216; Lake Forest Park Reservoir, WA-217; Seattle,
Washington, King County; International Engineering Company, Inc., Northwest District, Boise, Idaho, September 1980.

3. Ordonez, G. and Barker, 13. (1993); Periodic Dana Safety Inspection Report, West Seattle Reservoir. Washington State Department of Ecology, Dam Safety Section, Report 92-120, March, 1993.

4. Ordonez, G. and Cummings, D. (2001); Periodic Dam Safety Inspection of West Seattle Reservoir. Washington State Department of Ecology, Dam Safety Office, November, 2001.

5. U.S. Department of Commerce, NOAA. Hydrometeorological Report No. 57: Probable Maximum Precipitation - Northwest States, Silver Spring, MI). October 1994.

6. PanGEO, Inc. (2002). *Draft Geotechnical Engineering Report – West Seattle Reservoir – Seismic Safety Evaluation – Seattle, Washington.* Project No. 02-003, Seattle, Washington.

Appendix B - Figures

WEST SEATTLE RESERVOIR LOCATION MAP

Figure 1 – Location Map

WEST SEATTLE RESERVOIR

N
W E
S

200 0 200 Feet

Figure 2
Vicinity Map

Produced by the City of Seattle

May 25, 2004

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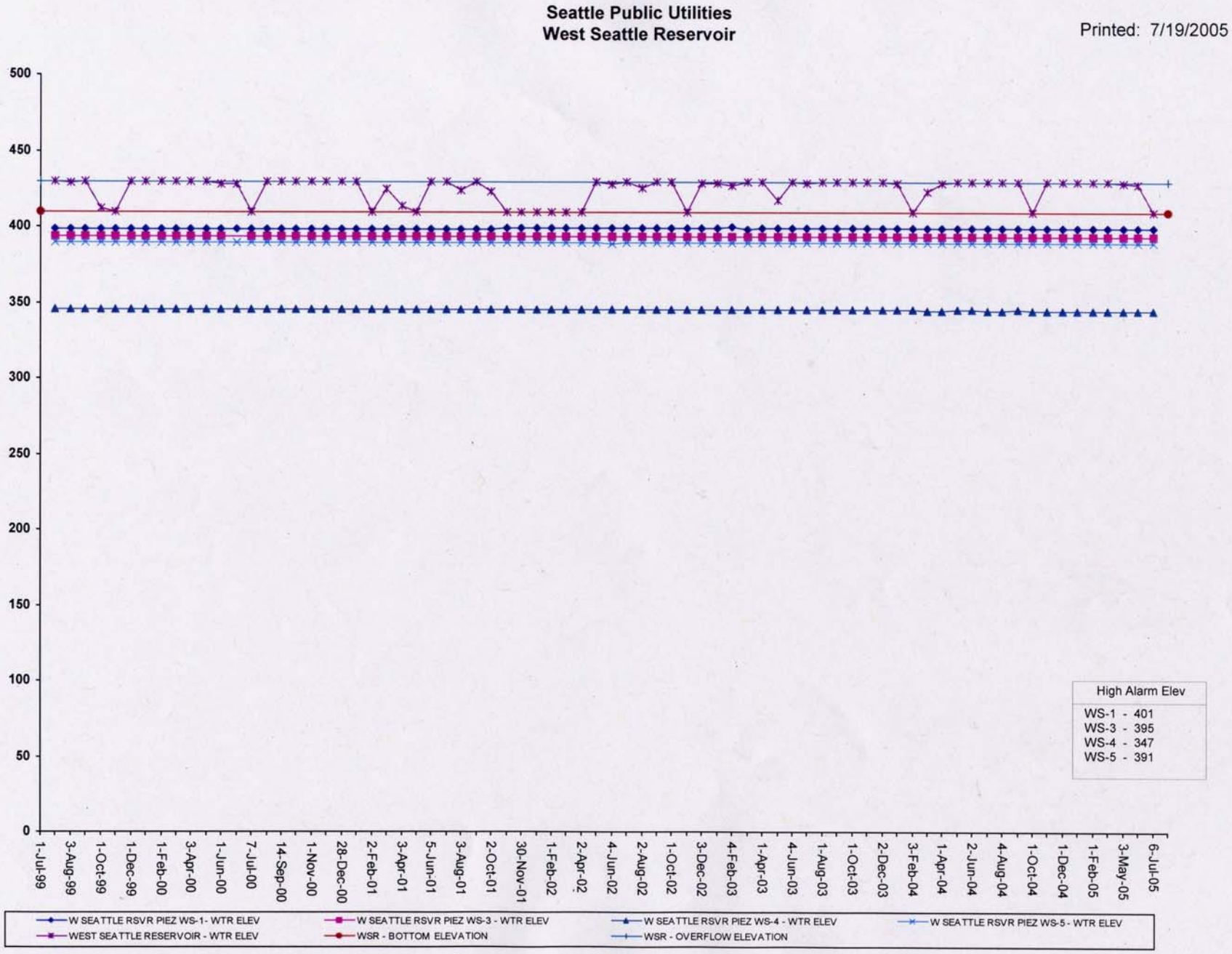

Figure 3 – Piezometer Data

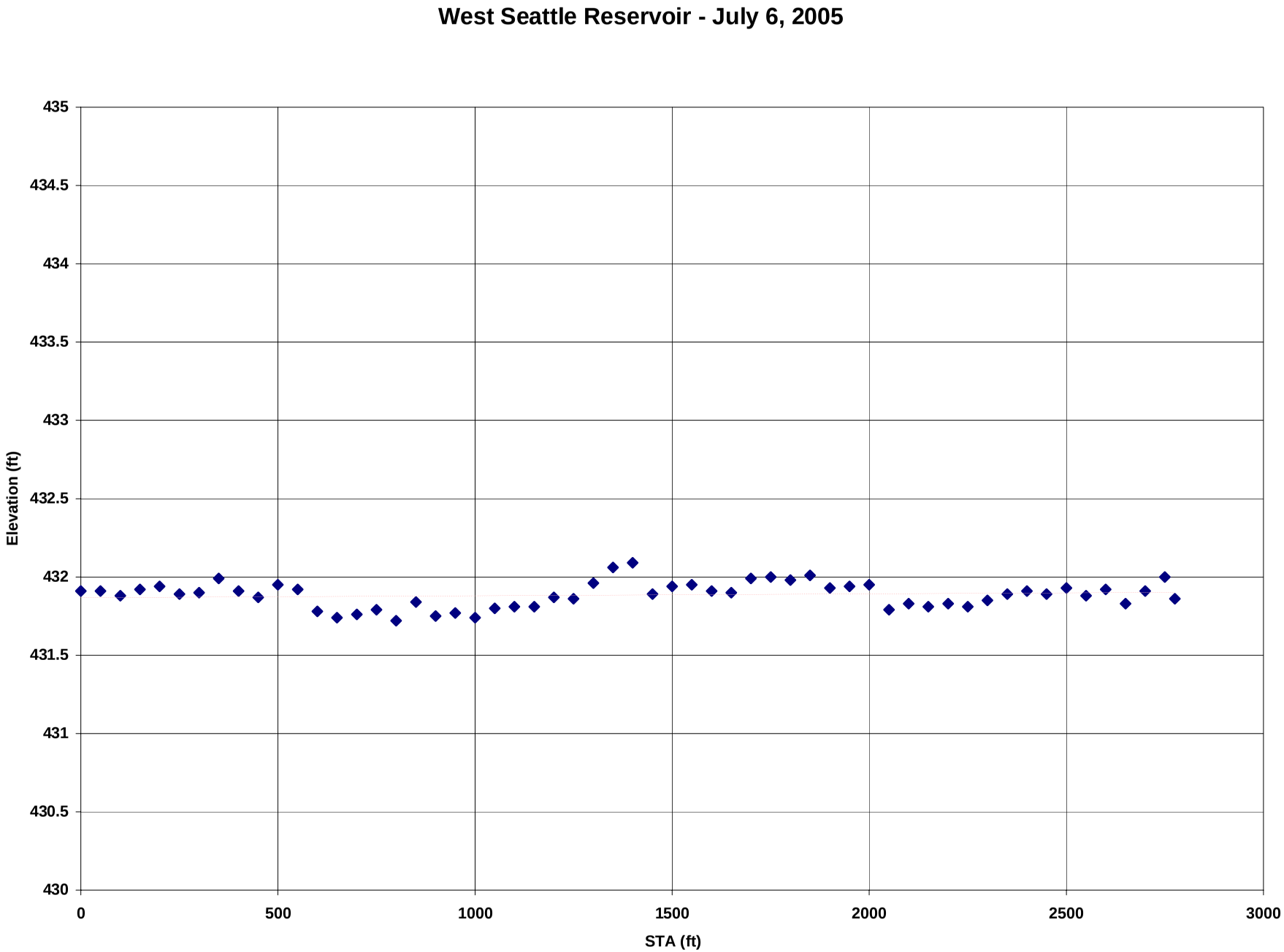

Figure 4 - Crest Elevation Survey

Appendix C - Photos

Photo 1 – Looking North Along Parapet Wall

Photo 2 – Looking South, SE Embankment Downstream Face

Photo 3 – Animal Burrows, SE Corner

Photo 4 – Hypalon Liner, Standing Water in NE Corner of Reservoir

Photo 5 – Looking Along Torn Liner and Batten

Photo 6 – Reservoir Overflow, North End of Reservoir, Hypalon Liner

Appendix D

Owner Interview Form

West Seattle Reservoir

STATE OF WASHINGTON
DAM SAFETY OFFICE
PERIODIC INSPECTION PROGRAM

★FAX MEMO★
TO: Gustavo Ordonez
FAX # (360) 407-6574
FROM: Carlos Albarracin
FAX #
PHONE (206) 381-4680 DATE 8/4/05 PGS 8

OWNER/OPERATOR INTERVIEW

PROJECT NAME: West Seattle Reservoir DSO FILE NO.:

DATE OF INTERVIEW: 08/03/05

INSPECTION TEAM MEMBERS:

OWNERS REPRESENTATIVES INTERVIEWED:

1. NORMAL OPERATING PROCEDURES

A) Operation Plan for Facility

- Is there a formal (written) plan/procedure?
- If not, what procedures are there for operating dam and reservoir

Yes

B) Seasonal Reservoir Operation

- When is reservoir normally filled?
- When is reservoir drawn down?
- What is operation of reservoir keyed to? (E.g. staff gage)

The rsvr is normally with water all the time except during cleaning periods

C) **Normal maximum reservoir pool elevation**

- Datum / reference elevation
- Approximate time of year

Maximum = 430 ft → City of Seattle datum

D) **Normal minimum reservoir pool elevation**

- Datum / reference elevation
- Approximate time of year

Minimum = 410 ft. → City of Seattle datum

E) **Dam Tender / Operator**

- Who is responsible for operation and control of keys, actuating mechanisms?
- When is operator on site?
- Where is residence/location of operator?

Water System Operators at Operations Control Center (OCC)

The operators are 24 hrs/7 days

D) **Spillway operation**

- Stoplog placement/gate operation procedures (if applicable)
- Are gates periodically operated or "bounced" with auxiliary control mechanism?
- Seasonal frequency of spillway flows (all year, winter, summer, etc.)

When we need to improve the water quality

E) **Outlet Works Operation**

- Seasonal water releases
- How are outlet works operated?

Daily water release

Outlet valve is manually operated

F) **Seepage observations**

- Seasonal seepage characteristics (reservoir level)
- Internal drainage outlet flow - seasonal characteristics
- Wet spots on downstream face or toe (seasonal)

No seepage or wet spots.

G) **Measurements taken at dam site (if any)**

- Piezometer levels
- Reservoir pool levels
- Seepage quantities
- Survey monuments
- Reservoir inflow/outflow measurements (cfs)

Piezometers, Reservoir pool level, reservoir outflow

The piezometers readings are taken once a month

H) **Maintaining Records**

- Normal recording (reservoir levels, inflow, outflow, maintenance work, etc.).
- Unusual observations recorded?

Daily reservoir levels, inflow, outflow.

2. UNUSUAL CONDITIONS OBSERVED

A) **Maximum historic reservoir pool level (ft)**

- Stoplog/gate operation at time

B) **Maximum inflow/outflow during floods**

- Typical climatic conditions during floods (rain, rain on snow, snowmelt, thunderstorms etc.)

C) **Maximum rainfall, an/ord snowpack observed**

- Time period
- Duration on ground

E) **Past Deficiencies Observed on Dam/abutments**

- Slumping or slides, abnormal seepage or wet areas, settlement, animal burrows, cracking etc.

No deficiencies observed.

F) **Toe drain and other internal drainage outlets(if applicable)**

- Cloudy drainage
- Unusual flowrate
- Obstructions

No toe drain.

G) **Outlet conduit**

- Unusual seepage
- Obstructions
- Settlement

No problems

H) **Spillway**

- Erosion
- Performance during floods
- Debris problems during past floods

Working fine

I) **Mechanical and electrical systems (if applicable)**

J) **Reservoir rim stability problems**

None

K) **Other noteworthy problems identified by owner/operator**

3. HISTORY OF PROJECT

A) **Dates of construction**

1931/32

B) **Significant events/problems during construction**

None known.

C) **Any modifications to original structure?**

Relined with Hyplanon in 1994

New parapet wall built in 1994

D) **Any repairs to original structure?**

Removal & replacement of the upper concrete slabs at the four corners done in 1994

E) **Any recent or proposed downstream homes or other development? (for downstream hazard rating)**

None Known

4. MAINTENANCE ACTIVITIES / INSPECTION PROGRAM (BY OWNER)

A) **Are maintenance and inspection activities contained in a formal, written plan?**

Yes

B) **What elements are maintained, and how often is maintenance perfomed?**

Vegetation → anually or as required / Liner → anually or when rsvr is empty.

Burrowing animals → montly. / Parapet wall → as required.

Erosion control → as required / Piezometers → monthly.

D) **Who is responsible for maintenance?**

The maintenance staff

E) **Noteworthy maintenance problems**

- Recent repairs to embankment, spillway?
- Operational problems with gates, valves, etc.
- Animal Burrows?

The liner has been repaired couple times at the east side of the detention chamber because it was found ripped along the batten strip.

F) **How often is project inspected?**

- Type of inspection
- What is inspected?
- Who performs inspection?

- Once or twice a year
- Inspection covers inside/outside slopes, the crest, valves, parapet wall alignment.
- Dam Safety engineer

5. EMERGENCY PROCEDURES

A) **Is there a formal (written) Emergency Action Plan (EAP)?**

Yes

B) **If not, what would be your normal procedure for handling an emergency event (i.e., earthquake, flood, unusual seepage, etc.)?**

C) **Who would be responsible for action during emergency?**

Observer, Water System Operator to initiate any action

D) **Who would be notified in event of emergency?**

SPU Response Team

E) Are emergency procedures and backup systems tested?

No

6. OTHER PROJECT SPECIFIC QUESTIONS TO BE ASKED