GEI Consultants

Geotechnical
Environmental and
Water Resources
Engineering

FINAL

Coal Ash Impoundment Specific Site Assessment Report

Arizona Public Service

Cholla Power Plant

Submitted to:
Lockheed-Martin Corporation
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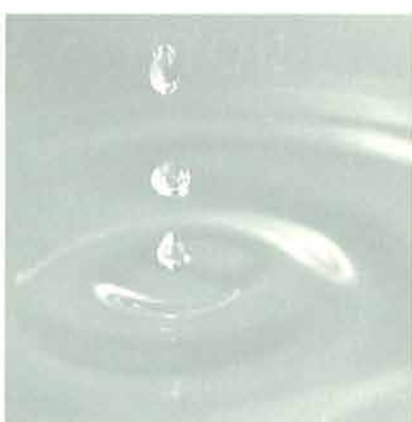

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1.0 Introduction

1.1 Purpose

This report presents the results of a specific site assessment of the dam safety of the Fly Ash Pond and Bottom Ash Pond coal combustion waste impoundments at the Arizona Public Service (APS) Cholla Power Plant in Joseph City, Arizona. The assessments were completed on September 2, 2009.

These impoundments were assessed because their failure may result in significant economic loss, environmental damage, disruption of lifeline facilities or loss of life (significant or high hazard according to U.S. Environmental Protection Agency (EPA) classification). The specific site assessment was performed with reference to Federal Emergency Management Agency (FEMA) guidelines for dam safety, which includes other federal agency guidelines and regulations (such as U.S. Army Corps of Engineers (USACE) and U.S. Bureau of Reclamation) for specific issues, and defaults to state requirements where not specifically addressed by federal guidance or if the state requirements were more stringent.

1.2 Scope of Work

The scope of work between GEI Consultants, Inc. (GEI) and Lockheed-Martin Corporation for the site assessment is summarized in the following tasks:

1. Acquire and review existing reports and drawings relating to the safety of the project provided by the EPA and Owners.
2. Conduct detailed physical inspections of the project facilities. While on-site, fill out Field Assessment Check Lists provided by EPA for each management unit being assessed.
3. Review and evaluate stability analyses of the project's coal combustion waste impoundment structures.
4. Review the appropriateness of the inflow design flood (IDF), and adequacy of spillways or ability to store IDF, including considering the hazard potential in light of conditions observed during the inspections or to the downstream channel.
5. Review existing performance monitoring programs and recommend any additional monitoring required.
6. Review existing geologic assessments for the projects.
7. Submit draft and final reports.

1.3 Authorization

GEI performed the coal combustion waste impoundment assessment for the EPA as a subcontractor to Lockheed-Martin who is a contractor to the EPA. This work was authorized by Lockheed-Martin under the P.O. No.: 7100052068; EAC #0-381 between Lockheed-Martin and GEI, dated June 5, 2009.

1.4 Project Personnel

The scope of work for this task order was completed by the following personnel from GEI:

Steven R. Townsley, P.E.	Senior Project Engineer/Task Leader
Stephen G. Brown, P.E.	Project Manager
Mary C. Nodine, P.E.	Staff Geotechnical Engineer
Daniel L. Johnson, P.E.	Senior Technical Review

Program Manager for the EPA was Stephen Hoffman. Program Manager for Lockheed-Martin Corporation was Dennis Miller.

1.5 Limitation of Liability

This report summarizes the assessment of dam safety of the identified coal combustion waste impoundments at the Cholla Power Plant. The purpose of each assessment is to evaluate the structural integrity of the impoundments and provide summaries and recommendations based on engineering judgment. GEI used a professional standard of practice to review, analyze, and apply pertinent data. No warrantees, expressed or implied, are provided by GEI. Reuse of this report for any other purpose, in part or in whole, is at the sole risk of the user.

1.6 Project Datum

All elevations in this report are National Geodetic Vertical Datum (NGVD) 1929 mean sea level.

1.7 Prior Inspections

The Arizona Department of Water Resources (ADWR) inspects the Bottom Ash and Fly Ash Pond dams annually. The last ADWR safety inspection was performed on September 25 and 26, 2008. References for the reports on these inspections are provided in Section 13 of this report. In addition, an APS professional engineer performs annual inspections of the Bottom Ash and Fly Ash Pond Dams, typically in the spring. The last independent safety inspections were performed in the summer of 2009, but the report for these inspections was not available. The reference for the previous inspection report, dated July 2008, is provided in Section 13 of this report.

2.0 Description of Project Facilities

2.1 General

The Cholla facility is a coal-fired power plant located in northeastern Arizona in the town of Joseph City in Navajo County (Figure 1). The Cholla power plant is composed of four units with a total net generating capacity of 1,027 megawatts (MW). Unit 1 was constructed in 1961, and the much larger Units 2, 3 and 4 were constructed between 1976 and 1981. Units 1, 2 and 3 are owned by APS and Unit 4, the largest unit, is owned by Pacificorp (APS, 2009a). The power plant is located on the Little Colorado River.

APS Cholla has three process water impoundments on site: Cholla Lake, the Sedimentation Pond, and the West Area Retention Pond. Cholla Lake was originally constructed as a cooling pond for Unit 1 and since 1978 serves as the cooling pond for both Unit 1 and Unit 2. It also stores water for the plant's other processes, including providing short term backup cooling water for Unit 3 and Unit 4 if the well system for cooling these units becomes inadequate. Cholla Lake does not contain any coal combustion waste products. The Sedimentation Pond collects water from drains located on the plant site, and receives minimal amounts of coal combustion byproducts in storm water, process water, plant water, and slurry from system leaks. The West Area Retention Pond receives minimal amounts of coal combustion byproducts in storm water, process water, and plant washdown from the west side of the plant. The Sedimentation Pond and the West Area Retention Pond are both sub-grade impoundments and do not meet the definition of a dam as set forth in the Arizona Revised Statutes 45-1202 (1), and are therefore not regulated by the state. The Sedimentation Pond and the West Area Retention Pond were not included in our Field Assessment or document review but are discussed briefly in Section 2.2. Cholla Lake was not included in this specific site assessment since it does not contain coal combustion byproducts.

In addition to the on-site impoundments, the Cholla plant has two major impoundments located off site. The Fly Ash Pond is located approximately 1.5 miles east of the plant, and the Bottom Ash Pond is located approximately two miles north of the plant. Both units have been classified as high hazard impoundments due to the potential for loss of life in the event of a dam breach because of the close proximity of the Cholla power plant, U.S. Interstate 40 (I-40), a freight railroad line and several residences downstream of the dams. An overall view of the onsite and offsite ponds is shown on the satellite photograph (Figure 2).

2.2 Dams and Reservoirs

Two on-site reservoirs at the Cholla plant – the Sedimentation Pond and the West Area Retention Pond – contain minimal amounts of coal combustion waste products, but are mainly intended to store water. The storage in these two ponds is below natural grade and therefore the ponds do not have dams.

The Sedimentation Pond was placed into service in 1976. It collects discharges of wastewater from an on-site secondary wastewater treatment plant, effluent from the oil/water separator, vehicle wash water from a spray wash station, plant wash water containing small amounts of coal dust and coal ash from various drainage sumps and ditches, and flue gas desulfurization wastes from scrubber or scrubber feed tank upsets. The sedimentation pond has two cells with a total surface area of about 1.4 acres and a total storage capacity of about 10.5 acre-feet. The maximum depth of the pond is 10 feet. The top of the pond side slope is at El. 5019.0. The pond currently stores 0.5 acre-feet of material. Water collected in the Sedimentation Pond is pumped to the Cholla facility's General Water Sump for recycling as process water. The pond also has an overflow weir at its south end which connects to a channel that conveys flows to the West Area Retention Pond (described below). Solids are removed from the Sedimentation Pond periodically and transferred to the Bottom Ash Pond or the Fly Ash Pond. The Sedimentation Pond has a two-foot-thick compacted clay liner.

The West Area Retention pond was placed into service in 2002 to collect surface drainage. It has a surface area of about ½ acre and a total storage capacity of about 1.6 acre-feet. The maximum depth of the pond is 4.5 feet. The top of the pond side slope ranges from El. 5013.8 to El. 5019.1. Currently a negligible volume of material is stored in this pond. Stored material includes stormwater, process water and plant wash-down water with minimal amounts of coal combustion byproducts from incidental discharges of process wastewater. Water collected in West Area Retention Pond is pumped to the Sedimentation Pond and recycled as process water in the Cholla Facility. The West Area Retention Pond has an earth liner. An aerial photograph of the Sedimentation Pond and the West Area Retention Pond is shown in Figure 3.

The Cholla plant includes two large coal combustion waste dams at the two off-site impoundments. The dams included in this report are:

- Fly Ash Pond Dam
- Bottom Ash Pond Dam

The Fly Ash Pond has a total surface area of 420 acres and a storage capacity of about 18,000 acre-feet at the normal operating pool of El. 5114. Fly ash is pumped into the pond as a slurry from the Cholla plant's coal-fired generating units. The fly ash settles out of the slurry and water evaporates from the pond's surface. The Fly Ash Pond stores primarily fly ash but also contains some bottom ash, boiler slag, flue gas emission control residuals, storm water, sedimentation pond solids, boiler cleaning wastes, and oil/water separator solids.

The Fly Ash Pond Dam was constructed starting in 1976 and placed into service in 1978. The dam has a crest elevation of 5120 feet giving it 6 feet of freeboard over its normal operating pool. The dam is 4,565 feet long with a maximum height of 80 feet and a crest width of 24 feet. The upstream and downstream slopes of the dam are constructed at 3H:1V. The dam is constructed of earth fill and has a zoned cross section with a central clay core. The clay core extends to bedrock where bedrock is relatively shallow. In the central portion of the dam, where bedrock is relatively deep (greater than about 20 feet below the original ground surface), a slurry cutoff wall extends 1 foot into bedrock or 2 feet into stiff clay. In addition, there is a clay blanket extending about 250 feet from the right (west) abutment. The Fly Ash Pond Dam has no internal drain system. Where seepage has been observed, valley drains have been constructed to collect surface water and groundwater and return it to the ponds. An aerial photograph of the Fly Ash Pond is shown in Figure 4. Drawings including a plan, profile and sections of the Fly Ash Pond Dam are attached in Exhibits 1 and 2. A profile of the Fly Ash Pond Dam is attached in Exhibit 3.

The Bottom Ash Pond has a total surface area of 80 acres and a total storage capacity of about 2,300 acre-feet at the normal operating pool of El. 5117.8. The pond consists of a reservoir directly behind the dam and two coal combustion waste storage cells (the West Cell and the East Cell) upstream, as shown in the aerial photograph in Figure 5. Bottom ash is pumped into the storage cells as a slurry from the Cholla plant's coal-fired generating units. The bottom ash settles to the bottom of the pond and the water is decanted to the reservoir and ultimately siphoned back to the plant for reuse. At any given time, waste is being pumped to one of the upstream cells, and the bottom ash in the other cell is drained and excavated for storage in a monofill north of the bottom ash pond. Through this practice the total storage volume in the bottom ash pond remains relatively constant. The elevations of the intermediate dikes separating the coal combustion waste storage cells from the main reservoir are higher than that of the Bottom Ash Pond Dam downstream, and excess water from the upstream cells is drained to the main reservoir via a channel along the right abutment of the dam. The Bottom Ash Pond primarily stores bottom ash, but also contains some fly ash, boiler slag, flue gas emission control residuals, sedimentation pond effluent, sedimentation pond solids, cooling tower blowdown, oil/water separators effluent, oil/water separator solids, boiler cleaning wastes, and stormwater.

The Bottom Ash Pond Dam was constructed starting in 1976 and placed into service in 1978. It was originally built with a crest at Elevation 5120. Due to an error, the pond was constructed with less storage capacity than required, and in 1993 the dam crest was raised 3.3 feet to El. 5123.3 to increase the storage capacity to required levels. The current crest elevation provides 5.5 feet of freeboard above the normal pool elevation. The Bottom Ash Pond Dam is 4,200 feet long with a maximum height of 73 feet, a 12-foot-wide crest and

3H:1V upstream and downstream slopes. The dam is constructed of earth fill and has a zoned cross section with a central clay core. The clay core extends to bedrock where bedrock is relatively shallow. In the central portion of the dam, where bedrock is relatively deep (greater than about 20 feet below the original ground surface), a slurry cutoff wall extends 1 foot into bedrock or 2 feet into stiff clay. In addition, there is a 400-foot-long slurry wall beyond the right (west) abutment of the dam. The Bottom Ash Pond Dam has no internal drain system. Where seepage has been observed, valley drains have been constructed to collect surface water and groundwater and return it to the ponds. An aerial photograph of the Bottom Ash Pond is shown in Figure 5. Drawings including a plan, profile and sections of the Bottom Ash Pond Dam are attached in Exhibit 4. A plan for the siphon system for the Bottom Ash Pond is attached in Exhibit 5. A profile of the Bottom Ash Pond Dam is attached in Exhibit 6.

Information concerning the dams at the Cholla facility is presented in Table 2.1.

Table 2.1: Cholla Power Plant - Dam Parameters Summary

Parameter	Value	
Dam	Fly Ash Pond Dam	Bottom Ash Pond Dam
Height (ft)	80	73
Length (ft)	4,565	4,200
Crest Width (ft)	24	12
Crest Elevation (ft)	5120	5123.3
Downstream Side Slopes	3H:1V	3H:1V
Upstream Side Slopes	3H:1V	3H:1V
Operating Pool El. (ft)	5118.6	5114
Normal Storage Volume (ac-ft)	18,000	2,300
Normal Surface Area (acres)	420	80

2.3 Spillways

Neither of the dams at the Cholla power plant have spillways. The dams are designed to contain the probable maximum flood (PMF).

2.4 Intakes and Outlet Works

There are no intake or outlet work structures associated with the Fly Ash Pond. Water levels are controlled by changing the pumping rate of ash slurry into the pond. Water is only removed from the pond through evaporation.

The Bottom Ash Pond has no intake structures. Water from the two upstream waste-containing cells is routed to the reservoir. Water exits the Bottom Ash Pond reservoir via a siphon system. The system consists of four 12-inch-diameter high density polyethylene (HDPE) pipes that float near the surface of the reservoir at the inlet end and extend above the top of the dam and down the downstream face to a common valve chamber and subsequent return pipe to the power plant. The pipes were originally 8 inches in diameter but have been replaced with 12-inch-diameter pipes within the past several years. The four 12-inch-diameter HDPE pipes reduce and connect to the original 8-inch-diameter pipes near the toe of the dam.

2.5 Drains

The dams at the Cholla facility were not constructed with internal drains. Since the dams' construction, however, several seepage locations have been observed and continually monitored. Valley drain and toe drain systems have been constructed at most of the seepages to collect surface and subsurface water, and typically consist of underground french drains routed to a collection sump. The water collected is returned to the Ash Ponds, and the flow rate and the quantity of seepage collected are measured. The seepage collection systems for the dams are discussed further in Section 5.

2.6 Vicinity Map

The Cholla Power Plant is located within Navajo County, Arizona in the town of Joseph City, as shown on Figure 1. The plant is located in the Southwest ¼ of Section 23, Township 18 North, Range 19 East. The Fly Ash Pond is located primarily in Section 30, Township 18 North, Range 20 East. The Fly Ash Pond is not located on or very near to a waterway. The Bottom Ash Pond is located approximately two miles north of the plant, and the Fly Ash Pond is located approximately 1.5 miles east of the plant. The Bottom Ash Pond is located at the intersection of (clockwise from top left) Sections 14, 13, 24 and 23, Township 18 North, Range 19 East. The Bottom Ash Pond is located adjacent to Tanner Wash, a tributary to the Little Colorado River that was dry at the time of our site visit.

2.7 Plans and Sectional Drawings

Engineering drawings and reports for various project features are available in the Owner's files. For reference purposes, project plan and sectional drawings from the Owner's files are reproduced in this report as follows:

Fly Ash Pond Plan	Exhibit 1 (Drawing G-557)
Fly Ash Pond Sections and Details	Exhibit 2 (Drawing G-44558)
Fly Ash Pond Embankment Alignment Profiles	Exhibit 3 (Figure 13, Ebasco, 1975)
Bottom Ash Pond Plan and Sections	Exhibit 4 (Drawing G-44556)
Bottom Ash Pond Siphon System and Floating Pipeline	Exhibit 5 (Drawing G-556-S02)
Bottom Ash Pond Embankment Alignment Profiles	Exhibit 6 (Figure 15, Ebasco, 1975)

2.8 Standard Operational Procedures

The Cholla facility is a coal fired power plant that provides electric power to millions of customers. The plant is composed of four units with a total net generating capacity of 1,027 MW. Coal is delivered to the power plant by trains and conveyor systems, where it is then combusted to power the steam turbines. The burning of coal produces several gases which are vented from the boiler. Bottom ash, which is made of coarse fragments, falls to the bottom of the boiler and is removed along with boiler slag. Fly ash is removed from Units 1, 3 and 4 with fabric filters. Unit 2 uses a combination of a mechanical dust collector and a venturi scrubber system (a wet particulate/SO_2 removal system) to remove fly ash.

Approximately 70 percent of the fly ash generated at the Cholla plant is sold for reuse. The remaining fly ash is pumped as a slurry along with flue gas desulfurization residuals to the Fly Ash Pond, where it settles and evaporates.

The bottom ash from the four coal-fired units is pumped as a slurry to the waste storage cells in the northern portion of the bottom ash pond. The bottom ash settles out and the remaining water is routed to the reservoir portion of the pond, in its southern portion and directly behind the Bottom Ash Pond Dam. When one waste storage cell is full, it is drained of water and the settled bottom ash is excavated and stored permanently in a monofill north of the Bottom Ash Pond. Meanwhile, bottom ash slurry is pumped into the other waste storage cell. The functions of the two waste storage cells alternate annually.

3.0 Summary of Construction History and Operation

The power plant is composed of four units with a net generating capacity of 1,027 MW. Unit 1 was constructed in 1961 and has a net capacity of 116 MW. The much larger Units 2, 3 and 4 were constructed between 1976 and 1981 and have net capacities of 260MW, 271MW, and 380 MW, respectively.

When Unit 1 was originally constructed, prior to passage of the Clean Water Act in 1972, coal combustion waste from the plant was discharged to an impoundment located just north of the Little Colorado River. Water was decanted from the coal combustion waste and discharged to the Little Colorado River. When Units 2, 3 and 4 were constructed starting in 1976, the Bottom Ash and Fly Ash Ponds were placed into service. Coal combustion waste products have since been pumped into these ponds for storage.

The Fly Ash Pond Dam was designed and constructed by Ebasco Services, Inc. (Ebasco) starting in 1976, and it was placed into service in 1978. The embankment is zoned earth fill, with a clay core and a shell consisting of sandy random fill. The clay core extends to bedrock where bedrock is relatively shallow. In the central portion of the dam, where bedrock is relatively deep (greater than about 20 feet below the original ground surface), a slurry cutoff wall extends 1 foot into bedrock or 2 feet into stiff clay. In addition, there is a clay blanket extending about 250 feet from the right (west) abutment.

The Fly Ash Pond has a saddle dam in the northeast corner that is shown on the design drawings but is not visible in recent aerial photos. It is also clear from aerial photos that the location where the saddle dam should be is flooded with water and/or ash. APS personnel indicated to us that the saddle dam was constructed to prevent the pond from flooding a bay in this area in order to keep it within property lines. However, APS has since purchased the property in this area and the dam was breached. There is no low area within this bay that could potentially release material in the Fly Ash Pond.

The Bottom Ash Pond Dam was designed and constructed by Ebasco starting in 1976, and it was placed into service in 1978. The embankment is zoned earth fill, with a clay core and a shell consisting of sandy random fill. The clay core extends to bedrock where bedrock is relatively shallow. In the central portion of the dam, where bedrock is relatively deep (greater than about 20 feet below the original ground surface), a slurry cutoff wall extends 1 foot into bedrock or 2 feet into stiff clay. In addition, there is a 400-foot-long slurry wall beyond the right (west) abutment of the dam.

A mistake in the design calculations led to significant undersizing of the Bottom Ash Pond. The pond was originally intended to store bottom ash for 35 years but instead filled up in 13 years. In 1993, several modifications were made to the pond in order to increase storage capacity, including raising the Bottom Ash Pond Dam by 3.3 feet to its current crest elevation of 5123.3 feet and constructing intermediate ash retention dikes upstream of the Bottom Ash Pond Dam. The dikes were constructed in a configuration such that they created two ash storage cells upstream of the main reservoir cell. Surveyed plans, crest profiles and a typical section of the dikes were provided to us. The maximum operating pool elevation after the dam was raised increased from El. 5115 to El. 5118.6. However, in 1997 the flood pool allocation was reassessed and the operating level was lowered to El. 5117.8. In 1999, APS obtained a permit to store dewatered bottom ash as a monofill on the 40 acres adjacent to and upstream of the bottom ash pond.

Our assessment of the pre-construction conditions at the Fly Ash Pond and Bottom Ash Pond Dams included review of information on the design drawings. Construction reports were not available for review. The dams were constructed at the same time as Units 2, 3 and 4 at the Cholla plant. Prior to construction of the Fly Ash and Bottom Ash Ponds, coal combustion waste from Unit 1 was discharged directly into the Little Colorado River. A geotechnical report by Sergent, Hauskins and Beckwith, including subsurface explorations, was completed in 1973 prior to design and construction of the Fly Ash and Bottom Ash Ponds. There is no evidence, in the geotechnical report or otherwise, to suggest that either dam was constructed over coal combustion waste or on disturbed land. Evidence of prior releases, failures or patchwork construction were not observed during the site visit or disclosed by plant personnel during the site visit.

4.0 Geologic and Seismic Considerations

The Cholla Power Plant and its associated impoundments are located in and near the town of Joseph City in Navajo County, Arizona. This area of Arizona is within the Colorado Plateau Physiographic Province, which encompasses the southeastern half of Utah, extreme western and southwestern Colorado, northwestern New Mexico, and the northern half of Arizona. The Colorado Plateau Physiographic Province is characterized by horizontal-bedded sedimentary rock, high elevation and deep canyons. Riverbeds in this region are generally narrow and widely-spaced.

The bedrock in the Cholla Power Plant vicinity consists of several geologic units including the Coconino Sandstone, the Wupatki, Moqui and Holbrook Members of the Moenkopi Formation, the Shinarump Member of the Chinle Formation, and the Little Colorado and Wash Alluviums.

The Coconino Sandstone is of Permian age and underlies both the Bottom Ash and Fly Ash Pond Dams below about El. 4915. This formation is the oldest exposed formation in the region. The Coconino Sandstone consists of very fine to medium-grained quartz grains cemented with silicious cement. The formation is pale orange to pure white and is believed to be of eolian origin.

The Triassic-age Moenkopi Formation overlies the Coconino Sandstone. The Wupatki Member, which consists mainly of reddish brown, thin-bedded siltstone and fine-grained sandstone with thin-bedded sandstone and mudstone at its base, is the oldest member. The Moqui Member overlies the Wupatki Member and consists of pale brown to reddish-brown mudstone and siltstone beds with gypsum. The youngest member is the Holbrook Member, which is present at both abutments of the Bottom Ash Pond Dam above approximately El. 5070. The Holbrook Member consists of pale red, medium- to very-fine-grained well-graded sandstone with silt.

The Shinarump Member of the Triassic-age Chinle Formation is present in a channel at the right abutment of the Bottom Ash Pond Dam. The Shinarump consists of weakly- to well-cemented sandstone and conglomerate with rounded pebbles of quartz, quartzite, jasper and chert and subangular pebbles of petrified wood as well as petrified logs. At the channel adjacent to the Bottom Ash Pond Dam, the Shinarump is well-cemented and fractures easily, making it very permeable.

The Little Colorado River and Wash Alluviums overlie the bedrock and are composed of unconsolidated clay, silt, sand and gravel. The alluvium thickness ranges up to about 50 feet thick beneath the Fly Ash Pond Dam and up to about 100 feet thick beneath the Bottom Ash Pond Dam.

A peak horizontal acceleration coefficient of 0.05g was applied as a pseudo-static coefficient in the facility design. This would be generally consistent with accelerations of about 0.08g as shown on the 2008 United States Geological Survey (USGS) regional probabilistic seismic hazard map for 2 percent Probability of Exceedance within 50 years (recurrence interval of approximately 2,500 years). The Maximum Considered Earthquake (MCE) loading is applicable to the design earthquake for high hazard classification impoundments based on federal dam safety guidance. A seismotechtonic study to develop the MCE has not been documented for the Joseph City area.

For this assessment, application of a background, or floating, earthquake concept is employed for an assessment-level check on the peak horizontal acceleration for the Joseph City area. A maximum background earthquake was established by dePolo (1994) for the Basin and Range physiographic province at a value of M 6.5 at a hypocentral depth of 15 kilometers (km). An approximate range of peak horizontal acceleration for the background earthquake would be 0.15g to 0.18g based on attenuation relationships developed for the Western United States. Lacking a more detailed study, this range of acceleration will be considered for checking structural stability in this assessment.

Site-specific documentation presenting geologic information for the facilities at the Cholla Power Plant included:

- Sergent, Hauskins & Beckwith, 1973 "Preliminary Soil and Geologic Study Report on Proposed Ash Disposal Areas"
- Ebasco Services Inc. 1975 "Ash Disposal Sites Seepage and Foundation Studies"

Borings drilled at the location of the Fly Ash Pond from the Sergent, Hauskins & Beckwith (1973) and Ebasco (1975) reports indicate that the stratigraphic section includes between 0 and 50 feet of alluvium consisting mainly of silty clay with some sand and gravel. The overburden soils are underlain by claystone and siltstone with gypsum (Moqui Member of the Moenkopi Formation). Several borings near the center of the embankment encountered the Wupatki Member of the Moenkopi Formation below about 70-foot depth, which consists here of sandstone with traces of gypsum.

Borings drilled at the location of the Bottom Ash Pond for the Ebasco (1975) report indicate that the stratigraphic section includes between 0 and 90 feet of alluvium consisting mainly of sandy clay with some gravel and silt. The overburden soils are underlain by weathered claystone with some gypsum and interbedded siltstone (Moqui Member of the Moenkopi Formation). The Holbrook Formation outcrops at both abutments of the dam above the Moqui and consists of clayey sand overlying weathered sandstone and claystone A channel of the highly-permeable Shinarump Formation, which consists of well-cemented sandstone and conglomerate, was encountered near the right abutment of the Bottom Ash Pond dam.

5.0 Instrumentation

5.1 Location and Type

A large network of instrumentation is installed near the Fly Ash and the Bottom Ash Ponds at the Cholla facility. Several piezometers were installed in each dam at the time of construction. Additional instrumentation has been added to monitor movement, seepage quantities, water levels and water quality at specific locations. The instrumentation is monitored by APS on a regular basis.

5.1.1 Fly Ash Pond

Piezometers, movement monitoring points and seepage flow measurement totalizers have been installed on and near the Fly Ash Pond Dam. Forty piezometers are currently monitored at the Fly Ash Pond Dam. Eight piezometers (assigned identifying numbers less than 100) were installed just beyond the downstream toe and at the right abutment at the time the dam was constructed for the purpose of monitoring water levels in the major geologic formations underlying the dam. Piezometers F-100 through F-122 and W-123 through W-125 were installed along the toe and crest and at the abutments of the dam shortly after construction, in 1979. Piezometers F-123 through F-134 were installed in 1999 during an investigation of cracks on the dam crest. Four of the piezometers installed in 1999 measure water levels in the embankment core, and three measure water levels in the shell. The remaining five piezometers installed in 1999 and the piezometers installed prior to 1999 measure water levels in the dam foundation. The piezometers at the Fly Ash Pond Dam are currently monitored quarterly, except those installed in 1999 are monitored weekly. Cracks in the embankment were first observed by APS in about 1999, at which time ADWR determined that the new wells should be monitored weekly in order to observe any fluctuations in water levels. ADWR lifted the dam's safety deficiency in 2007 after seepage rates measured in the totalizers downstream were stable for several years. APS has submitted an application to ADWR to reduce the frequency of these measurements and is currently under review by ADWR. All piezometers are distributed on the crest, upstream slope, downstream toe and at the abutments of the Fly Ash Pond. A more detailed description of the history of cracks in the Fly Ash Pond Dam is provided in Section 6.4.6.1. Piezometers F-114, F-115 and F-116, located at the toe of the dam near the left abutment, have been dry for at least ten years. APS did not report data for these wells in the 2008 Basic Data Report (2008b), but the wells are monitored quarterly as part of the regular monitoring program. Sixteen survey monuments are installed on the crest of the Fly Ash Pond Dam for the purpose of monitoring horizontal movement and settlement. Ten of these were installed at the time of dam construction, and the remaining six were installed in the area around

Geronimo Knob (near the center of the dam) in 2001 as part of the investigation of cracks in the dam crest. The survey monuments are monitored annually.

Seepage collection and monitoring systems have been installed at two locations at and beyond the toe of the Fly Ash Pond Dam where seepage has been observed, in order to collect water and return it to the pond, as well as to measure the volume of water collected. Currently seepage is monitored weekly at the Geronimo Seep, located about 50 feet beyond the downstream toe and 2,000 feet from the right abutment, and quarterly at the Hunt Seep, located about 1,500 feet beyond the downstream toe. Seepage totalizers at these locations measure the seepage collected and returned to the Bottom Ash Pond, which includes water potentially originating from the pond as well as surface water and groundwater. Turbidity was measured at water collected from both the Hunt and Geronimo Seep starting in November 2001. Turbidity measurements were terminated in October 2002 for the Hunt Seep, but continue to be measured for the Geronimo Seep.

5.1.2 Bottom Ash Pond

Piezometers, movement monitoring points, and seepage totalizers have been installed on and near the Bottom Ash Pond Dam. A total of 46 piezometers are currently monitored on the Bottom Ash Pond Dam. Three piezometers (B-94, B-95 and B-96) were installed just beyond the downstream toe at the time the dam was constructed for the purpose of monitoring water levels in the major geologic formations underlying the dam. Piezometers B-200 through B-230 and W-301 through W-309 were installed shortly after the dam was constructed in 1979. Piezometers DM-5 and CR-1 were also installed shortly after the dam was constructed to monitor the water levels adjacent to the Little Colorado River. The piezometers at the Bottom Ash Pond Dam are monitored quarterly. The piezometers are distributed on the crest, upstream slope, downstream toe and around the perimeter of the Bottom Ash Pond.

Ten survey monuments are installed on the crest of the Bottom Ash Pond Dam for the purpose of monitoring horizontal movement and settlement. The monuments were first installed when the dam was constructed. All of the monuments were moved in conjunction with the 3.3-foot dam raise in 1993 with the exception of monument M14, which is located on the upstream slope of the dam. The survey points are monitored annually.

Seepage is monitored at four locations at and beyond the toe of the Bottom Ash Pond Dam by means of four seepage totalizers and one weir. Seepage collection and monitoring systems have been installed at four locations at and beyond the toe of the Bottom Ash Pond Dam where seepage has been observed in order to collect water and return it to the pond, as well as to measure the volume of water collected. Currently seepage is monitored quarterly at the West Abutment Seep, located about 100 feet downstream of the right abutment toe; the Tanner Wash Seep, located about 350 feet beyond the left abutment of the dam; the

Petroglyph Seep, location about 150 feet beyond the dam toe on the east side; and the P-226 Seep, located about 250 feet beyond the left abutment toe. Seepage totalizers at these locations measure the seepage collected and returned to the Bottom Ash Pond, which includes water potentially originating from the pond as well as surface water and groundwater. There is also a weir at the West Abutment Seep upstream of the totalizer which measures the amount of water that daylights at the dam toe. Turbidity was measured at the seep locations from November 2001 until October 2002.

5.2 Time Versus Reading Graphs of Data

5.2.1 Fly Ash Pond Dam

Data from piezometers, movement monuments and seepage totalizers for the Fly Ash Pond Dam are provided in Appendix A.

5.2.1.1 Piezometers

Tabulated water level data for the piezometers at the Fly Ash Pond Dam for the period 1989 to 1995 were available for our review. Digital data for the piezometers for the period of 1996 to 2007 were available for review.

The water levels in the piezometers installed in the Moqui Member of the Moenkopi Formation at the dam abutments (F-100, F-117, F-118, F-120 and F-121) have remained relatively steady with time. Two piezometers at the downstream toe in the Moqui Member (F-89 and F-112) have remained steady, while a third shows a steady upward trend generally consistent with the trend in the reservoir water level.

Two piezometers are installed in the Moqui and Holbrook Members of the Moenkopi Formation at the right abutment of the dam (F-81 and F-35). The water level in piezometer F-81 decreased steadily to El. 5064 during the period of 1989 to 1993, then increased suddenly to El. 5091, which was close to the elevation of the water in the Fly Ash Pond Reservoir at that time. Only water level data for 1996 and later are included in Appendix A of this report, but the fluctuations in piezometer F-81 are shown in the 1999 Basic Data Report (APS, 1999b) which we also reviewed. The water level then decreased rapidly over the course of the next year to El. 5075 and has steadily decreased ever since. The water level in piezometer F-35 was steady around El. 5070 until it became “inaccessible,” according to records provided by APS, in 2003. When it was measured again in 2007, the water level had risen to El. 5094, approximately the elevation of the reservoir water level. The water level in F-35 remains close to the reservoir water level.

Five piezometers are installed in the alluvium near the center of the Fly Ash Pond Dam crest (F-104, F-105, F-108, F-109 and F-110). The water levels in these piezometers have remained relatively steady with time and tend to follow trends in the water level of the reservoir. The piezometers on the upstream side of the crest have water levels within 10 feet of the Fly Ash Pond water surface elevation, while those on the downstream side of the have water levels at least 30 feet below the Fly Ash Pond water surface. The piezometers in the alluvium at the downstream toe (F-106, F-111, F-92, F-93 and W-123) have remained steady with time.

Deeper wells in the Wupatki Member of the Moenkopi Formation and in the Coconino Formation at the Fly Ash Pond Dam toe (F-88, F-90 and F-91, W-124 and W-125) show a general downward trend over time. Water levels in these wells have decreased about 25 feet since 1989. The APS July 2008 Dam Safety Inspection Report indicates that the decrease in water level elevation is due to fly ash buildup along the upstream toe of the dam.

The piezometers installed in the dam shell, the shell foundation and the core foundation in 1999 (F-125, F-126, F-127, F-129, F-130, F-131, F-133, and F-134) have generally been steady since at least 2001. These piezometers tend to follow trends in the water level of the reservoir.

Three of the piezometers installed in 1999 in the dam core (F-123, F-128 and F-132). These piezometers had water levels 5 to 10 feet higher than the water level in the reservoir starting in 2001, but their water levels have steadily fallen and currently correspond to the reservoir water level (El. 5094). The fourth piezometer in the core (F-124) had an upward trend from 2001 to 2003 but appears to have stabilized around El. 5089. These piezometers have generally shown steady trends since 2001 (two years after their installation), and do not respond to changes in the water level of the reservoir.

5.2.1.2 Survey Monuments

Data for the settlement monuments that were installed at the time of construction indicate that a maximum settlement of about 1.7 feet has occurred since construction of the dam near its maximum section. Settlement has been minor (less than 0.3 feet) since 1993. We reviewed tabulated data, which is available since construction. Graphical movement data were only available starting in 1996 (as shown in Appendix A). At the time the monuments were installed, all were located at elevations at or above the design dam crest elevation of 5120. Currently, eight of the sixteen survey monuments show that the dam crest has settled to an elevation below 5120. Monument M-5B was most recently surveyed at El. 5118.0 and represents the lowest area on the dam crest.

Generally the left side of the dam, which is a saddle, has experienced net upstream movement, and the main portion of the dam has experienced net downstream movement. Horizontal movement has been less than 0.3 feet upstream and less than 0.4 feet downstream.

5.2.1.3 Seepage Totalizers

Seepage measured at the Geronimo totalizer was less than 8 gallons per minute (gpm) from the start of measurements in 1993 until 2003, when readings began to vary widely. After 2003, flows as high as 47 gpm were recorded, but the 2008 APS Dam Safety Inspection Report (2008a) indicates that the equipment sometimes malfunctions and some of the readings are incorrect. A similar comment is made in the 1999 APS Dam Safety Inspection Report (1999a), which indicates that the totalizers will be replaced with more reliable mechanical flow meters. The situation does not appear to have been addressed. Similarly, the Hunt Seep Totalizer generally recorded less than 2 gpm from the start of measurements in 1997 until 2005, when its readings began to vary widely and seepage quantities up to 12 gpm were recorded. However, APS personnel indicated that the Geronimo Seep readings are calculated based on the Hunt Seep readings, and therefore readings for both seeps may be affected when the totalizers malfunction.

Turbidity measured in the Hunt Seep from November 2001 to October 2002 was typically less than 0.5 Nephelometric Turbidity Unit (NTU), but isolated readings up to about 2.5 NTU were recorded. Recent readings at the Geronimo Seep have typically been less than 0.5 NTU. Isolated readings greater than 5 NTU have been recorded, but the 2008 APS Dam Safety Inspection Report (2008a) attributes these readings to an equipment malfunction which has since been corrected.

5.2.2 Bottom Ash Pond Dam

Data from piezometers, movement monuments and seepage totalizers for the Bottom Ash Pond Dam are provided in Appendix A.

5.2.2.1 Piezometers

Water level data for piezometers at the Bottom Ash Pond Dam were provided to us starting in 1989. Digital data were provided starting in 1996.

Piezometer B-221 was installed in the alluvium and the Holbrook Member of the Moenkopi Formation in the area upstream of the Bottom Ash Pond. This piezometer was taken out of service in 2003 due to monofill activities. Prior to 2003, the water level in the piezometer had a general upward trend, rising about 10 feet over the course of 13 years.

Piezometers installed north of the pond and at the left abutment in the shallow Chinle formation (B-217, B-222 and B-224) showed a slight rise in water elevation between 1989 and 1999, following the trend of the Bottom Ash Pond water surface elevation. After 1999, B-217 and 224 generally followed the slight fall in elevation of the Bottom Ash Pond water surface, while B-222 rose about 10 feet in 2002 and remained steady thereafter. The elevation of the water in B-224 has always been about 10 feet higher than that of the reservoir.

Piezometers installed at the right abutment in the Chinle Formation or the Holbrook and Moqui Members of the Moenkopi Formation (B-218, B-219, B-220 and B-223) generally follow the slight downward trend of the water surface in the Bottom Ash Pond. The water level in B-223 coincides very closely with the elevation of the water surface in the Bottom Ash Pond.

Piezometers in the alluvium and in the Holbrook Member of the Moenkopi Formation in the embankment and at the toe near the right abutment (B-202, B-203, B-204, B-205 and B-227) follow the slight downward trend of the water surface in the Bottom Ash Pond. The piezometer located on the upstream slope of the dam shows a water level about 10 feet below the water surface of the Bottom Ash Pond, while those on the downstream slope of the dam (B-203 and B-205) have water levels about 50 feet below the water surface of the Bottom Ash Pond.

Piezometers in the alluvium and in the Holbrook and Moqui Members of the Moenkopi Formation at the embankment toe (B-95, B-96, B-200, B-202, B-201, B-206, B-207, B-208B, B-209, B-210, B-211, B-212, B-213, B-214, B-215, B-216, B-225, B-226, B-228, B-229 and B-230) have remained relatively steady. B-208B, B-209, B-211 and B-212 have a slight downward trend similar to that of the water surface in the Bottom Ash Pond.

Piezometers B-94 and W-301 through W-314 are located downstream of the dam in the alluvium, the Moqui Member of the Moenkopi Formation, or the Coconino Sandstone. The water levels in these piezometers have generally remained steady over time. W-310, W-311 and W-313 and B-94 show a slight downward trend similar to that of the water surface in the Bottom Ash Pond. W-312 shows significant fluctuations in groundwater level, but these are attributed in the APS 2008 Dam Safety Inspection Report (2008a) to slow recovery after water quality sampling.

Piezometers DM-5 and CR-1 are installed in the alluvium and monitor water levels adjacent to the Little Colorado River. These wells show a slight downward trend with time.

5.2.2.2 Survey Monuments

The monument settlement profiles typically show about 0.3 feet of settlement over the last 10 years. Monument M-14, which is located near the maximum dam section on the upstream dam slope about 3 feet below the crest, shows about 0.7 feet of settlement in the last 10 years. When the dam was raised and the monuments were installed, all except M-14 were located at elevations at or above the new design dam crest elevation of 5123.3. Currently three of the nine survey monuments located on the crest show that the dam crest has settled slightly below El. 5123.3. Monument M-12 was recently surveyed at El. 5123.1 and represents the lowest area on the dam crest.

Net horizontal movement has been less than 0.8 feet downstream, with larger movements occurring at the monuments located on the west side of the dam near the tallest section. Earlier monument readings were erratic but they leveled somewhat after APS switched from a triangulation survey system to a Global Positioning System (GPS) system in June of 1999.

5.2.2.3 Seepage Totalizers

The totalizer at the West Abutment seep shows a downward trend since measurements began in 1995, with flows from around 15 gpm to flows averaging about 8 gpm in the past several years. Flows measured at the weir at the West Abutment Seep have generally been 4 gpm or less since measurements began in 1996, though records from the year 2000 indicate that the weir overflowed. The flow rate at the P-226 Seep has varied widely since measurements began in 1993, with maximum flows of about 27 gpm and averaging about 13 gpm. No flow has been measured at the P-226 Seep since March of 2008. Flows at the Tanner Wash seep were less than 5 gpm when measurements began in 1996, increased to a maximum of about 15 gpm in 2004 and decreased to around 4 gpm in 2009. Flows in the Petroglyph Seep have increased steadily to around 13 gpm since measurements began in 1996.

Turbidity measured between November 2001 to October 2002 at the Bottom Ash Pond Dam seeps was typically less than 0.5 NTU.

5.3 Evaluation

5.3.1 Fly Ash Pond Dam

The piezometers installed on and near the Fly Ash Pond Dam indicate that the groundwater in the area has not fluctuated significantly in the past 20 years, and groundwater levels generally follow the same trends as the water surface in the Fly Ash Pond. Piezometer Response Profiles presented in the June 1999 Basic Data Report (APS, 1999b) compare water levels in the piezometers at the time of installation with water levels in 1999 for piezometers installed at the time the dam was constructed and screened in the alluvium or bedrock in the dam foundation. The profiles indicate that water levels in the piezometers increased between 0 and 20 feet between dam construction in 1978 and the 1999 readings. This rise in water level is not unusual considering the pool elevation in the Fly Ash Pond, and these readings do not represent a dam safety issue based on the phreatic surface used in stability analyses.

Piezometers located on the downstream side of the embankment have water levels significantly lower than the elevation of the water surface in the Fly Ash Pond, indicating that the dam core and cutoff wall are reducing seepage through the dam. Piezometers F-81 and F-35 are exceptions, as their water levels increased suddenly to match the reservoir water level in the Fly Ash Pond in 1993 and prior to 2007, respectively. The fractured Shinarump Formation is known to be present near the location of piezometers F-81 and F-35, and these readings may indicate that the clay blanket at the right abutment is not effective at reducing seepage through this formation.

The piezometers installed in 1999 and screened in the dam core (F-123, F-124, F-128 and F-132) have unusual readings that should be investigated further. Three of these piezometers (F-123, F-128 and F-132) showed water levels 5 to 10 feet above the level of the reservoir in 2001, and their water levels slowly decreased until 2008, when the water levels approximately matched the water level in the reservoir. Piezometer F-124 appears to have stabilized about 5 feet below the reservoir water level. These piezometers show a slow response to fluctuations in the reservoir water level, which may indicate that the dam core has very low permeability. However, the fact that three of the piezometers have had readings above the reservoir water level is unusual. These high readings may be caused by any of several factors including water that was possibly trapped in the piezometers from construction activities, a broken surface seal, or due to consolidation settlement of the dam core. The water levels in these piezometers have always been well below the maximum storage pool of the dam, which was the water level modeled in the stability analyses (Section 8.0), and therefore are not expected to negatively affect dam stability. These piezometers should be evaluated to determine if they are functioning as expected and, if not, they should be rehabilitated, repaired, or replaced.

The crest of the Fly Ash Pond Dam has settled about 1.7 feet at the maximum section in the thirty years since construction. The majority of the settlement occurred in the first three years after construction. Both settlement and horizontal movement have been minor since 1993, the earliest year that graphical data were available (see Appendix A). Movements are considered to be within a normal range for a dam of this size. Current monument elevations indicate that the dam crest is up to about 2 feet lower than the design crest elevation of 5120. Dam freeboard should be checked using the lowest crest elevation of 5118, and the maximum allowable storage pool should be reduced if necessary.

The seepage totalizers at the Geronimo and Hunt Seeps show widely fluctuating readings with maximum seepage quantities up to 47 gpm at the Geronimo Seep and 12 gpm at the Hunt Seep. The Geronimo Seep is very close to the toe of the dam and therefore seepage quantities as high as 47 gpm could be of concern with regard to dam stability. APS should repair or replace the seepage totalizers as soon as possible to determine the actual quantity of seepage at the Geronimo Seep. If it is still relatively high, an investigation of the seepage origin should be undertaken and stability analyses completed in order to determine whether seepage of this magnitude could compromise dam stability. The turbidity measured in the

Geronimo Seep has apparently been low since the equipment malfunction was corrected, but turbidity measurements should be closely monitored.

The Hunt Seep is far from the toe of the dam and is not considered a concern from a dam safety standpoint.

The instrumentation installed at the Fly Ash Pond Dam is generally thorough, though there are several inadequacies that should be addressed. The piezometers installed in the dam core in 1999 should be investigated to determine, if possible, why they showed readings above the reservoir water level. If these piezometers are found not to provide reliable readings, they should be replaced. The issue of potential loss of freeboard as related to settlement monuments on the dam crest should be addressed as further discussed in Section 7.2.2. Totalizers at the Geronimo and Hunt Seeps should be repaired so they can again provide a reliable measure of seepage. The frequency of instrumentation readings is considered adequate.

5.3.2 Bottom Ash Pond Dam

The piezometers installed on and near the Bottom Ash Pond Dam indicate that the groundwater in the area has not fluctuated significantly in the past 20 years, and groundwater levels generally follow the same trends as the water surface in the Bottom Ash Pond. Piezometer Response Profiles presented in the June 1999 Basic Data Report (APS, 1999b) compare water levels in the piezometers at the time of installation with water levels in 1999 for piezometers installed at the time the dam was constructed and screened in the alluvium or bedrock in the dam foundation. The profiles indicate that water levels in the piezometers increased between 0 and 60 feet between dam construction in 1978 and the 1999 readings. This rise in water level is not unusual considering the pool elevation in the Fly Ash Pond, and these readings do not represent a dam safety issue based on the phreatic surface used in stability analyses.

Piezometers located on the downstream side of the embankment have water levels significantly lower than the elevation of the water surface in the Bottom Ash Pond, indicating that the dam core and cutoff wall are reducing seepage through the dam. Piezometer W-312 has fluctuated significantly; however, the APS 2008 Dam Safety Inspection Report (2008a) indicates that the fluctuations are due to slow recovery after groundwater sampling. If this is the case, the well screen may be clogged, and if so the well should be refurbished or a new one should be installed.

Movement monuments indicate that in general, both settlement and horizontal movement of the Bottom Ash Pond Dam are minor and within a normal range for a dam of this size. Current surveys indicate that portions of the dam crest are slightly below the design crest elevation of 5123.3. Monitoring settlement of the dam should be continued and the reported elevation of the crest should correspond with the surveyed elevations, and the maximum storage pool and available freeboard should be determined accordingly.

The West Abutment Seep is the only one of the four seeps associated with the Bottom Ash Pond Dam that is considered a potential concern to dam safety. The other three seeps (P-226, Tanner Wash and Petroglyph) are relatively far from the dam toe. The seepage totalizer at the West Abutment Seep indicates moderate flow rates, though the weir, which collects only surface water originating at the dam toe, indicates very low flow rates.

The instrumentation installed at the Bottom Ash Pond Dam is thorough and generally considered adequate. The frequency of readings is also adequate.

6.0 Field Assessment

6.1 General

Site visits to assess the condition of the Fly Ash Pond Dam and Bottom Ash Pond Dam at the APS Cholla Power Plant were performed on September 2, 2009 by Steven R. Townsley, P.E., and Mary C. Nodine, P.E., of GEI. John D. Mitchell, Ted Tindall, Doug Lavarnway and Sheila Chairez of APS accompanied GEI during the assessment. Conrad Spencer, Cholla Plant Manager, coordinated the APS resources including staff and plant information to facilitate the assessment.

The weather during the site visits was sunny with temperatures around 85 to 95 degrees Fahrenheit. The ground surface was dry.

Field observations are organized as follows:

- Fly Ash Pond Dam
- Bottom Ash Pond Dam

Inspection checklists are provided in Appendix B and photographs are provided in Appendix C. Sections 6.2 and 6.3 describe observations made during the assessment relative to key project features. Section 6.4 presents specific observations.

6.2 Fly Ash Pond

Field assessment of the Fly Ash Pond included driving around the pond and along the entire length of the embankment crest and toe, walking representative sections and closely investigating areas of interest. We saw no obvious signs of settlement or displacement. Several seepage locations were observed at and beyond the downstream toe of the dam. These are closely monitored by APS and are discussed further in Section 6.4.4. A general photo of the Fly Ash Pond is shown in Photo 1.

6.2.1 Embankment Crest

The embankment crest appeared to be in good condition (Photo 2). No signs of cracks or settlement were observed during the assessment. Occasional vegetation (brush) was present on the dam crest. This vegetation should be cleared in routine maintenance. Settlement monitoring points (Photo 3) and piezometers (Photo 4) are present along the dam crest.

6.2.2 Upstream Slope

The upstream slope of the bottom ash pond embankment is protected from erosion by riprap (Photo 5) and appeared to be in good condition. Some vegetation is present on the upstream slope. We observed the fly ash slurry discharge pipes on the upstream slope (Photo 6). The discharge system appeared to be in good condition.

6.2.3 Downstream Slope

The downstream slope of the embankment is protected from erosion by riprap and appeared to be in good condition (Photo 7). Some vegetation was present on the downstream slope. The slurry discharge pipes traversing the downstream face are shown in Photo 8.

6.2.4 Water Surface Elevations and Reservoir Discharge

The water surface in the Fly Ash Pond at the time of our site visit was El. 5093.2. The dam crest is at El. 5120. No discharge was observed at the Fly Ash Ponds.

6.3 Bottom Ash Pond

Field assessment of the Bottom Ash Pond included driving around the pond and along the entire length of the embankment crest and toe, walking representative sections and closely investigating areas of interest. We saw no obvious signs of settlement or displacement. Several seepage locations were observed at and beyond the downstream toe of the dam. These are closely monitored by APS and are discussed further in Section 6.4.4. The Bottom Ash Pond has one main reservoir (Photos 9 and 10) as well as two upstream cells used to store bottom ash slurry as well as drained bottom ash prior to its final storage in the monofill north of the pond. The east cell, which currently stores drained bottom ash, is shown in Photo 11. The west cell currently receives bottom ash slurry (Photo 12). A vortex is visible in Photo 12 where water is exiting through a pipe to be discharged in the main reservoir. The monofill is shown in Photo 13. Excess water from the two upstream cells drains to the main reservoir near the left abutment of the Bottom Ash Pond Dam (Photo 14).

6.3.1 Dam Crest

The embankment crest appeared to be in good condition (Photo 15). No signs of cracking or settlement were observed during the assessment. Occasional vegetation (brush) was present on the dam crest. This vegetation should be cleared in routine maintenance. The 3.3-foot dam crest raise that took place in 1993 is evident in Photo 16.

6.3.2 Upstream Slope

The upstream slope of the embankment is protected from erosion by riprap and appeared to be in good condition (Photo 17). Some vegetation is present on the upstream slope.

6.3.3 Downstream Slope

The downstream slope of the embankment is protected from erosion by riprap and appeared to be in good condition (Photo 18). Some vegetation (brush) is present on the downstream slope.

6.3.4 Water Surface Elevations and Reservoir Discharge

The water surface in the Bottom Ash Pond at the time of our site visit was El. 5111.3. The dam crest is at El. 5123.3.

Water exits the Bottom Ash Pond via four floating siphon pipes and is returned to the power plant for reuse. The siphon re-circulation system was in operation during our site visit, but we could not see any visible signs of operation since it is a closed pipe system.

6.4 Field Inspection Observations

6.4.1 Settlement

There was no obvious evidence of settlement observed during the assessment in either embankment. An investigation of cracks in the Fly Ash Pond Dam was completed in 2001, and six survey monuments were added at that time to monitor potential movement in the area of cracking. The monuments have indicated that minor settlement (about 0.2 feet in 8 years) is taking place. The cracks are located around the maximum section of the dam, where the largest magnitude of settlement has occurred over the life of the dam (about 1.7 feet). The eastern, saddle portion of the dam is adjacent to the area with the cracks, and this area has settled a maximum of about 0.7 feet over the life of the dam. It is, therefore, possible that differential settlement has contributed to the formation of cracks in the dam crest. However, the amount of settlement is within the range expected for a dam as large as the Fly Ash Pond Dam, and it does not appear to be a threat to dam safety.

6.4.2 Movement

There was no evidence observed during the inspection to indicate differential movement of project structures. The survey monuments installed on the Fly Ash Pond Dam crest in response to observations of cracks have not indicated excessive movement in this area (see Appendix A).

6.4.3 Erosion

There was no significant erosion of the dams or abutments noted during the assessment.

6.4.4 Seepage

Seepage locations were observed at and beyond the downstream toes of both dams. APS monitors flow and water quality at these seepage locations, collects seepage and returns the water to the reservoirs. The seepage locations are monitored closely mainly due to environmental concerns associated with dam material entering the nearby waterways. The major seepage locations monitored by APS are described below. Signs of seepage including salt patches and tamarisk growth have been observed at other locations along the toe (e.g. Photos 19 and 20), and these minor seepage locations are observed daily for changes and to determine whether seepage collection measures should be taken.

6.4.4.1 Fly Ash Pond

I-40 Seep: The I-40 Seep is located just beyond the downstream toe of the Fly Ash Pond Dam at the right abutment. This seep does not have drain system to return water to the pond, but an evaporation pond was constructed to collect seepage in this area (Photo 21).

Geronimo Seep: The Geronimo Seep is located less than 50 feet beyond the downstream toe of the Fly Ash Pond Dam, about 2,000 feet from the right abutment. An underground french drain system and wellpoints have been installed to monitor and collect the seepage in this area (Photos 22 and 23). Relatively large flows (up to about 47 gpm) have been measured at this location, but APS indicates that the totalizer at this location has malfunctioned recently and readings may not be accurate. No flowing surface water was observed at this seep location at the time of our assessment.

Hunt Seep: The Hunt Seep is located more than 1,500 feet beyond the downstream toe of the Fly Ash Pond Dam. The previously-damp soil indicating the seep in this area is shown in Photo 24. An underground french drain system is used to monitor and collect seepage in this area. No flowing water was observed at the time of the dam assessment at this location. The Hunt Seep is far enough from the dam that it is not considered a potential threat to dam safety.

6.4.4.2 Bottom Ash Pond

West Abutment Seep: The West Abutment Seep is located about 100 feet downstream of the Bottom Ash Pond Dam toe (Photo 25). APS monitors the flow that daylights in this area by means of a weir (Photo 26), in addition to an underground french drain system several hundred feet east along the face (Photo 27). The general West Abutment Seep area is shown in Photo 28. We observed water flowing through the weir at the time of our site visit, and a rough measurement indicated that the flow at this time was less than 2 gpm. Flows in the weir are typically 4 gpm or less, and the totalizer at this location has measured a maximum of about 16 gpm since 1996.

P-226 Seep: The P-226 Seep is located about 250 feet beyond the left abutment of the Bottom Ash Pond Dam. Seepage is collected and measured via an underground french drain system with a totalizer. No surface water was observed at this seep at the time of our assessment, and no flow has been measured at this seep since March of 2008. This seep is far enough from the dam toe and is in the area where the dam is at its lowest height, and therefore it is not considered a dam safety concern.

Tanner Wash Seep: The Tanner Wash Seep is located about 350 feet beyond the toe of the Bottom Ash Pond Dam near the left abutment. Seepage is collected and measured via an underground french drain system with a totalizer (Photo 29). Both salt patches (Photo 30) and flowing surface water (Photo 31) were observed at this seep at the time of our assessment. A maximum flow of about 15 gpm has been measured at this location since 1995. This seep is far enough from the dam that it is not considered a dam safety concern. This seep prevents a greater environmental concern than other seeps due to its proximity to Tanner Wash (Photo 32).

Petroglyph Seep: The Petroglyph Seep is located about 150 feet beyond the dam toe on the east side of the dam, south of the Tanner Wash Seep. Seepage is collected and measured via an underground french drain system with a totalizer (Photo 33). Flowing surface water was observed at this seep at the time of our assessment (Photo 34). A maximum flow of about 13 gpm has been measured at this location since 1993. This seep is far enough from the dam that it is not considered a dam safety concern.

6.4.5 Leakage

We did not observe water leaking from any of the project structures.

6.4.6 Cracking

No cracks were observed in either dam at the time of our assessment. Cracks were observed in the crests of both dams in 1999 (Fly Ash Pond Dam) and 2007 (Bottom Ash Pond Dam), and have been investigated and monitored. Because the cracks are no longer visible and have not been shown to be associated with dam movements or seepage, they are not considered a dam safety issue. Details on the history of cracks in both dams are discussed below.

6.4.6.1 Fly Ash Pond Dam

We reviewed the report *Transverse Crack Evaluation and Monitoring for Fly Ash Pond Dam* (URS, 2001). Cracks were first observed in the crest of the Fly Ash Pond Dam in 1980. Both transverse and longitudinal cracks have been recorded since, mainly in the area near the center of the dam where the embankment turns to the north. This location is also the intersection of the main portion of the dam and a saddle portion on the left (east) side. APS and URS completed field studies in 1999 to investigate the cracks, which included excavating an exploratory trench. Thirty-one primarily transverse cracks were identified in the trench, ranging from 0.2 feet deep to more than 12 feet deep at one location. URS concluded that a likely explanation for the cracks was differential settlement of the embankment due to variable thickness of overburden, variable dam height, seepage at the transition between the slurry cutoff trench and the clay core cutoff, as well as downstream restraint of the left, saddle portion of the dam. URS also concluded that the potential for very deep cracks is small and that the predicted flow velocity through the cracks is unlikely to cause erosion.

URS recommended that APS construct a fly ash beach adjacent to the area of cracking to maintain a minimum lateral distance of 300 feet between the impounded water in the reservoir and the area of cracking. We observed a marker placed to indicate this 300-foot distance and the water in the reservoir was well beyond the marker (Photo 35). In addition, URS recommended that APS place additional survey monuments in the area of cracking, and APS did so. Movement data for these six additional monuments (M-5a, 5b, 5c 6a, 6b and 6c) are presented in Appendix A.

APS also installed 12 new piezometers (F-123 to F-134) in the vicinity of the observed cracks in 1999, at the request of ADWR. These piezometers have since been monitored weekly but, since seepage quantities measured in the downstream totalizers have remained stable, APS has submitted a request to ADWR to reduce the frequency of monitoring. The request is currently being reviewed.

6.4.6.2 Bottom Ash Pond Dam

We reviewed the report *Test Trench Investigation of Cracks Observed on the Cholla Bottom Ash Pond Dam* (URS, 2009). The report indicated that transverse cracks were observed in the center portion of the crest of the Bottom Ash Pond Dam in October 2007 during an ADWR inspection. The cracks ranged from hairline-size to 1 inch in width.

URS investigated the cracks through a geophysical survey in April 2008 (performed by subcontractor AMEC Environmental) as well as a test trench completed in September 2008. The geophysical investigation is fully documented in the report *Seismic Evaluation of Potential Embankment Cracking, Bottom Ash Embankment at Cholla Power Plant* (AMEC, 2008). In addition, a visual inspection was performed by a URS engineer in April 2008 and no visible cracking was observed.

The geophysical investigation did not indicate the presence of any deep-seated cracks in the Bottom Ash Pond Dam. The data did indicate a surficial layer of low-velocity material which could indicate desiccation as a cause of the cracks. The test trenching investigation indicated that shallow transverse and longitudinal cracks were present at the surface of the embankment. In addition, the surficial soil in which the cracks were found was drier and coarser-grained than that found deeper in the embankment. The drier, coarser soil and the cracks generally extended no more than 4 feet deep, which correlates with the 3.3-foot height of the dam raise completed in 1990. The study concluded that the cracks in the crest of the Bottom Ash Pond Dam are related to shrinkage of the cohesive soil placed when the dam was raised. The cracks are narrow and there is no evidence that they extend deep into the embankment. The cracks are therefore not considered a dam safety concern.

6.4.7 Deterioration

No significant deterioration of project structures was observed.

6.4.8 Geologic Conditions

The geology of the project features is as described in Section 4.0 and in the referenced reports. There have been no studies or events (landslide, earthquake, etc.) that would result in changes to the description of local geologic conditions.

6.4.9 Foundation Deterioration

No signs of foundation deterioration were observed.

6.4.10 Condition of Spillway and Outlet Works

There are no spillways at either dam, and the Fly Ash Pond has no outlet. Four siphon pipes are the only outlet for the Bottom Ash Pond, and they appear to be in good condition. The siphon pipes are shown in Photos 36 (upstream side) and 37 (downstream side). The siphon pipes extend through the dam crest in a 36-inch diameter corrugated metal pipe (CMP) culvert, providing a potential discharge pathway through the dam at about El. 5120.5, according to the drawings (Exhibit 5). The drawings show a the culvert is sealed by a 4-inch thick concrete plug at the upstream end of the CMP and the integrity of this seal must be maintained to prevent the culvert becoming a discharge pathway. The condition of the concrete plug was not verified in the field. The siphon collection point, where water from the siphon pipes is combined and routed to the plant, is shown in Photos 38 and 39.

6.4.11 Reservoir Rim Stability

The reservoir rims visible did not show any evidence of landslides or shoreline instability that would threaten the safety of the dams.

6.4.12 Uplift Pressures on Structures, Foundations, and Abutments

No evidence of uplift pressure issues was observed.

6.4.13 Other Significant Conditions

The storage of dry bottom ash in the Bottom Ash Pond is at a higher elevation than the water level in the pond. The effective storage area of the pond is therefore reduced, and this situation should be monitored to determine whether the pond can safely store the design flood. This condition is discussed in detail in Section 7.2.2.

7.0 Spillway Adequacy

7.1 Floods of Record

Floods of record have not been evaluated for the ponds at the Cholla power plant.

7.2 Inflow Design Floods

Both the Fly Ash and Bottom Ash Pond Dams have been classified as high hazard structures by the ADWR. The USACE Guidelines for dams requires that the spillways on high-hazard dams be able to store or pass the full PMF associated with the 72-hour probable maximum precipitation (PMP). The ponds were originally designed to store at least runoff from the 100-year storm (Ebasco, 1975). ADWR guidelines specify that reservoirs without spillways should have at least 3 feet of freeboard above the maximum flood pool (ADWR, 1996).

7.2.1 Determination of the PMF

The PMF based on the 72-hour PMP was estimated using Hydrometeorological Report No. 49 (NOAA, 1984). The report indicated that the 72-hour PMP is about 8.5 inches. We also checked the precipitation for the local-storm 6-hour PMP due to the small size of the drainage basins for the ponds, and found the local-storm PMP to have a 6-hour precipitation of 10.2 inches. We used 10.2 inches of precipitation to check the freeboard of the dams.

The original design report for the Fly Ash and Bottom Ash Pond Dams (Ebasco, 1975) indicates that the Fly Ash Pond will collect runoff from an area of about 1,230 acres. Neglecting potential infiltration into the soil, the 10.2 inches of rainfall for the local-storm PMP will result in a flood volume of about 1,045.5 acre-feet in the Fly Ash Pond's drainage basin.

The design report (Ebasco, 1975) indicates that the Bottom Ash Pond will collect runoff from an area of about 128 acres. The 10.2 inches of rainfall for the local-storm PMP will result in a flood volume of about 108.8 acre-feet in the Bottom Ash Pond's drainage basin. The feasibility study for Bottom Ash Pond modifications (Dames & Moore, 1991) indicates that with an intermediate dike, the main reservoir behind the dam will collect runoff from an area of about 49 acres, for a total flood volume of about 41.7 acre-feet.

We performed a check of freeboard adequacy and assumed that the Fly Ash and Bottom Ash Ponds would be required to store the entire design flood.

7.2.2 GEI Check Calculation of Freeboard Adequacy

The Fly Ash Pond Dam does not have a spillway, and water only exits the pond through evaporation. Therefore, the pond must be able to safely store the PMF with the reservoir at its maximum storage level. Based on the Area and Capacity Curve provided in the Ebasco (1975) design report, the 1,045.5 acre-foot flood volume from the local-storm PMP would increase the elevation of the water surface in the Fly Ash Pond to about El. 5116, which is about 2 feet above the maximum storage pool at El. 5114. Based on the current elevations of the survey monuments on the dam crest, the center of the dam is at about El. 5118. Based on the conservative assumption of no infiltration, the dam therefore has about 2 feet of freeboard remaining, which is less than the 3 feet recommended by ADWR (1996).

The Bottom Ash Pond Dam does not have a spillway. Water exits the pond through evaporation and via four siphon pipes for reuse at the power plant. Because the rate at which water exits the pond via the siphon pipes is slow, we assume that the pond must be able to safely store the PMF. The Bottom Ash Pond is about 80 acres in area, but this area includes the ash storage cells upstream of the main reservoir, which impound water and ash at elevations above the maximum operating level of the reservoir. The main reservoir has an area of approximately 27 acres based on hand measurements from a recent topographic survey. The total runoff volume for the main reservoir alone is approximately 41.7 acre-feet for the local-storm PMP, which results in a required flood pool of about 1.5 feet. With the maximum reservoir storage at El. 5117.8 and dam crest at El. 5123.1 at its lowest point, this flood leaves about 3.8 feet of freeboard remaining. This amount of freeboard is adequate according the ADWR (1996). However, the invert of the 36-inch CMP carrying the siphon pipes is located at El. 5120.5 (Exhibit 5) and could provide a discharge pathway through the dam if the 4-inch concrete plug at the upstream end is compromised in any way. The condition of this concrete plug was not verified in the field.

Another concern was the available capacity behind the Bottom Ash Pond Dam to store the contents of the two ash storage cells located in the upstream part of the reservoir in event of failure of an intermediate storage cell dike. The ash storage cells store hydraulically-placed bottom ash and water at a higher elevation than the maximum operating level in the main reservoir. APS provided us with a recent survey of the Bottom Ash Pond (completed on September 4, 2009), including the crest elevations of the intermediate dikes. Based on our hand measurements of the survey drawings, if the East Cell is filled to the top of the dike with water or ash and the Main Reservoir is filled to its maximum storage level, a failure of the East intermediate dike would raise the water level in the Bottom Ash Pond by about 2 feet, resulting in about 3 feet of freeboard remaining at the Bottom Ash Pond Dam. Similarly, if the West Cell were filled to the top of the dike and the West intermediate dike failed, the water level in the Bottom Ash Pond would increase by about 1 foot, resulting in about 4 feet of remaining freeboard. If both intermediate dikes were to fail, our calculations indicate that the Bottom Ash Pond Dam would have just under 3 feet of remaining freeboard. Our analyses are approximate because of the hand measured areas and are conservative because of the assumption that the upstream cells were filled to the top of the dike, which is not the typical operational condition.

7.2.3 Dam Break Analysis

A dam break analyses and inundation map are available for the Bottom Ash Pond Dam (Stantec, 2000). The inundation map for the Bottom Ash Pond Dam reveals that a breach of this dam would cause shallow flooding of nearby I-40 bridges and high erosive velocities, 2 to 3 feet overtopping of the Atchinson Topeka & Santa Fe Railroad trestles, flooding up to a 3-foot-depth in much of the APS Cholla power plant complex and shallow flooding of residences and the I-40 road south of Joseph City. The inundation map was reviewed for this assessment and is considered adequate.

A dam break analysis has not been completed for the Fly Ash Pond Dam. APS personnel indicated that a dam break analysis has not been required for this dam based on ADWR inspections. The Fly Ash Pond Dam is farther from Interstate 40, the Cholla Plant and the town of Joseph City than the Bottom Ash Pond Dam, but it has significantly more storage capacity (18,000 acre-feet versus 2,300 acre-feet). The volume of water released in a failure could therefore be much greater. Analyses should be performed to investigate whether the incremental increase in impact due to a larger reservoir could make the consequences of failure more significant than those identified for the Bottom Ash Pond Dam. If so, a dam break analysis should also be performed for the Fly Ash Pond Dam and an inundation map prepared to enable evaluation of the consequences.

7.3 Evaluation

Based on our conservative hydrologic calculations, the Fly Ash Pond Dam, based on its maximum crest elevation of 5118 feet, currently has about 2 feet of freeboard above the maximum flood pool. This amount is less than the 3 feet of freeboard recommended by ADWR (1996). A detailed evaluation of the maximum storage pool should be performed for the dam crest based on the minimum elevation of 5118 in order to check that the dam will have sufficient freeboard in the event of a flood. At the time of our inspection the reservoir pool was at El. 5093.2, which is 20.8 feet below the maximum storage pool of El. 5114.

Based on our hydrologic calculations, the Bottom Ash Pond main reservoir has adequate freeboard to store the PMF, and is likely to have adequate freeboard to store water or bottom ash from the upstream cells if either intermediate dike is breached. Our calculations were based on the current configuration and operating procedures of the Bottom Ash Pond. We recommend that APS regularly complete updated hydrologic analyses for the Bottom Ash Pond as the elevations of material in the three cells fluctuate, and particularly if the pond configuration or operations change, in order to monitor available freeboard in the main reservoir in the event of a failure of an intermediate dike.

8.0 Structural Stability

8.1 Visual Observations

No visible signs of instability were evident associated with the any of the dams or embankments during the September 2009 site assessments.

8.2 Discussion of Stability Analysis

The results of slope stability analyses performed for the design of the Fly Ash and Bottom Ash Pond Dams are reported in the Ash Disposal Sites Seepage and Foundation Studies (Ebasco, 1975). Stability analyses were performed on one embankment section for the original design of both dams. The section analyzed corresponds with the maximum dam section and the maximum bedrock depth. The analyses were performed using the simplified Bishop Method of Slices with the computer program MIT ICES-LEASE 1. The analysis assumed a circular failure surface. The report indicates that strength parameters were obtained from laboratory tests. According to Ebasco (1975), both construction and "operating" conditions were checked, as well as the "dynamic" load case. Details of the analyses, including soil parameters selected for both static cases (construction and operating) the pseudo-static load and the assumed phreatic surface are not provided. Graphic results of the analysis with static loading are presented, and based on the soil parameters assumed the reported results appear to be for a drained (steady state seepage) analysis. The report indicates that the soil parameters reported are those that resulted in the minimum factor of safety, and therefore it is likely that the Ebasco analysis performed for undrained (end of construction) conditions was not found to be critical.

Stability analyses were performed for the Bottom Ash Pond Dam in 1991 when plans were made to modify the dam to provide additional ash storage (Dames & Moore, 1991). The Dames & Moore report that we reviewed was a feasibility-level report. We did not review the final design report for the Bottom Ash Pond modifications. The analyses were performed assuming that the dam crest would be raised 5 feet, though it was ultimately raised only 3.3 feet. The analyses were performed using the slope stability computer program PCSTABL5. The program used the Modified Bishop Method of Slices for circular failure surfaces and the Modified Janbu Method for noncircular failure surfaces. Both circular and noncircular failure surfaces were checked to find the failure surface with the lowest factor of safety. Load cases analyzed included steady-state seepage and pseudo-static conditions (acceleration of 0.05g). The end of construction case was not analyzed since at the time the dam had been in place for 13 years. Analyses were performed both for a reservoir pool at El. 5120 (higher than the current allowed maximum pool of El. 5117.8) and at El. 5112 (the reservoir water level at the time the analyses were completed). The shape of the phreatic surface was estimated using readings from three piezometers distributed along the cross section of the dam. The actual elevations of the water in the piezometers was used for the analysis with a water surface at El. 5112, and the water surface was raised proportionately to create a similar piezometric surface for a reservoir water level at El. 5120. The Dames & Moore report indicates that soil parameters were obtained from a report presented by Harza (1987) which we did not review as part of this assessment. The parameters used for the analysis are generally more conservative than those assumed for the Ebasco stability analysis performed in 1975 and discussed above. However, the Dames & Moore Analysis assumes that the impounded material behind the dam consists of bottom ash with a unit weight of 85 pounds per cubic foot (pcf) and a friction angle of 24 degrees, rather than water (62.4 pcf and no shear strength), which the reservoir behind the dam currently holds. This assumption may be unconservative.

Soil parameters assumed for both previous analyses are presented in Table 8.1.

Table 8.1: Material Properties used for Slope Stability Analyses presented in Reviewed Reports

Material	Ebasco (1975)			Dames & Moore (1991)		
	Friction Angle, ϕ (degrees)	Cohesion, c (psf)	Unit Weight (psf)	Friction Angle, ϕ (degrees)	Cohesion, c (psf)	Unit Weight (Total/ Saturated) (psf)
Clay Core and Embankment Raise	25	2500	110	28	0	120/128
Shell	35	500	110	33	0	121/125
Foundation/ Overburden (Sand)	30	0	115	26	0	120/120
Foundation/ Overburden (Clay)	30	0	115	26	0	128/128
Bedrock	--	--	--	65	1000	150/150

In our opinion, the slope stability analyses presented in the Ebasco (1975) report are incomplete. Undrained soil parameters, pseudo-static loads and the assumed phreatic surface are not specified, and results are not presented for the end of construction or dynamic load cases. The stability analyses presented in the Dames & Moore 1991 report are more comprehensive, but these do not analyze the Bottom Ash Pond Dam in its current configuration with a 3.3-foot crest raise and a maximum pool at El. 5117.8. The Dames & Moore 1991 analyses also may be unconservative due to the assumption that the dam is impounding hydraulically placed bottom ash rather than water. Neither report presents a rapid drawdown analysis. Though the case of rapid drawdown is not likely to occur for reservoirs with no outlet structures, the reservoir could be drawn down in the case of a leak or other malfunction, and the analysis is required by the Federal Energy Regulatory Commission (FERC).

To check the stability of the Fly Ash and Bottom Ash Pond embankments, we performed stability analyses for the maximum section of each dam in its current configuration using the limit equilibrium slope stability program SLOPE/W. We used Spencer's Method, which solves for both moment and force equilibrium. The initial search was for circular slip surfaces, but we used the optimization feature in SLOPE/W to check for noncircular slip surfaces (Geo-Slope, 2007). The geometry for the Fly Ash Pond Dam was the same as that analyzed in the Ebasco (1975) report, and the geometry for the Bottom Ash Pond Dam was determined using the as-built drawings, which included the 1993 dam raise to El. 5123.3. We assigned the same material properties to the sand and clay layers in the foundation as reported by Ebasco and Dames and Moore. The phreatic surfaces were determined using recent water level readings in embankment piezometers: F-124 and F-113 for the Fly Ash Pond Dam, and B-205 and B-206 for the Bottom Ash Pond Dam. Analyses were performed for steady-seepage, pseudo-static (coefficient of 0.08g, which is about ½ the peak acceleration as discussed in Section 4.0) and rapid drawdown load cases. The end-of-construction load case was not analyzed since the dam has been in place for several decades. We used drained soil strength parameters and unit weights as developed in the Dames & Moore (1991) analysis (see Table 8.2) since these parameters were more conservative than those assumed in the Ebasco (1975) analysis. Rapid drawdown analyses were performed using the three-stage analysis method available in the SLOPE/W software package, in which both drained and undrained strengths are checked at the base of each slice and the smaller strength is chosen for use in the limit equilibrium analysis at the final drawdown water level (Geo-Slope, 2007). Undrained strengths are required in this analysis in addition to drained strengths. Undrained strengths were also used for the pseudo-static analyses. The clay core is the only material in the dam expected to have significant cohesion, and its undrained strength was estimated assumed to have a cohesion of 2,500 psf cohesion as developed by Ebasco (1975) with a friction angle of zero. Undrained strengths were assigned to be the same as drained strengths for the dam shell, foundation soil and bedrock. Strengths for the cutoff wall were estimated conservatively based on GEI's experience with similar projects. Based on the boring logs we reviewed from the Ebasco (1975) report, the estimated strength parameters appear to be reasonably conservative.

Soil parameters used for the analyses of the Fly Ash and Bottom Ash Pond Dams are shown in Table 8.2.

Table 8.2: Material Properties used for Check Slope Stability Analyses of Fly Ash and Bottom Ash Pond Dams

Material	Drained Friction Angle, ϕ' (degrees)	Drained Cohesion, c' (psf)	Undrained Friction Angle, ϕ (degrees)	Undrained Cohesion, c (psf)	Unit Weight, γ (Total/ Saturated) (psf)
Clay Core and Embankment Raise	28	0	0	2500	110
Shell	33	0	33	0	120/128
Foundation/Overburden (Sand)	26	0	26	0	128/128
Foundation/Overburden (Clay)	26	0	26	0	128/128
Bedrock	65	0	65	0	150/150
Cutoff Wall	15	0	0	10	125/125

An intermediate dike was constructed in 1993 to divide the upstream part of the reservoir into smaller cells (East Cell and West Cell), which were created to store bottom ash, see Figure 5. The intermediate dike was constructed with a lower part that consists of hydraulically placed bottom ash and an upper part that consists of compacted bottom ash. Stability analyses were not performed for the feasibility design (Dames & Moore, 1991), but its foundation design and side slope configuration was determined based on laboratory test strengths of the bottom ash material. According to the feasibility design report, shear strength for the compacted bottom ash was developed from consolidated-undrained triaxial compression tests with pore pressure measurements, and strength parameters for hydraulically-placed bottom ash and foundation bottom ash (hydraulically-placed bottom ash beneath the dike that has been consolidated) were estimated using empirical correlations. Dames & Moore assigned an effective stress friction angle (ϕ') of 37 degrees for the compacted bottom ash and effective friction angles of 24 and 30 degrees for foundation and hydraulically-placed bottom ash, respectively. The bottom ash was assigned a unit weight of 85 psf.

The stability of the intermediate bottom ash dike constructed in 1993 is not as critical as the Bottom Ash Pond Dam, because the intermediate dike is only 4 feet higher than the Bottom Ash Pond Dam and, if the intermediate dike were to fail, the water and ash impounded by it will be contained by the Bottom Ash Pond Dam. As part of our assessment, we reviewed the stability information provided for the intermediate dike and performed a check stability analysis. A preliminary cross section of the dike is provided in the feasibility design report, and APS provided GEI with a recent survey of the Bottom Ash Pond, including profiles and a section of the dikes. The feasibility design report recommended 3H:1V side slopes for the dike, but the APS survey indicated that the dike was constructed with approximately 4.3H:1V side slopes. To evaluate the stability of the dike, GEI performed a check stability analysis for steady state seepage using the surveyed dike section and the soil parameters specified for bottom ash in the feasibility design report. We used the same parameters for our stability analysis of the intermediate dike since no other information on bottom ash was available.

Soil parameters used for the analyses of the Intermediate Dike are shown in Table 8.3.

Table 8.3: Material Properties used for Check Slope Stability Analysis of Intermediate Dike

Material	Drained Friction Angle, ϕ' (degrees)	Drained Cohesion, c' (psf)	Unit Weight, γ (Total/ Saturated) (psf)
Compacted Bottom Ash	37	0	85/85
Hydraulically-Placed Bottom Ash	24	0	85/85
Foundation Bottom Ash	30	0	85/85

8.3 Factors of Safety

The Ebasco (1975) report indicates that the critical embankment section, which represents both the Fly Ash Pond Dam and the original Bottom Ash Pond Dam prior to its crest raise of 3.3 feet in 1993, has a minimum static factor of safety of 2.0 (we assume this analysis represents the steady seepage case) and a minimum “dynamic” factor of safety of 1.4 (we assume this analysis represents a pseudo-static earthquake load condition).

The Dames & Moore (1991) analyses for the Bottom Ash Pond Dam with a crest raise of 5 feet found minimum static factors of safety of 1.81 for the existing piezometric surface and 1.38 for the projected piezometric surface, and pseudo-static earthquake loading factors of safety of 1.52 for the existing piezometric surface and 1.38 for the projected piezometric surface. Minimum factors of safety in each load case analyzed by Dames & Moore were for non-circular failure surfaces.

We compared the reported calculated factors of safety for the Fly Ash and Bottom Ash Pond Dams, as well as the factors of safety calculated in our analyses of these dams and the Bottom Ash Pond intermediate dike, to minimum required factors of safety in accordance with FERC guidelines in Table 8.4. Values shown are the minimum factor of safety found in any of the analyses performed. Graphical results of our stability analyses are attached in Appendix D.

Table 8.4: Stability Factors of Safety for Cholla Facility Dams and Guidance Values

Loading Condition	Min. Calculated FOS, (Ebasco, 1975)	Min. Calculated FOS, Bottom Ash Pond Dam Crest El. 5125 (Dames & Moore, 1991)	Min. Calculated FOS, Fly Ash Pond Dam (GEI)	Min. Calculated FOS, Bottom Ash Pond Dam (GEI)	Min. Calculated FOS, Intermediate Bottom Ash Pond Dike (GEI)	Min. Required FOS (FERC)
Full Reservoir – Steady Seepage	2.0	1.6	1.67	1.71	2.08	1.5
Full Reservoir – SS with Earthquake	1.4 (0.05g)	1.3 (0.05g)	1.09 (0.08g)	1.09 (0.08g)	--	1.0
Rapid Drawdown	--	--	1.44	1.50	--	1.2

As indicated in Table 8.2, the calculated factors of safety for static and seismic conditions meet or exceed the minimum required FERC guidelines.

8.4 Seismic Stability - Liquefaction Potential

Saturated granular soils that are potentially liquefiable do not appear to be present in the dam embankment and foundation of either the Fly Ash Pond Dam or the Bottom Ash Pond Dam. The foundation soils consist mainly of silty clay and sandy clay alluvium with some gravel, overlying sandstone and claystone bedrock.

The hydraulically-placed bottom ash that comprises the lower part of the intermediate dike that divides the Bottom Ash Pond reservoir may be susceptible to liquefaction. Dames & Moore recommend in the 1991 feasibility study that a liquefaction analysis be performed for the intermediate dike. We are not aware that a liquefaction analysis was performed. However, as discussed in Sections 7.2.2 and 7.3, our calculations indicate that a failure of either intermediate dike is still likely to leave 3 feet or more of freeboard below the crest of the Bottom Ash Pond Dam. APS should continue to monitor the water levels and volumes of all three Bottom Ash Pond cells in order to maintain sufficient freeboard at the Bottom Ash Pond Dam should the interior dikes fail for any reason.

9.0 Adequacy of Maintenance and Methods of Operation

9.1 Procedures

Operations Guidelines for the APS Cholla impoundments are included in the Emergency Action Plan described in Section 10. The guidelines detail routine tasks including maintenance as well as detailed emergency procedures for a variety of potential incidents.

9.2 Maintenance of Dams

Maintenance of the dams and embankments at the Cholla facility is performed or subcontracted by APS Cholla staff. Annual inspections are made by the ADWR as well as by APS engineers. Daily inspection rounds are performed of the entire ash pond facilities by operations staff to observe the general condition of structures and embankments. Identified deficiencies are documented and repaired.

9.3 Surveillance

APS Cholla staff is responsible for the surveillance of the dams and appurtenant facilities. Monitoring of the dams instrumentation occurs monthly or quarterly. The main power plant is manned 24 hours a day and operators can respond to potential emergency situation at the dams. There are no automatic warning systems for the dams.

10.0 Emergency Action Plan

Emergency Action Plans (EAPs) were developed for both the Fly Ash and Bottom Ash Pond dams in 2001, and the plans were revised in 2006. The purpose of the EAPs is to provide notice to protect the public and notify appropriate agencies in case of potential flooding downstream from the dams. It also includes Operations and Maintenance procedures designed to identify and mitigate conditions that may compromise the dam and lead to failure.

The Fly Ash Pond Dam and the Bottom Ash Pond Dam were both classified (ADWR, 2009a and 2009b) as High Hazard dams due to the high potential for loss of life and extensive property damage in the event of a failure.

11.0 Conclusions

11.1 Assessment of Dams

11.1.1 Fly Ash Pond

- The seepage totalizer at the Geronimo seep has measured relatively large flow rates (up to 47 gpm), and readings have varied widely in the past several years. The 2008 APS Dam Safety Inspection Report (2008a) indicates that the totalizer is malfunctioning.

- Piezometers F-81 and F-35, which measure water levels in the Shinarump formation at the right abutment, have both had water levels equal to that of the reservoir since the dam was constructed. These results indicate that there is seepage from the reservoir into the Shinarump formation in this area.

- Piezometers F-123, F-128 and F-132 have had water level readings above the reservoir water level since at least 2001. The cause of these unusual readings is unknown.

- Survey monuments on the crest of the Fly Ash Pond Dam indicate that the dam crest has settled since construction and is currently as much as 2 feet below the design crest elevation of 5120.

- Based on a conservative hydrologic analysis of the dam with its actual minimum crest elevation of 5118, the Fly Ash Pond Dam has about 2 feet of freeboard above the flood pool resulting from the local-storm PMP, which is greater than the 72-hour PMP.

- No dam break analysis has been completed for the Fly Ash Pond Dam despite the fact that it has nearly eight times the storage capacity of the Bottom Ash Pond Dam.

- Moderate quantities of vegetation were observed on the upstream and downstream slopes, and a small amount of vegetation was observed on the dam crest.

11.1.2 Bottom Ash Pond

- Moderate quantities of seepage (up to 15 gpm) have been measured at the West Abutment Seep totalizer. Seepage quantities measured at the weir have been small.

- Survey monuments on the crest of the Bottom Ash Pond Dam indicate that portions of the dam crest have settled slightly since the dam was raised. The crest is currently as much as 0.2 feet below the design crest elevation of 5123.3.

- Based on a conservative hydrologic analysis, the main reservoir of the Bottom Ash Pond has about 4 feet of freeboard above the flood pool resulting from the local-storm PMP, which is greater than the 72-hour PMP. However, the discharge pathway provided by the 36-inch CMP carrying the siphon pipes through the dam is at El. 5120.5, which leaves only 1.2 feet of freeboard above the flood pool if the 4-inch thick concrete plug that seals the upstream end of the CMP is compromised in any way.

- The Bottom Ash Pond has intermediate dikes that are higher than the main dam. These dikes store water and bottom ash at higher elevations than the main reservoir, and excess water drains into the reservoir. The total flood storage capacity of the Bottom Ash Pond Dam depends on the quantity and height of material stored in the upstream cells, which is constantly changing as part of normal operations.

- The intermediate dikes in the Bottom Ash Pond have been founded on hydraulically-placed bottom ash that has been subjected to an unknown amount of consolidation. The susceptibility of hydraulically-placed bottom ash to liquefaction has not been evaluated.

- Based on a conservative analysis, the main reservoir of the Bottom Ash Pond is expected to have about 3 or more feet of freeboard above a flood pool that results from release of the contents of the upstream cells if one or both of the intermediate dikes fail due to liquefaction or for any other reason.

11.1.3 Stability Analysis (Adequacy of Factors of Safety)

Factors of safety calculated in the original dam design, in the design of the Bottom Ash Pond raise, and in check analyses performed by GEI, exceed the minimum FERC recommended factors of safety for each of the load cases.

11.1.4 Stress Evaluation

Stress evaluation is not applicable to the dams at the Cholla facility because there are no structural elements or buildings that would warrant a stress evaluation.

11.1.5 Spillway Adequacy

The Fly Ash and Bottom Ash Pond Dams do not have spillways and are designed to store the design flood. Based on conservative hydrologic analyses, the Fly Ash Pond Dam currently has 2 feet of freeboard over the maximum flood pool, which is less than the 3 feet recommended by ADWR.

The main reservoir of the Bottom Ash Pond Dam has sufficient freeboard to store the design flood. However, the flood storage capacity of the Bottom Ash Pond Dam varies depending on the quantity and height of the material stored in the two cells behind the intermediate dikes, upstream of the main dam. Based on conservative analyses, the main reservoir of the Bottom Ash Pond Dam has sufficient freeboard to store the released contents of the upstream cells in the event of a failure of one or both intermediate dikes.

11.2 Adequacy of Instrumentation and Monitoring of Instrumentation

The quantity of instrumentation and frequency of monitoring for the ponds at the Cholla facility are both adequate. Several instruments, including the totalizer at the Geronimo Seep and piezometers F-123, F-128 and F-132 in the Fly Ash Pond Dam, may be malfunctioning. These instruments should be repaired or replaced, if necessary.

11.3 Adequacy of Maintenance and Surveillance

The dams and embankments and the APS Cholla facility have satisfactory maintenance and surveillance programs.

11.4 Hazard Classification

The Fly Ash Pond Dam was classified (ADWR, 2009b) as a High Hazard dam due to the high potential for loss of life and extensive property damage in the event of a failure. We consider this hazard classification as appropriate.

The Bottom Ash Pond Dam was classified (ADWR, 2009a) as a High Hazard dam due to the high potential for loss of life and extensive property damage in the event of a failure. We consider this hazard classification as appropriate.

Both the Sedimentation Pond and the West Area Retention Pond store water and a minimal amount of waste below the natural grade. These impoundments do not have dams and, therefore, are not classified by the State of Arizona. Based on the small size of these impoundments and the fact that spilling of the impounded material is very unlikely because they are sub-grade structures, we consider these ponds to have a Less-than-Low Hazard Potential according to EPA standards.

12.0 Recommendations

12.1 Corrective Measures for the Structures

12.1.1 Fly Ash Pond

1. The seepage totalizer at Geronimo Seep should be repaired or replaced so reliable readings of flow rates at this location, and at the Hunt Seep location, can be obtained.
2. Flow rates at the Geronimo Seep should be monitored closely when the totalizer is fixed. If flows at this location continue to be much higher than has typically been measured at other seepage totalizers around the dams (above about 20 gpm), action should be taken to examine possible causes of seepage and investigate whether this seepage could be compromising dam stability.
3. Piezometers F-81 and F-35, which measure water levels in the Shinarump formation at the right abutment, have both had water levels equal to that of the reservoir since the dam was constructed. These results indicate that there is seepage from the reservoir into the Shinarump formation in this area. Analyses should be performed to evaluate potential effects of seepage in this area on dam stability.
4. The cause of readings above the water level in piezometers F-123, F-128 and F-132 should be investigated. The piezometers should be repaired if necessary.
5. A detailed hydrologic analysis of the Fly Ash Pond should be completed taking into account the current surveyed crest height of the dam. If necessary, the maximum storage pool should be revised to take into account the lower crest height.
6. The potential increase in dam failure consequences due to the larger storage capacity of the Fly Ash Pond compared to the Bottom Ash Pond should be considered to determine whether a separate dam break analysis and inundation map should be completed for the Fly Ash Pond Dam.
7. Vegetation that exceeds the FEMA-534-Impact-of-Plants-on-Earthen-Dams definition of woody plants on both dam slopes and on the crest should be removed during routine maintenance.

12.1.2 Bottom Ash Pond

1. Survey monuments indicate that portions of the Bottom Ash Pond Dam are slightly lower than the design crest elevation of 5123.3. Though the settlement is minor and the current freeboard appears to be sufficient based on our preliminary calculations, the survey points should continue to be monitored to determine if a reduction in the maximum storage pool is required in the future.

2. The Bottom Ash Pond should be surveyed regularly in order to determine its flood storage capacity. The storage volume should be calculated each time the geometry of the cells are reconfigured, when operations change, or at a minimum every five years. If the storage is found to be insufficient to store the PMF with the required freeboard, then operations should be modified to attain the required storage capacity as quickly as possible. In addition, the flood pool in the main reservoir resulting from failures of one or both intermediate dikes should be computed regularly to determine whether freeboard is adequate. The invert elevation of the 36-inch CMP carrying the siphon pipes (El. 5120.5) should be taken into consideration when determining flood storage capacity and freeboard, as this culvert provides a potential discharge pathway through the dam if the seal provided by the 4-inch concrete plug is compromised. The condition of the concrete plug should be inspected regularly.
3. Vegetation that exceeds the FEMA-534-Impact-of-Plants-on-Earthen-Dams definition of woody plants on both dam slopes and on the crest should be removed during routine maintenance.

12.2 Corrective Measures Required for Maintenance and Surveillance Procedures

None.

12.3 Corrective Measures Required for the Methods of Operation of the Project Works

None.

12.4 Any New or Additional Monitoring Instruments, Periodic Observations, or Other Methods of Monitoring Project Works or Conditions That May Be Required

None.

12.5 Acknowledgement of Assessment

I acknowledge that the management unit(s) referenced herein was personally inspected by me and was found to be in the following condition (select one only):

SATISFACTORY

FAIR

POOR

UNSATISFACTORY

SATISFACTORY
No existing or potential management unit safety deficiencies are recognized. Acceptable performance is expected under all applicable loading conditions (static, hydrologic, seismic) in accordance with the applicable criteria. Minor maintenance items may be required.

FAIR
Acceptable performance is expected under all required loading conditions (static, hydrologic, seismic) in accordance with the applicable safety regulatory criteria. Minor deficiencies may exist that require remedial action and/or secondary studies or investigations.

POOR
A management unit safety deficiency is recognized for any required loading condition (static, hydrologic, seismic) in accordance with the applicable dam safety regulatory criteria. Remedial action is necessary. POOR also applies when further critical studies or investigations are needed to identify any potential dam safety deficiencies.

UNSATISFACTORY
Considered unsafe. A dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution. Reservoir restrictions may be necessary.

I acknowledge that the management unit referenced herein:

Has been assessed on September 2, 2009

Signature: ______________________

COLORADO REGISTERED PROFESSIONAL ENGINEER
STEVEN R. TOWNSLEY
27730

List of Participants:

Steve Townsley, P.E.	GEI Consultants, Inc.
Mary Nodine, P.E.	GEI Consultants, Inc.
John D. Mitchell, P.E.	APS
Ted Tindall, P.E.	APS
Doug Lavarnway	Cholla Power Plant
Conrad M. Spencer	Cholla Power Plant
Sheila Chairez	Cholla Power Plant

13.0 References

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Figures and Exhibits

Assessment of Dam Safety of Coal Combustion Waste Impoundments at APS Cholla	GEI Consultants	SITE VICINITY MAP
Lockheed-Martin Corporation Edison, NJ	Project 091330	December 2009 Figure 1

P:\091330 - Lockheed Martin Coal Ash Impoundments\APS Cholla\Figures\ FIGURE 1 SITE VICINITY MAP.dwg Nov 2009

Assessment of Dam Safety of Coal Combustion Waste Impoundments at APS Cholla	GEI Consultants	SATELLITE PHOTO
Lockheed-Martin Corporation Edison, NJ	Project 091330	December 2009 Figure 2

P:\091330 - Lockheed Martin Coal Ash Impoundments\APS Cholla\Figures\ FIGURE 2 SATELLITE MAP.dwg Nov 2009

Assessment of Dam Safety of Coal Combustion Waste Impoundments at APS Cholla	GEI Consultants	ON SITE PONDS PLAN VIEW
Lockheed-Martin Corporation Edison, NJ	Project 091330	December 2009 Figure 3

P:\091330 - Lockheed Martin Coal Ash Impoundments\APS Cholla\Figures\ FIGURE 3 ONSITE PONDS.dwg Nov 2009

Assessment of Dam Safety of Coal Combustion Waste Impoundments at APS Cholla

Lockheed-Martin Corporation
Edison, NJ

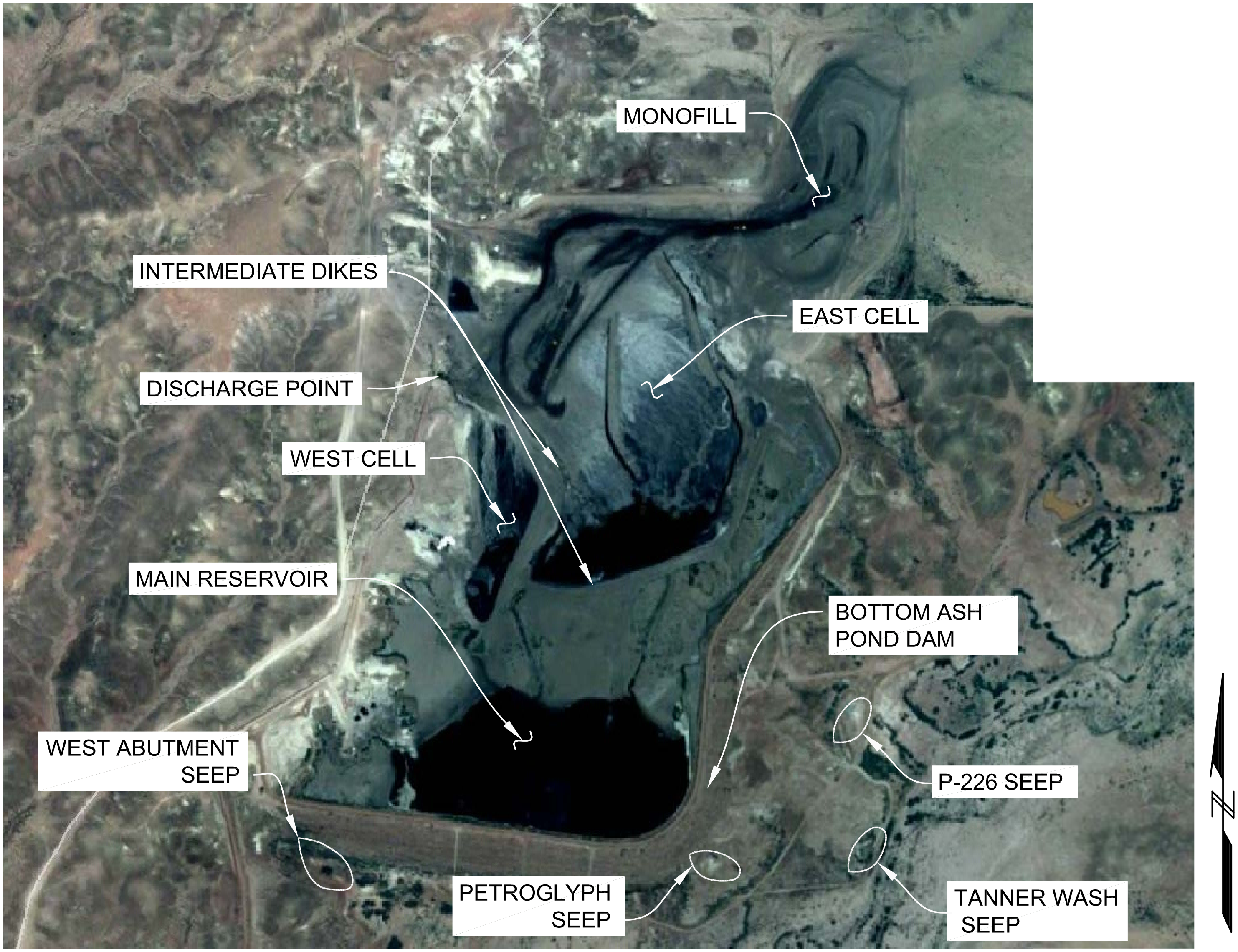
GEI Consultants

Project 091330

FLY ASH POND PLAN VIEW

December 2009

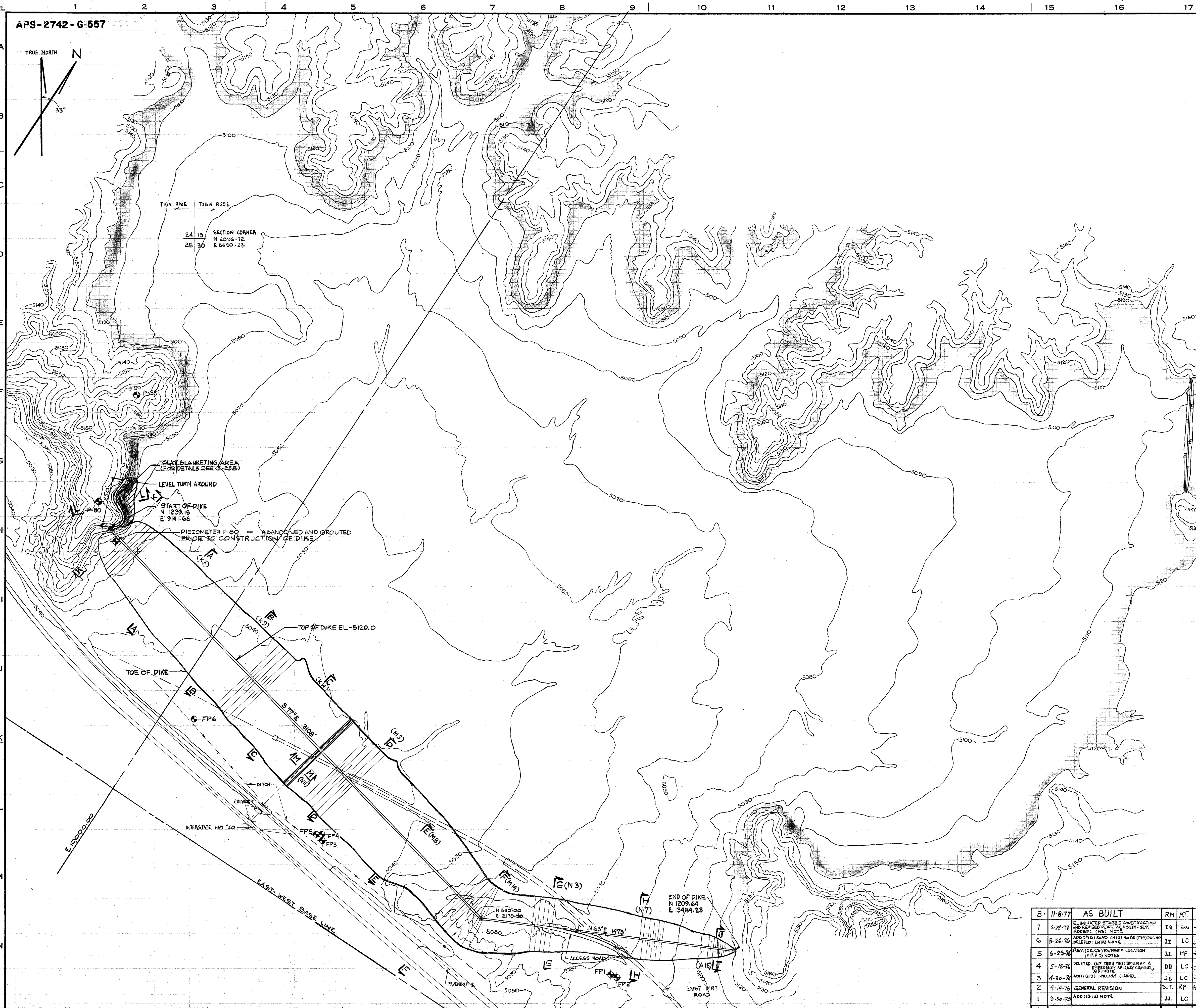
Figure 4

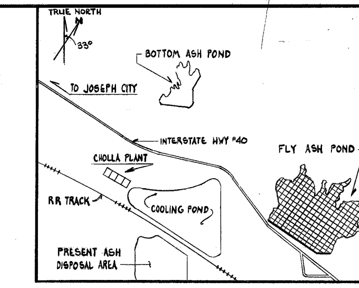


Assessment of Dam Safety of Coal Combustion Waste Impoundments at APS Cholla	GEI Consultants	BOTTOM ASH POND PLAN VIEW
Lockheed-Martin Corporation Edison, NJ	Project 091330	December 2009 Figure 5

P:\091330 - Lockheed Martin Coal Ash Impoundments\APS Cholla\Figures\ FIGURE 5 BOTTOM ASH POND.dwg Dec 2009

APS-2742-G-557





KEY PLAN

NOTES

SECTION CORNER AT (C2) IS AT JUNCTION OF TOWNSHIP 18N AND RANGE 19E AND TOWNSHIP 18N AND RANGE 20E

FOR ADDITIONAL NOTES SEE DRAWING G-556 & G-558

FOR QUANTITIES SEE DRAWING G 558

FOR PIEZOMETER DETAILS SEE DRAWING G 556

FOR ASH DISCHARGE PIPE DETAILS SEE DRAWINGS G-632 AND G-633

FOR LOCATION OF NEW PIEZOMETERS SEE DRAWING SK-CH-J20

LEGEND

DENOTES EXISTING PIEZOMETER

REFERENCE DRAWINGS

CHOLLA FLY ASH POND SITE
KENNEY AERIAL MAPPING INC PHOENIX, ARIZONA G-44248 SH1

ANDREW ANTHONY FERLITO No. 7421 2/28/77

CERTIFICATE NO. 9161 STEPHEN I. CSIBOR 8-19-75

WORK THIS DRAWING WITH G-558

NO.	DATE	REVISION	BY	CH.	APPROVED		
8	11-8-77	AS BUILT	R.M.	M.T.			
7	2-28-77	ELIMINATED STAGE I CONSTRUCTION AND REVISED PLAN ACCORDINGLY. ADDED: (H3) NOTE	T.R.	EW	—		
6	8-26-76	ADD: (M8) ROAD (N10) NOTE (F19) DWG NO. DELETED: (N12) NOTE	J.I.	LC	JR		
5	6-29-76	REV: (C2, C3) TOWNSHIP LOCATION (F17, F19) NOTES	J.I.	MF	JR	BW	
4	5-18-76	DELETED: (N7 THRU M10) SPILLWAY & EMERGENCY SPILLWAY CHANNEL, (G5) NOTE	D.D.	LC	JR		
3	4-30-76	ADD: (N9) SPILLWAY CHANNEL	J.I.	LC	JR		
2	4-14-76	GENERAL REVISION	D.T.	RP	BW	JR	
1	9-30-75	ADD: (G18) NOTE	J.I.	LC		BW	

ARIZONA PUBLIC SERVICE COMPANY
CHOLLA S.E. STATION
1977 - 250 MW INSTALLATION - UNIT No. 2
1978 - 250 MW EXTENSION - UNIT No. 3

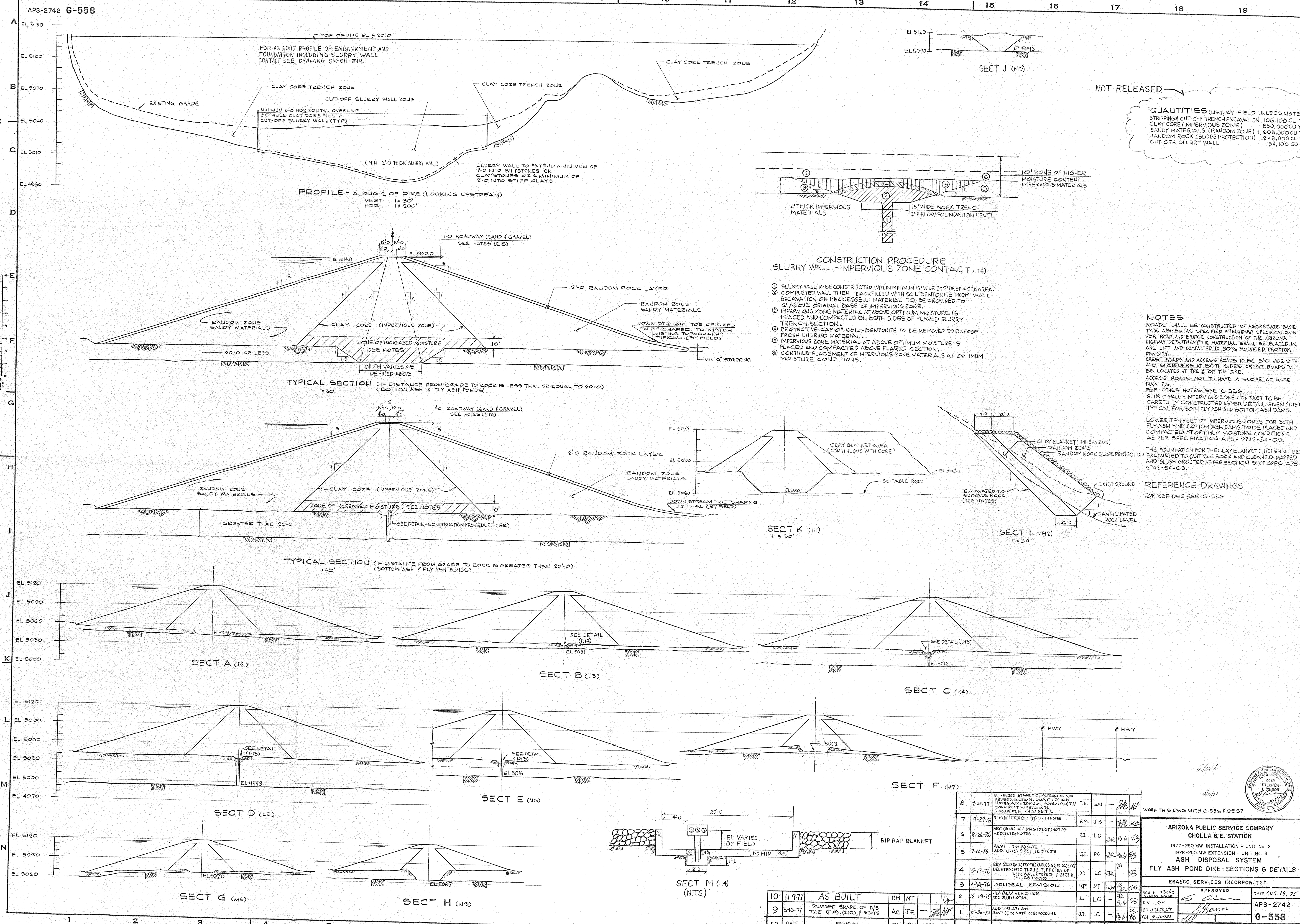
ASH DISPOSAL SYSTEM
FLY ASH POND-PLAN

EBASCO SERVICES INCORPORATED

SCALE 1" = 200'
APPROVED
DATE AUG. 19, 75
DIV. C-H
DR. G.H. J.I.
CH. R JONES
APS-2742
G-557

APS DWG. #G-44557

Exhibit 1-4



NOTES

ROADS SHALL BE CONSTRUCTED OF AGGREGATE BASE TYPE AB-5a AS SPECIFIED IN "STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION OF THE ARIZONA HIGHWAY DEPARTMENT." THE MATERIAL SHALL BE PLACED IN ONE LIFT AND COMPACTED TO 90% MODIFIED PROCTOR DENSITY.

CREST ROADS AND ACCESS ROADS TO BE 15'-0 WIDE WITH 4'-0 SHOULDERS AT BOTH SIDES. CREST ROADS TO BE LOCATED AT THE ℄ OF THE DIKE.

ACCESS ROADS NOT TO HAVE A SLOPE OF MORE THAN 7%.

FOR OTHER NOTES SEE G-556.

SLURRY WALL - IMPERVIOUS ZONE CONTACT TO BE CAREFULLY CONSTRUCTED AS PER DETAIL GIVEN (D13) TYPICAL FOR BOTH FLY ASH AND BOTTOM ASH DAMS.

LOWER TEN FEET OF IMPERVIOUS ZONES FOR BOTH FLY ASH AND BOTTOM ASH DAMS TO BE PLACED AND COMPACTED AT OPTIMUM MOISTURE CONDITIONS AS PER SPECIFICATION APS-2742-54-09.

THE FOUNDATION FOR THE CLAY BLANKET (H15) SHALL BE EXCAVATED TO SUITABLE ROCK AND CLEANED, MAPPED AND SLUSH GROUTED AS PER SECTION 9 OF SPEC. APS-2742-54-09.

REFERENCE DRAWINGS

FOR REF. DWG SEE G-556

WORK THIS DWG WITH G-556 & G557

ARIZONA PUBLIC SERVICE COMPANY
CHOLLA S.E. STATION
1977-250 MW INSTALLATION - UNIT No. 2
1978-250 MW EXTENSION - UNIT No. 3
ASH DISPOSAL SYSTEM
FLY ASH POND DIKE - SECTIONS & DETAILS

EBASCO SERVICES INCORPORATED

SCALE 1"=50'-0 UNLESS NOTED
DIV C-H
DR J. IAFRATE
CH R JONES
APPROVED
DATE AUG. 19, 75
APS-2742
G-558

APS DWG #G-44558

Exhibit 2

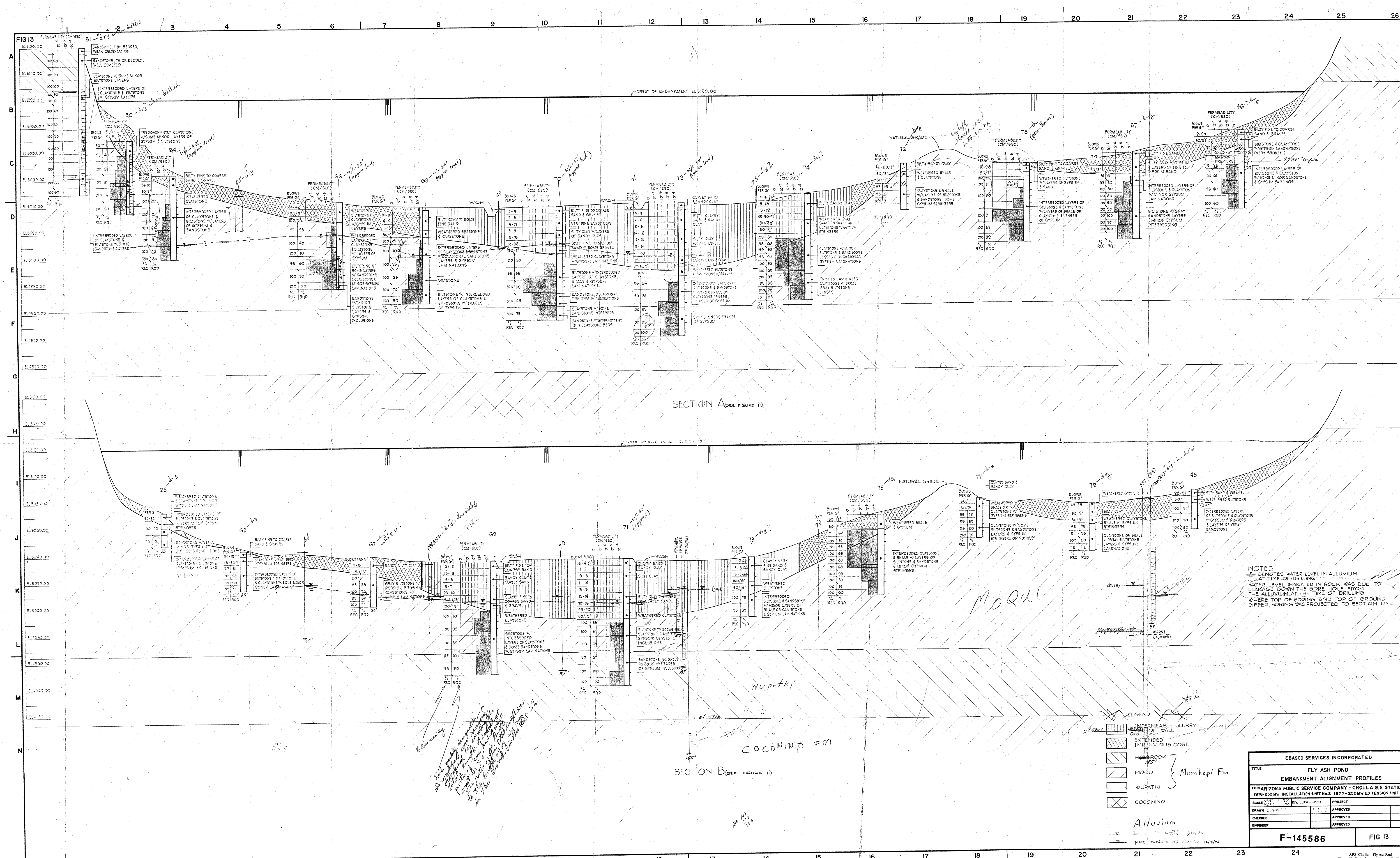
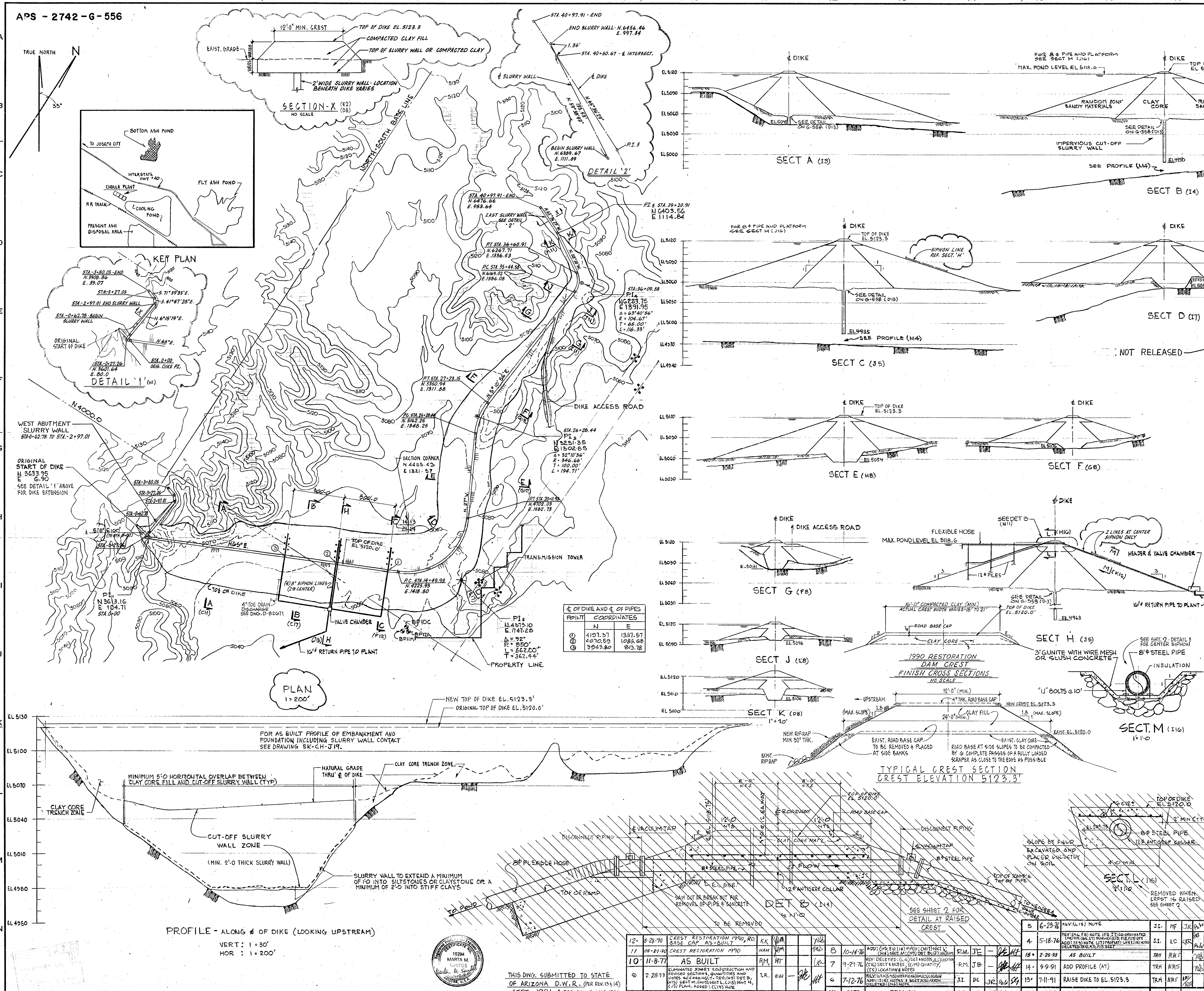


FIG 13
CREST OF EMBANKMENT EL 5120.00
NATURAL GRADE
SECTION A (SEE FIGURE 11)
SECTION B (SEE FIGURE 11)
MOQUI
Wupatki
COCONINO FM
NOTES
DENOTES WATER LEVEL IN ALLUVIUM AT TIME OF DRILLING
WATER LEVEL INDICATED IN ROCK WAS DUE TO LEAKAGE DOWN THE BORE HOLE FROM THE ALLUVIUM AT THE TIME OF DRILLING
WHERE TOP OF BORING AND TOP OF GROUND DIFFER, BORING WAS PROJECTED TO SECTION LINE
LEGEND
IMPERMEABLE SLURRY CUT OFF WALL
EXTENDED IMPERVIOUS CORE
HOLBROOK
MOQUI
WUPATKI
COCONINO
Moenkopi Fm
Alluvium
EBASCO SERVICES INCORPORATED
FLY ASH POND
EMBANKMENT ALIGNMENT PROFILES
FOR ARIZONA PUBLIC SERVICE COMPANY - CHOLLA S.E STATION
1976-250 MW INSTALLATION-UNIT No.2 1977-250MW EXTENSION-UNIT No.3
F-145586
FIG 13
APS Cholla Fly Ash Pnd
Figure 13 Embankment Alignment Profiles

Exhibit 3

APS - 2742 - G - 556

STATE OF ARIZONA
DEPARTMENT OF WATER RESOURCES
SAFETY OF DAMS SECTION
THIS DRAWING IS APPROVED
FOR CONSTRUCTION
DEPUTY DIRECTOR, ENGINEERING
APPLICATION NO. 09-27
DATE OCT 16 1991



QUANTITIES (NET, BY FIELD UNLESS NOTED)

STRIPPING & CUTOFF TRENCH EXCAVATION	55,400 CU YD
CLAY CORE (IMPERVIOUS ZONE)	430,515 CU YD
SANDY MATERIAL (RANDOM ZONE)	775,000 CU YD
RANDOM ROCK (SLOPE PROTECTION)	115,228 CU YD
CUT-OFF SLURRY WALL	78,900 SQ FT

NOTES: (CREST RESTORATION PROJECT)

1. RESTORATION OF BOTTOM ASH DAM TO ELEV. 5120' IS COVERED BY WORK AUTHORIZATION 54-9976 AND IS SPECIFIED IN CONSTRUCTION CONTRACT - APPENDIX A, SCOPE OF WORK.
2. RAISING OF BOTTOM ASH DAM TO EL. 5123.3' IS COVERED BY W.A. 55-3701 AND IS SPECIFIED IN CONSTRUCTION CONTRACT NO. ELC91-49071.

NOTES

DIKE TO BE CONSTRUCTED IN ACCORDANCE WITH REQUIREMENTS OF EBASCO SPECIFICATION APS-2742-54-09, "EMBANKMENT DIKES-ASH POND SITES" LATEST REVISION.

THE AREA BENEATH THE EMBANKMENT DIKE SHALL BE CLEARED OF ALL BRUSH, GRASS, DEBRIS, STRUCTURES AND OTHER ENCUMBRANCES AND THEN STRIPPED TO A MINIMUM DEPTH OF SIX INCHES.

TYPICAL EMBANKMENT DIKE SECTIONS ARE SHOWN ON DRAWING 2742-G-558.

SECTION CORNER SHOWN AT H6 IS IN TOWNSHIP 18N AND RANGE 19E.

ALL COORDINATES REFER TO THE PLANT AREA GRID SYSTEM.

EMBANKMENT DIKE GEOMETRY TO BE VERIFIED BY FIELD SURVEY.

FOR LOCATIONS OF BORINGS, BORING LOGS AND SUB-SURFACE PROFILES AND BORROW AREA DETAILS SEE EBASCO REPORT "ASH DISPOSAL SITES - SEEPAGE AND FOUNDATION STUDIES" VOLUMES I & II AUGUST, 1975.

PIEZOMETERS SHALL BE INSTALLED AT THE LOCATIONS SHOWN ON THE PLAN FOLLOWING COMPLETION OF CONSTRUCTION. ANY PIEZOMETER DAMAGED BY CONSTRUCTION ACTIVITY SHALL BE REPLACED AT A LOCATION SPECIFIED BY OWNER.

MINIMUM RADIUS OF DIKE ℄ 100' UNLESS NOTED.

FOR LOCATION OF NEW PIEZOMETERS SEE DRAWING SK-CH-J21.

THE MAXIMUM AVERAGE SOLIDS STORAGE LEVELS INDICATED ON THE TYPICAL DIKE SECTIONS SHOWN ON G-558 WILL PERMIT COMPLETE STORAGE OF THE PROBABLE MAXIMUM THUNDERSTORM RUNOFF WITH 4 FEET OF RESIDUAL FREEBOARD.

PROBABLE MAXIMUM THUNDERSTORM RUNOFF VOLUMES ARE:

FLY ASH POND	964.4 ACRE-FT
BOTTOM ASH POND	107.7 ACRE-FT

LEGEND

- INDICATES NEW PIEZOMETER
- INDICATES EXISTING PIEZOMETER

REFERENCE DRAWINGS

FLY ASH POND DIKE - SECT & DET	2742-G-558
KENNEY AERIAL MAPPING INC., PHOENIX, ARIZ	G-44249-SH1
BOTTOM ASH POND SYPHON SYSTEM & FLOATING PLATFORM	G556-S02

WORK THIS DRAWING WITH 2742-G-558

THIS DWG. SUBMITTED TO STATE OF ARIZONA D.W.R. (PER REV. 13 & 14) SEPT. 1991 & PER REV. 15 MAR. 1993

NO	DATE	REVISION	BY	CH	APPROVED
12	8-28-90	CREST RESTORATION 1990, RD. BASE CAP AS-BUILT	KK		
11	04-24-90	CREST RESTORATION 1990	HAM		
10	11-8-77	AS BUILT	RM	MT	
9	2-28-77	ELIMINATED STAGED CONSTRUCTION AND REVISED SECTIONS, QUANTITIES AND NOTES ACCORDINGLY. REV: (N9) DET B, (N13) SECT M, (M17) SECT L, (J15) SECT H, (J5) PLAN, ADDED: (L19) NOTE	T.R.	EW	

NO	DATE	REVISION	BY	CH	APPROVED
8	10-14-76	ADD: (H5, E10, I14) PIPES; (M17) SECT L; (N14) SECT. M; (N9) DET B; (J7, H6) DIM	R.M.	JE	
7	9-29-76	REV: DELETED: (L16) DET. & NOTES, (L5) LOCATION (I16) SECT & NOTES, (G19) QUATITY, (I5) LOCATION & NOTES	R.M.	JB	
6	7-12-76	REV: (L7, K5, M15) NOTE (F10, K16) DIM (L3) LOCATION ADD: (I15) NOTES & SECT (K5) ARROW DELETED: (M6) NOTE	J.I.	DC	

NO	DATE	REVISION	BY	CH	APPROVED
5	6-29-76	REV: (L15) NOTE	J.I.	MF	
4	5-18-76	REV: (M6, F8) NOTE (F8, I7) CO-ORDINATES (H4) DIM (G6, E7) BEARINGS (E19, F18, F19) QTY ADD: (E9) NOTE (J7) PROPERTY LINE (J18) NOTES DELETED: (K10, M9, M13) SECT	J.I.	LC	
15	2-25-93	AS BUILT	TRH	MMS	
14	9-9-91	ADD PROFILE (A7)	TRH	MMS	
13	7-11-91	RAISE DIKE TO EL. 5123.3	TRH	MMS	

ARIZONA PUBLIC SERVICE COMPANY
CHOLLA S.E. STATION
1977 - 250 MW INSTALLATION - UNIT No. 2
1978 - 250 MW EXTENSION - UNIT No. 3
ASH DISPOSAL SYSTEM
BOTTOM ASH POND - PLAN & SECT

EBASCO SERVICES INCORPORATED

SCALE 1"=50'-0" UNLESS NOTED
DIV. C-H
DR. G.H. J.I.
CH. R JONES
APPROVED
DATE AUG. 19, 75
APS-2742
G-556
APS DWG. #G-44556

"INDEX"

Exhibit 4

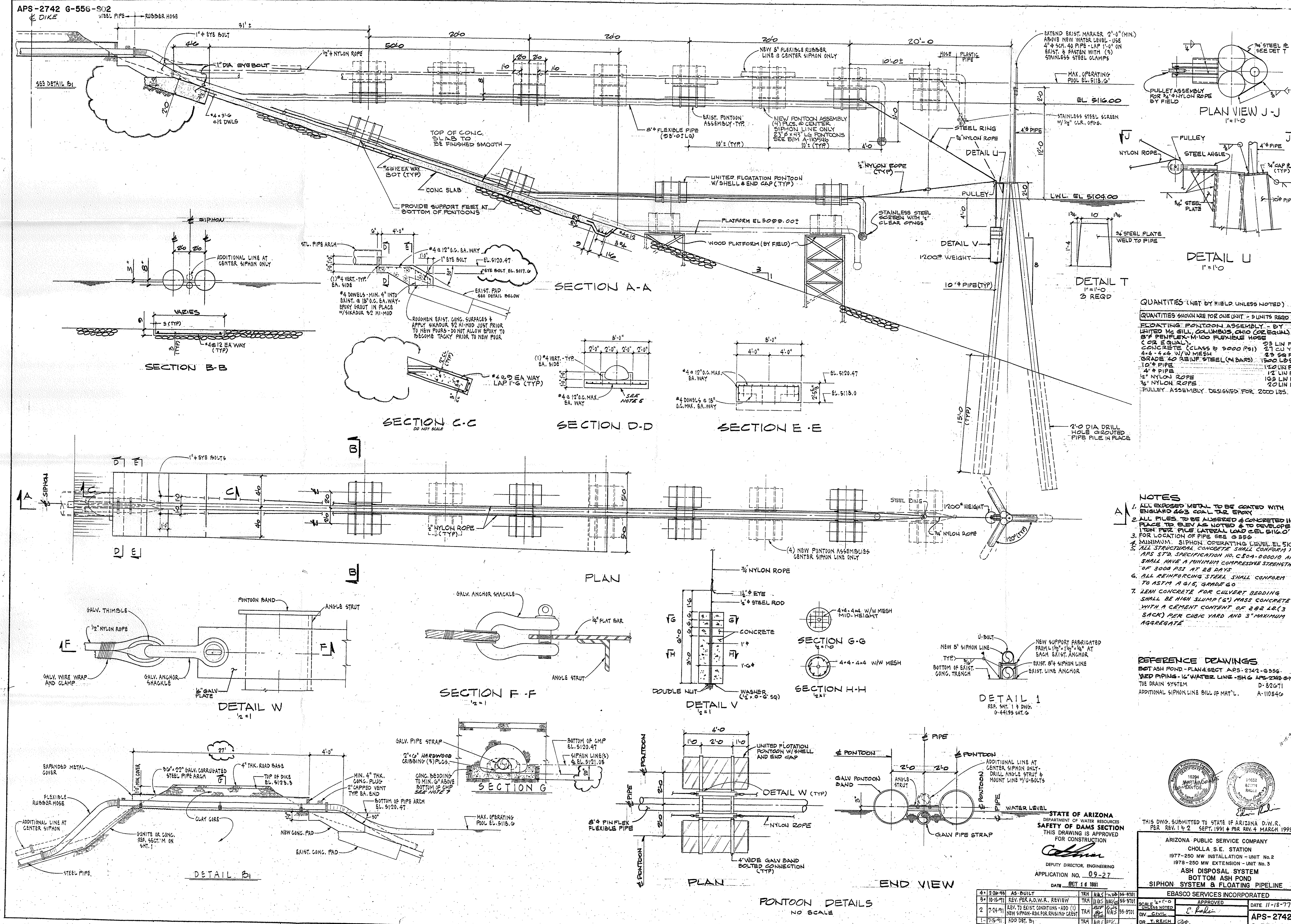


Exhibit 5

#G-44556 sht2

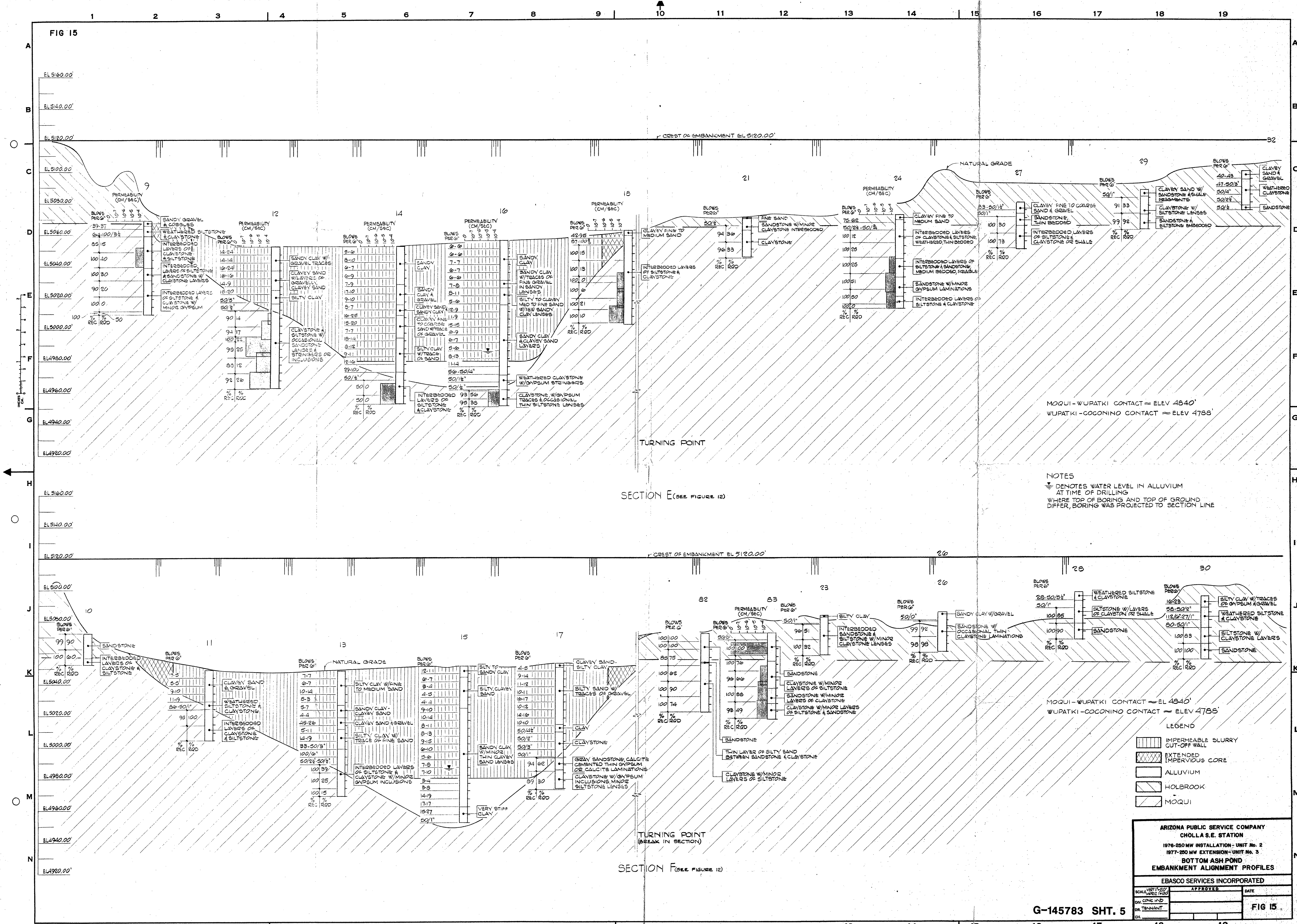
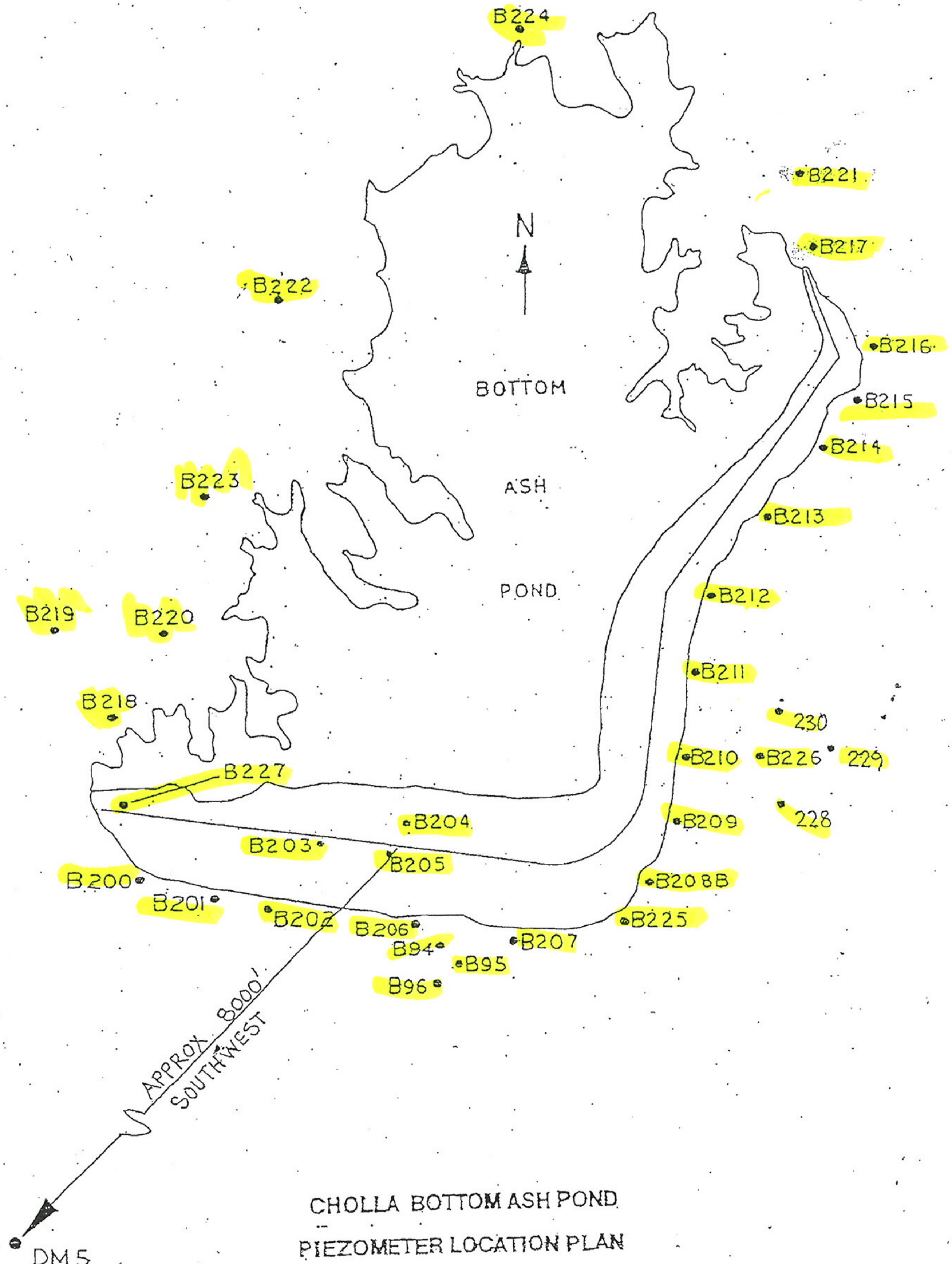


FIG 15
CREST OF EMBANKMENT EL 5120.00'
NATURAL GRADE
SECTION E (SEE FIGURE 12)
SECTION F (SEE FIGURE 12)
TURNING POINT
TURNING POINT (BREAK IN SECTION)
MOQUI-WUPATKI CONTACT ≈ ELEV 4840'
WUPATKI-COCONINO CONTACT ≈ ELEV 4788'
NOTES
DENOTES WATER LEVEL IN ALLUVIUM AT TIME OF DRILLING
WHERE TOP OF BORING AND TOP OF GROUND DIFFER, BORING WAS PROJECTED TO SECTION LINE
LEGEND
IMPERMEABLE SLURRY CUT-OFF WALL
EXTENDED IMPERVIOUS CORE
ALLUVIUM
HOLBROOK
MOQUI
ARIZONA PUBLIC SERVICE COMPANY
CHOLLA S.E. STATION
1976-250 MW INSTALLATION - UNIT No. 2
1977-250 MW EXTENSION - UNIT No. 3
BOTTOM ASH POND
EMBANKMENT ALIGNMENT PROFILES
EBASCO SERVICES INCORPORATED
G-145783 SHT. 5
FIG 15

Exhibit 6

Appendix A

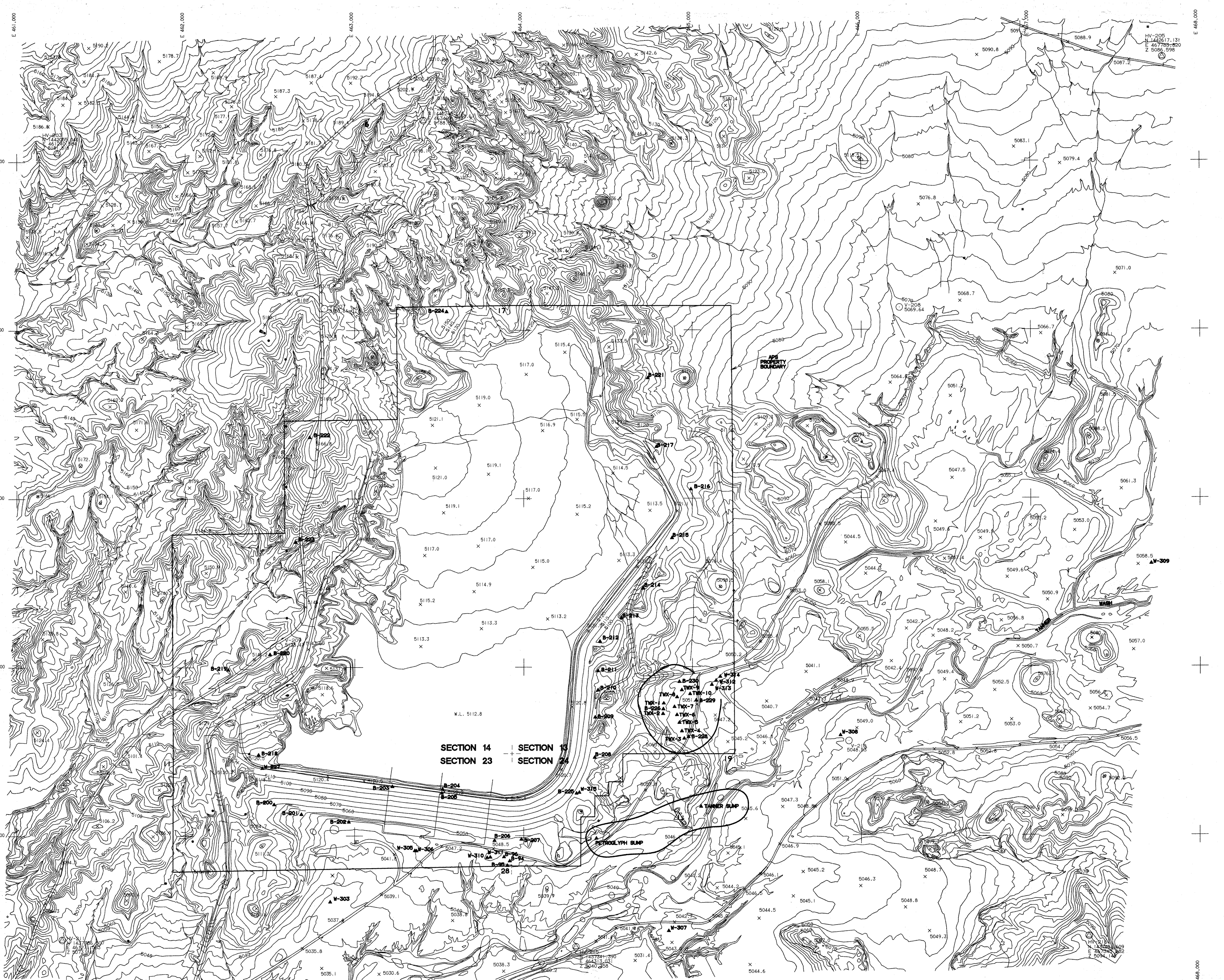
Instrumentation



CHOLLA BOTTOM ASH POND

PIEZOMETER LOCATION PLAN

FIGURE 17



CHOLLA MISSION, BOTTOM ASH POND AREA,
PHOTO DATE: 7-15-92,
COOPER AERIAL OF PHOENIX.

NO.	DATE	REVISION	DWN	CHK	EXD	APPD	APPD	W.A.
1	3-22-94	ADD TWX & MONITOR WELLS & SUMPS	PRATT	MMS		MMS		62-9072

CHOLLA S.E.S.
BOTTOM ASH POND
TOPOGRAPHICAL MAP

ARIZONA **PUBLIC SERVICE** COMPANY

SCALE 1"=200' C.I. 2'
DATE 09-09-92

DRAWN SMITHERS
CHECKED M. SANTOS
EXAMINED
APPROVED M. SANTOS FOR N. SVOR, ENGINEERING MANAGER
APPROVED
W.A. 30-9072
DRAWING NO. G-114113
SHEET 1 OF 1

THIS IS A CADAM DRAWING, DO NOT REVISE MANUALLY

*G . . . FORMAT . . FOOT

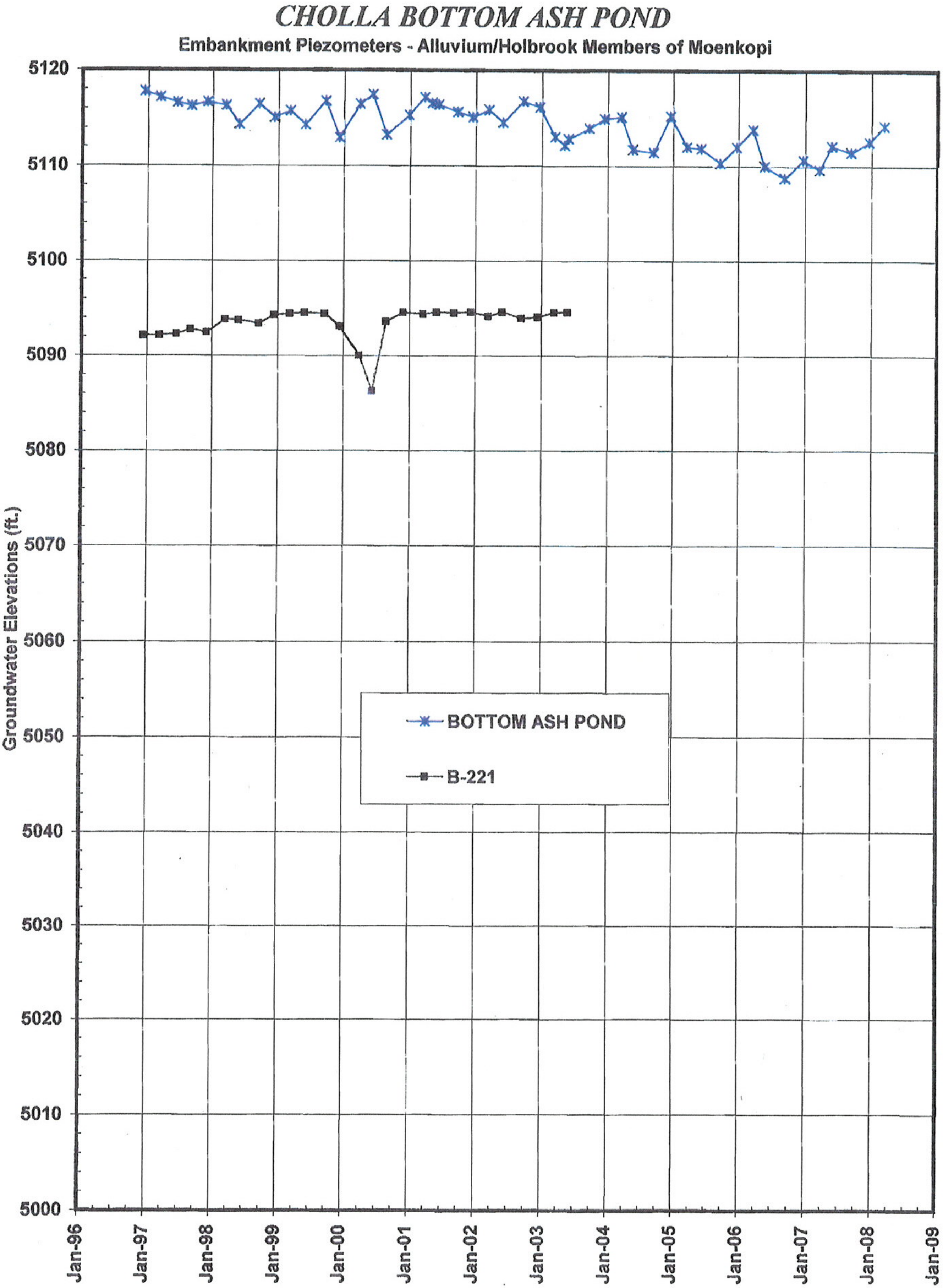

CHOLLA BOTTOM ASH POND
Embankment Piezometers - Alluvium/Holbrook Members of Moenkopi
Groundwater Elevations (ft.)
5120
5110
5100
5090
5080
5070
5060
5050
5040
5030
5020
5010
5000
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
BOTTOM ASH POND
B-221

FIGURE 18

CHOLLA BOTTOM ASH POND

Abutment Piezometers - Chinle Formation

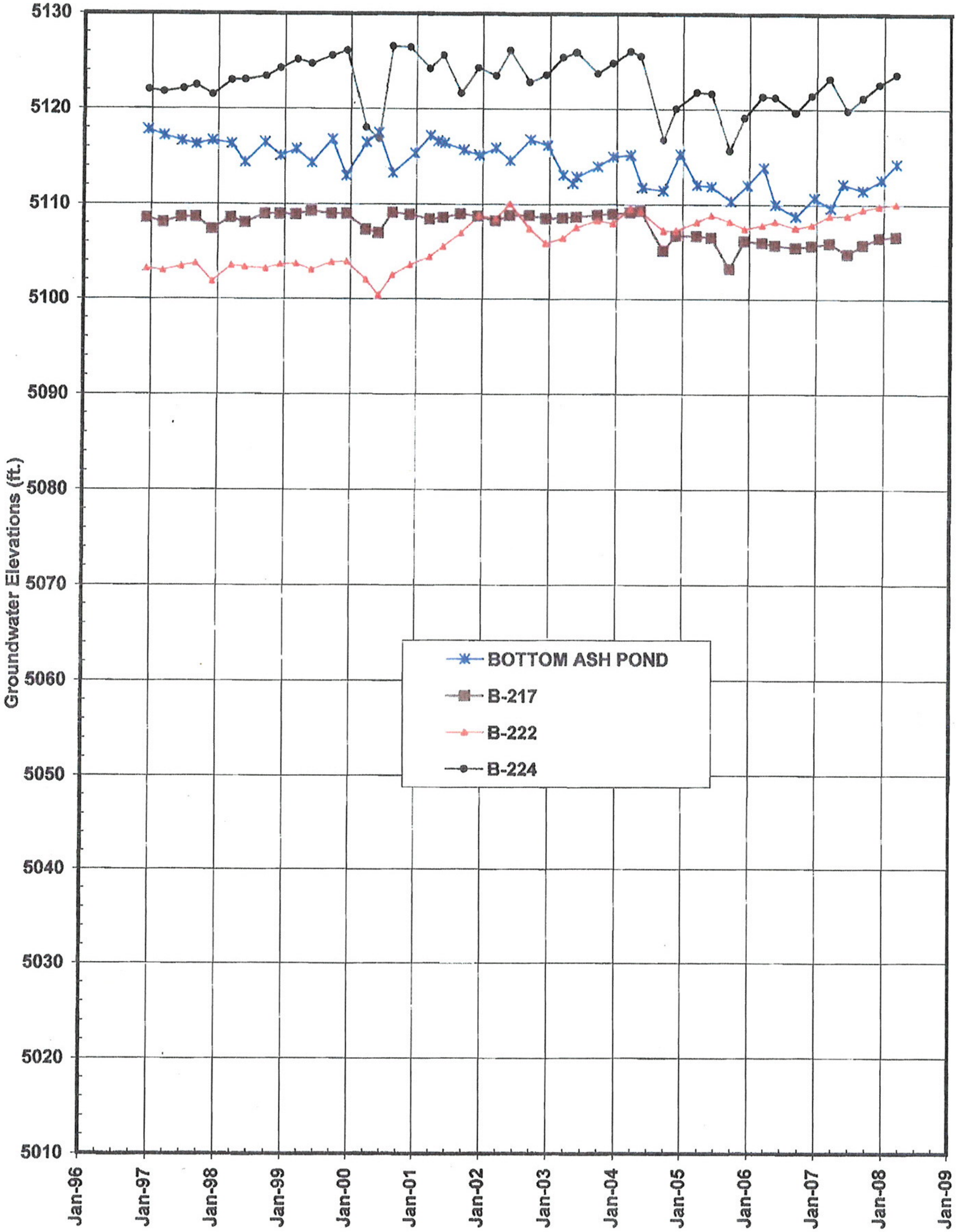
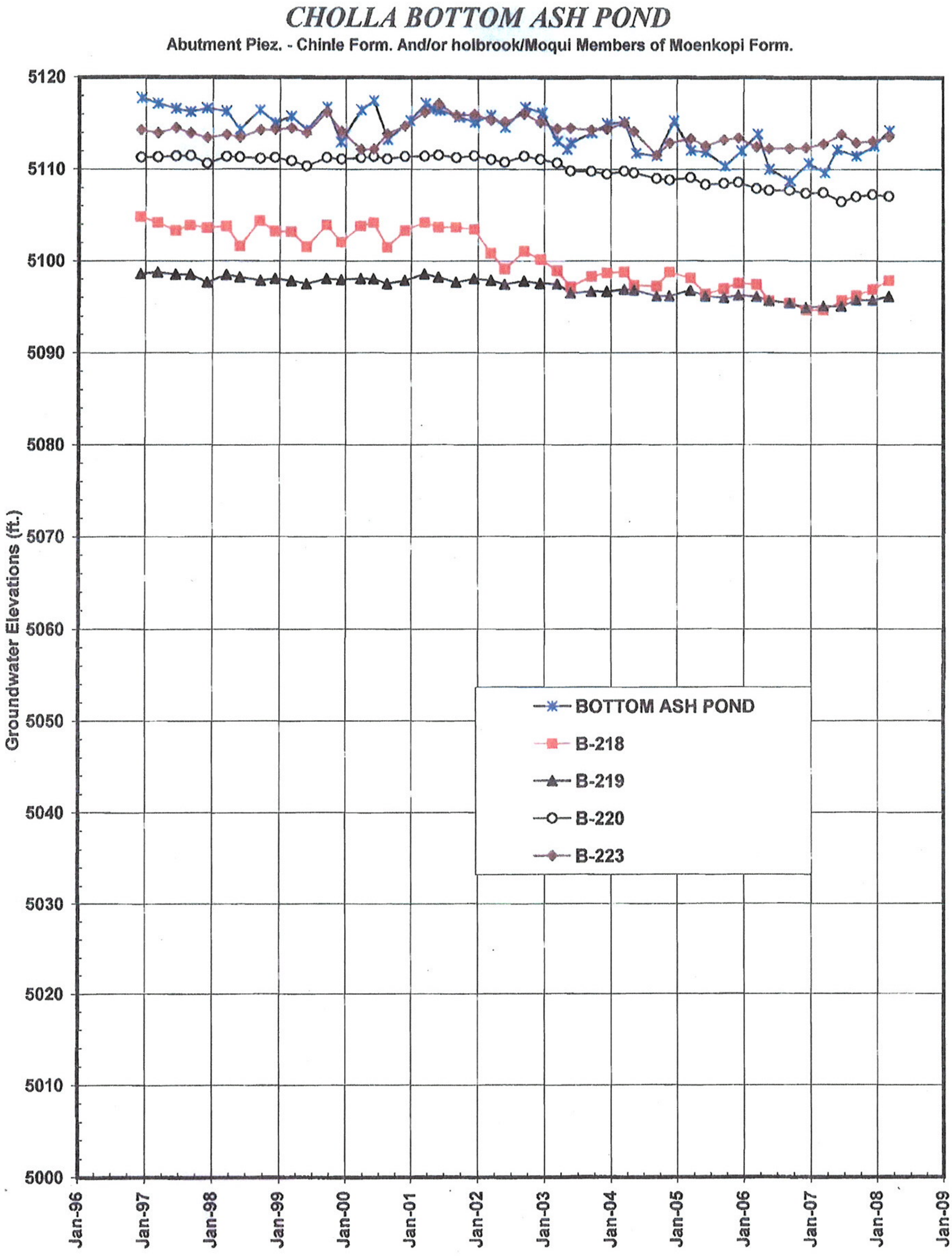


FIGURE 19



CHOLLA BOTTOM ASH POND
Abutment Piez. - Chinle Form. And/or holbrook/Moqui Members of Moenkopi Form.
Groundwater Elevations (ft.)
5120
5110
5100
5090
5080
5070
5060
5050
5040
5030
5020
5010
5000
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
BOTTOM ASH POND
B-218
B-219
B-220
B-223

FIGURE 20

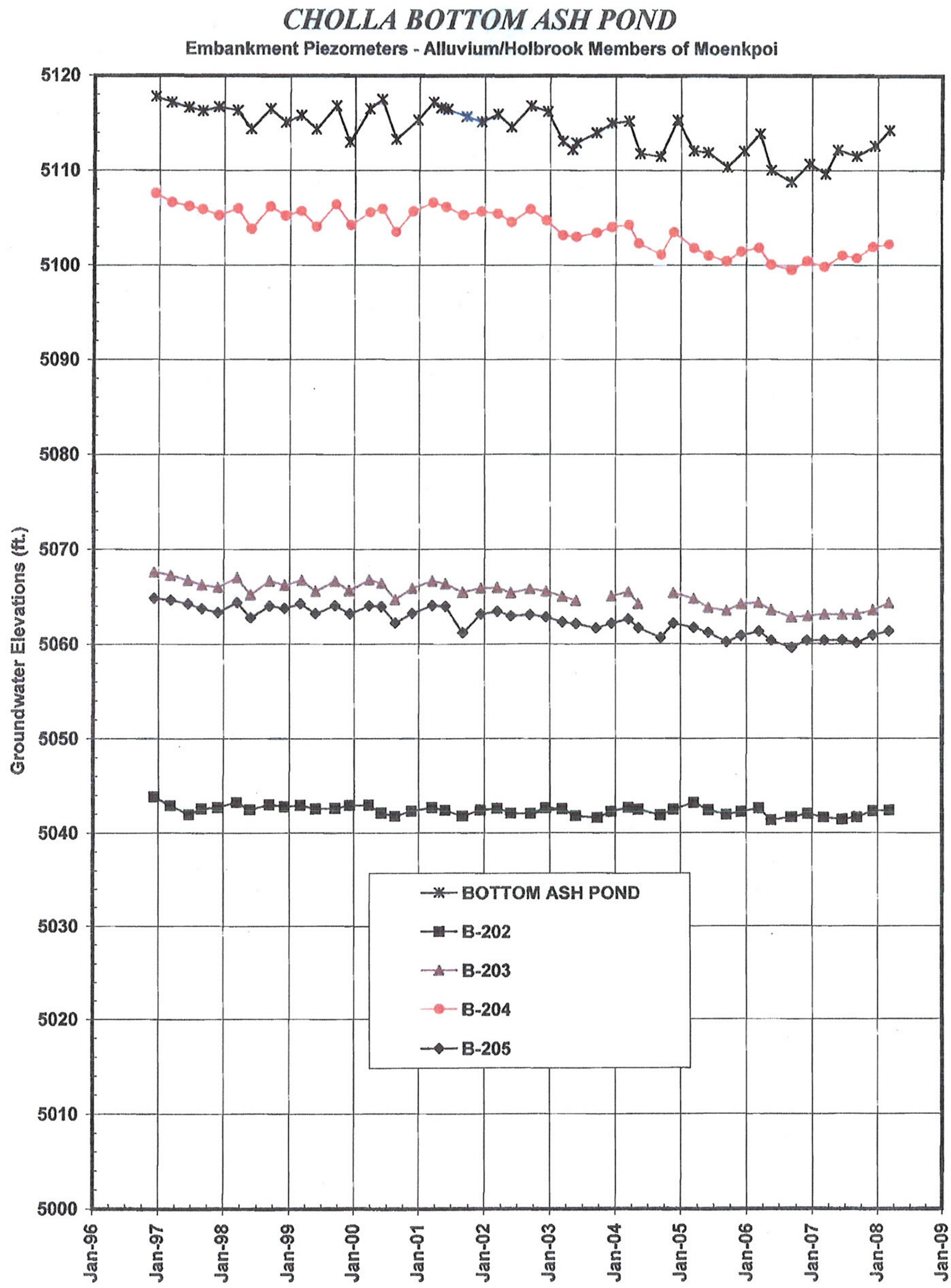

CHOLLA BOTTOM ASH POND
Embankment Piezometers - Alluvium/Holbrook Members of Moenkpoi
Groundwater Elevations (ft.)
5120
5110
5100
5090
5080
5070
5060
5050
5040
5030
5020
5010
5000
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
BOTTOM ASH POND
B-202
B-203
B-204
B-205

FIGURE 21

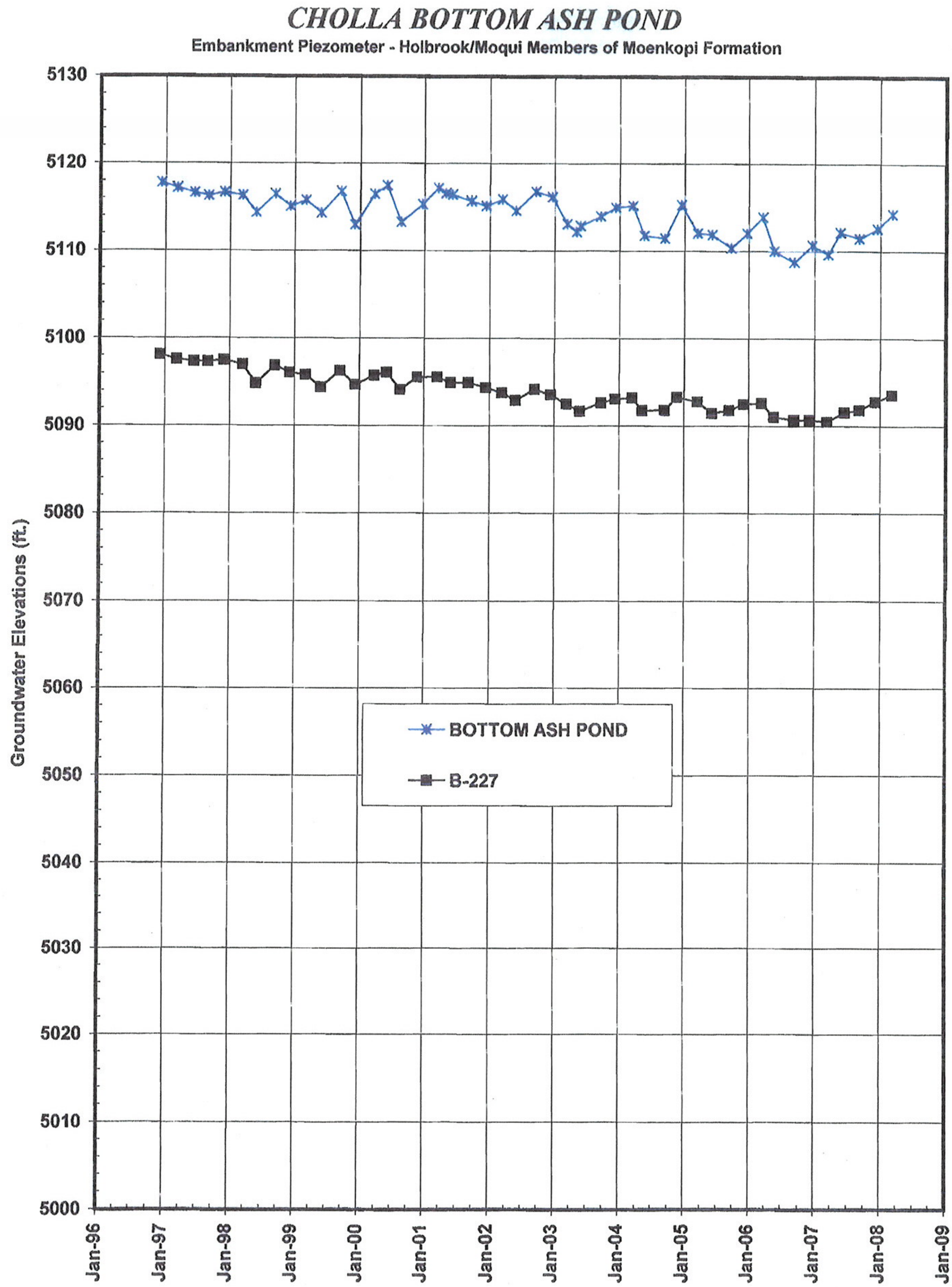
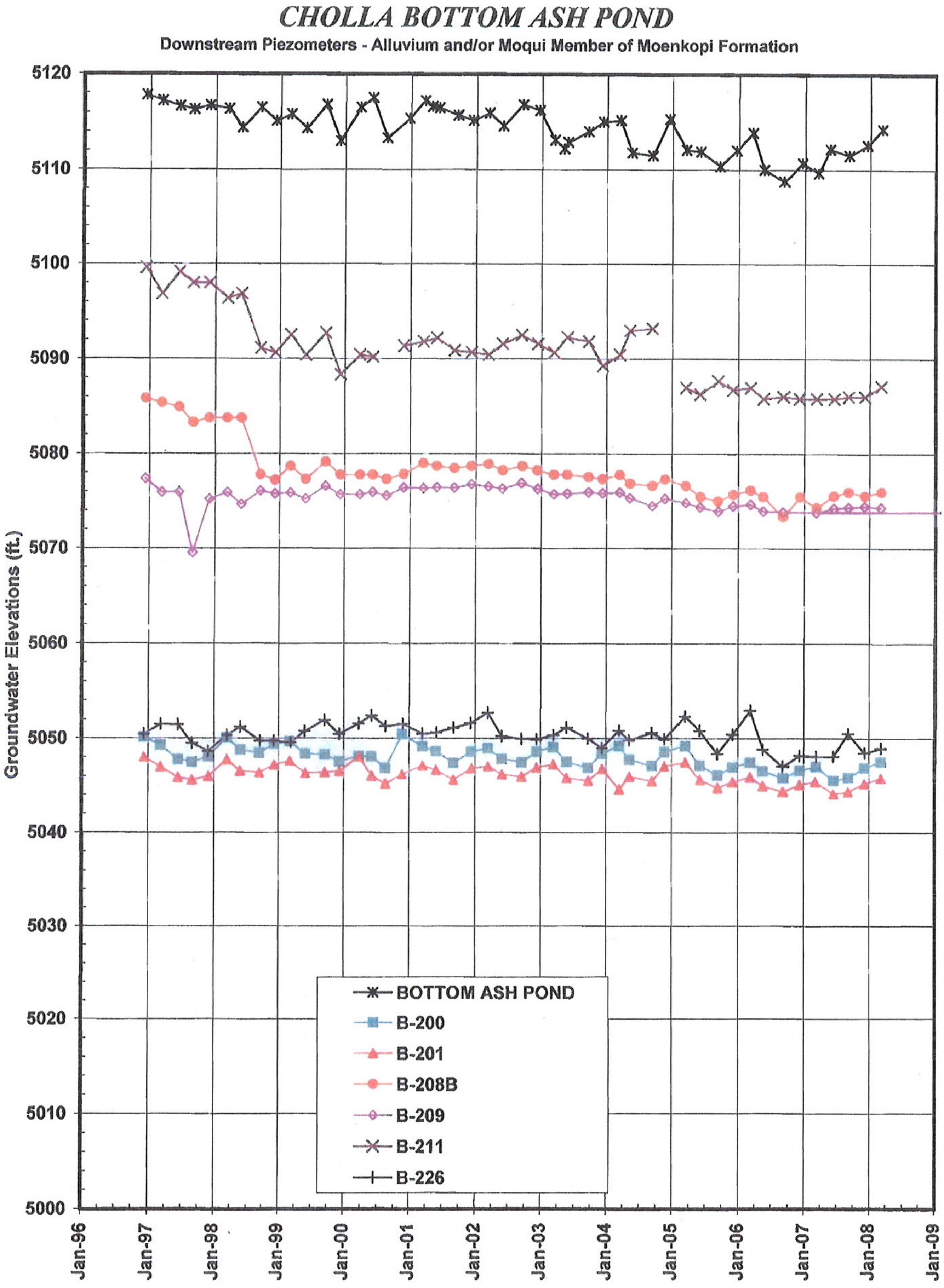

CHOLLA BOTTOM ASH POND
Embankment Piezometer - Holbrook/Moqui Members of Moenkopi Formation
Groundwater Elevations (ft.)
5130
5120
5110
5100
5090
5080
5070
5060
5050
5040
5030
5020
5010
5000
BOTTOM ASH POND
B-227
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09

FIGURE 22



CHOLLA BOTTOM ASH POND
Downstream Piezometers - Alluvium and/or Moqui Member of Moenkopi Formation
Groundwater Elevations (ft.)
5120
5110
5100
5090
5080
5070
5060
5050
5040
5030
5020
5010
5000
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
BOTTOM ASH POND
B-200
B-201
B-208B
B-209
B-211
B-226

FIGURE 23

CHOLLA BOTTOM ASH POND

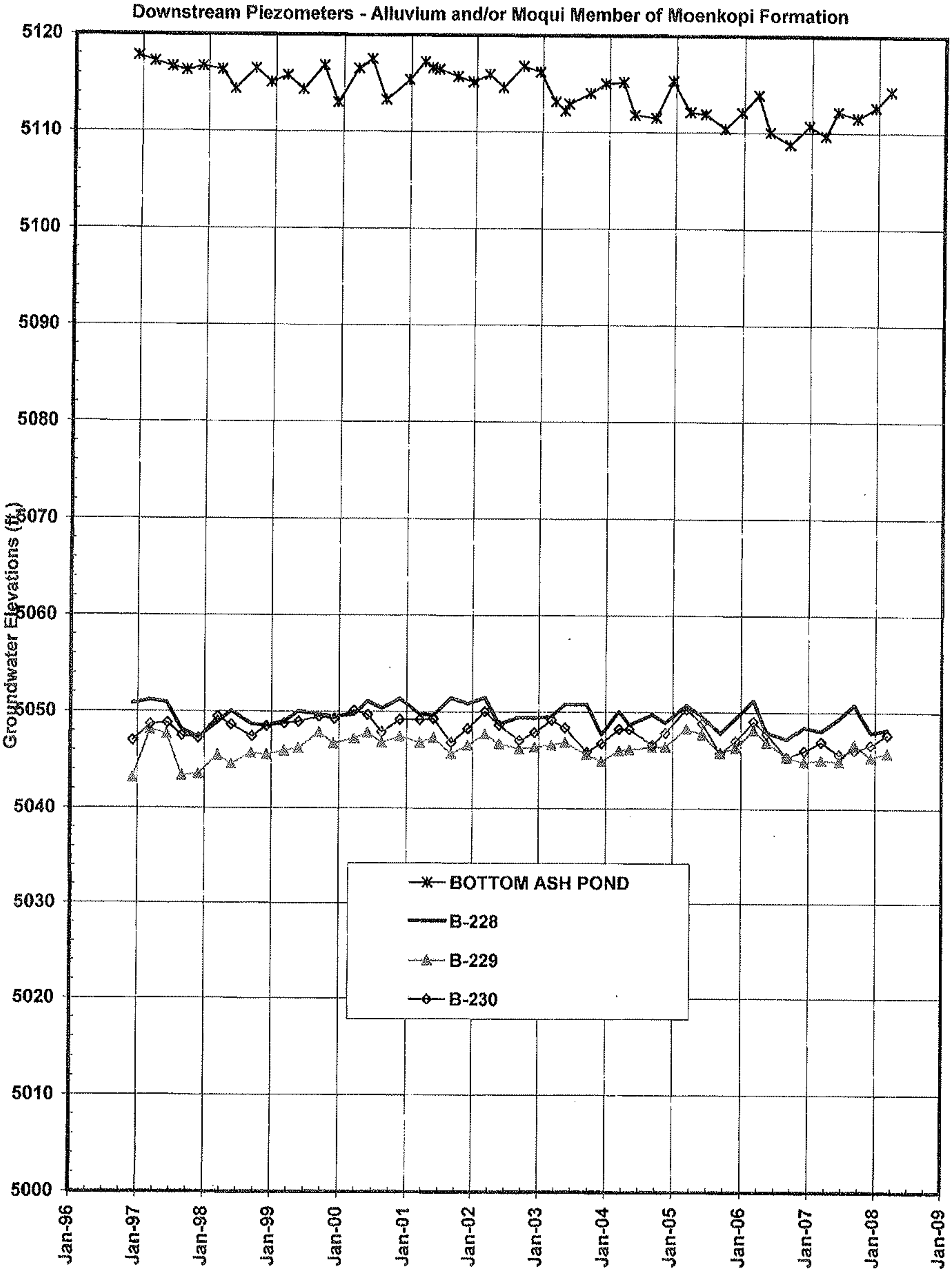


FIGURE 23A

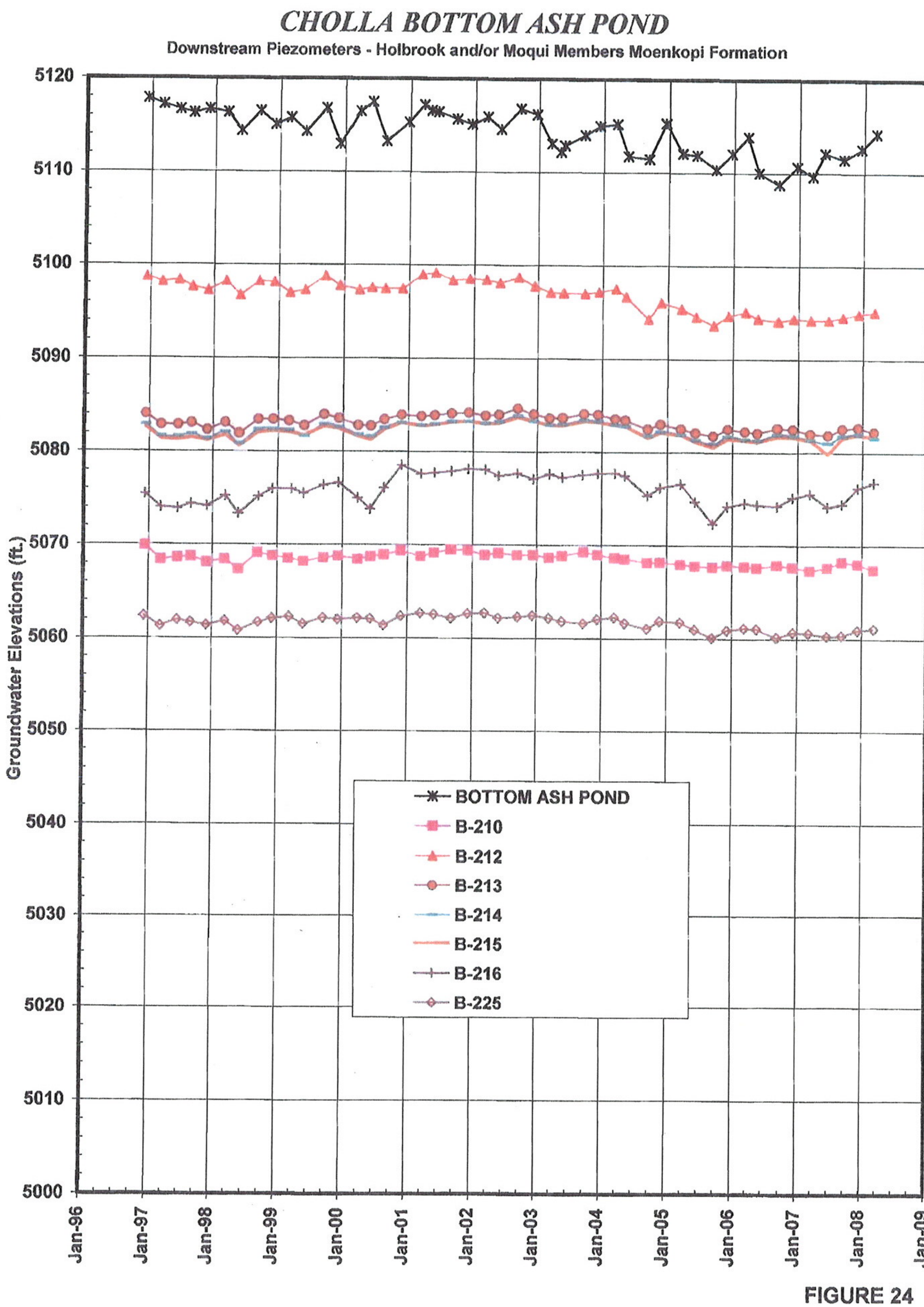

CHOLLA BOTTOM ASH POND
Downstream Piezometers - Holbrook and/or Moqui Members Moenkopi Formation
Groundwater Elevations (ft.)
5120
5110
5100
5090
5080
5070
5060
5050
5040
5030
5020
5010
5000
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
BOTTOM ASH POND
B-210
B-212
B-213
B-214
B-215
B-216
B-225

FIGURE 24

CHOLLA BOTTOM ASH POND

Downstream Piezometers - Alluvium and/or Moqui Member of Moenkopi Formation

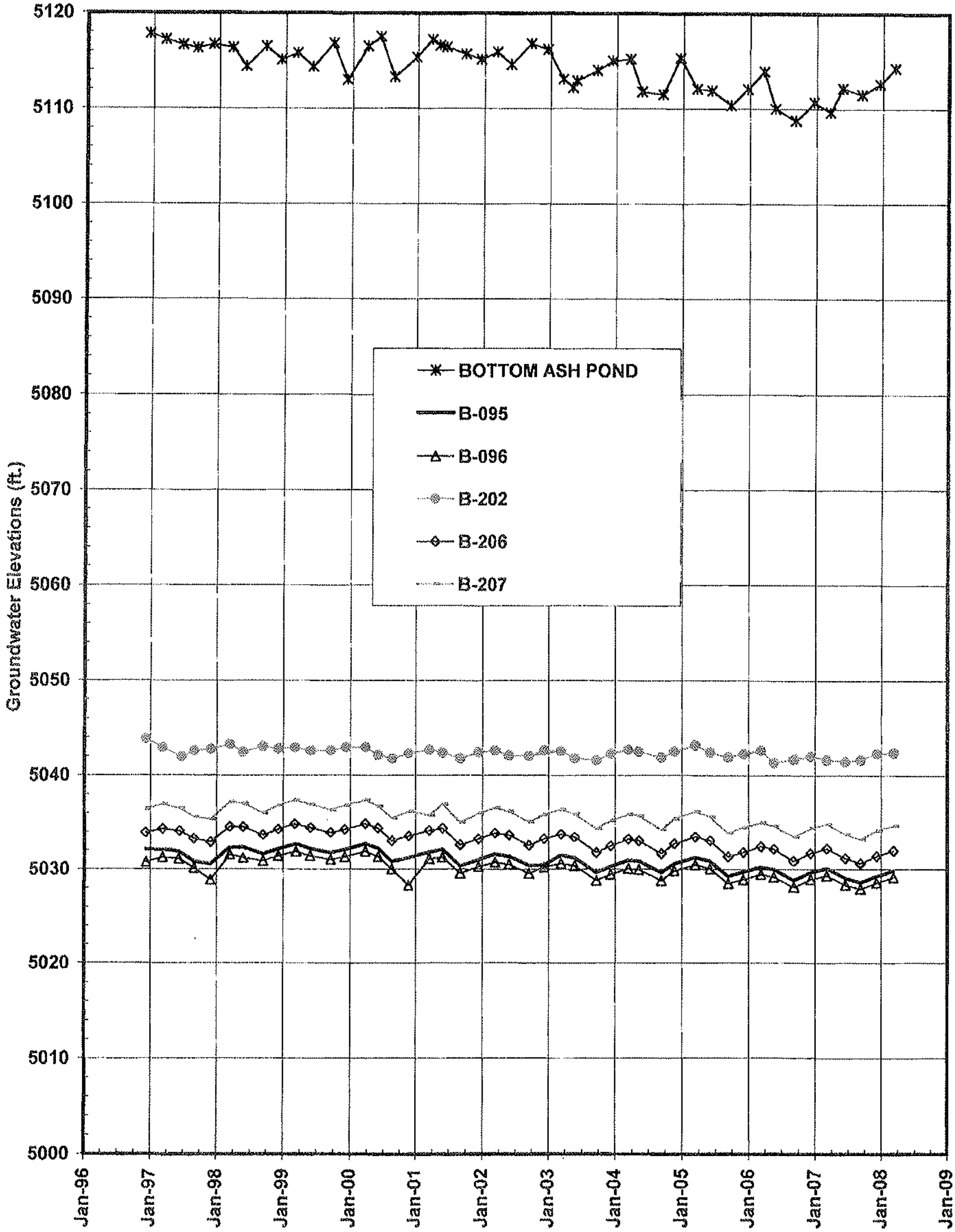


FIGURE 25

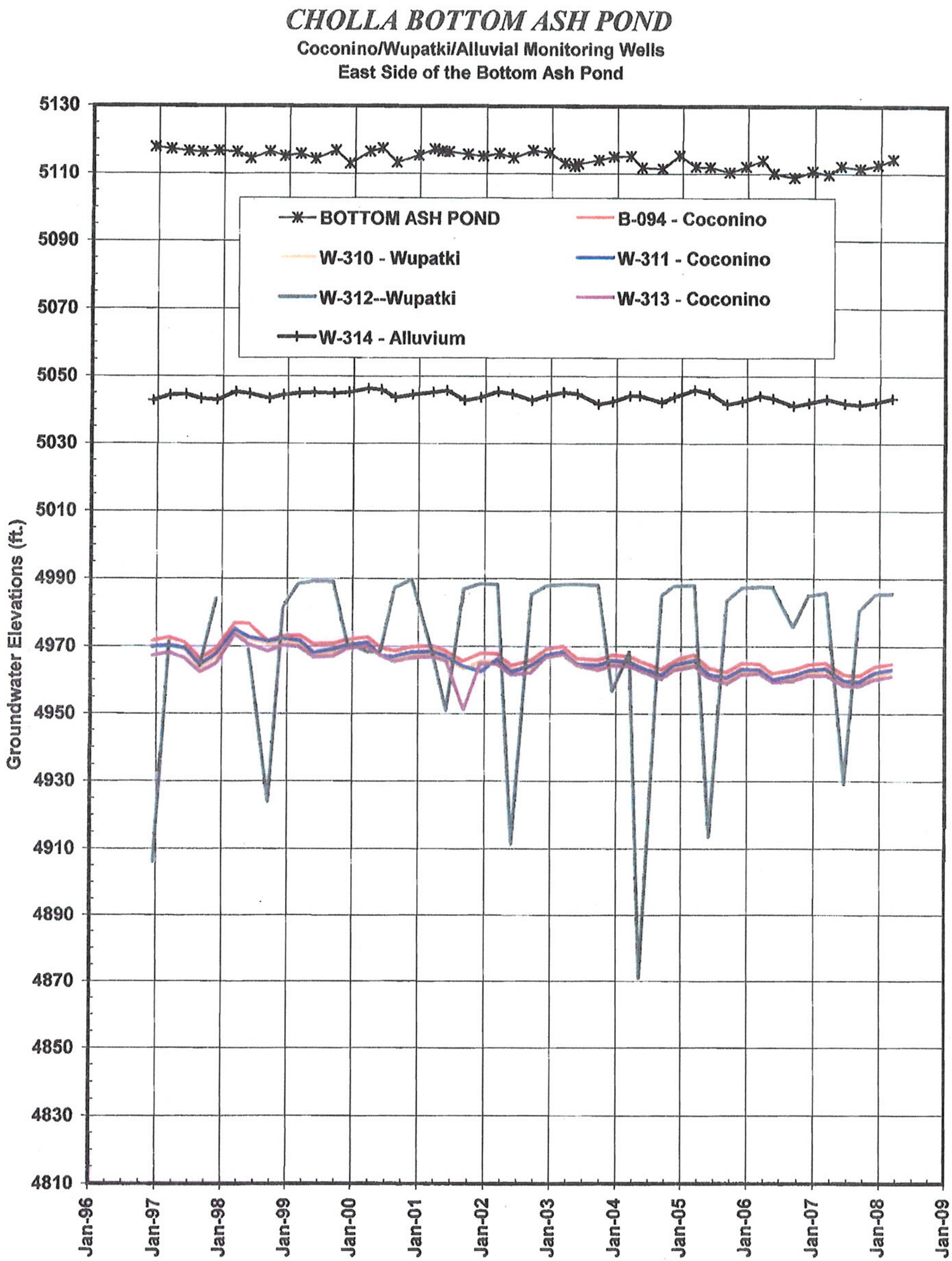

CHOLLA BOTTOM ASH POND
Coconino/Wupatki/Alluvial Monitoring Wells
East Side of the Bottom Ash Pond
BOTTOM ASH POND
B-094 - Coconino
W-310 - Wupatki
W-311 - Coconino
W-312--Wupatki
W-313 - Coconino
W-314 - Alluvium
Groundwater Elevations (ft.)
5130
5110
5090
5070
5050
5030
5010
4990
4970
4950
4930
4910
4890
4870
4850
4830
4810
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09

FIGURE 25A

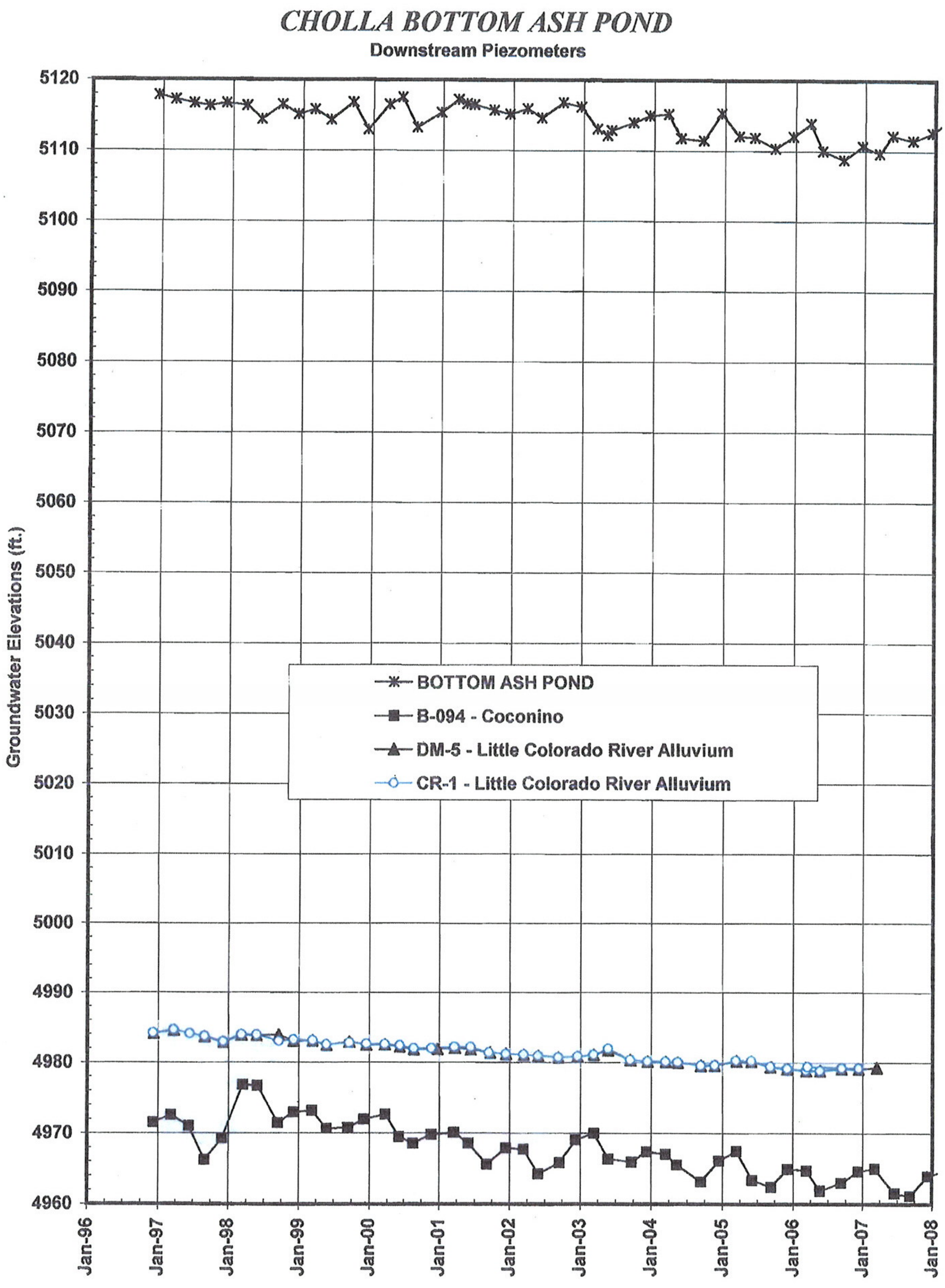

CHOLLA BOTTOM ASH POND
Downstream Piezometers
Groundwater Elevations (ft.)
5120
5110
5100
5090
5080
5070
5060
5050
5040
5030
5020
5010
5000
4990
4980
4970
4960
BOTTOM ASH POND
B-094 - Coconino
DM-5 - Little Colorado River Alluvium
CR-1 - Little Colorado River Alluvium
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08

FIGURE 26

CHOLLA BOTTOM ASH POND

Monitor Wells - Tanner Wash Alluvium or Moqui Member of Moenkopi Formation

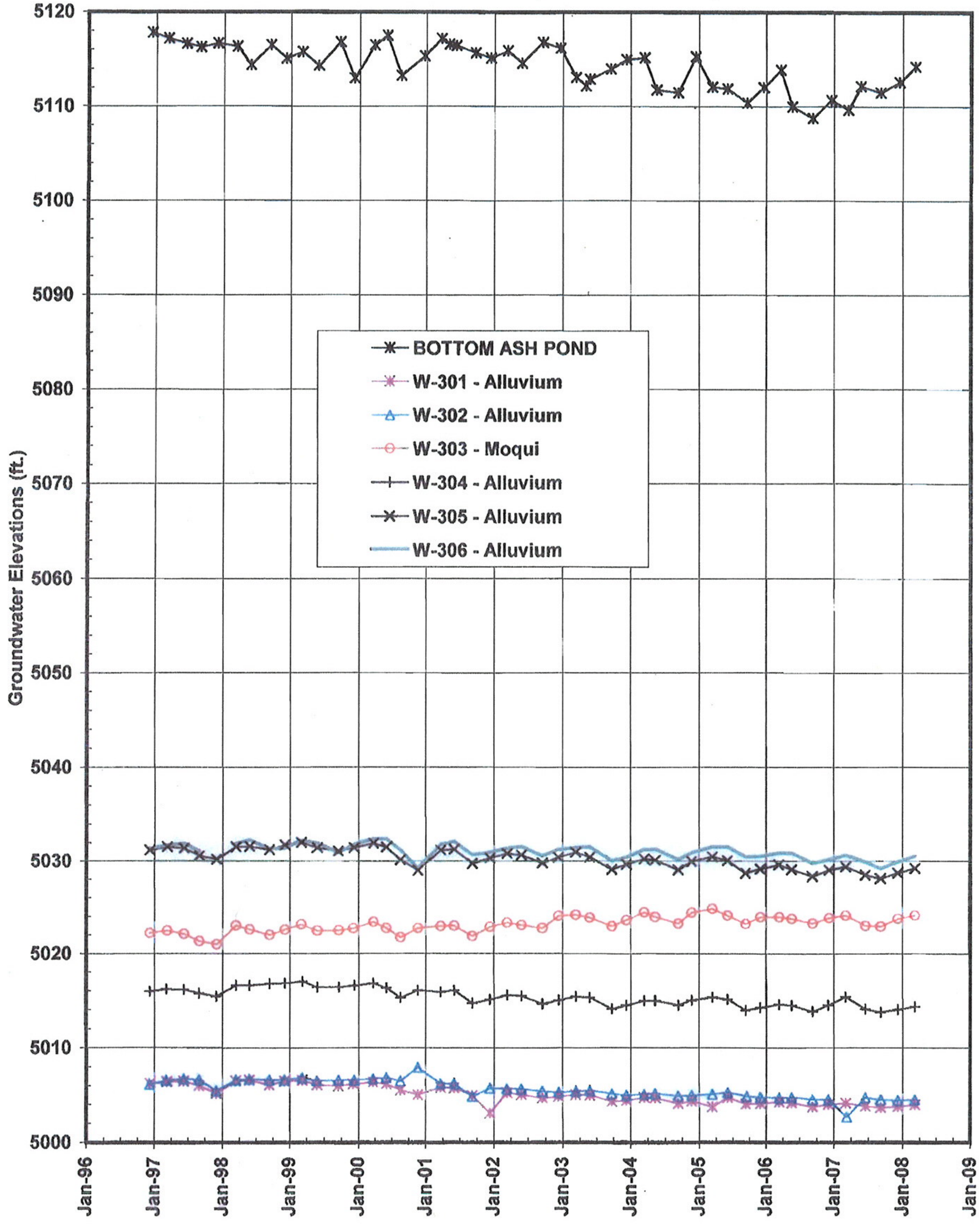


FIGURE 28

CHOLLA BOTTOM ASH POND

Monitor Wells - Tanner Wash Alluvium

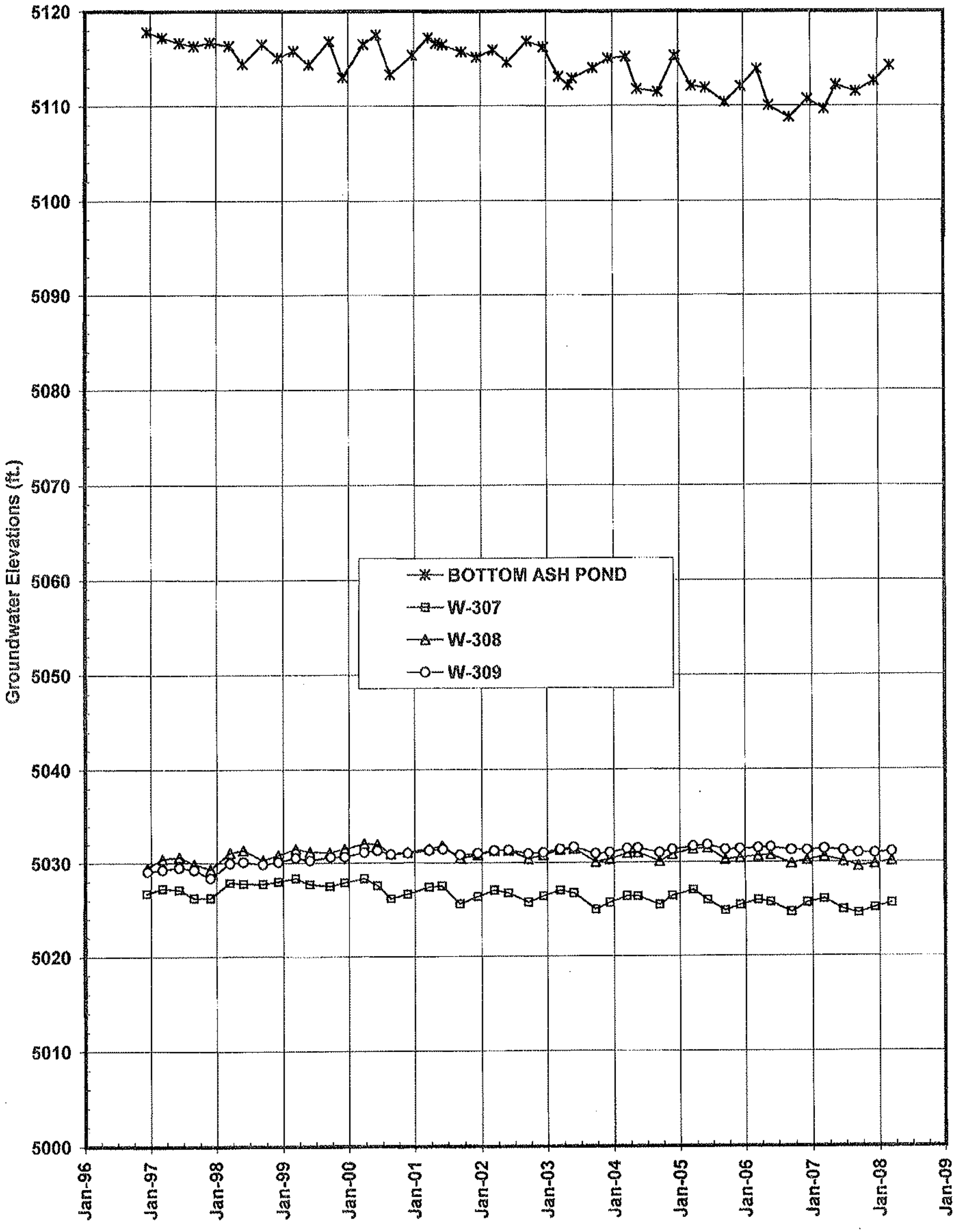
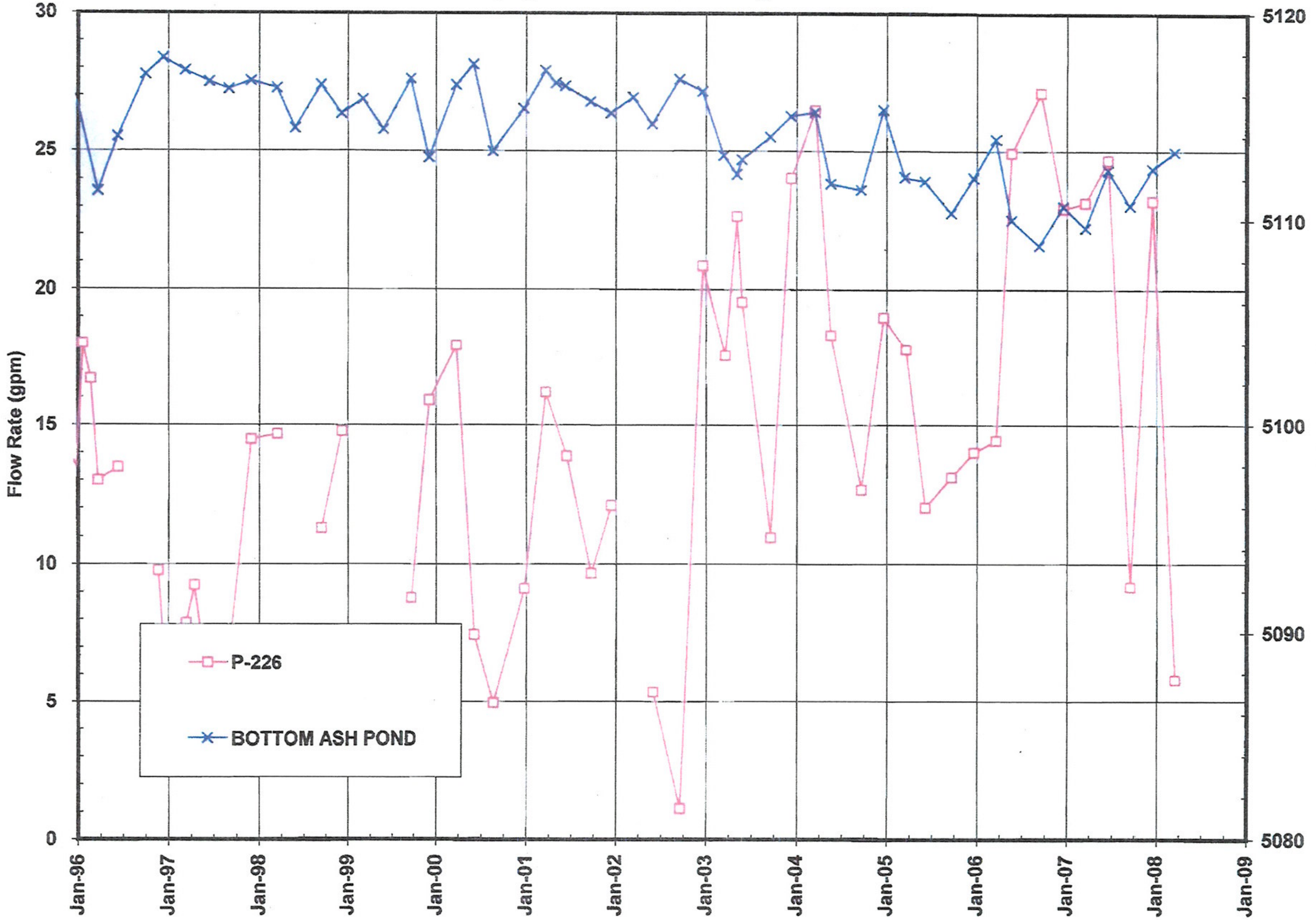


FIGURE 29

CHOLLA BOTTOM ASH DAM

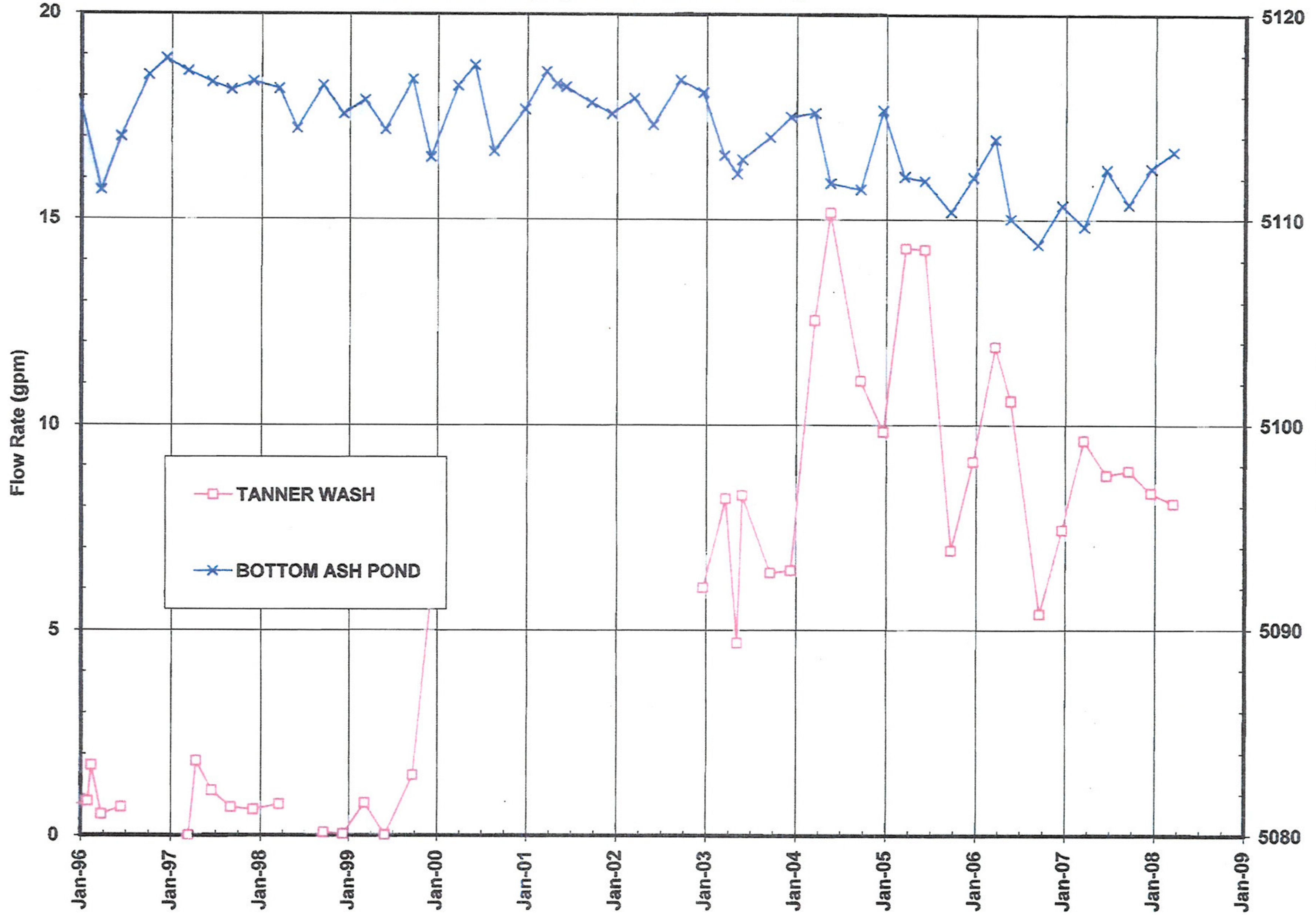
P-226 Pumping Station Totalizer Readings



GRAPH 31A

CHOLLA BOTTOM ASH DAM

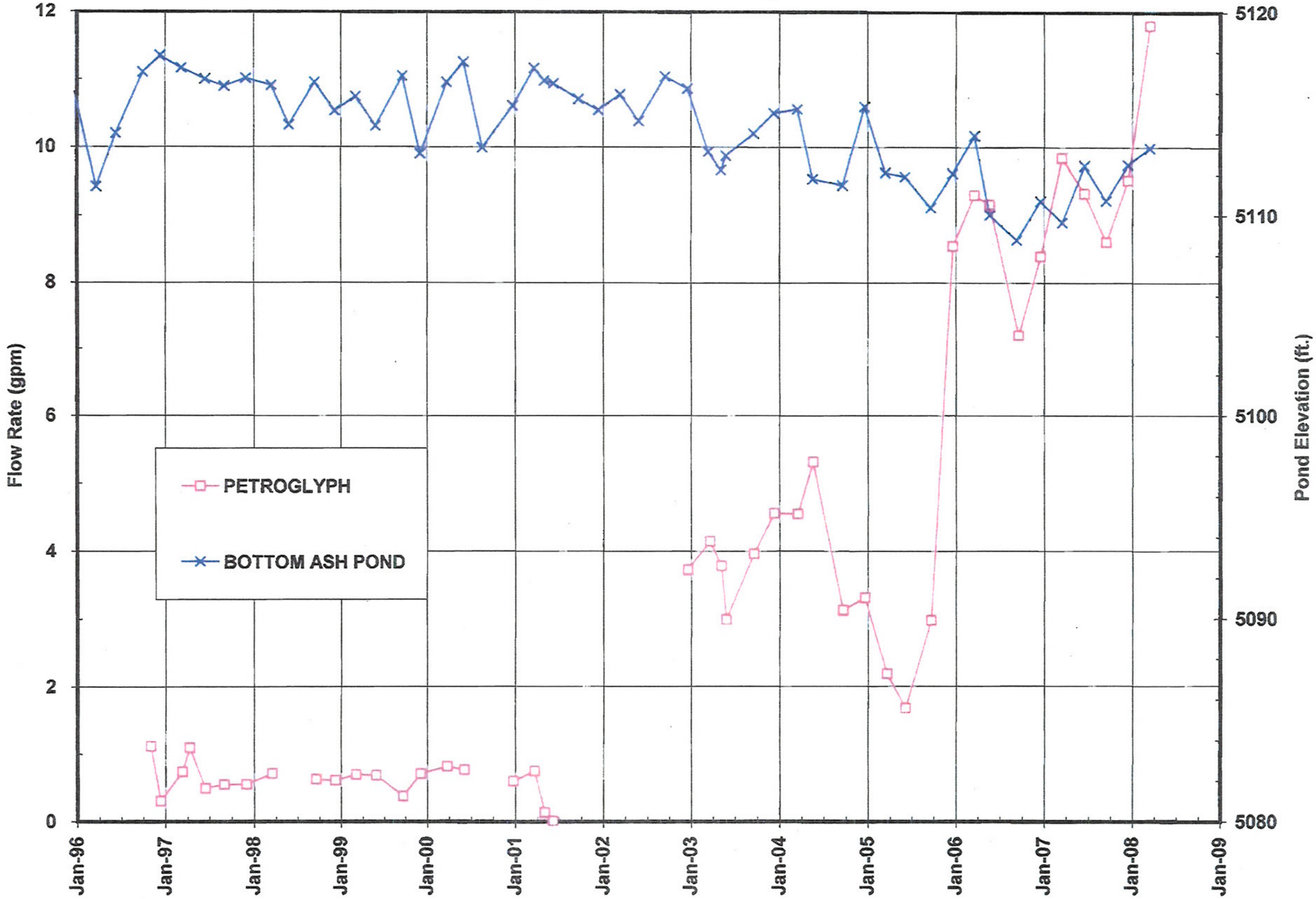
Tanner Wash Pumping Station Totalizer Readings



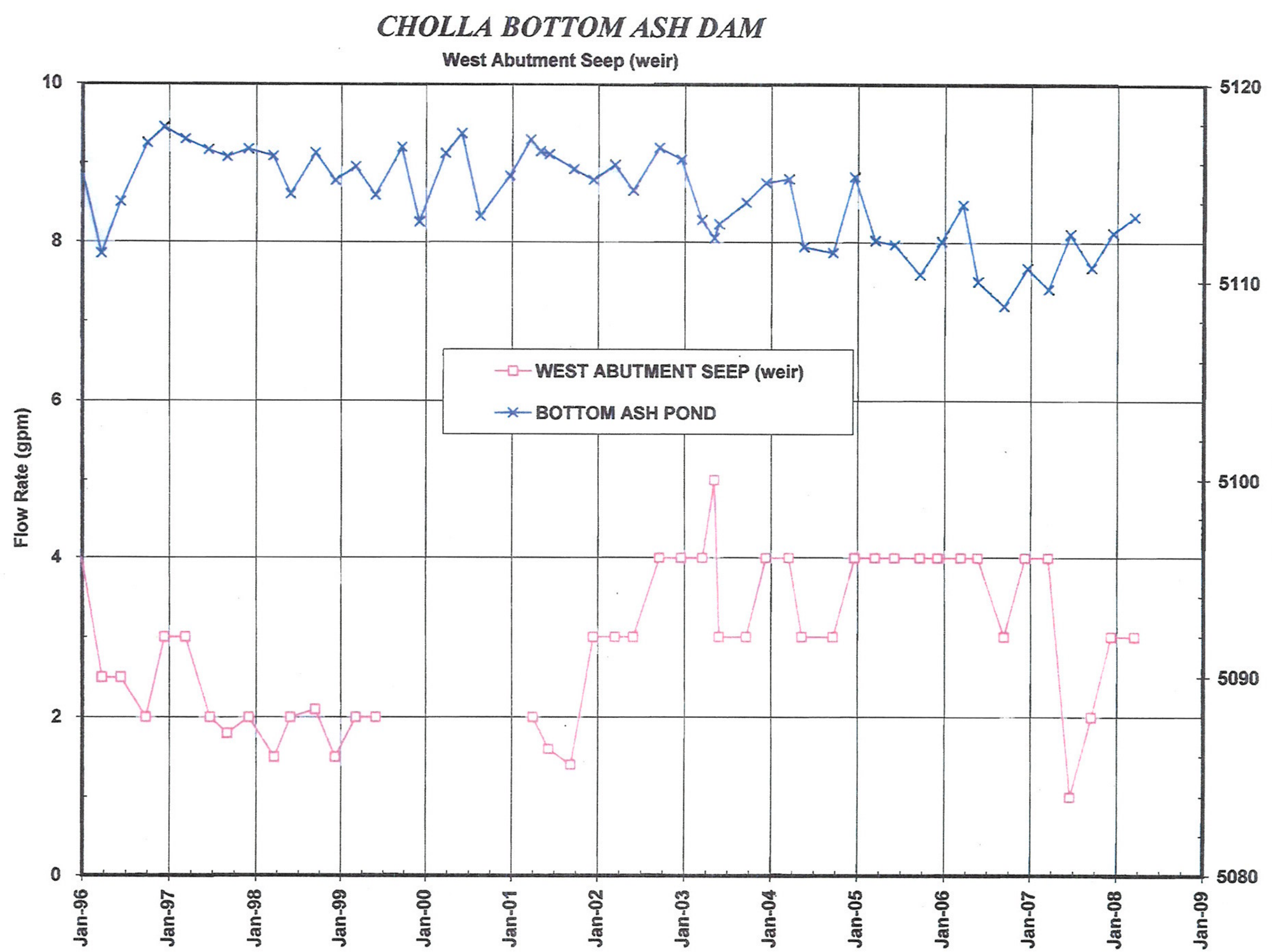
GRAPH 31C

CHOLLA BOTTOM ASH DAM

Petroglyph Pumping Station Totalizer Readings



GRAPH 31B

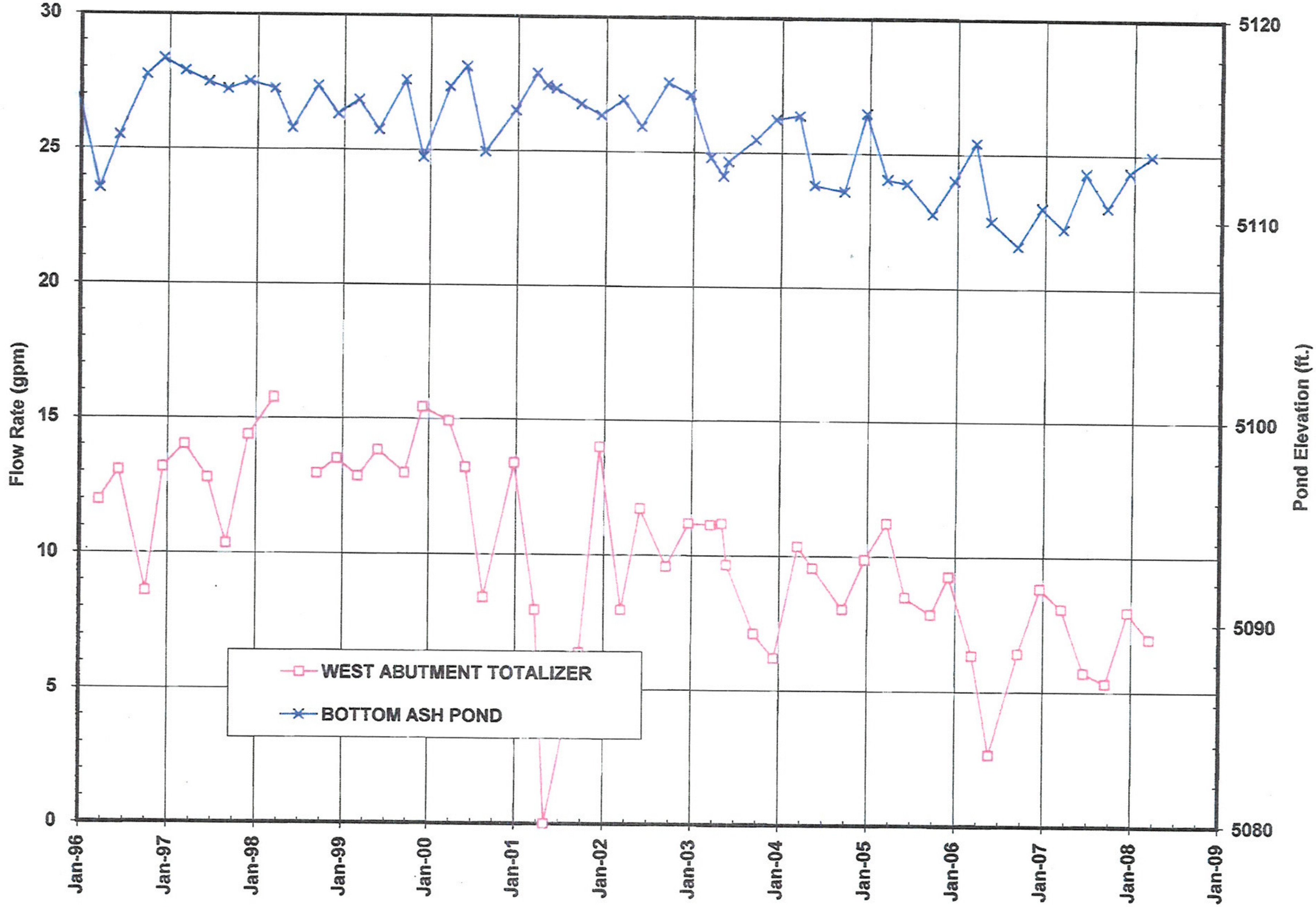


CHOLLA BOTTOM ASH DAM
West Abutment Seep (weir)
Flow Rate (gpm)
Pond Elevation (ft.)
WEST ABUTMENT SEEP (weir)
BOTTOM ASH POND
10
8
6
4
2
0
5120
5110
5100
5090
5080
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09

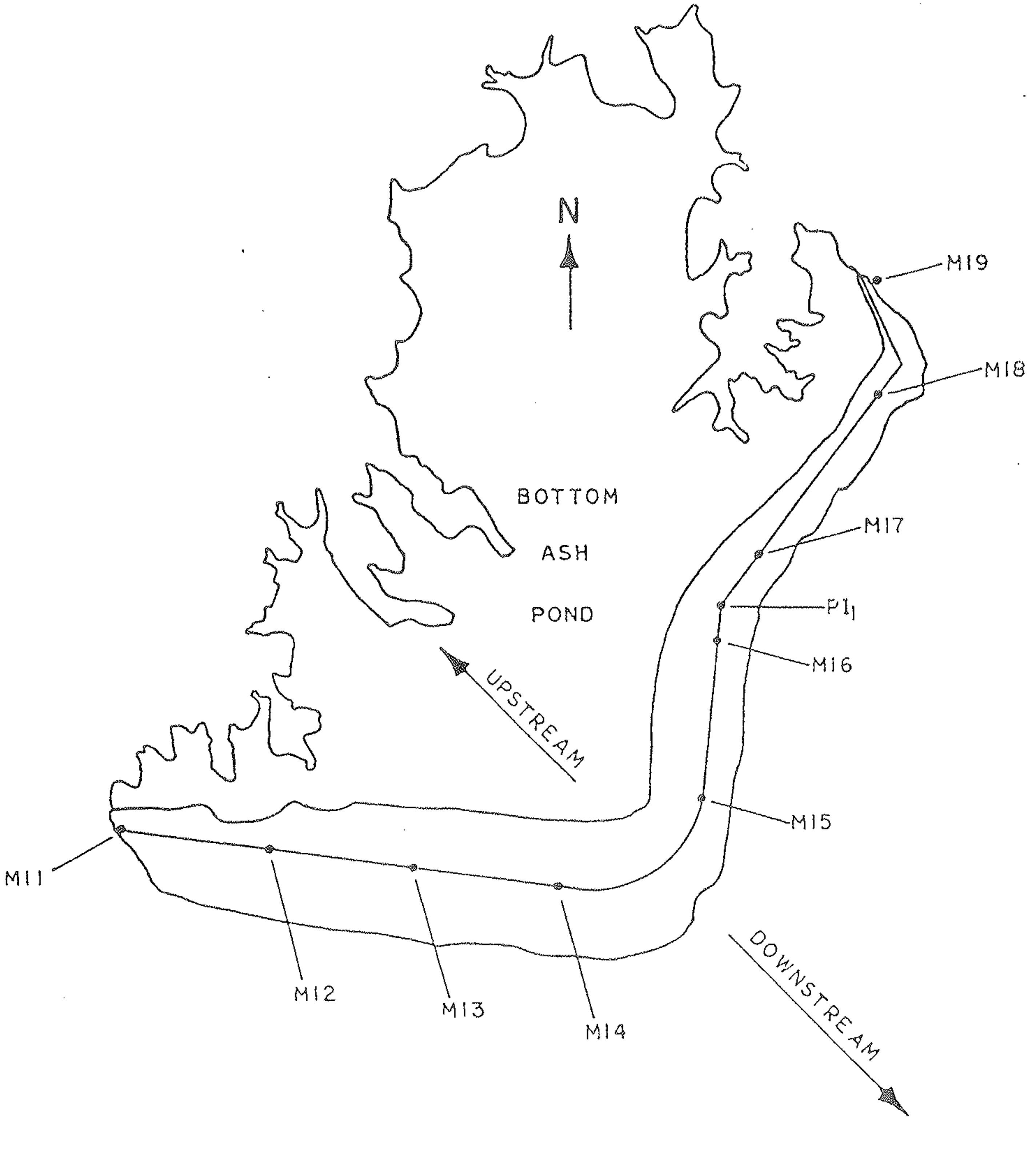
GRAPH 32

CHOLLA BOTTOM ASH DAM

West Abutment Pumping Station Totalizer Readings



GRAPH 36



CHOLLA BOTTOM ASH POND

MONUMENT LOCATION PLAN

FIGURE 37

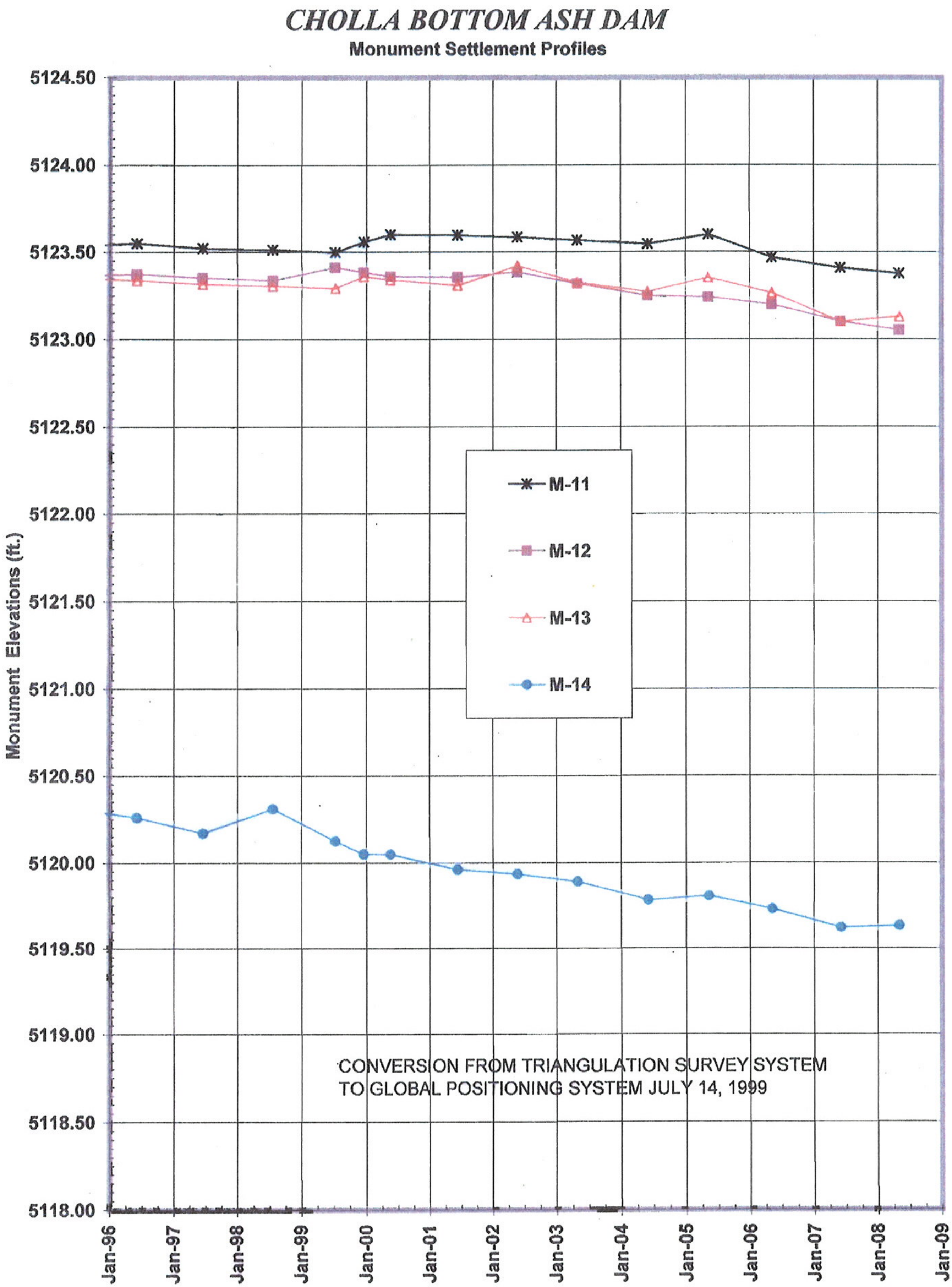

CHOLLA BOTTOM ASH DAM
Monument Settlement Profiles
Monument Elevations (ft.)
5124.50
5124.00
5123.50
5123.00
5122.50
5122.00
5121.50
5121.00
5120.50
5120.00
5119.50
5119.00
5118.50
5118.00
M-11
M-12
M-13
M-14
CONVERSION FROM TRIANGULATION SURVEY SYSTEM
TO GLOBAL POSITIONING SYSTEM JULY 14, 1999
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09

FIGURE 38

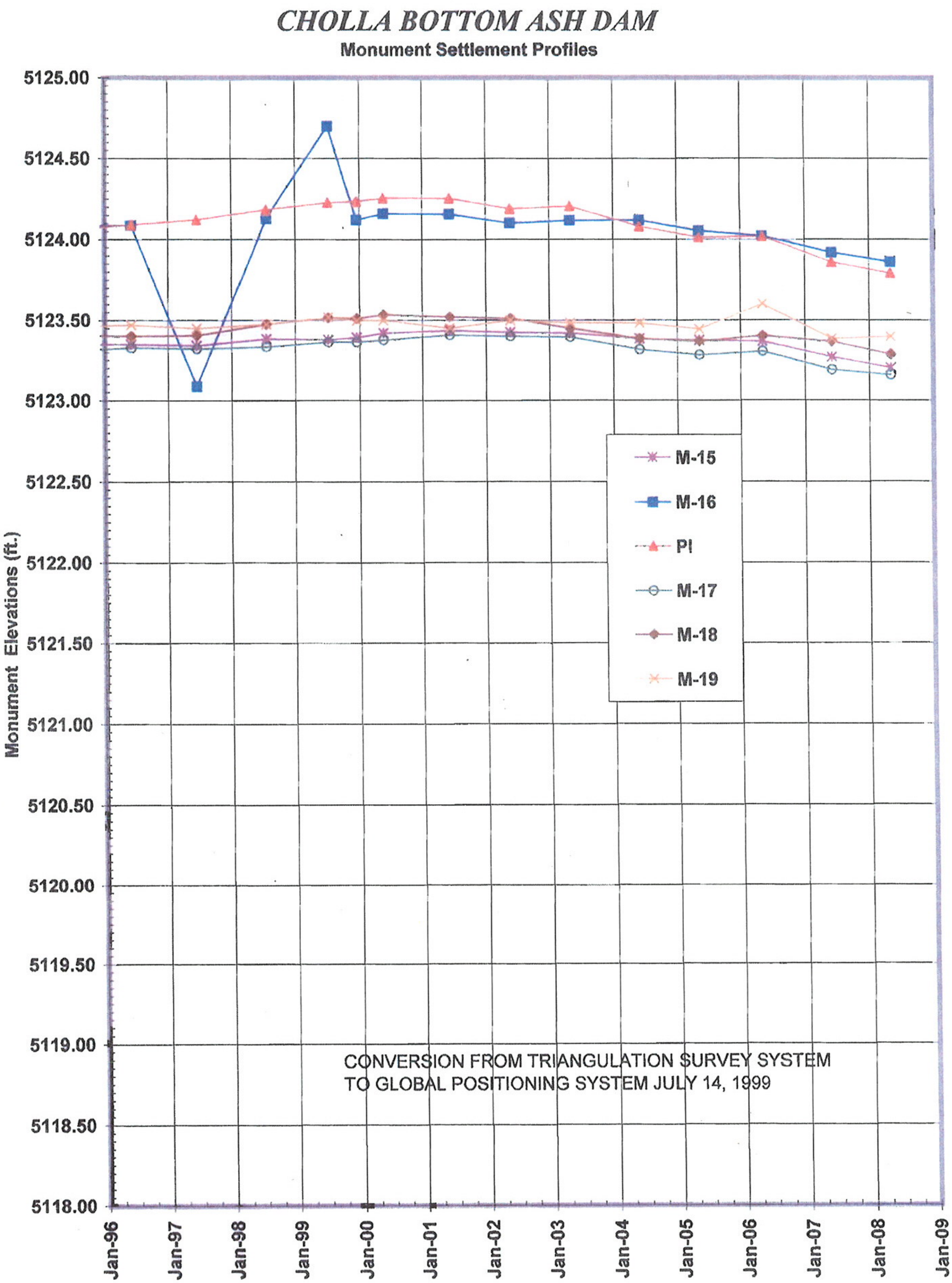

CHOLLA BOTTOM ASH DAM
Monument Settlement Profiles
Monument Elevations (ft.)
5125.00
5124.50
5124.00
5123.50
5123.00
5122.50
5122.00
5121.50
5121.00
5120.50
5120.00
5119.50
5119.00
5118.50
5118.00
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
M-15
M-16
PI
M-17
M-18
M-19
CONVERSION FROM TRIANGULATION SURVEY SYSTEM
TO GLOBAL POSITIONING SYSTEM JULY 14, 1999

FIGURE 39

CHOLLA BOTTOM ASH DAM

Horizontal Movement

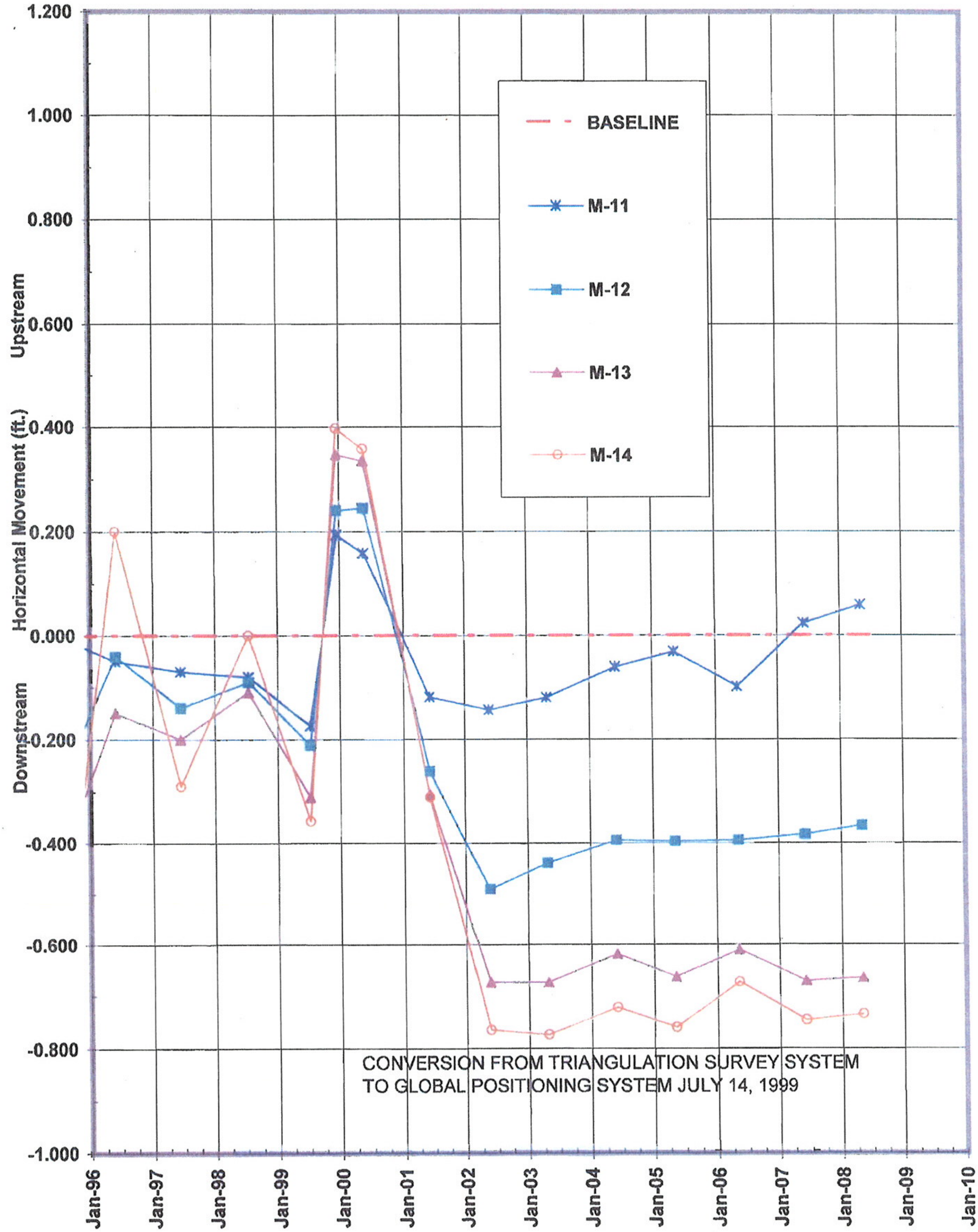


FIGURE 40

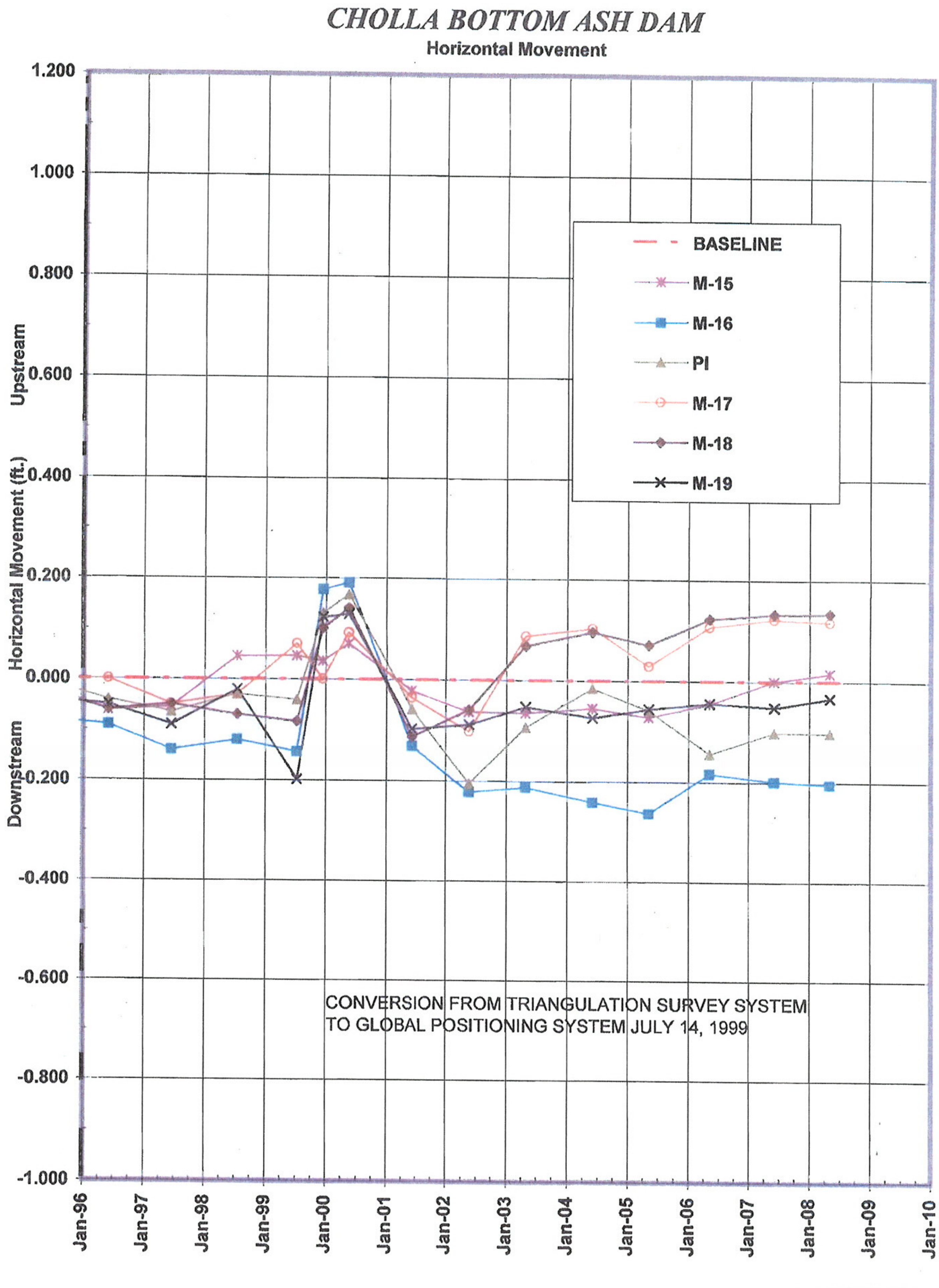

CHOLLA BOTTOM ASH DAM
Horizontal Movement
Upstream
Horizontal Movement (ft.)
Downstream
1.200
1.000
0.800
0.600
0.400
0.200
0.000
-0.200
-0.400
-0.600
-0.800
-1.000
BASELINE
M-15
M-16
PI
M-17
M-18
M-19
CONVERSION FROM TRIANGULATION SURVEY SYSTEM
TO GLOBAL POSITIONING SYSTEM JULY 14, 1999
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

FIGURE 40A

Appendix B

Inspection Checklists

September 2, 2009

Site Name: **Cholla Generating Station, Joseph City, AZ** Date: **Sept 2, 2009**

Unit Name: **Fly Ash Pond Dam** Operator's Name: **Arizona Public Service**

Unit ID: Hazard Potential Classification: **High** Significant Low

Inspector's Name: **Steve Townsley/GEI Consultants, Mary Nodine/GEI Consultants**

Check the appropriate box below, Provide comments when appropriate. If not applicable or not available, record "N/A", Any unusual conditions or construction practices that should be noted in the comments section, For large diked embankments, separate checklists may be used for different embankment areas. If separate forms are used, identify approximate area that the form applies to in comments.

	Yes	No		Yes	No
1. Frequency of Company's Dam Inspections?	Annual		18. Sloughing or bulging on slopes?		X
2. Pool elevation (operator records)?	5093.2		19. Major erosion or slope deterioration?		X
3. Decant inlet elevation (operator records)?	NA		20. Decant Pipes		
4. Open channel spillway elevation (operator records)?	NA		Is water entering inlet, but not exiting outlet?		X
5. Lowest dam crest elevation (operator records)?	5120		Is water exiting outlet, but not entering inlet?		X
6. If instrumentation is present, are readings recorded (operator records)?	X		Is water exiting outlet flowing clear?	NA	
7. Is the embankment currently under construction?		X	21. Seepage (specify location, if seepage carries fines, and approximate seepage rate below):		
8. Foundation preparation (remove vegetation, stumps, topsoil in area where embankment fill will be placed)?		X	From underdrain?		X
9. Trees growing on embankment? (If so, indicate largest diameter below.)		X	At isolated points on embankment slopes?		X
10. Cracks or scarps on crest?		X	At natural hillside in the embankment area?		X
11. Is there significant settlement along the crest?		X	Over widespread areas?		X
12. Are decant trashracks clear and in place?	NA		From downstream foundation area?	X	
13. Depressions or sink holes in tailings surface or whirlpool in the pool area		X	"Boils" beneath stream or ponded water?		X
14. Clogged spillways, groin or diversion ditches?		X	Around the outside of the decant pipe?		X
15. Are spillway or ditch linings deteriorated?		X	22. Surface movements in valley bottom or on hillside?		X
16. Are outlets of decant or underdrains blocked?		X	23. Water against downstream toe?		X
17. Cracks or scarps on slopes		X	24. Were Photos taken during the dam inspection?	X	

Major adverse changes in these items could cause instability and should be reported for further evaluation. Adverse conditions noted in these items should normally be described (extent, location, volume, etc.) in the space below and on the back of this sheet.

Inspection Issue #	Comments
21. Seepage locations beyond dam toe	**See discussion page 7**
9. Vegetation on upstream and downstream slopes	**Brush should be cleared during routine maintenance**

Coal Combustion Waste (CCW)
Impoundment Inspection

Impoundment NPDES Permit # **NA** INSPECTOR **Steve Townsley/GEI**

Date **Sept 2, 2009**

Impoundment Name **Fly Ash Pond Dam, Cholla Generating Station, Joseph City, AZ**

Impoundment Company **Arizona Public Service**

EPA Region **6**

State Agency (Field Office) Address **2225 W. Peoria Avenue, Phoenix, AZ 85029-4929**

Name of Impoundment **Fly Ash Pond Dam**
(Report each impoundment on a separate form under the same Impoundment NPDES Permit number)

New **X** Update ______

	Yes	No
Is impoundment currently under construction?		**X**
Is water or ccw currently being pumped into the impoundment?	**X**	

IMPOUNDMENT FUNCTION: **Fly Ash and Decant Water Storage**

Nearest Downstream Town: Name **Joseph City**
Distance from the impoundment **4 miles**

Impoundment Location:							
	Longitude	**34**	Degrees	**57**	Minutes	**22**	Seconds
	Latitude	**110**	Degrees	**20**	Minutes	**5**	Seconds
	State	**AZ**	County	**Navajo**			

Does a state agency regulate this impoundment? YES **X** NO ______

If So Which Sate Agency? **Arizona Department of Water Resources**

HAZARD POTENTIAL (In the event the impoundment should fail, the following would occur):

_____ **LESS THAN LOW** HAZARD POTENTIAL: Failure or misoperation of the dam results in no probable loss of human life or economic or environmental losses.

_____ **LOW HAZARD POTENTIAL:** Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

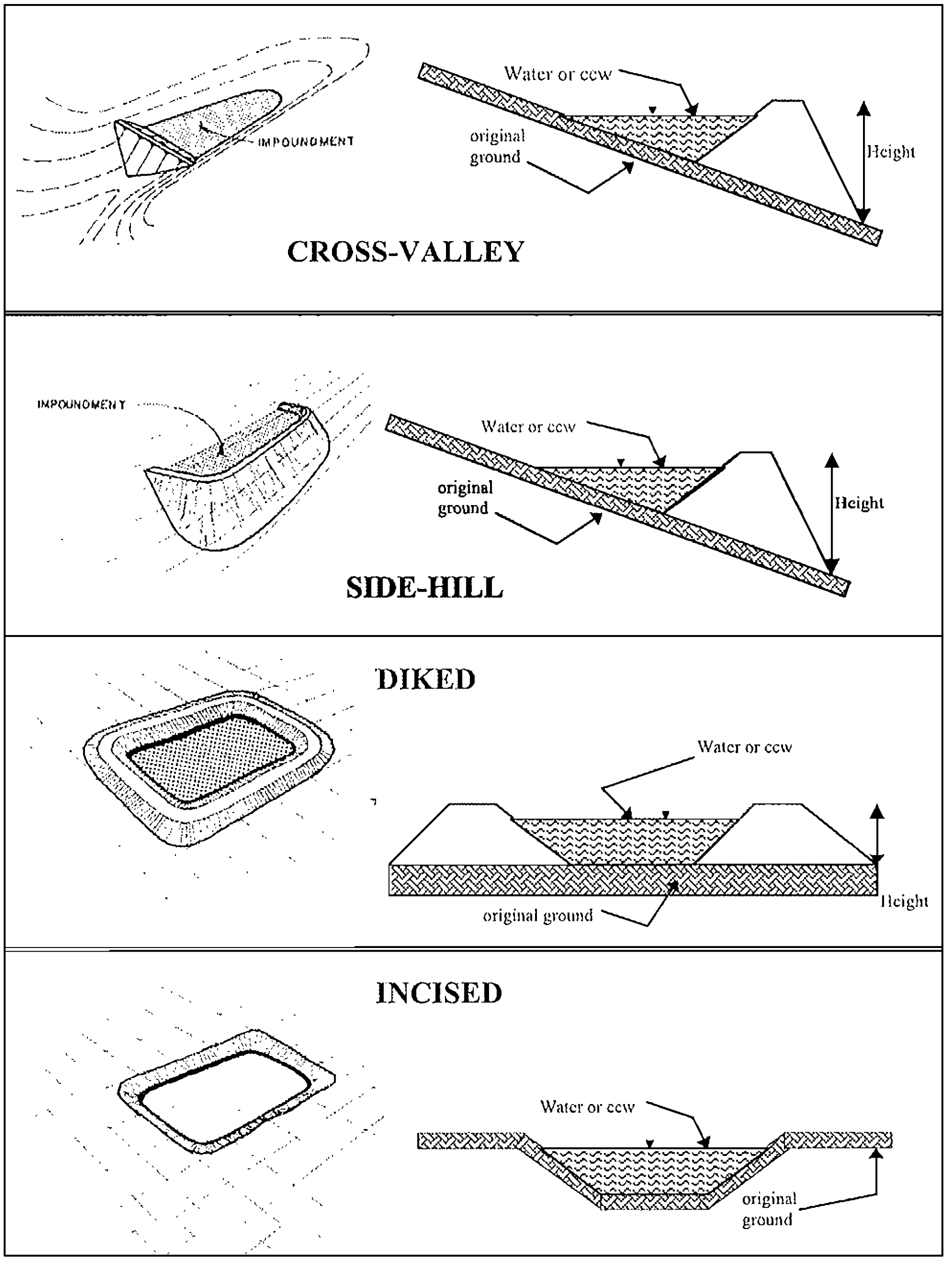
_____ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

__X__ **HIGH HAZARD POTENTIAL:** Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

DESCRIBE REASONING FOR HAZARD RATING CHOSEN:

A failure of the dam may cause inundation of Interstate 40, a freight railroad line and the APS Cholla Power Plant, all located just downstream of the Fly Ash Pond Dam. Flooding of these facilities would certainly cause significant economic losses and would likely cause loss of life.

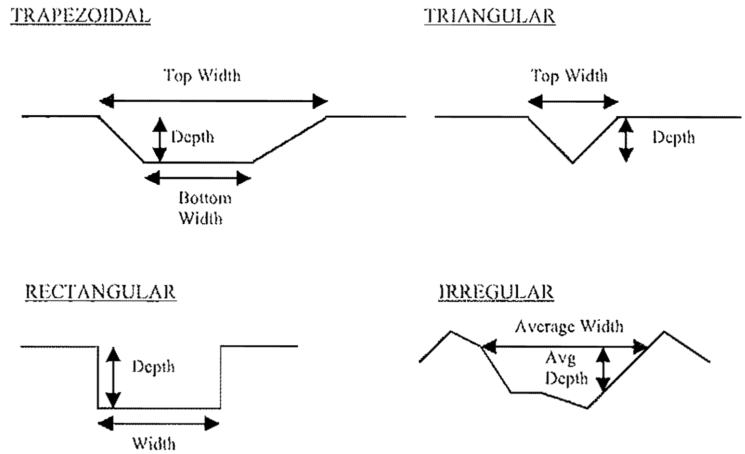
CONFIGURATION:



__X__ Cross-Valley
______ Side-Hill
______ Diked
______ Incised (form completion optional)
______ Combination Incised/Diked

Embankment Height _80__ feet   Embankment Material **Random earth shell with clay core**
Pool Area __420__ acres   Liner **None**
Current Freeboard _26.8_ ft   Liner Permeability **NA**

<u>TYPE OF OUTLET</u> (Mark all that apply)

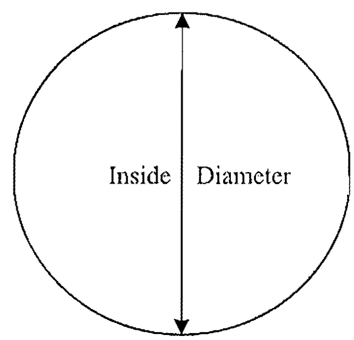


______ **Open Channel Spillway**
Trapezoidal
______ Triangular
______ Triangular

______ Depth
______ Bottom (or average) width
______ Top width

______ **Outlet**

______ inside diameter



Material
______ corrugated metal
______ welded steel
______ concrete
______ plastic (hdpe, pvc, etc.)
______ other (specify ________________

Is water flowing through the outlet? YES______ NO______

__X__ **No Outlet –**

______ **Other Type of Outlet (Specify)** ____

The Impoundment was designed By **Ebasco Services, Inc.**

Has there ever been a failure at this site? YES ______ NO __X__

If So When?____

If So Please Describe:

Has there ever been significant seepages at this site? YES __X__ NO______

If So When? **Monitored since 1993.**

If So Please Describe: **Several seepages have been identified in the dam foundation downstream of the toe. The seepages are monitored regularly and frequently. Cholla monitors the seepages mainly due to the environmental concerns associated with dam material entering into nearby waterways. Water is collected at these seepage locations and returned to the reservoir. The main seepages identified are listed below.**

Geronimo Seep: This seepage is located less than 50 feet beyond the downstream toe about 2000 feet from the right abutment. An underground French drain system and wellpoints have been installed to monitor and collect the seepage in this area This seepage is the nearest to the fly ash dam and is the most voluminous of the three major seeps and most likely the only one to influence dam stability. A maximum flow of 46.8 gpm has been measured at this seep since measurements began in November 1993. No flowing surface water was observed at the time of the dam assessment at this seep location. We will look closely at the data associated with this seep when we prepare our report to investigate whether it may negatively affect dam safety.

Hunt Seep: This seepage is located more than 1,500 feet beyond the downstream toe of the dam, across I-40. No flowing water was observed at the time of the dam assessment at this location. An underground French drain system is used to monitor and collect the seepage in this area. A maximum flow of 12.5 gpm has been measured at this seep since measurements began in March 1997.

I-40 Seep: This seepage is located less than 50 feet beyond the right abutment toe. Salt patches are visible and the soil at this location has been damp in the past, but no flowing surface water is associated with this seep.

Has there ever been any measures undertaken to monitor/lower Phreatic water table levels based on past seepages or breaches at this site? YES ______ NO__X___

If So which method (e.g., piezometers, gw pumping, …)? ________________________

If So Please Describe: ____

Site Name: Cholla Generating Station, Joseph City, AZ

Date: Sept 2, 2009

Unit Name: Bottom Ash Pond Dam

Operator's Name: Arizona Public Service

Unit ID:

Hazard Potential Classification: High Significant Low

Inspector's Name: Steve Townsley/GEI Consultants, Mary Nodine/GEI Consultants

Check the appropriate box below, Provide comments when appropriate. If not applicable or not available, record "N/A", Any unusual conditions or construction practices that should be noted in the comments section, For large diked embankments, separate checklists may be used for different embankment areas. If separate forms are used, identify approximate area that the form applies to in comments.

	Yes	No		Yes	No
1. Frequency of Company's Dam Inspections?	Annual		18. Sloughing or bulging on slopes?		X
2. Pool elevation (operator records)?	5111.3		19. Major erosion or slope deterioration?		X
3. Decant inlet elevation (operator records)?	NA		20. Decant Pipes		
4. Open channel spillway elevation (operator records)?	NA		Is water entering inlet, but not exiting outlet?		X
5. Lowest dam crest elevation (operator records)?	5123.3		Is water exiting outlet, but not entering inlet?		X
6. If instrumentation is present, are readings recorded (operator records)?	X		Is water exiting outlet flowing clear?	NA	
7. Is the embankment currently under construction?		X	21. Seepage (specify location, if seepage carries fines, and approximate seepage rate below):		
8. Foundation preparation (remove vegetation, stumps, topsoil in area where embankment fill will be placed)?		X	From underdrain?		X
9. Trees growing on embankment? (If so, indicate largest diameter below.)		X	At isolated points on embankment slopes?		X
10. Cracks or scarps on crest?		X	At natural hillside in the embankment area?		X
11. Is there significant settlement along the crest?		X	Over widespread areas?		X
12. Are decant trashracks clear and in place?	NA		From downstream foundation area?	X	
13. Depressions or sink holes in tailings surface or whirlpool in the pool area		X	"Boils" beneath stream or ponded water?		X
14. Clogged spillways, groin or diversion ditches?		X	Around the outside of the decant pipe?		X
15. Are spillway or ditch linings deteriorated?		X	22. Surface movements in valley bottom or on hillside?		X
16. Are outlets of decant or underdrains blocked?		X	23. Water against downstream toe?		X
17. Cracks or scarps on slopes		X	24. Were Photos taken during the dam inspection?	X	

Major adverse changes in these items could cause instability and should be reported for further evaluation. Adverse conditions noted in these items should normally be described (extent, location, volume, etc.) in the space below and on the back of this sheet.

Inspection Issue #	Comments
21. Seepage locations beyond dam toe	**See discussion page 7**
9. Vegetation on upstream and downstream slopes	**Brush should be cleared during routine maintenance**
2. North pond cells are partially filled with bottom ash	**Required freeboard should be calculated and maximum**
and do not contribute to reservoir storage.	**pool elevation revised based on reduced pond volume.**

Coal Combustion Waste (CCW)
Impoundment Inspection

Impoundment NPDES Permit # NA INSPECTOR Steve Townsley/GEI

Date Sept 2, 2009

Impoundment Name Bottom Ash Pond Dam, Cholla Generating Station, Joseph City, AZ

Impoundment Company Arizona Public Service

EPA Region 6

State Agency (Field Office) Address 2225 W. Peoria Avenue, Phoenix, AZ 85029-4929

Name of Impoundment Bottom Ash Pond Dam
(Report each impoundment on a separate form under the same Impoundment NPDES Permit number)

New X Update ______

	Yes	No
Is impoundment currently under construction?		X
Is water or ccw currently being pumped into the impoundment?	X	

IMPOUNDMENT FUNCTION: Bottom Ash and Decant Water Storage

Nearest Downstream Town: Name Joseph City
Distance from the impoundment 2 miles
Impoundment
Location:

Longitude	34	Degrees	57	Minutes	22	Seconds
Latitude	110	Degrees	20	Minutes	5	Seconds
State	AZ	County	Navajo			

Does a state agency regulate this impoundment? YES X NO ______

If So Which State Agency? Arizona Department of Water Resources

<u>HAZARD POTENTIAL</u> (In the event the impoundment should fail, the following would occur):

______ **LESS THAN LOW** HAZARD POTENTIAL: Failure or misoperation of the dam results in no probable loss of human life or economic or environmental losses.

______ **LOW HAZARD POTENTIAL:** Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

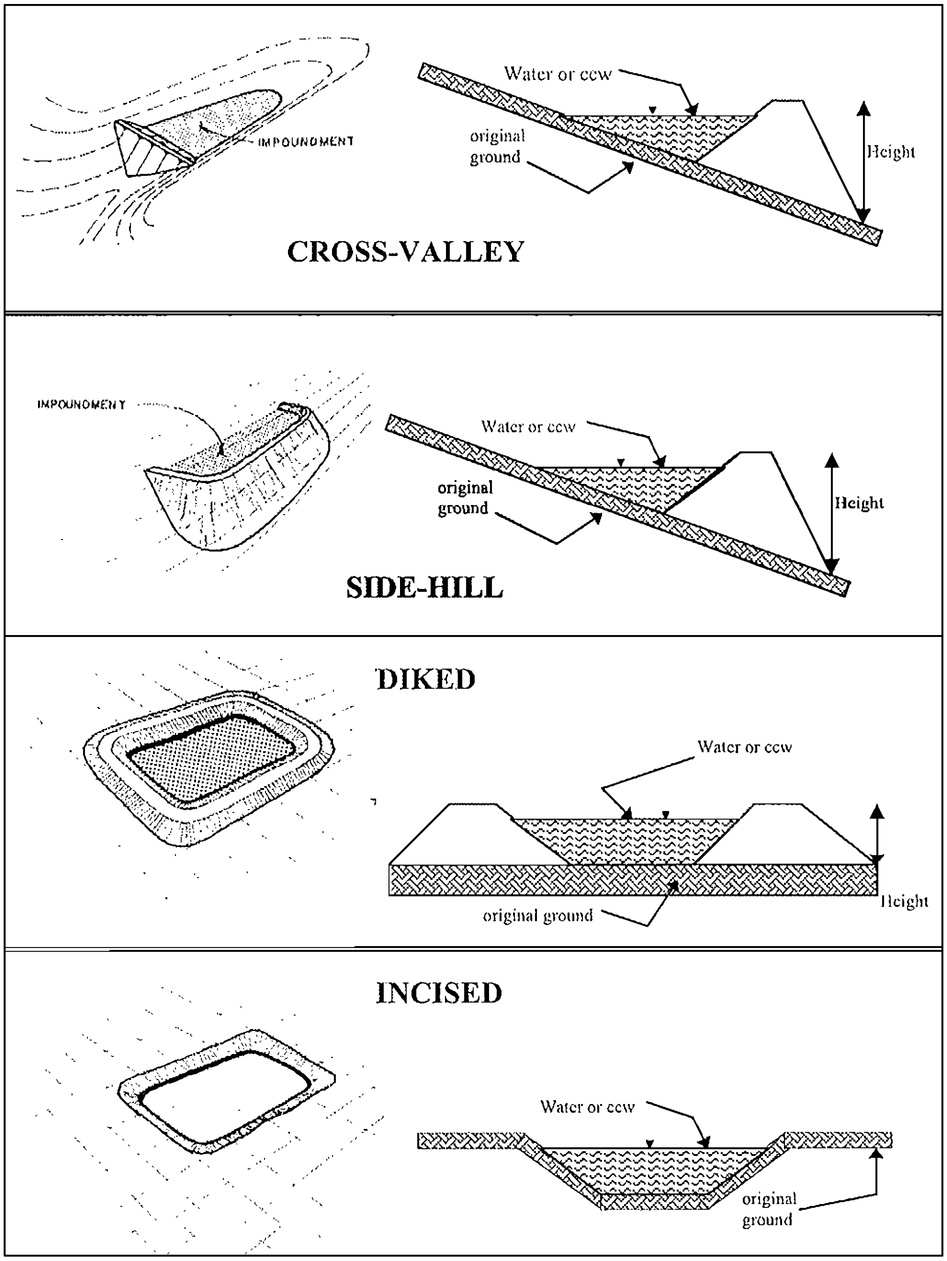
______ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

__X___ **HIGH HAZARD POTENTIAL:** Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

DESCRIBE REASONING FOR HAZARD RATING CHOSEN:

A failure of the dam may cause inundation of Interstate 40, a freight railroad line and the APS Cholla Power Plant, all located just downstream of the Bottom Ash Pond Dam. Flooding of these facilities would certainly cause significant economic losses and would likely cause loss of life.

CONFIGURATION:



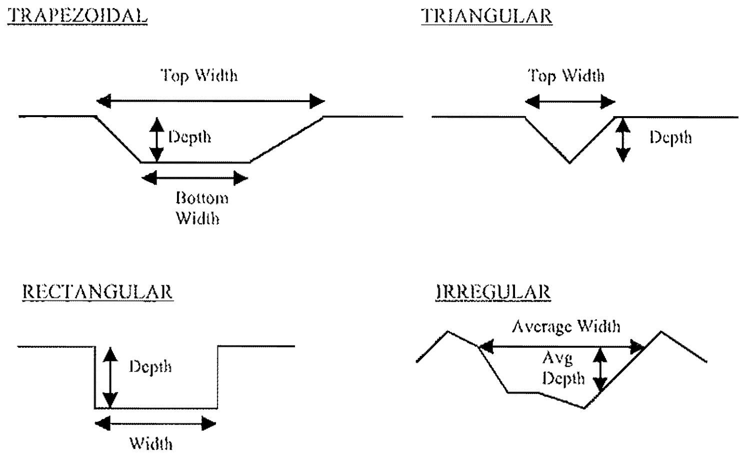
______ Cross-Valley
__X__ Side-Hill
______ Diked
______ Incised (form completion optional)
______ Combination Incised/Diked

Embankment Height _73_ feet   Embankment Material **Random earth shell with clay core**
Pool Area _80_ acres   Liner **None**
Current Freeboard _12.0_ ft   Liner Permeability **NA**

TYPE OF OUTLET (Mark all that apply)

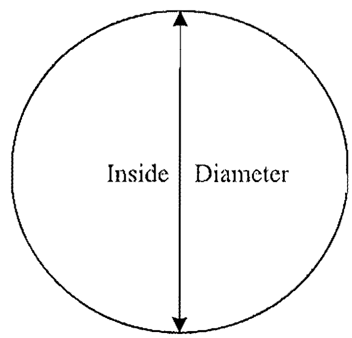
_____**Open Channel Spillway**
Trapezoidal
______ Triangular
______ Triangular

______Depth
______Bottom (or average) width
______Top width



X (4) **Outlet**

12 in inside diameter



Material
______ corrugated metal
______ welded steel
______ concrete
X plastic (hdpe, pvc, etc.)
______ other (specify ________________

Is water flowing through the outlet? YES X NO______

______**No Outlet –**

______ **Other Type of Outlet (Specify)** ____

The Impoundment was Designed By **Ebasco Services, Inc.**

Has there ever been a failure at this site? YES ______ NO __X__

If So When? ____________________

If So Please Describe: ____________________

Has there ever been significant seepages at this site? YES **X** NO______

If So When? **Monitored since 1993.**

If So Please Describe: **Several seepages have been identified in the dam foundation downstream of the toe. The seepages are monitored regularly and frequently. Cholla monitors the seepages mainly due to the environmental concerns associated with dam material entering into nearby waterways. Water is collected at these seepage locations and returned to the reservoir. The main seepages identified are listed below.**

West Abutment Seep: This seepage is located about 100 feet downstream of the west abutment toe. APS Cholla monitors the flow that daylights in this area using a weir, in addition to measuring the quantity collected via a French drain system several hundred feet east along the face. Water was observed flowing through the weir at the time of our site visit, and a rough measurement indicated the flow at this time was less than 2 gpm. The quantity of flow measured in the weir was about 2.7 gpm the last time it was read in June 2009, and has been 5 gpm or less since readings began in January 1996, with the exception of readings in 2000 when the log indicates that the weir overflowed. The flow measured in the French drain has had a maximum of 15.8 gpm since measurements began in December 1995. Of the four seepages monitored by APS Cholla, the West Abutment Seep is the nearest to the Bottom Ash Dam and most likely the only one with potential to influence dam stability. We will look closely at the data associated with this seep when we prepare our report to investigate whether it may negatively affect dam safety.

Tanner Wash Seep: This seepage is located about 350 feet beyond the left abutment of the dam. Seepage is collected via an underground French drain system. The water collected is regularly tested for turbidity due to its proximity to Tanner Wash to the west, and no significant quantity of turbidity has been measured. Flowing surface water was observed at the location of this seep at the time of our assessment. A maximum flow of 15.2 gpm has been measured at this seep since measurements began in January 1994.

Petroglyph Seep: This seepage is located south of the Tanner Wash Seep, about 150

feet beyond the dam toe. It is also collected by an underground French drain system. Flowing surface water was observed at the location of this seep at the time of our assessment. A maximum flow of 12.6 gpm has been measured at this seep since measurements began in December 1993.

P-226 Seep: This seepage is located about 250 feet beyond the left abutment toe. Seepage is collected by an underground French drain system. No surface water was present at this seep at the time of our site visit, and no flow has been measured in this seep since March of 2008. A maximum flow of 27.1 gpm has been measured at this seep since measurements began in December 1993.

Has there ever been any measures undertaken to monitor/lower Phreatic water table levels based on past seepages or breaches at this site? YES ______ NO__X___

If So which method (e.g., piezometers, gw pumping, …)? ______________________

If So Please Describe:

Appendix C

Inspection Photographs

September 2, 2009

Photo 1: Fly Ash Pond - Overview looking north from embankment. Note downstream fly ash beach.

Photo 2: Fly Ash Pond Dam - Crest of embankment with dirt road, looking east.

Photo 3: Movement monument on Fly Ash Pond Dam.

Photo 4: Crest of Fly Ash Pond Dam with piezometer, looking east at bend in embankment.

Photo 5: Fly Ash Pond Dam - Upstream slope, looking west. Note vegetation.

Photo 6: Fly Ash Pond Dam - Slurry discharge point on upstream face.

Photo 7: Fly Ash Pond Dam - Downstream slope, looking west. Note vegetation.

Photo 8: Fly Ash Pond Dam - Slurry pipes on downstream face.

Photo 9: Bottom Ash Pond - Main reservoir, looking southwest from left abutment.

Photo 10: Bottom Ash Pond - Main Reservoir, looking west along upstream face of dam.

Photo 11: Bottom Ash Pond - East cell with drained bottom ash. Note construction operations moving bottom ash to monofill.

Photo 12: Bottom Ash Pond - West cell, which is currently being filled with bottom ash slurry. Note vortex through which water flows to main reservoir.

Photo 13: Bottom Ash Pond - Monofill for final storage of drained bottom ash.

Photo 14: Bottom Ash Pond - Drainage way for overflow water from upstream cells to main reservoir.

Photo 15: Bottom Ash Pond Dam - Crest of embankment with dirt road, looking west.

Photo 16: Bottom Ash Pond Dam - Crest near left abutment with dam raise visible.

Photo 17: Bottom Ash Pond Dam - Upstream slope, looking east.

Photo 18: Bottom Ash Pond - Downstream slope looking west.

Photo 19: Fly Ash Pond - Salt patch associated with seepage near right abutment toe (known as the "Hoodoo Salt Patch").

Photo 20: Fly Ash Pond - Tamarisks near downstream toe indicating seepage.

Photo 21: Fly Ash Pond - Evaporation Pond for I-40 Seep.

Photo 22: Fly Ash Pond - Seepage collection system for Geronimo Seep.

Photo 23: Fly Ash Pond - Seepage collection system for Geronimo Seep.

Photo 24: Fly Ash Pond - Hunt Seep area. Note seepage collection system on left. Also note the highway embankment seen on the top left of this photo.

Photo 25: Bottom Ash Pond - West Abutment Seep from embankment crest. Siphon pipes (center) and siphon collection system (lower left) are also visible.

Photo 26: Bottom Ash Pond - Weir at West Abutment Seep.

Photo 27: Bottom Ash Pond - Seepage collection system at West Abutment Seep.

Photo 28: Bottom Ash Pond - Overview of West Abutment Seep area, looking from weir east toward seepage collection sump.

Photo 29: Bottom Ash Pond - Seepage collection system for Tanner Wash Seep.

Photo 30: Bottom Ash Pond - Salt patches at Tanner Wash Seep.

Photo 31: Bottom Ash Pond - Flowing surface water at Tanner Wash Seep.

Photo 32: Bottom Ash Pond - Tanner Wash.

Photo 33: Bottom Ash Pond - Seepage collection system for Petroglyph Seep.

Photo 34: Bottom Ash Pond - Flowing surface water at Petroglyph Seep.

Photo 35: Fly Ash Pond - Buoy marking 300-foot distance from area where cracks were observed in embankment crest. Fly ash beach must extend upstream of this distance.

Photo 36: Bottom Ash Pond - Floating siphon pipes to return water from main reservoir to power plant – upstream side of dam.

Photo 37: Bottom Ash Pond - Siphon pipes extending along downstream slope of dam.

Photo 38: Bottom Ash Pond - Siphon collection station at toe of dam.

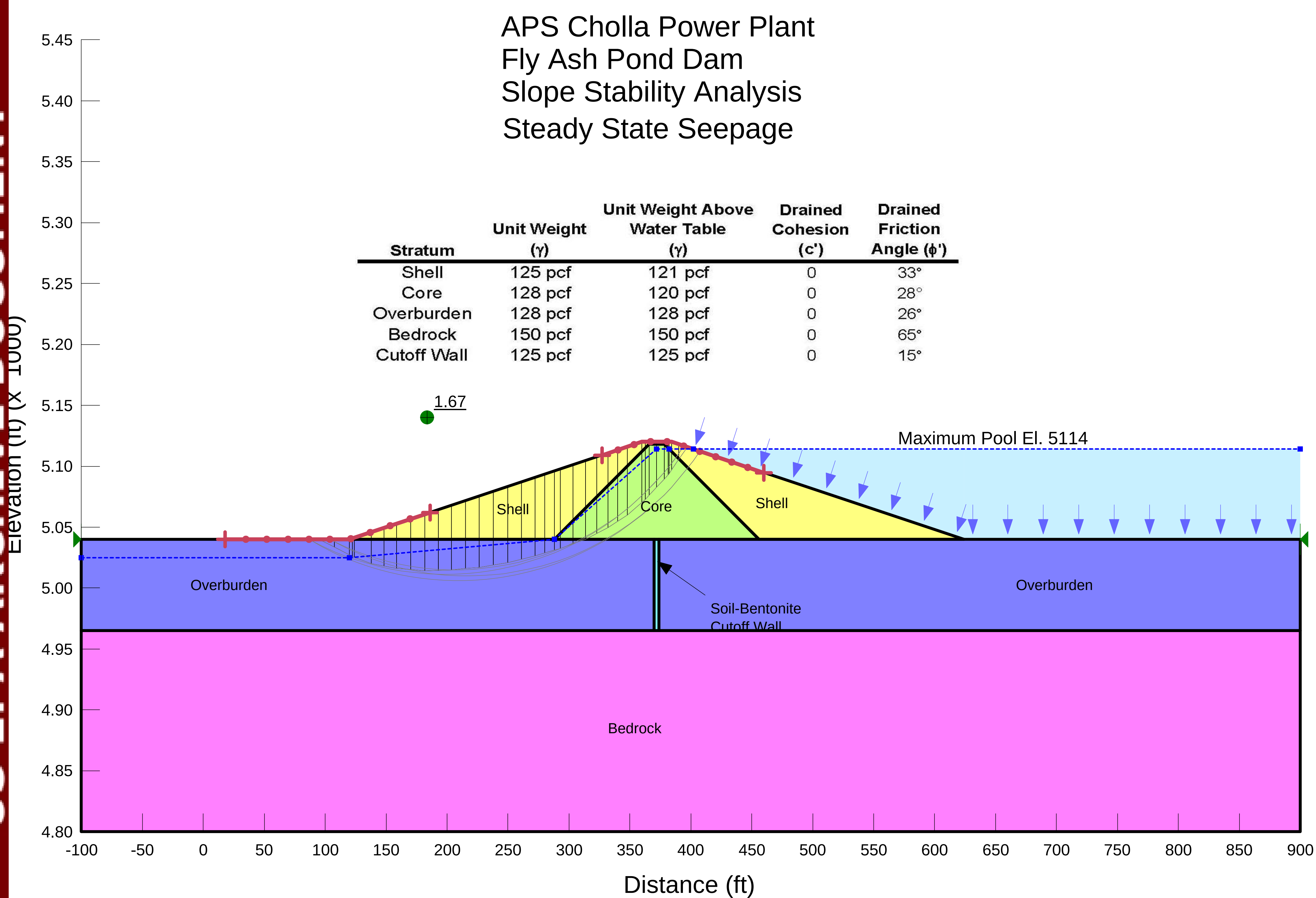
Photo 39: Bottom Ash Pond - Siphon pipes extending along downstream slope, and siphon collection station.

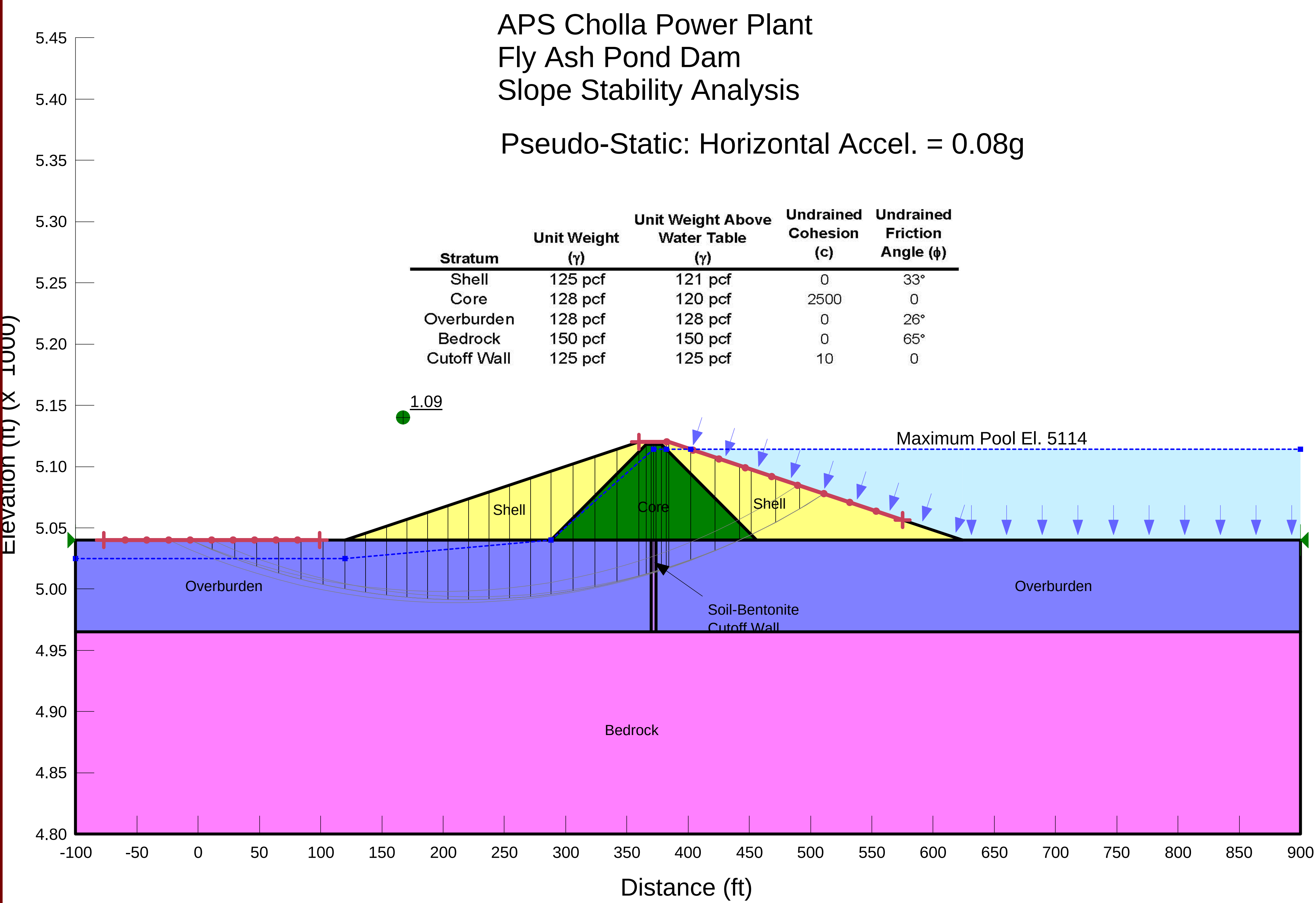
Appendix D

Stability Analyses

APS Cholla Power Plant
Fly Ash Pond Dam
Slope Stability Analysis
Steady State Seepage

Stratum	Unit Weight (γ)	Unit Weight Above Water Table (γ)	Drained Cohesion (c')	Drained Friction Angle (ϕ')
Shell	125 pcf	121 pcf	0	33°
Core	128 pcf	120 pcf	0	28°
Overburden	128 pcf	128 pcf	0	26°
Bedrock	150 pcf	150 pcf	0	65°
Cutoff Wall	125 pcf	125 pcf	0	15°



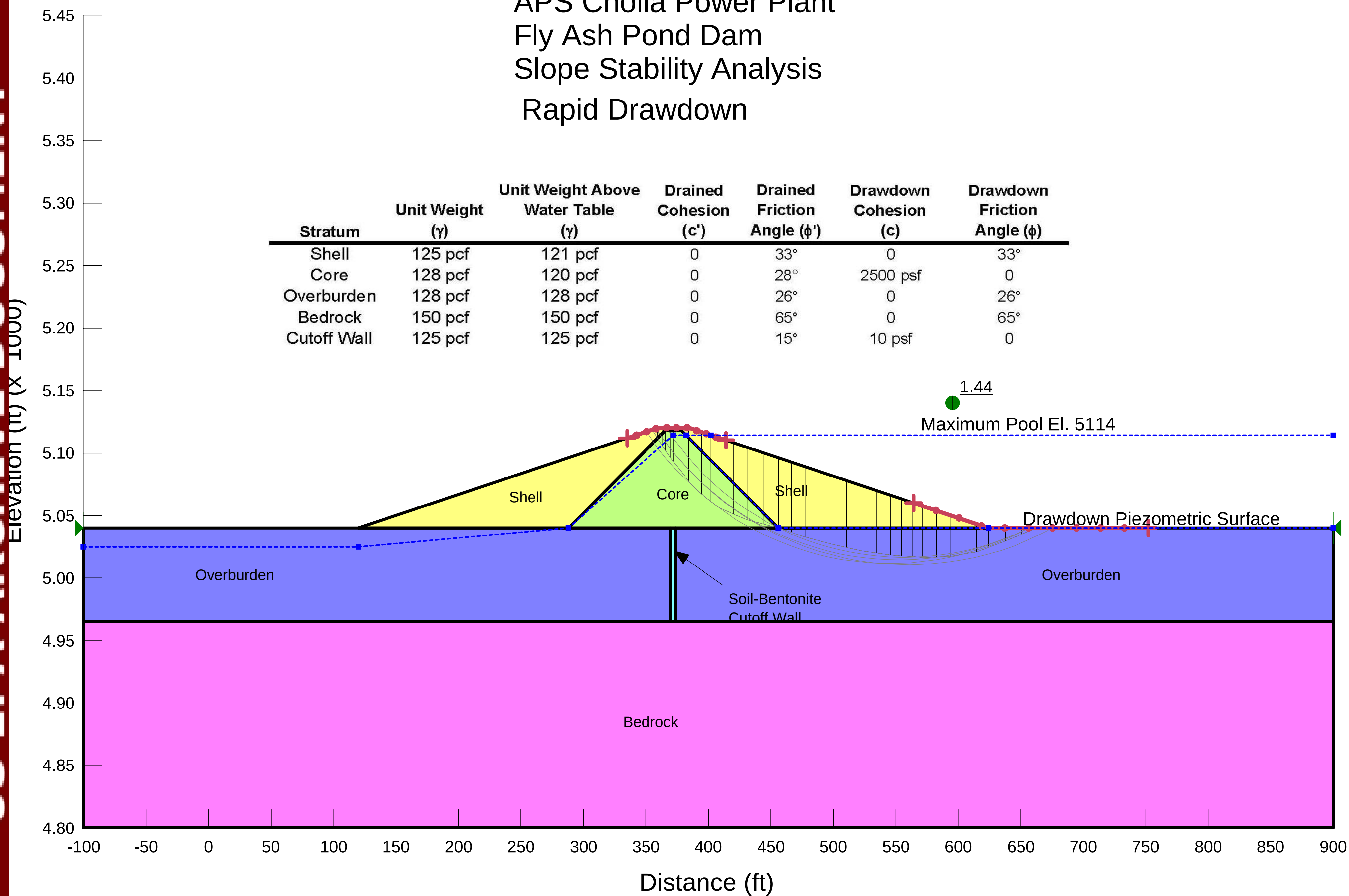


Stratum	Unit Weight (γ)	Unit Weight Above Water Table (γ)	Undrained Cohesion (c)	Undrained Friction Angle (ϕ)
Shell	125 pcf	121 pcf	0	33°
Core	128 pcf	120 pcf	2500	0
Overburden	128 pcf	128 pcf	0	26°
Bedrock	150 pcf	150 pcf	0	65°
Cutoff Wall	125 pcf	125 pcf	10	0

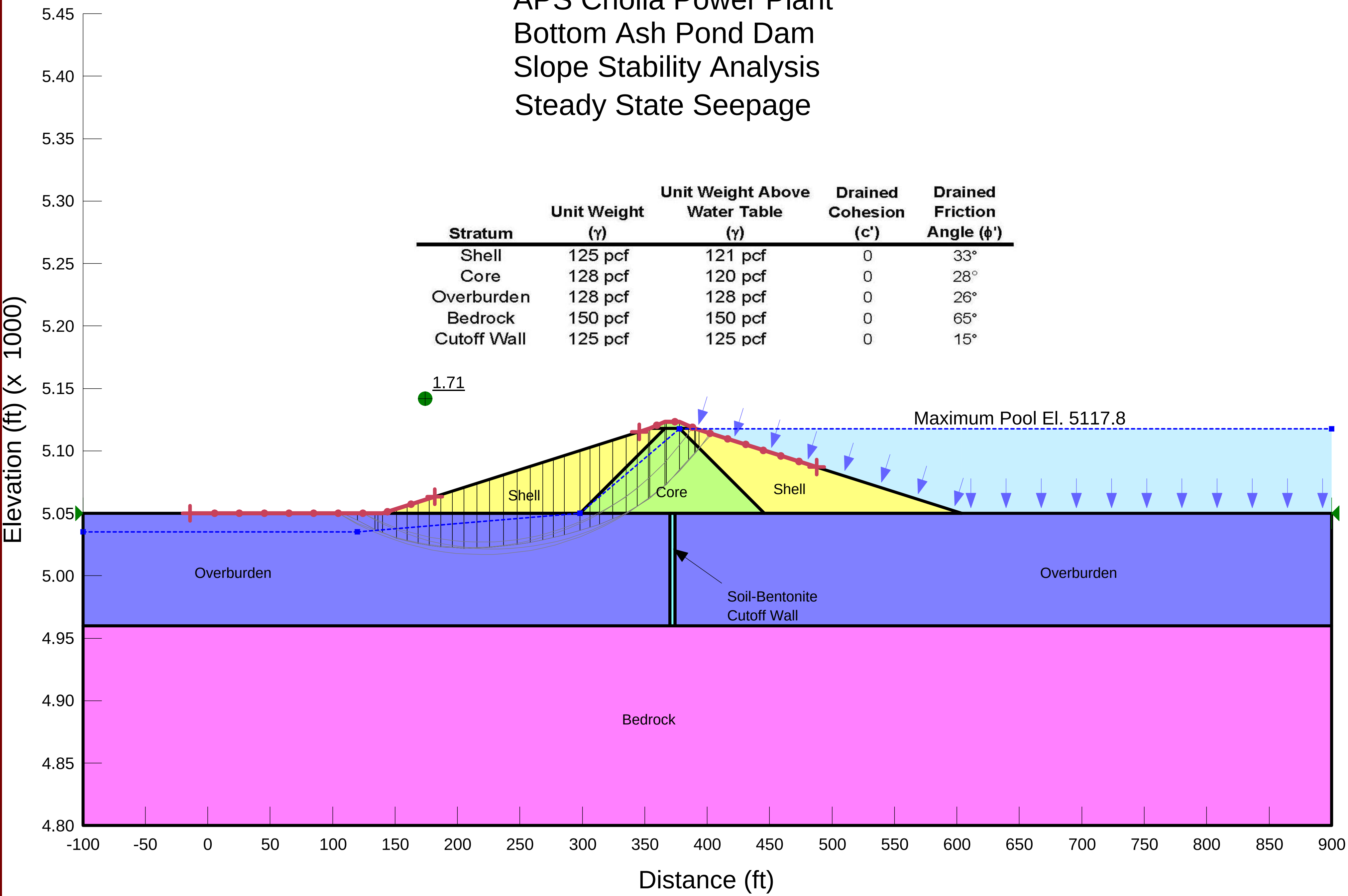
APS Cholla Power Plant
Fly Ash Pond Dam
Slope Stability Analysis

Rapid Drawdown

Stratum	Unit Weight (γ)	Unit Weight Above Water Table (γ)	Drained Cohesion (c')	Drained Friction Angle (ϕ')	Drawdown Cohesion (c)	Drawdown Friction Angle (ϕ)
Shell	125 pcf	121 pcf	0	33°	0	33°
Core	128 pcf	120 pcf	0	28°	2500 psf	0
Overburden	128 pcf	128 pcf	0	26°	0	26°
Bedrock	150 pcf	150 pcf	0	65°	0	65°
Cutoff Wall	125 pcf	125 pcf	0	15°	10 psf	0



APS Cholla Power Plant
Bottom Ash Pond Dam
Slope Stability Analysis
Steady State Seepage

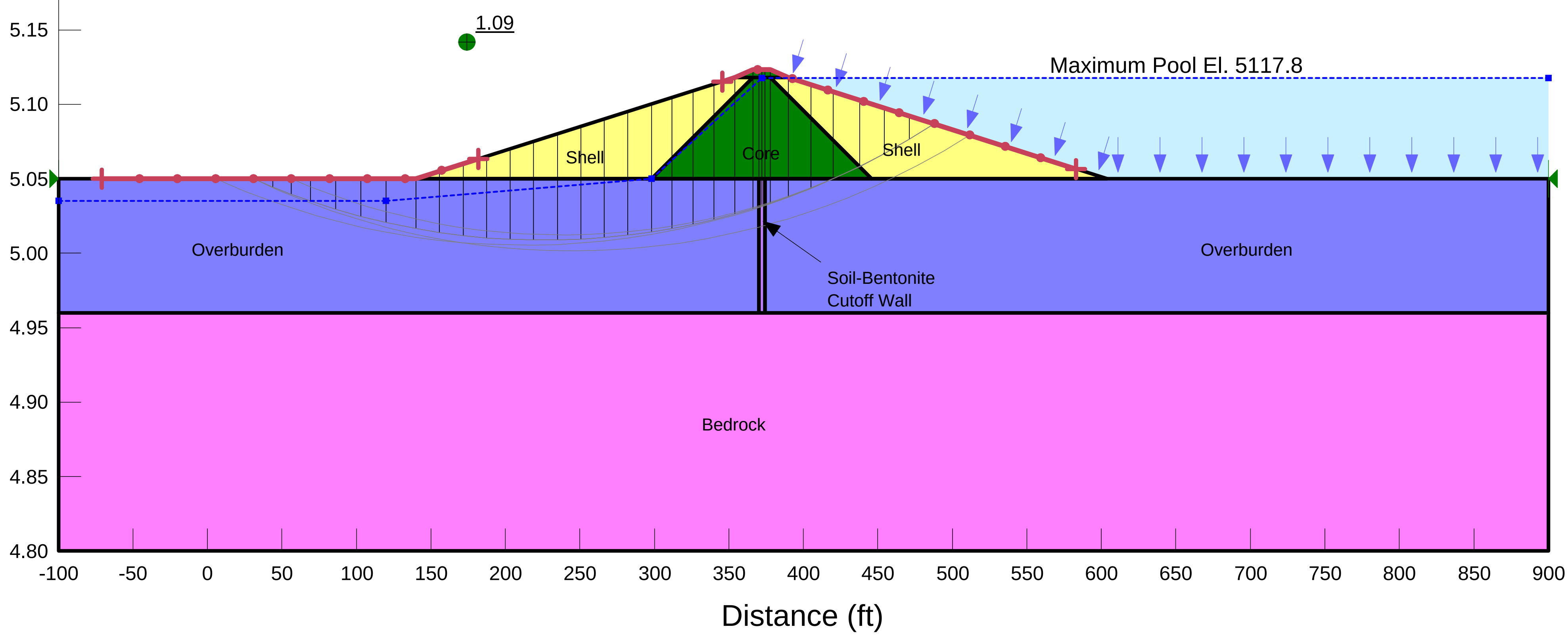


Stratum	Unit Weight (γ)	Unit Weight Above Water Table (γ)	Drained Cohesion (c')	Drained Friction Angle (ϕ')
Shell	125 pcf	121 pcf	0	33°
Core	128 pcf	120 pcf	0	28°
Overburden	128 pcf	128 pcf	0	26°
Bedrock	150 pcf	150 pcf	0	65°
Cutoff Wall	125 pcf	125 pcf	0	15°

APS Cholla Power Plant
Bottom Ash Pond Dam
Slope Stability Analysis

Pseudo-Static: Horizontal Accel. = 0.08g

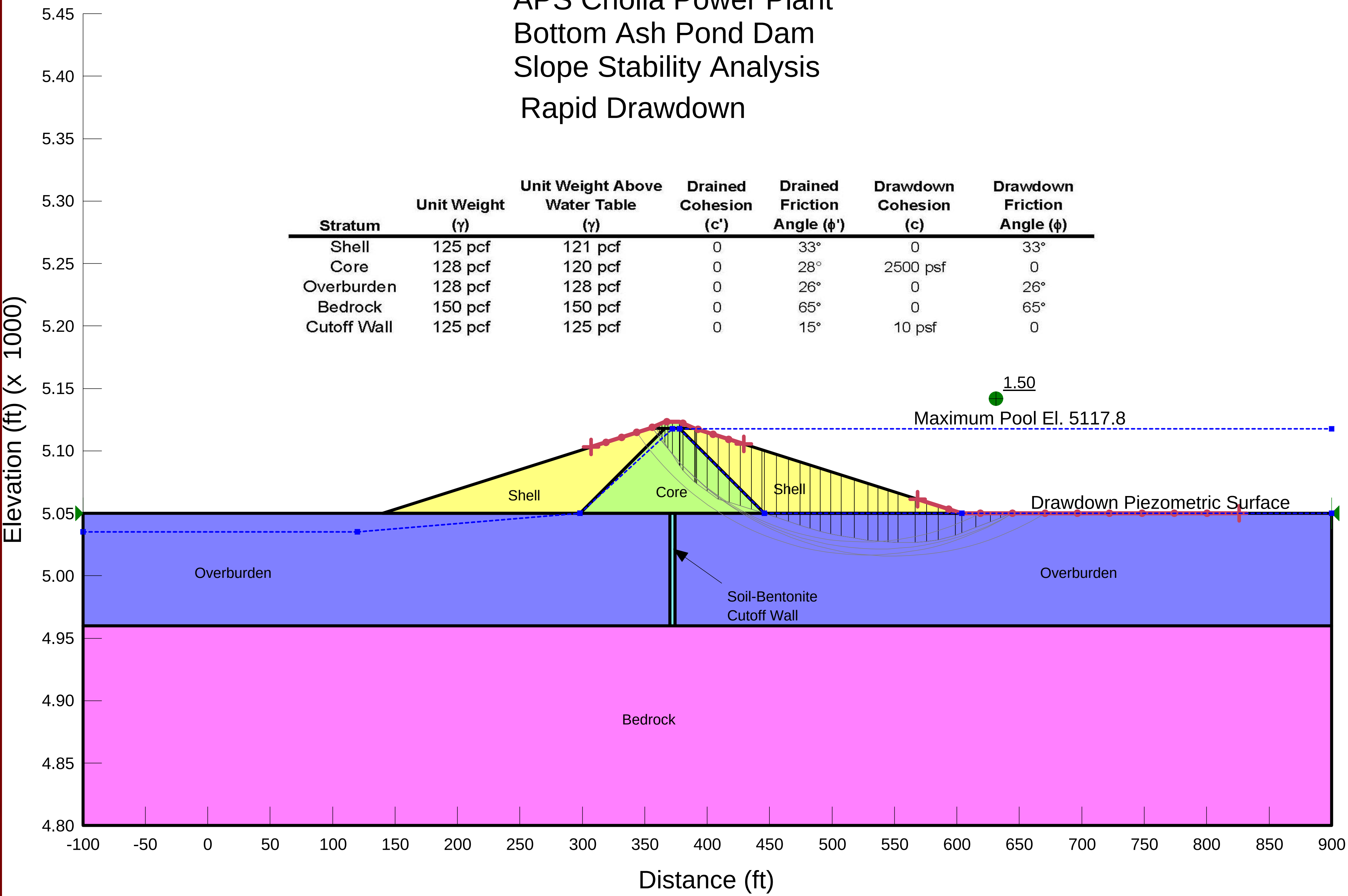
Stratum	Unit Weight (γ)	Unit Weight Above Water Table (γ)	Undrained Cohesion (c)	Undrained Friction Angle (ϕ)
Shell	125 pcf	121 pcf	0	33°
Core	128 pcf	120 pcf	2500	0
Overburden	128 pcf	128 pcf	0	26°
Bedrock	150 pcf	150 pcf	0	65°
Cutoff Wall	125 pcf	125 pcf	10	0



APS Cholla Power Plant
Bottom Ash Pond Dam
Slope Stability Analysis

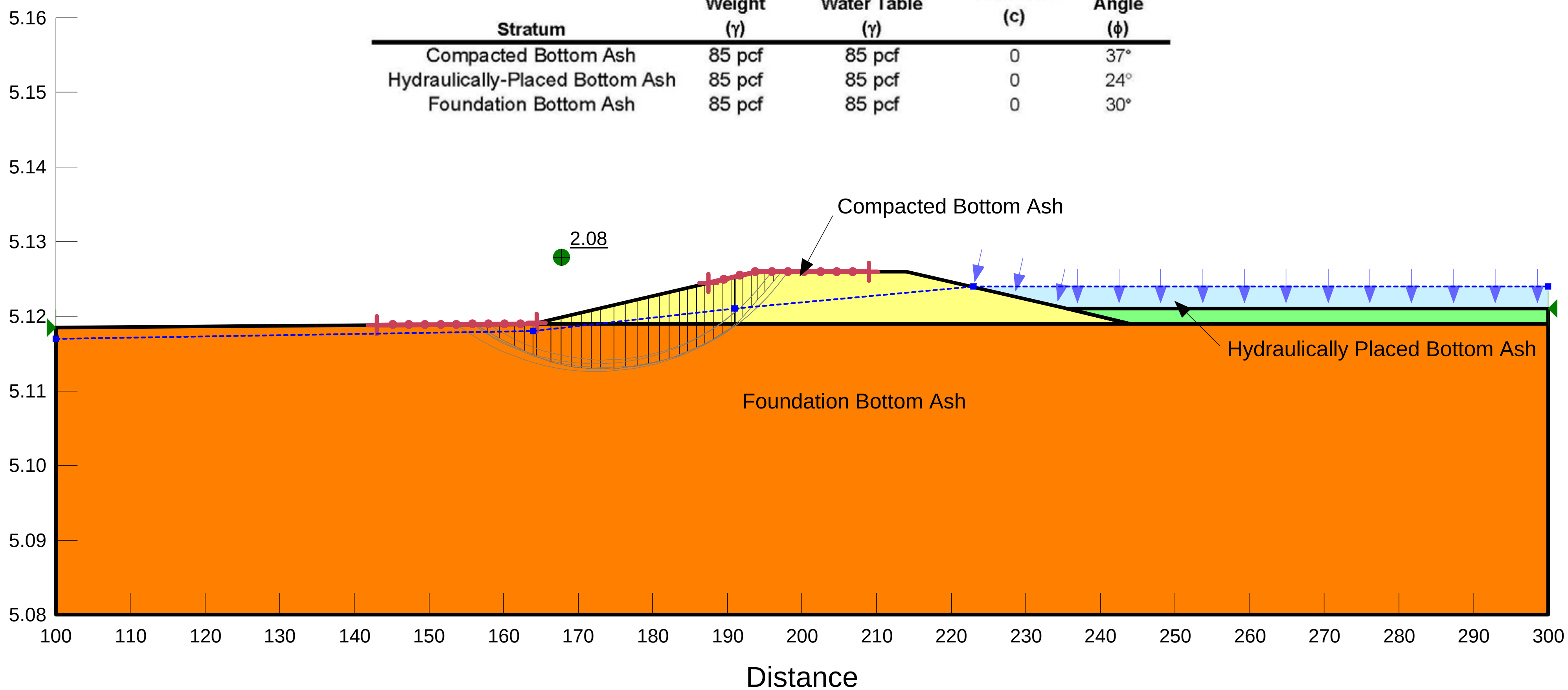
Rapid Drawdown

Stratum	Unit Weight (γ)	Unit Weight Above Water Table (γ)	Drained Cohesion (c')	Drained Friction Angle (ϕ')	Drawdown Cohesion (c)	Drawdown Friction Angle (ϕ)
Shell	125 pcf	121 pcf	0	33°	0	33°
Core	128 pcf	120 pcf	0	28°	2500 psf	0
Overburden	128 pcf	128 pcf	0	26°	0	26°
Bedrock	150 pcf	150 pcf	0	65°	0	65°
Cutoff Wall	125 pcf	125 pcf	0	15°	10 psf	0



APS Cholla Power Plant
Bottom Ash Pond
Intermediate Dike
Slope Stability Analysis

Stratum	Unit Weight (γ)	Unit Weight Above Water Table (γ)	Cohesion (c)	Friction Angle (ϕ)
Compacted Bottom Ash	85 pcf	85 pcf	0	37°
Hydraulically-Placed Bottom Ash	85 pcf	85 pcf	0	24°
Foundation Bottom Ash	85 pcf	85 pcf	0	30°



Appendix E

Reply to Request for Information Under Section 104(e)

THE POWER TO MAKE IT HAPPEN℠

John R. Denman
Senior Vice President
Fossil

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Fax 602-250-3902
jdenman@apsc.com

Mail Station 9046
PO Box 53999
Phoenix, Arizona 85072-3999

VIA FEDERAL EXPRESS

March 26, 2009

Mr. Richard Kinch
U.S. Environmental Protection Agency
5th Floor N-5783
Two Potomac Yard
2733 S. Crystal Drive
Arlington, Virginia 22202-2733

Re: Arizona Public Service Company – Cholla Generating Station: Request for Information Under 104(e) of the Comprehensive Environmental Response, Compensation, and Liability Act, 42 U.S.C. 9604(e) ("104(e) Request").

Dear Mr. Kinch:

On March 13, 2009, Arizona Public Service Company ("APS") received the above referenced 104(e) Request for each surface impoundment or similar diked or bermed management unit(s) or management units designated as landfills at the Cholla Generating Station which receive liquid-borne material for the storage or disposal of residuals or by-products from the combustion of coal, including, but not limited to, fly ash, bottom ash, boiler slag, or flue gas emission control residuals. APS's response for the Cholla Generating Station is attached.

I certify that the information contained in this response to EPA's request for information and the accompanying documents is true, accurate, and complete. As to the identified portions of this response for which I cannot personally verify their accuracy, I certify under penalty of law that this response and all attachments were prepared in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

Signature: John R Denman
Name: John R. Denman
Title: Sr. V.P., Fossil Generation

Arizona Public Service Company's 104(e) Response for the Cholla Generating Station

Plant Description

The Cholla Generating Station is a four unit, coal fired, 1160 megawatt steam electric power plant. As part of its operations, the plant generates residuals and by-products from the combustion of coal. The residuals and by-products are conveyed to four surface impoundments for storage and disposal: a Bottom Ash Pond, a Fly Ash Pond, a Sedimentation Pond, and a retention pond named the West Area Retention Pond. Approximately 70% of the fly ash generated at the plant is sold for beneficial reuse.

Impoundment Descriptions

Bottom Ash Pond

The Bottom Ash Pond is a zoned clay core earthen embankment, which receives bottom ash (slurried with process water) from all four of the plant's generating units. The bottom ash settles to the bottom of the Bottom Ash Pond, and the process water is siphoned back to the general water sump and re-used.

Fly Ash Pond

The Fly Ash Pond is a zoned clay core earthen embankment (with a ten foot by 650 foot saddle dike), which receives fly ash from all four of the plant's generating units.

Fabric filters remove dry fly ash from generating units 1, 3, and 4. Generating unit 2 uses a mechanical dust collector to remove some fly ash on a dry basis, and a venturi scrubber system (a wet particulate/ SO_2 removal system) removes additional fly ash. The dry fly ash that is not sold for beneficial re-use and all of the wet fly ash are slurried with flue gas desulfurization residuals and pumped to the fly ash pond.

Sedimentation Pond

The Sedimentation Pond is a sub-grade impoundment, with a two foot thick compacted clay liner, which receives *de minimis* amounts of coal combustion by-products in storm water, process water, plant wash down water, and slurry from system leaks, from drains located on the plant site.

West Area Retention Pond

The West Area Retention Pond is a sub-grade impoundment, with an earthen liner, which receives *de minimis* amounts of coal combustion by-products in storm water, process water, and plant wash down water, from the west side of the plant.

104(e) Questions

Please provide the information requested below for each surface impoundment or similar diked or bermed management unit(s) or management units designated as landfills which receive liquid-borne material for the storage or disposal of residuals or by-products from the combustion of coal, including, but not limited to, fly ash, bottom ash, boiler slag, or flue gas emission control residuals. This includes units that no longer receive coal combustion residues or by-products, but still contain free liquids.

1. Relative to the National Inventory of Dams criteria for High, Significant, Low, or Less than Low Hazard Potential, please provide the potential hazard rating for each management unit and indicate who established the rating, what the basis for the rating is, and what federal or state agency regulates the unit(s) . If the unit(s) does not have a rating, please note that fact.

Bottom Ash Pond

The rating, which is designated by the Arizona Department of Water Resources, Dam Safety and Flood Mitigation Division, which regulates the unit, is "High Hazard Potential." The basis for the rating is set forth in the Arizona Administrative Code ("A.A.C."), Article 12. Dam Safety Procedures, Section R12-15-1206 B, attached to this response as Exhibit A (Section R12-15-1202, which contains the definitions of the terms "Hazard potential" and Hazard potential classification," is also attached as part of Exhibit A).

Fly Ash Pond

The rating, which is designated by the Arizona Department of Water Resources, Dam Safety and Flood Mitigation Division, which regulates the unit, is "High Hazard Potential." The basis for the rating is set forth in the A.A.C., Article 12. Dam Safety Procedures, Section R12-15-1206 B, attached to this response as Exhibit A (Section R12-15-1202, which contains the definitions of the terms "Hazard potential" and Hazard potential classification," is also attached as part of Exhibit A).

Sedimentation Pond

Because the Sedimentation Pond does not meet the definition of a dam, as set forth in the Arizona Revised Statutes § 45-1201(1), the unit is not regulated as a dam.

West Area Retention Pond

Because the West Area Retention Pond does not meet the definition of a dam, as set forth in the Arizona Revised Statutes § 45-1201(1), the unit is not regulated as a dam.

2. What year was each management unit commissioned and expanded?

Bottom Ash Pond

Commissioned (in-service) in 1978. Expanded in 1991.

Fly Ash Pond

Commissioned (in-service) in 1978.

Sedimentation Pond

Commissioned (in-service) in 1976

West Area Retention Pond

Commissioned (in-service) in 2002.

3. What materials are temporarily or permanently contained in the unit? Use the following categories to respond to this question: (1) fly ash; (2) bottom ash: (3) boiler slag; (4) flue gas emission control residuals; (5) other. If the management unit contains more than one type of material, please identify all that apply. Also, if you identify "other," please specify the other types of materials that are temporarily or permanently contained in the unit(s).

Bottom Ash Pond

(1) Fly ash ; (2) bottom ash; (3) boiler slag; (4) flue gas emission control residuals; and (5) other. Other types include: sedimentation pond effluent, sedimentation pond solids, cooling tower blowdown, oil/water separators effluent, oil/water separator solids, boiler cleaning wastes, and storm water.

Fly Ash Pond

(1) Fly ash; (2) bottom ash; (3) boiler slag; (4) flue gas emission control residuals; and (5) other. Other types include: storm water, sedimentation pond solids, boiler cleaning wastes, and oil/water separator solids.

Sedimentation Pond

(1) Fly ash (*de minimis* amounts); (2) bottom ash (*de minimis* amounts); (3) boiler slag (*de minimis* amounts); (4) flue gas emission control residuals (*de minimis* amounts); and (5) other. Other types include: discharges of domestic wastewater from the secondary wastewater treatment plant, effluent from the oil/water separator, storm water, and vehicle wash water from the spray wash station.

West Area Retention Pond

(1) Fly ash (*de minimis* amounts); (2) bottom ash (*de minimis* amounts); (3) boiler slag (*de minimis* amounts); (4) flue gas emission control residuals (*de minimis* amounts); and (5) other (storm water).

4. Was the management unit(s) designed by a Professional Engineer? Is or was the construction of the waste management unit(s) under the supervision of a Professional Engineer? Is inspection and monitoring of the safety of the waste management unit(s) under the supervision of a Professional Engineer?

Bottom Ash Pond

The Bottom Ash Pond was designed by a Professional Engineer. Its construction was under the supervision of a Professional Engineer. Inspection and monitoring of the safety of the Bottom Ash Pond is under the supervision of a Professional Engineer.

Fly Ash Pond

The Fly Ash Pond was designed by a Professional Engineer. Its construction was under the supervision of a Professional Engineer. Inspection and monitoring of the safety of the Fly Ash Pond is under the supervision of a Professional Engineer.

Sedimentation Pond

The Sedimentation Pond was designed by a Professional Engineer. Its construction was under the supervision of a Professional Engineer. Inspection and monitoring of the safety of the Sedimentation Pond is not under the supervision of a Professional Engineer.

West Area Retention Pond

The West Area Retention Pond was designed by a Professional Engineer. Its construction was under the supervision of a Professional Engineer. Inspection and monitoring of the safety of the West Area Retention Pond is not under the supervision of a Professional Engineer.

5. When did the company last assess or evaluate the safety (i.e., structural integrity) of the management unit(s)? Briefly describe the credentials of those conducting the structural integrity assessments/evaluations. Identify actions taken or planned by facility personnel as a result of these assessments or evaluations. If corrective actions were taken, briefly describe the credentials of those performing the corrective actions, whether they were company employees or contractors. If the company plans an assessment or evaluation in the future, when is it expected to occur?

Bottom Ash Pond

APS last assessed or evaluated the safety of the Bottom Ash Pond on May 8-9, 2008. The individual who conducted the assessment/evaluation was an APS Generation Engineering, Civil and Structural Engineer (P.E.). No safety deficiencies were identified. The next assessment/evaluation is scheduled for May 2009.

Note that APS's assessment/evaluation included an examination of dessication cracks in the crest of the embankment of the Bottom Ash Pond (above the water line). These cracks were observed during the Arizona Department of Water Resources, Dam Safety and Flood Mitigation Division's ("ADWR") 2007 inspection, at which time, ADWR did not designate the cracks as a safety deficiency. The cracks were also noted in ADWR's 2008 inspection report, which also indicated that there were no safety deficiencies found during the inspection.

APS has determined that the cracks are shallow and do not represent a safety issue, and APS is working with ADWR to close out the evaluation.

Fly Ash Pond

APS last assessed or evaluated the safety of the Fly Ash Pond on May 8-9, 2008. The individual who conducted the assessment/evaluation was an APS Generation Engineering, Civil and Structural Engineer (P.E.). No safety deficiencies were identified. The next assessment/evaluation is scheduled for May 2009.

Sedimentation Pond

Because the Sedimentation Pond does not meet the definition of a dam, as set forth in the Arizona Revised Statutes § 45-1201(1), safety assessments/evaluations are not necessary for this sort of structure.

West Area Retention Pond

Because the West Area Retention Pond does not meet the definition of a dam, as set forth in the Arizona Revised Statutes § 45-1201(1), safety assessments/evaluations are not necessary for this sort of structure.

6. When did a State or a Federal regulatory official last inspect or evaluate the safety (structural integrity) of the management unit(s)? If you are aware of a planned state or federal inspection or evaluation in the future, when is it expected to occur? Please identify the Federal or State regulatory agency or department which conducted or is planning the inspection or evaluation. Please provide a copy of the most recent official inspection report or evaluation.

Bottom Ash Pond

The Arizona Department of Water Resources, Dam Safety and Flood Mitigation Division, last inspected the Bottom Ash Pond on September 24-25, 2008. The next planned inspection is scheduled for September 2009. A copy of the most recent official inspection report is attached as Exhibit B.

Fly Ash Pond

The Arizona Department of Water Resources, Dam Safety and Flood Mitigation Division, last inspected the Fly Ash Pond on September 24-25, 2008. The next planned inspection is scheduled for September 2009. A copy of the most recent official inspection report is attached as Exhibit C.

Sedimentation Pond

Because the Sedimentation Pond does not meet the definition of a dam, as set forth in the Arizona Revised Statutes § 45-1201(1), safety inspections are not conducted.

West Area Retention Pond

Because the West Area Retention Pond does not meet the definition of a dam, as set forth in the Arizona Revised Statutes § 45-1201(1), safety inspections are not conducted.

7. Have assessments or evaluations, or inspections conducted by State or Federal regulatory officials conducted within the past year uncovered a safety issue(s) with the management unit(s), and, if so, describe the actions that have been or are being taken to deal with the issue or issues. Please provide any documentation that you have for these actions.

Bottom Ash Pond

No.

Fly Ash Pond

No.

Sedimentation Pond

Not applicable. See response to Question #6.

West Area Retention Pond

Not applicable. See response to Question #6.

8. What is the surface area (acres) and total storage capacity of each of the management units? What is the volume of material currently stored in each of the management unit(s). Please provide the date that the volume measurement(s) was taken. Please provide the maximum height of the management units(s). The basis for determining maximum height is explained later in this Enclosure.

Bottom Ash Pond

Surface area: 80 surface acres.

Total storage capacity: 2,300 acre feet.

Volume of materials currently stored: APS estimates that the Bottom Ash Pond currently holds 1,440 acre feet of bottom ash. This number is based on annual calculations of ash disposed of, which are performed as part of the annual Toxic Release Inventory Reporting submissions. The plant does not take physical measurements of volume.

Date volume measurement was taken: N/A (see explanation above).

The statutory dam height, established by the Arizona Department of Water Resources, Dam Safety and Flood Mitigation Division, is 73 feet.

Fly Ash Pond

Surface area: 420 surface acres.

Total storage capacity: 18,000 acre feet.

Volume of materials currently stored: APS estimates that the Fly Ash Pond currently holds 4,415 acre feet of material. This number is based on annual calculations of ash disposed of, which are performed as part of the annual Toxic Release Inventory Reporting submissions. The plant does not take physical measurements of volume.

Date volume measurement was taken: N/A (see explanation above).

The statutory dam height, established by the Arizona Department of Water Resources, Dam Safety and Flood Mitigation Division, is 80 feet.

Sedimentation Pond

Surface area: 1/2 surface acre.

Total storage capacity: 10.7 acre feet.

Volume of materials currently stored: 0.5 acre feet.

Date volume measurement was taken: March 19, 2009 (visual observation of sedimentation).

Dam height: N/A

West Area Retention Pond

Surface area: 1/4 surface acres.

Total storage capacity: 4.6 acre feet.

Volume of materials currently stored: Negligible.

Date volume measurement was taken: 03/19/09 (visual observation of sedimentation).

Dam height: N/A

9. Please provide a brief history of known spills or unpermitted releases from the unit within the last ten years, whether or not these were reported to State or federal regulatory agencies. For purposes of this question, please include only releases to surface water or to the land (do not include releases to groundwater).

APS's responses below do not include permitted releases.

Bottom Ash Pond

There have been no known spills or unpermitted releases within the last ten years.

Fly Ash Pond

There have been no known spills or unpermitted releases within the last ten years.

Sedimentation Pond

There have been no known spills or unpermitted releases within the last ten years.

West Area Retention Pond

There have been no known spills or unpermitted releases within the last ten years.

10. Please identify all current legal owner(s) and operator(s) at the facility.

For all four facilities, APS and PacifCorp are the owners, and APS is the operator.