DRAFT REMEDIAL ACTION PLAN

FOR

ADAIR PARK ARCHERY RANGE, YUMA, AZ.

VRP SITE CODE 505354-00

ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY
VOLUNTARY REMEDIATION PROGRAM

MAY 2020

Prepared for:

Yuma County
Department of Public Works
4343 South Avenue 5 ½ E.
Yuma, Arizona 85365

Prepared by:

1851 W 24TH STREET, SUITE 101
YUMA, AZ 85364

Registered Professional Engineer (Civil)
CERTIFICATE NO.
55066
ERIC SOL
GARDNER
Date Signed 5/28/20
ARIZONA U.S.A.
EXPIRES 9/30/22

Table of Contents

Figures

Tables

Appendix

List of Acronyms

ADEQ	Arizona Department of Environmental Quality
AOC	area of concern
A.R.S.	Arizona Revised Statute
bgs	below ground surface
DEUR	Declaration of Environmental Use Restriction
ECP	Engineering Control Plan
ft.	feet
IDW	Investigative Derived Waste
MDL	Method Detection Limit
mg/kg	milligrams per kilogram
NFA	No Further Action
NHI	National Highway Institute
NR	Non-residential
RAP	Remedial Action Plan
RCRA	Resource Conservation and Recovery Act
SBR	Setback Ratio
SPLP	Synthetic Precipitation Leaching Procedure
SRL	Soil Remedial Level
SWPPP	Stormwater Pollution Protection Plan
TCLP	toxicity characteristic leaching procedures
TFG	The Fehling Group
USBR	United States Bureau of Reclamation
USEPA	United States Environmental Protection Agency
VRP	Voluntary Remediation Program
XRF	X-ray Fluorescence

1.0 INTRODUCTION

This Remedial Action Plan (RAP) presents the remedial activities that will be implemented at the Adair Park Archery Range (site) located at 4760 South US Highway 95 and is accessed via Adair Park Road, approximately 12 miles north of Yuma, Arizona (Figure 1). In August 2000, an initial site assessment of the Adair Park Archery Range revealed the presence of elevated lead concentrations in the soil within the archery range. The subsequent investigation of the site discovered the site had previously been used for silver mine ore processing and that residual lead was discarded on site in the tailings from the silver ore mill. Remediation of the site performed in 2006 included excavation of contaminated soil, moving it to another area of the site that contained lead impacted soil and placing a gravel and double chip seal cap over the stockpiled contaminated soil (Figure 2). Yuma County entered the Voluntary Remediation Program (VRP) to address Arizona Department of Environmental Quality (ADEQ) concerns of residual lead contamination remaining at the site and the adequacy of the existing stormwater conveyance to protect the existing capped area of the site. Additional site characterization was performed in 2018 and 2019 in order to seek a No Further Action (NFA) letter from the ADEQ and having a Declaration of Environmental Use Restriction (DEUR) placed on the site.

2.0 SITE BACKGROUND

The site consists of 24 acres that was dedicated to Yuma County by the United States Bureau of Reclamation (USBR) in 1967 for rifle, pistol, and archery range uses. The archery range site is located in a dry ephemeral wash that is surrounded by the Gila River to the south, desert hills to the north and west and a shooting range to the east (Figure 2). The site currently consists of an archery range, several buildings, a shade structure, elevated shooting structures, archery targets and materials, and maintenance equipment.

2.1 PREVIOUS INVESTIGATIONS

An investigation of the site was performed in 2000. The investigation discovered that the site was formerly used as a silver ore mill during the late 1800s and early 1900s. The silver ore was brought to the site from the mine and processed at the mill. The tailings from the silver ore processing, which contained elevated lead concentrations, were placed in a tailings pond located on the site. The silver ore processing and associated tailings resulted in lead contaminated soil migrating throughout the site via stormwater runoff and wind-borne transportation.

Subsequent investigations by Yuma County and the ADEQ, through its Brownfields Site Cleanup Grant awarded by the US Environmental Protection Agency (USEPA) in 2004, revealed lead contaminated soil was present in the archery range and the archery practice area. Laboratory analytical results indicated that lead was present in the soil at concentrations up to 38,000 milligrams per kilogram (mg/kg). No other metals were detected in the soil that exceeded their respective soil remediation levels (SRLs). The lead contaminated soil was limited to an area within the boundaries of the site. In 2006, Yuma County entered the VRP and performed remedial activities at the site.

In 2006, the site was divided into three (3) areas of concern (AOCs) (Figure 2). Soil excavated from AOC 2 and AOC 3 was placed in AOC 1 where it was capped with a gravel base and a double chip seal surface (Kleinfelder 2006) . Fill from a nearby source was used to backfill the excavated areas in AOC 2. Soil excavated from AOC 3 created two stormwater retention basins currently used as part of the stormwater management system at the site. Additionally, engineering controls were constructed to divert stormwater around the capped area toward drainage channels on both sides of the capped area, into drainage channels through AOC 2 and into the retention basins located in AOC 3.

Following completion of the remediation, Yuma County intended to pursue an NFA and DEUR for the site. However, a reversion clause in the USBR dedication resulted in delaying the preparation of the NFA and DEUR. The archery range reopened in 2007 and Yuma County began inspection and maintenance of the engineering controls constructed to protect the integrity of the capped area.

ADEQ conducted a site inspection on March 5, 2014 and conducted a subsequent file review by the ADEQ VRP on March 7, 2014. The site inspection and file review indicated that several issues remain to be addressed at the site. Based on the ADEQ site inspection, the following recommendations were presented in a letter to Yuma County dated June 4, 2014:

1. An analysis of the stormwater conveyance should be prepared prior to application for a DEUR. The analysis should include an assessment of the stormwater flow and whether it is adequately diverted around the capped area or if peak flows result in flow across the top of the capped area.

2. Rip rap was used as a protective wall upstream (north) of the capped area instead of the originally designed concrete cutoff wall. The stormwater conveyance assessment should also evaluate the protectiveness of the rip rap wall and ensure the cap will not be undermined during a peak storm event.
3. An engineering control or calculation of a site specific alternate soil remediation standard should be prepared for the uncapped areas where lead may be present in concentrations greater than the established non-residential (NR) SRL.

4. Repair areas where the stormwater drainage channels have been eroded. All repairs or modifications to the erosion control system should be prepared and performed under the direction of an Arizona Professional Engineer.

5. Develop an alternate GPL for the site to evaluate potential impact to groundwater at the site.

Based on the file review conducted by ADEQ VRP, the ADEQ recommended the following in a letter dated March 7, 2014:

1. Approximately 35,000 to 40,000 cubic yards of fill material was used to replace the soil removed from AOC 2. The fill material was not certified clean and documentation that the fill material is free of environmental contaminants was not provided. Therefore, the ADEQ requested that the soil used as fill material be sampled and analyzed for Resource Conservation and Recovery Act (RCRA) eight (8) metals.

2. Protectiveness of groundwater was not evaluated during any of the assessments or remedial actions. Therefore, the ADEQ recommended eight (8) soil samples be collected and analyzed

for RCRA 8 total and leachable metals concentrations to enable the calculation of an alternate GPL for the site.

3. AOC 3 still contains lead in concentrations that exceed the NR SRL of 800 mg/kg. The ADEQ recommended the entire AOC 3 area be evaluated for RCRA 8 metals.
4. Based on previous investigations, lead contamination remains in the soil and engineering controls have been constructed to minimize exposure to the employees and users of the archery range. The ADEQ recommends a DEUR be submitted for approval. The DEUR should include the DEUR fee, an Engineering Control Plan (ECP), and proof of financial assurance.
5. The Phase II Environmental Site Assessment report did not document sample location or data used for background concentrations that were used to calculate the alternate background concentration cleanup levels. The ADEQ recommends conducting sampling to establish background concentrations for lead.

Based on this cap inspection and file review, Nicklaus Engineering, Inc. conducted additional site characterization and performed a stormwater conveyance evaluation for the site in 2019. The stormwater conveyance evaluation concluded several locations have experienced minor erosion that will be required to be repaired. Additionally, the channels downstream of the capped area will also require repair or upgrading in order to prevent stormwater overflow and erosion of the adjacent soil.

The distribution of lead in soil indicates that the top one feet of soil in several areas outside the capped area contain lead in concentrations greater than the NR SRL of 800 mg/kg. Additionally, the former tailings pile location contains lead in concentrations greater than 800 mg/kg and one location contains lead and cadmium in toxicity characteristic leaching procedures (TCLP) concentrations above their respective regulatory limit making the soil in the immediate area around this sample a characteristic hazardous waste due to its lead and cadmium toxicity.

Groundwater was encountered only on the southern third of the site, approximately along the northern edge of the detention basins located in AOC 3A and AOC 3B. The depth to groundwater in the southern area of the site is approximately 15 feet below ground surface (bgs). The portion of the site north of the detention basins, including the capped area and the former tailings pile area is underlain by shallow granitic bedrock and no groundwater is present in the alluvium. An alternate site-specific GPL of 50,899 mg/kg was calculated for lead at the site. No soil sample results exceeded the site specific GPL by the x-ray fluorescence (XRF) analyzer or by laboratory analysis.

The first attempt to evaluate groundwater quality resulted in sand heaving into the borehole preventing collection of a groundwater sample. A temporary groundwater monitoring well was installed at the site on November 6, 2019 and a groundwater sample was collected from the well on November 18, 2019. Lead was not detected in the groundwater at a concentration exceeding its laboratory reporting limit.

3.0 EXTENT OF CONTAMINATION

3.1 REMEDIATION GOALS

Soil remediation goals for the site are the non-residential SRL established by the ADEQ for metals. The arsenic non-residential SRL is 10 mg/kg and the non-residential (NR) SRL for lead is 800 mg/kg. To ensure that any existing soil contamination will not cause an exceedance of the aquifer water quality standard (AWQS), a site-specific GPL was calculated for lead utilizing *A Screening Method to Determine Soil Concentrations Protective of Groundwater Quality* (ADEQ 1996) methodology. The analytical results, in this case the method detection limit of 0.019 mg/L, for the SPLP analysis were entered into the model to calculate a site-specific GPL. The calculated site-specific GPL supersedes the minimum GPL for lead. A site-specific GPL of 50,899 mg/kg was calculated.

Table 1 Site Specific Remediation Goals

Constituent	Residential SRL (mg/kg)	Non-Residential SRL (mg/kg)	GPL (mg/kg)	Comments
Lead	400	800	50,899*	*Calculated site specific GPL value
Arsenic	10	10	290**	**Minimum GPL

3.2 EXTENT OF LEAD IN SOIL

3.2.1 Background Soil

Eight (8) background soil samples were collected from areas surrounding AOCs 1, 2 and 3 (Figure 3). The background samples were collected from a depth of 0.0 feet (ft) to 0.5 ft bgs at each location. Each location was screened for lead using the portable x-ray florescence (XRF) analyzer prior to sample collection for comparison purposes (Table 2). Arsenic was detected in all samples and range in concentration from 10 mg/kg to 15 mg/kg, all above the NR SRL of 10 mg/kg. The arsenic is believed to be naturally occurring and not related to the silver milling activities. Lead ranged in concentrations from 16 mg/kg to 620 mg/kg, below the NR SRL of 800 mg/kg. The results of the background soil sampling are summarized in Table 3.

3.2.2 AOC 2 EXTENT

At the time the soil was removed from AOC 2, the non-residential SRL for lead was 2,000 mg/kg but has subsequently been lowered to 800 mg/kg. Therefore, removal of contaminated soil may have only addressed lead to 2,000 mg.kg. Additionally, the backfill soil used to replace the soil that was removed from AOC 2 was not documented and the source of the fill material was not certified clean prior to backfilling. The objective of the soil sampling effort in AOC 2 was to assess the fill soil, both depth of fill and whether it contained any constituent of concern, and to assess the soil left in place below the fill.

Based on the estimated total area of AOC 2, approximately 13,000 square yards, and the estimated amount of fill material reported to be between 35,000 and 40,000 cubic yards of soil, the depth of fill was estimated to be between 2.5 and 3 feet in thickness in AOC 2. Based on the results of the soil sampling in AOC 2, the depth of fill ranged between 1 and 3.5-feet bgs, for an average depth of 2.2 feet bgs. Additionally, none of the samples collected from the fill in AOC 2 exceeded the residential SRL for lead of 400 mg/kg, ranging from 38 mg/kg to 370 mg/kg.

Eight (8) soil sample locations were sampled and a total of 16 soil samples and one duplicate sample were collected in AOC 2 for submission to the analytical laboratory (Figure 3). Each location was drilled using hollow stem auger (HSA) drilling techniques and were continuously sampled to a total depth of 6 feet bgs. The soil samples were screened every 6-inches from the surface to 5 feet bgs for lead using a portable XRF analyzer (Figure 3 and Table 2). Soil samples in AOC 2 were collected from the fill material at the surface, 0.0 ft to 0.5 ft bgs, and from the natural soil below the fill material with the highest XRF reading at each location and submitted to the laboratory for confirmation analysis.

The results of the laboratory analysis of the soil below the fill were compared to the current NR SRL for lead of 800 mg/kg and the site-specific GPL (Figure 4 and Table 2). Only one sample from AOC2, AOC2-6-4.0, a sample collected from the natural soil at 4 feet bgs, contained lead at a concentration of 1,600 mg/kg (Figure 4). No other sample from AOC 2 contained lead at a concentration greater than the NR SRL of 800 mg/kg. The laboratory analytical results for the soil sampling in AOC 2 are summarized in Table 4. The boring logs for each sample location are presented in Appendix A.

3.2.3 Soil in AOC 3

Based on historical soil data, the lead contamination was limited to the surface in AOC 3. Large parts of AOC 3 were excavated to create the stormwater detention areas on either side of the primary operating area of the Archery range. Yuma County subdivided AOC 3 into the following areas: the eastern detention pond area is identified as AOC 3A, the area between the two detention ponds, where no soil was excavated, is identified as AOC 3B, and the western detention pond area is identified as AOC 3C (Figure 2).

Thirty-two (32) soil samples were collected from 24 locations within AOC 3. Nine (9) samples from eight locations within AOC 3A, 13 samples from eight locations within AOC 3B and 11 samples and one duplicate sample were collected from eight locations within AOC 3C (Figure 4). Each location was drilled using HSA drilling techniques and were continuously sampled to a total depth of 6 feet bgs. The soil samples were screened every 6-inches from the surface to 6 feet bgs for lead using a portable XRF analyzer (Table 2). Soil samples from the surface, 0.0 ft to 0.5 ft bgs, at each location were submitted to the laboratory for analysis and a total of seven additional soil samples were collected in AOC 3 from deeper soil when the XRF screening indicated the lead concentration was above 800 mg/kg. Additionally, selected soil samples from seven locations in AOC 3B were used for lead leachability analysis using the synthetic precipitation leaching procedure (SPLP) and the results were used to calculate a site-specific GPL for lead.

Five soil samples collected from AOC 3 contained lead in concentrations greater than the NR SRL for lead of 800 mg/kg. Sample AOC3A-4-1 contained lead at a concentration of 1,800 mg/kg, AOC3A-5-2 at 930 mg/kg, AOC3B-2-1 at 820 mg/kg, AOC3B-8-0.5 at 820 mg/kg and AOC3C-6-0.5 at 1,000 mg/kg. None of the samples collected for SPLP analysis contained lead at a concentration exceeding the method detection limit (MDL) of 0.019 mg/L. The laboratory analytical results for total metals in soil at AOC 3 are summarized in Table 4 and the SPLP results are summarized in Table 5. The boring logs for each sample location is presented in Appendix A.

3.2.4 Soil in Former Tailings Pile Area

During XRF screening for background sample locations, the former tailings pile area was also screened. Based on the initial screening, 13 locations were selected to be screened with the XRF analyzer (Figure 5). Eight (8) XRF screening locations contained lead ranging from 1,316 parts per million (ppm) to 15,000 ppm (Figures 5 and 6) . Based on those readings, a soil sample was collected from the surface, 0.0 to 0.5 ft bgs, at the locations with the two highest readings, location TP-8 with a reading of 7,995 ppm and location TP-13 with a reading of 15,000 ppm. These samples were submitted for conformational laboratory analysis. In addition, both samples were submitted for TCLP analysis to test if the samples were a characteristic hazardous waste due to its lead toxicity. Sample TP-8 contained lead at a concentration of 5,800 mg/kg but was not detected above the TCLP analysis reporting limit of 0.5 mg/L. Sample TP-13 contained lead at a concentration of 12,000 mg/kg and TCLP analysis indicated lead was detected at a concentration of 57 mg/L, above the regulatory limit of 5 mg/L for lead, and cadmium was detected at a concentration of 1.4 mg/L, above the regulatory limit of 1 mg/L, making this sample a characteristic hazardous waste due to its lead and cadmium toxicity. The laboratory analytical results for the soil sampling in tailings pile area are summarized in Table 4.

3.3 EXTENT OF CONTAMINATION IN GROUNDWATER

The extent of groundwater at the site is limited. Based on the results of the drilling, it appears that only the southern third of the site is underlain by groundwater. Groundwater was not encountered on the northern portion of the site due to elevated bedrock (Figure 7). The results of the groundwater sample analysis from the temporary well indicated that the COCs were not present in concentrations exceeding their respective method detection limits and that groundwater was not impacted by the constituents of concern at the site.

3.4 RISK ASSESSMENT

The ADEQ obtained the assistance of The Fehling Group, LLC (TFG) to evaluate the reported concentrations of arsenic and lead in the soil, specifically in AOC 2 and AOC 3, and to perform a Human Health Risk Assessment on the residual concentrations of metals in the soil (TFG 2019). TFG concluded the background concentrations of arsenic and lead exceeded their respective calculated background concentration and further evaluation was warranted. Therefore, a human health risk assessment was performed to assess whether the residual concentration of arsenic and lead were protective of human health. TFG concluded that the residual concentrations of arsenic and lead in AOC 2 and AOC 3 where protective of human health and the ADEQ concluded that no additional remediation was warranted in these two areas. The risk assessment conclusions do not apply to the former tailing area. The Risk Assessment prepared by TFG is presented in Appendix B.

3.5 STORMWATER CONVEYANCE EVALUATION

The stormwater conveyance evaluation was performed to assess the current condition of the conveyance system and to evaluate whether additional engineering controls would be required to comply with stormwater management regulations. The stormwater conveyance system evaluation included an evaluation of the following:

- A topographic survey of the area was conducted to evaluate stormwater flow over and around the capped area and through the rest of the site.
- The capacity of the stormwater conveyance around the capped area was evaluated.
- The upstream protective wall, the stormwater drainage channels, and the retention basins were evaluated.
- Proposed modifications to the stormwater conveyance system were prepared, including recommended upgrades to the stormwater conveyance system
- Proposed maintenance that should be performed on a regular basis to protect the integrity of the stormwater conveyance system.
- Preparation of construction drawings for the proposed modifications and/or maintenance to be implemented; and,

The updated stormwater conveyance evaluation report is presented in Appendix C. Based on the results of the evaluation the following conclusions and recommendations were presented.

3.5.1 Stormwater Runoff - Volume

The existing stormwater retention basins have the capacity to retain approximately 16% of the stormwater runoff generated by the watershed that flows through the site and into the Gila River during a 100-year, 2-hour storm event. However, the storm water retention capacity of both existing retention basins combined is approximately 5 times the capacity required to retain the storm water runoff from the capped surface. A portion of the excess storm water runoff generated by the watershed for the entire site leaving the existing retention basins is retained by Adair Park Road at the southern boundary of the site. Using an AutoCAD – Civil 3D surface model to calculate the stormwater storage capacity of the site with a low point of Adair Park Road as an outfall elevation; the percentage of storm water runoff from the entire site retained on site before overflow into the Gila River is approximately 30% (Appendix C). Adding additional stormwater retention for the site was not deemed practical as there are no viable options for significantly increasing the stormwater retention capacity of the site.

3.5.2 Stormwater Runoff – Capped Area Drainage Channels

The cap drainage channel that is located on the western side of the caped area does not have the capacity to carry the storm water runoff for a 100-year storm (Figure 2). The cap drainage channel that is located on the eastern side of the caped area does have the capacity to carry the storm water runoff for a 100-year storm. The western side of the cap is slightly lower than the eastern side and thus receives a higher volume of stormwater per event. The western bank of the western channel could potentially erode and undermine the capped area in a high flow storm event. It is recommended that at least an additional 6-inches of 6-inch rip-rap rock be installed on the top portion of the west bank to increase the storm water carrying capacity of western cap drainage channel and minimize the potential for erosion and undermining of the capped area.

An inspection of the western cap drainage channel showed little signs of erosion through the majority of the channel. However, the north (upstream) end of western cap drainage channel near the protective rip-rap wall showed signs of erosion. To repair the erosion of the drainage channel; it is recommended that new 6-inch rip-rap rock be installed at the upstream ends of both the western and eastern drainage channels to protect the cap from potential damage during a high flow storm event.

3.5.3 Stormwater Runoff – Drainage Channels Downstream of Capped Area

The western and eastern drainage channels at the south end of the capped surface was also evaluated. It was determined that neither of the drainage channels had the capacity to carry the storm water runoff for a 100-year storm. Also, a site inspection of both downstream drainage channels showed significant signs of erosion outside of the channels indicating that the stormwater was not contained within the channels.

To repair the erosion and increase the storm water carrying capacity of both drainage channels, it is recommended that the drainage channel be reconstructed. The channels should be deepened, and the deepened channels should be lined with 6-inch rip-rap to prevent erosion of the channels.

3.5.4 Protective Rip-rap Wall

Rip-rap protective walls consist of a layer or facing of rock, dumped or hand-placed on channel and structure boundaries to limit the effects of erosion and is the most common type of erosional countermeasure due to its general availability, ease of installation and relatively low cost. Rip-rap design must account for several possible modes of failure. These include rip-rap particle erosion, substrate material erosion and mass failure.

3.5.4.1 Rip-Rap Wall Failure Modes

Particle Erosion

Particle erosion is the most common erosional mechanism for rip-rap walls. Particle erosion occurs when individual particles are dislodged by the hydraulic forces generated by the flowing water. Particle erosion can be initiated by abrasion, impingement of flowing water, eddy action/reverse flow, local flow acceleration, freeze/thaw action, ice, or toe erosion. Probable causes of particle erosion include: (1) stone size not large enough; (2) individual stones removed by impact or abrasion; (3) side slope of the bank so steep that the angle of repose of the rip-rap material is easily exceeded; and (4) gradation of rip-rap too uniform. (DOT 2009a)

Rip-rap particle erosion is minimized by sizing the rip-rap to withstand hydraulic and turbulence forces. Calculations for sizing the rock for the rip-rap wall can be found in Section 11.2 of the Stormwater Conveyance report (Appendix C). A site inspection to assess the steepness of the bank, gradation of rip-rap and inspect for missing stones is discussed below.

Substrate Particle Erosion

Substrate particle erosion occurs when the base material erodes and migrates through the rip-rap voids causing the rip-rap to settle. Substrate particle erosion is limited by placing a granular or geotextile filter between the rip-rap and the base material. A site inspection to evaluate the existing filter of the rip-rap wall is discussed below.

Mass Failure

Mass failure occurs when large sections of the rip-rap and/or base material slide or slump due to gravity forces. Mass failure can be caused by excess pore water pressures, bank steepness and loss of basal support through scour or channel migration. Also, a filter fabric that is too fine can clog and cause the buildup of pore water pressures in the underlying soil. Rip-rap that is large enough to resist all the hydraulic forces can fail if channel migration or scour undermines the toe support.

The following calculations estimate the scour depth of a transverse structure. Stormwater flow characteristics for the channel north of the protective rip-rap wall are used to determine the scour depth. A worse case water depth is estimated to be 1.0 feet.

Q = 355 cfs, Depth = 1.00 ft., Velocity = 2.45 ft/s

Several commonly used countermeasures for channel instability or scour protection project transversely into the flow (e.g., spurs, dikes, and jetties) or intercept overbank flow as it returns to the main channel (e.g., guide banks). Estimating scour at the nose of these structures is critical to successful design. The following equation is used when the projecting embankment/abutment length is large in relation the flow depth (DOT, 2009b).

Use: $\frac{a}{y_1} > 25$

Where: a = structure length projecting normal to the flow = 85 ft
y_1 = average upstream flow depth in the main channel or on the overbank outside the influence of the structure = 1.0 ft

$$\frac{85}{1.0} = 85$$

Calculate Froude Number:

Use: $F_r = \frac{V}{(gy)^{½}}$

Where: V = average velocity = 2.45 ft/s
g = gravity = 32 ft/ s^2
y_1 = depth of flow = 1.00 ft

$$F_r = \frac{2.45}{(32\ x\ \ 1.00)^{½}} = 0.4331$$

Since $\frac{a}{y_1} > 25$ use Equation 4.1 (DOT 2009, Vol. I)

Use: $\frac{y_s}{y_1} = 4F_r^{\ 0.33}$

Where: y_s = equilibrium depth of scour (measured from the mean bed level to the bottom of the scour hole), ft
y_1 = average upstream flow depth in the main channel or on the overbank outside the influence of the structure = 1.0 ft
F_r = upstream Froude Number outside the influence of the structure = 0.4331

$$\frac{y_s}{1.0} = 4(0.4331^{0.33}) = 3.03 \text{ ft.}$$

Overtopping
Standard design criteria for protective rip-rap walls recommends that the rip-rap to be placed on the bank to an elevation at least 2.0 feet greater than the design high water level. As stated above a worse case water depth is estimated to be 1.0 feet. Therefore, a rip-rap wall height of 3.0 feet is recommended. The majority of the protective wall is greater than three feet in height and overtopping is not expected to represent a significant failure mode. However, the potential for overtopping will be evaluated as discussed below..

3.5.4.2 Rip-Rap Protective Wall Inspection
The protective capped area shown in Figure 3 is protected from erosion caused by stormwater runoff with a protective rip-rap wall located at the north end of the capped area. The design specifications of the rip-rap protective wall were not documented at the time of construction and therefore a detailed engineering structural analysis cannot be performed. In order to completely evaluate the structural adequacy of the rip-rap protective wall, a detailed inspection will be performed that will consist of the following tasks.

Inspection of rip-rap placement typically consists of visual inspection of the installation procedures and the finished surface. A previous visual inspection of the existing wall observed a dense, rough surface of well-keyed, graded rock, placed such that voids were minimized. Further inspection is required to evaluate the thickness of the rip-rap blanket, average size of the rip-rap, the slope it was placed on, what type of material the subbase is composed of, and the depth of the rip-rap into the stream bed.

The inspection will require a portion of the wall to be dismantled so that a detailed as-built can be prepared with sufficient detail that will allow for the structural analysis to be completed following the guidance for inspecting rip-rap protective walls presented in the National Highway Institute (NHI) training course 135047, "Stream Stability and Scour at Highway Bridges for Bridge Inspectors" (DOT 2009a).

3.5.4.3 Rip-Rap Protective Wall Design Recommendations
Since the rip-rap wall was installed without documentation, the evaluation of the rip-rap wall will include an inspection to determine how the wall was built. The results of the inspection will be compared to the minimum design criteria for a protective rip-rap wall The following presents the minimum design requirements for a protective rip-rap wall:

- The rip-rap wall shall be a minimum of 3 feet in height, including the portion of the wall that is adjacent to the eastern and western drainage channels.

- The thickness of the rip-rap blanket shall be a minimum of 16 inches.
- The size of the rip-rap rock shall be a minimum of D_{50} = 10 inches
- The base of the rip-rap blanket shall have either a granular or geotextile fabric filter material installed.
- The maximum slope of the rip-rap wall and subbase shall be a slope no greater than 1:1.5
- The toe of the rip-rap wall shall be protected with either of the following:
  - Buried toe consisting of a rip-rap rock of D_{50} = 10 inches with a geotextile fabric filter material installed and shall be constructed 16 inches deep x 6.5 feet wide along the length of the toe of the protective rip-rap wall.
  - Mounded toe consisting of rip-rap rock that is a minimum of D_{50} = 10 inches constructed 32 inches deep x 3 feet in height along the length of the toe of the protective rip-rap wall.

If the visual inspection of the existing protective rip-rap wall identifies portions of the wall that do not meet at least the minimum requirements presented above, designs to remedy the deficiencies of the portions (or all) of the existing protective rip-rap wall that do not meet these requirements will be evaluated. The design remedy that best addresses any or all of the deficiency will be prepared and submitted to ADEQ for approval prior to implementation.

4.0 SUMMARY OF REMEDIAL ACTION

The analytical results indicated that metal constituents lead and cadmium are present in concentrations that are characteristic of hazardous waste in the tailings area of the site. The tailings area has not been completely characterized and therefore additional characterization will be performed to define the nature and extent of the impact to the soil by lead and cadmium. Following completion of the additional characterization of the tailings area, the tailings area will be capped to prevent exposure to the contaminated soil. Additionally, portions of the stormwater conveyance system require an upgrade and/or maintenance to maintain the protectiveness of the capped area..

4.1 PRE-REMEDIATION ACTIVITIES

Prior to the beginning of remedial activities, a site inspection will occur to document the existing conditions at the site. The results of this site inspection will be compared with the results of the remedial actions described below to evaluate the effectiveness of the remedial actions.

4.1.1 Permits

It is not anticipated that any permitting will be required to perform the characterization and remedial action activities. The soil borings will not penetrate ground water, therefore no drilling permit will be required.

4.1.2 Notice of Commencement

The ADEQ VRP will be sent written notification at least 7 days prior of the commencement of field activities to allow for the ADEQ to schedule a site visit during remedial activities.

4.1.3 Utility Clearance

Prior to any subsurface activities, the locations for the excavation area and each proposed ISCO injection location will be surveyed for underground utilities. Each cleared location will be marked and staked for utility clearance. Arizona 811 will be notified a minimum of 48 hours prior to excavation and injection activities to mark known existing underground utilities. In addition, an independent utility locator service will be used to ensure that each boring and injection location is clear of existing underground utilities.

4.1.4 Site Security and Mobilization

All equipment and field personnel will be mobilized to the site. Mobilization will include delivery of fencing for the laydown area, excavation and soil moving equipment, portable sanitary facilities, and other supplies as necessary.

A laydown area will be established to stage excavation-related equipment and stockpile equipment and other supplies, such as clean backfill and a stockpile of 6-inch rip-rap. The location of the laydown area has not been established. The laydown area will be secured with temporary fencing with a clearly marked entrance that may be secured with a chain and padlock. A notice will be posted on the fence next to the gate to provide the contact information for the corrective action contractor. Upon completion of the project, the laydown area will be returned to its original condition. The laydown area should also be used for portable sanitary facilities.

4.1.5 Clearing and Grubbing

Clearing and grubbing will be minimal at the site. Any vegetative growth within the drainage channels south of the capped area will be removed. The existing cobbles that line the two drainage channels south of the capped area will also be removed. Those materials will be reused, if possible.

4.1.6 Protection of Existing Site Features

No existing features at the site, primarily the Archery Range facilities, will be impacted by remedial activities. In the event that archery targets or other archery range object will be required to be moved, the objects will be replaced during site restoration activities.

4.1.7 Stockpile Area Construction

Any materials that will be brought on site for the construction of the cap, modification of the drainage channels or repair/maintenance of the existing cap will be stored at adjacent to the laydown area. Since the construction area is less than 1 acre, a Stormwater Pollution Prevention Plan (SWPPP) will not be required. However, best management practices will be implemented to prevent the stockpiled materials from impacting the site of the nearby Gila River during a storm event. Best management practices will include siting the stockpile area in an area that will not be impacted by flash flooding and will utilize berms, straw waddles and/or silt fences to prevent the materials from migrating away from the stockpile area during a storm event.

4.1.8 Establishment of Work Support and Decontamination Areas

Work areas will established to prevent public exposure to potentially lead impacted soil. The areas in which excavation of soil is occurring will be delineated with traffic barriers and caution tape.

4.2 TAILINGS PILE DELINEATION

Samples collected from the tailings pile area contained lead in concentrations that were characteristic of a hazardous waste. Therefore, the tailings pile area will be further characterized to define the extent of the area impacted by lead contaminated soil. Once the extent of the lead contaminated soil has been established, an engineered cap will be designed to prevent future exposure to the users of the archery range.

In order to fully characterize the tailings pile area, the entire area will be screened at the surface utilizing an XRF analyzer for lead in soil. The areas that contain the highest XRF readings will be further characterized by advancing up to four soil borings using a hollow stem auger drilling rig. Each soil boring will be continuously sampled from the surface to a total depth of six feet begs or refusal, whichever occurs first, with a California-modified split spoon sampler. Soil samples will be screened, collected and analyzed by the laboratory as described in the following sections.

4.2.1 Soil Sample Screening and Collection

A total of nine soil samples will be collected from 4 soil borings advanced in the tailings area and submitted to the laboratory for analyses. The following soil sampling procedures will be used.

- Soil samples will be collected from each soil boring continuously to a depth of 6 ft bgs by driving a California-modified split spoon sampler 18-inches into the soil to obtain 4 discrete soil samples per boring.
- The soil will be screened every 6-inches utilizing an XRF analyzer for lead content.
- Two soil samples from each boring with the highest XRF reading will be placed into 4-ounce glass jars.
- Each soil sample will be labeled and placed into a plastic baggie and stored in a cooler containing ice to maintain the sample at approximately 4° Celsius pending delivery to the laboratory.
- The split spoon sampler will be decontaminated prior to use. The split spoon sampler will be washed in tap water containing a non-phosphate detergent, such as Alconox®, with a scrub brush, followed by a tap water rinse and a second rinse in deionized water. The split spoon sampler will be allowed to air dry prior to use. The decontamination water will be containerized for disposal as described in Section 3.2.5 below.
- A field duplicate soil sample will be collected at a frequency of one duplicate per twenty samples. Based on the estimated number of samples to be collected from the tailings area, one (1) duplicate soil samples will be collected. One duplicate soil sample will be collected from the sample with the with the highest XRF reading.
- An equipment blank will be collected from the spilt spoon sampler by pouring deionized water through the sampler into the appropriate sample containers supplied by the laboratory.

- One field blank sample will be collected from the water used for the second rinse in the decontamination procedure for the hand auger and hand sampler.
- A temperature blank sample will accompany each sample container shipped to the laboratory. The temperature blank will be used to ensure the temperature of the samples is maintained at approximately 4°Celcius.
- Each sample collected will be labeled with a unique sample identifier, date and time the sample was collected, preservation used, the sampler's initials and the analysis to be performed. Each sample will then be logged onto a chain–of–custody form for delivery to the laboratory.

4.2.2 Soil Sample Laboratory Analysis

Nine (9) soil samples will be analyzed for the following:

- RCRA 8 Metals using EPA Test Method 6010C/7471B.
- The Synthetic Precipitation Leaching Procedure (SPLP) extraction using EPA Test Method 1312 and analyzed for Lead using EPA Test Method 6010C. An alternative to the SPLP extraction is the Toxicity Characteristic Leaching Procedure (TCLP) extraction using EPA Test Method 1311. The analytical method for TCLP lead will remain the same.

The quality assurance/quality control procedures are presented in the abbreviated QAPP presented in Appendix D.

4.2.3 Record Keeping

Field notes and measurements will be recorded in a field notebook, which will be maintained by the Sampling Team Leader. Original copies of Chain of Custody forms, raw data, and analytical results will be maintained by the respective laboratories performing the analyses.

4.2.4 Laboratory Confirmation Analyses

Eight (8) soil samples and one duplicate soil sample will be collected from four soil borings advanced in the tailings area. The samples will be selected by after screening with an XRF analyzer for lead in soil.

4.2.5 Laboratory QA/QC

An equipment blank sample will be collected from the California-modified split spoon sampler and a field blank will be collected from the water used to decontaminate the sampler. Each sample container will

4.3 SITE RESTORATION

Site restoration activities will include deepening the drainage channels south of the capped area, repair of damaged portions of the stormwater conveyance in the capped area and capping the tailings pile area.

4.3.1 Stormwater Conveyance Upgrade and Maintenance

The stormwater drainage channels south of the capped area are not deep enough to contain water from a storm event. Inspection of the channels after a storm event indicated that water overflowed and eroded the soil surrounding the channels. Therefore, the channels will be deepened to ensure containment of future stormwater and to prevent erosion of the areas around the channels. Additionally, a small amount of damage to the cap has occurred where stormwater flows into the drainage channel on the capped area and cap drainage channel that is located on the western side of the caped area does not have the capacity to carry the storm water runoff for a 100-year storm.

New 6-inch rip-rap rock will be installed at the upstream ends of both the western and eastern drainage channels to protect the cap from potential damage during a high flow storm event. Also a minimum of 6-inches of 6-inch rip-rap rock be installed on the top portion of the west bank of western cap drainage channel to increase the storm water carrying capacity over the capped area.

4.3.1.1 Stormwater Conveyance Upgrade

The stormwater conveyance upgrade to the western and eastern channels south of the capped area will provide the flow capacity required for each to contain stormwater flow from a 100- year storm. Each channel will be over excavated to provide the required drainage capacity as presented below. Since the soil in the drainage channels may contain lead above the NR SRL of 800 mg/kg, the excavated soil will be placed in the tailings pile area and capped with the tailings.

Western Channel Design

The existing western drainage channel is configured to manage 6.14 cfs. A 100-year storm could create as much as 325.41 cfs of flow within the channel. The existing stormwater carrying capacity is significantly less than the required storm water carrying capacity required for a 100-year storm and must therefore be upgraded to manage greater stormwater flow.

A new drainage channel has been designed to have the storm water carrying capacity required for the above referenced storm. The revised drainage channel cross-section, using 6" rip-rap rock, (Figure 8) and calculations are as follows:

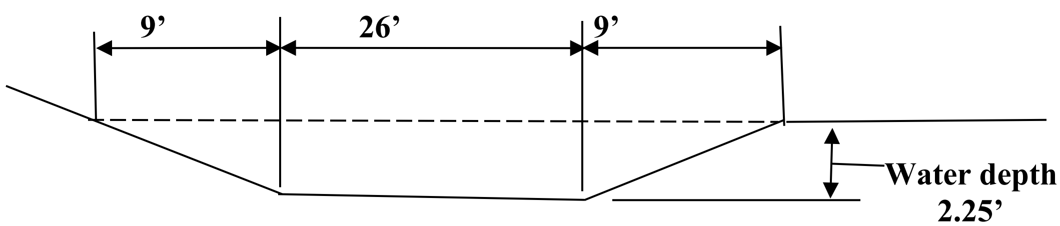


Figure 8 Cross-Section, Proposed Western Drainage Channel
(Looking North)

Use:

Q = 325.41 cfs
B = bottom width of channel = 26'
Z = side Slopes = 4
S_o = channel bottom slope = 0.0122 ft/ft
γ_s = unit weight of rip-rap rock = 165 lbs./sf
γ = unit weight of water = 62.4 lbs./sf

Assume D_{50} = 0.50'
Assume water depth = 2.25'

Using geometric properties of a trapezoid:

$$A = Bd + Zd^2$$
$$= 26(2.25) + 4\,(2.25^2)$$
$$= 58.50 + 20.25$$
$$= 78.75 \text{ sf}$$

$$P = B + 2d\sqrt{Z^2 + 1}$$
$$= 26 + 2\,(2.25)\sqrt{4^2 + 1}$$
$$= 26 + 18.55$$
$$= 44.55'$$

$$R = A/P = 78.75/44.55 = 1.7677$$

$$T = B + 2dZ = 26 + 2\,(2.25)\,(4) = 44$$

$$d_a = A/T = 78.75/44 = 1.7898$$

Relative depth ration: $\frac{da}{D_{50}} = \frac{1.7898}{0.50} = 3.5796$

Determine Manning's N value:

(HEC 15, 2005, Equation 6.1)

Use: $N = \frac{\alpha d_a^{0.1667}}{2.25 + 5.23\log\left(\frac{da}{D_{50}}\right)}$

Where: N = Manning's roughness coefficient
d_a = average flow depth in the channel = 1.7898 ft
D_{50} = median rip-rap size = 0.50 ft
α = unit conversion constant = 0.262

$$N = \frac{\alpha d_a^{0.1667}}{2.25 + 5.23\log\left(\frac{da}{D_{50}}\right)} = \frac{(0.262)1.7898^{0.1667}}{2.25 + 5.23\log\left(\frac{1.7898}{0.50}\right)} =$$

$$\frac{0.2887}{2.25 + 5.23\log(3.5796)} = \frac{0.2887}{5.1466} = 0.0561$$

Use Manning's equation to determine maximum flow for rip-rap D_{50} = 0.50':

S = 1.22%, A = 50.00 sf, R = 1.4930, N = 0.0561

$Q = 1.49/N\,(A)(R)^{2/3}\,S^{1/2}$

$Q = 1.49/0.0561 (78.75) (1.7677)^{2/3} (0.0122)^{1/2}$
$Q = 26.46 (78.75) (1.4620) (0.1105)$
$Q = 336.63$ cfs

Capacity

336.63 cfs

Therefore, the new design would provide a flow capacity of 336.63 cfs. This design represents the minimum design capacity for the western drainage channel to control the flow from a 100-year storm event, 325.41 cfs. Additionally, a foot path will be installed over the western channel to allow archers a means to retrieve errant arrows.

Eastern Channel Design

The existing eastern drainage channel is configured to manage 19.69 cfs. A 100-year storm could create as much as 43.52 cfs of flow within the channel. The existing stormwater carrying capacity is less than the required storm water carrying capacity required for a 100-year storm and must therefore be upgraded to manage greater stormwater flow.

A new drainage channel has been designed to have the storm water carrying capacity required for the above referenced storm. The revised drainage channel cross-section, using 6" rip-rap rock, (Figure 9) and calculations are as follows:

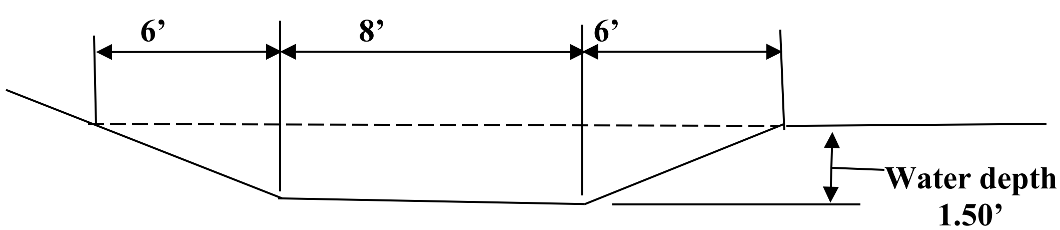


Figure 9 Cross-Section, Propose Eastern Drainage Channel
(Looking North)

Use:

Q = 43.52 cfs
B = bottom width of channel = 8'
Z = side Slopes = 4
S_o = channel bottom slope = 0.0115 ft/ft
γ_s = unit weight of rip-rap rock = 165 lbs./sf
γ = unit weight of water = 62.4 lbs./sf
Assume D_{50} = 0.50'
Assume water depth = 1.50'

Using geometric properties of a trapezoid:

$A = Bd + Zd^2$
$= 8(1.50) + 4\,(1.50^2)$
$= 12 + 9$
$= 21.00$ sf

$P = B + 2d\sqrt{Z^2 + 1}$
$= 8 + 2\,(1.50)\sqrt{4^2 + 1}$
$= 8 + 12.37$
$= 20.37'$

$R = A/P = 21.00/20.37 = 1.0309$

$T = B + 2dZ = 8 + 2\,(1.50)\,(4) = 20$

$d_a = A/T = 21.00/20.00 = 1.0500$

Relative depth ration: $\frac{da}{D_{50}} = \frac{1.0500}{0.50} = 2.100$

Determine Manning's N value:

(HEC 15, 2005, Equation 6.1)

Use: $N = \frac{\alpha d_a^{0.1667}}{2.25 + 5.23 log\left(\frac{da}{D_{50}}\right)}$

Where: N = Manning's roughness coefficient
d_a = average flow depth in the channel = 2.6042 ft
D_{50} = median rip-rap size = 0.50 ft
α = unit conversion constant = 0.262

$$N = \frac{\alpha d_a^{0.1667}}{2.25 + 5.23 log\left(\frac{da}{D_{50}}\right)} = \frac{(0.262) 1.0500^{0.1667}}{2.25 + 5.23 log\left(\frac{1.0500}{0.50}\right)} =$$

$$\frac{0.2641}{2.25 + 5.23 log(2.100)} = \frac{0.2641}{3.9352} = 0.0671$$

Use Manning's equation to determine maximum flow for rip-rap $D_{50} = 0.50'$:

S = 1.15%, A = 21.00 sf, R = 1.0309, N = 0.0671

$Q = 1.49/N\,(A)(R)^{2/3}\,S^{1/2}$
$Q = 1.49/0.0671\,(21.00)\,(1.0309)^{2/3}\,(0.0115)^{1/2}$
$Q = 22.21\,(21.00)\,(1.0205)\,(0.1072)$
$Q = 51.02$ cfs

Capacity

51.02 cfs

Therefore, the new design would provide a flow capacity of 51.02 cfs. This design represents the minimum design capacity for the eastern drainage channel to control the flow from a 100-year storm event, 43.52 cfs.

The design specifications for both drainage channels will be prepared with any design changes implemented on the rip-rap wall and the cap design for the tailings pile area following completion of the tailings pile area evaluation. .

4.3.1.2 Stormwater Conveyance Maintenance

A maintenance plan will be prepared as part of the ECP to define procedures for maintain the drainage channels in the future. The old drainage channels will be required to be periodically cleared of vegetation and other potential obstructions that may impede flow through the channels. Additionally, maintenance protocols will be established to repair any portion of the drainages that may be damaged by stormwater flow or for other reasons.

4.3.2 Tailings Pile Area Cap Installation

Following the completion of the tailing pile assessment and the extent of the area has been defined, a cap for the tailings pile area will be designed to prevent human contact with the impacted soil and to prevent erosion onto the Archery facility. At a minimum, the cap will include the following:

- Grading the area to be capped so that the stormwater run-off flows toward the eastern drainage channel.
- A minimum of 1 foot certified clean soil will be placed over the top of the lead impacted soil.
- A minimum of 2 inches asphalt chip seal will be placed over the clean fill.

Following the completion of the tailings pile area delineation, the cap design will be modified as necessary and will incorporate the design of the eastern drainage channel improvements to facilitate drainage from the capped area. The cap design will be submitted for approval by ADEQ and upon approval the cap will be installed following the approved design.

4.3.3 IDW Disposition

Auger cuttings will be placed back into each boring. Therefore, no soil investigative derived wastes (IDW) will be produced. Decontamination water and purge water will be containerized and disposed of following Federal, State and local regulation.

Soil removed from the drainage channels during deepening will be placed into the tailings area and capped with the tailings.

4.3.4 Demobilization

All equipment and field personnel will be demobilized from the site. Demobilization will include removal of fencing for the laydown area, excavation and soil moving equipment, portable sanitary facilities, and other supplies brought on the site. The laydown stockpile areas will also be restored to their original condition.

5.0 REPORTING

A Remedial Action Report will be prepared to document the result of the soil sampling in the tailings area, the modifications to the stormwater drainages and protective dam, and the capping of the tailings area. The Remedial Action Report will include as-built drawings for the tailings cap and the stormwater conveyance system and an engineering control plan to document the inspection/maintenance schedule. Following approval of the Remedial Action Report by ADEQ VRP and no further investigation and/or remediation is required, a no further action (NFA) letter will be prepared following the requirements of Arizona Revised Statute (A.R.S.) § 49-181. A DEUR, as required by A.R.S § 49-151 through 49-159, for the site will also be prepared by ADEQ following approval of the NFA letter..

6.0 REFERENCES

ADEQ 1996. *A Screening Method to Determine Soil Concentrations Protective of Groundwater Quality.*

ADEQ 2019. *Review and Comments: Summary of Findings Report Letter*. December 23.

ADEQ 2014A. *Adair Park Site Inspection Memorandum*. March 7.

ADEQ 2014B. *Adair Park file Review Concerns at Site Letter*. June 4.

ADWR 2008. Well Abandonment Handbook. September.

Kleinfelder 2006. *Work Plan Lead Contaminated Soil Remediation, Adair Memorial Park, 4760 South Highway 95, Yuma, AZ 85366.* April.

Nicklaus Engineering, Inc. 2019. Summary of Findings at Adair Park Archery Range, Yuma, AZ. VRP Site Code 505354-00. June.

________ 2019. Groundwater Monitoring Report at Adair Park Archery Range, Yuma, AZ. VRP Site Code 505354-00. December.

The Fehling Group (TFG) 2019. Summary of Findings at Adair Park Archery Range, Yuma, Arizona, Site Code 505354-00. December 16.

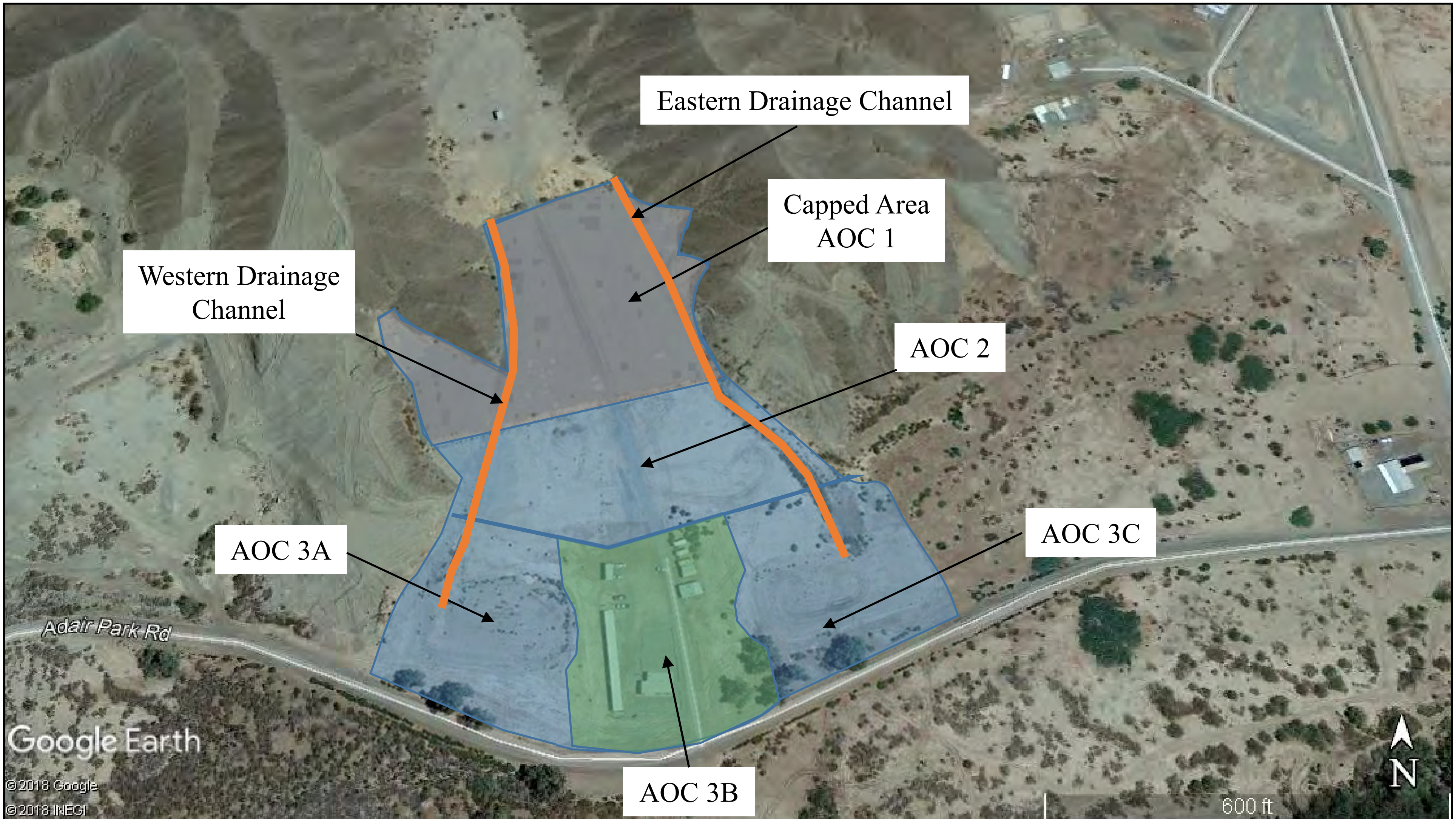
U.S. Department of Transportation, 2009a. *Federal Highway Administration, Chapter 5 of the Hydraulic Engineering Circular No. 23 Bridge Scour and Stream Instability Countermeasures: Experience, Selection, and Design Guidance.* Third Edition, Volume 1 - (Publication No. FWHA-NHI-09-111). September.

________, 2009b. *Design Guide 14 (DG14) of the U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular No. 23, Volume 2 - Bridge Scour and Stream Instability Countermeasures: Experience, Selection, and Design Guidance*. Third Edition, Volume 2 (Publication No. FWHA-NHI-09-112). September.

FIGURES

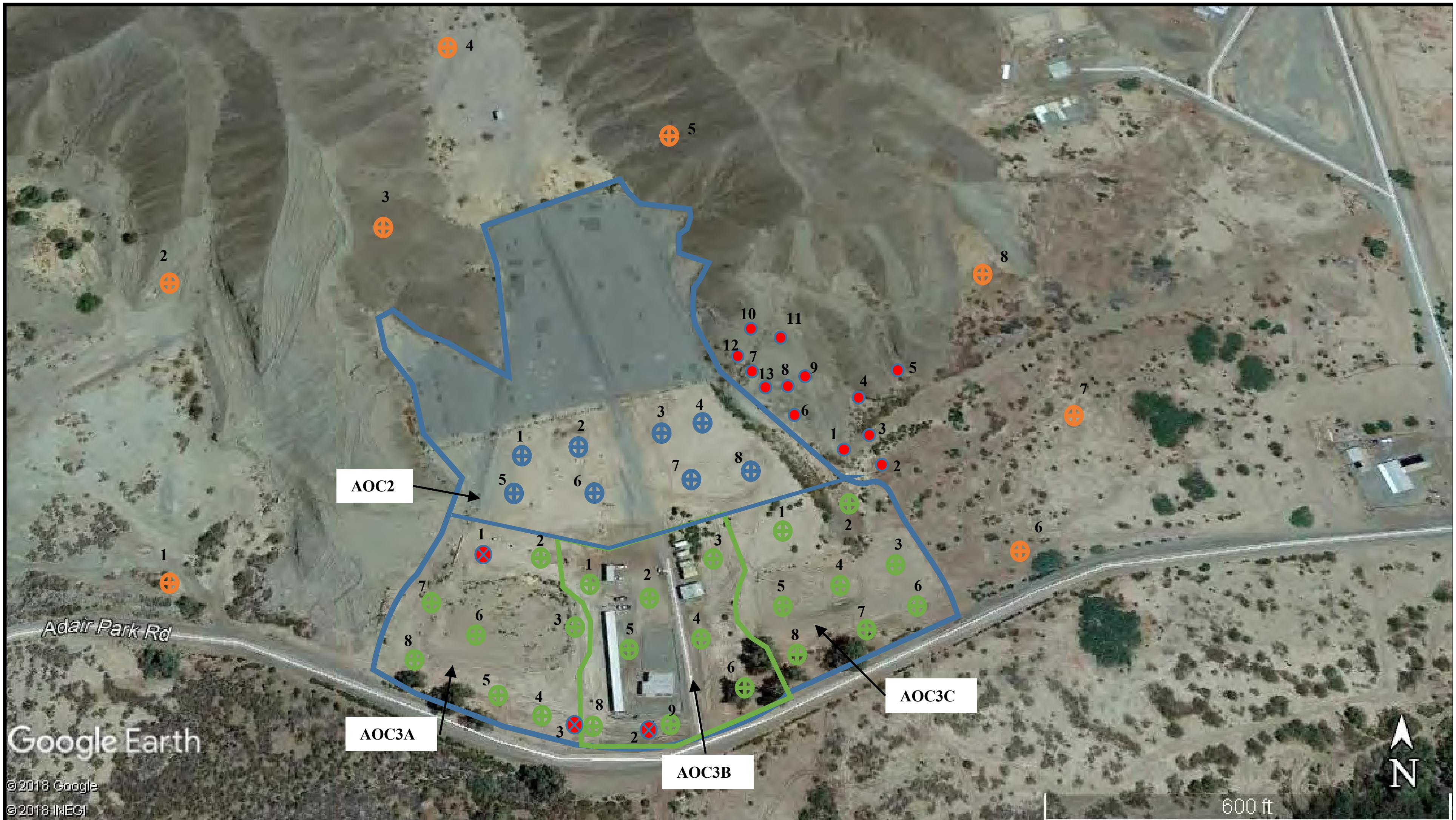
Adair Memorial Park Archery Range
4760 S. Highway 95
Yuma, Arizona

Figure 1
Site Location Map



Adair Memorial Park Archery Range
4760 S. Highway 95
Yuma, Arizona

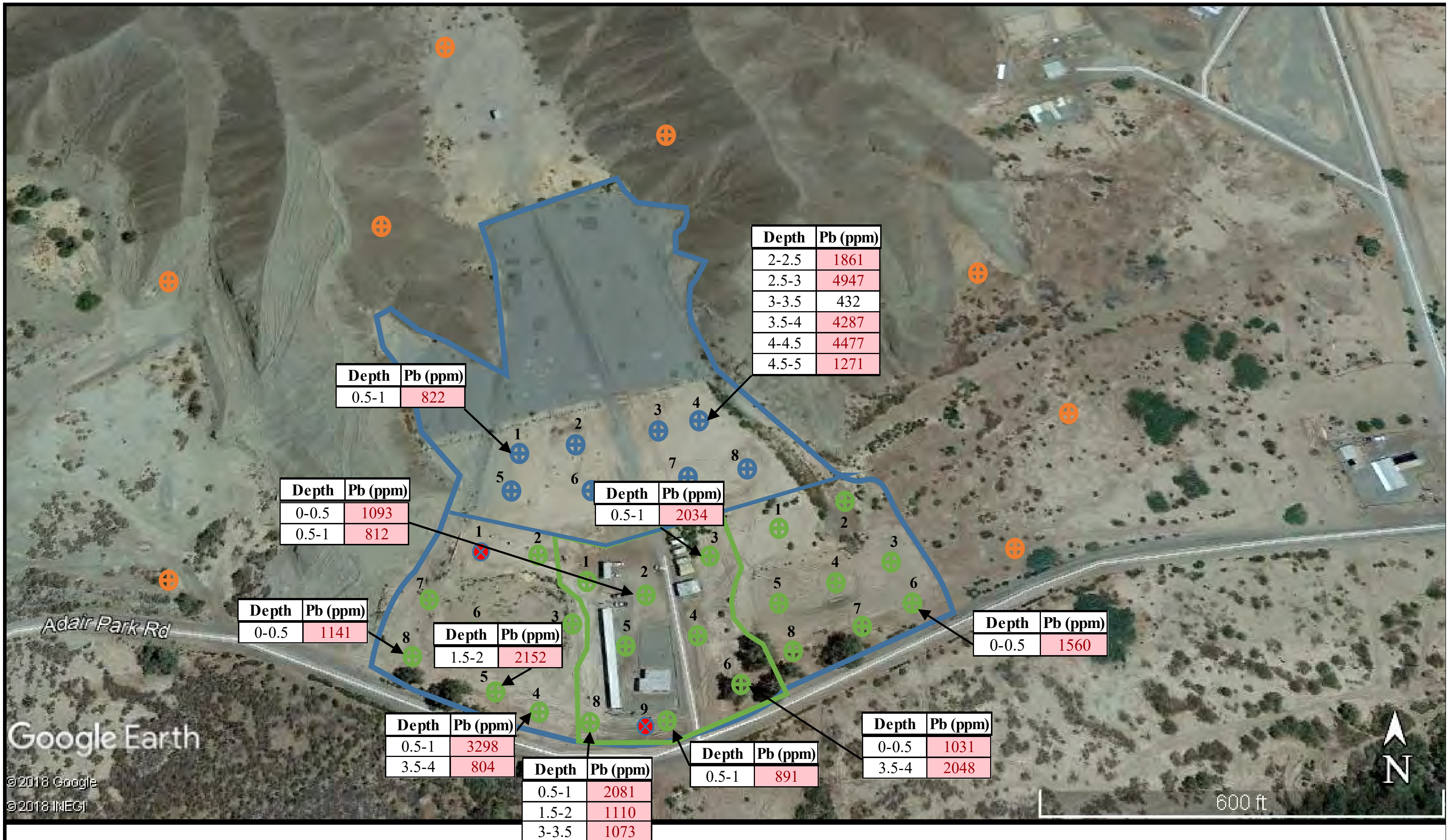
Figure 2
Site Map



- AOC 2 Sample Location
- AOC 3 Sample Location
- Temporary Well and Soil Sample Location
- Background Sample Location
- XRF Reading From Tailings Pile

Adair Memorial Park Archery Range
4760 S. Highway 95
Yuma, Arizona

Figure 3
Sample Location Map



AOC 2 Sample Location

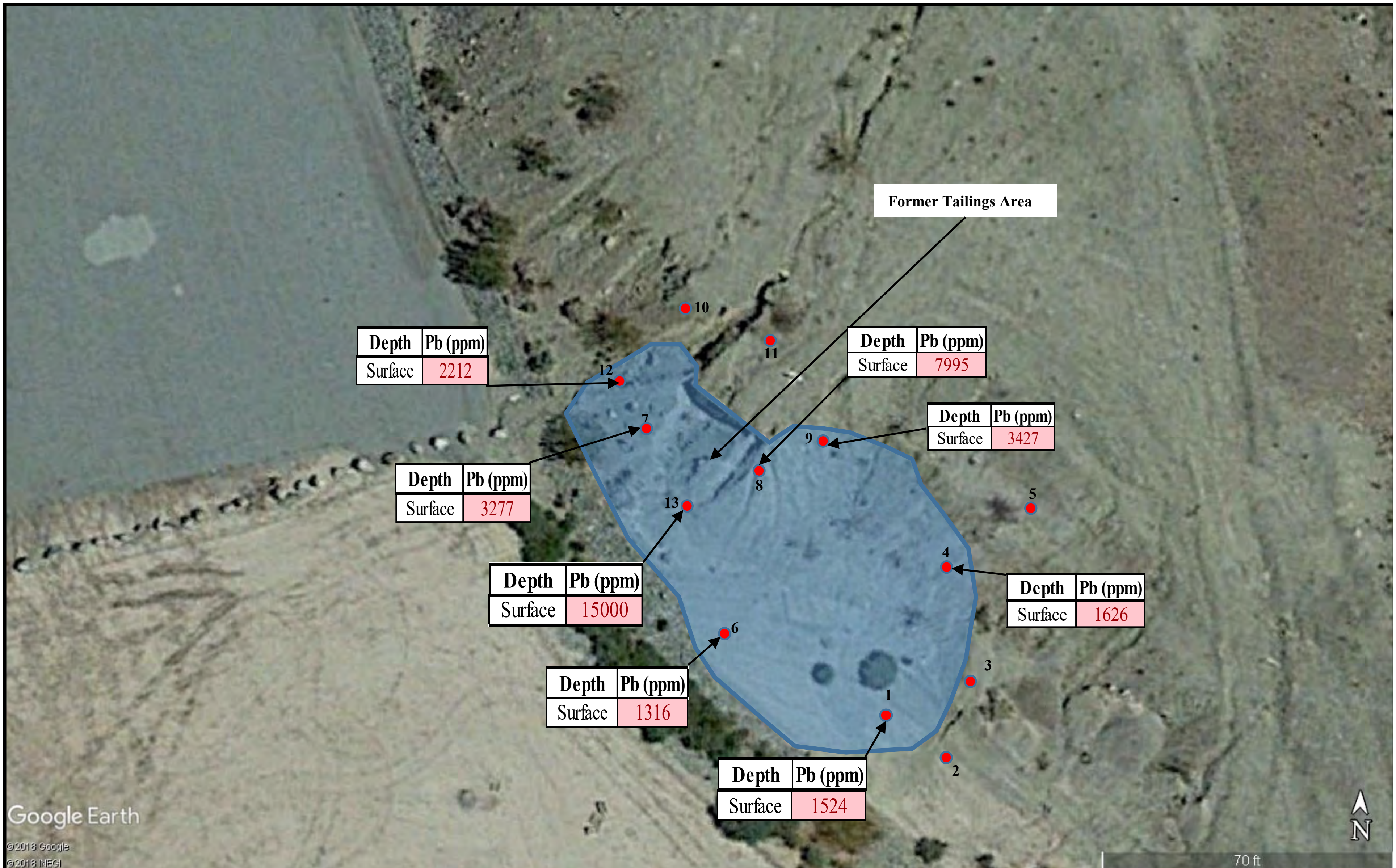
AOC 3 Sample Location

Temporary Well and Soil Sample Location

Background Sample Location

Adair Memorial Park Archery Range
4760 S. Highway 95
Yuma, Arizona

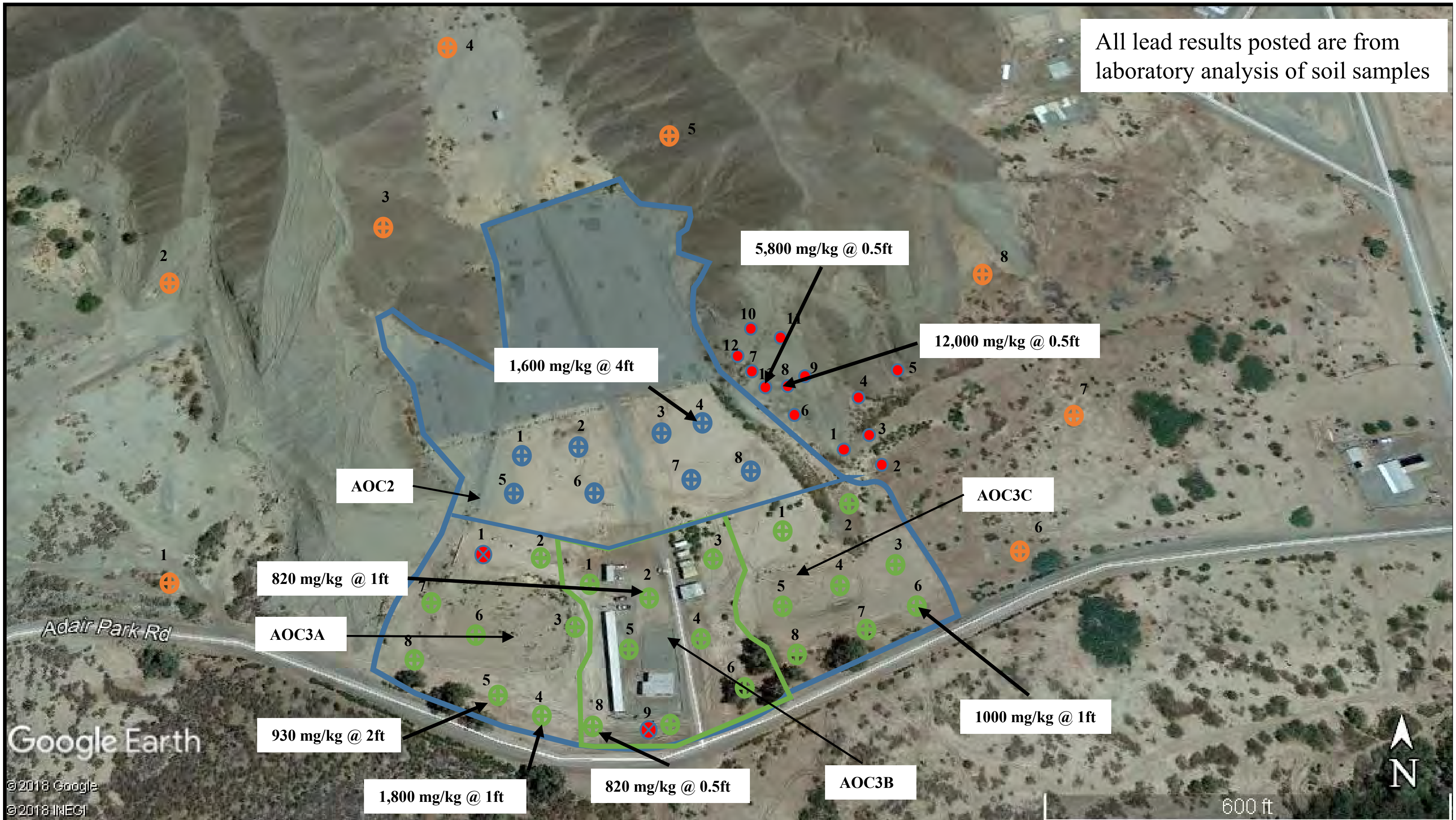
Figure 4
XRF Screening Lead Map



Recommended Fenced Area

Adair Memorial Park Archery Range
4760 S. Highway 95
Yuma, Arizona

Figure 5
Former Tailings Area XRF Screening Map



AOC 2 Sample Location

AOC 3 Sample Location

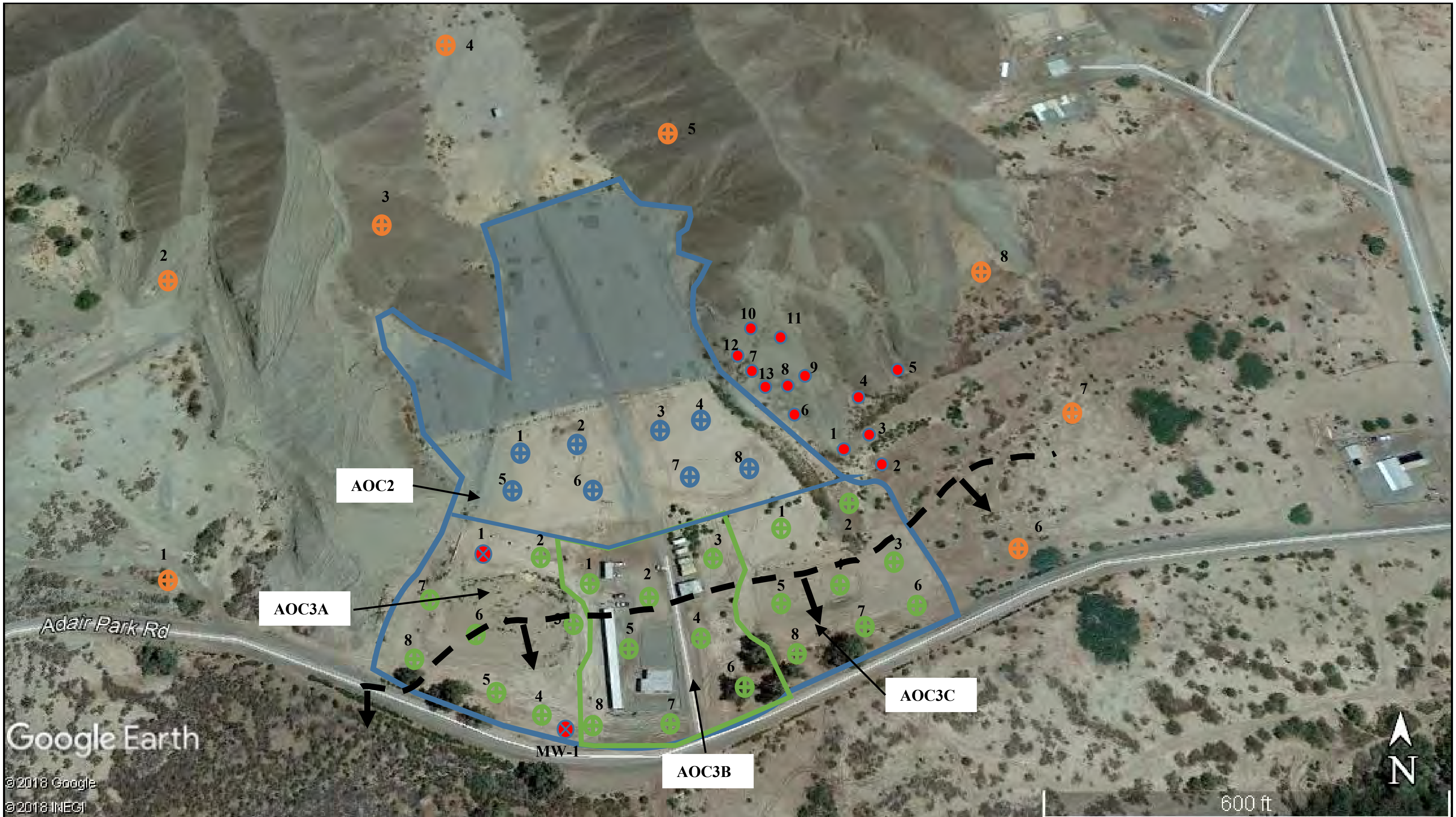
Temporary Well and Soil Sample Location

Background Sample Location

XRF Reading From Tailings Pile

Adair Memorial Park Archery Range
4760 S. Highway 95
Yuma, Arizona

Figure 6
Lead Distribution Map



AOC 2 Sample Location

AOC 3 Sample Location

Temporary Well and Soil Sample Location

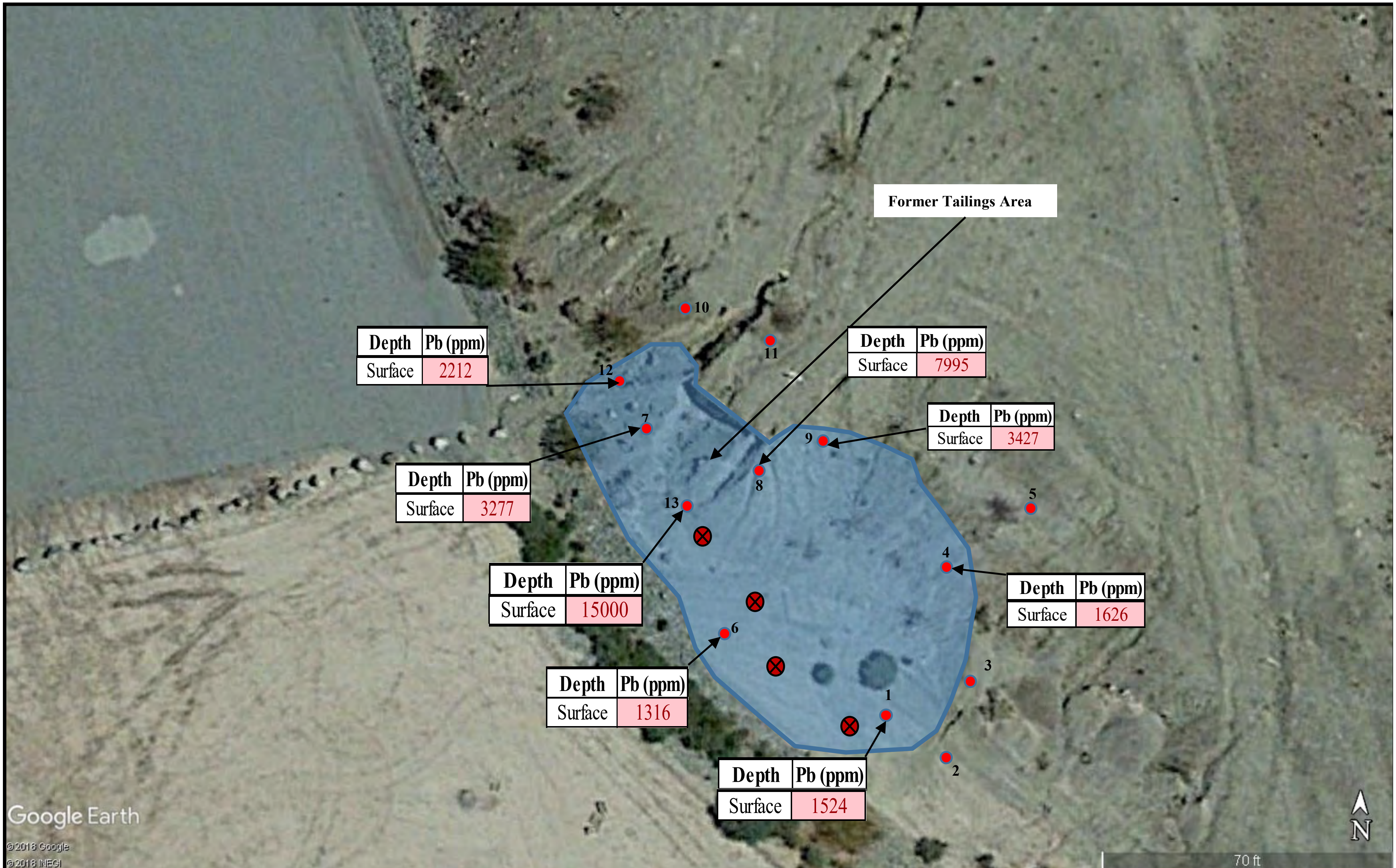
Background Sample Location

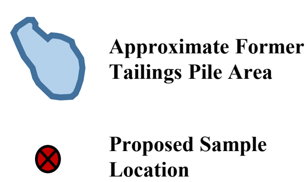
XRF Reading From Tailings Pile

Approximate Groundwater Boundary

Adair Memorial Park Archery Range
4760 S. Highway 95
Yuma, Arizona

Figure 7
Groundwater Occurrence Map





Adair Memorial Park Archery Range
4760 S. Highway 95
Yuma, Arizona

Figure 8
Former Tailings Area
XRF Screening Map

TABLES

Table 2 Summary of XRF Data with Labortory Data Comparison - Adair Memorial Park

Time	Date	Borehole	Depth	Pb (ppm)	Pb ± 2σ	Lab (mg/kg)	Lab Dup (mg/kg)
1250	1/24/2019	AOC2-1	0-0.5	102	11	100	150
1252	1/24/2019	AOC2-1	0.5-1	822	30	460	
1254	1/24/2019	AOC2-1	1-1.5	473	23		
1257	1/24/2019	AOC2-1	1.5-2	148	13		
1300	1/24/2019	AOC2-1	2-2.5	504	22		
1302	1/24/2019	AOC2-1	2.5-3	19	7		
1304	1/24/2019	AOC2-1	3-3.5	245	15		
1306	1/24/2019	AOC2-1	3.5-4	18	7		
1309	1/24/2019	AOC2-1	4-4.5	24	8		
1311	1/24/2019	AOC2-1	4.5-5	134	14		
1337	1/24/2019	AOC2-2	0-0.5	273	17	370	
1339	1/24/2019	AOC2-2	0.5-1	26	7		
1341	1/24/2019	AOC2-2	1-1.5	30	8		
1343	1/24/2019	AOC2-2	1.5-2	163	13		
1345	1/24/2019	AOC2-2	2-2.5	15	7		
1347	1/24/2019	AOC2-2	2.5-3	22	7		
1349	1/24/2019	AOC2-2	3-3.5	94	13	73	
1351	1/24/2019	AOC2-2	3.5-4	15	7		
1353	1/24/2019	AOC2-2	4-4.5	17	7		
1355	1/24/2019	AOC2-2	4.5-5	55	9		
1420	1/23/2019	AOC2-3	0-0.5	74	15	58	
1422	1/23/2019	AOC2-3	0.5-1	70	11		
1424	1/23/2019	AOC2-3	1-1.5	32	11		
1426	1/23/2019	AOC2-3	1.5-2	40	11		
1429	1/23/2019	AOC2-3	2-2.5	40	10		
1431	1/23/2019	AOC2-3	2.5-3	29	10		
1433	1/23/2019	AOC2-3	3-3.5	112	15	43	
1435	1/23/2019	AOC2-3	3.5-4	35	8		
1437	1/23/2019	AOC2-3	4-4.5	24	10		
1440	1/23/2019	AOC2-3	4.5-5	93	14		
1305	1/23/2019	AOC2-4	0-0.5	59	9	34	
1307	1/23/2019	AOC2-4	0.5-1	33	8		
1309	1/23/2019	AOC2-4	1-1.5	22	7		
1311	1/23/2019	AOC2-4	1.5-2	59	9		
1313	1/23/2019	AOC2-4	2-2.5	1861	49		
1315	1/23/2019	AOC2-4	2.5-3	4947	99		
1317	1/23/2019	AOC2-4	3-3.5	432	22	330	
1320	1/23/2019	AOC2-4	3.5-4	4287	85	1600	
1322	1/23/2019	AOC2-4	4-4.5	4477	87		
1325	1/23/2019	AOC2-4	4.5-5	1271	51		

Table 2 Summary of XRF Data with Labortory Data Comparison - Adair Memorial Park

Time	Date	Borehole	Depth	Pb (ppm)	Pb ± 2σ	Lab (mg/kg)	Lab Dup (mg/kg)
1055	1/24/2019	AOC2-5	0-0.5	74	15	68	
1057	1/24/2019	AOC2-5	0.5-1	70	11		
1059	1/24/2019	AOC2-5	1-1.5	32	11		
1101	1/24/2019	AOC2-5	1.5-2	40	11		
1103	1/24/2019	AOC2-5	2-2.5	40	10		
1105	1/24/2019	AOC2-5	2.5-3	29	10		
1107	1/24/2019	AOC2-5	3-3.5	112	15		
1110	1/24/2019	AOC2-5	3.5-4	35	8		
1112	1/24/2019	AOC2-5	4-4.5	24	10	31	
1114	1/24/2019	AOC2-5	4.5-5	93	14		
1146	1/24/2019	AOC2-6	0-0.5	307	19	150	
1148	1/24/2019	AOC2-6	0.5-1	44	9		
1150	1/24/2019	AOC2-6	1-1.5	39	8		
1152	1/24/2019	AOC2-6	1.5-2	144	13		
1154	1/24/2019	AOC2-6	2-2.5	93	13		
1156	1/24/2019	AOC2-6	2.5-3	17	7		
1158	1/24/2019	AOC2-6	3-3.5	249	17	94	
1200	1/24/2019	AOC2-6	3.5-4	0	13		
1202	1/24/2019	AOC2-6	4-4.5	0	12		
1204	1/24/2019	AOC2-6	4.5-5	93	10		
1430	1/24/2019	AOC2-7	0-0.5	577	25	150	
1432	1/24/2019	AOC2-7	0.5-1	25	7		
1434	1/24/2019	AOC2-7	1-1.5	62	10		
1436	1/24/2019	AOC2-7	1.5-2	103	11	46	
1438	1/24/2019	AOC2-7	2-2.5	13	6		
1440	1/24/2019	AOC2-7	2.5-3	14	7		
1442	1/24/2019	AOC2-7	3-3.5	79	10		
1444	1/24/2019	AOC2-7	3.5-4	20	7		
1446	1/24/2019	AOC2-7	4-4.5	15	7		
1448	1/24/2019	AOC2-7	4.5-5	28	8		
1218	1/23/2019	AOC2-8	0-0.5	200	14	38	
1220	1/23/2019	AOC2-8	0.5-1	29	8		
1222	1/23/2019	AOC2-8	1-1.5	22	7		
1224	1/23/2019	AOC2-8	1.5-2	52	8		
1226	1/23/2019	AOC2-8	2-2.5	17	7		
1228	1/23/2019	AOC2-8	2.5-3	0	15		
1230	1/23/2019	AOC2-8	3-3.5	337	18	14	
1232	1/23/2019	AOC2-8	3.5-4	20	7		
1324	1/23/2019	AOC2-8	4-4.5	28	7		
1236	1/23/2019	AOC2-8	4.5-5	89	10		

Table 2 Summary of XRF Data with Labortory Data Comparison - Adair Memorial Park

Time	Date	Borehole	Depth	Pb (ppm)	Pb ± 2σ	Lab (mg/kg)	Lab Dup (mg/kg)
940	1/24/2019	AOC3A-1	0-0.5	171	15		
942	1/24/2019	AOC3A-1	0.5-1	15	8		
944	1/24/2019	AOC3A-1	1-1.5	17	7		
946	1/24/2019	AOC3A-1	1.5-2	53	9		
948	1/24/2019	AOC3A-1	2-2.5	42	8		
950	1/24/2019	AOC3A-1	2.5-3	52	9		
952	1/24/2019	AOC3A-1	3-3.5	50	8		
954	1/24/2019	AOC3A-1	3.5-4	44	8		
956	1/24/2019	AOC3A-1	4-4.5	0	18		
958	1/24/2019	AOC3A-1	4.5-5	81	10		
1004	1/24/2019	AOC3A-1	10-10.5	19	7		
1006	1/24/2019	AOC3A-1	10.5-11.0	0	20		
1008	1/24/2019	AOC3A-1	11-11.5	129	14		
1010	1/24/2019	AOC3A-1	15-15.5	0	20		
1013	1/24/2019	AOC3A-1	15.5-16.0	34	9		
1016	1/24/2019	AOC3A-1	16-16.5	0	12		
1018	1/24/2019	AOC3A-1	20-20.5	35	10		
1020	1/24/2019	AOC3A-1	20.5-21	0	18		
1022	1/24/2019	AOC3A-1	21-21.5	18	7		
1117	1/22/2019	AOC3A-2	0-0.5	112	14	70	
1119	1/22/2019	AOC3A-2	0.5-1	146	16		
1121	1/22/2019	AOC3A-2	1-1.5	13	4		
1123	1/22/2019	AOC3A-2	1.5-2	174	15		
1125	1/22/2019	AOC3A-2	2-2.5	19	9		
1126	1/22/2019	AOC3A-2	2.5-3	15	8		
1128	1/22/2019	AOC3A-2	3-3.5	65	6		
1130	1/22/2019	AOC3A-2	3.5-4	24	8		
1131	1/22/2019	AOC3A-2	4-4.5	0	7		
1133	1/22/2019	AOC3A-2	4.5-5	47	10		
1155	1/22/2019	AOC3A-3	0-0.5	335	22	130	
1157	1/22/2019	AOC3A-3	0.5-1	49	6		
1159	1/22/2019	AOC3A-3	1-1.5	0	7		
1201	1/22/2019	AOC3A-3	1.5-2	97	6		
1203	1/22/2019	AOC3A-3	2-2.5	31	5		
1205	1/22/2019	AOC3A-3	2.5-3	28	5		
1207	1/22/2019	AOC3A-3	3-3.5	95	7		
1209	1/22/2019	AOC3A-3	3.5-4	14	4		
1211	1/22/2019	AOC3A-3	4-4.5	284	2		
1213	1/22/2019	AOC3A-3	4.5-5	63	12		

Table 2 Summary of XRF Data with Labortory Data Comparison - Adair Memorial Park

Time	Date	Borehole	Depth	Pb (ppm)	Pb ± 2σ	Lab (mg/kg)	Lab Dup (mg/kg)
810	1/22/2019	AOC3A-4	0-0.5	378	21		
812	1/22/2019	AOC3A-4	0.5-1	3298	67	1800	
814	1/22/2019	AOC3A-4	1-1.5	40	6		
816	1/22/2019	AOC3A-4	1.5-2	677	30		
818	1/22/2019	AOC3A-4	2-2.5	20	5		
820	1/22/2019	AOC3A-4	2.5-3	19	9		
821	1/22/2019	AOC3A-4	3-3.5	539	27		
822	1/22/2019	AOC3A-4	3.5-4	804	32	370	
824	1/22/2019	AOC3A-4	4-4.5	31	10		
826	1/22/2019	AOC3A-4	4.5-5	234	18		
842	1/22/2019	AOC3A-5	0-0.5	177	16		
844	1/22/2019	AOC3A-5	0.5-1	347	22	680	
846	1/22/2019	AOC3A-5	1-1.5	16	5		
847	1/22/2019	AOC3A-5	1.5-2	2152	53	930	
849	1/22/2019	AOC3A-5	2-2.5	14	4		
851	1/22/2019	AOC3A-5	2.5-3	19	4		
853	1/22/2019	AOC3A-5	3-3.5	369	20		
855	1/22/2019	AOC3A-5	3.5-4	23	5		
856	1/22/2019	AOC3A-5	4-4.5	20	5		
858	1/22/2019	AOC3A-5	4.5-5	252	18		
1022	1/22/2019	AOC3A-6	0-0.5	649	27	47	
1023	1/22/2019	AOC3A-6	0.5-1	17	8		
1025	1/22/2019	AOC3A-6	1-1.5	19	8		
1027	1/22/2019	AOC3A-6	1.5-2	23	8		
1029	1/22/2019	AOC3A-6	2-2.5	18	7		
1031	1/22/2019	AOC3A-6	2.5-3	17	8		
1032	1/22/2019	AOC3A-6	3-3.5	20	9		
1034	1/22/2019	AOC3A-6	3.5-4	0	10		
1036	1/22/2019	AOC3A-6	4-4.5	0	8		
1038	1/22/2019	AOC3A-6	4.5-5	39	10		
932	1/22/2019	AOC3A-7	0-0.5	244	18	280	
933	1/22/2019	AOC3A-7	0.5-1	13	4		
935	1/22/2019	AOC3A-7	1-1.5	0	4		
936	1/22/2019	AOC3A-7	1.5-2	42	11		
938	1/22/2019	AOC3A-7	2-2.5	143	15		
939	1/22/2019	AOC3A-7	2.5-3	0	7		
941	1/22/2019	AOC3A-7	3-3.5	45	10		
942	1/22/2019	AOC3A-7	3.5-4	16	8		
944	1/22/2019	AOC3A-7	4-4.5	17	8		
945	1/22/2019	AOC3A-7	4.5-5	36	9		

Table 2 Summary of XRF Data with Labortory Data Comparison - Adair Memorial Park

Time	Date	Borehole	Depth	Pb (ppm)	Pb ± 2σ	Lab (mg/kg)	Lab Dup (mg/kg)
915	1/22/2019	AOC3A-8	0-0.5	1141	38	540	
917	1/22/2019	AOC3A-8	0.5-1	23	9		
918	1/22/2019	AOC3A-8	1-1.5	22	5		
920	1/22/2019	AOC3A-8	1.5-2	434	22		
922	1/22/2019	AOC3A-8	2-2.5	129	13		
923	1/22/2019	AOC3A-8	2.5-3	21	9		
925	1/22/2019	AOC3A-8	3-3.5	213	16		
927	1/22/2019	AOC3A-8	3.5-4	215	16		
929	1/22/2019	AOC3A-8	4-4.5	16	8		
930	1/22/2019	AOC3A-8	4.5-5	159	22		
1150	1/21/2019	AOC3B-1	0-0.5	217	15	61	
1152	1/21/2019	AOC3B-1	0.5-1	794	29		
1154	1/21/2019	AOC3B-1	1-1.5	26	7		
1156	1/21/2019	AOC3B-1	1.5-2	199	15		
1157	1/21/2019	AOC3B-1	2-2.5	37	8		
1159	1/21/2019	AOC3B-1	2.5-3	24	10		
1200	1/21/2019	AOC3B-1	3-3.5	82	10		
1202	1/21/2019	AOC3B-1	3.5-4	0	18		
1203	1/21/2019	AOC3B-1	4-4.5	23	7		
1205	1/21/2019	AOC3B-1	4.5-5	53	11		
820	1/21/2019	AOC3B-2	0-0.5	1093	36	820	
822	1/21/2019	AOC3B-2	0.5-1	812	29	640	
823	1/21/2019	AOC3B-2	1-1.5	265	17		
825	1/21/2019	AOC3B-2	1.5-2	205	15		
829	1/21/2019	AOC3B-2	2-2.5	101	11		
830	1/21/2019	AOC3B-2	2.5-3	35	8		
831	1/21/2019	AOC3B-2	3-3.5	87	11		
832	1/21/2019	AOC3B-2	3.5-4	0	14		
833	1/21/2019	AOC3B-2	4-4.5	16	7		
834	1/21/2019	AOC3B-2	4.5-5	56	9		
1245	1/21/2019	AOC3B-3	0-0.5	604	26	570	
1246	1/21/2019	AOC3B-3	0.5-1	2034	60	770	
1248	1/21/2019	AOC3B-3	1-1.5	35	8		
1250	1/21/2019	AOC3B-3	1.5-2	196	14		
1251	1/21/2019	AOC3B-3	2-2.5	34	8		
1252	1/21/2019	AOC3B-3	2.5-3	19	7		
1254	1/21/2019	AOC3B-3	3-3.5	386	19		
1256	1/21/2019	AOC3B-3	3.5-4	19	7		
1257	1/21/2019	AOC3B-3	4-4.5	14	7		
1259	1/21/2019	AOC3B-3	4.5-5	212	15		

Table 2 Summary of XRF Data with Labortory Data Comparison - Adair Memorial Park

Time	Date	Borehole	Depth	Pb (ppm)	Pb ± 2σ	Lab (mg/kg)	Lab Dup (mg/kg)
1010	1/21/2019	AOC3B-4	0-0.5	593	27	200	
1012	1/21/2019	AOC3B-4	0.5-1	66	10		
1014	1/21/2019	AOC3B-4	1-1.5	59	9		
1016	1/21/2019	AOC3B-4	1.5-2	56	12		
1018	1/21/2019	AOC3B-4	2-2.5	30	8		
1020	1/21/2019	AOC3B-4	2.5-3	26	8		
1022	1/21/2019	AOC3B-4	3-3.5	125	17		
1024	1/21/2019	AOC3B-4	3.5-4	24	10		
1026	1/21/2019	AOC3B-4	4-4.5	23	9		
1028	1/21/2019	AOC3B-4	4.5-5	56	13		
921	1/21/2019	AOC3B-5	0-0.5	572	24	230	
923	1/21/2019	AOC3B-5	0.5-1	530	26		
927	1/21/2019	AOC3B-5	1-1.5	293	17		
930	1/21/2019	AOC3B-5	1.5-2	412	22		
932	1/21/2019	AOC3B-5	2-2.5	33	8		
935	1/21/2019	AOC3B-5	2.5-3	21	7		
937	1/21/2019	AOC3B-5	3-3.5	298	17		
939	1/21/2019	AOC3B-5	3.5-4	24	7		
940	1/21/2019	AOC3B-5	4-4.5	21	7		
941	1/21/2019	AOC3B-5	4.5-5	92	11		
1106	1/21/2019	AOC3B-6	0-0.5	1031	35	750	
1108	1/21/2019	AOC3B-6	0.5-1	334	25		
1110	1/21/2019	AOC3B-6	1-1.5	305	18		
1111	1/21/2019	AOC3B-6	1.5-2	773	28		
1113	1/21/2019	AOC3B-6	2-2.5	530	23		
1114	1/21/2019	AOC3B-6	2.5-3	0	19		
1116	1/21/2019	AOC3B-6	3-3.5	206	15		
1118	1/21/2019	AOC3B-6	3.5-4	2048	53		
1119	1/21/2019	AOC3B-6	4-4.5	37	9	17	
1120	1/21/2019	AOC3B-6	4.5-5	349	19		
1330	1/21/2019	AOC3B-7	0-0.5	189	14	120	
1332	1/21/2019	AOC3B-7	0.5-1	891	30	200	
1334	1/21/2019	AOC3B-7	1-1.5	24	8		
1336	1/21/2019	AOC3B-7	1.5-2	268	16		
1338	1/21/2019	AOC3B-7	2-2.5	18	7		
1340	1/21/2019	AOC3B-7	2.5-3	16	6		
1342	1/21/2019	AOC3B-7	3-3.5	50	12		
1344	1/21/2019	AOC3B-7	3.5-4	19	7		
1346	1/21/2019	AOC3B-7	4-4.5	21	7		
1348	1/21/2019	AOC3B-7	4.5-5	115	12		

Table 2 Summary of XRF Data with Labortory Data Comparison - Adair Memorial Park

Time	Date	Borehole	Depth	Pb (ppm)	Pb ± 2σ	Lab (mg/kg)	Lab Dup (mg/kg)
1422	1/21/2019	AOC3B-8	0-0.5	398	20		
1424	1/21/2019	AOC3B-8	0.5-1	2081	54	820	
1426	1/21/2019	AOC3B-8	1-1.5	88	12		
1428	1/21/2019	AOC3B-8	1.5-2	1110	35		
1430	1/21/2019	AOC3B-8	2-2.5	27	7	15	
1432	1/21/2019	AOC3B-8	2.5-3	17	7		
1434	1/21/2019	AOC3B-8	3-3.5	1073	34		
1436	1/21/2019	AOC3B-8	3.5-4	27	7		
1438	1/21/2019	AOC3B-8	4-4.5	54	10		
1440	1/21/2019	AOC3B-8	4.5-5	253	23		
1148	1/23/2019	AOC3C-1	0-0.5	48	9	660	
1150	1/23/2019	AOC3C-1	0.5-1	28	8		
1152	1/23/2019	AOC3C-1	1-1.5	32	8		
1154	1/23/2019	AOC3C-1	1.5-2	338	18		
1156	1/23/2019	AOC3C-1	2-2.5	0	13		
1158	1/23/2019	AOC3C-1	2.5-3	0	12		
1200	1/23/2019	AOC3C-1	3-3.5	430	21	470	
1202	1/23/2019	AOC3C-1	3.5-4	14	6		
1204	1/23/2019	AOC3C-1	4-4.5	22	8		
1206	1/23/2019	AOC3C-1	4.5-5	351	19		
923	1/23/2019	AOC3C-2	0-0.5	93	11	56	56
925	1/23/2019	AOC3C-2	0.5-1	18	7		
927	1/23/2019	AOC3C-2	1-1.5	19	7		
929	1/23/2019	AOC3C-2	1.5-2	16	6		
931	1/23/2019	AOC3C-2	2-2.5	21	7		
934	1/23/2019	AOC3C-2	2.5-3	16	8		
937	1/23/2019	AOC3C-2	3-3.5	29	7		
940	1/23/2019	AOC3C-2	3.5-4	25	14		
942	1/23/2019	AOC3C-2	4-4.5	0	7		
945	1/23/2019	AOC3C-2	4.5-5	25	5		
856	1/23/2019	AOC3C-3	0-0.5	356	19	230	
858	1/23/2019	AOC3C-3	0.5-1	22	7		
900	1/23/2019	AOC3C-3	1-1.5	19	7		
902	1/23/2019	AOC3C-3	1.5-2	84	10		
904	1/23/2019	AOC3C-3	2-2.5	23	8		
906	1/23/2019	AOC3C-3	2.5-3	0	13		
908	1/23/2019	AOC3C-3	3-3.5	50	8		
910	1/23/2019	AOC3C-3	3.5-4	20	7		
912	1/23/2019	AOC3C-3	4-4.5	17	7		
915	1/23/2019	AOC3C-3	4.5-5	33	7		

Table 2 Summary of XRF Data with Labortory Data Comparison - Adair Memorial Park

Time	Date	Borehole	Depth	Pb (ppm)	Pb ± 2σ	Lab (mg/kg)	Lab Dup (mg/kg)
953	1/23/2019	AOC3C-4	0-0.5	22	7	29	
955	1/23/2019	AOC3C-4	0.5-1	27	8		
957	1/23/2019	AOC3C-4	1-1.5	19	7		
959	1/23/2019	AOC3C-4	1.5-2	22	7		
1002	1/23/2019	AOC3C-4	2-2.5	26	7		
1004	1/23/2019	AOC3C-4	2.5-3	28	8		
1006	1/23/2019	AOC3C-4	3-3.5	35	8		
1008	1/23/2019	AOC3C-4	3.5-4	31	7		
1010	1/23/2019	AOC3C-4	4-4.5	16	7		
1012	1/23/2019	AOC3C-4	4.5-5	16	6		
1043	1/23/2019	AOC3C-5	0-0.5	147	12	120	
1045	1/23/2019	AOC3C-5	0.5-1	129	13		
1047	1/23/2019	AOC3C-5	1-1.5	24	9		
1050	1/23/2019	AOC3C-5	1.5-2	28	7		
1052	1/23/2019	AOC3C-5	2-2.5	17	6		
1054	1/23/2019	AOC3C-5	2.5-3	0	13		
1056	1/23/2019	AOC3C-5	3-3.5	29	8		
1058	1/23/2019	AOC3C-5	3.5-4	19	6		
100	1/23/2019	AOC3C-5	4-4.5	16	6		
1103	1/23/2019	AOC3C-5	4.5-5	18	8		
826	1/23/2019	AOC3C-6	0-0.5	1560	43	1000	
828	1/23/2019	AOC3C-6	0.5-1	722	27	450	
832	1/23/2019	AOC3C-6	1-1.5	571	23		
835	1/23/2019	AOC3C-6	1.5-2	616	24		
837	1/23/2019	AOC3C-6	2-2.5	423	20		
840	1/23/2019	AOC3C-6	2.5-3	431	20		
842	1/23/2019	AOC3C-6	3-3.5	433	20		
844	1/23/2019	AOC3C-6	3.5-4	28	8		
846	1/23/2019	AOC3C-6	4-4.5	32	8		
848	1/23/2019	AOC3C-6	4.5-5	163	13		
1341	1/22/2019	AOC3C-7	0-0.5	276	17	26	
1344	1/22/2019	AOC3C-7	0.5-1	234	16		
1346	1/22/2019	AOC3C-7	1-1.5	0	15		
1348	1/22/2019	AOC3C-7	1.5-2	231	17		
1350	1/22/2019	AOC3C-7	2-2.5	27	7		
1352	1/22/2019	AOC3C-7	2.5-3	30	8		
755	1/23/2019	AOC3C-7	3-3.5	105	12		
800	1/23/2019	AOC3C-7	3.5-4	14	7		
802	1/23/2019	AOC3C-7	4-4.5	16	7		
803	1/23/2019	AOC3C-7	4.5-5	30	8		

Table 2 Summary of XRF Data with Labortory Data Comparison - Adair Memorial Park

Time	Date	Borehole	Depth	Pb (ppm)	Pb ± 2σ	Lab (mg/kg)	Lab Dup (mg/kg)
1238	1/22/2019	AOC3C-8	0-0.5	127	14	140	
1240	1/22/2019	AOC3C-8	0.5-1	45	6		
1242	1/22/2019	AOC3C-8	1-1.5	20	5		
1245	1/22/2019	AOC3C-8	1.5-2	36	5		
1248	1/22/2019	AOC3C-8	2-2.5	15	8		
1251	1/22/2019	AOC3C-8	2.5-3	17	4		
1253	1/22/2019	AOC3C-8	3-3.5	17	4		
1255	1/22/2019	AOC3C-8	3.5-4	59	13		
1258	1/22/2019	AOC3C-8	4-4.5	24	9		
1300	1/22/2019	AOC3C-8	4.5-5	24	5		
730	1/25/2019	BG-1	0.5	37	8	16	
745	1/25/2019	BG-2	0.5	85	10	620	
815	1/25/2019	BG-3	0.5	109	11	87	
832	1/25/2019	BG-4	0.5	24	7	23	
855	1/25/2019	BG-5	0.5	318	17	250	
914	1/25/2019	BG-6	0.5	151	13	90	
934	1/25/2019	BG-7	0.5	35	8	34	
959	1/25/2019	BG-8	0.5	167	14	85	

Former Tailings Area

1030	1/25/2019	1	Surface	1524	8		
1034	1/25/2019	2	Surface	448	10		
1036	1/25/2019	3	Surface	626	11		
1038	1/25/2019	4	Surface	1626	7		
1042	1/25/2019	5	Surface	388	17		
1046	1/25/2019	6	Surface	1316	13		
1053	1/25/2019	7	Surface	3277	8		
1057	1/25/2019	8	Surface	7995	14	5800	
1059	1/25/2019	9	Surface	3427	7		
1105	1/25/2019	10	Surface	347	17		
1110	1/25/2019	11	Surface	583	13		
1115	1/25/2019	12	Surface	2212	8		
1120	1/25/2019	13	Surface	15000	14	12000	

Table 3: Summary of Background Soil Samples - Adair Memorial Park

Sample Name	Date	Unit	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
BG-1-0.5	1/25/2019	mg/kg	**10**	63	<0.49	13	16	<0.092	<4.9	<2.5
BG-2-0.5	1/25/2019	mg/kg	**10**	53	<0.49	12	620	<0.099	<4.9	<2.4
BG-3-0.5	1/25/2019	mg/kg	**10**	99	<0.5	15	87	<0.098	<5	<2.5
BG-4-0.5	1/25/2019	mg/kg	**14**	60	<0.5	11	23	<0.098	<5	<2.5
BG-5-0.5	1/25/2019	mg/kg	**15**	110	0.84	17	250	<0.1	<5	<2.5
BG-6-0.5	1/25/2019	mg/kg	**13**	170	<0.49	23	90	<0.09	<4.9	<2.5
BG-7-0.5	1/25/2019	mg/kg	**12**	120	<0.5	22	34	<0.099	<5	<2.5
BG-8-0.5	1/25/2019	mg/kg	**14**	110	<0.49	25	85	<0.1	<4.9	<2.5
Non Residential SRL		mg/kg	10	170,000	510	65	800	310	5,100	5,100

Note: mg/kg - milligram per kilogram

Table 4: Summary of Total Metals in Soil - Adair Memorial Park

Sample Name	Date	Unit	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
AOC2-1-0.5	1/24/2019	mg/kg	**14**	76	<0.5	16	100	<0.091	<5	<2.5
AOC2-1-0.5	1/23/2019	mg/kg	**15**	120	<0.49	21	150	<0.095	<4.9	<2.4
AOC2-1-1	1/24/2019	mg/kg	**15**	140	1	17	460	0.11	<4.9	<2.5
AOC2-2-0.5	1/24/2019	mg/kg	**15**	140	0.67	21	370	<0.097	<4.9	<2.5
AOC2-2-3.5	1/24/2019	mg/kg	**13**	120	<0.5	26	73	<0.095	<5	<2.5
AOC2-3-0.5	1/23/2019	mg/kg	**20**	83	<0.49	19	58	<0.1	<4.9	<2.4
AOC2-3-3.5	1/23/2019	mg/kg	**14**	130	<0.5	25	43	<0.094	<5	<2.5
AOC2-4-0.5	1/23/2019	mg/kg	**13**	86	<0.5	15	34	<0.097	<5	<2.5
AOC2-4-3.0	1/23/2019	mg/kg	**22**	85	<0.49	57	330	<0.095	<4.9	<2.4
AOC2-5-0.5	1/23/2019	mg/kg	**17**	59	<0.5	15	68	<0.089	<5	<2.5
AOC2-5-4.5	1/23/2019	mg/kg	**15**	130	<0.5	24	31	<0.087	<5	<2.5
AOC2-6-0.5	1/23/2019	mg/kg	**17**	120	0.77	21	150	<0.094	<4.9	<2.5
AOC2-6-3.5	1/23/2019	mg/kg	**16**	120	<0.49	22	94	<0.095	<4.9	<2.4
AOC2-6-4.0	1/23/2019	mg/kg	**19**	180	3.4	25	**1600**	<0.09	<4.9	<2.5
AOC2-7-0.5	1/24/2019	mg/kg	**14**	110	<0.49	19	150	<0.099	<4.9	<2.5
AOC2-7-2	1/24/2019	mg/kg	9.1	62	<0.49	14	46	<0.095	<4.9	<2.4
AOC2-8-0.5	1/23/2019	mg/kg	**16**	62	<0.49	9.1	38	<0.099	<4.9	<2.5
AOC2-8-3.5	1/23/2019	mg/kg	**13**	120	<0.49	20	14	<0.095	<4.9	<2.5
AOC3A-2-0.5	1/22/2019	mg/kg	**13**	110	<0.49	19	70	<0.088	<4.9	<2.4
AOC3A-3-0.5	1/22/2019	mg/kg	**17**	120	<0.49	16	130	<0.086	<4.9	<2.5
AOC3A-4-1	1/22/2019	mg/kg	**23**	310	3	29	**1800**	0.26	<4.9	<2.4
AOC3A-4-4	1/22/2019	mg/kg	**16**	170	1.2	25	370	<0.098	<4.9	<2.4
AOC3A-5-0.5	1/22/2019	mg/kg	**18**	200	1.4	25	680	0.22	<4.9	<2.5
AOC3A-5-2	1/22/2019	mg/kg	**19**	220	1.7	26	**930**	0.15	<4.9	<2.5
AOC3A-6-0.5	1/22/2019	mg/kg	**15**	140	<0.49	21	47	<0.092	<4.9	<2.5
AOC3A-7-0.5	1/22/2019	mg/kg	**14**	160	0.66	24	280	<0.089	<5	<2.5
AOC3A-8-0.5	1/22/2019	mg/kg	**17**	190	1.5	26	540	0.18	<5	<2.5
AOC3B-1-0.5	1/21/2019	mg/Kg	**14**	130	<0.49	21	61	<0.088	<4.9	<2.5
AOC3B-2-0.5	1/21/2019	mg/Kg	**14**	180	1.3	18	640	0.18	<4.9	<2.5
AOC3B-2-1	1/21/2019	mg/kg	**19**	230	1.6	24	**820**	0.12	<4.9	<2.4
Non Residential SRL			10	170,000	510	65	800	310	5,100	5,100

Table 4: Summary of Total Metals in Soil - Adair Memorial Park

Sample Name	Date	Unit	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
AOC3B-3-0.5	1/21/2019	mg/Kg	**16**	190	1.8	23	570	<0.087	<5	<2.5
AOC3B-3-1	1/21/2019	mg/Kg	**15**	150	0.54	24	770	<0.095	<4.9	<2.5
AOC3B-4-0.5	1/21/2019	mg/Kg	**15**	120	<0.49	20	200	<0.096	<4.9	<2.5
AOC3B-5-0.5	1/21/2019	mg/Kg	**11**	110	0.52	13	230	<0.092	<4.9	<2.5
AOC3B-6-0.5	1/21/2019	mg/Kg	**13**	120	1.1	18	750	<0.092	<4.9	<2.4
AOC3B-6-4	1/21/2019	mg/Kg	8	120	<0.49	18	17	<0.091	<4.9	<2.5
AOC3B-7-0.5	1/21/2019	mg/Kg	**12**	130	<0.49	21	120	<0.1	<4.9	<2.4
AOC3B-7-1	1/21/2019	mg/kg	**18**	150	<0.5	26	200	<0.091	<5	<2.5
AOC3B-8-0.5	1/21/2019	mg/Kg	**19**	210	1.1	25	**820**	0.097	<4.9	<2.5
AOC3B-8-2	1/21/2019	mg/kg	8.5	120	<0.49	23	15	<0.098	<4.9	<2.4
AOC3C-1-.5	1/23/2019	mg/kg	**18**	160	1.3	24	660	<0.094	<4.9	<2.5
AOC3C-1-3.5	1/23/2019	mg/kg	**18**	190	1.3	24	470	<0.09	<4.9	<2.4
AOC3C-2-0.5	1/23/2019	mg/kg	**150**	1700	<4.9	240	580	<0.098	<49	<24
AOC3C-2-0.5	3/8/2019	mg/Kg	**14**	140	<0.49	20	56		<4.9	<2.5
AOC3C-2-0.5-D	3/8/2019	mg/Kg	**14**	140	<0.49	20	56		<4.9	<2.5
AOC3C-3-0.5	1/23/2019	mg/kg	**18**	140	0.78	24	230	<0.1	<4.9	<2.5
AOC3C-4-0.5	1/23/2019	mg/kg	**19**	150	<0.5	24	29	<0.096	<5	<2.5
AOC3C-5-0.5	1/23/2019	mg/kg	**17**	140	<0.49	26	120	<0.098	<4.9	<2.5
AOC3C-6-0.5	1/23/2019	mg/kg	**20**	180	2.1	25	**1000**	<0.093	<5	<2.5
AOC3C-6-1.0	1/23/2019	mg/kg	**12**	140	<0.49	26	450	<0.095	<4.9	<2.4
AOC3C-7-0.5	1/22/2019	mg/kg	**15**	110	<0.49	20	26	<0.087	<4.9	<2.4
AOC3C-8-0.5	1/22/2019	mg/kg	**13**	130	1.8	22	140		<4.9	<2.5
TP-13-0.5	1/29/2019	mg/kg	**31**	610	39	7.8	**5800**	1.3	<5	6.5
TP-8-0.5	1/29/2019	mg/kg	**47**	1100	75	6.1	**12000**	1.8	<9.9	6.8

Note: mg/kg - milligram per kilogram

Non Residential SRL			10	170,000	510	65	800	310	5,100	5,100

Table 5: Summary of SPLP and TCLP Metals in Soil - Adair Memorial Park

Sample Name	:ollection Date	Unit	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
AOC3B-1-1	1/21/2019	mg/L	<0.028	0.046	<0.003	<0.0055	<0.019	<0.00008	<0.026	<0.007
AOC3B-3-1	1/21/2019	mg/L	<0.028	0.13	<0.003	<0.0055	<0.019	<0.00008	0.035	<0.007
AOC3B-4-1	1/21/2019	mg/L	<0.028	<0.0035	<0.003	<0.0055	<0.019	<0.00008	<0.026	<0.007
AOC3B-5-1	1/21/2019	mg/L	<0.028	<0.0035	<0.003	<0.0055	<0.019	<0.00008	<0.026	<0.007
AOC3B-6-2.0	1/21/2019	mg/L	<0.028	<0.0035	<0.003	<0.0055	<0.019	<0.00008	<0.026	<0.007
AOC3B-7-1	1/21/2019	mg/L	<0.028	0.11	<0.003	<0.0055	<0.019	<0.00008	0.031	<0.007
AOC3B-8-1	1/21/2019	mg/L	0.031	0.11	<0.003	<0.0055	<0.019	<0.00008	<0.026	<0.007
TP-13-0.5	1/29/2019	mg/L	<0.028	<0.0035	<0.003	<0.0055	<0.019	<0.00008	<0.026	<0.007
TP-8-0.5	1/29/2019	mg/L	<0.028	<0.0035	**1.4**	<0.0055	**57**	<0.00008	<0.026	<0.007
TCLP Limit		mg/L	5.0	100	1.0	5.0	5.0	0.2	1.0	5.0

Note: mg/L - milligram per liter

APPENDIX A
Boring Logs

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC2-1

CLIENT Yuma County Department of Public Works

PROJECT NAME Adair Park Archery Range

PROJECT NUMBER 018-0069

PROJECT LOCATION Yuma, AZ

DATE STARTED 1/24/19 **COMPLETED** 1/24/19

GROUND ELEVATION **HOLE SIZE** 8 inches

DRILLING CONTRACTOR Nicklaus Engineering

GROUND WATER LEVELS:

DRILLING METHOD Hollow Stem Auger

AT TIME OF DRILLING ---

LOGGED BY BC **CHECKED BY** MLD

AT END OF DRILLING ---

NOTES

AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0	SS	100	5-8-10 (18)			(Fill) Gravelly Silt - Pale yellowish brown (10YR 6/4), loose, damp, gravel 25%, to 1 inch, subangular to subrounded, no odor, no stain.	XRF = 102 XRF = 822
	SS	100	7-7-6 (13)				XRF = 473 XRF = 148 XRF = 504
2.5				ML	2.5	(ML) Clayey Silt - Moderate yellowish brown (10YR 5/4), loose to medium dense, clay soft to medium stiff, damp, low plasticity, clay 20%, no odor, no stain.	
	SS	100	6-5-5 (10)				XRF = 19 XRF = 245 XRF = 18
5.0	SS	100	4-8-13 (21)				XRF = 24 XRF = 134
					6.0	Bottom of borehole at 6.0 feet.	

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC2-2

CLIENT Yuma County Department of Public Works
PROJECT NAME Adair Park Archery Range
PROJECT NUMBER 018-0069
PROJECT LOCATION Yuma, AZ
DATE STARTED 1/24/19 **COMPLETED** 1/24/19
GROUND ELEVATION **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Nicklaus Engineering
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY BC **CHECKED BY** MLD
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0						(Fill) Gravelly Silt - Pale yellowish brown (10YR 6/4), loose, slightly damp, gravel 20%, to 1 inch, subangular to subrounded, no odor, no stain.	
	SS	100	8-10-11 (21)				XRF = 273 XRF = 26
	SS	100	7-7-9 (16)		2.0	(CL-ML) Silty Clay - Moderate yellowish brown (10YR 5/4), damp, soft to stiff, low plasticity, no odor, no stain.	XRF = 30 XRF = 163 XRF = 15
2.5							
	SS	100	3-4-4 (8)	CL-ML			XRF = 22 XRF = 94 XRF = 15
5.0	SS	100	2-3-3 (6)		6.0		XRF = 17 XRF = 55

Bottom of borehole at 6.0 feet.

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC2-3

CLIENT Yuma County Department of Public Works
PROJECT NAME Adair Park Archery Range
PROJECT NUMBER 018-0069
PROJECT LOCATION Yuma, AZ
DATE STARTED 1/23/19 **COMPLETED** 1/23/19
GROUND ELEVATION **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Nicklaus Engineering
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY BC **CHECKED BY** MLD
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0	SS	100	8-8-9 (17)			(Fill) Gravelly Silt - Pale yellowish brown (10YR 6/4), loose, slightly damp, gravel 30%, to 2 inches, subangular to subrounded, no odor, no stain.	XRF = 74 XRF = 70
2.5	SS	100	9-7-8 (15)				XRF = 32 XRF = 40 XRF = 40
	SS	100	7-7-8 (15)		3.5		XRF = 29
				ML		(ML) Clayey Silt - Moderate yellowish brown (10YR 5/4), loose to soft, low plasticity, no odor, no stain.	XRF = 112 XRF = 35
5.0	SS	100	5-7-8 (15)		6.0		XRF = 24 XRF = 93

Bottom of borehole at 6.0 feet.

GENERAL BH / TP / WELL - GINT STD US LAB.GDT - 3/14/19 13:40 - N:\2018\018-0069 YUMA COUNTY ADAIR PARK ARCHERY RANGE\TECHNICAL\BORING LOGS\ADAIR PARK ARCHERY RANGE.GPJ

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC2-4

CLIENT Yuma County Department of Public Works
PROJECT NAME Adair Park Archery Range
PROJECT NUMBER 018-0069
PROJECT LOCATION Yuma, AZ
DATE STARTED 1/23/19 **COMPLETED** 1/23/19
GROUND ELEVATION **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Nicklaus Engineering
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY BC **CHECKED BY** MLD
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0	SS	100	7-10-10 (20)	ML		(ML) (Fill) Gravelly Silt - Pale yellowish brown (10YR 6/4), loose, dry, gravel 25%, to 2 inches, subangular to subrounded, no odor, no stain.	XRF = 273 XRF = 26
	SS	100	7-8-8 (16)		2.0		XRF = 30
2.5				ML		(ML) Clayey Silt - Moderate yellowish brown (10YR 5/4), soft, damp, low plasticity, no odor, no stain.	XRF = 163 XRF = 15
	SS	100	8-8-7 (15)				XRF = 22 XRF = 94 XRF = 15
5.0	SS	100	2-5-9 (14)		6.0		XRF = 17 XRF = 55

Bottom of borehole at 6.0 feet.

GENERAL BH / TP / WELL - GINT STD US LAB.GDT - 3/14/19 13:40 - N:\2018\018-0069 YUMA COUNTY ADAIR ARCHERY RANGE\TECHNICAL\BORING LOGS\ADAIR PARK ARCHERY RANGE.GPJ

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC2-5

CLIENT Yuma County Department of Public Works
PROJECT NAME Adair Park Archery Range
PROJECT NUMBER 018-0069
PROJECT LOCATION Yuma, AZ
DATE STARTED 1/24/19 **COMPLETED** 1/24/19
GROUND ELEVATION **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Nicklaus Engineering
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY BC **CHECKED BY** MLD
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0	SS	100	6-12-12 (24)	ML		(ML) (Fill) Gravelly Silt - Pale yellowish brown (10YR 6/4), loose, damp, gravel 30%, to 2.5 inches, subangular to subrounded, no odor, no stain.	XRF = 164 XRF = 67
	SS	100	10-11-12 (23)		2.0		XRF = 38 XRF = 47 XRF = 0
2.5				ML		(ML) Clayey Silt - Moderate yellowish brown (10YR 5/4), loose to medium dense, clay soft to medium stiff, damp, low plasticity, no odor, no stain.	
	SS	100	6-10-9 (19)				XRF = 0 XRF = 0 XRF = 17
5.0	SS	100	4-6-8 (14)		6.0		XRF = 40 XRF = 25

Bottom of borehole at 6.0 feet.

GENERAL BH / TP / WELL - GINT STD US LAB.GDT - 3/14/19 13:40 - N:\2018\018-0069 YUMA COUNTY ADAIR ARCHERY RANGE\TECHNICAL\BORING LOGS\ADAIR PARK ARCHERY RANGE.GPJ

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC2-6

CLIENT Yuma County Department of Public Works
PROJECT NAME Adair Park Archery Range
PROJECT NUMBER 018-0069
PROJECT LOCATION Yuma, AZ
DATE STARTED 1/24/19 **COMPLETED** 1/24/19
GROUND ELEVATION **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Nicklaus Engineering
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY BC **CHECKED BY** MLD
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0	SS	100	13-25-44 (69)	ML		(ML) (Fill) Gravelly Silt - Pale yellowish brown (10YR 6/4), loose, dry, gravel 25%, to 2 inches, subangular to subrounded, no odor, no stain.	XRF = 307 XRF = 44
2.5	SS	100	7-12-10 (22)		2.8		XRF = 39 XRF = 144 XRF = 93
	SS	100	4-4-4 (8)	ML		(ML) Silt - Moderate yellowish brown (10YR 5/4), loose to medium dense, damp, no odor, no stain.	XRF = 17 XRF = 249 XRF = 0
5.0	SS	100	2-3-4 (7)		6.0		XRF = 0 XRF = 93

Bottom of borehole at 6.0 feet.

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC2-7

CLIENT Yuma County Department of Public Works
PROJECT NAME Adair Park Archery Range
PROJECT NUMBER 018-0069
PROJECT LOCATION Yuma, AZ
DATE STARTED 1/24/19 **COMPLETED** 1/24/19
GROUND ELEVATION **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Nicklaus Engineering
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY BC **CHECKED BY** MLD
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0	SS	100	7-10-9 (19)	ML		(ML) (Fill) Gravelly Silt - Pale yellowish brown (10YR 6/4), loose, dry, gravel 30%, to 3 inches, subangular to subrounded, no odor, no stain.	XRF = 577
					1.0	(ML) Clayey Silt - Moderate yellowish brown (10YR 5/4), loose to medium dense, damp, clay 20%, soft, low plasticity, no odor, no stain.	XRF = 25
	SS	100	6-6-5 (11)	ML			XRF = 62
2.5							XRF = 103
							XRF = 13
	SS	100	2-3-3 (6)				XRF = 14
							XRF = 74
							XRF = 20
5.0	SS	100	3-4-3 (7)				XRF = 15
							XRF = 28
					6.0		

Bottom of borehole at 6.0 feet.

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC2-8

CLIENT Yuma County Department of Public Works
PROJECT NAME Adair Park Archery Range
PROJECT NUMBER 018-0069
PROJECT LOCATION Yuma, AZ
DATE STARTED 1/23/19 **COMPLETED** 1/23/19
GROUND ELEVATION **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Nicklaus Engineering
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY BC **CHECKED BY** MLD
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0	SS	100	7-8-12 (20)	ML		(ML) (Fill) Gravelly Silt - Pale yellowish brown (10YR 6/4), loose, dry, gravel 25%, to 2 inches, subangular to subrounded, no odor, no stain.	XRF = 200 XRF = 29
2.5	SS	100	7-10-15 (25)	SC	2.0	(SC) Clayey Sand - Moderate yellowish brown (10YR 5/4), loose to soft, damp, fine sand, 70%, clay 30%, low plasticity, no odor, no stain, well sorted.	XRF = 22 XRF = 52 XRF = 17
	SS	100	6-8-9 (17)	SC			XRF = 0 XRF = 337 XRF = 20
5.0	SS	100	3-4-4 (8)	SC	6.0		XRF = 28 XRF = 89

Bottom of borehole at 6.0 feet.

GENERAL BH / TP / WELL - GINT STD US LAB.GDT - 3/14/19 13:40 - N:\2018\018-0069 YUMA COUNTY ADAIR ARCHERY RANGE\TECHNICAL\BORING LOGS\ADAIR PARK ARCHERY RANGE.GPJ

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC3A-1

CLIENT Yuma County Department of Public Works
PROJECT NAME Adair Park Archery Range
PROJECT NUMBER 018-0069
PROJECT LOCATION Yuma, AZ
DATE STARTED 1/24/19 **COMPLETED** 1/24/19
GROUND ELEVATION **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Nicklaus Engineering
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY BC **CHECKED BY** MLD
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0	SS	100	2-10-8 (18)	ML		(ML) Silt - Moderate yellowish brown (10YR 5/4), loose, slight damp, no odor, no stain.	XRF = 171 XRF = 15
	SS	100	6-5-5 (10)		2.5		XRF = 17 XRF = 53 XRF = 42
	SS	100	4-5-3 (8)	SM		(SM) Silty Sand w/gravel - Moderate yellowish brown (10YR 5/4), loose, damp, very fine to fine, gravel 10%, to 1 inch, subangular to subrounded, no odor, no stain.	XRF = 52 XRF = 50 XRF = 44
5	SS	100	3-3-3 (6)		5.5		XRF = 0 XRF = 81
				ML		(ML) Clayey Silt - Moderate yellowish brown (10YR 5/4), soft, damp, no odor, no stain, low plasticity.	
10	SS	100	3-4-5 (9)		11.0		XRF = 19 XRF = 0 XRF = 129
				CL		(CL) Clay - Moderate yellowish brown (10YR 5/4), damp, soft to medium stiff, low plasticity, no odor, no stain.	
15	SS	83	14-50-50 (100)		17.0		XRF = 0 XRF = 34 XRF = 0
						Degraded bedrock w/ gravel, sand and clay - Light greenish gray (GLEY1 7/1), loose, soft to medium stiff, damp, fine sand 20%, moderately sorted, clay 70%, low plasticity, Iron oxide staining at 15ft, gravel 10%, to 1 inch, subangular to subrounded, no odor.	
20	SS	39	31-50		21.5		XRF = 35 XRF = 0 XRF = 18

No groundwater encountered.
Auger refusal due to bedrock at 21.5.
Bottom of borehole at 21.5 feet.

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC3A-2

CLIENT Yuma County Department of Public Works		**PROJECT NAME** Adair Park Archery Range	
PROJECT NUMBER 018-0069		**PROJECT LOCATION** Yuma, AZ	
DATE STARTED 1/22/19	**COMPLETED** 1/22/19	**GROUND ELEVATION**	**HOLE SIZE** 8 inches
DRILLING CONTRACTOR Nicklaus Engineering		**GROUND WATER LEVELS:**	
DRILLING METHOD Hollow Stem Auger		**AT TIME OF DRILLING** ---	
LOGGED BY BC	**CHECKED BY** MLD	**AT END OF DRILLING** ---	
NOTES		**AFTER DRILLING** ---	

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0	SS	100	3-4-6 (10)	ML		(ML) Silt - Moderate yellowish brown (10YR 5/4), loose, very slightly damp, no odor, no stain.	XRF = 112 XRF = 146
2.5	SS	100	5-5-6 (11)				XRF = 13 XRF = 174 XRF = 19
	SS	100	4-3-3 (6)				XRF = 15 XRF = 65 XRF = 24
5.0	SS	100	3-4-4 (8)		6.0		XRF = 0 XRF = 47

Bottom of borehole at 6.0 feet.

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC3A-3

CLIENT Yuma County Department of Public Works
PROJECT NAME Adair Park Archery Range
PROJECT NUMBER 018-0069
PROJECT LOCATION Yuma, AZ
DATE STARTED 1/22/19 **COMPLETED** 1/22/19
GROUND ELEVATION **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Nicklaus Engineering
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY BC **CHECKED BY** MLD
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0	SS	100	13-12-2 (14)	ML		(ML) Gravelly Silt - Moderate yellowish brown (10YR 5/4), loose, damp, gravel 10%, to .5 inches, subangular to subrounded, no odor, no stain.	XRF = 335 XRF = 49
2.5	SS	100	3-5-5 (10)				XRF = 0 XRF = 97 XRF = 31
	SS	100	3-4-4 (8)		4.0		XRF = 28 XRF = 95 XRF = 14
				CL-ML		(CL-ML) Silty Clay - Moderate yellowish brown (10YR 5/4), soft to medium stiff, damp, low plasticity, no odor, no stain.	
5.0	SS	100	3-3-5 (8)		6.0		XRF = 284 XRF = 63

Bottom of borehole at 6.0 feet.

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC3A-4

CLIENT Yuma County Department of Public Works
PROJECT NAME Adair Park Archery Range
PROJECT NUMBER 018-0069
PROJECT LOCATION Yuma, AZ
DATE STARTED 1/21/19 **COMPLETED** 1/21/19
GROUND ELEVATION **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Nicklaus Engineering
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY BC **CHECKED BY** MLD
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0	SS	100	7-11-8 (19)	ML		(ML) Silt - Moderate yellowish brown (10YR 5/4), loose to medium dense, very slightly damp, no odor, no stain.	XRF = 398 XRF = 3298
	SS	100	5-5-5 (10)		2.0	(ML) Clayey Silt - Moderate yellowish brown (10YR 5/4), damp, soft, low plasticity, no odor, no stain.	XRF = 40 XRF = 677 XRF = 20
2.5	SS	100	4-6-6 (12)	ML			XRF = 19 XRF = 539 XRF = 804
5.0	SS	100	3-4-4 (8)		6.0		XRF = 31 XRF = 234

Bottom of borehole at 6.0 feet.

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC3A-5

CLIENT Yuma County Department of Public Works
PROJECT NAME Adair Park Archery Range
PROJECT NUMBER 018-0069
PROJECT LOCATION Yuma, AZ
DATE STARTED 1/22/19 **COMPLETED** 1/22/19
GROUND ELEVATION **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Nicklaus Engineering
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY BC **CHECKED BY** MLD
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0	SS	100	5-9-9 (18)	SM		(SM) Silty Sand - Moderate yellowish brown (10YR 5/4), loose to occasional medium dense, slightly damp, moderately sorted, fine sand, no odor, no stain.	XRF = 177 XRF = 317 XRF = 16
2.5	SS	100	4-4-4 (8)	SP	2.0	(SP) Fine Sand - Moderate yellowish brown (10YR 5/4), loose, slightly damp, well sorted, no odor, no stain.	XRF = 2152 XRF = 14 XRF = 19
	SS	100	3-3-5 (8)	CL	3.5	(CL) Silty Clay - Moderate yellowish brown (10YR 5/4), soft to medium stiff, damp, low plasticity, no odor, no stain.	XRF = 369 XRF = 23 XRF = 20
5.0	SS	100	3-4-4 (8)		6.0		XRF = 252

Bottom of borehole at 6.0 feet.

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC3A-6

CLIENT Yuma County Department of Public Works
PROJECT NAME Adair Park Archery Range
PROJECT NUMBER 018-0069
PROJECT LOCATION Yuma, AZ
DATE STARTED 1/22/19 **COMPLETED** 1/22/19
GROUND ELEVATION **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Nicklaus Engineering
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY BC **CHECKED BY** MLD
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0	SS	100	3-5-5 (10)	SP		(SP) Sand - Moderate yellowish brown (10YR 5/4), loose, damp, fine grained, well sorted, no odor, no stain.	XRF = 649 XRF = 17
	SS	100	1-3-2 (5)		2.0	(CL) Silty Clay - Moderate yellowish brown (10YR 5/4), soft, damp, low plasticity, no odor, no stain.	XRF = 19 XRF = 23 XRF = 18
2.5	SS	100	3-4-4 (8)	CL			XRF = 17 XRF = 20 XRF = 0
5.0	SS	100	2-2-3 (5)		6.0		XRF = 0 XRF = 39

Bottom of borehole at 6.0 feet.

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC3A-7

CLIENT Yuma County Department of Public Works		**PROJECT NAME** Adair Park Archery Range	
PROJECT NUMBER 018-0069		**PROJECT LOCATION** Yuma, AZ	
DATE STARTED 1/22/19	**COMPLETED** 1/22/19	**GROUND ELEVATION**	**HOLE SIZE** 8 inches
DRILLING CONTRACTOR Nicklaus Engineering		**GROUND WATER LEVELS:**	
DRILLING METHOD Hollow Stem Auger		**AT TIME OF DRILLING** ---	
LOGGED BY BC	**CHECKED BY** MLD	**AT END OF DRILLING** ---	
NOTES		**AFTER DRILLING** ---	

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0	SS	100	7-9-8 (17)	ML		(ML) Silt w/occasional gravel - Pale yellowish brown (10YR 6/4), loose, slightly damp, gravel (<5%) to 0.5 inches, subangular to subrounded, no odor, no stain.	XRF = 244 XRF = 13
2.5	SS	100	4-7-5 (12)		3.0		XRF = 0 XRF = 42 XRF = 143
	SS	100	3-3-6 (9)	SM		(SM) Silty Sand w/occasional gravel - Medium yellowish brown (10YR 5/4), damp, fine sand, gravel (<5%) to 0.5 inches, subangular to subrounded, no odor, no stain.	XRF = 0 XRF = 45 XRF = 16
5.0	SS	100	4-3-3 (6)		6.0		XRF = 17 XRF = 36

Bottom of borehole at 6.0 feet.

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC3A-8

CLIENT Yuma County Department of Public Works
PROJECT NAME Adair Park Archery Range
PROJECT NUMBER 018-0069
PROJECT LOCATION Yuma, AZ
DATE STARTED 1/22/19 **COMPLETED** 1/22/19
GROUND ELEVATION **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Nicklaus Engineering
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY BC **CHECKED BY** MLD
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0						(ML) Silt - Pale yellowish brown (10YR 6/4), loose, slightly damp, no odor, no stain.	
	SS	100	3-7-7 (14)				XRF = 1141 XRF = 23
2.5	SS	100	3-5-4 (9)				XRF = 22 XRF = 434 XRF = 129
	SS	100	3-5-6 (11)	ML			XRF = 21 XRF = 213 XRF = 215
5.0	SS	100	3-5-5 (10)			6.0	XRF = 16 XRF = 159

Bottom of borehole at 6.0 feet.

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC3B-1

CLIENT Yuma County Department of Public Works
PROJECT NAME Adair Park Archery Range
PROJECT NUMBER 018-0069
PROJECT LOCATION Yuma, AZ
DATE STARTED 1/21/19 **COMPLETED** 1/21/19
GROUND ELEVATION
HOLE SIZE 8 inches
DRILLING CONTRACTOR Nicklaus Engineering
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY BC **CHECKED BY** MLD
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0		100	3-4-3 (7)	ML		(ML) Clayey Silt - Moderate yellowish brown (10YR 5/4), loose, soft clay, damp, low plasticity, no odor, no stain.	XRF = 217 XRF = 794
2.5		100	3-3-3 (6)				XRF = 26 XRF = 199 XRF = 37
		100	3-3-3 (6)				XRF = 24 XRF = 82 XRF = 0
5.0		100	2-2-3 (5)			6.0	XRF = 23 XRF = 53

Bottom of borehole at 6.0 feet.

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC3B-2

CLIENT	Yuma County Department of Public Works	**PROJECT NAME**	Adair Park Archery Range
PROJECT NUMBER	018-0069	**PROJECT LOCATION**	Yuma, AZ
DATE STARTED	1/21/19 **COMPLETED** 1/21/19	**GROUND ELEVATION**	**HOLE SIZE** 8 inches
DRILLING CONTRACTOR	Nicklaus Engineering	**GROUND WATER LEVELS:**	
DRILLING METHOD	Hollow Stem Auger	**AT TIME OF DRILLING**	---
LOGGED BY	BC **CHECKED BY** MLD	**AT END OF DRILLING**	---
NOTES		**AFTER DRILLING**	---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0	SS	100	4-5-5 (10)	SM	1.0	(SM) Silty Sand - Moderate yellowish brown (10YR 5/4), loose, slight damp, 90% fine sand, well sorted, no odor, no stain.	XRF = 1093 XRF = 812
2.5	SS	100	5-4-5 (9)	ML		(ML) Clayey Silt - Moderate yellowish brown (10YR 5/4), damp, soft, low plasticity, no odor, no stain.	XRF = 265 XRF = 205 XRF = 101
	SS	100	4-4-4 (8)				XRF = 35 XRF = 87 XRF = 0
5.0	SS	100	3-4-3 (7)		6.0		XRF = 16 XRF = 56

Bottom of borehole at 6.0 feet.

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC3B-3

CLIENT Yuma County Department of Public Works
PROJECT NAME Adair Park Archery Range
PROJECT NUMBER 018-0069
PROJECT LOCATION Yuma, AZ
DATE STARTED 1/21/19 **COMPLETED** 1/21/19
GROUND ELEVATION **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Nicklaus Engineering
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY BC **CHECKED BY** MLD
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0	SS	100	5-10-10 (20)	SM	1.0	(SM) Silty Sand - Moderate yellowish brown (10YR 5/4), loose, slightly damp, well sorted, fine sand, no odor, no stain.	XRF = 604
				ML	2.0	(ML) Silt - Moderate yellowish brown (10YR 5/4), loose to medium dense, damp, no odor, no stain.	XRF = 2034
	SS	100	4-3-3 (6)				XRF = 35
2.5				SM	4.5	(SM) Silt - Moderate yellowish brown (10YR 5/4), loose to medium dense, damp, no odor, no stain.	XRF = 196
							XRF = 34
	SS	100	4-3-2 (5)				XRF = 19
							XRF = 386
							XRF = 19
5.0	SS	100	3-4-4 (8)	ML	6.0	(ML) Clayey Silt - Moderate yellowish brown (10YR 5/4), soft, damp, low plasticity, no odor, no stain.	XRF = 14
							XRF = 212

Bottom of borehole at 6.0 feet.

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC3B-4

CLIENT Yuma County Department of Public Works
PROJECT NAME Adair Park Archery Range
PROJECT NUMBER 018-0069
PROJECT LOCATION Yuma, AZ
DATE STARTED 1/21/19 **COMPLETED** 1/21/19
GROUND ELEVATION **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Nicklaus Engineering
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY BC **CHECKED BY** MLD
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0	SS	100	4-6-7 (13)	SP	1.5	(SP) Sand - Moderate yellowish brown (10YR 5/4), loose, damp, fine sand, well sorted, no odor, no stain.	XRF = 593 XRF = 66
2.5	SS	100	6-5-6 (11)	ML	3.0	(ML) Sandy Silt - Moderate yellowish brown (10YR 5/4), loose, damp, 20% fine sand, no odor, no stain.	XRF = 59 XRF = 56 XRF = 30
	SS	100	3-3-4 (7)	CL-ML		(CL-ML) Silty Clay - Moderate yellowish brown (10YR 5/4), soft, damp, low plasticity, no odor, no stain.	XRF = 26 XRF = 125 XRF = 24
5.0	SS	100	3-3-3 (6)		6.0		XRF = 23 XRF = 56

Bottom of borehole at 6.0 feet.

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC3B-5

CLIENT Yuma County Department of Public Works
PROJECT NAME Adair Park Archery Range
PROJECT NUMBER 018-0069
PROJECT LOCATION Yuma, AZ
DATE STARTED 1/21/19 **COMPLETED** 1/21/19
GROUND ELEVATION **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Nicklaus Engineering
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY BC **CHECKED BY** MLD
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0	SS	100	5-4-6 (10)	SP		(SP) Sand - Moderate yellowish brown (10YR 5/4), loose, damp, fine grained, well sorted, no odor, no stain.	XRF = 572 XRF = 530
	SS	100	4-4-3 (7)		2.0		XRF = 293
2.5				ML		(ML) Clayey Sandy Silt - Moderate yellowish brown (10YR 5/4), loose sand, soft clay, damp, low plasticity, 20% fine sand, no odor, no stain.	XRF = 412 XRF = 33
	SS	100	3-3-4 (7)	CL-ML	3.0	(CL-ML) Silty Clay - Moderate yellowish brown (10YR 5/4), soft, damp, low plasticity, no odor, no stain.	XRF = 21 XRF = 298 XRF = 24
5.0	SS	100	3-3-4 (7)		6.0		XRF = 21 XRF = 92

Bottom of borehole at 6.0 feet.

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC3B-6

CLIENT Yuma County Department of Public Works
PROJECT NAME Adair Park Archery Range
PROJECT NUMBER 018-0069
PROJECT LOCATION Yuma, AZ
DATE STARTED 1/21/19 **COMPLETED** 1/21/19
GROUND ELEVATION **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Nicklaus Engineering
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY BC **CHECKED BY** MLD
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0	SS	100	4-5-8 (13)	SM	1.5	(SM) Silty Sand - Moderate yellowish brown (10YR 5/4), loose, damp, well sorted, fine sand,	XRF = 1031 XRF = 334
2.5	SS	100	4-5-5 (10)	ML	3.0	(ML) Clayey Silt - Moderate yellowish brown (10YR 5/4), soft, damp, low plasticity, no odor, no stain.	XRF = 305 XRF = 773 XRF = 530
	SS	100	4-3-3 (6)	SP	4.5	(SP) Sand - Pale yellowish brown (10YR 6/4), damp, loose, fine to very fine, no odor, no stain, well sorted.	XRF = 0 XRF = 206 XRF = 2048
5.0	SS	100	3-3-4 (7)	ML	6.0	(ML) Clayey Silt - Moderate yellowish brown (10YR 5/4), soft, damp, low plasticity, no odor, no stain.	XRF = 37 XRF = 349

Bottom of borehole at 6.0 feet.

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC3B-7

CLIENT Yuma County Department of Public Works
PROJECT NAME Adair Park Archery Range
PROJECT NUMBER 018-0069
PROJECT LOCATION Yuma, AZ
DATE STARTED 1/21/19 **COMPLETED** 1/21/19
GROUND ELEVATION **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Nicklaus Engineering
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY BC **CHECKED BY** MLD
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0	SS	100	3-8-10 (18)	SM		(SM) Silty Sand - Moderate yellowish brown (10YR 5/4), loose, slightly damp, fine sand, well sorted, no odor, no stain.	XRF = 189 XRF = 891
					1.5	(ML) Clayey Silt - Moderate yellowish brown (10YR 5/4), soft, low plasticity clay, no odor, no stain.	
2.5	SS	100	5-5-5 (10)	ML			XRF = 24 XRF = 268 XRF = 18
	SS	100	4-3-4 (7)				XRF = 16 XRF = 50 XRF = 19
5.0	SS	100	2-3-4 (7)				XRF = 21 XRF = 115
					6.0	Bottom of borehole at 6.0 feet.	

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC3B-8

CLIENT Yuma County Department of Public Works
PROJECT NAME Adair Park Archery Range
PROJECT NUMBER 018-0069
PROJECT LOCATION Yuma, AZ
DATE STARTED 1/21/19 COMPLETED 1/21/19
GROUND ELEVATION HOLE SIZE 8 inches
DRILLING CONTRACTOR Nicklaus Engineering
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY BC CHECKED BY MLD
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0	SS	100	8-15-14 (29)	ML		(ML) Silt - Moderate yellowish brown (10YR 5/4), loose to medium dense, slightly damp, no odor, no stain.	XRF = 398 XRF = 2081
2.5	SS	100	6-4-4 (8)				XRF = 88 XRF = 1110 XRF = 27
	SS	100	3-3-4 (7)		4.0		XRF = 17 XRF = 1073 XRF = 27
5.0	SS	100	3-2-4 (6)	SC	6.0	(SC) Clayey Sand - Moderate yellowish brown (10YR 5/4), loose, damp, low plasticity, 70% fine sand, well sorted, soft clay, no odor, no stain.	XRF = 54 XRF = 253

Bottom of borehole at 6.0 feet.

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC3C-1

CLIENT Yuma County Department of Public Works
PROJECT NAME Adair Park Archery Range
PROJECT NUMBER 018-0069
PROJECT LOCATION Yuma, AZ
DATE STARTED 1/23/19 **COMPLETED** 1/23/19
GROUND ELEVATION
HOLE SIZE 8 inches
DRILLING CONTRACTOR Nicklaus Engineering
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY BC **CHECKED BY** MLD
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0	SS	100	4-4-4 (8)	SM		(SM) Silty Sand - Moderate yellowish brown (10YR 5/4), loose, damp, fine sand, well sorted, no odor, no stain.	XRF = 48 XRF = 28
2.5	SS	100	3-4-5 (9)		3.0		XRF = 32 XRF = 338 XRF = 0
	SS	100	5-4-2 (6)	CL		(CL) Clay - Moderate yellowish brown (10YR 5/4), soft to medium stiff, damp, low plasticity, no odor, no stain.	XRF = 0 XRF = 430 XRF = 14
5.0	SS	100	6-5-4 (9)		6.0		XRF = 22 XRF = 351

Bottom of borehole at 6.0 feet.

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC3C-2

CLIENT	Yuma County Department of Public Works	**PROJECT NAME**	Adair Park Archery Range
PROJECT NUMBER	018-0069	**PROJECT LOCATION**	Yuma, AZ
DATE STARTED	1/23/19 **COMPLETED** 1/23/19	**GROUND ELEVATION**	**HOLE SIZE** 8 inches
DRILLING CONTRACTOR	Nicklaus Engineering	**GROUND WATER LEVELS:**	
DRILLING METHOD	Hollow Stem Auger	**AT TIME OF DRILLING**	---
LOGGED BY	BC **CHECKED BY** MLD	**AT END OF DRILLING**	---
NOTES		**AFTER DRILLING**	---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0	SS	100	2-4-3 (7)	ML		(ML) Sandy Silt - Moderate yellowish brown (10YR 5/4), loose, damp, fine sand, well sorted, no odor, no stain.	XRF = 93 XRF = 18
2.5	SS	100	2-4-4 (8)	ML	3.0		XRF = 19 XRF = 16 XRF = 21
	SS	100	2-3-3 (6)	CL-ML		(CL-ML) Clayey Silt/Silty Clay - Moderate yellowish brown (10YR 5/4), damp, soft, low plasticity, no odor, no stain.	XRF = 16 XRF = 29 XRF = 25
5.0	SS	100	2-3-4 (7)	CL-ML	6.0		XRF = 0 XRF = 25

Bottom of borehole at 6.0 feet.

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC3C-3

CLIENT Yuma County Department of Public Works
PROJECT NAME Adair Park Archery Range
PROJECT NUMBER 018-0069
PROJECT LOCATION Yuma, AZ
DATE STARTED 1/23/19 **COMPLETED** 1/23/19
GROUND ELEVATION **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Nicklaus Engineering
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY BC **CHECKED BY** MLD
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0	SS	100	4-4-5 (9)	SC		(SC) Clayey Sand - Moderate yellowish brown (10YR 5/4), damp, fine sand, clay 30%, soft, low plasticity.	XRF = 356 XRF = 22
2.5	SS	100	2-4-4 (8)	SC			XRF = 19 XRF = 84 XRF = 23
	SS	100	2-3-3 (6)	SC / CL	4.0	(CL) Clay - Moderate yellowish brown (10YR 5/4), soft, damp, low plasticity, no odor, no stain.	XRF = 0 XRF = 50 XRF = 26
5.0	SS	100	2-2-3 (5)	CL	6.0		XRF = 17 XRF = 33

Bottom of borehole at 6.0 feet.

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC3C-4

CLIENT Yuma County Department of Public Works
PROJECT NAME Adair Park Archery Range
PROJECT NUMBER 018-0069
PROJECT LOCATION Yuma, AZ
DATE STARTED 1/23/19 **COMPLETED** 1/23/19
GROUND ELEVATION **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Nicklaus Engineering
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY BC **CHECKED BY** MLD
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0	SS	100	3-3-4 (7)	CL-ML	1.5	(CL-ML) Clayey Silt/Silty Clay - Moderate yellowish brown (10YR 5/4), soft, damp, low plasticity, no odor, no stain.	XRF = 22 XRF = 27
2.5	SS	100	2-3-2 (5)	CH	3.0	(CH) Clay - Moderate yellowish brown (10YR 5/4), soft to medium stiff, medium plasticity, no odor, no stain.	XRF = 19 XRF = 22 XRF = 26
	SS	100	2-4-5 (9)	SP	3.5	(SP) Sand - Moderate yellowish brown (10YR 5/4), loose, damp, fine grained, well sorted, no odor, no stain.	XRF = 28
				CH	5.5	(CH) Clay - Moderate yellowish brown (10YR 5/4), soft to medium stiff, medium plasticity, no odor, no stain.	XRF = 35 XRF = 31
5.0	SS	100	2-4-4 (8)				XRF = 16 XRF = 16
				SP	6.0	(SP) grades to 6" sand lense at 5.5 ft, pale yellowish brown (10YR 6/4), loose, damp, fine grained, well sorted, no odor, no stain.	

Bottom of borehole at 6.0 feet.

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC3C-5

CLIENT Yuma County Department of Public Works
PROJECT NAME Adair Park Archery Range
PROJECT NUMBER 018-0069
PROJECT LOCATION Yuma, AZ
DATE STARTED 1/23/19 **COMPLETED** 1/23/19
GROUND ELEVATION **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Nicklaus Engineering
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY BC **CHECKED BY** MLD
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0	SS	100	4-6-7 (13)	ML		(ML) Clayey Silt - Moderate yellowish brown (10YR 5/4), damp, soft clay, low plasticity, no odor, no stain.	XRF = 147 XRF = 129
2.5	SS	100	3-2-4 (6)		3.0		XRF = 24 XRF = 28 XRF = 17
	SS	100	2-4-4 (8)	CH		(CH) Clay - Moderate yellowish brown (10YR 5/4), high plasticity, soft to medium stiff, no odor, no stain.	XRF = 0 XRF = 29 XRF = 19
5.0	SS	100	4-5-5 (10)		5.0		XRF = 16
				SP	6.0	(SP) Sand - Moderate yellowish brown (10YR 5/4), damp, loose, fine grained, well sorted, no odor, no stain.	XRF = 18

Bottom of borehole at 6.0 feet.

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC3C-6

CLIENT Yuma County Department of Public Works
PROJECT NAME Adair Park Archery Range
PROJECT NUMBER 018-0069
PROJECT LOCATION Yuma, AZ
DATE STARTED 1/23/19 **COMPLETED** 1/23/19
GROUND ELEVATION **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Nicklaus Engineering
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY BC **CHECKED BY** MLD
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0	SS	100	4-6-7 (13)	SC	1.0	(SC) Clayey Sand - Moderate yellowish brown (10YR 5/4), loose, damp, fine sand, well sorted, clay 30%, soft, low plasticity, no odor, no stain.	XRF = 1560
				SM	2.0	(SM) Silt - Pale yellowish brown (10YR 6/4), loose, slightly damp, no odor, no stain.	XRF = 722 XRF = 571
2.5	SS	100	5-5-5 (10)	SP	3.0	(SP) Sand - Pale yellowish brown (10YR 6/4), loose, slightly damp, very fine to fine sand, well sorted, no odor, no stain.	XRF = 616 XRF = 423
	SS	100	2-3-4 (7)	CL		(CL) Silty Clay - Moderate yellowish brown (10YR 5/4), soft to medium stiff, damp, low plasticity, no odor, no stain.	XRF = 431 XRF = 433 XRF = 28
5.0	SS	100	3-3-4 (7)		6.0		XRF = 32 XRF = 163

Bottom of borehole at 6.0 feet.

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC3C-7

CLIENT Yuma County Department of Public Works
PROJECT NAME Adair Park Archery Range
PROJECT NUMBER 018-0069
PROJECT LOCATION Yuma, AZ
DATE STARTED 1/22/19 **COMPLETED** 1/23/19
GROUND ELEVATION **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Nicklaus Engineering
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY BC **CHECKED BY** MLD
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0	SS	100	5-6-9 (15)	ML		(ML) Silt - Moderate yellowish brown (10YR 5/4), loose to medium dense, damp, no odor, no stain.	XRF = 276 XRF = 234
2.5	SS	100	4-4-6 (10)		3.0		XRF = 0 XRF = 231 XRF = 27
	SS	100	3-3-5 (8)	ML	4.0	(ML) Sandy Silt - Moderate yellowish brown (10YR 5/4), loose, damp, fine sand, moderately sorted, no odor, no stain.	XRF = 30 XRF = 105
				ML	4.5	(ML) Clayey Silt - Moderate yellowish brown (10YR 5/4), soft, damp, low plasticity, no odor, no stain.	XRF = 14
5.0	SS	100	3-4-5 (9)	CL	5.5	(CL) Silty Clay - Moderate yellowish brown (10YR 5/4), soft, damp, low plasticity, no odor, no stain.	XRF = 16 XRF = 30
				SP	6.0	(SP) Sand - Moderate yellowish brown (10YR 5/4), damp, loose, fine, well sorted, no odor, no stain.	

Bottom of borehole at 6.0 feet.

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER AOC3C-8

CLIENT Yuma County Department of Public Works
PROJECT NAME Adair Park Archery Range
PROJECT NUMBER 018-0069
PROJECT LOCATION Yuma, AZ
DATE STARTED 1/22/19 **COMPLETED** 1/22/19
GROUND ELEVATION **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Nicklaus Engineering
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING ---
LOGGED BY BC **CHECKED BY** MLD
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	ENVIRONMENTAL DATA
0.0	SS	100	3-7-8 (15)	ML		(ML) Silty - Moderate yellowish brown (10YR 5/4), loose, damp, no odor, no stain.	XRF = 127 XRF = 45
	SS	100	4-3-3 (6)		2.0		XRF = 20
2.5				SP	2.5	(SP) Sand - Pale yellowish brown (10YR 6/4), loose, slight damp, fine grained, well sorted, no odor, no stain.	XRF = 36 XRF = 15
	SS	100	3-2-3 (5)	ML		(ML) Clayey Silt - Moderate yellowish brown (10YR 5/4), loose, damp, soft clay, low plasticity, no odor, no stain.	XRF = 17 XRF = 17 XRF = 59
5.0	SS	100	3-4-4 (8)		6.0		XRF = 24 XRF = 29

Bottom of borehole at 6.0 feet.

GENERAL BH / TP / WELL - GINT STD US LAB.GDT - 3/14/19 13:41 - N:\2018\018-0069 YUMA COUNTY ADAIR PARK ARCHERY RANGE\TECHNICAL\BORING LOGS\ADAIR PARK ARCHERY RANGE.GPJ

Nicklaus Engineering
1851 W. 24th Street
Yuma, AZ 85364
Telephone: (928)344-8374
Fax: (928)726-6994

BORING NUMBER DeepBH-2

CLIENT Yuma County Department of Public Works
PROJECT NAME Adair Park Archery Range
PROJECT NUMBER 018-0069
PROJECT LOCATION Yuma, AZ
DATE STARTED 3/6/19 **COMPLETED** 3/6/19
GROUND ELEVATION **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Nicklaus Engineering
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
∇ **AT TIME OF DRILLING** 14.70 ft
LOGGED BY MLD **CHECKED BY** MLD
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0						Cover Soil
5	SS	40	2-2-2 (4)	CL-ML	5.0	(CL-ML) Silty Clay - Dark reddish brown 10YR 3/4, damp, soft, <5% fine sand, slightly micaceous, no odor, no stain.
10	SS	100	2-2-3 (5)	CL-ML		(CL-ML) Silty Clay - Dark reddish brown 10YR 3/4, damp, soft, <5% fine sand, slightly micaceous, no odor, no stain, groundwater 14.7ft.
15	SS	100	3-6-6 (12)	SP-SM	15.0 ∇	(SP-SM) Sand With Silt - Dark reddish brown 10YR 3/4, loose, saturated, fine to occasional medium grained, moderately sorted, no odor, no stain, flowing sands heaved in auger, unable to get sample.
20					20.0	Bottom of borehole at 20.0 feet.

APPENDIX B
Risk Assessment and Lead GPL Calculation

The Fehling Group, LLC

December 16, 2019

Scott Green
Manager, Voluntary Remediation Program Unit
Arizona Department of Environmental Quality
Remedial Projects Section, Voluntary Remediation Program
1110 West Washington Street, 6th Floor
Phoenix, AZ 85007

RE: Summary of Findings at Adair Park Archery Range, Yuma, Arizona, Site Code 505354-00

Dear Mr. Green:

At your request, the Fehling Group, LLC (TFG) reviewed the "Summary of Findings at Adair Park Archery Range, Yuma AZ" (hereafter referred to as the "Report of Findings") submitted by Nicklaus Engineering Inc. (NEI) June 2019. NEI prepared the report on behalf of the Yuma County Department of Public Works to present the results of the investigations and voluntary remediation activities that have been conducted at the Adair Memorial Park Archery Range. This investigation was conducted to address the Arizona Department of Environmental Quality's (ADEQ) concerns to the No Further Action (NFA) request. The purpose of our analysis provided herein, is to document our assessment of potential human health risks associated with residual levels of inorganics, specifically arsenic and lead in the top 6 to 12 inches of soil at the site. It should be noted that these two chemicals are the only chemicals of potential concern (COPCs) addressed herein as they were detected in site soils at concentrations greater than the Arizona Non-Residential Soil Remediation Levels (SRLs) and/or site background (Table 1).

Summary of Site Background and Soil Investigation Data

As summarized in the Report, the Adair Memorial Park Archery Range is 24 acres dedicated to Yuma County by the United States Bureau of Reclamation (USBR) in 1967 for the expressed use as a rifle, pistol and archery range, thus only non-residential exposures would occur on site. The site is located at 4760 South US Highway 95 and is about 12 miles north of Yuma, Arizona (Figure 1).

The archery range is located in a dry ephemeral wash built on top of tailings surrounded by the Gila River to the south, desert hills to the north and west and a shooting range to the east (Figure 2). The site currently consists of an archery range, several buildings, a shade structure, elevated shooting structures, archery targets and materials and maintenance equipment.

The site was formerly used as a silver ore mill during the late 1800s and early 1900s. The tailings from the silver ore processing were placed in a tailings pond and the silver ore processing and associated tailings resulted in lead contaminated soil via stormwater runoff and wind-borne transportation.

As shown in Figure 2, the site was divided into three areas of concern (AOCs) for the purpose of the environmental investigation: AOC 1 (area to the north) received impacted soil from AOCs 2 and 3 and was capped; AOC 2, and AOC 3, which was further broken into AOC 3a (archery haybales), 3b (archery parking), and 3c (drainage from AOC 1). Investigation sampling locations are provided in Figures 3 and 4. Soil analyses for metals by USEPA Method 6010C was used for this investigation. It should be noted that XRF samples collected for the purpose of approximately identifying areas of elevated metals concentrations were not included in this analysis because USEPA Method 6010C provides a higher degree of accuracy for soil concentrations.

Soil Investigations

Eight background soil samples were collected outside the AOCs (Figure 3). Background lead concentrations detected ranged from 16 to 620 mg/kg, and arsenic concentrations detected ranged from 10 to 15 mg/kg. A statistical analysis of site background by Neptune and Company, Inc. compared site background concentrations of metals to site metals data in AOCs 2 and 3. This analysis indicated that site metals concentrations were above background for only arsenic and lead (analysis not shown) indicating that further evaluation of AOC arsenic and lead concentrations was warranted.

AOC 2

In AOC 2, 10 soil samples were collected between 6 and 12 inches below ground surface (bgs) (Figures 2 and 4). Arsenic was detected ranging from 13 to 20 mg/kg, with a 95% upper confidence limit (UCL)[1] of 17 mg/kg. All of the arsenic soil concentrations are above the ADEQ non-residential SRL of 10 mg/kg. Lead was detected at concentrations ranging from 38 to 460, with a 95% UCL of 242 mg/kg, and all are below the ADEQ non-residential SRL of 800 mg/kg.

AOC 3a

In AOC3a, seven soil samples were collected from 6 and 12 inches bgs. Arsenic concentrations ranged from 3 to 23 mg/kg, while lead was detected at concentrations ranging from 47 to 1800 mg/kg. Both arsenic and lead are present in this AOC at concentrations in excess of their respective ADEQ non-residential SRLs.

AOC 3b

In AOC3b, 11 soil samples were collected from 6 and 12 inches bgs. Arsenic was detected at concentrations ranging from 11 to 19 mg/kg, with a 95% UCL of 16 mg/kg. All of the arsenic detected concentrations are greater than the ADEQ non-residential SRL of 10 mg/kg. Lead was detected ranging from 61 to 820 mg/kg, with a 95%UCL of 639 mg/kg. Although the maximum lead result of 820 mg/kg is detected above the ADEQ non-residential SRL of 800 mg/kg, the 95%UCL is below that SRL.

[1] All UCLs in this analysis were calculated using ProUCL version 5.1.1; USEPA, 2015.

AOC 3c

In AOC3c, 10 soil samples were collected from 6 and 12 inches bgs.[2] Arsenic was detected at soil concentrations ranging from 12 to 20 mg/kg, with a 95% UCL of 18 mg/kg. All of the arsenic detected concentrations are above the ADEQ non-residential SRL of 10 mg/kg. Lead was detected at soil concentrations ranging from 26 to 1000 mg/kg, with a 95%UCL of 505 mg/kg. Although the maximum value is above the ADEQ non-residential SRL of 800 mg/kg, the 95%UCL is below that SRL.

The ProUCL output files for each AOC is provided as Appendix A.

Exposure Assessment

Because arsenic and lead have been detected in one or more AOCs at concentrations above ADEQ non-residential SRLs, this technical memorandum further evaluates the potential health effects related to adolescent and adult exposures to arsenic and lead in surface soils at AOCs 2 and 3a, 3b, and 3c.

Exposure Assumptions

The ADEQ non-residential SRLs, and the USEPA regional screening levels (RSLs), are two sets of published soil risk-based soil screening criteria that may be used to assess potential health risks from exposures to soils that contain elevated levels of hazardous chemicals. Both SRLs and RSLs assume a non-residential (that is, commercial or industrial land use) exposure frequency of 225 to 250 days per year. However, a reduced exposure frequency of 45 days per year (approximately one visit per week) for an adolescent/adult was selected as a more appropriate value for the Adair Memorial Park Archery Range. This value presumes that park visitors do not go to the park more than once per week, averaged over many years of park visits. The Archery Range does not routinely have any park employees in the AOC areas, so the typical commercial/industrial exposure frequency (225 to 250 days per year) is not applicable to park employees. In addition, it was assumed that an adolescent/adult visitor is not exposed to ore tailings in AOC 1 (which is capped) or to the tailings pile located on a hillside above AOC 3c, as this area is above grade to all park use areas and is cordoned off to prevent exposure in this area.

The primary route of exposure for chemicals like arsenic and lead in soil is through incidental soil ingestions. The USEPA Adult Lead Model uses a default outdoor soil and indoor dust ingestion rate is 50 mg/day (USEPA, 2003). However given that the site is used for archery, it is likely that park users would be picking up arrows, targets, and other items off the ground and, as such, it is entirely likely that the soil contact rate and subsequent outdoor soil ingestion rate, may be higher (with no "indoor dust" ingested). Thus, twice the "normal" ingestion rate of 100 mg/day was used as a conservative, health protective, measures and that it was derived from on-site soil. This rate is consistent with that used by USEPA in the industrial/commercial Regional Screening Level

[2] It was noted in the laboratory report that USEPA Method 6010C required confirmation because the initial analysis produced a significant negative result for [*one or more metals*] (absolute value exceeded the reporting limit; Test America Job ID 550-116886-1, Revision 1; 3/18/19). In addition, the original preparation batch was reviewed, and it was noted that there was a data entry error in the weight of one of the soil samples. The weight was mistakenly listed as 1/10th of the actual weight. In the initial analysis, the arsenic detection was 150 mg/kg; however, the re-analyses indicated an arsenic concentration of 14 mg/kg and the duplicate analysis confirmed the 14 mg/kg. Therefore, this analysis used the data from the re-analysis reported in March 2019.

(RSL) for arsenic (although it is recognized this latter value is once again inclusive of indoor dust and outdoor soil).

Arsenic RSL Adjustment

The USEPA risk-based, industrial/commercial (RSL) of 3 mg/kg (USEPA, 2019) was adjusted to account for the differences to the exposure frequency as noted above using a simple ratio approach (45 days/year versus 250 days/year). With this exposure parameter adjustment, the commercial/industrial RSL would increase to 17 mg/kg at a risk level of $1x10^{-6}$.

Adult Lead Model

The USEPA adult lead model (USEPA, 2019) was used to calculate a soil RSL for the site. This model focuses on estimating fetal blood lead concentrations in pregnant women exposed to lead-impacted media and uses a fetal target lead blood level of 5 µg/dL as the threshold at which adverse health effects might be observed. It is noted that the ADEQ still relies upon the previous blood lead target of 10 µg/dL; however, the more protective newer level currently recommended by USEPA was used here. The adult lead model was set to calculate a target soil lead level such that there is a 95% probability that the fetal blood lead level will not exceed the 5 µg/dL threshold.

As noted above, the exposure frequency and soil ingestion rate parameters were modified from the adult lead model defaults of 250 days/year and 50 mg/day to 45 days/year and 100 mg/day; respectively. The resultant RSL from the USEPA Adult Lead Model is 2,556 mg/kg as shown in Table 2. This value is compared to the 95%UCL of soil lead concentrations in each AOC.

Risk Characterization Summary

Arsenic

AOC	95% UCL (mg/kg)	Site-Specific RSL (mg/kg)	UCL Exceeds Site-Specific RSL?
AOC 3a	17	17	No
AOC 3b	16	17	No
AOC 3c	18	17	Yes

In all but AOC3c, the 95% UCLs for arsenic are at or below the site-specific RSL of 17 mg/kg. For AOC3c, the 95% UCL of 18 represents a risk of 1.06×10^{-6}; essentially 1×10^{-6} as well such that this slight exceedance of the site-specific RSL may be considered equivalent to said RSL.

Lead

AOC	95% UCL (mg/kg)	Site-Specific RSL (mg/kg)	UCL Exceeds Site-Specific RSL?
AOC 3a	242	2,556	No
AOC 3b	820	2,556	No
AOC 3c	1,000	2,556	No

None of the lead 95% UCLS for AOCs 2, 3a, 3b, and 3c exceed the site-specific lead soil screening level of 2,556 mg/kg. It is worth noting that none of the detected concentrations individually exceed this RSL either.

Closing

This analysis assessed residual arsenic and lead levels in the top 6 and 12 inches of soil in which adolescents/adults may come into contact at the Adair Memorial Archery Range site. Several conservative (e.g., health protective) assumptions were relied upon as part of this analysis most notably, an outdoor soil ingestion rate that is at least twice that of the standard, default assumption. Based on this analysis, it does not appear that there would be significant exposure to lead and arsenic in soil above site-specific, health-based levels. It should be noted that the UCL for arsenic in AOC 3c is 18 mg/kg as compared to the site-specific RSL of 17 mg/kg. It is likely that this exceedance will not appreciably increase risk above the *de minimis* level of 10^{-6} but, ultimately, that is a decision for the site risk managers and regulators. It is recommended that the ore tailings locations in AOC 1 and the tailings pile located on the hillside above AOC 3c be posted with "No Trespassing" signs if they are not already.

We appreciate the opportunity to provide a review of the subject document. If you have any questions, please contact Kurt Fehling at (707) 478-3484.

Sincerely,

Kurt A. Fehling
Principal Health Scientist

Joanne M. Otani
Senior Health Scientist

References

Nicklaus Engineering, Inc. (2019). Summary of Findings at Adair Park Archery Range, Yuma AZ. VRP Site Code 505354-00. Arizona Department of Environmental Quality, Voluntary Remediation Program. Prepared for Yuma County, Department of Public Works, June.

United States Environmental Protection Agency (USEPA) (2003). Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil. https://www.epa.gov/superfund/lead-superfund-sites-software-and-users-manuals

USEPA. (2015). ProUCL Version 5.1 User Guide. EPA/600/R-07/041. October. https://www.epa.gov/sites/production/files/2016-05/documents/proucl_5.1_user-guide.pdf

USEPA. (2019). Risk-Based Screening Levels. November. https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables

TABLES

Table 1: Summary of Total Metals in Soil - Adair Memorial Park

Sample Name	Date	Unit	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
AOC2-1-0.5	1/24/2019	mg/kg	**14**	76	<0.5	16	100	<0.091	<5	<2.5
AOC2-1-0.5	1/23/2019	mg/kg	**15**	120	<0.49	21	150	<0.095	<4.9	<2.4
AOC2-1-1	1/24/2019	mg/kg	**15**	140	1	17	460	0.11	<4.9	<2.5
AOC2-2-0.5	1/24/2019	mg/kg	**15**	140	0.67	21	370	<0.097	<4.9	<2.5
AOC2-2-3.5	1/24/2019	mg/kg	**13**	120	<0.5	26	73	<0.095	<5	<2.5
AOC2-3-0.5	1/23/2019	mg/kg	**20**	83	<0.49	19	58	<0.1	<4.9	<2.4
AOC2-3-3.5	1/23/2019	mg/kg	**14**	130	<0.5	25	43	<0.094	<5	<2.5
AOC2-4-0.5	1/23/2019	mg/kg	**13**	86	<0.5	15	34	<0.097	<5	<2.5
AOC2-4-3.0	1/23/2019	mg/kg	**22**	85	<0.49	57	330	<0.095	<4.9	<2.4
AOC2-5-0.5	1/23/2019	mg/kg	**17**	59	<0.5	15	68	<0.089	<5	<2.5
AOC2-5-4.5	1/23/2019	mg/kg	**15**	130	<0.5	24	31	<0.087	<5	<2.5
AOC2-6-0.5	1/23/2019	mg/kg	**17**	120	0.77	21	150	<0.094	<4.9	<2.5
AOC2-6-3.5	1/23/2019	mg/kg	**16**	120	<0.49	22	94	<0.095	<4.9	<2.4
AOC2-6-4.0	1/23/2019	mg/kg	**19**	180	3.4	25	**1600**	<0.09	<4.9	<2.5
AOC2-7-0.5	1/24/2019	mg/kg	**14**	110	<0.49	19	150	<0.099	<4.9	<2.5
AOC2-7-2	1/24/2019	mg/kg	9.1	62	<0.49	14	46	<0.095	<4.9	<2.4
AOC2-8-0.5	1/23/2019	mg/kg	**16**	62	<0.49	9.1	38	<0.099	<4.9	<2.5
AOC2-8-3.5	1/23/2019	mg/kg	**13**	120	<0.49	20	14	<0.095	<4.9	<2.5
AOC3A-2-0.5	1/22/2019	mg/kg	**13**	110	<0.49	19	70	<0.088	<4.9	<2.4
AOC3A-3-0.5	1/22/2019	mg/kg	**17**	120	<0.49	16	130	<0.086	<4.9	<2.5
AOC3A-4-1	1/22/2019	mg/kg	**23**	310	3	29	**1800**	0.26	<4.9	<2.4
AOC3A-4-4	1/22/2019	mg/kg	**16**	170	1.2	25	370	<0.098	<4.9	<2.4
AOC3A-5-0.5	1/22/2019	mg/kg	**18**	200	1.4	25	680	0.22	<4.9	<2.5
AOC3A-5-2	1/22/2019	mg/kg	**19**	220	1.7	26	**930**	0.15	<4.9	<2.5
AOC3A-6-0.5	1/22/2019	mg/kg	**15**	140	<0.49	21	47	<0.092	<4.9	<2.5
AOC3A-7-0.5	1/22/2019	mg/kg	**14**	160	0.66	24	280	<0.089	<5	<2.5
AOC3A-8-0.5	1/22/2019	mg/kg	**17**	190	1.5	26	540	0.18	<5	<2.5
AOC3B-1-0.5	1/21/2019	mg/Kg	**14**	130	<0.49	21	61	<0.088	<4.9	<2.5
AOC3B-2-0.5	1/21/2019	mg/Kg	**14**	180	1.3	18	640	0.18	<4.9	<2.5
AOC3B-2-1	1/21/2019	mg/kg	**19**	230	1.6	24	**820**	0.12	<4.9	<2.4
Non Residential SRL			10	170,000	510	65	800	310	5,100	5,100

Table 1: Summary of Total Metals in Soil - Adair Memorial Park

Sample Name	Date	Unit	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
AOC3B-3-0.5	1/21/2019	mg/Kg	**16**	190	1.8	23	570	<0.087	<5	<2.5
AOC3B-3-1	1/21/2019	mg/Kg	**15**	150	0.54	24	770	<0.095	<4.9	<2.5
AOC3B-4-0.5	1/21/2019	mg/Kg	**15**	120	<0.49	20	200	<0.096	<4.9	<2.5
AOC3B-5-0.5	1/21/2019	mg/Kg	**11**	110	0.52	13	230	<0.092	<4.9	<2.5
AOC3B-6-0.5	1/21/2019	mg/Kg	**13**	120	1.1	18	750	<0.092	<4.9	<2.4
AOC3B-6-4	1/21/2019	mg/Kg	8	120	<0.49	18	17	<0.091	<4.9	<2.5
AOC3B-7-0.5	1/21/2019	mg/Kg	**12**	130	<0.49	21	120	<0.1	<4.9	<2.4
AOC3B-7-1	1/21/2019	mg/kg	**18**	150	<0.5	26	200	<0.091	<5	<2.5
AOC3B-8-0.5	1/21/2019	mg/Kg	**19**	210	1.1	25	**820**	0.097	<4.9	<2.5
AOC3B-8-2	1/21/2019	mg/kg	8.5	120	<0.49	23	15	<0.098	<4.9	<2.4
AOC3C-1-.5	1/23/2019	mg/kg	**18**	160	1.3	24	660	<0.094	<4.9	<2.5
AOC3C-1-3.5	1/23/2019	mg/kg	**18**	190	1.3	24	470	<0.09	<4.9	<2.4
AOC3C-2-0.5	1/23/2019	mg/kg	**150**	1700	<4.9	240	580	<0.098	<49	<24
AOC3C-2-0.5	3/8/2019	mg/Kg	**14**	140	<0.49	20	56		<4.9	<2.5
AOC3C-2-0.5-D	3/8/2019	mg/Kg	**14**	140	<0.49	20	56		<4.9	<2.5
AOC3C-3-0.5	1/23/2019	mg/kg	**18**	140	0.78	24	230	<0.1	<4.9	<2.5
AOC3C-4-0.5	1/23/2019	mg/kg	**19**	150	<0.5	24	29	<0.096	<5	<2.5
AOC3C-5-0.5	1/23/2019	mg/kg	**17**	140	<0.49	26	120	<0.098	<4.9	<2.5
AOC3C-6-0.5	1/23/2019	mg/kg	**20**	180	2.1	25	**1000**	<0.093	<5	<2.5
AOC3C-6-1.0	1/23/2019	mg/kg	**12**	140	<0.49	26	450	<0.095	<4.9	<2.4
AOC3C-7-0.5	1/22/2019	mg/kg	**15**	110	<0.49	20	26	<0.087	<4.9	<2.4
AOC3C-8-0.5	1/22/2019	mg/kg	**13**	130	1.8	22	140		<4.9	<2.5
Non Residential SRL			10	170,000	510	65	800	310	5,100	5,100

Note: mg/kg - milligram per kilogram

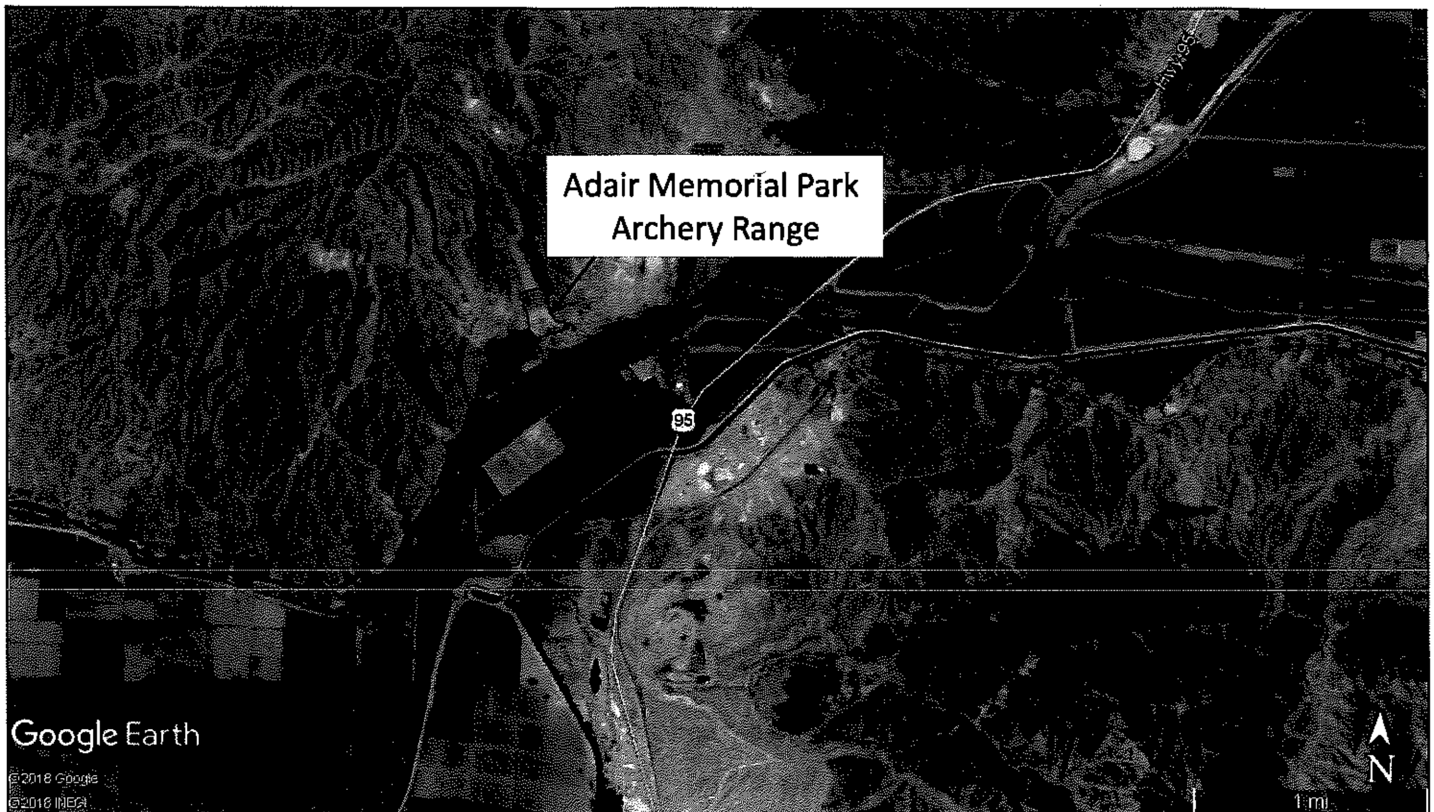
Table 2: 'Calculations of Preliminary Remediation Goals (PRGs) for Soil in Nonresidential Areas
U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee
Adair Memorial Archery Park

EDIT RED CELLS

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 2009-2014
$PbB_{fetal, 0.95}$	Target PbB in fetus (e.g., 2-8 µg/dL)	µg/dL	5
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4
GSD_i	Geometric standard deviation PbB	--	1.8
PbB_0	Baseline PbB	µg/dL	0.6
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.100
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	45
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365
PRG in Soil for no more than 5% probability that fetal PbB exceeds target PbB		**ppm (mg/kg)**	**2,556**

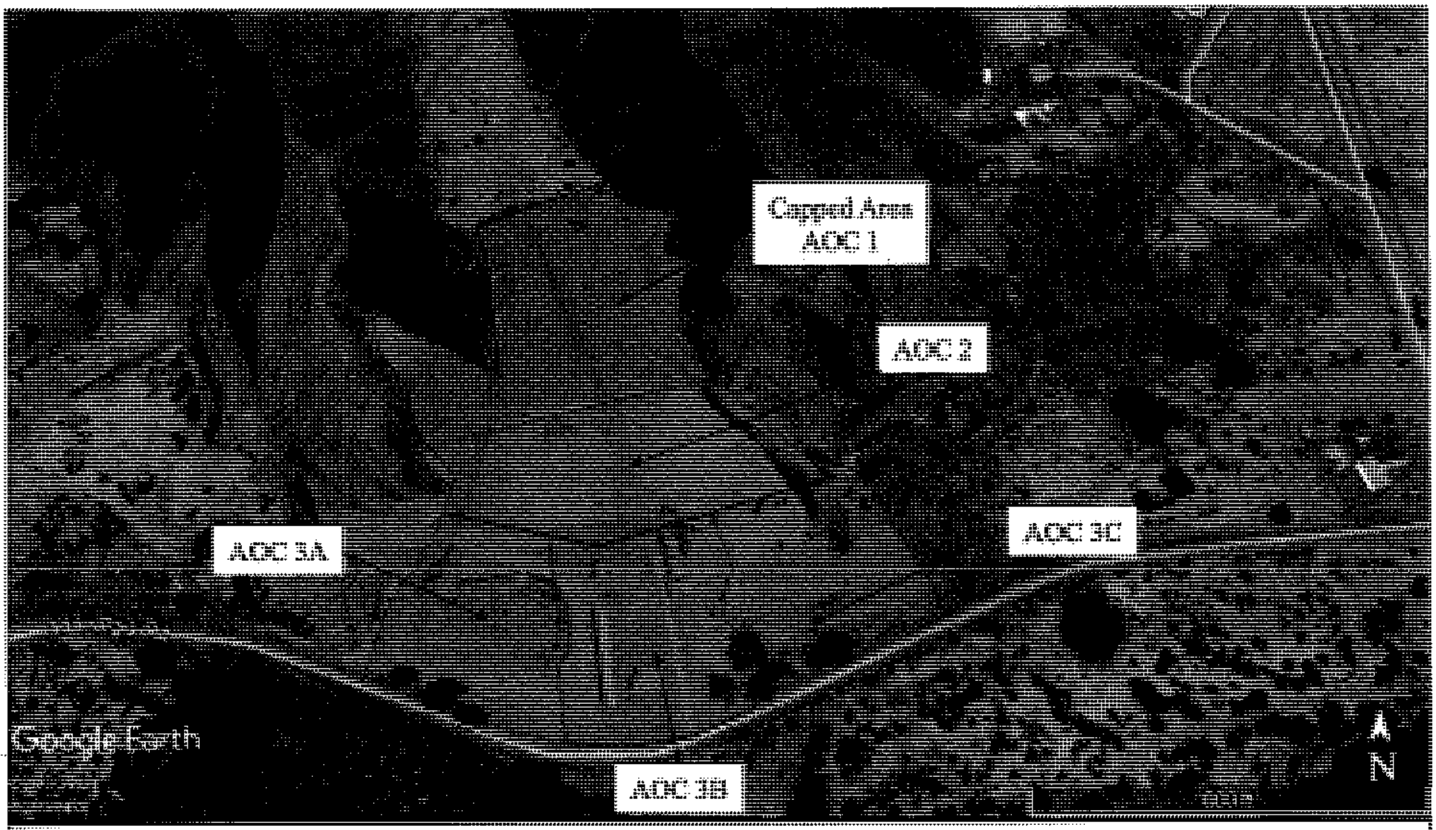
Note: all input parameters are Model defaults with the exception of the Exposure frequency and Soil ingestion rate; see text for discussion.

FIGURES



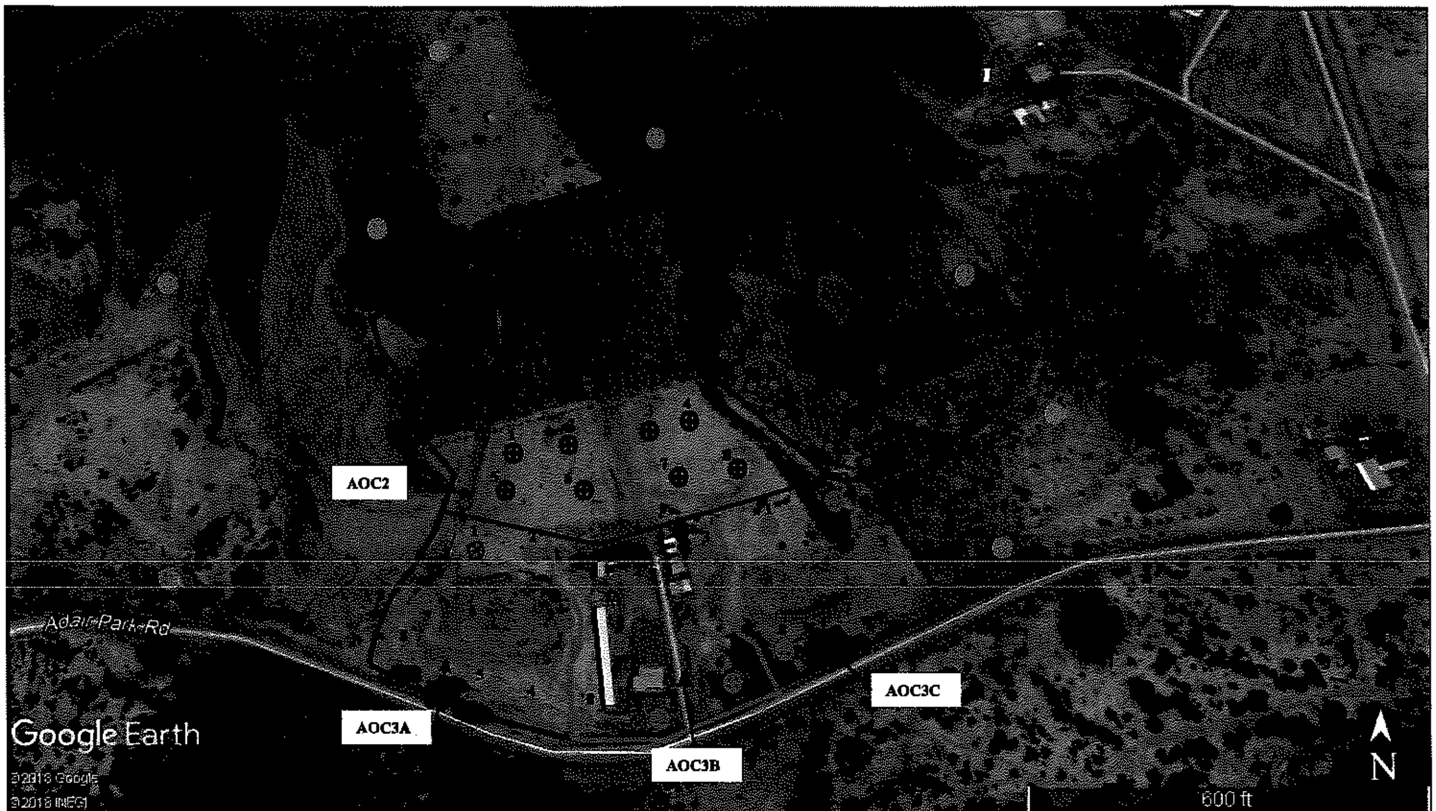
Adair Memorial Park Archery Range
4760 S. Highway 95
Yuma, Arizona

Figure 1
Site Location Map



Adair Memorial Park Archery Range
4760 S. Highway 95
Yuma, Arizona

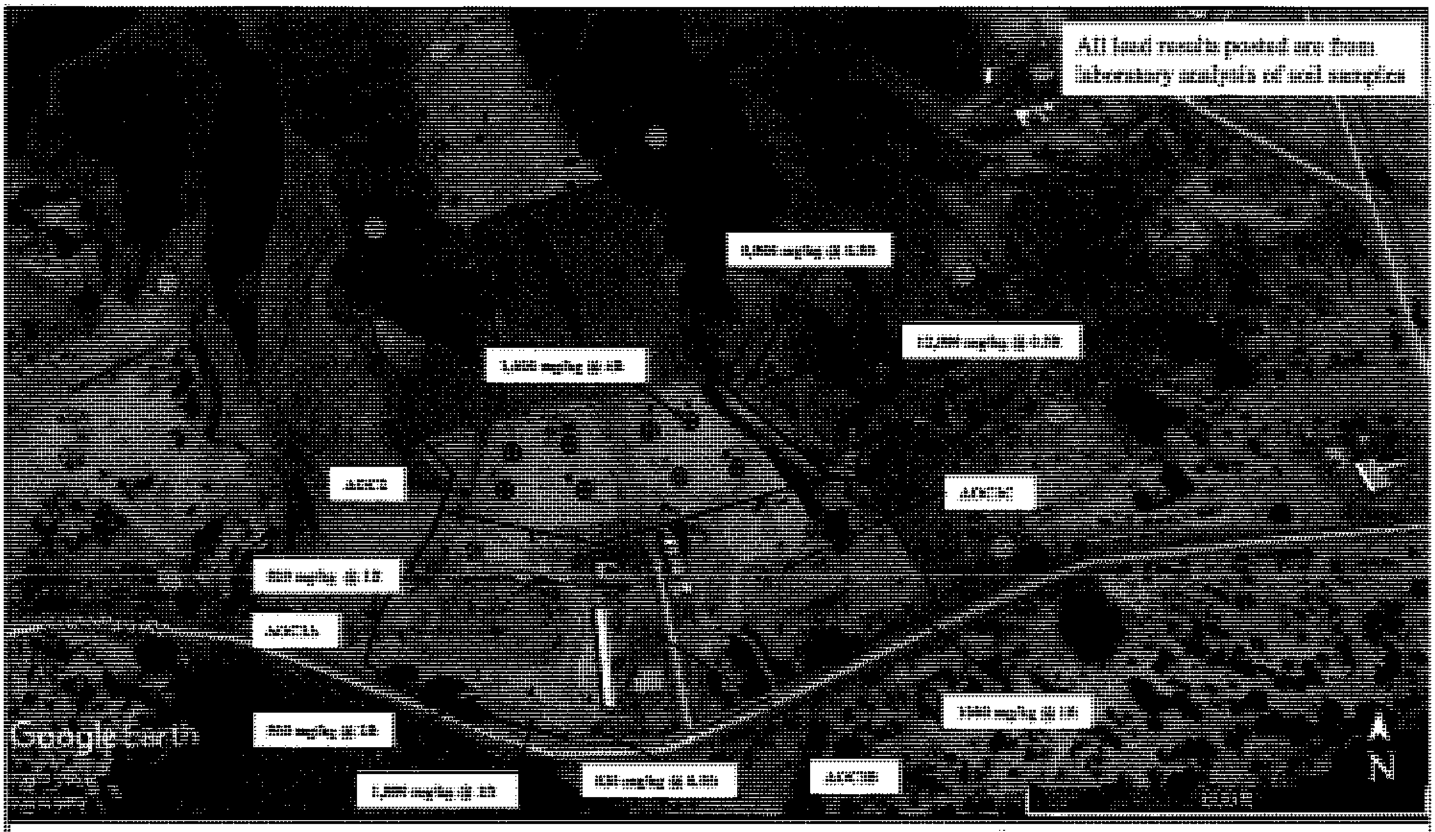
Figure 2
Site Map



- AOC 2 Sample Location
- AOC 3 Sample Location
- Temporary Well and Soil Sample Location
- Background Sample Location
- XRF Reading From Tailings Pile

Adair Memorial Park Archery Range
4760 S. Highway 95
Yuma, Arizona

Figure 3 Sample Location Map



- AOC 2 Sample Location
- AOC 1 Sample Location
- Temporary Well and Soil Sample Location
- Background Sample Location
- XRF Reading From Tailings Pile

Adair Memorial Park Archery Range
4760 S. Highway 95
Yuma, Arizona

Figure 4
Lead Distribution Map

APPENDIX A

	A	B	C	D	E	F	G	H	I	J	K	L
1	UCL Statistics for Uncensored Full Data Sets											
2												
3	User Selected Options											
4	Date/Time of Computation			ProUCL 5.112/8/2019 2:04:50 PM								
5	From File			WorkSheet.xls								
6	Full Precision			OFF								
7	Confidence Coefficient			95%								
8	Number of Bootstrap Operations			2000								

AOC2 0.5 ft bgs Pb

General Statistics

Total Number of Observations	9	Number of Distinct Observations	7
		Number of Missing Observations	2
Minimum	34	Mean	124.2
Maximum	370	Median	100
SD	103.7	Std. Error of Mean	34.58
Coefficient of Variation	0.835	Skewness	1.877

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1

Normal GOF Test

Shapiro Wilk Test Statistic	0.786	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.829	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.291	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.274	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	188.5	95% Adjusted-CLT UCL (Chen-1995)	204.2
		95% Modified-t UCL (Johnson-1978)	192.1

Gamma GOF Test

A-D Test Statistic	0.366	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.73	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.194	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.282	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	2.023	k star (bias corrected MLE)	1.422
Theta hat (MLE)	61.42	Theta star (bias corrected MLE)	87.33
nu hat (MLE)	36.41	nu star (bias corrected)	25.6
MLE Mean (bias corrected)	124.2	MLE Sd (bias corrected)	104.2
		Approximate Chi Square Value (0.05)	15.07
Adjusted Level of Significance	0.0231	Adjusted Chi Square Value	13.4

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	211	95% Adjusted Gamma UCL (use when n<50)	237.4

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.945	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.829	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.168	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.274	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.526	Mean of logged Data	4.555
Maximum of Logged Data	5.914	SD of logged Data	0.769

Assuming Lognormal Distribution

95% H-UCL	269.9	90% Chebyshev (MVUE) UCL	219.9
95% Chebyshev (MVUE) UCL	263.9	97.5% Chebyshev (MVUE) UCL	324.9
99% Chebyshev (MVUE) UCL	444.7		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	181.1	95% Jackknife UCL	188.5
95% Standard Bootstrap UCL	177.4	95% Bootstrap-t UCL	232.2
95% Hall's Bootstrap UCL	413.8	95% Percentile Bootstrap UCL	180.7
95% BCA Bootstrap UCL	210.4		
90% Chebyshev(Mean, Sd) UCL	228	95% Chebyshev(Mean, Sd) UCL	275
97.5% Chebyshev(Mean, Sd) UCL	340.2	99% Chebyshev(Mean, Sd) UCL	468.3

Suggested UCL to Use

95% Adjusted Gamma UCL	237.4		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

AOC2 0.5-1 ft bgs Pb

General Statistics			
Total Number of Observations	10	Number of Distinct Observations	8
		Number of Missing Observations	1
Minimum	34	Mean	157.8
Maximum	460	Median	125
SD	144.4	Std. Error of Mean	45.65
Coefficient of Variation	0.915	Skewness	1.46
Normal GOF Test			
Shapiro Wilk Test Statistic	0.792	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.842	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.322	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.262	Data Not Normal at 5% Significance Level	
Data Not Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	241.5	95% Adjusted-CLT UCL (Chen-1995)	255.4
		95% Modified-t UCL (Johnson-1978)	245
Gamma GOF Test			
A-D Test Statistic	0.423	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.739	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.218	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.271	Detected data appear Gamma Distributed at 5% Significance Level	
Detected data appear Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	1.58	k star (bias corrected MLE)	1.172
Theta hat (MLE)	99.89	Theta star (bias corrected MLE)	134.6
nu hat (MLE)	31.59	nu star (bias corrected)	23.45
MLE Mean (bias corrected)	157.8	MLE Sd (bias corrected)	145.7
		Approximate Chi Square Value (0.05)	13.43
Adjusted Level of Significance	0.0267	Adjusted Chi Square Value	12.13
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50)	275.5	95% Adjusted Gamma UCL (use when n<50)	305
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.941	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.842	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.167	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.262	Data appear Lognormal at 5% Significance Level	
Data appear Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	3.526	Mean of logged Data	4.713
Maximum of Logged Data	6.131	SD of logged Data	0.88
Assuming Lognormal Distribution			
95% H-UCL	379.4	90% Chebyshev (MVUE) UCL	291.9
95% Chebyshev (MVUE) UCL	353.4	97.5% Chebyshev (MVUE) UCL	438.7
99% Chebyshev (MVUE) UCL	606.4		
Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution at 5% Significance Level			
Nonparametric Distribution Free UCLs			
95% CLT UCL	232.9	95% Jackknife UCL	241.5
95% Standard Bootstrap UCL	231	95% Bootstrap-t UCL	365.8
95% Hall's Bootstrap UCL	717.7	95% Percentile Bootstrap UCL	233.6
95% BCA Bootstrap UCL	246.2		
90% Chebyshev(Mean, Sd) UCL	294.8	95% Chebyshev(Mean, Sd) UCL	356.8
97.5% Chebyshev(Mean, Sd) UCL	442.9	99% Chebyshev(Mean, Sd) UCL	612
Suggested UCL to Use			
95% Adjusted Gamma UCL	305		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

AOC3a 0.5 ft bgs Pb

General Statistics

Total Number of Observations	6	Number of Distinct Observations	6
		Number of Missing Observations	2
Minimum	47	Mean	291.2
Maximum	680	Median	205
SD	263.7	Std. Error of Mean	107.7
Coefficient of Variation	0.906	Skewness	0.73

Note: Sample size is small (e.g., <10), If data are collected using ISM approach, you should use
guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.
For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).
Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1

Normal GOF Test

Shapiro Wilk Test Statistic	0.877	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.788	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.229	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.325	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	508.1	95% Adjusted-CLT UCL (Chen-1995)	502.5
		95% Modified-t UCL (Johnson-1978)	513.5

Gamma GOF Test

A-D Test Statistic	0.297	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.711	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.189	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.339	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.282	k star (bias corrected MLE)	0.752
Theta hat (MLE)	227.1	Theta star (bias corrected MLE)	387.1
nu hat (MLE)	15.39	nu star (bias corrected)	9.027
MLE Mean (bias corrected)	291.2	MLE Sd (bias corrected)	335.7
		Approximate Chi Square Value (0.05)	3.343
Adjusted Level of Significance	0.0122	Adjusted Chi Square Value	2.223

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	786.2	95% Adjusted Gamma UCL (use when n<50)	1182

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.934	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.788	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.167	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.325	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.85	Mean of logged Data	5.236
Maximum of Logged Data	6.522	SD of logged Data	1.092

Assuming Lognormal Distribution

95% H-UCL	2992	90% Chebyshev (MVUE) UCL	690.6
95% Chebyshev (MVUE) UCL	867.9	97.5% Chebyshev (MVUE) UCL	1114
99% Chebyshev (MVUE) UCL	1597		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	468.3	95% Jackknife UCL	508.1
95% Standard Bootstrap UCL	449.2	95% Bootstrap-t UCL	651.4
95% Hall's Bootstrap UCL	638.2	95% Percentile Bootstrap UCL	461.2
95% BCA Bootstrap UCL	465		
90% Chebyshev(Mean, Sd) UCL	614.2	95% Chebyshev(Mean, Sd) UCL	760.5
97.5% Chebyshev(Mean, Sd) UCL	963.5	99% Chebyshev(Mean, Sd) UCL	1362

Suggested UCL to Use

95% Student's-t UCL	508.1		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

AOC3a 0.5-1 ft bgs PB

General Statistics

Total Number of Observations	7	Number of Distinct Observations	7
		Number of Missing Observations	1
Minimum	47	Mean	506.7
Maximum	1800	Median	280
SD	619	Std. Error of Mean	234
Coefficient of Variation	1.222	Skewness	1.892

Note: Sample size is small (e.g., <10), If data are collected using ISM approach, you should use
guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.
For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).
Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1

Normal GOF Test

Shapiro Wilk Test Statistic	0.775	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.803	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.247	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.304	Data appear Normal at 5% Significance Level

Data appear Approximate Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	961.4	95% Adjusted-CLT UCL (Chen-1995)	1070
		95% Modified-t UCL (Johnson-1978)	989.2

Gamma GOF Test

A-D Test Statistic	0.25	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.732	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.173	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.321	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.876	k star (bias corrected MLE)	0.596
Theta hat (MLE)	578.2	Theta star (bias corrected MLE)	850.2
nu hat (MLE)	12.27	nu star (bias corrected)	8.344
MLE Mean (bias corrected)	506.7	MLE Sd (bias corrected)	656.4
		Approximate Chi Square Value (0.05)	2.936
Adjusted Level of Significance	0.0158	Adjusted Chi Square Value	2.058

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	1440	95% Adjusted Gamma UCL (use when n<50)	2055

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.967	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.803	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.14	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.304	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.85	Mean of logged Data	5.559
Maximum of Logged Data	7.496	SD of logged Data	1.312

Assuming Lognormal Distribution

95% H-UCL	7270	90% Chebyshev (MVUE) UCL	1268
95% Chebyshev (MVUE) UCL	1610	97.5% Chebyshev (MVUE) UCL	2085
99% Chebyshev (MVUE) UCL	3018		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	891.6	95% Jackknife UCL	961.4
95% Standard Bootstrap UCL	867.3	95% Bootstrap-t UCL	1570
95% Hall's Bootstrap UCL	2285	95% Percentile Bootstrap UCL	912.4
95% BCA Bootstrap UCL	1004		
90% Chebyshev(Mean, Sd) UCL	1209	95% Chebyshev(Mean, Sd) UCL	1527
97.5% Chebyshev(Mean, Sd) UCL	1968	99% Chebyshev(Mean, Sd) UCL	2835

Suggested UCL to Use

95% Student's-t UCL	961.4		

When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test
When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

AOC3b 0.5 ft bgs Pb

General Statistics

Total Number of Observations	8	Number of Distinct Observations	8
		Number of Missing Observations	4
Minimum	61	Mean	423.9
Maximum	820	Median	400
SD	303.1	Std. Error of Mean	107.2
Coefficient of Variation	0.715	Skewness	0.107

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1

Normal GOF Test

Shapiro Wilk Test Statistic	0.885	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.818	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.239	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.283	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	626.9	95% Adjusted-CLT UCL (Chen-1995)	604.5
		95% Modified-t UCL (Johnson-1978)	627.6

Gamma GOF Test

A-D Test Statistic	0.431	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.727	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.244	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.298	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.671	k star (bias corrected MLE)	1.128
Theta hat (MLE)	253.6	Theta star (bias corrected MLE)	375.8
nu hat (MLE)	26.74	nu star (bias corrected)	18.05
MLE Mean (bias corrected)	423.9	MLE Sd (bias corrected)	399.1
		Approximate Chi Square Value (0.05)	9.426
Adjusted Level of Significance	0.0195	Adjusted Chi Square Value	7.9

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	811.6	95% Adjusted Gamma UCL (use when n<50)	968.4

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.898	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.818	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.242	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.283	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.111	Mean of logged Data	5.721
Maximum of Logged Data	6.709	SD of logged Data	0.96

Assuming Lognormal Distribution

95% H-UCL	1617	90% Chebyshev (MVUE) UCL	916.3
95% Chebyshev (MVUE) UCL	1128	97.5% Chebyshev (MVUE) UCL	1421
99% Chebyshev (MVUE) UCL	1998		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	600.1	95% Jackknife UCL	626.9
95% Standard Bootstrap UCL	589.2	95% Bootstrap-t UCL	642.3
95% Hall's Bootstrap UCL	558.7	95% Percentile Bootstrap UCL	588.9
95% BCA Bootstrap UCL	606.3		
90% Chebyshev(Mean, Sd) UCL	745.4	95% Chebyshev(Mean, Sd) UCL	891
97.5% Chebyshev(Mean, Sd) UCL	1093	99% Chebyshev(Mean, Sd) UCL	1490

Suggested UCL to Use

95% Student's-t UCL	626.9		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

AOC3b 0.5-1 ft bgs Pb

General Statistics

Total Number of Observations	11	Number of Distinct Observations	9
		Number of Missing Observations	1
Minimum	61	Mean	471
Maximum	820	Median	570
SD	307.5	Std. Error of Mean	92.71
Coefficient of Variation	0.653	Skewness	-0.112

Normal GOF Test

Shapiro Wilk Test Statistic	0.844	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.85	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.238	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.251	Data appear Normal at 5% Significance Level

Data appear Approximate Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	639	95% Adjusted-CLT UCL (Chen-1995)	620.1
		95% Modified-t UCL (Johnson-1978)	638.5

Gamma GOF Test

A-D Test Statistic	0.743	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.74	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.241	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.259	Detected data appear Gamma Distributed at 5% Significance Level

Detected data follow Appr. Gamma Distribution at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.827	k star (bias corrected MLE)	1.389
Theta hat (MLE)	257.8	Theta star (bias corrected MLE)	339.1
nu hat (MLE)	40.19	nu star (bias corrected)	30.56
MLE Mean (bias corrected)	471	MLE Sd (bias corrected)	399.6
		Approximate Chi Square Value (0.05)	18.93
Adjusted Level of Significance	0.0278	Adjusted Chi Square Value	17.46

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	760.2	95% Adjusted Gamma UCL (use when n<50)	824.6

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.855	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.85	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.25	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.251	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	4.111	Mean of logged Data	5.857
Maximum of Logged Data	6.709	SD of logged Data	0.909

Assuming Lognormal Distribution

95% H-UCL	1190	90% Chebyshev (MVUE) UCL	938.9
95% Chebyshev (MVUE) UCL	1136	97.5% Chebyshev (MVUE) UCL	1410
99% Chebyshev (MVUE) UCL	1948		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	623.5	95% Jackknife UCL	639
95% Standard Bootstrap UCL	616.4	95% Bootstrap-t UCL	636.2
95% Hall's Bootstrap UCL	594.1	95% Percentile Bootstrap UCL	612.7
95% BCA Bootstrap UCL	614.5		
90% Chebyshev(Mean, Sd) UCL	749.1	95% Chebyshev(Mean, Sd) UCL	875.1
97.5% Chebyshev(Mean, Sd) UCL	1050	99% Chebyshev(Mean, Sd) UCL	1393

Suggested UCL to Use

95% Student's-t UCL	639

When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test .

When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.

AOC3c 0.5 ft bgs Pb

General Statistics

Total Number of Observations	9	Number of Distinct Observations	8
		Number of Missing Observations	3
Minimum	26	Mean	257.4
Maximum	1000	Median	120
SD	341.6	Std. Error of Mean	113.9
Coefficient of Variation	1.327	Skewness	1.732

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.
For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).
Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1

Normal GOF Test

Shapiro Wilk Test Statistic	0.721	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.829	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.31	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.274	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	469.2	95% Adjusted-CLT UCL (Chen-1995)	515
		95% Modified-t UCL (Johnson-1978)	480.2

Gamma GOF Test

A-D Test Statistic	0.516	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.75	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.207	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.289	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.796	k star (bias corrected MLE)	0.605
Theta hat (MLE)	323.4	Theta star (bias corrected MLE)	425.7
nu hat (MLE)	14.33	nu star (bias corrected)	10.89
MLE Mean (bias corrected)	257.4	MLE Sd (bias corrected)	331
		Approximate Chi Square Value (0.05)	4.503
Adjusted Level of Significance	0.0231	Adjusted Chi Square Value	3.677

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50)	622.4	95% Adjusted Gamma UCL (use when n<50)	762.2

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.932	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.829	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.171	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.274	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	3.258	Mean of logged Data	4.805
Maximum of Logged Data	6.908	SD of logged Data	1.292

Assuming Lognormal Distribution

95% H-UCL	1690	90% Chebyshev (MVUE) UCL	572.8
95% Chebyshev (MVUE) UCL	721.5	97.5% Chebyshev (MVUE) UCL	927.9
99% Chebyshev (MVUE) UCL	1333		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	444.8	95% Jackknife UCL	469.2
95% Standard Bootstrap UCL	435.6	95% Bootstrap-t UCL	1094
95% Hall's Bootstrap UCL	1470	95% Percentile Bootstrap UCL	454.9
95% BCA Bootstrap UCL	479.4		
90% Chebyshev(Mean, Sd) UCL	599.1	95% Chebyshev(Mean, Sd) UCL	753.8
97.5% Chebyshev(Mean, Sd) UCL	968.6	99% Chebyshev(Mean, Sd) UCL	1391

Suggested UCL to Use

95% Adjusted Gamma UCL	762.2		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

AOC3c 0.5-1 ft bgs Pb

General Statistics			
Total Number of Observations	10	Number of Distinct Observations	9
		Number of Missing Observations	2
Minimum	26	Mean	276.7
Maximum	1000	Median	130
SD	327.8	Std. Error of Mean	103.7
Coefficient of Variation	1.185	Skewness	1.502
Normal GOF Test			
Shapiro Wilk Test Statistic	0.788	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.842	Data Not Normal at 5% Significance Level	
Lilliefors Test Statistic	0.262	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.262	Data Not Normal at 5% Significance Level	
Data Not Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	466.7	95% Adjusted-CLT UCL (Chen-1995)	499.8
		95% Modified-t UCL (Johnson-1978)	474.9
Gamma GOF Test			
A-D Test Statistic	0.379	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.753	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.182	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.275	Detected data appear Gamma Distributed at 5% Significance Level	
Detected data appear Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	0.856	k star (bias corrected MLE)	0.666
Theta hat (MLE)	323.4	Theta star (bias corrected MLE)	415.7
nu hat (MLE)	17.11	nu star (bias corrected)	13.31
MLE Mean (bias corrected)	276.7	MLE Sd (bias corrected)	339.2
		Approximate Chi Square Value (0.05)	6.103
Adjusted Level of Significance	0.0267	Adjusted Chi Square Value	5.278
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50)	603.6	95% Adjusted Gamma UCL (use when n<50)	697.8
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.943	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.842	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.16	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.262	Data appear Lognormal at 5% Significance Level	
Data appear Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	3.258	Mean of logged Data	4.935
Maximum of Logged Data	6.908	SD of logged Data	1.286
Assuming Lognormal Distribution			
95% H-UCL	1559	90% Chebyshev (MVUE) UCL	642.1
95% Chebyshev (MVUE) UCL	805.9	97.5% Chebyshev (MVUE) UCL	1033
99% Chebyshev (MVUE) UCL	1480		
Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution at 5% Significance Level			
Nonparametric Distribution Free UCLs			
95% CLT UCL	447.2	95% Jackknife UCL	466.7
95% Standard Bootstrap UCL	444.8	95% Bootstrap-t UCL	654.5
95% Hall's Bootstrap UCL	537.8	95% Percentile Bootstrap UCL	444.4
95% BCA Bootstrap UCL	494.8		
90% Chebyshev(Mean, Sd) UCL	587.7	95% Chebyshev(Mean, Sd) UCL	728.6
97.5% Chebyshev(Mean, Sd) UCL	924.1	99% Chebyshev(Mean, Sd) UCL	1308
Suggested UCL to Use			
95% Adjusted Gamma UCL	697.8		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

AOC2 0.5 ft bgs As

General Statistics

Total Number of Observations	9	Number of Distinct Observations	6
		Number of Missing Observations	2
Minimum	13	Mean	15.67
Maximum	20	Median	15
SD	2.121	Std. Error of Mean	0.707
Coefficient of Variation	0.135	Skewness	0.965

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1

Normal GOF Test

Shapiro Wilk Test Statistic	0.929	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.829	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.179	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.274	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	16.98	95% Adjusted-CLT UCL (Chen-1995)	17.07
		95% Modified-t UCL (Johnson-1978)	17.02

Gamma GOF Test

A-D Test Statistic	0.286	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.72	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.175	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.279	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	64.54	k star (bias corrected MLE)	43.1
Theta hat (MLE)	0.243	Theta star (bias corrected MLE)	0.363
nu hat (MLE)	1162	nu star (bias corrected)	775.8
MLE Mean (bias corrected)	15.67	MLE Sd (bias corrected)	2.386
		Approximate Chi Square Value (0.05)	712.2
Adjusted Level of Significance	0.0231	Adjusted Chi Square Value	699.3

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	17.07	95% Adjusted Gamma UCL (use when n<50)	17.38

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.953	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.829	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.163	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.274	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.565	Mean of logged Data	2.744
Maximum of Logged Data	2.996	SD of logged Data	0.131

Assuming Lognormal Distribution

95% H-UCL	17.08	90% Chebyshev (MVUE) UCL	17.71
95% Chebyshev (MVUE) UCL	18.64	97.5% Chebyshev (MVUE) UCL	19.93
99% Chebyshev (MVUE) UCL	22.46		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	16.83	95% Jackknife UCL	16.98
95% Standard Bootstrap UCL	16.79	95% Bootstrap-t UCL	17.39
95% Hall's Bootstrap UCL	17.53	95% Percentile Bootstrap UCL	16.78
95% BCA Bootstrap UCL	16.78		
90% Chebyshev(Mean, Sd) UCL	17.79	95% Chebyshev(Mean, Sd) UCL	18.75
97.5% Chebyshev(Mean, Sd) UCL	20.08	99% Chebyshev(Mean, Sd) UCL	22.7

Suggested UCL to Use

95% Student's-t UCL	16.98		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

AOC2 0.5-1 ft bgs As

General Statistics			
Total Number of Observations	10	Number of Distinct Observations	6
		Number of Missing Observations	1
Minimum	13	Mean	15.6
Maximum	20	Median	15
SD	2.011	Std. Error of Mean	0.636
Coefficient of Variation	0.129	Skewness	1.098
Normal GOF Test			
Shapiro Wilk Test Statistic	0.914	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.842	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.217	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.262	Data appear Normal at 5% Significance Level	
Data appear Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	16.77	95% Adjusted-CLT UCL (Chen-1995)	16.88
		95% Modified-t UCL (Johnson-1978)	16.8
Gamma GOF Test			
A-D Test Statistic	0.357	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.724	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.213	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.266	Detected data appear Gamma Distributed at 5% Significance Level	
Detected data appear Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	70.84	k star (bias corrected MLE)	49.66
Theta hat (MLE)	0.22	Theta star (bias corrected MLE)	0.314
nu hat (MLE)	1417	nu star (bias corrected)	993.1
MLE Mean (bias corrected)	15.6	MLE Sd (bias corrected)	2.214
		Approximate Chi Square Value (0.05)	921
Adjusted Level of Significance	0.0267	Adjusted Chi Square Value	908.9
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	16.82	95% Adjusted Gamma UCL (use when n<50)	17.05
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.943	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.842	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.202	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.262	Data appear Lognormal at 5% Significance Level	
Data appear Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	2.565	Mean of logged Data	2.74
Maximum of Logged Data	2.996	SD of logged Data	0.124
Assuming Lognormal Distribution			
95% H-UCL	16.83	90% Chebyshev (MVUE) UCL	17.43
95% Chebyshev (MVUE) UCL	18.26	97.5% Chebyshev (MVUE) UCL	19.41
99% Chebyshev (MVUE) UCL	21.68		
Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution at 5% Significance Level			
Nonparametric Distribution Free UCLs			
95% CLT UCL	16.65	95% Jackknife UCL	16.77
95% Standard Bootstrap UCL	16.6	95% Bootstrap-t UCL	17.31
95% Hall's Bootstrap UCL	17.67	95% Percentile Bootstrap UCL	16.6
95% BCA Bootstrap UCL	16.8		
90% Chebyshev(Mean, Sd) UCL	17.51	95% Chebyshev(Mean, Sd) UCL	18.37
97.5% Chebyshev(Mean, Sd) UCL	19.57	99% Chebyshev(Mean, Sd) UCL	21.93
Suggested UCL to Use			
95% Student's-t UCL	16.77		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

AOC3a 0.5 ft bgs As

General Statistics

Total Number of Observations	6	Number of Distinct Observations	5
		Number of Missing Observations	2
Minimum	13	Mean	15.67
Maximum	18	Median	16
SD	1.966	Std. Error of Mean	0.803
Coefficient of Variation	0.126	Skewness	-0.254

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use
guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.
For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).
Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1

Normal GOF Test

Shapiro Wilk Test Statistic	0.927	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.788	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.251	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.325	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	17.28	95% Adjusted-CLT UCL (Chen-1995)	16.9
		95% Modified-t UCL (Johnson-1978)	17.27

Gamma GOF Test

A-D Test Statistic	0.347	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.697	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.274	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.332	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	74.5	k star (bias corrected MLE)	37.36
Theta hat (MLE)	0.21	Theta star (bias corrected MLE)	0.419
nu hat (MLE)	894	nu star (bias corrected)	448.4
MLE Mean (bias corrected)	15.67	MLE Sd (bias corrected)	2.563
		Approximate Chi Square Value (0.05)	400.3
Adjusted Level of Significance	0.0122	Adjusted Chi Square Value	383.7

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	17.55	95% Adjusted Gamma UCL (use when n<50)	18.31

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.924	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.788	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.255	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.325	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.565	Mean of logged Data	2.745
Maximum of Logged Data	2.89	SD of logged Data	0.128

Assuming Lognormal Distribution

95% H-UCL	17.56	90% Chebyshev (MVUE) UCL	18.12
95% Chebyshev (MVUE) UCL	19.23	97.5% Chebyshev (MVUE) UCL	20.77
99% Chebyshev (MVUE) UCL	23.8		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	16.99	95% Jackknife UCL	17.28
95% Standard Bootstrap UCL	16.87	95% Bootstrap-t UCL	17.29
95% Hall's Bootstrap UCL	16.71	95% Percentile Bootstrap UCL	16.83
95% BCA Bootstrap UCL	16.67		
90% Chebyshev(Mean, Sd) UCL	18.07	95% Chebyshev(Mean, Sd) UCL	19.17
97.5% Chebyshev(Mean, Sd) UCL	20.68	99% Chebyshev(Mean, Sd) UCL	23.65

Suggested UCL to Use

95% Student's-t UCL	17.28		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be
reliable. Chen's and Johnson's methods provide adjustments for positively skewed data sets.

AOC3a 0.5-1 ft bgs As

General Statistics

Total Number of Observations	7	Number of Distinct Observations	6
		Number of Missing Observations	1
Minimum	13	Mean	16.71
Maximum	23	Median	17
SD	3.302	Std. Error of Mean	1.248
Coefficient of Variation	0.198	Skewness	1.129

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.
For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).
Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1

Normal GOF Test

Shapiro Wilk Test Statistic	0.912	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.803	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.206	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.304	Data appear Normal at 5% Significance Level	

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	19.14	95% Adjusted-CLT UCL (Chen-1995)	19.34
		95% Modified-t UCL (Johnson-1978)	19.23

Gamma GOF Test

A-D Test Statistic	0.288	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.707	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.171	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.311	Detected data appear Gamma Distributed at 5% Significance Level	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	32.13	k star (bias corrected MLE)	18.46
Theta hat (MLE)	0.52	Theta star (bias corrected MLE)	0.906
nu hat (MLE)	449.8	nu star (bias corrected)	258.4
MLE Mean (bias corrected)	16.71	MLE Sd (bias corrected)	3.891
		Approximate Chi Square Value (0.05)	222.2
Adjusted Level of Significance	0.0158	Adjusted Chi Square Value	212

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	19.44	95% Adjusted Gamma UCL (use when n<50)	20.37

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.95	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.803	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.174	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.304	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.565	Mean of logged Data	2.801
Maximum of Logged Data	3.135	SD of logged Data	0.188

Assuming Lognormal Distribution

95% H-UCL	19.49	90% Chebyshev (MVUE) UCL	20.27
95% Chebyshev (MVUE) UCL	21.89	97.5% Chebyshev (MVUE) UCL	24.13
99% Chebyshev (MVUE) UCL	28.54		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	18.77	95% Jackknife UCL	19.14
95% Standard Bootstrap UCL	18.61	95% Bootstrap-t UCL	19.92
95% Hall's Bootstrap UCL	22.65	95% Percentile Bootstrap UCL	18.86
95% BCA Bootstrap UCL	19		
90% Chebyshev(Mean, Sd) UCL	20.46	95% Chebyshev(Mean, Sd) UCL	22.15
97.5% Chebyshev(Mean, Sd) UCL	24.51	99% Chebyshev(Mean, Sd) UCL	29.13

Suggested UCL to Use

95% Student's-t UCL	19.14		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

AOC3b 0.5 ft bgs As

General Statistics

Total Number of Observations	8	Number of Distinct Observations	7
		Number of Missing Observations	4
Minimum	11	Mean	14.25
Maximum	19	Median	14
SD	2.493	Std. Error of Mean	0.881
Coefficient of Variation	0.175	Skewness	0.802

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1

Normal GOF Test

Shapiro Wilk Test Statistic	0.958	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.818	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.165	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.283	Data appear Normal at 5% Significance Level	

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	15.92	95% Adjusted-CLT UCL (Chen-1995)	15.97
		95% Modified-t UCL (Johnson-1978)	15.96

Gamma GOF Test

A-D Test Statistic	0.181	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.715	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.148	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.294	Detected data appear Gamma Distributed at 5% Significance Level	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	38.96	k star (bias corrected MLE)	24.43
Theta hat (MLE)	0.366	Theta star (bias corrected MLE)	0.583
nu hat (MLE)	623.3	nu star (bias corrected)	390.9
MLE Mean (bias corrected)	14.25	MLE Sd (bias corrected)	2.883
		Approximate Chi Square Value (0.05)	346.1
Adjusted Level of Significance	0.0195	Adjusted Chi Square Value	335.4

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	16.1	95% Adjusted Gamma UCL (use when n<50)	16.61

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.983	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.818	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.136	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.283	Data appear Lognormal at 5% Significance Level	

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.398	Mean of logged Data	2.644
Maximum of Logged Data	2.944	SD of logged Data	0.17

Assuming Lognormal Distribution

95% H-UCL	16.14	90% Chebyshev (MVUE) UCL	16.82
95% Chebyshev (MVUE) UCL	17.99	97.5% Chebyshev (MVUE) UCL	19.61
99% Chebyshev (MVUE) UCL	22.8		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	15.7	95% Jackknife UCL	15.92
95% Standard Bootstrap UCL	15.6	95% Bootstrap-t UCL	16.19
95% Hall's Bootstrap UCL	17.22	95% Percentile Bootstrap UCL	15.63
95% BCA Bootstrap UCL	15.63		
90% Chebyshev(Mean, Sd) UCL	16.89	95% Chebyshev(Mean, Sd) UCL	18.09
97.5% Chebyshev(Mean, Sd) UCL	19.75	99% Chebyshev(Mean, Sd) UCL	23.02

Suggested UCL to Use

95% Student's-t UCL	15.92		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

AOC3b 0.5-1 ft bgs As

General Statistics			
Total Number of Observations	11	Number of Distinct Observations	8
		Number of Missing Observations	1
Minimum	11	Mean	15.09
Maximum	19	Median	15
SD	2.7	Std. Error of Mean	0.814
Coefficient of Variation	0.179	Skewness	0.218
Normal GOF Test			
Shapiro Wilk Test Statistic	0.942	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.85	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.15	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.251	Data appear Normal at 5% Significance Level	
Data appear Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	16.57	95% Adjusted-CLT UCL (Chen-1995)	16.49
		95% Modified-t UCL (Johnson-1978)	16.58
Gamma GOF Test			
A-D Test Statistic	0.259	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.729	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.141	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.255	Detected data appear Gamma Distributed at 5% Significance Level	
Detected data appear Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	34.28	k star (bias corrected MLE)	24.99
Theta hat (MLE)	0.44	Theta star (bias corrected MLE)	0.604
nu hat (MLE)	754.2	nu star (bias corrected)	549.8
MLE Mean (bias corrected)	15.09	MLE Sd (bias corrected)	3.019
		Approximate Chi Square Value (0.05)	496.5
Adjusted Level of Significance	0.0278	Adjusted Chi Square Value	488.2
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	16.71	95% Adjusted Gamma UCL (use when n<50)	17
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.953	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.85	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.128	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.251	Data appear Lognormal at 5% Significance Level	
Data appear Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	2.398	Mean of logged Data	2.699
Maximum of Logged Data	2.944	SD of logged Data	0.18
Assuming Lognormal Distribution			
95% H-UCL	16.79	90% Chebyshev (MVUE) UCL	17.56
95% Chebyshev (MVUE) UCL	18.67	97.5% Chebyshev (MVUE) UCL	20.23
99% Chebyshev (MVUE) UCL	23.27		
Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution at 5% Significance Level			
Nonparametric Distribution Free UCLs			
95% CLT UCL	16.43	95% Jackknife UCL	16.57
95% Standard Bootstrap UCL	16.37	95% Bootstrap-t UCL	16.65
95% Hall's Bootstrap UCL	16.47	95% Percentile Bootstrap UCL	16.36
95% BCA Bootstrap UCL	16.27		
90% Chebyshev(Mean, Sd) UCL	17.53	95% Chebyshev(Mean, Sd) UCL	18.64
97.5% Chebyshev(Mean, Sd) UCL	20.18	99% Chebyshev(Mean, Sd) UCL	23.19
Suggested UCL to Use			
95% Student's-t UCL	16.57		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

AOC3c 0.5 ft bgs As

General Statistics

Total Number of Observations	9	Number of Distinct Observations	7
		Number of Missing Observations	3
Minimum	13	Mean	16.44
Maximum	20	Median	17
SD	2.506	Std. Error of Mean	0.835
Coefficient of Variation	0.152	Skewness	-0.0383

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use
guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.
For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).
Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1

Normal GOF Test

Shapiro Wilk Test Statistic	0.926	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.829	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.177	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.274	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	18	95% Adjusted-CLT UCL (Chen-1995)	17.81
		95% Modified-t UCL (Johnson-1978)	18

Gamma GOF Test

A-D Test Statistic	0.406	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.721	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.197	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.279	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	47.71	k star (bias corrected MLE)	31.88
Theta hat (MLE)	0.345	Theta star (bias corrected MLE)	0.516
nu hat (MLE)	858.8	nu star (bias corrected)	573.9
MLE Mean (bias corrected)	16.44	MLE Sd (bias corrected)	2.912
		Approximate Chi Square Value (0.05)	519.3
Adjusted Level of Significance	0.0231	Adjusted Chi Square Value	508.3

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	18.17	95% Adjusted Gamma UCL (use when n<50)	18.56

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.921	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.829	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.188	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.274	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

Lognormal Statistics

Minimum of Logged Data	2.565	Mean of logged Data	2.789
Maximum of Logged Data	2.996	SD of logged Data	0.155

Assuming Lognormal Distribution

95% H-UCL	18.24	90% Chebyshev (MVUE) UCL	18.99
95% Chebyshev (MVUE) UCL	20.15	97.5% Chebyshev (MVUE) UCL	21.75
99% Chebyshev (MVUE) UCL	24.89		

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

Nonparametric Distribution Free UCLs

95% CLT UCL	17.82	95% Jackknife UCL	18
95% Standard Bootstrap UCL	17.73	95% Bootstrap-t UCL	17.89
95% Hall's Bootstrap UCL	17.64	95% Percentile Bootstrap UCL	17.78
95% BCA Bootstrap UCL	17.67		
90% Chebyshev(Mean, Sd) UCL	18.95	95% Chebyshev(Mean, Sd) UCL	20.08
97.5% Chebyshev(Mean, Sd) UCL	21.66	99% Chebyshev(Mean, Sd) UCL	24.75

Suggested UCL to Use

95% Student's-t UCL	18		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be
reliable. Chen's and Johnson's methods provide adjustments for positively skewed data sets.

AOC3c 0.5-1 ft bgs As

General Statistics			
Total Number of Observations	10	Number of Distinct Observations	8
		Number of Missing Observations	2
Minimum	12	Mean	16
Maximum	20	Median	16
SD	2.749	Std. Error of Mean	0.869
Coefficient of Variation	0.172	Skewness	0
Normal GOF Test			
Shapiro Wilk Test Statistic	0.939	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.842	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.167	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.262	Data appear Normal at 5% Significance Level	
Data appear Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	17.59	95% Adjusted-CLT UCL (Chen-1995)	17.43
		95% Modified-t UCL (Johnson-1978)	17.59
Gamma GOF Test			
A-D Test Statistic	0.356	**Anderson-Darling Gamma GOF Test**	
5% A-D Critical Value	0.724	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.184	**Kolmogorov-Smirnov Gamma GOF Test**	
5% K-S Critical Value	0.266	Detected data appear Gamma Distributed at 5% Significance Level	
Detected data appear Gamma Distributed at 5% Significance Level			
Gamma Statistics			
k hat (MLE)	37	k star (bias corrected MLE)	25.97
Theta hat (MLE)	0.432	Theta star (bias corrected MLE)	0.616
nu hat (MLE)	740	nu star (bias corrected)	519.4
MLE Mean (bias corrected)	16	MLE Sd (bias corrected)	3.14
		Approximate Chi Square Value (0.05)	467.5
Adjusted Level of Significance	0.0267	Adjusted Chi Square Value	458.9
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50))	17.77	95% Adjusted Gamma UCL (use when n<50)	18.11
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.938	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk Critical Value	0.842	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.174	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.262	Data appear Lognormal at 5% Significance Level	
Data appear Lognormal at 5% Significance Level			
Lognormal Statistics			
Minimum of Logged Data	2.485	Mean of logged Data	2.759
Maximum of Logged Data	2.996	SD of logged Data	0.175
Assuming Lognormal Distribution			
95% H-UCL	17.86	90% Chebyshev (MVUE) UCL	18.66
95% Chebyshev (MVUE) UCL	19.86	97.5% Chebyshev (MVUE) UCL	21.54
99% Chebyshev (MVUE) UCL	24.82		
Nonparametric Distribution Free UCL Statistics			
Data appear to follow a Discernible Distribution at 5% Significance Level			
Nonparametric Distribution Free UCLs			
95% CLT UCL	17.43	95% Jackknife UCL	17.59
95% Standard Bootstrap UCL	17.34	95% Bootstrap-t UCL	17.63
95% Hall's Bootstrap UCL	N/A	95% Percentile Bootstrap UCL	17.4
95% BCA Bootstrap UCL	17.3		
90% Chebyshev(Mean, Sd) UCL	18.61	95% Chebyshev(Mean, Sd) UCL	19.79
97.5% Chebyshev(Mean, Sd) UCL	21.43	99% Chebyshev(Mean, Sd) UCL	24.65
Suggested UCL to Use			
95% Student's-t UCL	17.59		

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

APPENDIX C
Updated Stormwater Conveyance Report

UPDATED
STORMWATER CONVEYANCE EVALUATION for
Adair Memorial Park Archery Range

YUMA COUNTY, ARIZONA

Prepared for:

Yuma County
Department of Public Works
4343 S. Avenue 5 ½ E.
Yuma, Arizona 85365

Prepared by:

Nicklaus Engineering, Inc.
1851 W. 24th Street
Yuma, Arizona 85364

Registered Professional Engineer (Civil)
CERTIFICATE NO.
55066
ERIC SOL
GARDNER
Date Signed 5/28/20
ARIZONA U.S.A.
EXPIRES 9/30/22

May 2020

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ATTACHMENTS

1.0 Objective

In August 2000, an initial site assessment of the Adair Park Archery Range revealed the presence of elevated lead concentrations in the soil and tailings within the archery range. In 2006 Yuma County entered the Arizona Department of Environmental Quality's (ADEQ) Voluntary Remediation Program (VRP) and prepared a work plan to remediate contaminated soil. Remediation activities in the work plan included excavating and relocating contaminated soil to an area within the site and capping it with a gravel base and a double chip seal surface. ADEQ conducted a subsequent field review of the project site to determine if additional characterization and remedial activities are necessary to meet the requirements for a No Further Action Determination (NFA). ADEQ made recommendations in their letter dated June 4, 2014 and September 2017 Summary. The Yuma County Department of Public Works retained Nicklaus Engineering Inc. to prepare a Stormwater Conveyance Evaluation Report that addresses the ADEQ site inspection recommendations.

This report analyzes the current conditions and the effects of stormwater runoff on the current upstream protective rip-rap wall, the protective capped surface, drainage channels, and the southern retention basins. Furthermore, upon the found conditions this report proposes recommendations and modifications to the current stormwater conveyance system.

2.0 Project Location

The Adair Park Archery Range is situated in the western portion of Adair Park which is located at 4760 South US Highway 95 at the intersection of Highway 95 and Adair Park Road in Yuma County, Arizona. The site is located approximately 12 miles northeast of Yuma, Arizona on the southern base of the Laguna Mountains. It can be described as being located within Section 5, Township 8 South, Range 21 West of the Gila and Salt River Base and Meridian in Yuma County, Arizona.

The site comprises mostly undeveloped desert with several improvements and structures suitable for rifle, pistol and archery ranges.

The area of analysis falls in within a dry ephemeral wash that drains into the Gila River. The watershed area of analysis is enclosed on the North, East and West by mountain ridge lines and bordered in the south by Adair Park Road. An aerial image with boundaries is depicted in Figure 2.0.

Figure 2.0 Aerial image with site boundaries

3.0 Geohydrology

The existing terrain of the watershed area is undeveloped desert, it is a dry ephemeral wash enclosed by mountain ridges. The soil condition as defined by the U.S. Department of Agriculture Soil Conservation Service is of the Laposa-Rock outcrop classification for the mountain area and of the Indio-Ripley-Lagunita classification for the dry wash area. The Laposa-Rock outcrop classification is moderately deep steep, well drained, extremely gravelly soils, and rock outcrops on hills and mountains. The Indio-Ripley-Lagunita classification is deep, nearly level to gently sloping, well drained and somewhat excessively drained, silty and sandy soils on flood plains, low terraces and alluvial fans and in drainageways.

According to the Federal Emergency Management Agency (FEMA), Flood Insurance Rate Map No. 04027C1245F, with an effective date of January 16, 2014, for Community No. 040099, in Yuma County, Arizona; approximately 600 feet of the southernmost portion of the site is located within Flood Zone AE and the remainder of the site is located within Flood Zone X. Flood Zone AE is described as “special flood hazard areas subject to inundation by the 1% annual chance flood". Flood Zone X is described as "areas determined to be outside the 0.2% annual chance floodplain".

According to the January 2018 revision of the U.S. Bureau of Reclamation Depth to Groundwater Map for the Wellton – Mohawk Valley, the average depth to groundwater at the area of the bottom of the existing retention basins is approximately 10 feet. On March 06, 2019 soil borings were performed at the site and groundwater was encountered at a depth of 14.70 feet. Additionally, a second soil boring at the middle of the site indicated that groundwater is only present under the southern portion of the site, primarily due to the presence of shallow bedrock under the site.

4.0 Methodology

The methodology used to obtain the stormwater quantification and movement is based upon calculations utilizing the rational method with input data from the Public Works Standards for Yuma County Volume III, Storm Drainage Facilities, August 21, 2006 along with the Drainage Policies and Standards Manual for Maricopa County, Arizona, August 22, 2018 Revision. On the other hand, the water dynamics around the areas of interest was modeled utilizing the geographic data from the topographic survey and using the HEC RAS US Army software.

5.0 Area Definition

The terrain was divided into four areas based upon changes in topography, and geomorphic compositions. Figure 5.0 shows the areas enclosed within the site. Based upon steepness for times of concentration purposes; Area A is denoted entirely as mountainous and having a steepness of more than 20%. Areas B/B1 are also labeled as mountainous with an approximate steepness of 5% and ends north of the protective capped surface. Areas C/C1 contains the existing capped surface that was built based on a previous environmental evaluation. This area consists of relocated in-site material, imported aggregate base course and a double chip seal surface. Areas D/D1 are desert range land with several structures and rip rap channels. Area E is desert range land with several structures and the existing retention basins. The purpose of the splitting the terrain was to quantify the generation of stormwater runoff and its effects on the protective wall, stormwater drainage channels, capped surface, and the stormwater retention capacity of the existing retention basins.

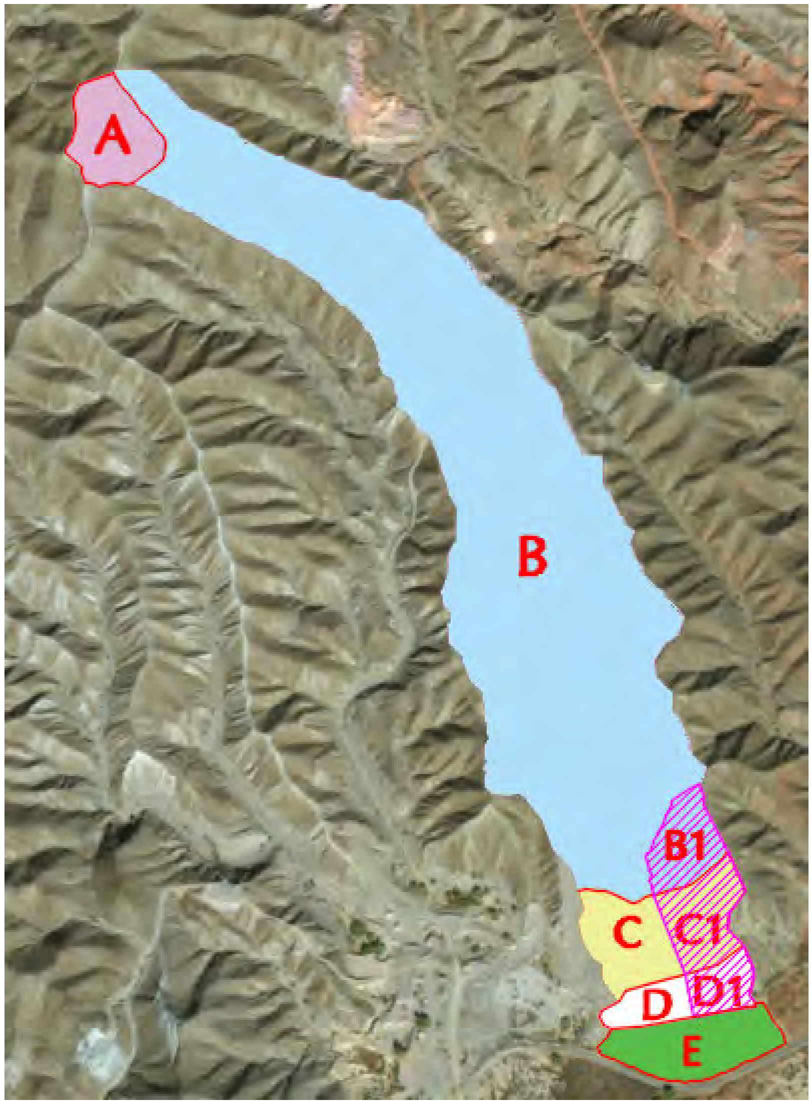


Figure 5.0 Areas Within the Site.

6.0 Storm water Runoff Volume Calculations

Storm Water Drainage Areas:

To quantify the storm water runoff water imputed to the existing retention basins, rainfall from the entire site (Areas A, B/B1, C/C1, D/D1 and E as shown in Figure 5.0) and a 100-year, 2-hour storm was used.

Figure 6.0 denotes the terrain types present at the site and they are differentiated with distinct colors.

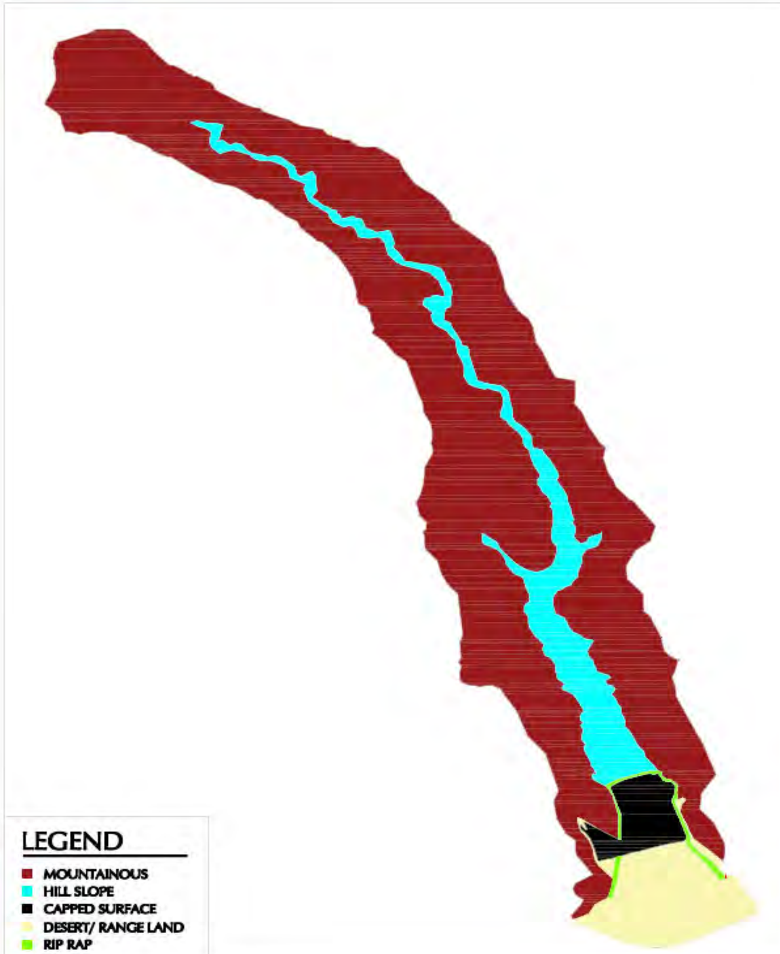


Figure 6.0: Site Terrain Types.

Table 6.0 summarizes the distinct types of terrains and characteristics obtained from the calculated areas shown in Figure 6.0. The "C" Factor for the Desert/Range Land has been determined from Appendix C, Runoff Curve Numbers by Soil Type & Zoning Classification, Public Works Standards for Yuma County, Volume III, Storm Drainage Facilities, August 21, 2006. The remaining terrain types are not shown in the Public Works Standards for Yuma County. The Drainage Policies and Standards for Maricopa County, Arizona, August 22, 2018 was used to determine the "C" Factor for the Mountainous, Hillslope and Cap Surface terrain types. The "C" Factor for Cap Surface was determined from Table 6.3, Rational Method Developed Condition C Coefficients. The "C" Factors for the Mountainous and Hillslope terrain types was determined from Table 6.4, Rational Method Natural Condition C Coefficients. The "C" Factor for the Rip-Rap terrain type was estimated.

TYPE OF TERRAIN	"C" FACTOR	AREA (ACRE)	C x A
MOUNTAINOUS	0.95	88.89	84.45
HILLSLOPE	0.69	12.28	8.47
CAP SURFACE	0.88	3.71	3.26
DESERT/ RANGE LAND	0.88	9.00	7.92
RIP-RAP	0.90	0.62	0.56
TOTAL	N/A	114.50	104.66

Table 6.0 Terrain Characteristics and Areas for the Entire Site.

A “C” factor of the various terrains was weighted with the result shown in the following calculation:

$$C_w = \frac{\sum(C \times A)}{\sum A}$$

$$C_w = \frac{104.66}{114.5} = 0.91$$

The storm water runoff – Entire Site for a 100-year, 2-hour storm is as follows:
The Public Works Standards for Yuma County, Volume III, Storm Drainage Facilities, August 21, 2006, Section 3.2.6 Retention and Detention Basins, Paragraph B, states if the rational method is used, the 100-year, 2-hour storm or 2.44 inches of total rainfall shall be used.

Use Rational Method: Q = CIA

Where: Q = Peak Runoff Rate in cubic feet per second (CFS)
C = Weighted “C” as shown above (unitless)
I = Rainfall Intensity for 100-year, 2-hour storm as specified by Appendix A “Rainfall Intensity-Duration-Frequency Relationship for Yuma, Arizona” of Public Works Standards for Yuma County, Volume III, Storm Drainage Facilities, August 21, 2006
A = Runoff Area in acres

$$Q = CiA$$
$$C = 0.91$$
$$i = 1.22\,\frac{in}{hr}$$
$$A = 114.50\ acres$$

$$Q = CiA = (0.91)(1.22)(114.50) = 127.12\ CFS$$

Storm water Runoff Volume – Entire Site:

The storm water runoff volume for the entire site (Areas A, B/B1, C/C1, D/D1 and E - Figure 5.0) was calculated to analyze current retention basins conditions and verify capacities. This volume was obtained considering a 100-year, 2hr-storm. The equation shown in Appendix E, Rational Method, Retention and Detention Basin Volume Design Data Sheet, Public Works Standards for Yuma County, Volume III, Storm Drainage Facilities, August 21, 2006 was used to calculate the storm water runoff volume as follows:

Use: $V = ½(2\ tc)Q \times\ 3{,}600 \frac{sec}{hr}$

Where: $V = volume\ in\ cubic\ feet$
$Q = Discharge\ in\ cubic\ feet\ per\ second (shown\ below)$
$tc = time\ of\ construction\ in\ hours$

$$V = ½(2\ x\ 2)127.12\ \times 3{,}600 = 915{,}264\ ft^3$$

The storm water runoff – entire site for a 100-year, 2-hour storm is as follows:

Use Rational Method: Q = CIA

Where: Q = Peak Runoff Rate in cubic feet per second (CFS)
C = Weighted “C” as shown above (unitless)
I = Rainfall Intensity for 100-year, 2-hour storm as specified by Appendix A “Rainfall Intensity-Duration-Frequency Relationship for Yuma, Arizona” of Public Works Standards for Yuma County, Volume III, Storm Drainage Facilities, August 21, 2006
A = Runoff Area in acres

$$Q = CiA$$
$$C = 0.91$$
$$i = 1.22 \frac{in}{hr}$$
$$A = 114.50\ acres$$

$$Q = CiA = (0.91)(1.22)(114.50) = 127.12\ CFS$$

Storm water Runoff Volume – capped surface:

The two existing retention basins were constructed as a part of Yuma County’s remediation activities conducted in 2006. The existing retention basins were designed to accommodate the storm water runoff from the capped surface (Areas C/C1- Figure 5.0) constructed during those remediation activities. Calculations to analyze the capacities of the current retention basins compared to the capped surface were conducted. This volume was obtained considering a 100-year, 2hr-storm. The equation shown in Appendix E, Rational Method, Retention and Detention Basin Volume Design Data Sheet, Public Works Standards for Yuma County, Volume III, Storm Drainage Facilities, August 21, 2006 was used to calculate the storm water runoff volume as follows:

Use: $V = ½(2\ tc)Q \times\ 3{,}600 \frac{sec}{hr}$

Where: $V = volume\ in\ cubic\ feet$
$Q = Discharge\ in\ cubic\ feet\ per\ second\ (shown\ below)$
$tc = time\ of\ construction\ in\ hours$

$$V = ½(2\ x\ 2)3.98\ \times 3{,}600 = 28{,}656\ ft^3$$

The storm water runoff – capped surface for a 100-year, 2-hour storm is as follows:

Use Rational Method: Q = CIA

Where: Q = Peak Runoff Rate in cubic feet per second (CFS)
C = Weighted "C" as shown above (unitless)
I = Rainfall Intensity for 100-year, 2-hour storm as specified by Appendix A "Rainfall Intensity-Duration-Frequency Relationship for Yuma, Arizona" of Public Works Standards for Yuma County, Volume III, Storm Drainage Facilities, August 21, 2006
A = Runoff Area in acres

$$Q = CiA$$
$$C = 0.88$$
$$i = 1.22 \frac{in}{hr}$$
$$A = 3.71\ acres$$

$$Q = CiA = (0.88)(1.22)(3.71) = 3.98\ CFS$$

7.0 Current Retention Basins Capacities

Considering the topographic survey, it was possible to calculate the volume of both existing retention basins found on site. The calculation is as follows:

Use: $V = h\left(\frac{A_{TOP} + A_{BOT}}{2}\right)$

Where:

h = depth of water, ft

A_{TOP} = area at top of retention basin, ft^2

A_{BOT} = area at bottom of retention basin, ft^2

East Retention Basin:

Average Top Elevation = 162.28

Average Bottom Elevation = 159.74

Average h = 2.54

A_{TOP} = 41,515 ft^2

A_{BOT} = 23,690 ft^2

$$V = 2.54\left(\frac{41{,}515+23{,}690}{2}\right) = 82{,}810\ ft^2$$

West Retention Basin:

Average Top Elevation = 163.08

Average Bottom Elevation = 160.61

Average h = 2.47

A_{TOP} = 37,238 ft^2

A_{BOT} = 15,487 ft^2

$$V = 2.47\left(\frac{37{,}238+15{,}487}{2}\right) = 65{,}115\ ft^2$$

Therefore, the capacity of both retention basins is:

$$Retention\ Basins\ Volume = East\ Basin + West\ Basin = 82{,}810\ ft^3 + 65{,}115\ ft^3 = 147{,}925\ ft^3$$

$$Retention\ Basins\ Capacity(entire\ site) = \frac{Retention\ Basins\ Volume}{Runoff - entire\ site} = \frac{147{,}925\ ft^3}{915{,}264\ ft^3} = 0.1616 = 16.16\%$$

$$Retention\ Basins\ Capacity(capped\ area) = \frac{Retention\ Basins\ Volume}{Runoff - capped\ surface} = \frac{147{,}925\ ft^3}{28{,}656\ ft^3} = 5.1621 = 516.21\%$$

The storm water retention capacity of both existing retention basins combined equals 16.16% of the retention capacity required to retain 100% of the storm water runoff generated by the entire site for a 100-year, 2-hour storm. However, the storm water retention capacity of both existing retention basins combined is approximately 5 times the capacity required to retain the storm water runoff from the capped surface. A portion of the excess storm water runoff generated by the entire site leaving the existing retention basins is retained by Adair Park Road at the southern boundary of the site. Therefore, the stormwater storage capacity of the site was calculated using a low point of Adair Park Road as an outfall elevation. Calculations from an AutoCAD – Civil 3D surface model are as follows:

Volume Summary							
Name	Type	Cut Factor	Fill Factor	2d Area (Sq. Ft.)	Cut (Cu. Yd.)	Fill (Cu. Yd.)	Net (Cu. Yd.)
East Basin Volume	full	1.000	1.000	74548.51	3863.77	0.00	3863.77<Cut>
West Basin Volume	full	1.000	1.000	83579.86	5810.63	0.00	5810.63<Cut>

Totals				
	2d Area (Sq. Ft.)	Cut (Cu. Yd.)	Fill (Cu. Yd.)	Net (Cu. Yd.)
Total	158128.37	9674.39	0.00	9674.39<Cut>

$$Overfill\ Volume = 9674.39\ yd^3 = 261208.5\ ft^3$$

$$Capacity = \frac{Overfill\ Volume}{Total\ Area\ Runoff} = \frac{261208.5\ ft^3}{885{,}096\ ft^3} = 0.2951 = 29.51\%$$

Considering the volume calculated with the surface model, the percentage of storm water runoff from the entire site retained on site before overflow occurs at Adair Park Road is approximately 30%.

8.0 Channel Analysis

The two existing channels found in this project are a vital component in the design as they transport storm water runoff generated from most of the terrain into the existing retention basins. Considering the difference in elevation at the north end of each of the channels and based on flow models; the two channels were analyzed with different flow inputs. Each channel was analyzed in two different areas. One, as they flow around the capped surface and two, the desert area between the capped surface and the existing retention basins. Figure 8.0 shows these four areas of analysis. Sections One and Two originate at north end of the capped surface and run south to the south end of the capped surface (Area C/C1, Figure 5.0). Sections Three and Four flow through the desert area between the south end capped surface and the existing retention basins (Area D/D1, Figure 5.0). The storm water runoff created by Areas A, B, and C shown in Figure 5.0 flow through the channel in Section One (Figure 8.0), while the storm water runoff from Areas B1 and C1 flow through the channel in Section Two. The storm water runoff created by Areas A, B, C and D (Figure 5.0) flow through the channel in Section Three, while the storm water runoff from Areas B1, C1 and D1 flow through the channel in Section Four. For that reason, different times of concentration are calculated and used for the analysis of each channel.

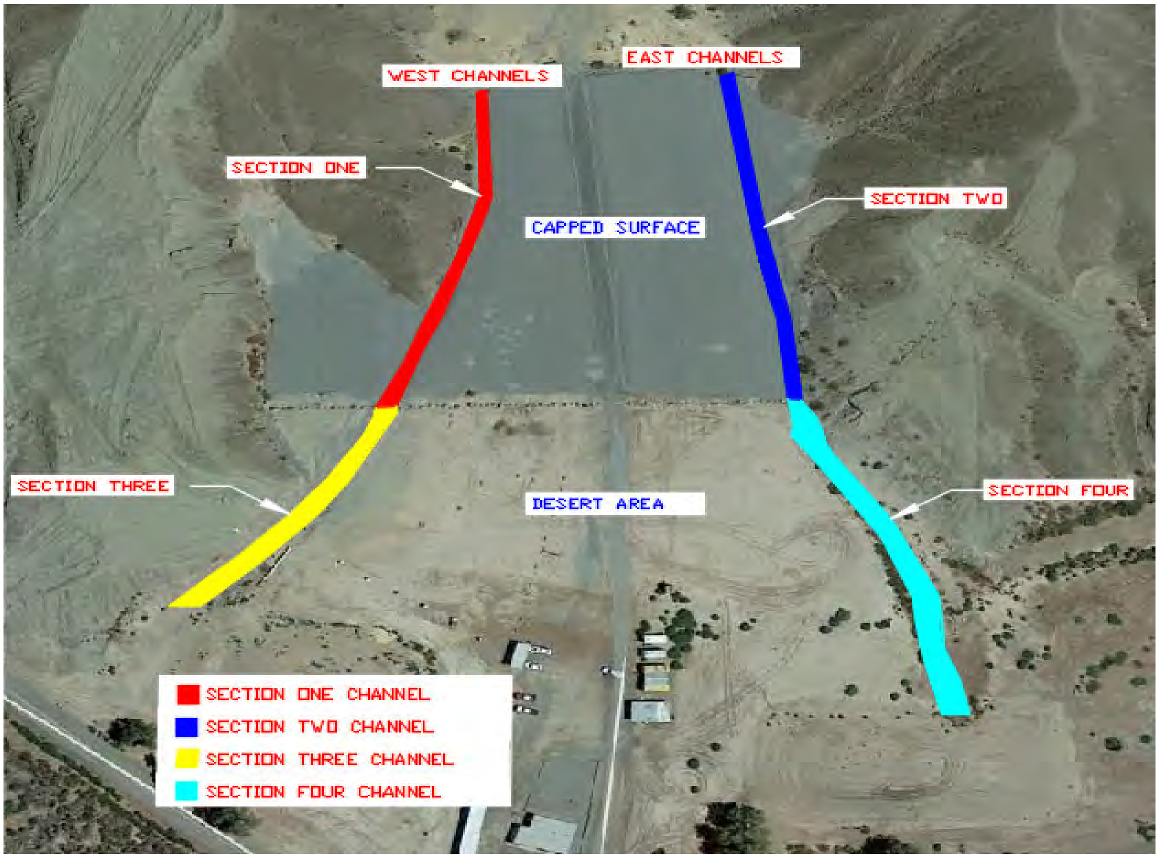


Figure 8.0 Storm water Drainage Channels.

Time of Concentration:

Time of concentration represent the accumulation of water from the furthest location of the tributary area to the point of interest. Due to changes in topography and geomorphic compositions, the time of concentration for each area was calculated separately and then combined for a total time of concentration.

The Public Works Standards for Yuma County, Volume III, Storm Drainage Facilities, August 21, 2006, Section 3.2.5 Rational Method, Paragraph A, states "The equation, $Q = CiA$, may be used to compute peak runoff from urbanized areas up to 10 acres or non-urbanized areas up to 80 acres". Since the total area of the subject site is approximately 114.50 acres, this method was not used. However, Section 3.1 of the Drainage Design Manual for Maricopa County, Hydrology, December 14, 2018 states that the Rational Method can be used op to 160 acres. Equation 3.2 of this manual is used to calculate the time of concentration as shown below:

(Maricopa Drainage Design, Equation 3.2)

$$T_c = 11.4L^{0.5}K_b^{0.52}S^{-0.31}i^{-0.38}$$

Where: T_c = time of concentration, in hours
L = length of the longest flow path, in miles
K_b = watershed resistance coefficient
S = watercourse slope, in feet/mile
i = rainfall intensity, in inches/hour.

8.1 Drainage Channel – Section One

Time of Concentration – Section One (Areas A, B, & C, Figure 5.0)

Area A:

L = 557 ft (0.1055 mi)
K_b = 0.05 (Table 6.6, Maricopa Co. Drainage Policies and Standards)
S = $\frac{621-429}{0.1055} = 1819.91$
i = 2.17 in/hr. (100-year, 60-minute storm, NOAA ATLAS 14, April 21, 2017)

$$T_{cA} = 11.4L^{0.5}K_b^{0.52}S^{-0.31}i^{-0.38}$$
$$T_{cA} = 11.4(0.1055)^{0.5}(0.05)^{0.52}(1819.91)^{-0.31}(2.17)^{-0.38}$$
$$T_{cA} = 0.0567\ hr = 3.40\ min$$

Area B:

L = 5535 ft (1.0483 mi)
K_b = 0.03 (Table 6.6, Maricopa Co. Drainage Policies and Standards)
S = $\frac{429-171}{1.0483} = 246.11$
i = 2.17 in/hr. (100-year, 60-minute storm, NOAA ATLAS 14, April 21, 2017)

$$T_{cB} = 11.4L^{0.5}K_b^{0.52}S^{-0.31}i^{-0.38}$$
$$T_{cB} = 11.4(1.0483)^{0.5}(0.03)^{0.52}(246.11)^{-0.31}(2.17)^{-0.38}$$
$$T_{cB} = 0.2548\ hr = 15.29\ min$$

Area C:

L = 436 ft (0.0826 mi)
K_b = 0.015 (Table 6.5, Maricopa Co. Drainage Policies and Standards)
S = $\frac{171-168}{0.0826} = 36.32$
i = 2.17 in/hr. (100-year, 60-minute storm, NOAA ATLAS 14, April 21, 2017)

$$T_{cC} = 11.4L^{0.5}K_b^{0.52}S^{-0.31}i^{-0.38}$$
$$T_{cC} = 11.4(0.0826)^{0.5}(0.015)^{0.52}(36.32)^{-0.31}(2.17)^{-0.38}$$
$$T_{cC} = 0.0903\ hr = 5.42\ min$$

Adding the three the times of concentration shown above, give a total time of concentration from the furthest part of the tributary at the north end of the site to the south end of the capped surface. This total time of concentration is:

$$T_{C\ SECTION\ ONE} = t_{cA} + t_{cB} + t_{cC} = 3.40\ \text{min} + 15.29\ min + 5.42\ min = 24.11\ min$$

The rainfall intensity from a 100-year storm correlating to this time of concentration was estimated to be 4.00 in/hr. using the Rainfall Intensity, Duration, Frequency Relationship for Yuma. This correlation and graph are shown in Figure 8.1-1

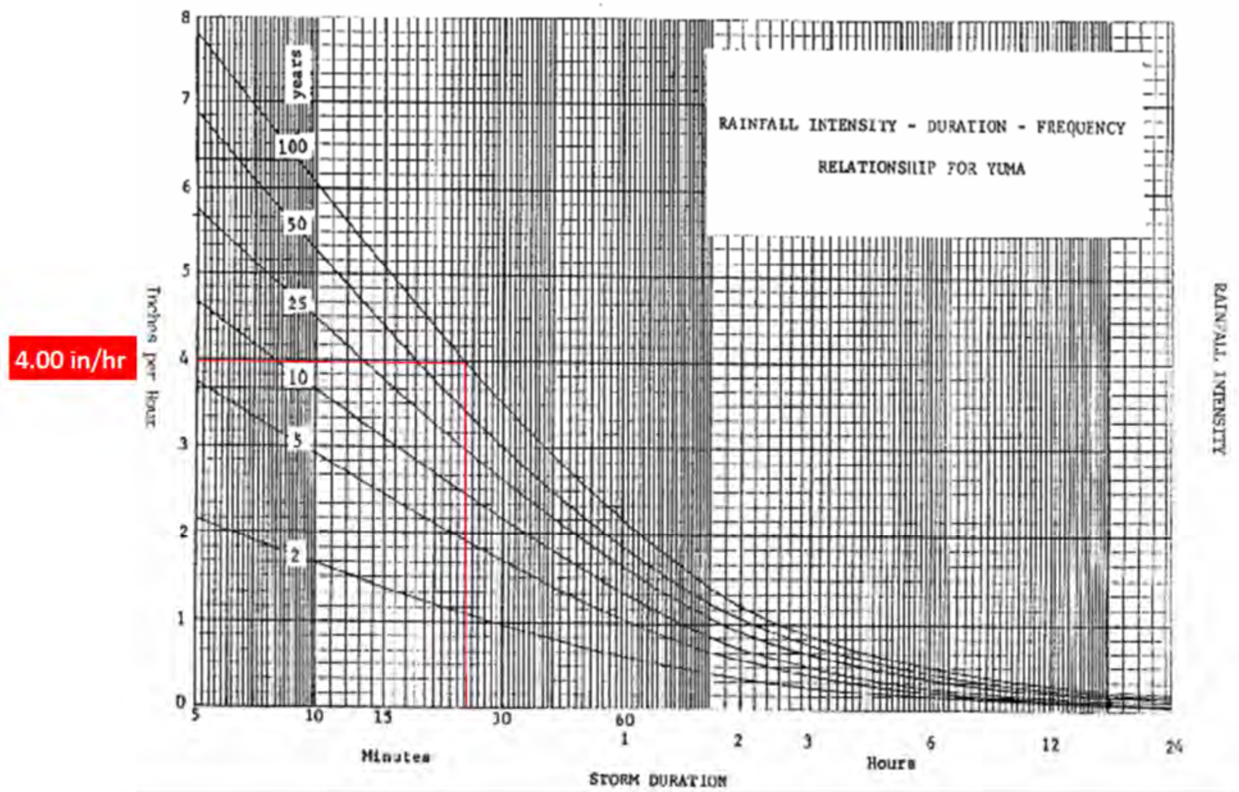


Figure 8.1-1 Rainfall Intensity - Duration – Frequency Relationship for Yuma (Section One)

Storm water Runoff – Section One:

The Public Works Standards for Yuma County, Volume III, Storm Drainage Facilities, August 21, 2006, Section 3.8 Open Channel Standards, Paragraph 3.8.1, states that open channels shall convey the 100-year storm peak runoff within the banks. The storm water runoff for Section One with a 100-year storm, calculated $T_c =$ 24.11 minutes is calculated using the Rational Method:

$$Q = CIA$$

Where: Q = Peak Runoff Rate in cubic feet per second (CFS)
C = Weighted "C" as shown below (unitless)
I = Rainfall Intensity as shown in Figure 8.1
A = Runoff Area in acres

Figure 8.1-2 denotes the terrain types present at Section One and are differentiated with distinct colors. Important to note that the hatched area, represents the drainage area for the east channels.

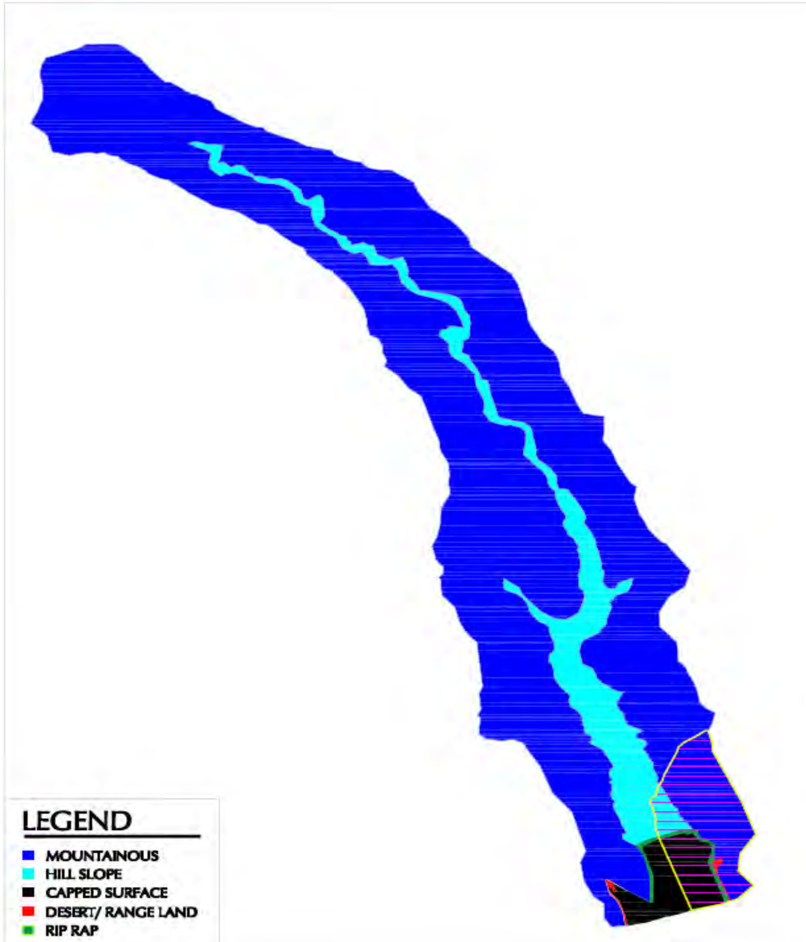


Figure 8.1-2 Types of Terrain Found for Section One.

Table 8.1-1 summarizes the distinct types of terrains and characteristics obtained from the calculated areas shown in Figure 8.1-2. The sources for the “C” Factors are discussed in the preparation of Table 6.0.

TYPE OF TERRAIN	"C" FACTOR	AREA (ACRE)	C x A
MONTAINOUS	0.95	82.79	78.65
HILLSLOPE	0.69	11.62	8.02
CAP SURFACE	0.88	1.86	1.64
DESERT/ RANGE LAND	0.88	0.10	0.09
RIP RAP	0.90	0.12	0.11
TOTAL	N/A	96.49	88.51

Table 8.1-1 Terrain Characteristics and Areas for Section One

The weighted “C” factor is then:

$$C_w = \frac{\sum(C \times A)}{\sum A}$$

$$C_w = \frac{88.51}{96.49} = 0.92$$

Use Rational Method:

$$Q = CiA$$
$$C = 0.92$$
$$i = 4.00\,\frac{in}{hr}$$
$$A = 96.49\ acres$$

$$Q = CiA = (0.92)(4.00)(96.49) = 355.08\ CFS$$

Capacity Provided: Drainage Channel Section One

A worse case location for Drainage Channel Section One has been identified as being located approximately 95 feet south of the protective rip-rap wall. At this location, the east bank and bottom of the channel consist of a double chip seal surface and the west bank is constructed out of 6” rip-rap rock. A cross-section of Drainage Channel Section One at this location is shown in Figure 8.1-3.

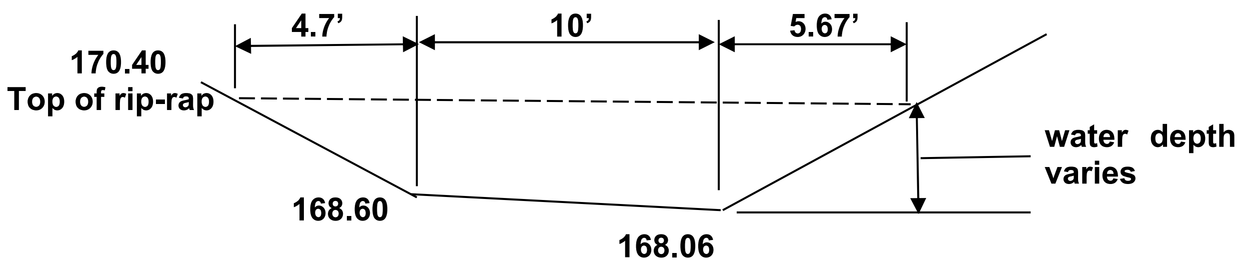


Fig. 8.1-3 Cross-Section Drainage Channel Section One, 95’ south, Looking North

The high-water elevation was calculated at the top of the rip-rap on the west bank of the drainage channel. Using the Manning’s Formula, the worst case, storm water carrying capacity for the Drainage Channel Section One is as Follows:

A = ½ (4.7’ x 1.80’) + (10’ x 1.80’) + ½ (10’ x 0.54’) + ½ (5.67’ x 2.34) = 31.56 sf
WP = 20.37’ R = A/WP = 31.56/20.37 = 1.5493 S = 0.73% N = 0.029 (N value weighted from N values for double chip seal surface (asphalt) and 6” rip-rap rock as shown on Tables 2.1 and 2.2, U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular No. 15, Third Edition (Publication No. FWHA-NHI-05-114, September 2005) Design of Roadside Channels with Flexible Linings.

Q = 1.49/N (A)(R)$^{2/3}$ S$^{1/2}$
Q = 1.49/0.029 (31.56) (1.5493)$^{2/3}$ (0.0073)$^{1/2}$
Q = 51.38 (31.56) (1.3389) (0.0854)
Q = 185.41 cfs

Velocity
185.41 cfs / 31.56 sf = 5.87 fps
Analysis
185.41 cfs provided < 355.08 cfs required.

Drainage Channel Section One (Option 1 – Additional 6" Rip-rap Rock, west bank)

The storm water carrying capacity provided at a worse case location of the Drainage Channel Section One, with a high-water elevation at the top of the rip-rap on the west bank of the drainage channel, is less than the required storm water carrying capacity required for a 100-year storm, calculated Tc = 24.11 minutes.

The grade break that defines the eastern limits of the east bank of the drainage channel is calculated to be approximately 11.33 feet east of the eastern edge of the calculated high-water elevation. Adding rip-rap rock to the west bank of the drainage channel will allow the high-water elevation to be raised. If the high-water elevation is raised by 0.85 feet, the drainage channel will have the storm water carrying capacity required for the above referenced storm. This revision will contain the storm water runoff within the drainage channel with the eastern edge of the high-water elevation calculated to be approximately 9.27 feet east of the existing eastern edge of the existing drainage channel. The revised drainage channel cross-section (Figure 8.1-4) and calculations are as follows:

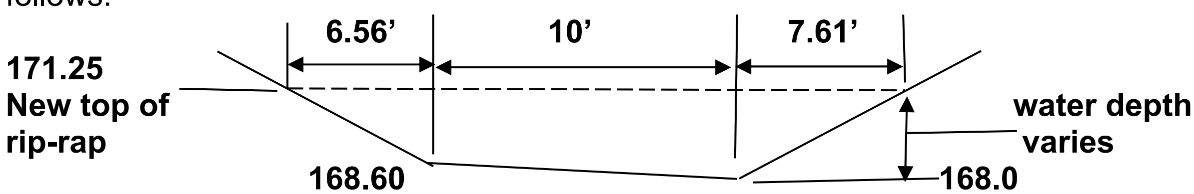


Fig. 8.1-4 Revised Cross-Section, Drainage Channel Section One, 95' south, Looking North

Using the Manning's Formula, the worst case, storm water carrying capacity for the Drainage Channel Section One is as Follows:

A = ½ (6.92' x 2.65') + (10' x 2.65') + ½ (10' x 0.54') + ½ (7.73' x 3.19) = 50.70 sf
WP = 24.65'
R = A/WP = 50.70/24.65 = 2.0568
S = 0.73%
N = 0.29 (As described above)

$Q = 1.49/N\ (A)(R)^{2/3}\ S^{1/2}$
$Q = 1.49/0.029\ (50.70)\ (2.0568)^{2/3}\ (0.0073)^{1/2}$
Q = 51.38 (50.70) (1.6174) (0.0854)
Q = 359.81 cfs

Velocity
359.81 cfs / 50.70 sf = 7.10 fps
Analysis
359.81 cfs provided > 355.08 cfs required.

8.2 Drainage Channel – Section Two

Time of Concentration – Section Two (Areas B1, & C1, Figure 5.0)

Area B1:

L = 293 ft (0.0555 mi)
K_b = 0.03 (Table 6.6, Maricopa Co. Drainage Policies and Standards)
S = $\frac{174-171}{0.0555} = 54.05$
i = 2.17 in/hr. (100-year, 60-minute storm, NOAA ATLAS 14, April 21, 2017)

$$T_{cB1} = 11.4L^{0.5}K_b^{0.52}S^{-0.31}i^{-0.38}$$
$$T_{cB1} = 11.4(0.0555)^{0.5}(0.03)^{0.52}(54.05)^{-0.31}(2.17)^{-0.38}$$
$$T_{cB1} = 0.0938\ hr = 5.63\ min$$

Area C1:

L = 436 ft (0.0826 mi)
K_b = 0.015 (Table 6.5, Maricopa Co. Drainage Policies and Standards)
S = $\frac{171-168}{0.0826} = 36.32$
i = 2.17 in/hr. (100-year, 60-minute storm, NOAA ATLAS 14, April 21, 2017)

$$T_{cC1} = 11.4L^{0.5}K_b^{0.52}S^{-0.31}i^{-0.38}$$
$$T_{cC1} = 11.4(0.0826)^{0.5}(0.015)^{0.52}(36.32)^{-0.31}(2.17)^{-0.38}$$
$$T_{cC1} = 0.0903\ hr = 5.42\ min$$

The total time of concentration is:

$$T_{C\ SECTION\ TWO} = t_{cB1} + t_{cC1} = 5.63\ min + 5.42\ min = 11.05\ min$$

The rainfall intensity from a 100-year storm correlating to this time of concentration was estimated to be 5.83 in/hr. using the Rainfall Intensity, Duration, Frequency Relationship for Yuma. This correlation and graph are shown in Figure 8.2-1.

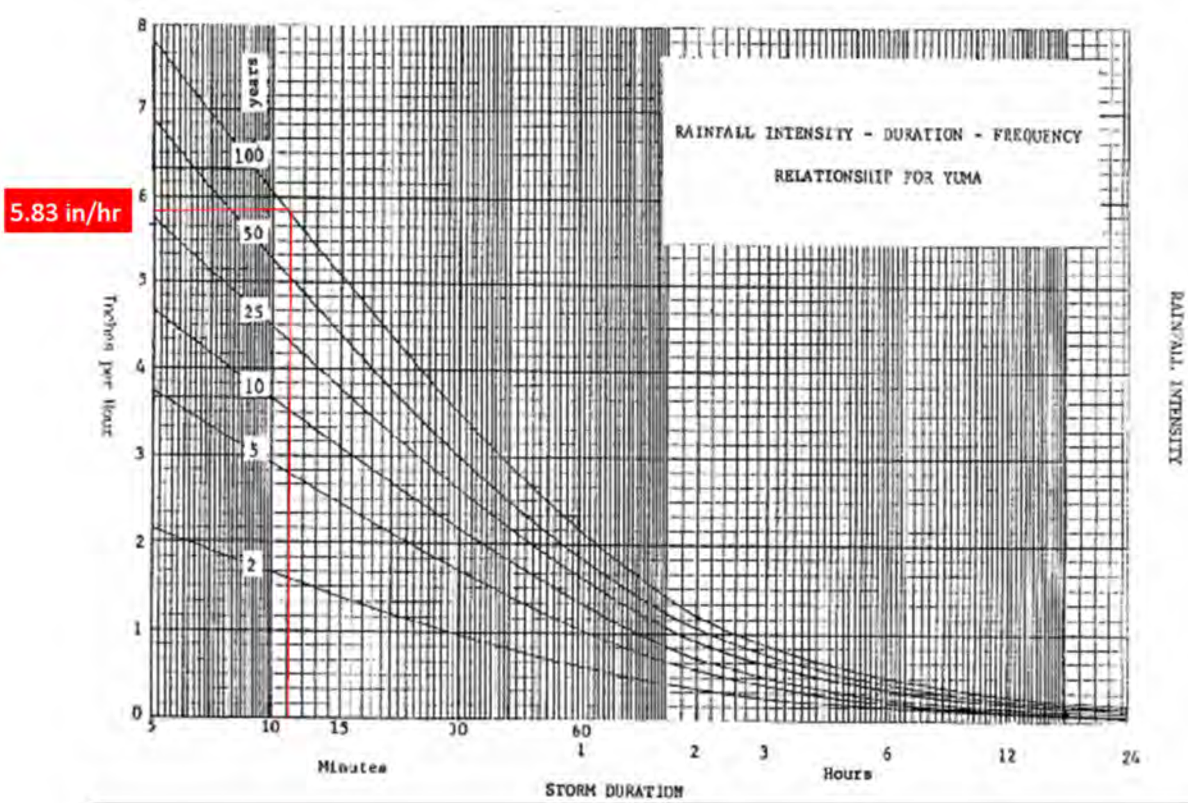


Figure 8.2-1 Rainfall Intensity - Duration – Frequency Relationship for Yuma (Section Two)

Storm water Runoff – Section Two:

The Public Works Standards for Yuma County, Volume III, Storm Drainage Facilities, August 21, 2006, Section 3.8 Open Channel Standards, Paragraph 3.8.1, states that open channels shall convey the 100-year storm peak runoff within the banks. The storm water runoff for Section One with a 100-year storm, calculated $T_c =$ 11.05 minutes is calculated using the Rational Method:

Q = CIA

Where: Q = Peak Runoff Rate in cubic feet per second (CFS)

C = Weighted "C" as shown below (unitless)

I = Rainfall Intensity as shown in Figure 8.5

A = Runoff Area in acres

Figure 8.2-2 Types of Terrain Found in Section Two (hatched area).

Table 8.2-1 summarizes the distinct types of terrains and characteristics obtained from the calculated areas shown in Figure 8.2-2. The sources for the “C” Factors are discussed in the preparation of Table 6.0.

TYPE OF TERRAIN	"C" FACTOR	AREA (ACRE)	C x A
MONTAINOUS	0.95	4.75	4.51
HILLSLOPE	0.69	0.66	0.46
CAP SURFACE	0.88	1.85	1.63
DESERT/ RANGE LAND	0.88	0.08	0.07
RIP RAP	0.90	0.21	0.19
TOTAL	N/A	7.55	6.86

Table 8.2-1 Terrain Characteristics and Areas for Section Two

The weighted “C” factor is then:

$$C_w = \frac{\sum(C \times A)}{\sum A}$$

$$C_w = \frac{6.86}{7.55} = 0.91$$

Use Rational Method:

$$Q = CiA$$
$$C = 0.91$$
$$i = 5.83 \frac{in}{hr}$$
$$A = 7.55\ acres$$

$$Q = CiA = (0.91)(5.83)(7.55) = 40.06\ CFS$$

Capacity Provided: Drainage Channel Section Two

A worse case location for Drainage Channel Section Two has been identified as being located approximately 260 feet south of the protective rip-rap wall. A cross-section of the drainage channel at this location is shown in Figure 8.2-3.

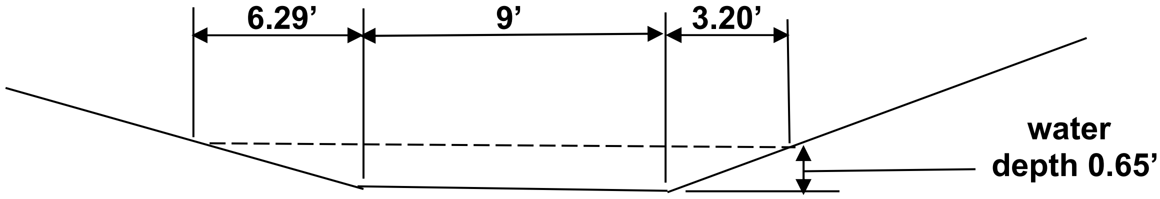


Figure 8.2-3 Cross-Section, Drainage Channel Section Two, 260' south, Looking North

Using the Manning's Formula, the worst case, storm water carrying capacity for the East Drainage Channel (Section Two) is as Follows:

A = ½ (6.29' x 0.65') + (9' x 0.65') + ½ (3.20' x 0.65) = 8.93 sf
WP = 18.49'
R = A/WP = 8.93/188888.49 = 0.4830
S = 0.70%
N = 0.016 (Tables 2.1, U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular No. 15, Third Edition (Publication No. FWHA-NHI-05-114, September 2005) Design of Roadside Channels with Flexible Linings.

$Q = 1.49/N\ (A)(R)^{2/3}\ S^{1/2}$
$Q = 1.49/0.016\ (8.93)\ (0.4830)^{2/3}(0.0070)^{1/2}$
Q = 93.13 (8.93) (0.6156) (0.0837)
Q = 42.85 cfs

Velocity
42.85 cfs / 8.93 sf = 4.80 fps
Analysis
42.85 cfs provided > 40.96 cfs required

The storm water carrying capacity provided at a worse case location of Drainage Channel Section Two, with a water depth of 0.65 feet is greater than the required storm water carrying capacity required for a 100-year storm, calculated Tc = 11.05 minutes.

The existing drainage channel will contain the storm water runoff within the drainage channel with the eastern edge of the high-water elevation calculated to be approximately 5.80 feet east of the eastern edge of the existing eastern edge of the existing drainage channel.

8.3 Drainage Channel – Section Three

Time of Concentration – Section Three (Areas A, B, C & D Figure 5.0)

Adding the time of concentration for Area D to the time of concentration calculated for Section One, as shown above, gives the time of concentration for Section Three:

Area D:

L = 333 ft (0.0631 mi)
K_b = 0.025 (Table 6.5, Maricopa Co. Drainage Policies and Standards)
S = $\frac{168-164}{0.0631} = 63.39$
i = 2.17 in/hr. (100-year, 60-minute storm, NOAA ATLAS 14, April 21, 2017)

$$T_{cD} = 11.4L^{0.5}K_b^{0.52}S^{-0.31}i^{-0.38}$$
$$T_{cD} = 11.4(0.0631)^{0.5}(0.025)^{0.52}(63.39)^{-0.31}(2.17)^{-0.38}$$
$$T_{cD} = 0.00866\,hr = 5.20\,min$$

Total time of concentration for Section Three is:

$$T_{C\,SECTION\,THREE} = T_{C\,SECTION\,ONE} + T_{cD} = 24.11\text{ min} + 5.20\,min = 29.31\,min$$

The rainfall intensity from a 100-year storm correlating to this time of concentration was estimated to be 3.58 in/hr. using the Rainfall Intensity, Duration, Frequency Relationship for Yuma. This correlation and graph are shown in Figure 8.3-1.

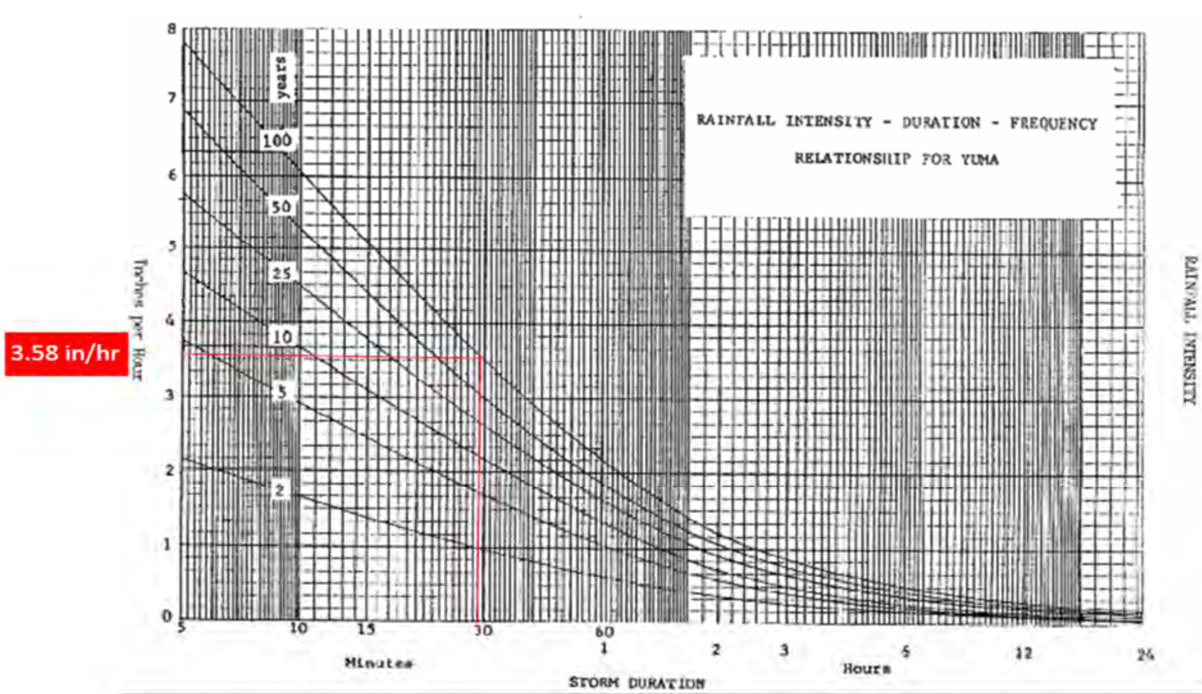


Figure 8.3-1 Rainfall Intensity - Duration – Frequency Relationship for Yuma (Section Three)

Storm water Runoff – Section Three:

The Public Works Standards for Yuma County, Volume III, Storm Drainage Facilities, August 21, 2006, Section 3.8 Open Channel Standards, Paragraph 3.8.1, states that open channels shall convey the 100-year storm peak runoff within the banks. The storm water runoff for Section Three with a 100-year storm, calculated T_c = 29.31 minutes is calculated using the Rational Method:

$$Q = CIA$$

Where: Q = Peak Runoff Rate in cubic feet per second (CFS)
C = Weighted "C" as shown below (unitless)
I = Rainfall Intensity as shown in Figure 8.8
A = Runoff Area in acres

Figure 8.9 denotes the terrain types present at the site and they are differentiated with distinct colors.

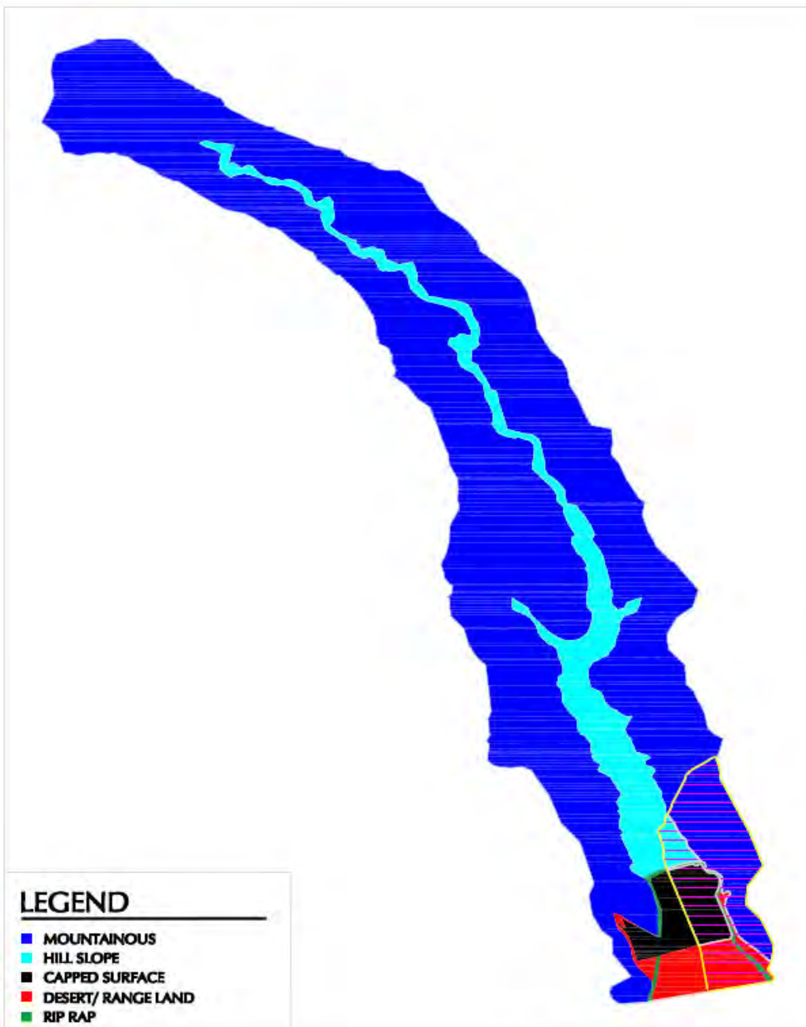


Figure 8.3-2 Types of Terrain Found in Section Three

Table 8.3-1 summarizes the distinct types of terrains and characteristics obtained from the calculated areas shown in Figure 8.3-2. The sources for the “C” Factors are discussed in the preparation of Table 6.0.

TYPE OF TERRAIN	"C" FACTOR	AREA (ACRE)	C x A
MONTAINOUS	0.95	83.5	79.33
HILLSLOPE	0.69	11.62	8.02
CAP SURFACE	0.88	1.86	1.64
DESERT/ RANGE LAND	0.88	1.58	1.39
RIP RAP	0.90	0.23	0.21
TOTAL	N/A	98.79	90.59

Table 8.3-1 Terrain Characteristics and Areas for Section Three

The weighted “C” factor is then:

$$C_w = \frac{\sum(C \times A)}{\sum A}$$

$$C_w = \frac{90.59}{98.79} = 0.92$$

Use Rational Method:

$$Q = CiA$$
$$C = 0.92$$
$$i = 2.42\,\frac{in}{hr}$$
$$A = 98.80\ acres$$

$$Q = CiA = (0.92)(3.58)(98.80) = 325.41\ CFS$$

Capacity Provided: Drainage Channel Section Three

A worse case location for Drainage Channel Section Three has been identified as being located approximately 195 feet south of the southern end of the capped section (Area C, Figure 5.0). This drainage channel consists of loos cobble and rip-rap (see Figure 9.5). A cross-section of the West Drainage Channel at this location is shown in Figure 8.3-3.

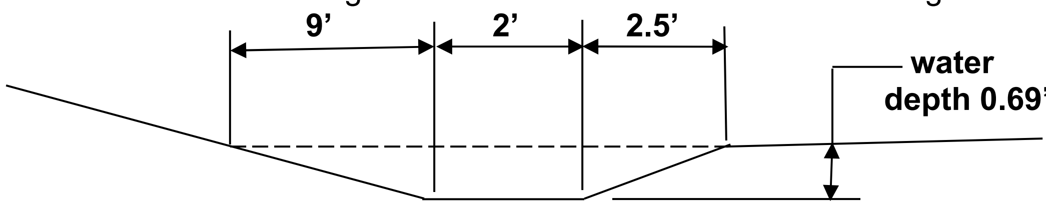


Figure 8.3-3 Cross-Section, Drainage Channel Section Three, 195’ south, Looking North

Using the Manning's Formula, the worst case, storm water carrying capacity for the West Drainage Channel (Section Three) is as Follows:

A = ½ (5.60' x 0.69') + (2' x 0.69') + ½ (2.5' x 0.60') = 4.17 sf
WP = 10.10'
R = A/WP = 4.17/10.10 = 0.4129
S = 1.22%   N = 0.062 (N value from Table7.7, Drainage Design Manual for Maricopa County, Arizona, December 14 ,2018)

$Q = 1.49/N\ (A)(R)^{2/3}\ S^{1/2}$
$Q = 1.49/0.062(4.17)\ (0.4129)^{2/3}(0.0122)^{1/2}$
Q = 24.03(4.17) (0.5545) (0.1105)
Q = 6.14 cfs

Velocity

6.14 cfs / 4.17 sf = 1.47 fps

Analysis

6.14 cfs provided < 325.41 cfs required

Drainage Channel Section Three (Option 1 – 6" Rip-rap Rock)

The storm water carrying capacity provided at a worse case location of Drainage Channel Section Three is less than the required storm water carrying capacity required for a 100-year storm, calculated Tc = 29.31 minutes.

A new drainage channel has been designed to have the storm water carrying capacity required for the above referenced storm. The revised drainage channel cross-section, using 6" rip-rap rock, (Figure 8.3-4) and calculations are as follows:

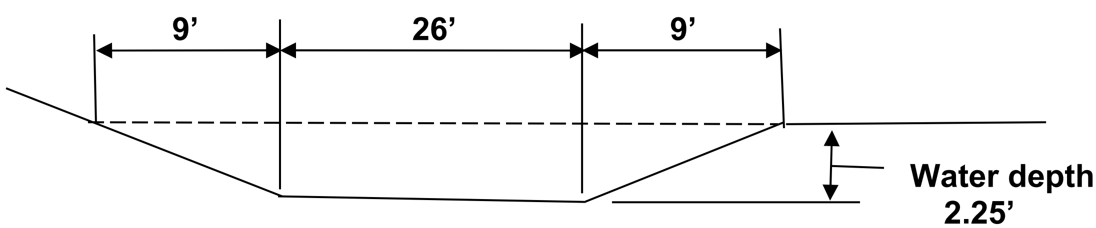


Figure 8.3-4 Cross-Section, Drainage Channel
Section Three (Option 1 - 6" rip-rap rock) Looking North

Use:

Q = 325.41 cfs
B = bottom width of channel = 26'
Z = side Slopes = 4
S_o = channel bottom slope = 0.0122 ft/ft
γ_s = unit weight of rip-rap rock = 165 lbs./sf

ɣ = unit weight of water = 62.4 lbs./sf

Assume $D_{50} = 0.50$'
Assume water depth = 2.25'

Using geometric properties of a trapezoid:

A = Bd+ Zd^2
= 26(2.25) + 4 (2.25^2)
= 58.50 + 20.25
= 78.75 sf

P = B + $2d\sqrt{Z^2+1}$
= 26 + $2\,(2.25)\sqrt{4^2+1}$
= 26 + 18.55
= 44.55'

R = A/P = 78.75/44.55 = 1.7677

T = B + $2dZ$ = 26 + 2 (2.25) (4) = 44

d_a = A/T = 78.75/44 = 1.7898

Relative depth ration: $\frac{da}{D_{50}} = \frac{1.7898}{0.50} = 3.5796$

Determine Manning's N value:

(HEC 15, 2005, Equation 6.1)

Use: $N = \frac{\alpha d_a^{0.1667}}{2.25+5.23log\left(\frac{da}{D_{50}}\right)}$

Where: N = Manning's roughness coefficient
d_a = average flow depth in the channel = 1.7898 ft
D_{50} = median rip-rap size = 0.50 ft
α = unit conversion constant = 0.262

$$N = \frac{\alpha d_a^{0.1667}}{2.25+5.23log\left(\frac{da}{D_{50}}\right)} = \frac{(0.262)1.7898^{0.1667}}{2.25+5.23log\left(\frac{1.7898}{0.50}\right)} =$$

$$\frac{0.2887}{2.25+5.23log(3.5796)} = \frac{0.2887}{5.1466} = 0.0561$$

Use Manning's equation to determine maximum flow for rip-rap $D_{50} = 0.50'$:

S = 1.22%, A = 50.00 sf, R = 1.4930, N = 0.0561

$Q = 1.49/N\ (A)(R)^{2/3}\ S^{1/2}$
$Q = 1.49/0.0561\ (78.75)\ (1.7677)^{2/3}\ (0.0122)^{1/2}$
Q = 26.46 (78.75) (1.4620) (0.1105)
Q = 336.63 cfs

Velocity

336.63 cfs / 78.75 sf = 4.27 fps

Analysis

336.63 cfs provided > 325.41 cfs required

Drainage Channel Section Three (Option 2 – shotcrete)

The storm water carrying capacity provided at a worse case location of Drainage Channel Section Three is less than the required storm water carrying capacity required for a 100-year storm, calculated Tc = 29.31 minutes.

A new drainage channel has been designed to have the storm water carrying capacity required for the above referenced storm. The revised drainage channel cross-section, using shotcrete, (Figure 8.3-5) and calculations are as follows:

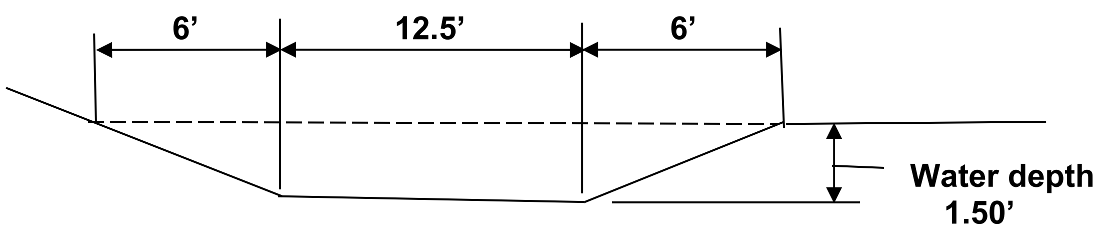


Figure 8.3-5 Cross-Section, Drainage Channel
Section Three (Option 2 - shotcrete) Looking North

Using the Manning's Formula, storm water carrying capacity for Drainage Channel Section Three (Option 2) is as Follows:

A = ½ (6' x 1.50') + (12.5' x 1.50') + ½ (6' x 1.50') = 27.75 sf

WP = 24.50'

R = A/WP = 27.75/24.50 = 1.1327
S = 1.22%

Q = 1.49/N (A)(R)$^{2/3}$ S$^{1/2}$
Q = 1.49/0.015(27.75) (1.1327)$^{2/3}$(0.0122)$^{1/2}$
Q = 99.33(27.75) (1.0866) (0.1105)
Q = 330.96 cfs

Velocity

330.96 cfs / 27.75 sf = 11.93 fps

Analysis

330.96 cfs provided > 325.41 cfs required

8.4 Drainage Channel – Section Four

Time of Concentration – Section Four (Areas B1, C1 & D1 Figure 5.0)

Adding the time of concentration for Area D1 to the time of concentration calculated for Section Two, as shown above, gives the time of concentration for Section Four:

Area D1:

L = 333 ft (0.0631 mi)
K_b = 0.025 (Table 6.5, Maricopa Co. Drainage Policies and Standards)
S = $\frac{168-164}{0.0631} = 63.39$
i = 2.17 in/hr. (100-year, 60-minute storm, NOAA ATLAS 14, April 21, 2017)

$$T_{cD1} = 11.4L^{0.5}K_b^{0.52}S^{-0.31}i^{-0.38}$$
$$T_{cD1} = 11.4(0.0631)^{0.5}(0.025)^{0.52}(63.39)^{-0.31}(2.17)^{-0.38}$$
$$T_{cD1} = 0.0866\ hr = 5.20\ min$$

Total time of concentration for Section Four is:

$$T_{C\ SECTION\ FOUR} = T_{C\ SECTION\ TWO} + t_{cD1} = 11.05 \text{ min} + 5.20\ min = 16.25\ min$$

The rainfall intensity correlating to the time of concentration was estimated to be 3.25 in/hr. using the Rainfall Intensity, Duration, Frequency Relationship for Yuma. This correlation and graph are shown in Figure 8.4-1.

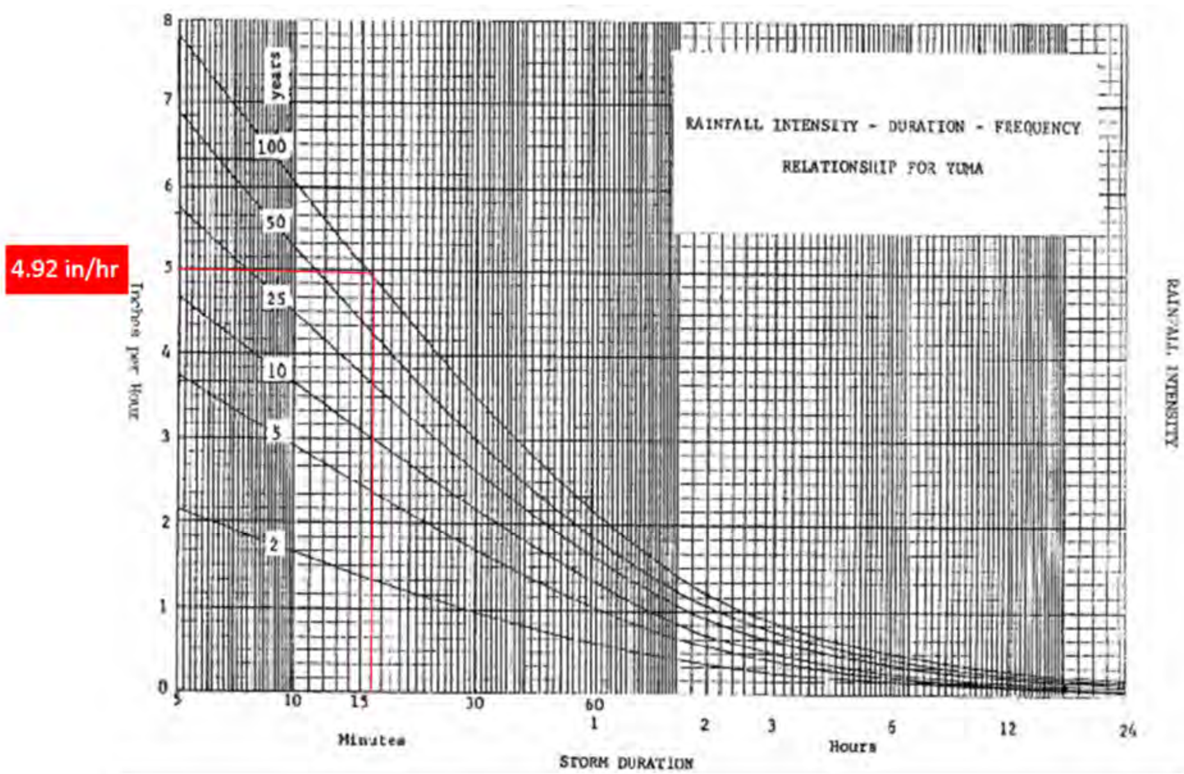


Figure 8.4-1 Rainfall Intensity - Duration – Frequency Relationship for Yuma (Section Four)

Storm water Runoff – Section Four:

The storm water runoff for Section Four with a 100-year storm, calculated T_c = 16.25 minutes is calculated using the Rational Method:

$$Q = CIA$$

Where: Q = Peak Runoff Rate in cubic feet per second (CFS)
C = Weighted "C" as shown below (unitless)
I = Rainfall Intensity as shown in Figure 8.12
A = Runoff Area in acres

Figure 8.4-2 Types of Terrain Found in Section Four (hatched area)

Table 8.4-1 summarizes the distinct types of terrains and characteristics obtained from the calculated areas shown in Figure 8.4-2. The sources for the "C" Factors are discussed in the preparation of Table 6.0.

TYPE OF TERRAIN	"C" FACTOR	AREA (ACRE)	C x A
MONTAINOUS	0.95	5.16	4.90
HILLSLOPE	0.69	0.66	0.46
CAP SURFACE	0.88	1.85	1.63
DESERT/ RANGE LAND	0.88	1.66	1.46
RIP RAP	0.90	0.39	0.35
TOTAL	N/A	9.72	8.80

Table 8.4-1 Terrain Characteristics and Areas for Section Four.

The weighted "C" factor is then:

$$C_w = \frac{\sum(C \times A)}{\sum A}$$

$$C_w = \frac{8.80}{9.72} = 0.91$$

Use Rational Method:

$$Q = CiA$$
$$C = 0.91$$
$$i = 4.92 \frac{in}{hr}$$
$$A = 9.72\ acres$$

$$Q = CiA = (0.91)(4.92)(9.72) = 43.52\ CFS$$

Capacity Provided: Drainage Channel Section Four

A worse case location for Drainage Channel Section Four has been identified as being located approximately 90 feet south of the southern end of the capped section (Area C, Figure 5.0). This drainage channel consists of loos cobble and rip-rap (see Figure 9.6). This A cross-section of Drainage Channel at this location is shown in Figure 8.4-3.

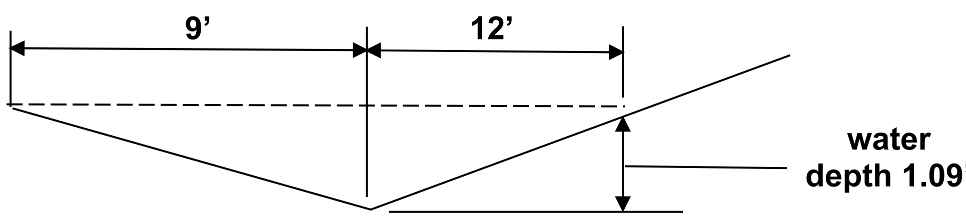


Figure 8.4-3 Cross-Section, Drainage Channel Section Four, 90' south, Looking North

Using the Manning's Formula, the worst case, storm water carrying capacity for the East Drainage Channel – Section Four is as Follows:

A = ½ (9' x 1.09') + ½ (12' x1.09) = 11.45 sf
WP = 21'
R = A/WP = 11.45/21 = 0.5452
S = 1.15%   N = 0.062 (N value from Table7.7, Drainage Design Manual for Maricopa County, Arizona, December 14 ,2018)

$Q = 1.49/N (A)(R)^{2/3} S^{1/2}$
$Q = 1.49/0.062(11.45) (0.6674)^{2/3}(0.0115)^{1/2}$
Q = 24.03(11.45) (0.6674) (0.1072)
Q = 19.69 cfs

Velocity

19.69 cfs / 11.45 sf = 1.72 fps

Analysis

19.69 cfs provided < 43.52 cfs required

Drainage Channel Section Four (Option 1 – 6" Rip-rap Rock)

The storm water carrying capacity provided at a worse case location of Drainage Channel Section Four is less than the required storm water carrying capacity required for a 100-year storm, calculated Tc = 16.25 minutes.

A new drainage channel has been designed to have the storm water carrying capacity required for the above referenced storm. The revised drainage channel cross-section, using 6" rip-rap rock, (Figure 8.4-4) and calculations are as follows:

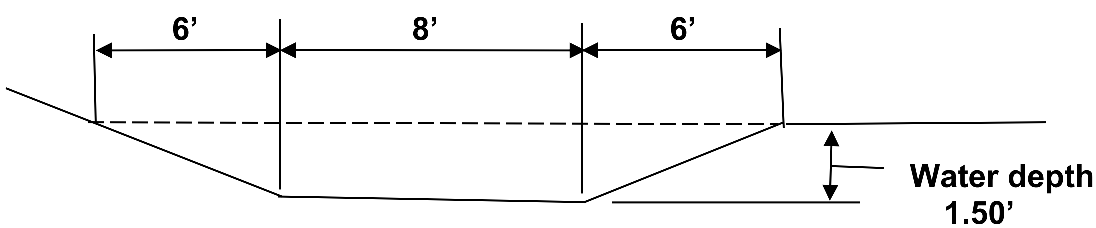


Figure 8.4-4 Cross-Section, Drainage Channel Section Four
(Option 1 - 6" rip-rap rock) Looking North

Use:

Q = 43.52 cfs
B = bottom width of channel = 8'
Z = side Slopes = 4
S_o = channel bottom slope = 0.0115 ft/ft
γ_s = unit weight of rip-rap rock = 165 lbs./sf

ɣ = unit weight of water = 62.4 lbs./sf
Assume $D_{50} = 0.50$’
Assume water depth = 1.50’

Using geometric properties of a trapezoid:

A = Bd+ Zd^2
= 8(1.50) + 4 (1.50^2)
= 12 + 9
= 21.00 sf

P = B + $2d\sqrt{Z^2+1}$
= 8 + $2\,(1.50)\sqrt{4^2+1}$
= 8 + 12.37
= 20.37’

R = A/P = 21.00/20.37 = 1.0309

T = B + $2dZ$ = 8 + 2 (1.50) (4) = 20

d_a = A/T = 21.00/20.00 = 1.0500

Relative depth ration: $\frac{da}{D_{50}} = \frac{1.0500}{0.50}$ = 2.100

Determine Manning’s N value:

(HEC 15, 2005, Equation 6.1)

Use: $$N = \frac{\alpha d_a^{0.1667}}{2.25+5.23log\left(\frac{da}{D_{50}}\right)}$$

Where: N = Manning’s roughness coefficient
d_a = average flow depth in the channel = 2.6042 ft
D_{50} = median rip-rap size = 0.50 ft
α = unit conversion constant = 0.262

$$N = \frac{\alpha d_a^{0.1667}}{2.25+5.23log\left(\frac{da}{D_{50}}\right)} = \frac{(0.262)1.0500^{0.1667}}{2.25+5.23log\left(\frac{1.0500}{0.50}\right)} =$$

$$\frac{0.2641}{2.25+5.23log(2.100)} = \frac{0.2641}{3.9352} = 0.0671$$

Use Manning's equation to determine maximum flow for rip-rap $D_{50} = 0.50'$:

S = 1.15%, A = 21.00 sf, R = 1.0309, N = 0.0671

$Q = 1.49/N\ (A)(R)^{2/3}\ S^{1/2}$
$Q = 1.49/0.0671\ (21.00)\ (1.0309)^{2/3}\ (0.0115)^{1/2}$
Q = 22.21 (21.00) (1.0205) (0.1072)
Q = 51.02 cfs

Velocity

51.02 cfs / 21.00 sf = 2.43 fps

Analysis

51.02 cfs provided > 43.52 cfs required

Drainage Channel Section Four (Option 2 – shotcrete)

The storm water carrying capacity provided at a worse case location of Drainage Channel Section Four is less than the required storm water carrying capacity required for a 100-year storm, calculated Tc = 16.25 minutes.

A new drainage channel has been designed to have the storm water carrying capacity required for the above referenced storm. The revised drainage channel cross-section, using shotcrete, (Figure 8.4-5) and calculations are as follows:

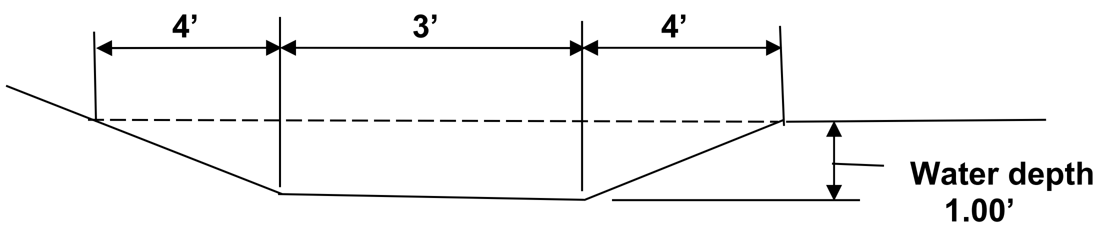


Figure 8.4-5 Cross-Section, Drainage Channel Section Four
(Option 2 – shotcrete) Looking North

Using the Manning's Formula, storm water carrying capacity for Drainage Channel Section Four (Option 2) is as Follows:

A = ½ (4' x 1.00') + (3' x 1.00') + ½ (4' x 1.00') = 7.0 sf
WP = 11'
R = A/WP = 7.0/11.0 = 0.6364
S = 1.15%
$Q = 1.49/N\ (A)(R)^{2/3}\ S^{1/2}$
$Q = 1.49/0.015(7.0)\ (0.6364)^{2/3}(0.0115)^{1/2}$
Q = 99.33(7.0) (0.7399) (0.1072)
Q = 55.15 cfs

Velocity

55.15 cfs / 7.0 sf = 7.88 fps

Analysis

55.15 cfs provided > 43.52 cfs required

9.0 Protective Rip-Rap Wall Analysis

9.1 Overview

Chapter 5 of the U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular No. 23, Volume 1 - (Publication No. FWHA-NHI-09-111, September 2009) Bridge Scour and Stream Instability Countermeasures: Experience, Selection, and Design Guidance – Third Edition, states: rip-rap consists of a layer or facing of rock, dumped or hand-placed on channel and structure boundaries to limit the effects of erosion. It is the most common type of countermeasure due to its general availability, ease of installation and relatively low cost. Rip-rap design must account for several possible modes of failure. These include rip-rap particle erosion, substrate material erosion and mass failure.

9.2 Failure Modes

Particle Erosion:

Particle erosion is the most considered erosion mechanism. Particle erosion occurs when individual particles are dislodged by the hydraulic forces generated by the flowing water. Particle erosion can be initiated by abrasion, impingement of flowing water, eddy action/reverse flow, local flow acceleration, freeze/thaw action, ice, or toe erosion. Probable causes of particle erosion include: (1) stone size not large enough; (2) individual stones removed by impact or abrasion; (3) side slope of the bank so steep that the angle of repose of the rip-rap material is easily exceeded; and (4) gradation of rip-rap too uniform. (DOT 2009, Vol. I)

Rip-rap particle erosion is minimized by sizing the rip-rap to withstand hydraulic and turbulence forces. Calculations for sizing the rock for the rip-rap wall can be found in Section 11.2 of this report. A site inspection to assess the steepness of the bank, gradation of rip-rap and inspect for missing stones is discussed in Section 10.0 of this report.

Substrate Particle Erosion:

Substrate particle erosion occurs when the base material erodes and migrates through the rip-rap voids causing the rip-rap to settle.

Substrate particle erosion is limited by placing a granular or geotextile filter between the rip-rap and the base material. A site inspection to evaluate the existing filter of the rip-rap wall is discussed in Section 10.0 of this report.

Mass Failure:

Mass failure occurs when large sections of the rip-rap and/or base material slide or slump due to gravity forces. Mass failure can be caused by excess pore water pressures, bank steepness and loss of basal support through scour or channel migration. Also, a filter fabric that is too fine can clog and cause the buildup of pore water pressures in the underlying soil. Rip-rap that is large enough to resist all the hydraulic forces can fail if channel migration or scour undermines the toe support. Scour calculations are shown below:

The following calculations estimate the scour depth of a transverse structure. Storm water flow characteristics for the channel north of the protective rip-rap wall are used to determine the scour depth. A worse case water depth is estimated to be 1.0 feet.

Q = 355 cfs, Depth = 1.00 ft., Velocity = 2.45 ft/s

Several commonly used countermeasures for channel instability or scour protection project transversely into the flow (e.g., spurs, dikes, and jetties) or intercept overbank flow as it returns to the main channel (e.g., guide banks). Estimating scour at the nose of these structures is critical to successful design. Equation 4.1 (DOT 2009, Vol I) is used when the projecting embankment/abutment length is large in relation the flow depth.

Use: $\frac{\boldsymbol{a}}{\boldsymbol{y_1}} > 25$

Where: a = structure length projecting normal to the flow = 85 ft
y_1 = average upstream flow depth in the main channel or on the overbank outside the influence of the structure = 1.0 ft

$$\frac{\mathbf{85}}{\mathbf{1.0}} = \mathbf{85}$$

Calculate Froude Number:

Use: $F_r = \frac{V}{(gy)^{½}}$

Where: V = average velocity = 2.45 ft/s
g = gravity = 32 ft/ s^2
y_1 = depth of flow = 1.00 ft

$$F_r = \frac{2.45}{(32 \ x \ 1.00)^{½}} = 0.4331$$

Since $\frac{a}{y_1}$ **>** 25 use Equation 4.1 (DOT 2009, Vol. I)

Use: $\frac{y_s}{y_1} = 4F_r^{\,0.33}$

Where: y_s = equilibrium depth of scour (measured from the mean bed level to the bottom of the scour hole), ft

y_1 = average upstream flow depth in the main channel or on the overbank outside the influence of the structure = 1.0 ft

F_r = upstream Froude Number outside the influence of the structure = 0.4331

$\frac{y_s}{1.0} = 4(0.4331^{0.33})$ = 3.03 ft.

Overtopping:

Chapter 4 (DOT 2009) recommends that rip-rap to be placed on the bank to an elevation at least 2.0 feet greater than the design high water level. As stated above a worse case water depth is estimated to be 1.0 feet. Therefore, a rip-rap wall height of 3.0 feet is recommended. A site inspection to evaluate the height is discussed in Section 10.0 of this report.

10.0 Site Inspection

The protective capped area shown as Areas C and C1 in Figure 5.0 is protected from erosion caused by storm water runoff with a protective rip-rap wall located at the north end of the capped area.

Inspection of rip-rap placement typically consists of visual inspection of the installation procedures and the finished surface. Since the existing rip-rap wall was installed without NEI's on-site inspection and as-built drawings from the construction of the existing rip-rap wall could not be obtained, this report includes a visual inspection of the finished surface only.

A visual inspection of the existing wall observed a dense, rough surface of well-keyed, graded rock, placed such that voids were minimized (Figures 10.0 thru 10.3). Further inspection is required to determine the thickness of the rip-rap blanket and to determine if a filter material was installed.

Guidance for inspecting rip-rap presented in the National Highway Institute (NHI) training course 135047, "Stream Stability and Scour at Highway Bridges for Bridge Inspectors" was followed as shown below:

1. Rip-rap should be angular and interlocking.

   No flat sections of broken concrete or rounded rock was observed.

2. Rig-rap should have a granular or synthetic geotextile filter between the rip-rap and the subgrade material.

   Further inspection is required to determine what type or if a filter material was installed.

3. Rip-rap should be well graded.

   The existing rip-rap appeared to be well graded with a rock size of approximately D_{50} = 10”.

The existing rip-rap wall was also inspected for indicators of problems as follows:

1. Has rip-rap been displaced downstream?

   No signs of displacement were observed.

2. Has angular rip-rap blanket slumped down slope?

   No signs of slumping were observed.

3. Has angular rip-rap material been replaced over time by smoother river run material?

   No river run material was observed in the rip-rap wall.

4. Has rip-rap material physically deteriorated, disintegrated, or been abraded over time?

   No deterioration was observed.

5. Are there holes in the rip-rap blanket where the filter has been exposed or breached?

   No holes in the rip-rap wall were observed.

Figure 10.0 Protective Rip-rap Wall
Looking South (10-03-2018)

Figure 10.1 Protective Rip-rap Wall
Looking East (10-03-2018)

Figure 10.2 Protective Rip-rap Wall
Looking South (10-03-2018)

Figure 10.3 Protective Rip-rap Wall
Rip-Rap Size (10-03-2018)

A site inspection of the protective capped area (Areas C & C1, Fig. 5.0) and drainage channel Sections One and Two (Figure 8.0) showed little signs of erosion (Figures 10.4 & 10.5). However, the north end of the drainage channels Sections One and Two (Fig. 8.0) located on either side of the protective rip-rap wall showed signs of erosion (Figure 10.6). Drainage channel Sections Three and Four (Fig. 8.0) were inspected and they were not well defined and showed signs of erosion (Figures 10.7 & 10.8). The desert area between the capped area and retention basins (Areas D & D1, Fig. 5.0) showed signs of erosion (Figure 10.9).

Fig. 10.4 Drainage Channel Section One (Capped Area) – Looking North (10-03-2018)

Fig. 10.5 Drainage Channel Section Two (Capped Area) – Looking South (10-03-2018)

Figure 10.6 North End of Drainage Channel Section One – Looking East (10-03-2018)

Fig. 10.7 Drainage Channel Section Three Looking North (10-04-2018)

Fig. 10.8 Drainage Channel Section Four Looking South (10-04-2018)

Fig. 10.9 East Side of Desert Area - Looking North (10-03-2018)

11.0 Rip-Rap Calculations

11.1 Size New Rip-Rap Rock for Drainage Channels

New rip-rap was designed to improve the north and south ends of drainage channel Sections One and Two and to replace drainage channels Sections Three and Four. It was determined that drainage channel Section One is a worse case location for the design of the new rip-rap as that location has the highest velocity and Q value. The calculations to size the new rip-rap have been prepared in accordance with Chapter 6, Section 6.3.1 of the U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular No. 15, Third Edition (Publication No. FWHA-NHI-05-114, September 2005) Design of Roadside Channels with Flexible Linings as follows:

Use:

Q = 355 cfs
B = bottom width of channel = 10’
Z = side Slopes = 2.58
S_o = channel bottom slope = 0.0073 ft/ft
γ_s = unit weight of rip-rap rock = 165 lbs./sf
γ = unit weight of water = 62.4 lbs./sf
Assume D_{50} = 0.50’
Assume water depth = 3.90’

Using geometric properties of a trapezoid:

A = Bd+ Zd^2
= 10(3.90) + 2.58 (3.90^2)
= 39.00 + 39.24
= 78.24 sf

P = B + $2d\sqrt{Z^2 + 1}$
= 10 + $2\ (3.90)\sqrt{2.58^2 + 1}$
= 10 + 21.58
= 31.58'

R = A/P = 78.24/31.58 = 2.4775

T = B + $2dZ$ = 10 + 2 (3.90) (2.58) = 30.12

d_a = A/T = 78.24/30.12 = 2.5976

Relative depth ratio: $\frac{da}{D_{50}}$ = $\frac{2.5976}{0.50}$ = 5.1952

Determine Manning's N value:

(HEC 15, 2005, Equation 6.1)

Use: $$N = \frac{\alpha d_a^{0.1667}}{2.25+5.23log\left(\frac{da}{D_{50}}\right)}$$

Where:
N = Manning's roughness coefficient
d_a = average flow depth in the channel = 2.5976 ft
D_{50} = median rip-rap size = 0.50 ft
α = unit conversion constant = 0.262

$$N = \frac{\alpha d_a^{0.1667}}{2.25+5.23log\left(\frac{da}{D_{50}}\right)} = \frac{(0.262)2.5976^{0.1667}}{2.25+5.23log\left(\frac{2.5976}{0.5}\right)} =$$

$$\frac{0.3072}{2.25+5.23log(5.1952)} = \frac{0.3072}{5.9926} = 0.0513$$

Use Manning's equation to determine maximum flow for rip-rap D_{50} = 0.50':

S = 0.73%, A = 78.24 sf, R = 2.4775, N = 0.0513

Q = 1.49/N (A)(R)$^{2/3}$ S$^{1/2}$
Q = 1.49/0.0513 (78.24) (2.4775)$^{2/3}$ (0.0073)$^{1/2}$
Q = 29.04 (78.24) (1.8310) (0.0854)
Q = 355.28 cfs

Analysis

355 cfs required = 355.28 cfs estimated
Estimated value is within 5% of the design Q value.

Shear Velocity

(HEC 15, 2005, Equation 6.10)

Use: $V_* = \sqrt{gdS}$

Where: V_* = shear velocity, ft/s
g = gravitational acceleration = 32.2 ft/s^2
d = maximum channel depth = 3.90 ft
S = channel bottom slope = 0.0073 ft/ft

$V_* = \sqrt{gdS} = \sqrt{(32.2)(3.90)(0.0073)}$ = 0.9575 ft/s

Reynold's Number

(HEC 15, 2005, Equation 6.9)

Use: $R_e = \frac{V_* D_{50}}{\text{v}}$

Where: R_e= particle Reynold's number, dimensionless
V_* = shear velocity = 0.9575 ft/s
v = kinematic viscosity = 1.217 x 10^{-5}

$R_e = \frac{V_* D_{50}}{\text{v}} = \frac{(0.9575)(0.5)}{1.217 \text{ x } 10{-}5}$ = 3.9 x 10^4

Since $R_e \leq$ 4 x 10^4, F_* = 0.047, SF = 1.0 and the channel slope is less than 5% use the following to calculate minimum stable D_{50}:

SG = $\frac{\gamma_s}{\gamma_w} = \frac{165}{62.4}$ = 2.64

(HEC 15, 2005, Equation 6.8)

$$D_{50} = \frac{SFdS_o}{F_*(SG-1)} = \frac{(1)(3.90)(0.0073)}{(0.047)(2.64-1)} = 0.37 \text{ ft}$$

Since 0.37 feet is the minimum allowable size of rip-rap rock use D_{50} = 0.50 ft (6")

Determine maximum depth of flow in channel for rip-rap D_{50} = 0.50':

(HEC 15, 2005, Equation 3.10)

Use: $d \leq \frac{t_p}{(SF)\,\gamma\,S_o}$

Where:
d = depth of flow in channel
t_p = permissible shear stress for the channel lining
rip-rap D_{50} = 0.50' has a permissible shear stress of t_p = 2.41 lbs/sf (shown below)
γ = unit weight of water, lbs/sf
S_o = channel bottom slope, ft/ft
SF = safety factor = 1.0

$$d \leq \frac{t_p}{(SF)\,\gamma\,S_o} = \frac{2.41}{(1.0)\,(62.4)(0.0073)} = 5.29'$$

Analysis

3.49' maximum depth of flow > 3.23 estimated above

Permissible shear stress for D_{50} = 0.50 ft (6"):

(HEC 15, 2005, Equation 6.7)

Use: $t_p = F_*(\gamma_s - \gamma)D_{50}$

Where:
t_p = permissible shear stress for the channel lining
F_* = Shield's parameter, dimensionless
γ_s = specific weight of the stone, lbs/sf
γ = specific weight of water, lbs/sf
D_{50} = mean rip-rap size, ft

$$t_p = F_*(\gamma_s - \gamma)D_{50} = 0.047(165 - 62.4)0.50 = 2.41 \text{ lbs/sf}$$

11.2 Rip-Rap Rock for Protective Rip-Rap Wall

The following calculations estimate the adequacy of the existing rip-rap blanket for the protective rip-rap wall. Storm water flow characteristics for the western half of the wall is used, as it has been determined to be a worse case location.

Determine Set Back Ratio:

Since the protective rip-rap wall extends west to the northern end of the Western Drainage Channel - Section One (Figure 8.0), the Set Back Ratio (SBR) equals zero and since the SBR < 5 the storm water flow characteristics of the Western Drainage Channel – Section One will be used for these calculations.

Q = 355 cfs, Depth = 3.25 ft., Velocity = 7.10 ft/s

Calculate Froude Number:

Use: $F_r = \frac{V}{(gy)^{½}}$

Where: V = average velocity = 7.10 ft/s
g = gravity = 32 ft/ s^2
y = depth of flow = 3.25 ft

$$F_r = \frac{7.10}{(32\ x\ \ 3.25)^{½}} = 0.70$$

Since F_r < 0.80 use Equation 14.1 from Section 14.3, Design Guide 14 (DG14) of the U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular No. 23, Volume 2 - (Publication No. FWHA-NHI-09-112, September 2009) Bridge Scour and Stream Instability Countermeasures: Experience, Selection, and Design Guidance – Third Edition, as follows:

Use: $\frac{D_{50}}{y} = \frac{K}{(S_s - 1)}\left(\frac{V^2}{gy}\right)$

Where: D_{50} = mean rip-rap size, ft
V = characteristic average velocity in the contracted section = 7.10 ft/s
S_s = specific gravity of rip-rap rock = 2.65
g = gravity = 32 ft/ s^2
y = depth of flow = 3.25 ft
K = 0.89 for spill through abutment

$$\frac{D_{50}}{3.25} = \frac{0.89}{(2.65-1)}\left(\frac{7.10^2}{(32)\ 3.25}\right) = \frac{0.89}{1.65}\left(\frac{50.4100}{104.000}\right) = 0.5394(0.4847) = 0.2615$$

$$D_{50} = 0.2615(3.25) = 0.8497 \text{ ft}$$

Determine rip-rap extents:

Use Step 6 of DG14.

- Extend rip-rap into floodplain 2(depth of flow) = 2(3.25) = 6.5 ft
- Vertical extent of rip-rap = depth of flow + 2’ = 3.25’ + 2’ = 5.25 ft
- Rip-rap blanket thickness = 1.5(D_{50}) = 1.5(0.85’) = 1.28 ft

12.0 Conclusions and Recommendations

12.1 Storm water Runoff - Volume

The existing stormwater retention basins have the capacity to retain approximately 16% of the stormwater runoff generated by the entire site for a 100-year, 2-hour storm. However, the storm water retention capacity of both existing retention basins combined is approximately 6 times the capacity required to retain the storm water runoff from the capped surface. A portion of the excess storm water runoff generated by the entire site leaving the existing retention basins is retained by Adair Park Road at the southern boundary of the site. Using an AutoCAD – Civil 3D surface model to calculate the stormwater storage capacity of the site with a low point of Adair Park Road as an outfall elevation; the percentage of storm water runoff from the entire site retained on site before overflow occurs at Adair Park Road is approximately 30%.

12.2 Storm water Runoff - Drainage Channels

Section One:

Drainage Channel Section One is located on the west side of Area C (Fig. 5.0). It originates at the north end of the capped surface and runs south to the south end of the capped surface. In Section 8.1, the storm water carrying capacity of Drainage Channel Section One was calculated at a worse case location. It was determined that at that location it did not have the capacity to carry the storm water runoff for a 100-year storm, calculated Tc = 24.11 minutes.

To increase the storm water carrying capacity of drainage channel Section One; it is recommended that additional 6” rip-rap rock be installed at the west bank of drainage channel Section One. A revised channel for Drainage Channel Section One was sized in “Drainage Channel Section One (Option 1 – Additional 6” Rip-Rap Rock, west bank)” of Section 8.1 and a revised cross-section for Drainage Channel Section One is shown in Figure 8.1-4. The new 6” rip-rap rock was sized in Section 9.1.

A site inspection of Drainage Channel Section One, showed little signs of erosion (Figures 9.2 & 9.3). However, the north end of Drainage Channel Section One located on the west side of the protective rip-rap wall showed signs of erosion (Figure 9.4).

To repair the erosion of the drainage channel; it is recommended that new 6” rip-rap rock be installed at the north and south ends of Drainage Channel Section One.

Section Two:

Drainage Channel Section Two is located within Area C1 (Fig. 5.0). It originates at the north end of the capped surface and runs south to the south end of the capped surface. In Section 8.1, the storm water carrying capacity of Drainage Channel Section Two was calculated at a worse case location. It was determined that at that location it has the capacity to carry the storm water runoff for a 100-year storm, calculated Tc = 11.05 minutes.

A site inspection of Drainage Channel Section Two, showed little signs of erosion (Figures 9.2 & 9.3).

However, to prevent erosion of the north and south ends of Drainage Channel Section Two; it is recommended that new 6" rip-rap rock be installed at the north and south ends of the drainage channel. New rip-rap rock was sized in Section 9.1.

Section Three:

Drainage Channel Section Three is located within Area D (Fig. 5.0). It originates at the south end of the capped surface and runs south through the desert area to the existing retention basin located on the west side of Area E (Fig. 5.0). In Section 8.3 the storm water carrying capacity of Drainage Channel Section Three was calculated at a worse case location. It was determined that at that location it did not have the capacity to carry the storm water runoff for a 100-year storm, calculated Tc = 29.31 minutes. Also, a site inspection of Drainage Channel Section Three, showed signs of erosion (Fig. 9.5).

To repair the erosion and increase the storm water carrying capacity of Drainage Channel Section Three, it is recommended that the drainage channel be reconstructed. Two options have been presented: Option 1 - 6" rip-rap rock and Option 2 – shotcrete. A revised channel for Drainage Channel Section Three was sized in "Drainage Channel Section Three (Option 1 – 6" Rip-Rap Rock)" of Section 8.3 and a revised cross-section for Drainage Channel Section Three (Option 1) is shown in Figure 8.3-4. The new 6" rip-rap rock was sized in Section 9.1. To reduce maintenance costs, a second revised channel for Drainage Channel Section Three was sized in "Drainage Channel Section

Three (Option 2 – shotcrete)" of Section 8.3 and a revised cross-section for Drainage Channel Section Three (Option 2) is shown in Figure 8.3-5.

Both options have the capacity to carry the storm water runoff for a 100-year storm, calculated Tc = 29.31 minutes. Preliminary construction cost estimates for Option 1 – 6" rip-rap rock, Option 2 – shotcrete and have been prepared. The preliminary costs for both options are as follows:

Option 1 – 6" rip-rap rock	$ 49,350.90 (includes estimated costs for 10-years of maintenance)
Option 2 – 4" shotcrete	$ 121,464.53

Section Four:

Drainage Channel Section Four is located within Area D1 (Fig. 5.0). It originates at the south end of the capped surface and runs south through the desert area to the existing retention basin located on the east side of Area E (Fig. 5.0). In Section 8.4 the storm water carrying capacity of Drainage Channel Section Four was calculated at a worse case location. It was determined that at that location it did not have the capacity to carry the storm water runoff for a 100-year storm, calculated Tc = 16.25 minutes. Also, a site inspection of Drainage Channel Section Four, showed signs of erosion (Fig. 9.6 & Fig. 9.7).

To repair the erosion and increase the storm water carrying capacity of Drainage Channel Section Four, it is recommended that the drainage channel be reconstructed. Two options have been presented: Option 1 - 6" rip-rap rock and Option 2 – concrete. A revised channel for Drainage Channel Section Four was sized in "Drainage Channel Section Four (Option 1 – 6" Rip-Rap Rock)" of Section 8.4 and a revised cross-section for Drainage Channel Section Four is shown in Figure 8.4-4. The new 6" rip-rap rock was sized in Section 9.1. To reduce maintenance costs, a second revised channel for Drainage Channel Section Four was sized in "Drainage Channel Section Four (Option 2 – shotcrete)" of Section 8.4 and a revised cross-section for Drainage Channel Section Four (Option 2) is shown in Figure 8.4-5.

Both options have the capacity to carry the storm water runoff for a 100-year storm, calculated Tc = 16.25 minutes. Preliminary construction cost estimates for Option 1 – 6" rip-rap rock, Option 2 – shotcrete have been prepared. The preliminary costs for both options are as follows:

Option 1 – 6" rip-rap rock	$ 49,350.90 (includes estimated costs for 10-years of maintenance)
Option 2 – 4" shotcrete	$ 70,150.80

12.3 Protective Rip-rap Wall

The north end of the protective capped area shown as Areas C and C1 in Figure 5.0 is protected from erosion caused by storm water runoff with a protective rip-rap wall. A site inspection of the protective rip-rap wall showed no holes, slumping or signs of erosion on the face of the protective rip-rap wall (Figures 10.0 thru 10.3) and no improvements are proposed.

Although the height of the protective rip-rap wall and the size of the rip-rap (as shown in Figures 10.0 thru 10.3) appear to meet the requirements stated in Section 11.2, an additional site inspection will be required to verify the height, depth of the rip-rap blanket, size of the rip-rap rock and filter material that comprise the protective rip-rap wall.

Also to meet the requirements stated in Section 11.2, it is proposed that a buried toe rip-rap bed consisting of D_{50} = 10" rock and geotextile fabric be constructed 16" deep x 6.5' wide along the length of the toe of the protective rip-rap wall. An alternative to the buried toe rip-rap bed described above, Chapter 4 (DOT 2009) allows a mounded toe rip-rap mound to be constructed at the ambient bed elevation two times the layer thickness and as high as the maximum scour depth.

Since the rip-rap wall was installed without documentation, the evaluation of the rip-rap wall will include an inspection to determine how the wall was built. The results of the inspection will be compared to the minimum design criteria for a protective rip-rap wall. The following presents the minimum design requirements for a protective rip-rap wall:

- The rip-rap wall shall be a minimum of 3 feet in height, including the portion of the wall that is adjacent to the eastern and western drainage channels.
- The thickness of the rip-rap blanket shall be a minimum of 16 inches.
- The size of the rip-rap rock shall be a minimum of D_{50} = 10 inches
- The base of the rip-rap blanket shall have either a granular or geotextile fabric filter material installed.
- The maximum slope of the protective rip-rap wall and subbase shall be a slope no greater than 1:1.5
- The toe of the rip-rap wall shall be protected with either of the following:
    - Buried toe consisting of a rip-rap rock of D_{50} = 10 inches with a geotextile fabric filter material installed and shall be constructed 16 inches deep x 6.5 feet wide along the length of the toe of the protective rip-rap wall.
    - Mounded toe consisting of rip-rap rock that is a minimum of D_{50} = 10 inches constructed 32 inches deep x 3 feet in height along the length of the toe of the protective rip-rap wall.

If the visual inspection of the existing protective rip-rap wall identifies portions of the wall that do not meet at least the minimum requirements presented above, designs to remedy the deficiencies of the portions (or all) of the existing protective rip-rap wall that do not meet these requirements will be evaluated. The design remedy that best addresses any or all the deficiency will be prepared and submitted to ADEQ for approval prior to implementation.

ATTACHMENT A

PRELIMINARY CONSTRUCTION COST ESTIMATE, SECTION THREE
(OPTION 1 – 6” RIP-RAP ROCK)

PRELIMINARY CONSTRUCTION COST ESTIMATE DRAINAGE CHANNEL SECTION THREE (Option 1 - 6" rip-rap rock) Adair Park Archery Range					
Item	**Description**	**Estimated Quantity**	**Unit**	**Unit Cost**	**TOTAL**
1	Mobilization	1	LS	$ 7,500.00	$ 7,500.00
2	Traffic Control & Project Sign	1	LS	$ 3,500.00	$ 3,500.00
3	SWPPP Plans & Implementation	1	LS	$ 3,500.00	$ 3,500.00
4	Clearing & Grubbing	1	LS	$ 5,000.00	$ 5,000.00
5	Earthwork	971	CY	$ 0.65	$ 631.15
6	New 6" Rip-Rap Rock (12" deep) w/ Geotextile Fabric	1,647	CY	$ 7.25	$ 11,940.75
7	Maintenance Costs (10-years)	10	YR	$ 2,000.00	$ 20,000.00
	SECTION A - SUBTOTAL (Items 1 - 7)				**$ 52,071.90**
	SECTION B - CONTINGENCY (10% of SECTION A)				$ 5,207.19
	TOTAL PROBABLE CONSTRUCTION COST (SECTIONS A + B)				**$ 57,279.09**

ATTACHMENT B

PRELIMINARY CONSTRUCTION COST ESTIMATE, SECTION THREE (OPTION 2 – SHOTCRETE)

PRELIMINARY CONSTRUCTION COST ESTIMATE DRAINAGE CHANNEL SECTION THREE (Option 2 - shotcrete) Adair Park Archery Range					
Item	**Description**	**Estimated Quantity**	**Unit**	**Unit Cost**	**TOTAL**
1	Mobilization	1	LS	$ 7,500.00	$ 7,500.00
2	Traffic Control & Project Sign	1	LS	$ 3,500.00	$ 3,500.00
3	SWPPP Plans & Implementation	1	LS	$ 3,500.00	$ 3,500.00
4	Clearing & Grubbing	1	LS	$ 5,000.00	$ 5,000.00
5	Earthwork	342	CY	$ 0.65	$ 222.30
6	New shotcrete 4" thick w/rebar & joints	907	SY	$ 100.00	$ 90,700.00
	SECTION A - SUBTOTAL (Items 1 - 6)				**$ 110,422.30**
	SECTION B - CONTINGENCY (10% of SECTION A)				$ 11,042.23
	TOTAL PROBABLE CONSTRUCTION COST (SECTIONS A + B)				**$ 121,464.53**

ATTACHMENT C

PRELIMINARY CONSTRUCTION COST ESTIMATE, SECTION FOUR
(OPTION 1 – 6” RIP-RAP ROCK)

PRELIMINARY CONSTRUCTION COST ESTIMATE DRAINAGE CHANNEL SECTION FOUR (Option 1 - 6" rip-rap rock) Adair Park Archery Range					
Item	**Description**	**Estimated Quantity**	**Unit**	**Unit Cost**	**TOTAL**
1	Mobilization	1	LS	$ 2,500.00	$ 2,500.00
2	Traffic Control & Project Sign	1	LS	$ 1,500.00	$ 1,500.00
3	SWPPP Plans & Implementation	1	LS	$ 1,500.00	$ 1,500.00
4	Clearing & Grubbing	1	LS	$ 5,000.00	$ 5,000.00
5	Earthwork	338	CY	$ 0.65	$ 219.70
6	New 6" Rip-Rap Rock (12" deep) w/ Geotextile Fabric	1,951	SY	$ 7.25	$ 14,144.75
7	Maintenance Costs (10-years)	10	YR	$ 2,000.00	$ 20,000.00
	SECTION A - SUBTOTAL (Items 1 - 7)				**$ 44,864.45**
	SECTION B - CONTINGENCY (10% of SECTION A)				$ 4,486.45
	TOTAL PROBABLE CONSTRUCTION COST (SECTIONS A + B)				**$ 49,350.90**

ATTACHMENT D

PRELIMINARY CONSTRUCTION COST ESTIMATE, SECTION FOUR (OPTION 2 – SHOTCRETE)

PRELIMINARY CONSTRUCTION COST ESTIMATE
DRAINAGE CHANNEL SECTION FOUR (Option 2 - shotcrete)
Adair Park Archery Range

Item	Description	Estimated Quantity	Unit	Unit Cost	TOTAL
1	Mobilization	1	LS	$ 2,500.00	$ 2,500.00
2	Traffic Control & Project Sign	1	LS	$ 1,500.00	$ 1,500.00
3	SWPPP Plans & Implementation	1	LS	$ 1,500.00	$ 1,500.00
4	Clearing & Grubbing	1	LS	$ 5,000.00	$ 5,000.00
5	Earthwork	113	CY	$ 0.65	$ 73.45
6	New shotcrete 4" thick w/rebar & joints	532	SY	$ 100.00	$ 53,200.00
	SECTION A - SUBTOTAL (Items 1 - 6)				**$ 63,773.45**
	SECTION B - CONTINGENCY (10% of SECTION A)				$ 6,377.35
	TOTAL PROBABLE CONSTRUCTION COST (SECTIONS A + B)				**$ 70,150.80**

APPENDIX D
Abbreviated Quality Assurance Project Plan

Abbreviated Quality Assurance Project Plan

1. Title and Approvals:

Project Name: Adair Park Archery Range Remedial Action Plan

Approvals: Joshua Scott, Director Yuma County Department of Public Works

Approvals: John Patricki, PM ADEQ VRP

Project Manager(s): Michael Daniel, RG

Sampling Team Leader(s): Brad Closson

Quality Assurance Coordinator(s): Michael Daniel, RG
Eric Gardner, PG

2. Distribution List:

Client: Joshua Scott, Director Yuma County Department of Public Works
Project Manager: Michael Daniel, RG
ADEQ VRP Project Manager: John Patricki,
Sampling Team Leader: Brad Closson
Quality Assurance Coordinators: Michael Daniel, RG and Eric Gardner, PE
Sampling Team Members: Brad Closson
Laboratory: TestAmerica, Inc. Phoenix, AZ

3. Project Description / Background: The Adair Park Archery Range (site) is located at 4760 South US Highway 95 approximately 12 miles north of Yuma, Arizona and is accessed via Adair Park Road (Figure 1). The site consists of 24 acres that was dedicated to Yuma County by the United States Bureau of Reclamation (USBR) in 1967 for rifle, pistol, and archery range uses. The archery range site is located in a dry ephemeral wash that is surrounded by the Gila River to the south, desert hills to the north and west and a shooting range to the east (Figure 2).

An investigation of the site was performed in 2000 due to a case of lead poisoning. The investigation discovered that the site was formerly used as a silver ore mill during the late 1800s and early 1900s. The silver ore was brought to the site from the mine and processed at the mill. The tailings from the silver ore processing, which contained elevated lead concentrations, were placed in a tailings pond located on the site. The silver ore processing and associated tailings resulted in lead contaminated soil migrating throughout the site via stormwater runoff and wind-borne transportation.

Subsequent investigations by Yuma County and the ADEQ, through its Brownfields Site Cleanup Grant awarded by the US Environmental Protection Agency (USEPA) in 2004, revealed lead contaminated soil was present in the archery range and the archery practice area. Laboratory analytical results indicated that lead was present in the soil at concentrations up to 38,000 milligrams per kilogram (mg/kg). No other metals were detected in the soil that exceeded their respective soil remediation levels (SRLs). The lead contaminated soil was limited to within the boundaries of the site. In 2006, Yuma County entered the Voluntary Remediation Program (VRP).

In 2006, the site was divided into three (3) areas of concern (AOCs) (Figure 2). Soil excavated from AOC 2 and AOC 3 was placed in AOC 1 where it was capped with a gravel base and a double chip seal surface. Fill from a nearby source was used to backfill the excavated areas in AOC 2. Soil excavated from AOC 3 created two stormwater retention basins currently used as part of the stormwater management system at the site. Additionally, engineering controls were constructed to divert stormwater around the capped area toward drainage swales on both sides of the capped area, into drainage channels through AOC 2 and into the retention basins located in AOC 3.

A follow on site evaluation was conducted between 2018 and 2019 to evaluate the stormwater conveyance system around and over the capped area, to evaluate soil conditions and to evaluate groundwater quality at the site. The stormwater conveyance evaluation concluded several locations have experienced minor erosion that will be required to be repaired. Additionally, the channels downstream of the capped area will also require repair or upgrading in order to prevent stormwater overflow and erosion of the adjacent soil.

The distribution of lead in soil indicates that the top one feet of soil in several areas outside the capped area contain lead in concentrations greater than the NR SRL of 800 mg/kg. Additionally, the former tailings pile location contains lead in concentrations greater than 800 mg/kg and one location contains lead and cadmium in toxicity characteristic leaching procedures (TCLP) concentrations above their respective regulatory limit making the soil in the immediate area around this sample a characteristic hazardous waste due to its lead and cadmium toxicity.

Groundwater was encountered only on the southern third of the site. The depth to groundwater in the southern area of the site is approximately 15 feet below ground surface (bgs). The portion of the site north of the detention basins, including the capped area and the former tailings pile area is underlain by shallow granitic bedrock and no groundwater is present in the alluvium. An alternate site-specific GPL of 50,899 mg/kg was calculated for lead at the site. No soil sample results exceeded the site specific GPL by the x-ray fluorescence (XRF) analyzer or by laboratory analysis. A temporary groundwater monitoring well was installed at the site on November 6, 2019 and a groundwater sample was collected from the well on November 18, 2019. Lead was not detected in the groundwater at a concentration exceeding its laboratory report limit

4. Project Technical Design:

Site(s) to be sampled: Soil sampling will be conducted to evaluate the concentrations of Resource Conservation and Recovery Act (RCRA) eight (8) metals, specifically lead, from the former tailings pile area (Figure 3). ,

Sampling Points: Nine (9) soil samples will be collected from the tailings pile area from 4 locations (Figure 3).

Sample Type(s): All soil samples collected will be grab samples.. Soil samples collected from soil boring samples to collected continuously from the surface to a depth of 5 feet bgs . Samples will be selected based on the results of screening the samples with a x-ray fluorescence (XRF) analyzer. The two samples with the highest XRF reading will be submitted to the laboratory for analysis. One duplicate sample will be collected from the sample with the highest XRF reading.

Parameters to be measured: All soil samples will be analyzed for RCRA 8 Metals using EPA Test Method 6010C/7471B. Additionally, two (2) soil samples collected from the tailings pile area will undergo Synthetic Precipitation Leaching Procedure (SPLP) extraction using EPA Test

Method 1312 and analyzed for Lead using EPA Test Method 6010C. An alternative to the SPLP extraction that may be used is the Toxicity Characteristic Leaching Procedure (TCLP) extraction using EPA Test Method 1311.

Quality Control (QC) Activities: An equipment blank sample will be collected from the hand driven sampler and a field blank will be collected from the water used to decontaminate the sampler.

Locational Information / Documentation: See Figure 3

Special Sample Requirements: None are applicable for this scope of work.

5. **Project Organization and Task Responsibilities:**

Project Manager is responsible for comprehensive oversight and final decision making for the Project.

Quality Assurance (QA) Coordinator will facilitate with proper planning documents and is available to review and approve plans. Questions regarding validity and usability of data will be directed to the QA Coordinator.

Sampling Team Leader is responsible for:

- Assembling sampling team and briefing members on requirements of the project
- Supervising preparation of equipment
- Overall collection of samples, record keeping, and delivery to laboratory
- Safety of field personnel
- Overall coordination and documentation of field activities related to the project

6. **Special Training Requirements:** None

7. **Project Schedule:** Project schedule is presented as Figure 5 in the Work Plan.

8. **Field Sampling Table:**

Matrix	Analyte	# Samples	Sample Volume[1]	Container	Preservation	Holding Time
Soil	RCRA 8 Metals	9	8 ounces	8 ounce glass jar	4° C ± 2° C	6 months
Soil	TCLP Lead	2	8 ounces	8 ounce glass jar	4° C ± 2° C	6 months

[1]For volume, give QA sample volume followed by a slash and the regular sample volume (i.e. 500ml/100ml)

9. **Field Sampling Requirements:**

Nine (9) soil samples will be collected from four soil borings advanced in the former tailings pile area. The soil samples will be continuously collected from the surface to a depth of 5 ft bgs at each location (Figure 3).

Procedures for the collection of soil and groundwater samples are detailed in the Remedial Action Plan (RAP) for Adair Memorial Park Archery Range.

10. **Sample Handling and Custody Requirements:** Each sample collected will be labeled with a unique sample identifier, date and time the sample was collected, preservation used, the sampler's initials and the

analysis to be performed. Each sample will then be logged onto a chain–of–custody form for delivery to the laboratory. All samples will be sent to the laboratory via UPS overnight delivery.

11. Analytical Method Requirements: Nine (9) soil samples will be analyzed for the following:

- RCRA 8 Metals using EPA Test Method 6010C/7471B.

Two (2) soil samples will also be analyzed for:

- The Synthetic Precipitation Leaching Procedure (SPLP) extraction using EPA Test Method 1312 and analyzed for Lead using EPA Test Method 6010C. An alternative to the SPLP extraction is the Toxicity Characteristic Leaching Procedure (TCLP) extraction using EPA Test Method 1311. The analytical method for TCLP lead will remain the same.

Analyte	Matrix	Analytical Method	Laboratory Name	Reporting Limit	Units of Reporting Limit
Lead	Soil	6010	TestAmerica	1	mg/kg
TCLP Lead	Soil	6010	TestAmerica	0.5	mg/L

12. Other Data Quality Indicators:

Representativeness: The soil samples from the former tailing pile area will be collected from a depth of 0.0 ft to 5 ft bgs at each location. All sample locations have been randomly selected to provide the best representative coverage over each of the sample area.

Comparability: The soil sample results will be compared to the Residential Soil Remediation Levels (R SRLs) for lead, and other metals as necessary. The calculated site specific GPL supersedes the minimum GPL for assessment of potential to impact groundwater and the NR SRL for lead, 800 mg/kg, will be used if the reported concentration is lower than the calculated GPL value.

Completeness: The completeness goal is 100 percent for each media to be sampled and will be met by collecting all anticipated samples.

13. Peer Review: Wood Environmental and Infrastructure will provide peer review of plans and reports presenting evaluation of the laboratory analytical results.

14. Instrument, Equipment, and Supplies Testing and Maintenance Requirements:
Instruments will be calibrated and maintained in accordance with manufacturer instructions and the procedures outlined in appropriate Standard Operating Procedures (SOPs). Sample containers will be new certified pre-cleaned containers.

Laboratory equipment will be tested, calibrated, and maintained in accordance with SOPs approved by each respective laboratory.

15. Assessments / Oversight:
Formal field audits by QA personnel are not anticipated for this project. Identification of problems related to technical performance will be the responsibility of the technical staff working on this project. The Sampling Team Leader will assess any problems that arise in the field, and make modifications to technical procedures, if needed, and will communicate with the Project Manager and any technical staff. Any changes in technical procedures will be documented in field notes and highlighted in reports related to this project.

Laboratory personnel will perform self audits and institute corrective actions in accordance with their respective written procedures.

16. Data Review, Validation, and Usability:
Data from other laboratories will be initially validated by the laboratory performing the analysis. The data will be reviewed and verified by TestAmerica, Inc. The data will also be verified by Nicklaus Engineering using the ADEQ data verification form attached to the QAPP. Third party validation is not required for this project.

Any questions regarding the verification and usability of the data will be discussed with the VRP Project Manager and decisions made appropriately.

17. Documentation and Records:
Field notes and measurements will be recorded in a field notebook, which will be maintained by the Sampling Team Leader. Original copies of Chain of Custody, raw data, and analytical results will be maintained by the respective laboratories performing the analyses.

At the end of each day, the Sampling Team Leader will prepare a summary of the sampling activities for the day. The summary will be in writing but may be submitted either as a hard copy or electronically. The summary should include the following:

- Name of Sampling Team Leader and Team Members
- Number of samples collected by matrix
- Locations samples
- On-site measurements made and results obtained at each location (including times)
- Disposition of all samples (where they were delivered for analysis)
- Air bill numbers for all shipped samples
- Photocopies of Chain of Custody
- Noteworthy observations at each sampling location

18. Data Management
A list electronic of copies and formats needed for reports and data include PDF copies of the laboratory reports as well as Electronic Data Deliverables (EDDs) in Microsoft Excel format.

In the event a groundwater well is required to be installed, groundwater quality data will be uploaded to ADEQ's database in the EDD format specified in Groundwater Data Submittal Guidance Document (Version 3.4).

Copies of all Plans, Reports, and Drawings will be provided to Yuma County and ADEQ for their files. NEI will also maintain an archive of all project plans, reports and drawings in their Yuma, AZ Office.