Arizona Public Service Company
CCR Program
Environmental Policy & Programs

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June 30, 2025

CCR Program Documentation
Closure – Notification of Intent to Close
CH_ClosNOI_002_20250630

Subject: Closure – Notification of Intent to Close; Fly Ash Pond - Cholla Power Plant

Pursuant to 40 C.F.R. §§ 257.101(a)(1), 257.101(a)(2), 257.101(b)(1), and 257.101(b)(3), APS is providing notice of its intent to close the Fly Ash Pond.

Note that a pending Alternative Closure Application, submitted in accordance with 40 CFR 103(f)(2), had been submitted and determined administratively complete and that this action tolled the cease receipt deadline of April 11, 2021. The application has remained pending final approval. Since APS has ceased placing CCR and non-CCR waste streams into the Fly Ash Pond, the application has been concurrently withdrawn.

In accordance with 40 CFR 257.102(g), the unit will be closed in accordance with its Closure Plan and the provisions of 40 CFR 257.102(d). A certification by a qualified professional engineer for the design of the final cover system as required by 40 CFR 257.102(d)(3)(iii) accompanies this notification.

If you have any questions about this or would like additional information, please consult the CCR information webpage located within APS.com or contact neal.brown@aps.com.

Cholla Fly Ash Pond Closure

Alternative Final Cover Design Documentation

Arizona Public Service

Project number: 60710305

June 27, 2025

Delivering a better world

Prepared for:

Arizona Public Service

Prepared by:

AECOM
7720 North 16th Street
Phoenix, AZ 85020
aecom.com

Table of Contents

1. Background

Arizona Public Service (APS) is the majority owner and operator of the Cholla Power Plant (Cholla, the Plant). The Plant is a coal-fired power plant near Joseph City, Arizona. The coal combustion process at the Plant produces coal combustion residuals (CCR), which consist of bottom ash, fly ash, and flue gas desulfurization (FGD) solids and sludge. The Fly Ash Pond (FAP) at the Plant impounds fly ash and FGD solids, which are classified as a CCR and as such are regulated by Title 40, Code of Federal Regulation (CFR), Part 257 (40 CFR §257), otherwise known as the CCR Rule. APS has elected to close the FAP in place in accordance with 40 CFR §257.102(d).

2. Objective

The objective of this report is to document the demonstration that the final cover system design for the FAP closure satisfies the requirements of Title 40, CFR § 257.102 "Criteria for conducting the closure or retrofit of CCR units and closure of CCR management units", (d) "Closure performance standard when leaving CCR in place –", (3) "Final cover system", (ii) "*the requirements of the alternative final cover system*" as described in Section 3.

APS, in consultation with its closure design engineer, AECOM Technical Services, Inc. (AECOM), has elected to use an alternative final cover system designed to meet the requirements of 40 CFR §257.102(d)(3) for closure of the FAP. An evapotranspiration (ET) soil cover, which is a type of water balance cover, is the selected alternative final cover system type. The following sections of this report demonstrate how the FAP closure design satisfies the requirements of 40 CFR §257.102(d)(3).

3. Regulation for Alternative Final Cover [40 CFR §257.102(d)(3)(ii)]

40 CFR §257.102(d)(3)(ii) states the following:

> *§257.102(d)(3)(ii): The owner or operator may select an alternative final cover system design, provided the alternative final cover system is designed and constructed to meet the criteria in paragraphs (d)(3)(ii)(A) through (C) of this section. The design of the final cover system must be included in the written closure plan required by paragraph (b) of this section.*
>
>> *§257.102(d)(3)(ii)(A): The design of the final cover system must include an infiltration layer that achieves an equivalent reduction in infiltration as the infiltration layer specified in paragraphs (d)(3)(i)(A) and (B) of this section.*
>>
>>> *§257.102(d)(3)(i)(A): The permeability of the final cover system must be less than or equal to the permeability of any bottom liner system or natural subsoils present, or a permeability no greater than 1 × 10^{-5} cm/sec, whichever is less.*
>>>
>>> *§257.102(d)(3)(i)(B): The infiltration of liquids through the closed CCR unit must be minimized by the use of an infiltration layer that contains a minimum of 18 inches of earthen material.*

§257.102(d)(3)(ii)(B): The design of the final cover system must include an erosion layer that provides equivalent protection from wind or water erosion as the erosion layer specified in paragraph (d)(3)(i)(C) of this section.

> *§257.102(d)(3)(i)(C): The erosion of the final cover system must be minimized by the use of an erosion layer that contains a minimum of six inches of earthen material that is capable of sustaining native plant growth.*

§257.102(d)(3)(ii)(C): The disruption of the integrity of the final cover system must be minimized through a design that accommodates settling and subsidence.

3.1 Criteria for Final Cover Permeability and Infiltration - 40 CFR §257.102(d)(3)(ii)(A)

The following provides documentation that the final cover is designed to meet the permeability and infiltration reduction requirements of 40 CFR §257.102(d)(3)(ii)(A) stated above. The following subsections provide a summary of the design of the final cover related to infiltration rate reduction.

As indicated in the preamble of the CCR Rule (80 Federal Register [FR] 21413 through 21414), the requirements for cover were generally modeled after the standards and technical requirements of 40 CFR 258.60 for MSWLFs. In addition, 80 FR 21413-214714 states the following:

"The final rule does not require the use of composite final covers, such as geomembrane underlain by a compacted soil infiltration layer. This is also the case in situations for a CCR unit that is designed with a composite bottom liner or if the permeability of the soil underlying the unit is comparable to the permeability of a geomembrane. As EPA has concluded for municipal solid waste landfills, in certain site-specific situations it may be possible to construct an infiltration layer that achieves an equivalent reduction in infiltration without matching the permeability in the bottom liner material (62 FR 40710)."

The last sentence in conclusion to the above excerpt indicates that a cover could be constructed that achieves an infiltration reduction that is lower than infiltration through the bottom liner or base of the unit without matching the permeability of the base soils or liner. An ET cover designed and constructed for arid and semi-arid climates could meet this site-specific situation as described above. ET soil covers have been utilized as final cover systems over several decades.

The following summary of the final cover design for the FAP site, which is in a semi-arid climate, provides documentation that the cover achieves adequate infiltration rate (unit area flux) reduction while not specifically matching the permeability of the natural subsoils present or bottom liner material.

3.1.1 Final Cover Unit Area Flux Equivalency to Permeability

The calculated unit area flux or infiltration rate of the final ET cover is equivalent to the permeability of the final cover. Permeability is a measure of material's inherent ability to allow fluid to pass through, independent of the flow vector and assumed to be fully saturated. Unit area flux or groundwater flux is the discharge of water through a unit area of material, which is simply the velocity of groundwater. Therefore, unit area flux is considered equivalent to permeability in the context of this report. The actual unit area flux, which is the infiltration rate through the cover system, is the calculated output of the numerical model used to evaluate the design of the ET soil cover (UNSAT-H). The following subsections will demonstrate that the unit area flux or infiltration rate of the final cover system is less than the permeability of the natural soil present below the FAP.

3.1.2 Permeability of Natural Subsoils Present

Site Geologic Setting

The FAP is within the Colorado Plateau Physiographic Province and is situated within the northwestern area of the Holbrook Basin. The FAP is built on younger alluvial deposits that are surrounded by and overlie much older Paleozoic and Mesozoic-aged sedimentary rock formations. A geologic map of the area is presented in Figure 1.

The younger alluvial deposits in the area consist of the Quaternary alluvium deposited in the unnamed drainage underlying the FAP. The surrounding sedimentary rock units are from youngest to oldest, the Triassic Chinle Formation (which includes the Shinarump Conglomerate Member), the Triassic Moenkopi Formation, and the Permian Coconino Sandstone. Figure 2 illustrates a simplified stratigraphic column for the site area.

The geology immediately underlying the FAP CCR consists of an Alluvial Unit, which overlies the Moqui Member of the Moenkopi Formation. Following a period of erosion in the underlying Moenkopi Formation, the FAP unconsolidated heterogeneous alluvial deposits composed of clay, silt, sand, and gravel, were deposited within the lower reach of the unnamed drainage. These alluvial soils are the natural subsoils present below the impounded CCR within the FAP. Based on the geotechnical data collected at this site, the alluvial soils consist of various interbedded layers of gravel, sand, silt, and clay. Hydraulic conductivities of unconsolidated alluvial soils (gravel, sand, silt, and clay) range over several orders of magnitude, and the soils information collected for this site indicate a range of between 10^{-3} and 10^{-8} centimeters/second (cm/sec).

SH&B Soil and Geologic Study (1973)

The report by Sergent, Hauskins & Beckwith (SH&B) titled *Proposed Ash Disposal Areas Soil and Geologic Study Report* (SH&B, 1973) described the alluvial soils consisting of unconsolidated clay, silt, sand, and gravel in the vicinity of the FAP. These alluvial soils are also present downstream of the FAP Dam as shown in the subsequent geotechnical investigations presented in other reports associated with the construction of the FAP Dam.

The SH&B report presents borehole permeability testing of alluvial materials used in the later designs for the FAP dam (SH&B, 1973). The borehole permeability tests were performed in companion borings drilled into the alluvium and saturated for several days prior to testing. Of the ten borehole permeability tests performed, five were located below the FAP footprint and showed permeabilities ranging from 1.01×10^{-5} to 1.45×10^{-6} cm/sec. The borehole permeability test results are provided in Attachment A.

Ebasco Seepage and Foundation Studies (1975)

The *Arizona Public Service Company Cholla Generating Station Ash Disposal Sites Seepage and Foundation Studies* engineering report by Ebasco (Ebasco, 1975a/b) provides information on the permeability of the alluvial soils underlying the FAP. The Ebasco engineering report presented geotechnical investigation data consisting of borings, test pits, and associated laboratory testing. The Ebasco engineering report also presented seepage analyses performed for the design of the FAP Dam. Ebasco performed an evaluation of the permeability testing performed during the Ebasco investigation (Ebasco, 1975a/b) and past geotechnical investigations (SH&B, 1973) and assigned an overburden alluvium permeability of 1×10^{-5} cm/sec (shallow soils at or near ground surface). Ebasco also assigned a permeability of 1×10^{-7} cm/sec for the recompacted dam clay core and cut off slurry wall. The Moenkopi Formations underlying the overburden alluvium were assigned a permeability of 5.5×10^{-6} cm/sec to an elevation of 4,985 feet, which is approximately 55 feet below existing grade at the low point of the FAP prior to dam construction.

The geotechnical laboratory testing, documented in the Ebasco engineering report (Ebasco, 1975a/b), included falling head permeability test on alluvial clay soil materials used for the construction of the clay core for the FAP Dam. Three laboratory falling head permeability tests were performed as part of evaluating the clay core design and indicated coefficients of permeability of 3.74×10^{-7}, 1.27×10^{-7}, and 3.40×10^{-8} cm/sec. The falling head permeability tests were performed on specimens of clay soil recompacted at or above 95 percent of maximum dry densities, as determined by both Modified and Standard Proctor testing. The results are presented in Attachment B. The geometric mean of these three falling head permeability test results is 1.17×10^{-7} cm/sec.

AECOM Geotechnical Investigation (2024)

The geotechnical investigation in 2024 for the FAP closure project includes laboratory testing of alluvial borrow soils within and directly upstream of the FAP reservoir area. The soils encountered in the investigation consisted of interbedded gravel, sand, silt, and clay. Soil samples collected and tested at the laboratory ranged from Gravel to Elastic Silt (MH) with hydraulic conductivity ranging from 1.2×10^{-3} to 6.0×10^{-5} cm/sec. These results are provided in Attachment C.

Permeability of the Natural Subsoils below the FAP

As the data presented above suggests, the soils at the base of the FAP CCR impoundment have a wide range of permeabilities. Based on the preponderance of information available, including from drilling investigations of the upper alluvium, AECOM concluded that clayey soils likely exist over a significant portion of the base of the CCR impoundment. On that basis, assignment of a single permeability for the base of the impoundment that is closer to the lower range permeabilities evident in the data is appropriate. This selection would be biased toward the finer-grained silts and clays. The results of the laboratory falling head permeability tests performed by Ebasco on the recompacted clay soil intended for the construction of the FAP Dam clay core, were some of the lowest reported values of permeability for the site soils. Therefore, the geometric mean of the three test results, 1.17×10^{-7} cm/sec, was assigned as the target permeability of the natural subsoils underlying the FAP, for the purposes of the ET cover design unit area flux analysis.

3.1.3 Permeability of the Final Cover System

The final cover system for the FAP is an ET soil cover constructed from earthen soil materials excavated from within the FAP depositional valley area. The ET soil cover design consists of a 12-inch Capillary Break Layer overlain by a 12-inch Compacted Clay Layer, 24-inch Infiltration Layer, and 7-inch Erosion Layer. The surface slope of the final cover system ranges from approximately 0.5 to 1.0 percent to shed stormwater off the cover to lined evaporation basins.

The cover was designed using UNSAT-H, a finite difference numerical modeling software, which simulates isothermal flow of liquid water and water vapor while also incorporating soil-water extraction by plants. An evaluation of approaches to simulate engineered cover performance degradation prepared for the U.S. Nuclear Regulatory Commission (CNWRA, 2007) indicates that UNSAT-H models have been used to simulate ET cover performance at various project sites in the United States and UNSAT-H is appropriate for simulating the hydrologic processes at arid and semiarid sites such as occur in northern Arizona, the location of the FAP site. Site specific properties for soil materials that will be used to construct the final cover system and meteorological data for the site area were input into the UNSAT-H model for the analysis.

The cover design included warmup model simulations to eliminate the inherent bias introduced to the model via the initial input parameters and converge on a vertical profile of initial moisture content (running model repeatedly for 15 years to converge). The model was then run through a 30-year simulation of daily weather to provide output of unit area flux. Daily meteorological data collected from nearby weather stations was aggregated into 30 meteorological simulation years as part of the model. The model also included a conservative assumption that plants failed to flourish and were unable to extract soil water from the cover system (no transpiration). The unit area flux (infiltration rate) target for the cover design was 1×10^{-7} cm/sec based on the review of FAP base subgrade permeability data as presented in Section 3.1.2.

At the end of the model 30-year simulation, the UNSAT-H model for the FAP cover system resulted in a final cover unit area flux (infiltration rate) of 1.27 x 10^{-8} cm/sec (1.10 x 10^{-3} cm/day), as presented in Attachment D for the design cover layer thicknesses described above.

3.1.4 Satisfaction of 40 CFR §257.102(d)(3)(ii)(A)

The above subsections demonstrate the satisfaction of §257.102(d)(3)(ii)(A) based on the following:

- The natural subsoils present below the FAP have a permeability ranging from 1.2 x 10^{-3} to 3.4 x 10^{-8} cm/sec. A single permeability of 1.17 x 10^{-7} cm/sec was selected to represent the base of the CCR impoundment.
- The unit area flux or infiltration rate of the FAP final cover system is estimated to be approximately 1.27 x 10^{-8} cm/sec.
- Calculated unit area flux or infiltration rate is equivalent to a permeability of the final cover.
- The infiltration rate of the FAP final cover system is less than the permeability of the natural subsoil present below the FAP as stated above, thus §257.102(d)(3)(i)(A) is satisfied.
- The FAP final cover system includes a 12-inch-thick, Compacted Clay Layer and 24-inch-thick, Infiltration layer, which combined create the ET cover infiltration layer. The closure design includes a 36-inch-thick Infiltration Layer and satisfies §257.102(d)(3)(i)(B) by having more than 18 inches of earthen material.

3.2 Criteria for Erosion Protection - 40 CFR §257.102(d)(3)(ii)(B)

The following provides documentation that the final cover is designed to meet the erosion protection requirements of 40 CFR §257.102(d)(3)(ii)(B) stated above. The following section provides a summary of the design of the erosion protection layer for the final cover.

As described in Section 3.1, the final cover system for the FAP includes an Erosion Layer that has a minimum thickness of 7 inches and will be seeded for vegetation growth. The Erosion Layer is comprised of a mixture of on-site rock and soil materials that will be vegetated with native plants as part of the FAP closure design.

The Erosion Layer was designed for protection against water erosion using methods from the United States Environmental Protection Agency (EPA) *Closing Small Tribal Landfills and Open Dumps* (EPA, 2007), and total potential soil losses were checked using the *Revised Universal Soil Loss Equation* (RUSLE) (David J.S. et. al., No Date). The *Closing Small Tribal Landfills and Open Dumps* (EPA, 2007) document presents guidance to calculate the thickness of and required gravel diameter for a rock armor layer to resist wind and water erosion. This guidance uses site specific design, precipitation, and wind information to generate a rock armor layer of adequate thickness of gravel to remain so that continued erosion is not progressed into the underlying Infiltration Layer. The RUSLE method provides an estimate of the average annual soil loss by water erosion.

The Erosion Layer was designed using a maximum slope grade of 2.0 percent, slope length of 1,000 feet, and the 1-hour duration, 100-year return period rainfall intensity of 1.99 inches per hour. Using the input parameters and methodologies from the EPA guidance, the Erosion Layer was indicated as requiring a combination of 2.2 inches of a gravel consisting of a minimum of 35 percent passing the 0.75-inch sieve designation, and 4.8 inches of the fine-grained sandy soils (maximum 40 percent passing No 200 sieve). A total depth of the resulting gravelly soil would therefore equal 7 inches (4.8 inches of infiltration soil with 2.2 inches of gravel). The RUSLE indicates that the Erosion Layer soil loss is estimated to be approximately 0.0057 inches per year or 0.17 inches in 30 years. Any soil loss from water and wind erosion will be monitored by APS as part of post-closure operations and will be repaired as required.

3.2.1 Satisfaction of 40 CFR §257.102(d)(3)(ii)(B)

The above section demonstrates that the engineering design of the Erosion Layer and planned post-closure operations meet §257.102(d)(3)(ii)(B) based on the following:

- The FAP closure design includes an Erosion Layer that has a minimum thickness of 7 inches.
- The Erosion Layer is comprised of a mixture of on-site rock and soil materials that will be seeded with native plants as part of the FAP closure design.
- The rock armor design, which follows the guidance in *Closing Small Tribal Landfills and Open Dumps (EPA, 2007)*, provides an Erosion Layer of an adequate thickness to protect against water and wind erosion of the underlying Infiltration Layer.

3.3 Criteria for Final Cover Settlement and Subsidence - 40 CFR §257.102(d)(3)(ii)(C)

The following provides documentation that the final cover is designed to meet the settlement and subsidence requirements of 40 CFR §257.102(d)(3)(ii)(C) stated above. The following subsections provide a summary of the design of the final cover related to settlement and subsidence.

The removal of a majority of the drainable pore water from the CCR within the FAP will occur before the final cover system is completed for the FAP closure. During the closure construction period, and before the drainable pore water removal system (dewatering wells) ceases operation, the majority of the cover system will be installed.

The dewatering process is expected to cause subsidence of the impounded CCR subgrade. The weight of fill for grading and the cover materials may cause settlement. The subsidence and settlement that appears due to dewatering and fill placement will be managed during the construction period, when a majority of the subsidence and settlement is expected to occur.

An assessment of the estimated settlement of the FAP closure was performed. This assessment considered consolidation potential due to the change in effective stress from the addition of the closure cover, fill placement, and subsidence due to drawdown of the phreatic levels in the impounded CCR from dewatering. The settlement calculations and analyses were performed using Excel spreadsheets using the classical theory of one-dimensional consolidation proposed by Terzaghi (Terzaghi, 1943) that included both primary consolidation and secondary compression.

The final cover will incorporate a 24-inch-thick, loosely compacted to between 80 and 90 percent of the maximum dry density as measured by ASTM D698, infiltration layer that will behave in a flexible manner to minimize the risk of disrupting the continuities of the ET cover due to settlement. The Compacted Clay Layer is the component of the final cover system considered most susceptible to loss of performance due to settlement and subsidence. The mechanism by which it would lose performance is through differential settlement causing sufficient tensile strain to open a crack that would allow water to infiltrate. The assessment of the estimated settlement of the FAP closure indicates the estimated magnitude of differential settlement is approximately 6 inches of vertical displacement over a distance of 100 feet (0.002% axial extension strain). The EPA *Draft Technical Guidance for RCRA/CERCLA Final Cover* (EPA, 2004) indicates that, based on previous studies of cracking in compacted clays, compacted clays tested under unconfined and low confinement conditions reached failure (cracking) at axial extensional strains of 0.02 to 4 percent. The projected maximum tensile strains caused to the FAP final cover system by settlement are at least one order of magnitude less than might be expected to cause cracking and loss of performance of a clay liner, so loss of integrity through settlement is not considered to be likely.

The assessment of the estimated settlement indicates that settlement will vary across the closure cover, depending on CCR thickness, fill thickness, and dewatered thickness, and a majority of the settlement

The assessment of the estimated settlement indicates that settlement will vary across the closure cover, depending on CCR thickness, fill thickness, and dewatered thickness, and a majority of the settlement and subsidence will occur during the closure construction and dewatering period, before the final cover system is installed. Minor settlement and subsidence of the final cover system is expected and repairs for settlement are part of the post-closure operations.

3.3.1 Satisfaction of 40 CFR §257.102(d)(3)(ii)(C)

The above section demonstrates that the cover design, phase of the installation of the final cover system, and planned post-closure operations meets §257.102(d)(3)(ii)(C) based on the following:

- The subsidence due to dewatering will be managed during the construction period, when a majority of the subsidence is expected. The subsidence will be managed by measuring the amount of vertical displacement during closure construction and placing additional fill or infiltration layer material to accommodate for the displacement.
- The final cover will incorporate a 24-inch-thick, loosely compacted infiltration layer that will behave in a flexible manner to minimize the risk of disrupting the continuities of the closure cover due to settlement.
- The projected maximum tensile strains caused to the FAP final cover system by settlement are at least one order of magnitude less than might be expected to cause cracking and loss of performance of a clay liner, so loss of integrity of the 12-inch-thick clay liner through settlement is not considered to be likely.
- Minor settlement and subsidence of the final cover system is expected and repairs for settlement are part of the post-closure operations.

Certification Statement 40 CFR § 257.102(d)(3)(ii) – Alternative Final Cover System Design

CCR Unit: Arizona Public Service, Cholla Power Plant, Fly Ash Pond

I, Jeffery Heyman, being a Registered Professional Engineer in good standing in the State of Arizona, do hereby certify, to the best of my knowledge, information, and belief, that the information contained in this certification package has been prepared in accordance with the accepted practice of engineering. I certify, for the above-referenced CCR Unit, that the documentation of the design of the alternative composite liner of the CCR Unit is accurate and satisfies the requirements of 40 CFR § 257.102(d)(3)(ii).

Jeffery Heyman

Printed Name

June 27, 2025

Date

References

Center for Nuclear Waste Regulatory Analysis (CNWRA). 2007. Evaluation of Approaches to Simulate Engineered Cover Performance and Degradation, Prepared for U.S. Nuclear Regulatory Commission, Contract NRC-02-07-006.

Ebasco Services Incorporated. 1975a. Arizona Public Service Company Cholla Generating Station Ash Disposal Sites Seepage and Foundation Studies, Volume I of II, engineering Report.

Ebasco Services Incorporated. 1975b. Arizona Public Service Company Cholla Generating Station Ash Disposal Sites Seepage and Foundation Studies, Volume II of II, Field and Laboratory Tests.

EPA. 2004. (Draft) Technical Guidance for RCRA/CERCLA Final Cover. EPA 540-R-04-007. April.

EPA. 2007. Closing Small Tribal Landfills and Open Dumps – How to Design Environmentally Safe Covers – Including additional design guidance for arid regions. EPA-909-R-11-007.

EPA. 2011. Fact Sheet on Evapotranspiration Cover Systems for Waste Containment. EPA 542-F-11-001. September.

EPA. 2015. 40 CFR Parts 257 and 261 – Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule. Federal Register Vol. 80, No. 74. April 17.

Jones, David S., David G. Kowalski, and Robert B. Shaw. No Date. Calculating Revised Universal Soil Loss Equation (RUSLE). Estimates on Department of Defense Lands: A Review of RUSLE Factors and U.S. Army Land Condition-Trend Analysis (LCTA) Data Gaps. Center for Ecological Management of Military Lands, Department of Forest Science, Colorado State University, Fort Collins, CO 80523.

Sergent, Hauskins & Beckwith (SH&B). 1973. Proposed Ash Disposal Areas Soil and Geologic Study Report.

Terzaghi, K. 1943. Theoretical Soil Mechanics, John Wiley, New York.

FIGURES

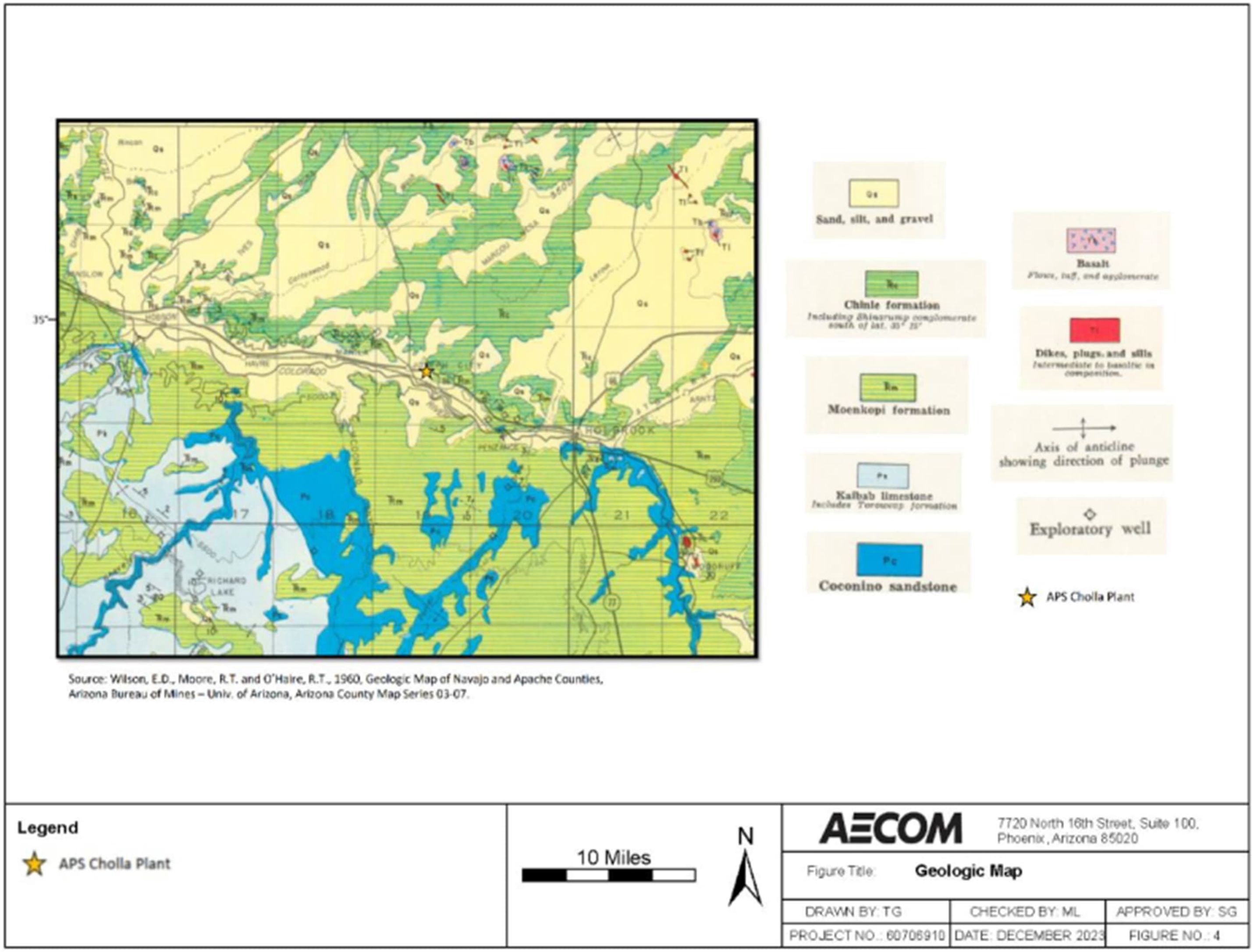


Figure 1 – Regional Geologic Map

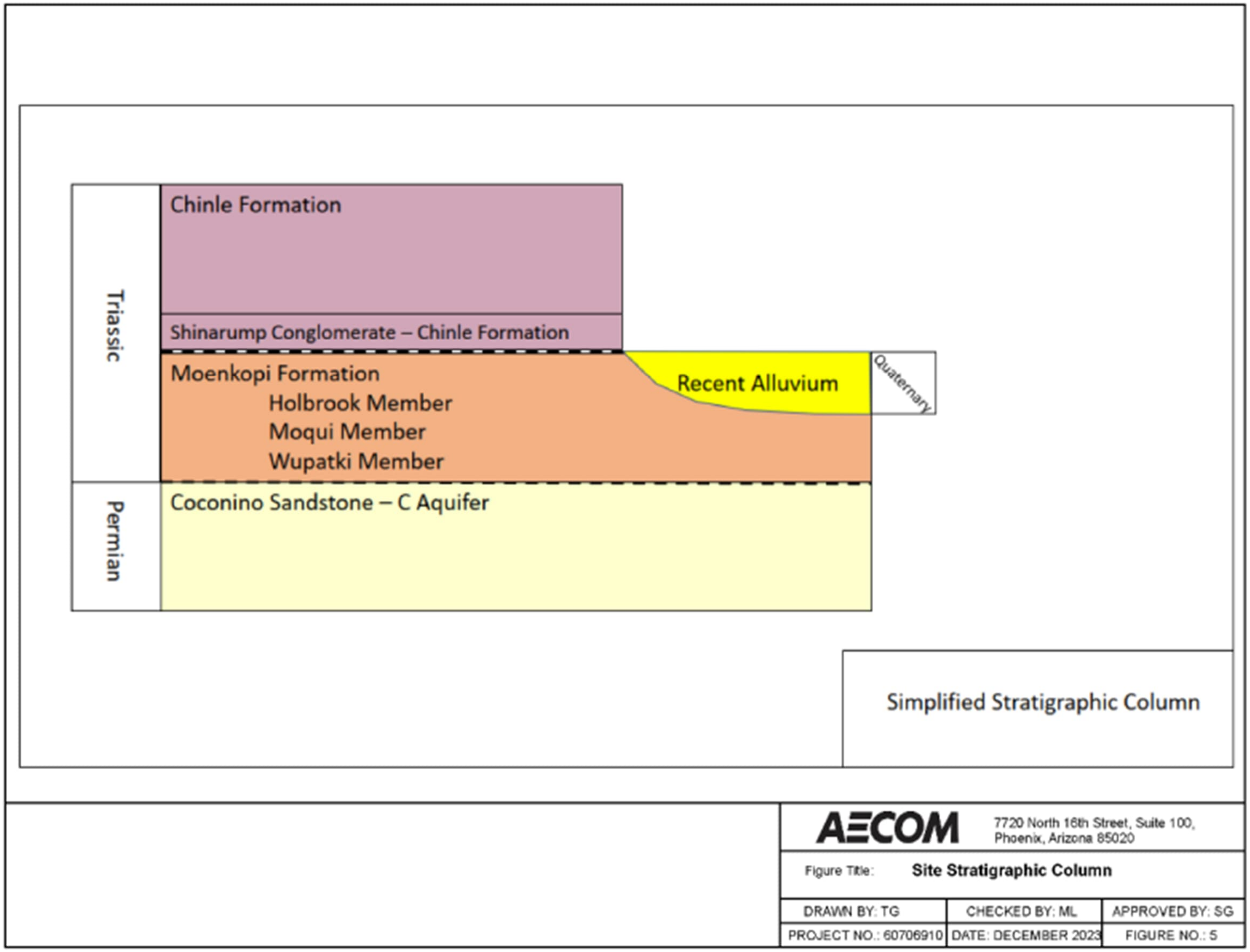


Figure 2 – Simplified Stratigraphic Column

ATTACHMENT A

Results of Permeability Tests

SH&B – Proposed Ash Disposal Areas Soil and Geologic Study Report, 1973

ASH DISPOSAL AREAS
APS CHOLLA PLANT
NEAR JOSEPH CITY, ARIZONA
JOB NO. E73-255

RESULTS OF PERMEABILITY TESTS (E-19)*

BORING NO.	DEPTH (FT.)	PERMEABILITY (FT./YR.)
4D	$2\frac{1}{2}$	16
8A	$8\frac{1}{2}$	1.8
9A	34	1.5
9B	25	5.8
11A	10	68
13A	34	33
14A	21	30
14B	37	13
14C	13	10.5
17A	$9\frac{1}{2}$	100

* THE TESTS WERE PERFORMED IN BORINGS DRILLED INTO THE ALLUVIUM AT LOCATIONS ADJACENT TO THE CORE BORING. THE BORINGS WERE ALLOWED TO SATURATE SEVERAL DAYS PRIOR TO TESTING. SOME OF THE BORINGS CAVED DURING THIS SOAKING PERIOD, THUS, THE TESTS WERE DISCONTINUED AT THESE LOCATIONS.

ATTACHMENT B

Summary of Ebasco Laboratory Falling Head Permeability Tests

Ebasco Engineering Report – Cholla Generating Station Ash Disposal Sites Seepage and Foundation Studies, 1975

ENGINEERS TESTING LABORATORIES, INC.
2525 E. Indian School Road, Phoenix, Arizona 85016, (602) 264-4781
423 S. Olsen Avenue, Tucson, Arizona 85719, (602) 624-8894
20 Mikes Pike, Flagstaff, Arizona 86001, (602) 774-4881
2020 Holly Drive, Lake Havasu City, Ariz. 86403, (602) 855-3730

REPORT ON LABORATORY TESTS

Lab. No. 512-157

Client:

Date 8/28/75

Date Rec'd

Project CHOLLA STEAM ELECTRIC STATION FLY ASH DISPOSAL POND

Location JOSEPH CITY, ARIZONA

Source of Sample NOTED BELOW

Material BORROW SOILS

Sampled By ETL & EBASCO

Submitted By ETL/BOYD

Requested By EBASCO/EHASZ

Tested PERMEABILITY - FALLING HEAD TESTS

TEST RESULTS

SAMPLE IDENTIFICATION	GROUP I	GROUP II	GROUP III
DRY DENSITY (PCF)*	121.1PCF	115.4PCF	103.6PCF
MOISTURE CONTENT %*	6.2%	9.0%	13.0%
COEFFICIENT OF PERMEABILITY (CM/SEC)	3.74×10^{-7}	1.27×10^{-7}	3.40×10^{-8}

*AS COMPACTED CONDITIONS

Copies To:

Respectfully submitted,
ENGINEERS TESTING LABORATORIES, INC.

ATTACHMENT C

Summary of Saturated Hydraulic Conductivity Test Results

Prepared for: Arizona Public Service

AECOM Project No. 60710305, May 2024

Daniel B. Stephens & Associates, Inc.

Saturated Hydraulic Conductivity
Flexible Wall Falling Head-Rising Tail Method

Job Name: AECOM
Job Number: DB24.1170.00
Sample Number: TP-72 (0-10) (85%)
Project Name: APS Cholla Fly Ash Pond
Project Number: 60710305

Remolded or Initial Sample Properties

Initial Mass (g):	1532.20
Diameter (cm):	10.193
Length (cm):	10.156
Area (cm^2):	81.60
Volume (cm^3):	828.74
Dry Density (g/cm^3):	1.67
Dry Density (pcf):	104.0
Water Content (%, g/g):	11.0
Water Content (%, vol):	18.3
Void Ratio (e):	0.63
Porosity (%, vol):	38.7
Saturation (%):	47.3

Post Permeation Sample Properties

Saturated Mass (g):	1677.34
Dry Mass (g):	1380.51
Diameter (cm):	10.249
Length (cm):	10.094
*Deformation (%)**:*	0.61
Area (cm^2):	82.50
Volume (cm^3):	832.75
Dry Density (g/cm^3):	1.66
Dry Density (pcf):	103.5
Water Content (%, g/g):	21.5
Water Content (%, vol):	35.6
Void Ratio(e):	0.64
Porosity (%, vol):	39.0
Saturation (%):*	91.4

Test and Sample Conditions

Permeant liquid used:	Tap Water
Sample Preparation:	☐ In situ sample, extruded ☑ Remolded Sample
Number of Lifts:	3
Split:	3/4"
Percent Coarse Material (%):	15.6
Particle Density(g/cm^3):	2.72 ☐ Assumed ☑ Measured
Cell pressure (PSI):	81.0
Influent pressure (PSI):	80.0
Effluent pressure (PSI):	80.0
Panel Used:	☑ A ☐ B ☐ C
Reading:	☐ Annulus ☑ Pipette

		Date/Time
B-Value (% saturation) prior to test*:	0.97	4/18/24 1000
B-Value (% saturation) post to test:	0.95	4/18/24 1400

* Per ASTM D5084 percent saturation is ensured (B-Value ≥ 95%) prior to testing, as post test saturation values may be exaggerated or skewed during depressurizing and sample removal.

**Percent Deformation: based on initial sample length and post permeation sample length.

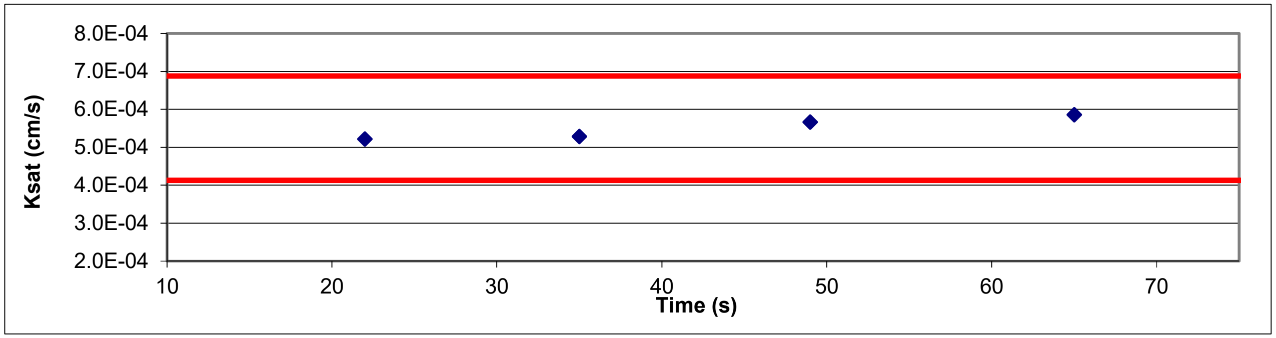
Laboratory analysis by: F. Cerno
Data entered by: F. Cerno
Checked by: J. Hines

Saturated Hydraulic Conductivity
Flexible Wall Falling Head-Rising Tail Method

Job Name: AECOM
Job Number: DB24.1170.00
Sample Number: TP-72 (0-10) (85%)
Project Name: APS Cholla Fly Ash Pond
Project Number: 60710305

Date	Time	Temp (°C)	Influent Pipette Reading	Effluent Pipette Reading	Gradient (ΔH/ΔL)	Average Flow (cm^3)	Elapsed Time (s)	Ratio (outflow to inflow)	Change in Head (Not to exceed 25%)	k_{sat} T°C (cm/s)	k_{sat} Corrected (cm/s)
Test # 1:											
18-Apr-24	10:41:00	21.4	10.00	20.00	1.14	0.87	22	1.00	20%	5.39E-04	5.21E-04
18-Apr-24	10:41:22	21.4	11.00	19.00	0.92						
Test # 2:											
18-Apr-24	10:41:22	21.4	11.00	19.00	0.92	0.43	13	1.00	12%	5.46E-04	5.28E-04
18-Apr-24	10:41:35	21.4	11.50	18.50	0.80						
Test # 3:											
18-Apr-24	10:41:35	21.4	11.50	18.50	0.80	0.43	14	1.00	14%	5.85E-04	5.66E-04
18-Apr-24	10:41:49	21.4	12.00	18.00	0.69						
Test # 4:											
18-Apr-24	10:41:49	21.4	12.00	18.00	0.69	0.43	16	1.00	17%	6.06E-04	5.86E-04
18-Apr-24	10:42:05	21.4	12.50	17.50	0.57						

***Average Ksat* (cm/sec):** **5.50E-04**
Calculated Gravel Corrected Average Ksat (cm/sec): 4.64E-04



ASTM Required Range (+/- 25%)

Ksat (-25%) (cm/s): 4.13E-04

Ksat (+25%) (cm/s): 6.88E-04

Daniel B. Stephens & Associates, Inc.

Saturated Hydraulic Conductivity
Flexible Wall Falling Head-Rising Tail Method

Job Name: AECOM
Job Number: DB24.1170.00
Sample Number: TP-73 (0-10) (85%)
Project Name: APS Cholla Fly Ash Pond
Project Number: 60710305

Remolded or Initial Sample Properties

Initial Mass (g):	410.61
Diameter (cm):	6.126
Length (cm):	7.607
Area (cm^2):	29.47
Volume (cm^3):	224.21
Dry Density (g/cm^3):	1.64
Dry Density (pcf):	102.1
Water Content (%, g/g):	12.0
Water Content (%, vol):	19.6
Void Ratio (e):	0.63
Porosity (%, vol):	38.8
Saturation (%):	50.4

Post Permeation Sample Properties

Saturated Mass (g):	447.41
Dry Mass (g):	366.73
Diameter (cm):	6.006
Length (cm):	7.590
*Deformation (%)**:*	0.22
Area (cm^2):	28.33
Volume (cm^3):	215.03
Dry Density (g/cm^3):	1.71
Dry Density (pcf):	106.5
Water Content (%, g/g):	22.0
Water Content (%, vol):	37.5
Void Ratio(e):	0.57
Porosity (%, vol):	36.2
Saturation (%):*	103.6

Test and Sample Conditions

Permeant liquid used:	Tap Water
Sample Preparation:	☐ In situ sample, extruded
	☑ Remolded Sample
Number of Lifts:	3
Split:	3/8"
Percent Coarse Material (%):	2.2
Particle Density(g/cm^3):	2.67 ☐ Assumed ☑ Measured
Cell pressure (PSI):	81.0
Influent pressure (PSI):	80.0
Effluent pressure (PSI):	80.0
Panel Used:	☑ G ☐ H ☐ I
Reading:	☐ Annulus ☑ Pipette

		Date/Time
B-Value (% saturation) prior to test*:	0.99	4/12/24 0830
B-Value (% saturation) post to test:	0.95	4/12/24 1115

* Per ASTM D5084 percent saturation is ensured (B-Value ≥ 95%) prior to testing, as post test saturation values may be exaggerated during depressurizing and sample removal.

**Percent Deformation: based on initial sample length and post permeation sample length.

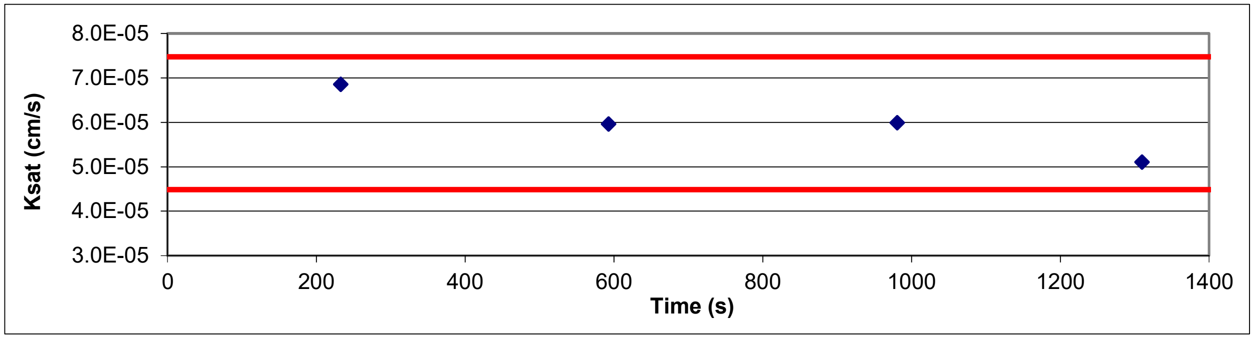
Laboratory analysis by: F.Cerno
Data entered by: F.Cerno
Checked by: J. Hines

Saturated Hydraulic Conductivity
Flexible Wall Falling Head-Rising Tail Method

Job Name: AECOM
Job Number: DB24.1170.00
Sample Number: TP-73 (0-10) (85%)
Project Name: APS Cholla Fly Ash Pond
Project Number: 60710305

Date	Time	Temp (°C)	Influent Pipette Reading	Effluent Pipette Reading	Gradient ($\Delta H/\Delta L$)	Average Flow (cm^3)	Elapsed Time (s)	Ratio (outflow to inflow)	Change in Head (Not to exceed 25%)	k_{sat} T°C (cm/s)	k_{sat} Corrected (cm/s)
Test # 1:											
12-Apr-24	08:34:00	22.8	2.00	24.00	3.35	1.30	233	1.00	14%	7.32E-05	6.85E-05
12-Apr-24	08:37:53	22.8	3.50	22.50	2.89						
Test # 2:											
12-Apr-24	08:37:53	22.8	3.50	22.50	2.89	1.48	360	1.00	18%	6.38E-05	5.96E-05
12-Apr-24	08:43:53	22.8	5.20	20.80	2.37						
Test # 3:											
12-Apr-24	08:43:53	22.8	5.20	20.80	2.37	1.30	388	1.00	19%	6.41E-05	5.99E-05
12-Apr-24	08:50:21	22.8	6.70	19.30	1.92						
Test # 4:											
12-Apr-24	08:50:21	22.8	6.70	19.30	1.92	0.78	329	1.00	14%	5.45E-05	5.10E-05
12-Apr-24	08:55:50	22.8	7.60	18.40	1.64						

***Average Ksat* (cm/sec):** **5.98E-05**
Calculated Gravel Corrected Average Ksat (cm/sec): ---



ASTM Required Range (+/- 25%)

Ksat (-25%) (cm/s): 4.48E-05

Ksat (+25%) (cm/s): 7.47E-05

Saturated Hydraulic Conductivity
Flexible Wall Falling Head-Rising Tail Method

Job Name:	AECOM
Job Number:	DB24.1170.00
Sample Number:	TP-76 (0-10) (85%)
Project Name:	APS Cholla Fly Ash Pond
Project Number:	60710305

Remolded or Initial Sample Properties

Initial Mass (g):	1556.33
Diameter (cm):	10.194
Length (cm):	10.157
Area (cm^2):	81.62
Volume (cm^3):	828.98
Dry Density (g/cm^3):	1.76
Dry Density (pcf):	109.6
Water Content (%, g/g):	6.9
Water Content (%, vol):	12.1
Void Ratio (e):	0.51
Porosity (%, vol):	34.0
Saturation (%):	35.6

Post Permeation Sample Properties

Saturated Mass (g):	1700.76
Dry Mass (g):	1455.93
Diameter (cm):	10.332
Length (cm):	10.104
*Deformation (%)**:*	0.52
Area (cm^2):	83.84
Volume (cm^3):	847.13
Dry Density (g/cm^3):	1.72
Dry Density (pcf):	107.3
Water Content (%, g/g):	16.8
Water Content (%, vol):	28.9
Void Ratio(e):	0.55
Porosity (%, vol):	35.4
Saturation (%):*	81.7

Test and Sample Conditions

Permeant liquid used:	Tap Water
Sample Preparation:	☐ In situ sample, extruded ☑ Remolded Sample
Number of Lifts:	3
Split:	3/4"
Percent Coarse Material (%):	36.2
Particle Density(g/cm^3):	2.66 ☐ Assumed ☑ Measured
Cell pressure (PSI):	81.0
Influent pressure (PSI):	80.0
Effluent pressure (PSI):	80.0
Panel Used:	☐ A ☑ B ☐ C
Reading:	☐ Annulus ☑ Pipette

		Date/Time
B-Value (% saturation) prior to test*:	0.97	4/18/24 1000
B-Value (% saturation) post to test:	0.97	4/18/24 1400

* Per ASTM D5084 percent saturation is ensured (B-Value ≥ 95%) prior to testing, as post test saturation values may be exaggerated or skewed during depressurizing and sample removal.
**Percent Deformation: based on initial sample length and post permeation sample length.

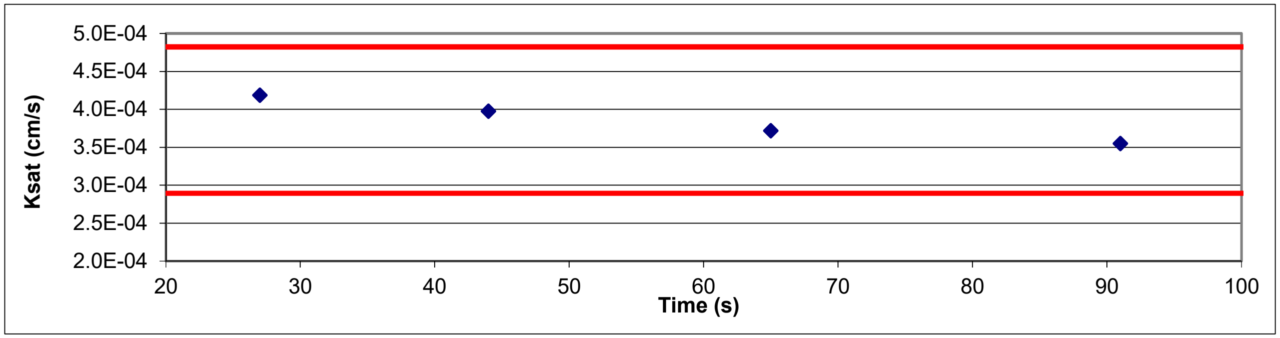
Laboratory analysis by:	F. Cerno
Data entered by:	F. Cerno
Checked by:	J. Hines

Saturated Hydraulic Conductivity
Flexible Wall Falling Head-Rising Tail Method

Job Name: AECOM
Job Number: DB24.1170.00
Sample Number: TP-76 (0-10) (85%)
Project Name: APS Cholla Fly Ash Pond
Project Number: 60710305

Date	Time	Temp (°C)	Influent Pipette Reading	Effluent Pipette Reading	Gradient (ΔH/ΔL)	Average Flow (cm^3)	Elapsed Time (s)	Ratio (outflow to inflow)	Change in Head (Not to exceed 25%)	k_{sat} T°C (cm/s)	k_{sat} Corrected (cm/s)
Test # 1:											
18-Apr-24	10:50:08	21.4	10.00	20.00	1.14	0.87	27	1.00	20%	4.33E-04	4.18E-04
18-Apr-24	10:50:35	21.4	11.00	19.00	0.91						
Test # 2:											
18-Apr-24	10:50:35	21.4	11.00	19.00	0.91	0.43	17	1.00	12%	4.11E-04	3.98E-04
18-Apr-24	10:50:52	21.4	11.50	18.50	0.80						
Test # 3:											
18-Apr-24	10:50:52	21.4	11.50	18.50	0.80	0.43	21	1.00	14%	3.84E-04	3.72E-04
18-Apr-24	10:51:13	21.4	12.00	18.00	0.69						
Test # 4:											
18-Apr-24	10:51:13	21.4	12.00	18.00	0.69	0.43	26	1.00	17%	3.67E-04	3.55E-04
18-Apr-24	10:51:39	21.4	12.50	17.50	0.57						

***Average Ksat* (cm/sec):** **3.86E-04**
Calculated Gravel Corrected Average Ksat (cm/sec): 2.46E-04



ASTM Required Range (+/- 25%)

Ksat (-25%) (cm/s): 2.89E-04

Ksat (+25%) (cm/s): 4.82E-04

Daniel B. Stephens & Associates, Inc.

Saturated Hydraulic Conductivity
Flexible Wall Falling Head-Rising Tail Method

Job Name:	AECOM
Job Number:	DB24.1170.00
Sample Number:	TP-77 (0-10) (85%)
Project Name:	APS Cholla Fly Ash Pond
Project Number:	60710305

Remolded or Initial Sample Properties

Initial Mass (g):	401.76
Diameter (cm):	6.121
Length (cm):	7.606
Area (cm^2):	29.43
Volume (cm^3):	223.82
Dry Density (g/cm^3):	1.60
Dry Density (pcf):	100.0
Water Content (%, g/g):	12.0
Water Content (%, vol):	19.3
Void Ratio (e):	0.66
Porosity (%, vol):	39.7
Saturation (%):	48.5

Post Permeation Sample Properties

Saturated Mass (g):	436.52
Dry Mass (g):	358.66
Diameter (cm):	6.049
Length (cm):	7.482
*Deformation (%)**:*	1.66
Area (cm^2):	28.74
Volume (cm^3):	215.02
Dry Density (g/cm^3):	1.67
Dry Density (pcf):	104.1
Water Content (%, g/g):	21.7
Water Content (%, vol):	36.2
Void Ratio(e):	0.59
Porosity (%, vol):	37.3
Saturation (%):*	97.2

Test and Sample Conditions

Permeant liquid used:	Tap Water
Sample Preparation:	☐ In situ sample, extruded
	☑ Remolded Sample
Number of Lifts:	3
Split:	3/8"
Percent Coarse Material (%):	24.1
Particle Density(g/cm^3):	2.66 ☐ Assumed ☑ Measured
Cell pressure (PSI):	81.0
Influent pressure (PSI):	80.0
Effluent pressure (PSI):	80.0
Panel Used:	☐ A ☐ B ☑ C
Reading:	☐ Annulus ☑ Pipette

		Date/Time
B-Value (% saturation) prior to test*:	0.98	4/16/24 0800
B-Value (% saturation) post to test:	0.97	4/16/24 1015

* Per ASTM D5084 percent saturation is ensured (B-Value ≥ 95%) prior to testing, as post test saturation values may be exaggerated or skewed during depressurizing and sample removal.
**Percent Deformation: based on initial sample length and post permeation sample length.

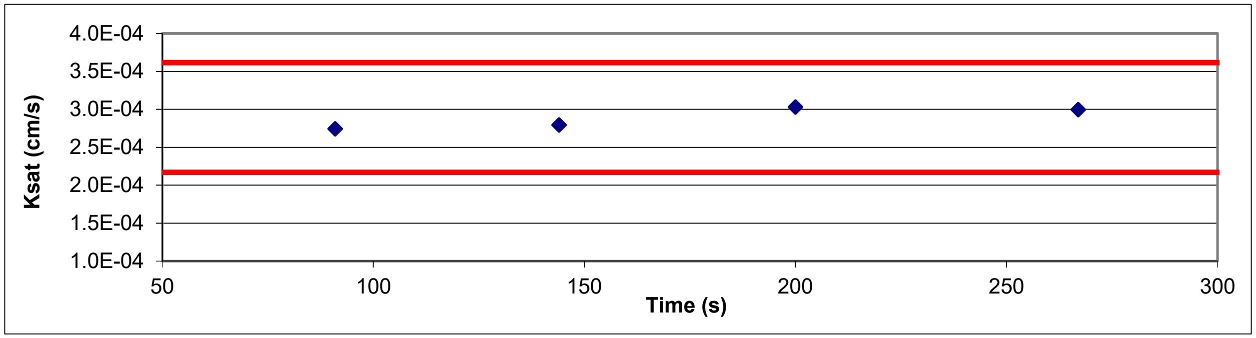
Laboratory analysis by: F. Cerno
Data entered by: F. Cerno
Checked by: J. Hines

Saturated Hydraulic Conductivity
Flexible Wall Falling Head-Rising Tail Method

Job Name: AECOM
Job Number: DB24.1170.00
Sample Number: TP-77 (0-10) (85%)
Project Name: APS Cholla Fly Ash Pond
Project Number: 60710305

Date	Time	Temp (°C)	Influent Pipette Reading	Effluent Pipette Reading	Gradient ($\Delta H/\Delta L$)	Average Flow (cm^3)	Elapsed Time (s)	Ratio (outflow to inflow)	Change in Head (Not to exceed 25%)	k_{sat} T°C (cm/s)	k_{sat} Corrected (cm/s)
Test # 1:											
16-Apr-24	08:16:00	20.4	10.00	20.00	1.54	0.87	91	1.00	20%	2.77E-04	2.74E-04
16-Apr-24	08:17:31	20.5	11.00	19.00	1.23						
Test # 2:											
16-Apr-24	08:17:31	20.5	11.00	19.00	1.23	0.43	53	1.00	12%	2.85E-04	2.79E-04
16-Apr-24	08:18:24	21.2	11.50	18.50	1.08						
Test # 3:											
16-Apr-24	08:18:24	21.2	11.50	18.50	1.08	0.43	56	1.00	14%	3.11E-04	3.03E-04
16-Apr-24	08:19:20	21.1	12.00	18.00	0.93						
Test # 4:											
16-Apr-24	08:19:20	21.1	12.00	18.00	0.93	0.43	67	1.00	17%	3.08E-04	3.00E-04
16-Apr-24	08:20:27	21.1	12.50	17.50	0.77						

***Average Ksat* (cm/sec): 2.89E-04**
Calculated Gravel Corrected Average Ksat (cm/sec): 2.19E-04



ASTM Required Range (+/- 25%)

Ksat (-25%) (cm/s): 2.17E-04

Ksat (+25%) (cm/s): 3.61E-04

Saturated Hydraulic Conductivity
Flexible Wall Falling Head-Rising Tail Method

Job Name: AECOM
Job Number: DB24.1170.00
Sample Number: TP-80 (0-10) (85%)
Project Name: APS Cholla Fly Ash Pond
Project Number: 60710305

Remolded or Initial Sample Properties

Initial Mass (g):	395.04
Diameter (cm):	6.12
Length (cm):	7.607
Area (cm^2):	29.42
Volume (cm^3):	223.77
Dry Density (g/cm^3):	1.58
Dry Density (pcf):	98.6
Water Content (%, g/g):	11.8
Water Content (%, vol):	18.6
Void Ratio (e):	0.71
Porosity (%, vol):	41.4
Saturation (%):	44.8

Post Permeation Sample Properties

Saturated Mass (g):	430.50
Dry Mass (g):	353.49
Diameter (cm):	5.947
Length (cm):	7.669
*Deformation (%)**:*	0.81
Area (cm^2):	27.78
Volume (cm^3):	213.02
Dry Density (g/cm^3):	1.66
Dry Density (pcf):	103.6
Water Content (%, g/g):	21.8
Water Content (%, vol):	36.2
Void Ratio(e):	0.63
Porosity (%, vol):	38.5
Saturation (%):*	93.9

Test and Sample Conditions

Permeant liquid used:	Tap Water
Sample Preparation:	☐ In situ sample, extruded
	☑ Remolded Sample
Number of Lifts:	3
Split:	3/8"
Percent Coarse Material (%):	20.3
Particle Density(g/cm^3):	2.70 ☐ Assumed ☑ Measured
Cell pressure (PSI):	81.0
Influent pressure (PSI):	80.0
Effluent pressure (PSI):	80.0
Panel Used:	☐ A ☐ B ☑ C
Reading:	☐ Annulus ☑ Pipette

		Date/Time
B-Value (% saturation) prior to test*:	0.98	4/12/24 830
B-Value (% saturation) post to test:	0.99	4/12/24 1115

* Per ASTM D5084 percent saturation is ensured (B-Value ≥ 95%) prior to testing, as post test saturation values may be exaggerated or skewed during depressurizing and sample removal.
**Percent Deformation: based on initial sample length and post permeation sample length.

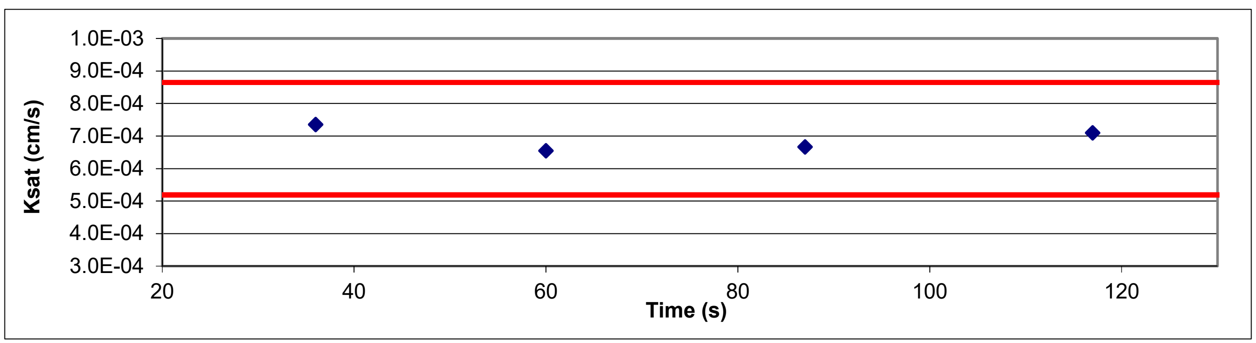
Laboratory analysis by: D. O'Dowd
Data entered by: D. O'Dowd
Checked by: J. Hines

Saturated Hydraulic Conductivity
Flexible Wall Falling Head-Rising Tail Method

Job Name: AECOM
Job Number: DB24.1170.00
Sample Number: TP-80 (0-10) (85%)
Project Name: APS Cholla Fly Ash Pond
Project Number: 60710305

Date	Time	Temp (°C)	Influent Pipette Reading	Effluent Pipette Reading	Gradient (ΔH/ΔL)	Average Flow (cm^3)	Elapsed Time (s)	Ratio (outflow to inflow)	Change in Head (Not to exceed 25%)	k_{sat} T°C (cm/s)	k_{sat} Corrected (cm/s)
Test # 1:											
12-Apr-24	10:07:00	20.4	10.00	20.00	1.51	0.87	36	1.00	20%	7.44E-04	7.36E-04
12-Apr-24	10:07:36	20.5	11.00	19.00	1.20						
Test # 2:											
12-Apr-24	10:07:36	20.5	11.00	19.00	1.20	0.43	24	1.00	12%	6.67E-04	6.54E-04
12-Apr-24	10:08:00	21.2	11.50	18.50	1.05						
Test # 3:											
12-Apr-24	10:08:00	21.2	11.50	18.50	1.05	0.43	27	1.00	14%	6.85E-04	6.67E-04
12-Apr-24	10:08:27	21.1	12.00	18.00	0.90						
Test # 4:											
12-Apr-24	10:08:27	21.1	12.00	18.00	0.90	0.43	30	1.00	17%	7.29E-04	7.10E-04
12-Apr-24	10:08:57	21.1	12.50	17.50	0.75						

***Average Ksat* (cm/sec):** **6.92E-04**
Calculated Gravel Corrected Average Ksat (cm/sec): 5.51E-04



ASTM Required Range (+/- 25%)

Ksat (-25%) (cm/s): 5.19E-04

Ksat (+25%) (cm/s): 8.65E-04

Saturated Hydraulic Conductivity
Flexible Wall Falling Head-Rising Tail Method

Job Name: AECOM
Job Number: DB24.1170.00
Sample Number: TP-81 (0-10) (85%)
Project Name: APS Cholla Fly Ash Pond
Project Number: 60710305

Remolded or Initial Sample Properties

Initial Mass (g):	396.47
Diameter (cm):	6.111
Length (cm):	7.607
Area (cm^2):	29.33
Volume (cm^3):	223.11
Dry Density (g/cm^3):	1.57
Dry Density (pcf):	97.8
Water Content (%, g/g):	13.4
Water Content (%, vol):	21.0
Void Ratio (e):	0.70
Porosity (%, vol):	41.1
Saturation (%):	51.2

Post Permeation Sample Properties

Saturated Mass (g):	433.74
Dry Mass (g):	349.52
Diameter (cm):	6.064
Length (cm):	7.543
*Deformation (%)**:*	0.85
Area (cm^2):	28.88
Volume (cm^3):	217.85
Dry Density (g/cm^3):	1.60
Dry Density (pcf):	100.2
Water Content (%, g/g):	24.1
Water Content (%, vol):	38.7
Void Ratio(e):	0.66
Porosity (%, vol):	39.7
Saturation (%):*	97.4

Test and Sample Conditions

Permeant liquid used:	Tap Water
Sample Preparation:	☐ In situ sample, extruded ☑ Remolded Sample
Number of Lifts:	3
Split:	3/8"
Percent Coarse Material (%):	11.41
Particle Density(g/cm^3):	2.66 ☐ Assumed ☑ Measured
Cell pressure (PSI):	81.0
Influent pressure (PSI):	80.0
Effluent pressure (PSI):	80.0
Panel Used:	☑ A ☐ B ☐ C
Reading:	☐ Annulus ☑ Pipette

		Date/Time
B-Value (% saturation) prior to test*:	0.98	4/12/24 830
B-Value (% saturation) post to test:	0.98	4/12/24 1115

* Per ASTM D5084 percent saturation is ensured (B-Value ≥ 95%) prior to testing, as post test saturation values may be exaggerated or skewed during depressurizing and sample removal.
**Percent Deformation: based on initial sample length and post permeation sample length.

Laboratory analysis by: F. Cerno
Data entered by: F. Cerno
Checked by: J. Hines

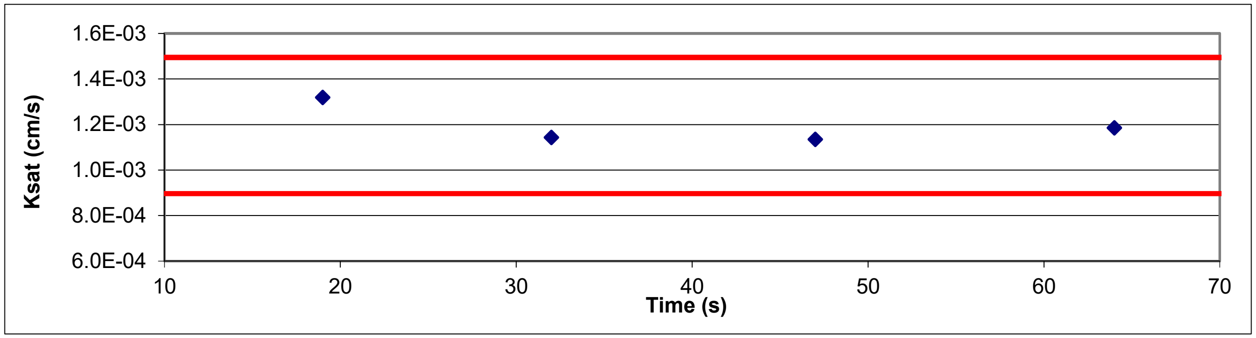
Saturated Hydraulic Conductivity
Flexible Wall Falling Head-Rising Tail Method

Job Name: AECOM
Job Number: DB24.1170.00
Sample Number: TP-81 (0-10) (85%)
Project Name: APS Cholla Fly Ash Pond
Project Number: 60710305

Date	Time	Temp (°C)	Influent Pipette Reading	Effluent Pipette Reading	Gradient ($\Delta H/\Delta L$)	Average Flow (cm^3)	Elapsed Time (s)	Ratio (outflow to inflow)	Change in Head (Not to exceed 25%)	k_{sat} T°C (cm/s)	k_{sat} Corrected (cm/s)
Test # 1:											
12-Apr-24	10:58:00	20.4	10.00	20.00	1.53	0.87	19	1.00	20%	1.33E-03	1.32E-03
12-Apr-24	10:58:19	20.5	11.00	19.00	1.22						
Test # 2:											
12-Apr-24	10:58:19	20.5	11.00	19.00	1.22	0.43	13	1.00	12%	1.17E-03	1.14E-03
12-Apr-24	10:58:32	21.2	11.50	18.50	1.07						
Test # 3:											
12-Apr-24	10:58:32	21.2	11.50	18.50	1.07	0.43	15	1.00	14%	1.17E-03	1.14E-03
12-Apr-24	10:58:47	21.1	12.00	18.00	0.92						
Test # 4:											
12-Apr-24	10:58:47	21.1	12.00	18.00	0.92	0.43	17	1.00	17%	1.22E-03	1.19E-03
12-Apr-24	10:59:04	21.1	12.50	17.50	0.77						

***Average Ksat* (cm/sec): 1.20E-03**

Calculated Gravel Corrected Average Ksat (cm/sec): 1.06E-03



ASTM Required Range (+/- 25%)

Ksat (-25%) (cm/s): 8.97E-04

Ksat (+25%) (cm/s): 1.49E-03

Saturated Hydraulic Conductivity
Flexible Wall Falling Head-Rising Tail Method

Job Name: AECOM
Job Number: DB24.1170.00
Sample Number: TP-84 (0-10) (85%)
Project Name: APS Cholla Fly Ash Pond
Project Number: 60710305

Remolded or Initial Sample Properties

Initial Mass (g):	412.90
Diameter (cm):	6.124
Length (cm):	7.606
Area (cm^2):	29.46
Volume (cm^3):	224.04
Dry Density (g/cm^3):	1.67
Dry Density (pcf):	104.1
Water Content (%, g/g):	10.5
Water Content (%, vol):	17.5
Void Ratio (e):	0.61
Porosity (%, vol):	37.8
Saturation (%):	46.4

Post Permeation Sample Properties

Saturated Mass (g):	450.59
Dry Mass (g):	373.67
Diameter (cm):	6.098
Length (cm):	7.496
*Deformation (%)**:*	1.47
Area (cm^2):	29.21
Volume (cm^3):	218.92
Dry Density (g/cm^3):	1.71
Dry Density (pcf):	106.6
Water Content (%, g/g):	20.6
Water Content (%, vol):	35.1
Void Ratio(e):	0.57
Porosity (%, vol):	36.3
Saturation (%):*	96.8

Test and Sample Conditions

Permeant liquid used:	Tap Water
Sample Preparation:	☐ In situ sample, extruded ☑ Remolded Sample
Number of Lifts:	3
Split:	3/8"
Percent Coarse Material (%):	5.97
Particle Density(g/cm^3):	2.68 ☐ Assumed ☑ Measured
Cell pressure (PSI):	81.0
Influent pressure (PSI):	80.0
Effluent pressure (PSI):	80.0
Panel Used:	☐ A ☐ B ☑ C
Reading:	☐ Annulus ☑ Pipette

		Date/Time
B-Value (% saturation) prior to test*:	0.99	4/16/24 0830
B-Value (% saturation) post to test:	0.98	4/16/24 1015

* Per ASTM D5084 percent saturation is ensured (B-Value ≥ 95%) prior to testing, as post test saturation values may be exaggerated or skewed during depressurizing and sample removal.
**Percent Deformation: based on initial sample length and post permeation sample length.

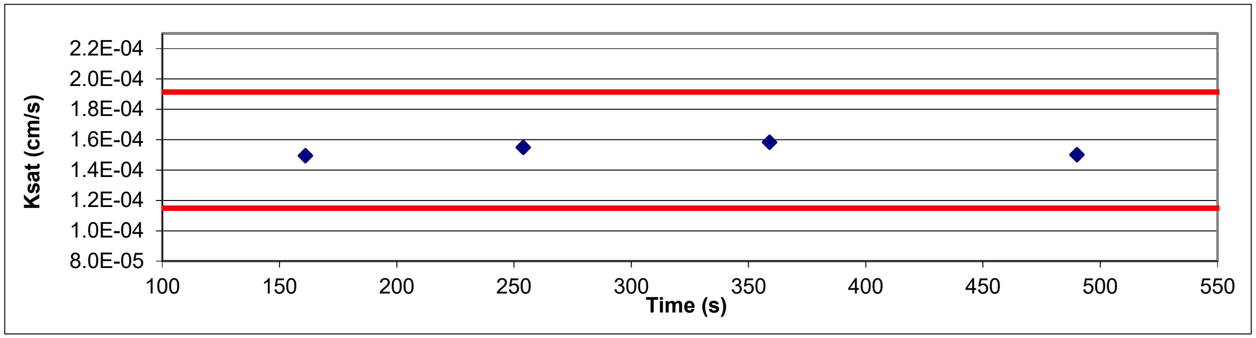
Laboratory analysis by: F. Cerno
Data entered by: F. Cerno
Checked by: J. Hines

Saturated Hydraulic Conductivity
Flexible Wall Falling Head-Rising Tail Method

Job Name: AECOM
Job Number: DB24.1170.00
Sample Number: TP-84 (0-10) (85%)
Project Name: APS Cholla Fly Ash Pond
Project Number: 60710305

Date	Time	Temp (°C)	Influent Pipette Reading	Effluent Pipette Reading	Gradient (ΔH/ΔL)	Average Flow (cm^3)	Elapsed Time (s)	Ratio (outflow to inflow)	Change in Head (Not to exceed 25%)	k_{sat} T°C (cm/s)	k_{sat} Corrected (cm/s)
Test # 1:											
16-Apr-24	08:26:00	21.4	10.00	20.00	1.54	0.87	161	1.00	20%	1.55E-04	1.49E-04
16-Apr-24	08:28:41	21.4	11.00	19.00	1.23						
Test # 2:											
16-Apr-24	08:28:41	21.4	11.00	19.00	1.23	0.43	93	1.00	12%	1.60E-04	1.55E-04
16-Apr-24	08:30:14	21.4	11.50	18.50	1.08						
Test # 3:											
16-Apr-24	08:30:14	21.4	11.50	18.50	1.08	0.43	105	1.00	14%	1.64E-04	1.58E-04
16-Apr-24	08:31:59	21.4	12.00	18.00	0.92						
Test # 4:											
16-Apr-24	08:31:59	21.4	12.00	18.00	0.92	0.43	131	1.00	17%	1.55E-04	1.50E-04
16-Apr-24	08:34:10	21.4	12.50	17.50	0.77						

***Average Ksat* (cm/sec): 1.53E-04**
Calculated Gravel Corrected Average Ksat (cm/sec): 1.44E-04



ASTM Required Range (+/- 25%)

Ksat (-25%) (cm/s): 1.15E-04

Ksat (+25%) (cm/s): 1.91E-04

Saturated Hydraulic Conductivity
Flexible Wall Falling Head-Rising Tail Method

Job Name: AECOM
Job Number: DB24.1170.00
Sample Number: TP-85 (0-10) (85%)
Project Name: APS Cholla Fly Ash Pond
Project Number: 60710305

Remolded or Initial Sample Properties

Initial Mass (g):	396.79
Diameter (cm):	6.126
Length (cm):	7.607
Area (cm^2):	29.47
Volume (cm^3):	224.21
Dry Density (g/cm^3):	1.59
Dry Density (pcf):	99.2
Water Content (%, g/g):	11.3
Water Content (%, vol):	18.0
Void Ratio (e):	0.68
Porosity (%, vol):	40.5
Saturation (%):	44.5

Post Permeation Sample Properties

Saturated Mass (g):	434.71
Dry Mass (g):	356.41
Diameter (cm):	6.107
Length (cm):	7.529
*Deformation (%)**:*	1.04
Area (cm^2):	29.29
Volume (cm^3):	220.54
Dry Density (g/cm^3):	1.62
Dry Density (pcf):	100.9
Water Content (%, g/g):	22.0
Water Content (%, vol):	35.5
Void Ratio(e):	0.65
Porosity (%, vol):	39.5
Saturation (%):*	90.0

Test and Sample Conditions

Permeant liquid used:	Tap Water
Sample Preparation:	☐ In situ sample, extruded ☑ Remolded Sample
Number of Lifts:	3
Split:	3/8"
Percent Coarse Material (%):	2.9
Particle Density(g/cm^3):	2.67 ☐ Assumed ☑ Measured
Cell pressure (PSI):	81.0
Influent pressure (PSI):	80.0
Effluent pressure (PSI):	80.0
Panel Used:	☐ A ☑ B ☐ C
Reading:	☐ Annulus ☑ Pipette

		Date/Time
B-Value (% saturation) prior to test*:	0.97	4/12/24 830
B-Value (% saturation) post to test:	0.99	4/12/24 1130

* Per ASTM D5084 percent saturation is ensured (B-Value ≥ 95%) prior to testing, as post test saturation values may be exaggerated or skewed during depressurizing and sample removal.

**Percent Deformation: based on initial sample length and post permeation sample length.

Laboratory analysis by: F. Cerno
Data entered by: F. Cerno
Checked by: J. Hines

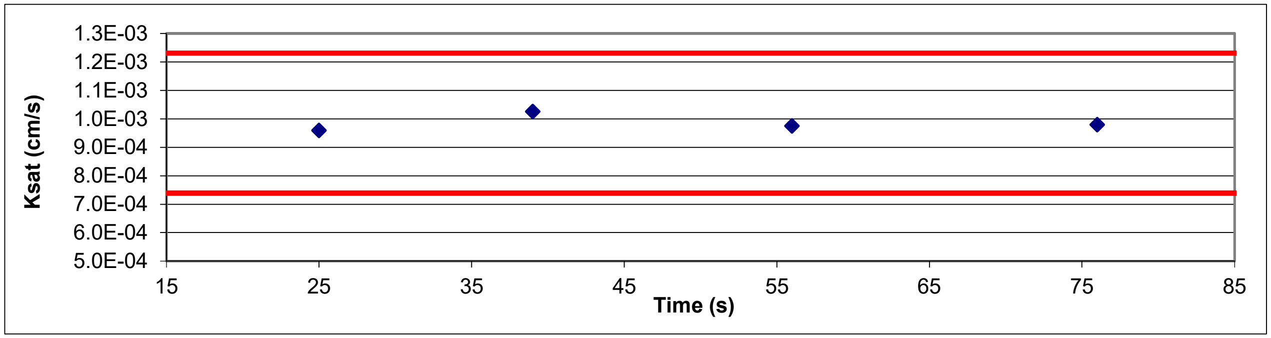
Daniel B. Stephens & Associates, Inc.

Saturated Hydraulic Conductivity
Flexible Wall Falling Head-Rising Tail Method

Job Name: AECOM
Job Number: DB24.1170.00
Sample Number: TP-85 (0-10) (85%)
Project Name: APS Cholla Fly Ash Pond
Project Number: 60710305

Date	Time	Temp (°C)	Influent Pipette Reading	Effluent Pipette Reading	Gradient (ΔH/ΔL)	Average Flow (cm^3)	Elapsed Time (s)	Ratio (outflow to inflow)	Change in Head (Not to exceed 25%)	k_{sat} T°C (cm/s)	k_{sat} Corrected (cm/s)
Test # 1:											
12-Apr-24	11:24:00	21.6	10.00	20.00	1.53	0.87	25	1.00	20%	9.97E-04	9.59E-04
12-Apr-24	11:24:25	21.6	11.00	19.00	1.23						
Test # 2:											
12-Apr-24	11:24:25	21.6	11.00	19.00	1.23	0.43	14	1.00	12%	1.07E-03	1.03E-03
12-Apr-24	11:24:39	21.6	11.50	18.50	1.07						
Test # 3:											
12-Apr-24	11:24:39	21.6	11.50	18.50	1.07	0.43	17	1.00	14%	1.01E-03	9.75E-04
12-Apr-24	11:24:56	21.6	12.00	18.00	0.92						
Test # 4:											
12-Apr-24	11:24:56	21.6	12.00	18.00	0.92	0.43	20	1.00	17%	1.02E-03	9.80E-04
12-Apr-24	11:25:16	21.6	12.50	17.50	0.77						

***Average Ksat* (cm/sec): 9.85E-04**
Calculated Gravel Corrected Average Ksat (cm/sec): ---



ASTM Required Range (+/- 25%)

Ksat (-25%) (cm/s): 7.39E-04

Ksat (+25%) (cm/s): 1.23E-03

ATTACHMENT D

Final ET Closure Cover System

Maximum Flux versus Depth for Design Section

UNSAT-H Model Output

Figure 10 from ET Cover Design Calculation Package

Prepared for: Arizona Public Service

AECOM Project No. 60710305, September 2024

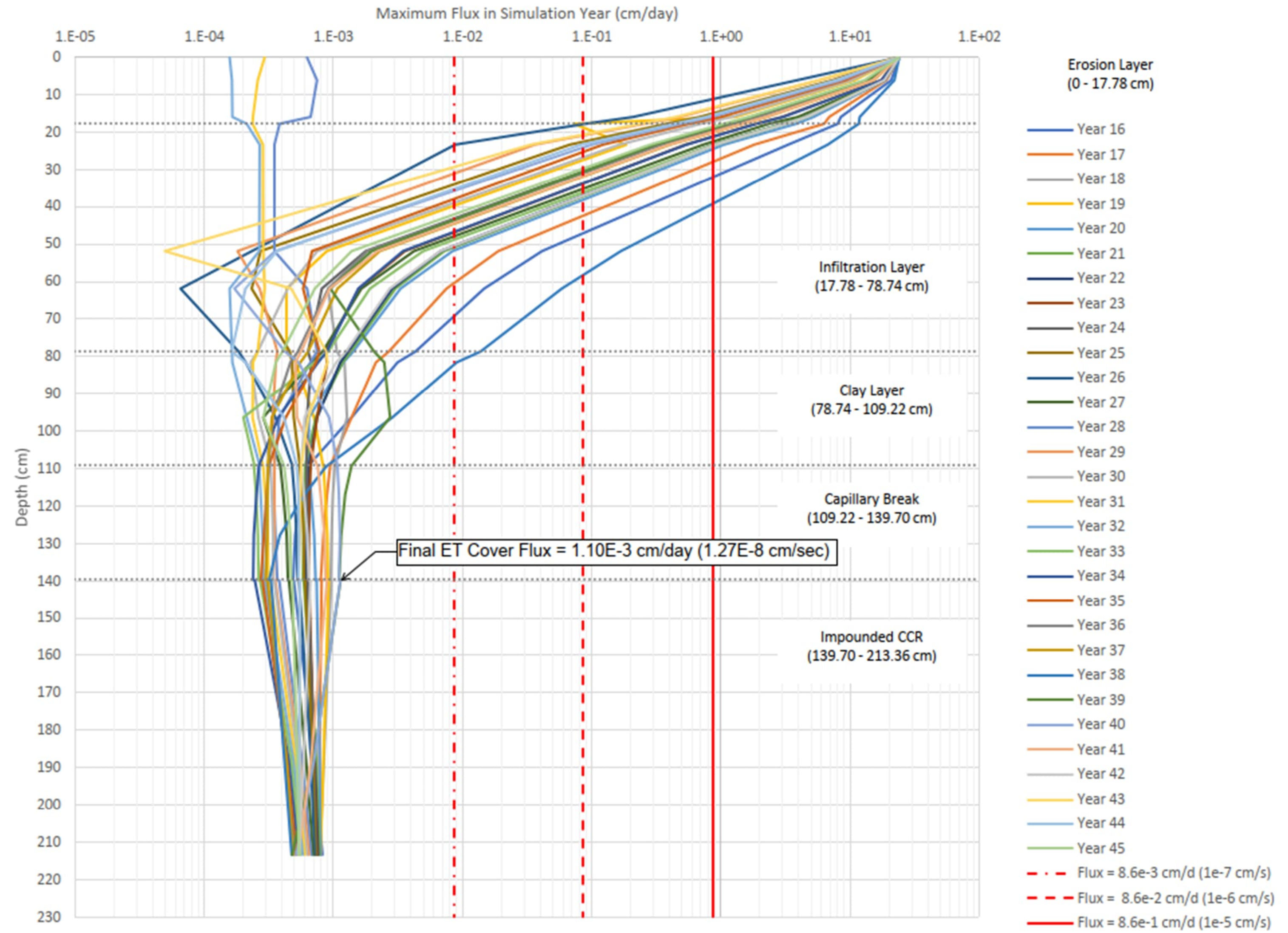


Figure 10. Maximum Flux (cm/day) versus Depth (Planned Section)

Cholla Fly Ash Pond ET Cover
Project No.:60710305

AECOM

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