EMID-701372

DEPARTMENT OF ENERGY

Environmental Management Los Alamos Field Office (EM-LA)
Los Alamos, New Mexico 87544

EMLA-2021-0186-02-001 April 8, 2021

Mr. Kevin Pierard
Bureau Chief
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505-6313

Subject: Submittal of the 2020 Monitoring Report for Los Alamos/Pueblo Watershed Sediment Transport Mitigation Project

Dear Mr. Pierard:

Enclosed please find two hard copies with electronic files of the "2020 Monitoring Report for Los Alamos/Pueblo Watershed Sediment Transport Mitigation Project." This annual monitoring report assesses overall performance of the mitigation efforts installed in the Los Alamos and Pueblo watershed since 2007. The evaluation of precipitation, storm water discharge, and constituent concentrations obtained in 2020 were used to determine the effects of mitigations installed over the years. The "2019 Monitoring Report for Los Alamos/Pueblo Watershed Sediment Transport Mitigation Project" was approved with minor comments by the New Mexico Environment Department (NMED) on July 1, 2020.

Pursuant to Section XXIII.C of the Consent Order, a pre-submission review meeting was held on December 9, 2020, with the U.S. Department of Energy Environmental Management Los Alamos Field Office (EM-LA); Newport News Nuclear BWXT-Los Alamos, LLC (N3B); and NMED to discuss changes in monitoring requirements for 2021.

If you have any questions, please contact Amanda White at (505) 309-1366 (amanda.white@em-la.doe.gov) or Cheryl Rodriguez at (505) 414-0450 (cheryl.rodriguez@em.doe.gov).

Sincerely,

Arturo Q. Duran

Digitally signed by Arturo Q. Duran
Date: 2021.04.01 14:04:04 -06'00'

Arturo Q. Duran
Compliance and Permitting Manager
Environmental Management
Los Alamos Field Office

Enclosures:

1. Two hard copies with electronic files – 2020 Monitoring Report for Los Alamos/ Pueblo Watershed Sediment Transport Mitigation Project (EM2021-0009)

CC (letter with hard-copy enclosure[s]):
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Cheryl Rodriguez, EM-LA

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April 2021
EM2021-0009

2020 Monitoring Report for Los Alamos/Pueblo Watershed Sediment Transport Mitigation Project

N3B Los Alamos

EM2021-0009

2020 Monitoring Report for Los Alamos/Pueblo Watershed Sediment Transport Mitigation Project

April 2021

Responsible program director:

Steve Veenis	Steve Veenis	T2S Program Director	Water Program	3/25/21
Printed Name	Signature	Title	Organization	Date

Responsible N3B representative:

Kim Lebak	Kimberly D Lebak	Program Manager	N3B Environmental Remediation Program	3/25/21
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Responsible DOE EM-LA representative:

Arturo Q. Duran	Arturo Q. Duran Digitally signed by Arturo Q. Duran Date: 2021.04.01 14:04:39 -06'00'	Compliance and Permitting Manager	Office of Quality and Regulatory Compliance	
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EXECUTIVE SUMMARY

This eleventh annual monitoring report provides a summary of analytical data, discharge measurements, geomorphic changes, and precipitation data associated with storm water samples collected from the Los Alamos/Pueblo (LA/P) watershed from June to November 2020. Monitoring objectives include collecting data to evaluate the effect of watershed mitigations installed in the LA/P watershed on stream flow and sediment and contaminant transport. Watershed mitigations evaluated include the Delta Prime (DP) Canyon grade-control structure (GCS) and associated floodplains; the Pueblo Canyon drop structure, willow planting, wetland, and GCS; the Los Alamos Canyon low-head weir and associated sediment-detention basins; and the storm water detention basins and vegetative buffer below the Solid Waste Management Unit 01-001(f) drainage in Los Alamos Canyon. Pursuant to Section VII of the 2005 Compliance Order on Consent (Consent Order), Los Alamos National Laboratory (the Laboratory) had implemented interim measures to reduce the migration of contaminants within the LA/P watershed. These mitigations have been implemented with the overall goals of minimizing the potentially erosive nature of storm water runoff, enhancing deposition of sediment, and reducing access of contaminated sediments to storm water. The submission of this annual report to the New Mexico Environment Department (NMED) is in accordance with the 2016 Consent Order.

Gaging station and sampling locations within the LA/P watershed monitor the hydrology and sediment transport, including stations that bound the mitigation sites. Stage height/discharge is monitored at 5-min intervals at a series of gaging stations. Precipitation data are collected across the Laboratory by means of 5 meteorological towers and an extended network of 14 precipitation gages. Sampling for analytical suites specific to each reach of the watershed is conducted using portable automated samplers. Sampling equipment and the extended rain gage network are deactivated during the winter months (December to April) and reactivated in the spring.

Attenuation of flow and associated sediment transport are primary goals of the sediment transport mitigation activities. Decreasing flow velocity allows for increased infiltration, thus reducing peak discharge, reducing the distance the flood bore travels downstream, and reducing the distance sediment and associated contaminants entrained in the storm water travel downstream. The 2020 monitoring season is characterized by the United States Drought Monitor as a period that began in moderate drought in the LA/P watershed and surrounding areas, increasing in severity through the season and ending in exceptional drought. No precipitation events generated sufficient flows above sampler trip levels to collect samples at any gaging station during the monitoring season. The 2020 monitoring data in the LA/P watershed indicate that, in general, the mitigations are performing as designed.

Geomorphic changes are monitored at one background area, five sediment transport mitigation sites, and two sediment detention basin areas that have been established in the LA/P watershed. The bank and thalweg surveys and repeat photographs support the conclusion of overall stability of the banks and channels in Pueblo, DP, and Los Alamos Canyons and establish the geomorphic change between 2019 and 2020 as minor, indicating that the watershed mitigations are performing as designed.

The 2020 monitoring year was affected by the COVID-19 pandemic. The U.S. Department of Energy Environmental Management Los Alamos Field Office (EM-LA) transitioned to essential mission critical activities (EMCA) status on March 24, 2020. As described in a March 31, 2020, letter from EM-LA to the NMED Hazardous Waste Bureau, fieldwork was limited to only the activities necessary to ensure the safety of the public, the workers, and the environment.

The resumption of N3B's operations at Los Alamos National Laboratory occurred in phases, starting with additional mission-critical activities that were both high-priority and low-risk. Even after field operations began to resume in June and July 2020, COVID-19 reduced staff availability. Sampler activation was

completed by July 28, 2020. Discharge was measured and surface-water sampling was attempted at 13 gaging stations in the LA/P watershed in 2020. Email updates on the status of compliance activities were sent to NMED biweekly until October 2020, when the frequency switched to monthly.

Continued monitoring in 2021 is expected to confirm that the sediment-transport mitigations in the LA/P watershed are performing as designed.

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1.0 INTRODUCTION

Los Alamos National Laboratory (LANL or the Laboratory) is a multidisciplinary research facility owned by the U.S. Department of Energy (DOE) and managed by Triad National Security, LLC. The Laboratory is located in north-central New Mexico approximately 60 mi northeast of Albuquerque and 20 mi northwest of Santa Fe. The Laboratory site comprises an area of approximately 36 mi^2, mostly on the Pajarito Plateau, which consists of a series of mesas separated by eastward-draining canyons. It also includes part of White Rock Canyon along the Rio Grande to the east.

This eleventh annual monitoring report summarizes analytical data, discharge measurements, and precipitation data associated with storm water collected from the Los Alamos and Pueblo (LA/P) watershed from June to November 2020; reports on geomorphic changes during 2020 at the sediment transport mitigation sites in the LA/P watershed; and documents watershed mitigation inspections in 2020. Appendix A includes acronyms and abbreviations. Appendix B addresses geomorphic and wetland changes in 2020, and Appendix C provides photographic documentation of watershed mitigation inspections. Appendix D (on CD included with this document) presents gaging station stage and discharge data. This monitoring was initially stipulated by the New Mexico Environment Department (NMED) approval with direction for the “Los Alamos and Pueblo Canyons Supplemental Investigation Report,” which states that “The Permittees must install surface water monitoring stations below each newly-installed weir and develop a monitoring plan to evaluate each weir’s effectiveness” (NMED 2007, 098284). Subsequent proposed mitigation and monitoring efforts were identified and implemented per the approved “Interim Measure Work Plan to Mitigate Contaminated Sediment Transport in Los Alamos and Pueblo Canyons” (hereafter, the IMWP) (LANL 2008, 101714; NMED 2008, 103007) and the approved “Supplemental Interim Measures Work Plan to Mitigate Contaminated Sediment Transport in Los Alamos and Pueblo Canyons” (hereafter, the SIMWP) (LANL 2008, 105716; NMED 2009, 105014). Monitoring in 2020 was performed in accordance with the “2020 Monitoring Plan for Los Alamos/Pueblo Watershed Sediment Transport Mitigation Project” (N3B 2020, 700841).

Monitoring objectives include collecting data to evaluate the effect of watershed mitigations installed in the LA/P watershed on stream flow and sediment and on contaminant transport. The discussion of flow and analytical results for suspended sediment and constituent concentrations focuses on an evaluation of the overall performance of the watershed, with specific emphasis on the effects of the mitigations implemented per the IMWP and SIMWP. The discussion in Appendix B of geomorphic stability focuses on sediment stability and mobility in the watershed as a measure of the overall stability of the watershed and the performance of the sediment-mitigation structures.

The NMED approval with modifications of the 2013 monitoring plan for sediment transport mitigation (LANL 2013, 243432; NMED 2013, 523106) also directed the Laboratory to monitor storm water above and below the detention basins below the Solid Waste Management Unit (SWMU) 01-001(f) drainage in upper Los Alamos Canyon. Watershed mitigations evaluated in this report include

- the Delta Prime (DP) Canyon grade-control structure (GCS) and associated floodplains;
- the Pueblo Canyon drop structure, willow plantings, wetland, and GCS;
- the Los Alamos Canyon low-head weir and associated sediment detention basins; and
- the storm water detention basins and associated vegetative buffer below the SWMU 01-001(f) drainage in Los Alamos Canyon.

Work began in 2014 to rehabilitate and mitigate damage to the Pueblo Canyon wetlands, GCS, and gaging station E060.1 from the September 2013 flooding. Work accomplished in 2014 included

- planting willows below the wetlands;
- planting canary reed grass;
- installing piezometer transects to record water levels and willow performance;
- stabilizing the local banks;
- and undertaking Phase I post-flooding mitigation activities at gaging station E060.1, including armoring of the north bank directly downstream of the flume and stabilizing select banks.

Work accomplished in 2015 included

- installing a drop structure at the Pueblo Canyon wetland headcut;
- installing gaging station E059.8 equipped with a v-notch flume;
- undertaking Phase II of gaging station E060.1 post-flooding mitigations, including redirecting the channel;
- installing spurs for bank protection;
- contouring the area around the gaging station;
- installing erosion protection measures at the downstream side of both the existing Pueblo Canyon GCS and gaging station E060.1; and
- constructing an access road.

Key constituents of concern in the watershed addressed in this monitoring report include radionuclides. Corrective actions at the Laboratory are subject to the 2016 Compliance Order on Consent (Consent Order). Information on radioactive materials and radionuclides, including the results of sampling and analysis of radioactive constituents, is voluntarily provided to NMED in accordance with DOE policy.

1.1 Project Goals and Methods

The mitigations specified in the IMWP and SIMWP have been implemented with the overall goal of minimizing the potentially erosive nature of storm water runoff to enhance deposition of sediment and to reduce or eliminate the susceptibility of contaminated sediments to flood erosion. Figures 1.1-1 and 1.1-2 show the locations of the mitigation and monitoring stations, including stream gaging stations, in the LA/P watershed. Mitigation/rehabilitation measures performed in 2014 and 2015 in response to the September 2013 floods are discussed in this report because these measures have become integral to the LA/P watershed monitoring. In the Pueblo Canyon watershed, the central focus of the mitigations is to maintain a physically, hydrologically, and biologically functioning wetland that can reduce peak flows and trap suspended sediment because of the presence of thick wetland vegetation. Stabilization and enhancement of the wetland were partially addressed with the installation of a GCS designed to inhibit headcutting below the terminus of the wetland and to promote the establishment of additional riparian or wetland vegetation beyond the current terminus of the wetland. Mitigations in upper portions of Pueblo Canyon above the wetland are designed primarily to reduce the flood peaks and to enhance channel/floodplain interaction before floods reach the wetland. Gaging stations are situated within the watershed to monitor the overall hydrology and sediment transport along the length of the watershed, including stations that bound the wetland.

In DP and Los Alamos Canyons, mitigations included stabilizing and partially burying the channel and adjacent floodplains in upper DP Canyon, which is a source of contaminants entrained in frequent floods that originate from a portion of the Los Alamos townsite. A GCS was installed with a height that encourages channel aggradation, thus reducing the potential for erosion of contaminated sediment deposits in adjacent banks during floods. Channel aggradation should also encourage the spreading of floodwaters, thereby reducing peak discharge because of transmission loss within the reach and thus enhancing sediment deposition. Lower flood peaks should also reduce the erosion of contaminated sediment deposits downcanyon of the DP GCS. Mitigations in Los Alamos Canyon several kilometers below the DP Canyon confluence involve removing accumulated sediment behind the Los Alamos Canyon low-head weir to increase the residence time of floodwaters and to enhance settling of suspended sediment and associated contaminants. (Sediment removal in Los Alamos Canyon was performed in April 2014 but not in 2015, 2016, 2017, 2018, 2019, or 2020 because not enough sediment had accumulated to warrant its removal.)

Additional mitigations were implemented in Los Alamos Canyon under a separate administrative requirement (LANL 2008, 104020; NMED 2009, 105858) to address polychlorinated biphenyl (PCB) contamination associated with SWMU 01-001(f). The mitigation actions at that location involved removing contaminated sediment from the hillslope and constructing detention basins and a willow-planted vegetation buffer at the bottom of the associated hillside drainage to promote the settling of PCB-contaminated sediments in runoff from the upgradient PCB-contaminated hillslope drainage. In addition, a pipeline was installed in 2015 under the National Pollutant Discharge Elimination System (NPDES) Permit NM0030759 (the Individual Permit) to divert townsite runoff around SWMU 01-001(f).

Inspections of all watershed mitigations are performed on a routine basis and after significant flow events (greater than 50 cubic feet per second [cfs] at locations with gaging stations or greater than 0.5 in. in 30 min at locations without gaging stations). These inspections are completed to ensure the watershed mitigations are functioning properly and to identify if maintenance may be required. Appendix C contains photographs and descriptions of each inspection and associated information.

2.0 MONITORING IN THE LA/P WATERSHED

2.1 Discharge and Precipitation Measurements and Sampling Activities

Discharge was measured and surface-water sampling was attempted at 13 gaging stations in the LA/P watershed in 2020. Gaging stations with concrete, trapezoidal, supercritical-flow flumes are designated as follows:

- Los Alamos below Low Head Weir (E050.1),
- Pueblo below Grade Control Structure (E060.1),
- DP below Grade Control Structure (E039.1), and
- Los Alamos above Low Head Weir (E042.1).

Nine other gaging stations that complete the monitoring network in the LA/P watershed are designated as

- Pueblo above Acid (E055),
- South Fork Acid Canyon (E055.5),
- Acid above Pueblo (E056),
- Los Alamos below Ice Rink (E026),

- Los Alamos above DP Canyon (E030),
- DP above TA-21 (E038),
- E059.5 Pueblo below LAC WWTF (E059.5),
- E059.8 Pueblo below Wetlands (E059.8), and
- DP above Los Alamos Canyon (E040).

Figure 1.1-2 shows the locations of stream gaging stations and watershed mitigations within the Laboratory's property boundary and on adjacent land owned by the County of Los Alamos.

Stage height was monitored at each LA/P gaging station at 5-min intervals in the LA/P watershed. Sutron 9210 data loggers stored each recorded stage-height measurement as it was made. Discharge was computed for each 5-min stage measurement using rating curves for each individual gaging station. Log check dams in Acid Canyon just below E055.5 installed in 2017 caused the channel bed to fluctuate significantly through 2017. In March 2018, the gaging station at E055.5 was relocated 35 feet upstream to a more stable location (Figure 2.1-1). At the beginning of the 2019 sampling season, one cross-section at the new gaging station's sensor location and the channel slope were surveyed before any flows in order to calculate a stage height for the sampling trip level. The survey data were used to calculate multiple discharge measurements at different stage heights using the Manning's formula to create a rating curve.

$$V = \frac{1}{n} s^{1/2} R^{2/3} \qquad \textbf{Equation 1}$$

Where V = the mean velocity of the flow,

s = the slope of the channel,

R = the hydraulic radius of the cross-section of the channel, and

n = the roughness coefficient.

While this is a proper method for creating a rating curve, it is not as robust as surveying multiple cross-sections and using the survey data in a Hydrologic Engineering Center River Analysis System (HEC-RAS) model from the U.S. Army Corps of Engineers (USACE 2008, 109517; USACE 2008, 109518), which is the method used for all other stations. Therefore, a more robust survey and rating curve was developed in 2020 using a Trimble total station to take multiple cross-sections in the channel reach, and those survey data were used in HEC-RAS to model the flow and create a rating curve. Shaft-encoder float sensors installed in stilling wells were used to measure water levels at E050.1 and E060.1. Self-contained bubbler pressure sensors (Sutron Accubar) were used to measure water levels at E059.5 and E059.8 for part of the year and to provide backup sensing for E050.1 and E060.1. Radar sensors were used to measure water levels at E026, E030, E038, E039.1, E040, E042.1, E055.5, E055, and E056; to replace the bubbler pressure sensor at E059.8 partway through the monitoring season; and to provide backup sensing at E050.1 and E060.1.

A complete record of 5-min stage-height measurements for the monitoring period from June 1, 2020, to October 31, 2020, exists at E026, E030, E038, E039.1, E040, E042.1, E050.1, E055, E055.5, E056, E059.5, E059.8, and E060.1. Appendix D contains the 5-min gaging station stage and discharge data for the LA/P watershed.

Programs that monitor storm water at the Laboratory use precipitation data collected at the Laboratory's meteorological towers. Figure 2.1-2 shows total precipitation for each month from 2015 to 2020 averaged over Laboratory sites; Figure 2.1-3 shows total precipitation for each month in 2020 in relation to historic totals; annual heterogeneity and increase in precipitation occurs during the summer monsoon. In addition, a seasonal, extended rain gage network is deployed from April to November to coincide with storm water monitoring periods. Storm water monitoring stations are assigned to individual rain gages by means of a geographic information system (GIS) using the method of Thiessen polygons. Rain gages, meteorological towers, Thiessen polygons and the drainage area for each stream gaging station associated with the LA/P watershed are presented in Figure 2.1-4.

Sampling was planned using ISCO 3700 portable automated samplers. Two ISCO samplers were installed at each of the following locations: E038, E039.1, E042.1, E050.1, E059.5, E059.8, and E060.1. At locations where two samplers were installed, one sampler was configured with a 24-bottle carousel to monitor primarily suspended sediment, and the second sampler was configured with a 12-bottle carousel to monitor inorganic and organic chemicals and radionuclides. At locations where a single sampler was installed, the sampler was configured with a 12-bottle carousel to monitor suspended sediment, inorganic and organic chemicals, and radionuclides. Sampler intake lines were set above the bottom of the channel or flume and were placed perpendicularly to the direction of flow. Trip levels (in discharge) and the dates during which the trip levels were active are presented in Table 2.1-1.

Sampling equipment at gaging stations in the LA/P watershed was shut down during the winter months and reactivated in mid-July. Sampling equipment is usually reactivated in the late spring. However, because of the transition to essential mission critical activities (EMCA) status on March 24, 2020, fieldwork for these sites was not permitted until mid-July. Automated samplers and equipment at gaging stations were inspected at least monthly for all of 2020, except during the EMCA status, during which all gaging stations were inspected remotely each week. For gaging station equipment at E050.1 and E060.1, inspection occurred weekly throughout the year and biweekly during the EMCA status, which was in effect from March 24 until July 14, during which inspection of these sites was permitted as essential work. Weekly remote inspections for all gaging stations occurred throughout the EM-LA COVID-19 EMCA status. Equipment found to be damaged or malfunctioning was repaired within 2 business days after the problem was discovered. However, an exception to this occurred at E059.8 when a bubbler pressure sensor malfunctioned during the EMCA status and a replacement with a radar sensor was installed 62 days later. Equipment at the 13 LA/P gaging stations was connected via telemetry to a base station, allowing real-time access to discharge measurements and battery state of charge. Inspectors reviewed telemetry daily to ensure gaging stations were functioning correctly, and gaging stations and samplers were inspected in the field when telemetry readings indicated discharge had occurred or equipment problems existed. Additionally, flumes at E039.1, E042.1, E050.1, and E060.1 were inspected for sedimentation after each discharge event.

2.2 Sampling at the Detention Basins below the SWMU 01-001(f) Drainage

In 2020, no samples were collected with an automated sampler above two constructed detention basins below the SWMU 01-001(f) drainage at location CO111041. No samples were collected downgradient of the detention basins at the culvert at the terminus of the vegetative buffer below the lower basin (CO101038) because the detention basins would have to be near capacity to collect a sample. Sampling locations and storm water control features at the detention basins below the SWMU 01-001(f) drainage are identified in Figure 2.2-1. No physical evidence of storm water flow across the lower basin spillway was observed during post-storm inspections in 2020.

2.3 Sampling at the Gaging Stations in the LA/P Watershed

During the 2020 monitoring period (June 1 to approximately October 31), no sample-triggering discharge occurred (5 cfs above base flow at E026, E050.1, E059.5, E059.8, E060.1; 100 cfs at E038; and 50 cfs at the other gaging stations). Table 2.3-1 shows rainfall totals and maximum daily discharge for storms during the season that exceeded 24-hr rainfall totals of 0.25 in. No precipitation events exceeding a sample-triggering discharge occurred before June 1 or after October 31. No sampling events occurred during the monitoring period at LA/P gaging stations. A sampling event is defined as the collection of one or more samples from a specific gaging station during a specific runoff event. Reasons that storm water was not collected during particular storm events are categorized and presented in Table 2.3-2. Deviations from the monitoring plan are explained more fully in section 2.5.

2.4 Samples Collected in the LA/P Watershed

Sample suites presented in the monitoring plan vary according to the monitoring location and are based on key indicator constituents as well as on requirements stipulated by NMED and per the 2017 memorandum of understanding between DOE and the Buckman Direct Diversion Board (BDDB) (DOE and BDD Board 2017, 602995) for a given portion of the watershed. Planned analyses were prioritized in the order presented in Table 2.4-1. Suspended sediment analyses were planned using American Society for Testing and Materials (ASTM) method D3977-97, from an entire sample, and reported using the designation “suspended sediment concentration” (SSC). Analyses were planned using the analytical methods presented in Table 2.4-2. Table 2.4-1 presents the prioritization matrix that was used to guide the submission of analyses during 2019. Except at E050.1 and E060.1, where all events are monitored for all parameters, if four runoff events have been sampled at a gaging station during the monitoring year, subsequent events with discharge less than the largest discharge of the sampled storm events will not be analyzed.

Analyses planned and analyses performed may differ during the year for several reasons, including the following:

1. Incomplete sample volumes were collected.
    a. Minimum volumes are required to obtain specified detection limits. If the volumes were insufficient, select analyses were not performed.
    b. Lowest-priority analyses are omitted when incomplete volumes are collected.
2. Samples are collected in glass or polyethylene bottles.
    a. Organic chemical analyses are conducted on samples collected in glass bottles. If glass bottles did not fill, analyses were not performed.
    b. Boron was analyzed as an addition to the TAL metals suite, and samples were collected in polyethylene bottles. If insufficient volume was collected in polyethylene bottles, boron analyses were not ordered.

2.5 Deviations from Monitoring Plan

The 2020 monitoring year was affected by the COVID-19 pandemic, and fieldwork was reduced to EMCA status beginning March 24, 2020. As described in a March 31, 2020, letter from EM-LA to the NMED Hazardous Waste Bureau (DOE 2020, 700826), fieldwork was limited to only the activities necessary to ensure the safety of the public, the workers, and the environment. The resumption of N3B’s operations at LANL occurred in phases, starting with additional mission-critical activities that were both high-priority and low-risk. Even after field operations began to resume in June and July, 2020, COVID-19 reduced staff availability. Sampler activation was completed by July 28, 2020. Between the anticipated activation date of June 1, 2020, and the actual activation date of July 28, 2020, there were no storm events large enough to potentially have triggered samplers.

If the stage or discharge could not be correctly measured because of damage or silting that occurred, these instances are documented in Table 2.5-2.

Battery voltage, stage height, and sensor function at each active gaging station were remotely monitored daily. An on-site inspection was performed if any malfunction or sample collection event was observed. Samplers and monitoring equipment were remotely inspected from March 24, 2020, until mid-July 2020. Samplers and monitoring equipment were physically inspected initially in mid-July, 2020, and at least monthly until November 2020.

3.0 WATERSHED HYDROLOGY

The topography, geology, geomorphology, and meteorology of the LA/P watershed are quite complex and include mesas, canyons, and large elevation gradients; alluvium, volcanic tuff, pumice, and basalt; ephemeral streams, evolving stream networks (both laterally and vertically), and sediment-laden stream discharge; winter snowfall that can create spring snowmelt; intense summer monsoonal rainfall and occasional late-summer to fall tropical storm activity; and severe spatial variability of rainfall. Consequently, monitoring of the LA/P watershed runoff is also complex and challenging.

3.1 Drainage Areas and Impervious Surfaces

The drainage area specific to each gaging station (i.e., not nested) was developed using the ArcHydro Data Model in ArcGIS, and these drainage areas are presented in Figure 2.1-3. Model inputs were developed using an elevation grid created from 1-ft light detecting and ranging (LiDAR) images (a digital elevation model from 2014) and manual site-specific controls based on field assessments. Each drainage area defines the area that drains to the particular gaging station from either the next upstream gaging station or the headwaters of the watershed.

The impervious surface area was derived from Los Alamos County's roads and structures GIS layers. Roads, parking lots, and structures were considered impervious, and the total impervious area was computed for each watershed. The total impervious area was then divided by the total area of each watershed to compute the percentage of impervious surface area. The following assumptions were made in determining the percent impervious surface area: because the roads/parking lots and structures GIS layers were developed in 2009, newer impervious surfaces will not be captured; and, other impervious surfaces such as sidewalks and rock outcroppings may not have been included in the calculations. A significant factor in the frequency of discharge at each gaging station is the ratio of pervious to impervious surface area discharging to the gaging station or within the canyon drainage (Table 3.1-1).

3.2 Water and Sediment Transmission

Figure 3.2-1 is a flow diagram of the LA/P watershed showing each gaging station and the location of sediment transport mitigation sites. Figure 3.2-2 shows box-and-whisker plots of SSC for DP, Los Alamos, and Pueblo/Acid Canyons from up- to downstream over the 7 yr of monitoring from 2013 to 2019. As expected, Los Alamos Canyon had high concentrations of suspended sediment in 2013 as a result of the 2011 Las Conchas fire and because there is less impervious area contributing to Los Alamos Canyon, thus making more sediment available for erosion. Large post-fire runoff events have tapered off since the fire, and SSC magnitudes have returned to pre-fire levels. Sampled SSC levels in 2019 were higher than in recent years and similar to post-fire levels, but that is likely due to SSC sampling from only the largest runoff events. The sampling trip levels at most gaging stations in Los Alamos, DP, and Pueblo Canyons were significantly increased in 2019 to ensure that only the largest runoff events were sampled. SSC in DP and Pueblo/Acid Canyons is significantly less than in Los Alamos Canyon. Historical observations show that SSC in Los Alamos Canyon generally decreases from E026 to E050.1, particularly after flowing through the lower Los Alamos Canyon sediment-detention basins and low-head weir (between E042.1 and E050.1). SSC then increases greatly after the Guaje Canyon confluence (E099) and decreases slightly at E109.9. Gaging station E109.9 was decommissioned after the September 2013 flood, and sampling has not been performed at E099 since 2014 because Guaje Canyon watershed is not impacted by the Laboratory; hence, sampling is not required as part of the LA/P monitoring efforts. In DP Canyon, SSC generally decreases from E038 to E039.1. This is likely because of the large percentage of impervious area in the E038 watershed, causing high-velocity, high-erodibility flows that scour the channel between the townsite and E038. The DP Canyon floodplains area and GCS then decrease the flow velocity before it reaches E039.1, removing sediment. With large storm events, DP Canyon flows join Los Alamos Canyon to increase the flow velocity and SSC measured at E042.1, and the lower Los Alamos sediment detention basins and low-head weir remove sediment, reducing the SSC at E050.1.

In Acid Canyon, SSC decreases slightly from E055.5 to E056, likely because of the largely impervious area associated with E055.5 and the largely pervious area associated with E056. Acid Canyon joins Pueblo Canyon just below E056 in Acid Canyon and E055 in Pueblo Canyon. Historically, SSC has been slightly higher at E055 in Pueblo Canyon above this confluence than at E056. Gaging station E059.5 is located in lower Pueblo Canyon below this confluence with Acid Canyon and after other inputs from many other tributaries. From E059.8 to below the GCS at E060.1, SSC increased significantly in 2015. However, in the last 8 years, 2015 was the only year E060.1 experienced flow large enough to sample.

No runoff events exceeded sampling triggers at any of the 13 gaging stations in the watershed in 2020. Figure 3.2-3 shows hydrographs for Los Alamos, DP, and Acid/Pueblo Canyons from upstream to downstream for the largest storm events of the monitoring season, those measuring 24-hr total precipitation of 0.25 in. or more. Table 3.2-1 summarizes the flood bore transmission downstream across the major sediment-transport mitigations, including travel time of flood bore from the upstream to the downstream gaging station, peak discharges of the flood bore at the gaging station, and the percentage of reduction in peak discharge between the stations for all storm events with 24-hr total precipitation of 0.25 in. or more. The flood bore is defined as the leading edge of the storm hydrograph as it transmits downcanyon, and peak discharge is the maximum 5-min instantaneous flow rate measured during a flood. The focus was on peak discharge because it is related to stream power. In ephemeral streams in semiarid climates, the greater the stream power, the greater the erosive force, hence the greater the sediment transport (Bagnold 1977, 111753; Graf 1983, 111754; Lane et al. 1994, 111757). As flood bores move from up- to downstream, peak discharge can increase by means of either alluvial groundwater and/or tributary contributions or decrease because of transmission losses (infiltration).

Figure 3.2-4 shows the linear relationship between sediment yield and runoff volume for the stations where SSC was measured throughout the runoff event over the 7 yr of monitoring from 2013 to 2019. Table 3.2-2 presents the values for 2013 through 2019 shown in Figure 3.2-4. Although SSC and instantaneous discharge are not always highly correlated (due to localized precipitation, sediment availability, or antecedent conditions), the linear relationship between sediment yield and runoff volume is well established (Onodera et al. 1993, 111759; Nichols 2006, 111758; Mingguo et al. 2007, 111756).

The runoff volume for each event was computed as follows:

$$V = \sum_{i=0}^{n} Q(t_i)(t_{i+1} - t_i) \quad , \qquad \textbf{Equation 2}$$

Where n = the number of instantaneous discharge measurements taken throughout the runoff event,

t_i = the time at which an instantaneous discharge measurement is taken, and

$Q(t_i)$ = the discharge (cfs) at time t_i (multiplied by 60 to convert from cfs to cfm).

The mass of sediment for each runoff event was computed as follows:

$$M = \sum_{j=0}^{m} Q(t_j)(t_{j+1} - t_j)\,SSC(t_j) \quad , \qquad \textbf{Equation 3}$$

Where m = the number of SSC samples taken throughout the storm event,

t_j = the time, j, at which an SSC sample is taken,

$Q(t_j)$ = the discharge (cfs) at time t_j interpolated from the instantaneous discharge measurements taken at time t_j (multiplied by 60 to convert from cfs to cfm), and

$SSC(t_j)$ = SSC (mg/L) at time t_j (multiplied by 28.3×10^{-6} to convert from mg/L to kg/ft^3).

Figure 3.2-5 shows the linear relationship between sediment yield and peak discharge, which is not as robust as the relationship between sediment yield and runoff volume during the past 7 yr, shown in Figure 3.2-4. The relationship between discharge and SSC is further discussed in section 4.2 of this report.

3.3 Geomorphic Changes and Vegetation Health

Geomorphic changes that occurred from 2011 to 2020 at sediment transport mitigation sites in the LA/P watershed were evaluated and are discussed in Appendix B.

In 2019, new aerial survey techniques replaced previously implemented ground-based global positioning system (GPS) survey methods. Tetra Tech was contracted to survey Los Alamos, DP, and Pueblo Canyon areas of interest using airborne hyperspectral and LiDAR equipment to collect geomorphic and vegetation data. A baseline LiDAR aerial survey was performed in 2018, during which points were measured at a density at least equivalent to the 2016 LiDAR data set (18–24 points per m^2). The LiDAR surveys provided a detailed digital elevation model of the entire active channel within the wetland area, allowing comparison with historic ground-based geomorphic survey data.

Vegetation features were surveyed using an AISA EAGLE II visible and near-infrared (VNIR) hyperspectral imaging sensor system affixed to a Cessna 172 Skyhawk. A total of 128 spectral bands for the VNIR were collected, producing a ground sampling distance of 0.5 m. Location and altitude data were collected by an Oxford Technical Solutions, Ltd., 2+ second-generation GPS.

Upon completion of airborne survey efforts, ground truthing was performed to identify reed canary grass, willow, and cattail. These data were used to develop a classification algorithm for the analysis of the hyperspectral data. Analysis resulted in seven target vegetation classes: reed canary grass, willow, cattail, mixed reed canary grass and willow, other vegetation, surface water, and non-vegetated. If no large storm events occur that create significant geomorphic change, aerial LiDAR surveys will be performed every third year, with the next survey scheduled for 2022. [See Attachment B-1 of the 2019 edition of this report for the most recent aerial survey maps (N3B 2020, 700835)].

3.4 Impact and Efficiency of Watershed Mitigations

Below is a discussion of each watershed mitigation and the impact and efficiency of that system.

DP Canyon: No samples were collected in DP Canyon in 2020.

Statistics over the 7 yr of monitoring from 2013 to 2019 are also useful in assessing performance. Figure 3.4-1 shows box-and-whisker plots for E038 and E039.1 for SSC and peak discharge. These plots show major reductions in SSC and slight reduction (depending on the year) in mean peak discharge (i.e., erosive force) over the 7 yr, which are consistent with the goals of the sediment transport mitigation activities. In 2019, most peak discharge values from runoff events in DP Canyon were lower than in prior years, but the sampled SSC values were higher than in recent years. This is likely due to the increased trip levels, which ensured that only the runoff events with high peak discharge and therefore increased erosive force and stream power to carry more sediment were sampled (Figure 3.4-1). Another potential contributor to the increased sediment is heavy construction at the head of the DP watershed.

Decreasing storm water velocity allows increased infiltration, thus reducing peak discharge as well as the distance traveled downstream by the flood bore and by sediment and associated contaminants entrained in the storm water. Increasing infiltration reduces peak discharge but can also decrease the total volume of storm water. In 2019, the peak discharge decreased in three of five measureable runoff events between E038 and E039.1, with an average decrease of 49% relative percent difference (RPD); and increased in two of five runoff events, with an increase of 52% RPD (Table 3.2-1).

Pueblo Canyon: No samples were collected in Pueblo Canyon in 2020.

The discharge magnitude is being reduced through this area, which is a primary goal of the mitigation actions. Indeed, discharge is being reduced so much that no samples were collected at E060.1 in 2012, 2013, 2016, 2017, 2018, 2019, or 2020. SSC was not analyzed for the one sample collected in 2014, and only two samples were collected in 2015. In addition, SSC magnitude was reduced through the mitigation structures in 2015.

Los Alamos Canyon: No samples were collected in Los Alamos Canyon in 2020. Sediment trapping efficiency is expected to be higher in smaller events and in events early in the season before the detention basins have filled with water. Flow is reduced through the weir and the upstream sediment detention basins, allowing sediment to settle out of suspension; hence, this mitigation feature is performing as designed.

In addition to examining coinciding sampling events, performance of the weir and upstream sediment detention basins can be assessed by examining statistics over the 7 yr of monitoring from 2013 to 2019. Figure 3.4-1 shows box-and-whisker plots for E042.1 and E050.1 for SSC and peak discharge. These plots show major reductions in SSC, particularly in the post-Las Conchas fire years of 2012 and 2013; hence, the weir is performing as designed. The SSC values in 2019 approximated the values seen in the post-fire years. This is likely due to sampling only the largest runoff events. Minor reductions in peak discharge occurred from 2011 to 2013 and 2016, 2018, and 2019; minor increases in peak discharge occurred in 2010, 2014, 2015, and 2017.

4.0 ANALYTICAL RESULTS

Appendix D (on CD included with the document) usually contains the analytical results for the LA/P watershed. However, in 2020, no samples were collected or analyzed; hence, there are no analytical data included in Appendix D.

Analytical results meet the N3B minimum data quality objectives (DQOs) as outlined in N3B-PLN-SDM-1000: “Sample and Data Management Plan.” N3B-PLN-SDM-1000 sets the validation frequency criteria at 100% Level 1 examination and Level 2 verification of data, and at 10% minimum Level 3 validation of data. A Level 1 examination assesses the completeness of the data as delivered from the analytical laboratory, identifies any reporting errors, and checks the usability of the data based on the analytical laboratory’s evaluation of the data. A Level 2 verification evaluates the data to determine the extent to which the laboratory met the analytical method and the contract-specific quality control and reporting requirements. A Level 3 validation includes Levels 1 and 2 criteria and determines the effect of potential anomalies encountered during analysis and possible effects on data quality and usability. A

Level 3 validation is performed manually with method-specific data validation procedures. Laboratory analytical data are validated by N3B personnel as outlined in N3B-PLN-SDM-1000; N3B-AP-SDM-3000: “General Guidelines for Data Validation”; N3B-AP-SDM-3014: “Examination and Verification of Analytical Data”; and additional method-specific analytical data validation procedures. All associated validation procedures have been developed, where applicable, from the EPA QA/G-8 Guidance on Environmental Data Verification and Data Validation, the Department of Defense/Department of Energy Consolidated Quality Systems Manual for Environmental Laboratories, the EPA National Functional Guidelines for Data Validation, and the American National Standards Institute/American Nuclear Society 41.5: Verification and Validation of Radiological Data.

4.1 Analytes Exceeding Comparison Values

The watershed mitigations in the LA/P watershed have been constructed to mitigate the transport of contaminated sediments, and the analytical results from monitoring are presented and evaluated within this context. The mitigation actions were not undertaken with the objective of reducing concentrations of waterborne contaminants to specific levels, and the analytical results are therefore not compared with water-quality standards or other criteria for that purpose or for the purpose of evaluating compliance with regulatory requirements. For this report, monitoring results are compared with water-quality standards at the request of NMED.

The New Mexico Water Quality Control Commission Standards for Interstate and Intrastate Surface Waters (20.6.4 New Mexico Administrative Code [NMAC]) establish surface-water criteria. Surface waters within DP Canyon at E038, Pueblo, and Acid Canyons are unclassified, nonperennial waters of the state under 20.6.4.98 NMAC, with segment-specific designated uses of livestock watering, wildlife habitat, marginal warm-water aquatic life, and primary contact. The criteria applicable to the marginal warm-water aquatic life designation include both acute and chronic aquatic life criteria and the human health–organism only (HH-OO) criteria. Surface waters within Los Alamos Canyon and DP Canyon at E039.1 are classified as ephemeral and intermittent waters of the state under 20.6.4.128 NMAC, with segment-specific designated uses of livestock watering, wildlife habitat, limited aquatic life, and secondary contact. The criteria applicable to the limited aquatic life designation include the acute aquatic life criteria and the HH-OO criteria but do not include the chronic aquatic life criteria.

Water-quality criteria for total and total recoverable pollutants are compared with unfiltered surface water sample concentrations. The water-quality criterion for total recoverable aluminum is for storm water samples filtered with a 10-µm pore size. Other water-quality criteria are for dissolved concentrations of pollutants, which are compared with storm water samples filtered with a 0.45-µm pore size. Acute and chronic aquatic life criteria for dissolved cadmium, chromium, copper, lead, manganese, nickel, and zinc, and acute aquatic life criteria for dissolved silver, are calculated based on the hardness of each sample. Concurrent hardness values in the LA/P watershed range from 7.89 mg/L to 43.3 mg/L (averaging 27.7 mg/L) of calcium carbonate ($CaCO_3$) calculated from calcium and magnesium values for storm water collected in 2019. Hardness-dependent metals criteria are strongly influenced by the hardness value used in the calculation, i.e., a low hardness value results in a low metals criterion and a high hardness value results in a high metals criterion. The water-quality criterion for dioxins is the sum of the dioxin toxicity equivalents expressed as 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD). No samples were collected during the 2020 monitoring season; hence, no analytical results from 2020 are available for this report.

The Los Alamos County townsite routes most of its storm water and entrained pollutants into Los Alamos and Pueblo Canyons. Storm water pollutant loading to receiving waters is derived from the decay of buildings, parking lots, roads, and automobile traffic emissions, all of which occur in a developed urban landscape and are common to urban developed landscapes throughout the developed world (Tsihrintzis and Hamid 1997, 602314; Göbel et al. 2007, 252959). Many of the structures and impervious surfaces within the Los Alamos County townsite are older and have weathered over the years, continuing to shed metals and organic compounds to Los Alamos and Pueblo Canyons adjacent to the townsite. In addition, pollutants have accumulated in sediments in canyon bottoms over time and are mobilized during storm flow events. They are commonly detected throughout the gage network adjacent to and downstream of the Los Alamos townsite.

A large portion of townsite runoff is routed to DP canyon, the south fork of Acid Canyon, and upper Pueblo Canyon. Most of the exceedances observed in analytical results from previous years are metals and PCBs detected at gaging stations located directly downstream from these routing pathways.

The EPA-recommended criterion for aluminum in fresh water reflects aluminum's bioavailability to living organisms such as fish and invertebrate species. The bioavailability and associated toxicity of aluminum are calculated using a multiple linear regression model that incorporates pH, dissolved organic carbon, and total hardness (EPA 2018, 700247).

Because hardness in storm water runoff is typically very low, the corresponding calculated aluminum water-quality criterion is low, resulting in a greater number of exceedances. Aluminum in storm water is representative of the natural background composition of the Bandelier Tuff (LANL 2013, 239557). On the Pajarito Plateau, much of the sediment-bound aluminum is associated with poorly crystalline silica-rich glass of Bandelier Tuff. As the tuff weathers, the glass particles and associated aluminum form sediment that accumulates, is entrained, and is then transported by storm water runoff. In addition, aluminum is generally not problematic in runoff from developed urban landscapes on a national scale and is not associated with current or historical industrial processes within the Los Alamos County townsite.

Copper is a component of brake pads and roofing materials and is a common constituent in storm water emanating from urban environments in both dissolved and colloidal form (TCD Environmental 2004, 602305). Consequently, copper exceedances are likely due to runoff from the impervious developed landscape within the Los Alamos townsite.

Lead is a common component of house paint, building siding, and automobiles and is commonly found in storm water runoff from urban landscapes on a national scale (Davis and Burns 1999, 602303; Göbel et al. 2007, 252959), such as the Los Alamos County townsite. Because of the low solubility in the neutral pH range, lead is usually present in particulate form entrained in urban storm water.

Although there have been discharges of legacy radionuclide pollutants in the past at select locations within the Laboratory, the alpha activity of those constituents when measured by alpha spectroscopy contributes an insignificant amount of activity to the gross alpha activity values (McNaughton et al. 2012, 254666).

PCBs were commonly used as stabilizing agents in paints, caulking, oils, hydraulic fluid, road paint, pigments, plastics, and a host of other industrial materials. The ubiquitous distribution of PCBs in an urban setting, in addition to atmospheric deposition and very low screening levels, accounts for the relatively high number of detections and exceedances in surface and storm water emanating from developed urban landscapes in Los Alamos County (LANL 2012, 219767). In addition, PCBs have been archived in sediment and organic material that is occasionally released from the terrestrial inventory and transported in storm water flow events to canyon bottoms.

In summary, exceedances in storm water are associated with pollutant loadings emanating from Los Alamos County and are mainly associated with the developed urban landscape and day-to-day activities associated with vehicle traffic and with the weathering of roads, parking lots, and structures that are in various stages of decay. The chemical signature of storm water runoff is representative of many urban landscapes on a national scale.

4.2 Relationships between Discharge and SSC

Discharge was calculated from stage height using a rating curve, which is the relationship between discharge in ft^3 per second and height of the water in feet, developed for each individual gaging station. Stage height was measured at 5-min intervals and logged continuously during each sampled storm event. SSC and particle size were measured during each storm in conjunction with inorganic and organic chemicals and radionuclides.

SSC and instantaneous discharge estimates were calculated for each sample using a linear relationship between the two corresponding analytically determined SSCs, or the two corresponding physically measured discharges, as follows:

$$y = mx + b \qquad \textbf{Equation 4}$$

Where y = the calculated SSC or discharge at the time of sample collection,

m = the slope of the line,

x = the time differential in minutes between SSC sample collections or discharge measurements, and

b = the concentration of analytically determined SSC before sample analyses or corresponding physically determined discharge.

The slope is determined by dividing the difference in SSC or discharge by the difference in time (in minutes) between SSC sample collection or discharge measurements before and after analytical sample collection. This equation was used to calculate SSC and instantaneous discharge for samples collected. Where analytical results are not bounded by sediment results, the concentration of the nearest sediment result is used as an estimate of the sediment concentration at the time the sample was collected. No samples were collected in 2020.

4.3 Relationship between SSC and Concentrations of Constituents

The projected total metal values for each sample with measured SSC analyses were planned to be calculated using equations presented in the “2015 Monitoring Report for Los Alamos/ Pueblo Watershed” (LANL 2016, 601433).

4.4 Storm Water Sampling below SWMU 01-001(f)

No storm water samples were collected at the inlet to the upper detention basin below the SWMU 01-001 in 2020. The results from 2010 through 2019 continue to indicate the hillslope is a source of PCBs, even after sediment and rock were removed during corrective action at SWMU 01-001(f) in 2010.

5.0 CHANGES FROM THE 2019 REPORT

Based on changes that occurred in 2020, this report has been updated from the 2019 report. The changes are summarized as follows:

- In 2020, no samples were collected at any site.
- The following tables and figures are not included in the 2020 report as they report sample analytical data.
    - ❖ Table 3.5-1, Otowi Well #2 Discharges during Development and Testing in 2019

- ❖ Table 4.1-1, Comparison of Detected Analytical results with Water Quality Criteria
- ❖ Table 4.2-1, Calculated SSC and Instantaneous Discharge Determined for each Sample Collected in the LA/P Watershed
- ❖ Table 4.3-1, Estimated Total Recoverable Metals Concentrations and Unfiltered Uranium Activities
- ❖ Figure 3.2-4, Measured Discharge and Measured SSC for Sample Events
- ❖ Figure 3.4-2, Discharge and SSC for Sample Events
- ❖ Figure 3.5-1, Discharge from Otowi Well #2 Development and Testing in 2019

- Appendix D (on CD included with this document) usually contains the analytical data and the gaging-station stage and discharge data. No samples were collected during the 2020 monitoring season; hence, no analytical data are included in Appendix D.

6.0 CONCLUSIONS

Attenuation of flow and associated sediment transport are primary goals of the sediment transport mitigation activities. Decreasing flow velocity allows increased infiltration, thus reducing peak discharge, reducing the distance the flood bore, sediment, and associated contaminants entrained in the storm water travel downstream. In DP Canyon, the GCS and associated floodplains between gaging stations E038 and E039.1 facilitated a significant reduction in the suspended sediment being transported downstream. In Pueblo Canyon, the wetland, willows, drop structure, and GCS between gaging stations E059.5 and E060.1 facilitated such a reduction in peak discharge that storm water runoff at E060.1 was not large enough to sample. In Los Alamos Canyon, reductions in peak discharge, runoff volume, and sediment yield transmission downstream between E042.1 and E050.1 were attributed to the low-head weir and associated sediment-detention basins between the two gaging stations. Monitoring data in the LA/P watershed indicate that, in general, the mitigations are performing as designed.

Geomorphic changes are monitored at one background area, five sediment transport mitigation sites, and two sediment-retention basin areas that have been established in the LA/P watershed. The bank and thalweg surveys and repeat photographs support the conclusion of overall stability of the banks and channels in Pueblo, DP, and Los Alamos Canyons and establish the geomorphic change between 2019 and 2020 as minor, indicating that the watershed mitigations are performing as designed.

Continued monitoring in 2021 is expected to confirm that the sediment-transport mitigations in the LA/P watershed are performing as designed.

7.0 REFERENCES AND MAP DATA SOURCES

7.1 References

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Tsihrintzis, V.A., and R. Hamid, 1997. “Modeling and Management of Urban Stormwater Runoff Quality: A Review,” *Water Resources Management,* Vol. 11, pp. 137-164. (Tsihrintzis and Hamid 1997, 602314)

USACE (U.S. Army Corps of Engineers), March 2008. “HEC-RAS River Analysis System, Hydraulic Reference Manual,” Computer Program Documentation No. CPD-69, Washington, D.C. (USACE 2008, 109517)

USACE (U.S. Army Corps of Engineers), March 2008. “HEC-RAS River Analysis System, User's Manual,” Version 4.0, Computer Program Documentation No. CPD-68, Washington, D.C. (USACE 2008, 109518)

7.2 Map Data Sources

GageStation; Los Alamos National Laboratory, ER-ES, As published, project folder 15-0013; \\slip\gis\GIS\Projects\15-Projects\15-0013\zip\2015_E059.8_GageStation.shp; 2015

Facility location; Los Alamos National Laboratory, ER-ES, As published, project folder 15-0013; \\slip\gis\GIS\Projects\15-Projects\15-0013\project_data.gdb;merge_sandia_features_AGAIN;2015

Erosion control structure; Los Alamos National Laboratory, ER-ES, As published, project folder 15-0013; \\slip\gis\GIS\Projects\15-Projects\15-0013\project_data.gdb;merge_sandia_features_AGAIN;2015

Sediment control structure; Los Alamos National Laboratory, ER-ES, As published, project folder 15-0013; \\slip\gis\GIS\Projects\15-Projects\15-0013\project_data.gdb;merge_sandia_features_AGAIN;2015

Willow planting area; Los Alamos National Laboratory, ER-ES, As published, project folder 14-0015; \\slip\gis\GIS\Projects\14-Projects\14-0015\shp\as_built_willow_banks.shp; 2015

Structures; County of Los Alamos, Information Services; as published 29 October 2007.

Drainage; County of Los Alamos, Information Services; as published 16 May 2006.

Los Alamos County Boundary; Los Alamos National Laboratory, ENV Environmental Remediation and Surveillance Program; Unknown publication date.

Road Centerlines for the County of Los Alamos; County of Los Alamos, Information Services; as published 04 March 2009.

Watersheds; Los Alamos National Laboratory, ENV Environmental Remediation and Surveillance Program; EP2006-0942; 1:2,500 Scale Data; 27 October 2006.

Contour, 4-ft interval; Los Alamos National Laboratory, ER-ES, As published, project folder 15-0013;\\slip\gis\Data\HYP\LiDAR\2014\Bare_Earth\BareEarth_DEM_Mosaic.gdb; 2015

Technical Area Boundaries; Los Alamos National Laboratory, Site Planning & Project Initiation Group, Infrastructure Planning Office; September 2007; as published 13 August 2010.

Sediment Geomorphology; Los Alamos National Laboratory, ENV Environmental Remediation and Surveillance Program, ER2002-0589; 1:1,200 Scale Data; 01 January 2002.

Monitoring area; Los Alamos National Laboratory, ER-ES, As published, project folder 15-0013; \\slip\gis\GIS\Projects\15-Projects\15-0013\zip\ZoomAreas.shp; 2015

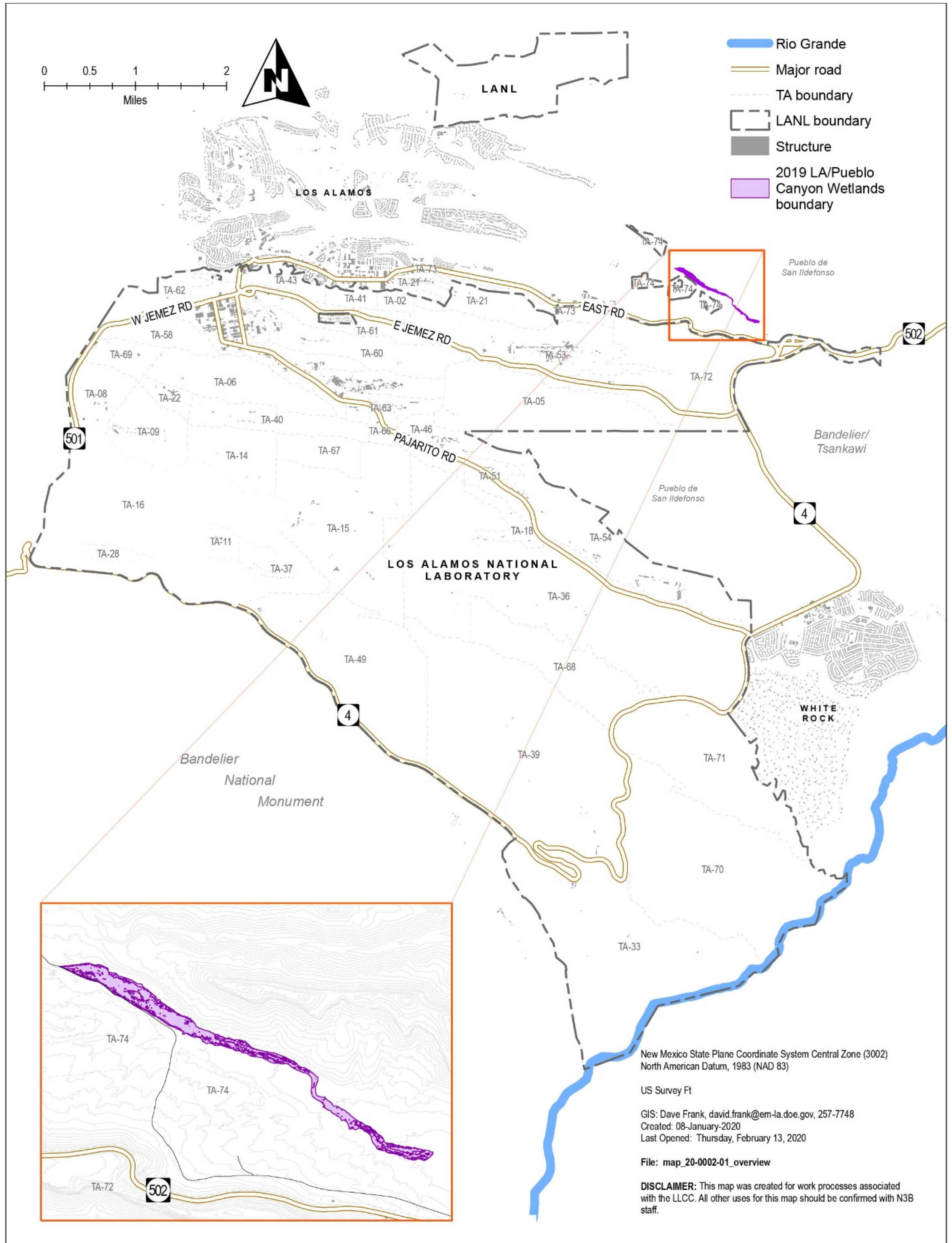


Figure 1.1-1 LA/P wetlands location in relation to Los Alamos National Laboratory property

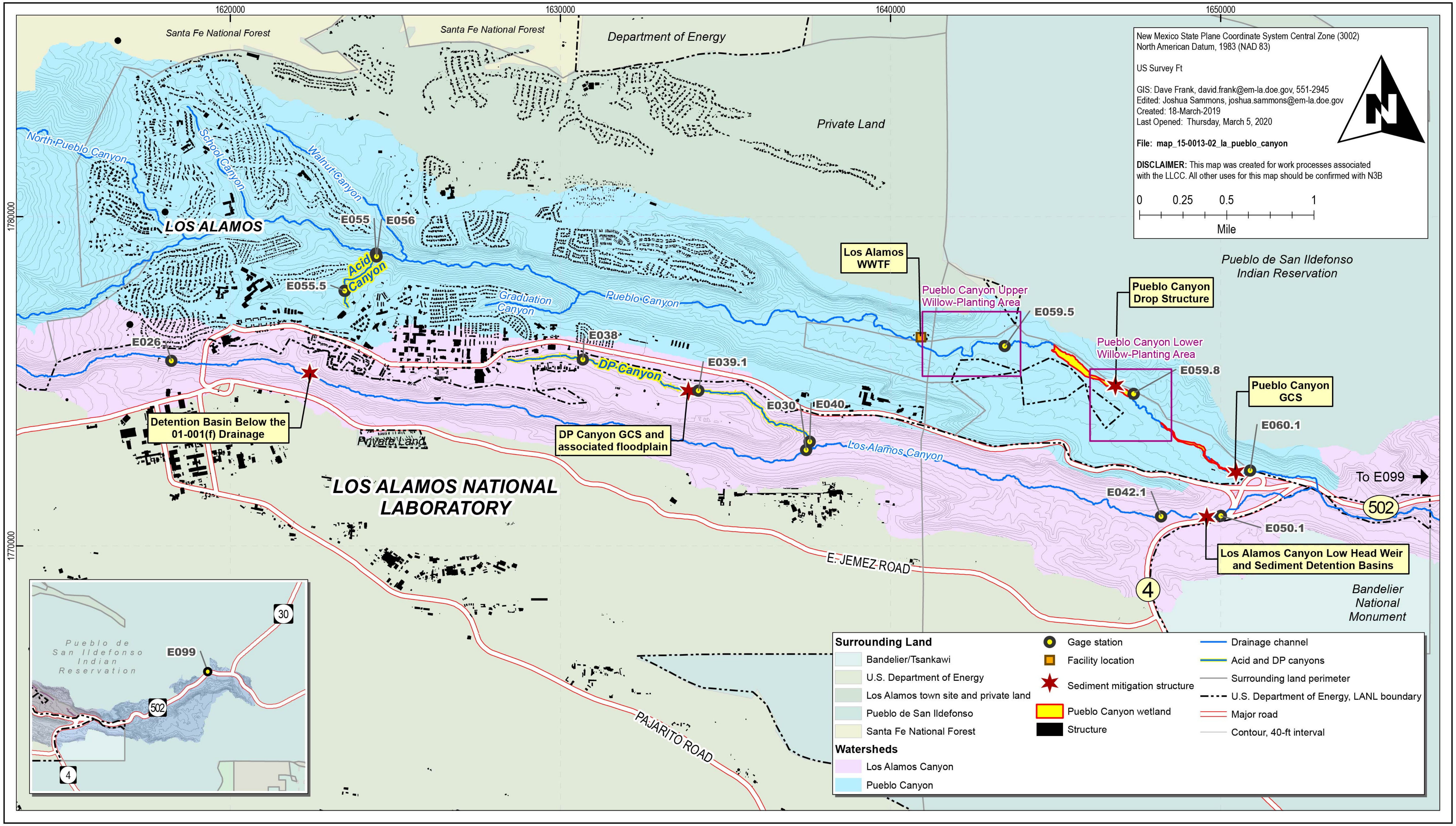
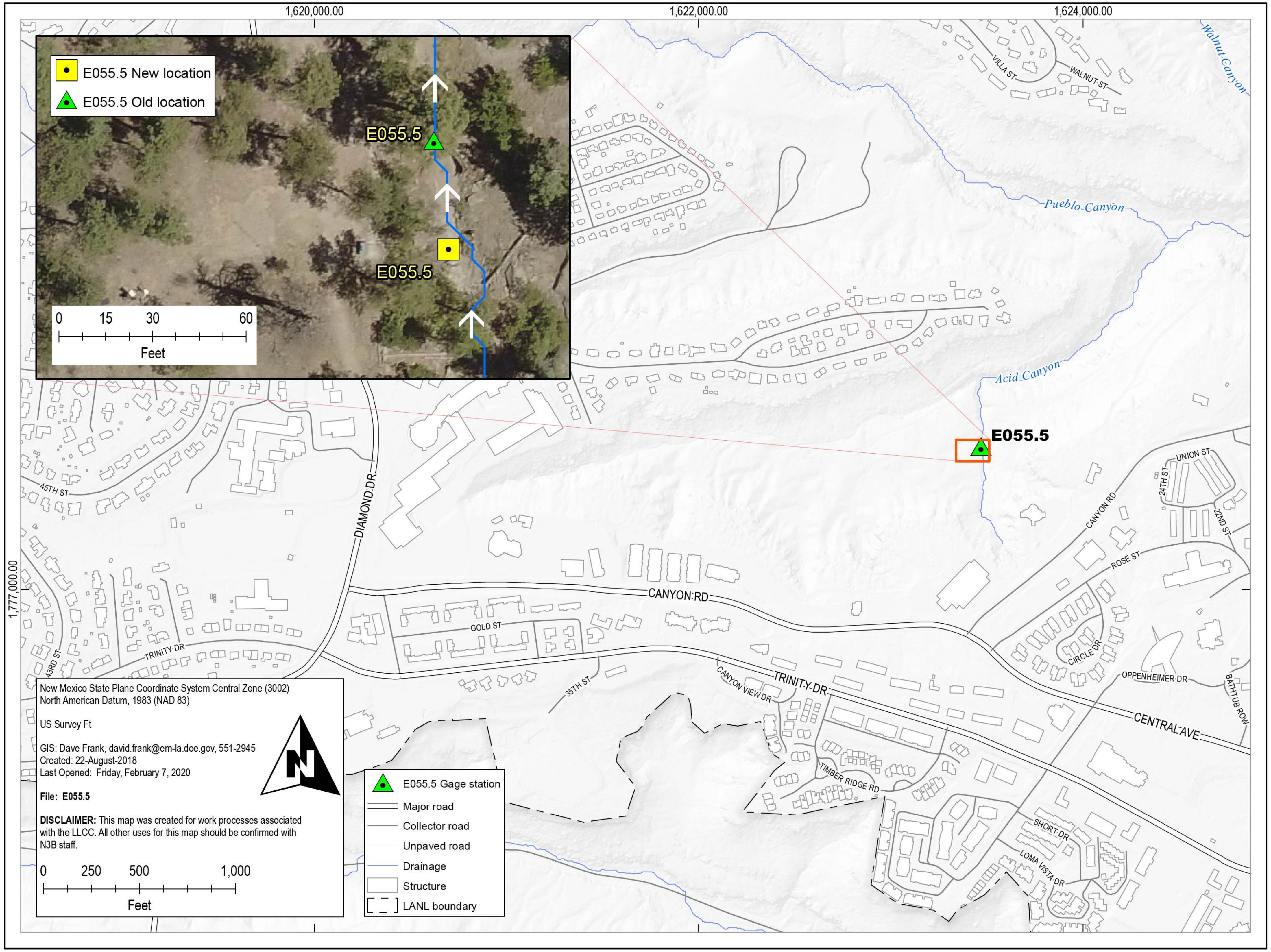
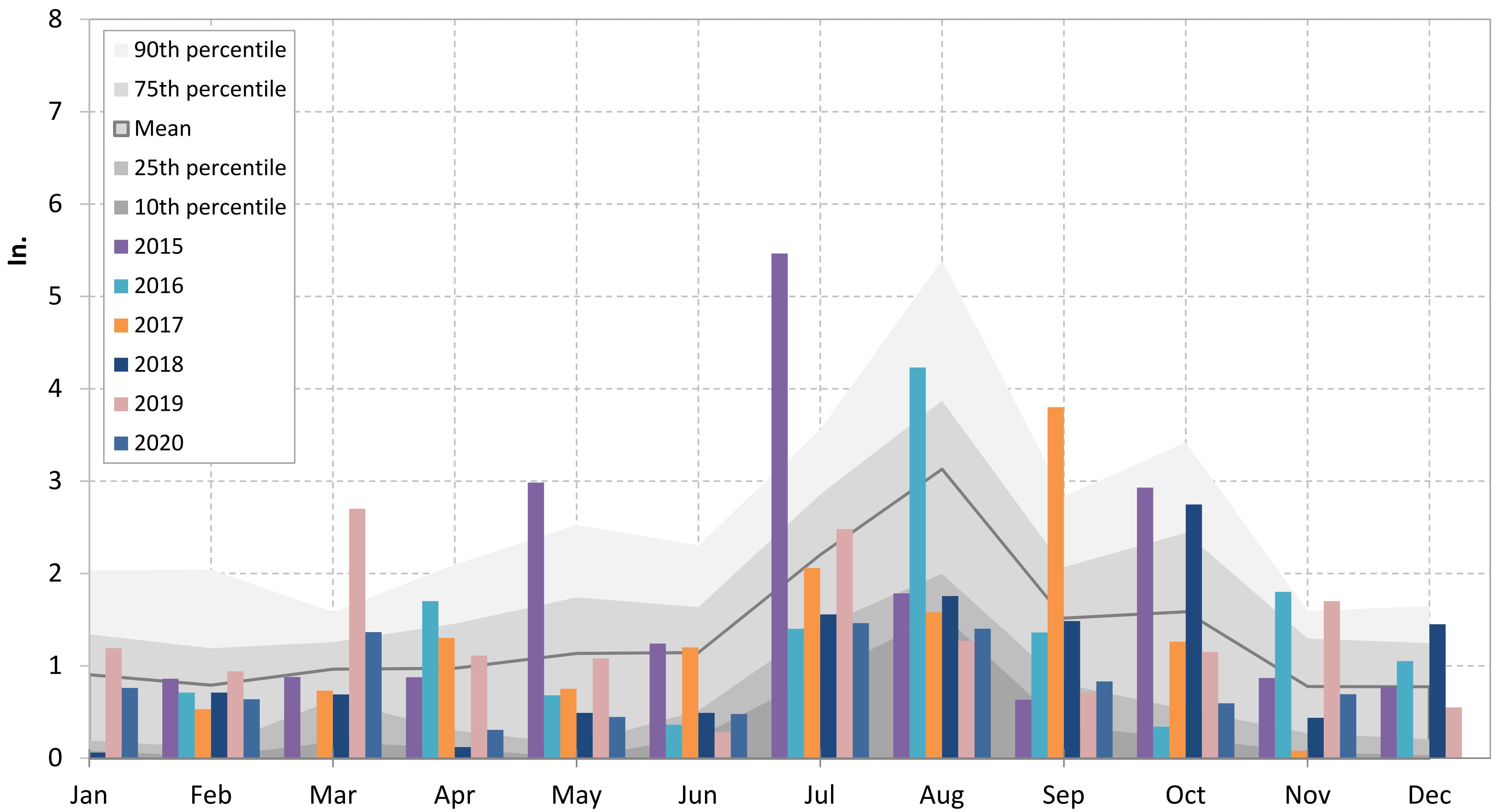


Figure 1.1-2 Los Alamos and Pueblo Canyons showing monitoring locations and sediment transport mitigation sites



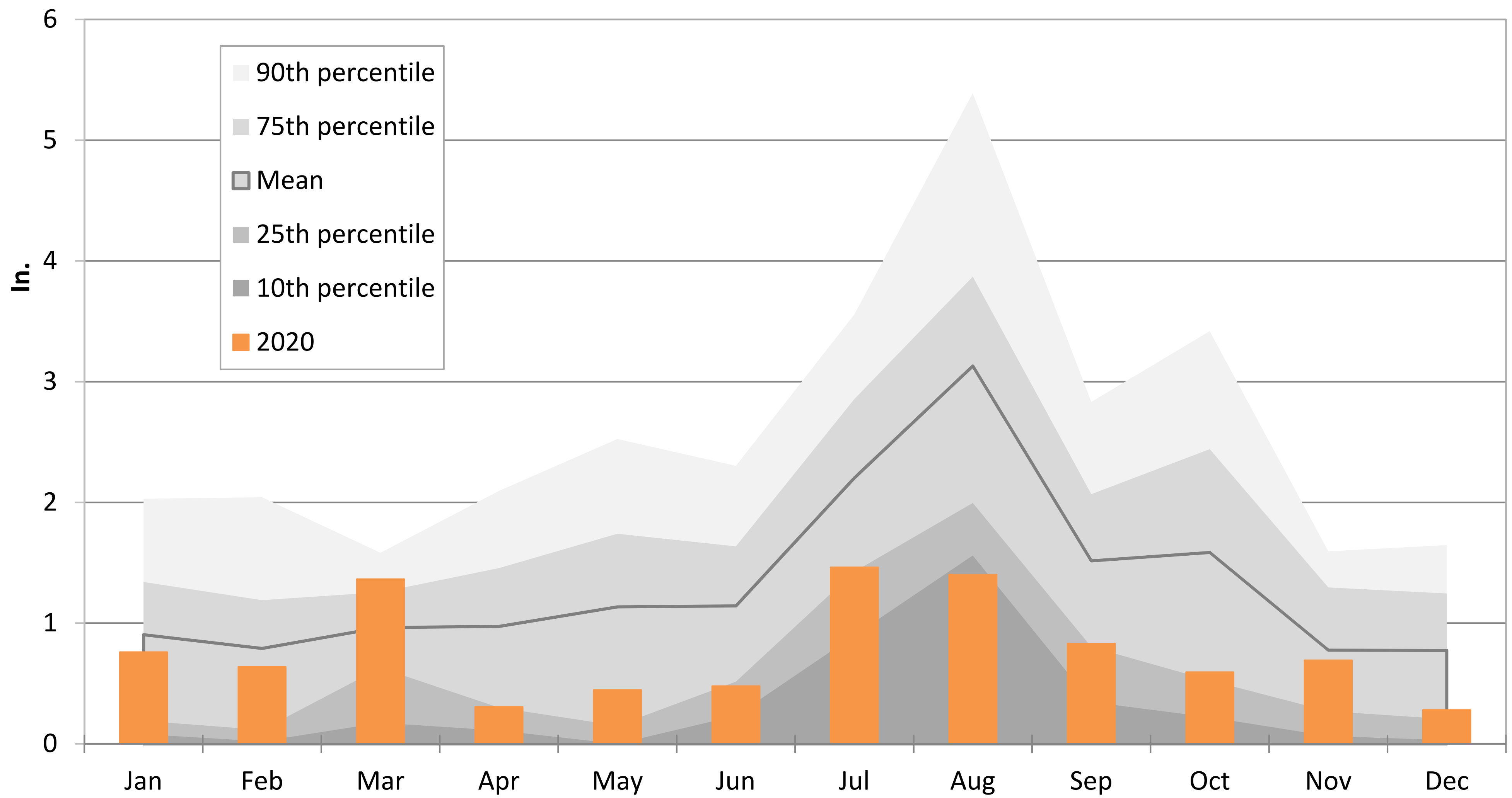
Note: The new station is located 35 ft upstream of the old station's location.

Figure 2.1-1 The new and old location of gaging station E055.5 in Acid Canyon



Note: Mean and percentiles are based on data from 1992 to 2010.

Figure 2.1-2 Total precipitation for each month between 2015 and 2020 based on meteorological tower data averaged across the Laboratory



Note: Mean and percentiles are based on data from 1992 to 2010.

Figure 2.1-3 Total precipitation for each month in 2020 based on meteorological tower data averaged across the Laboratory

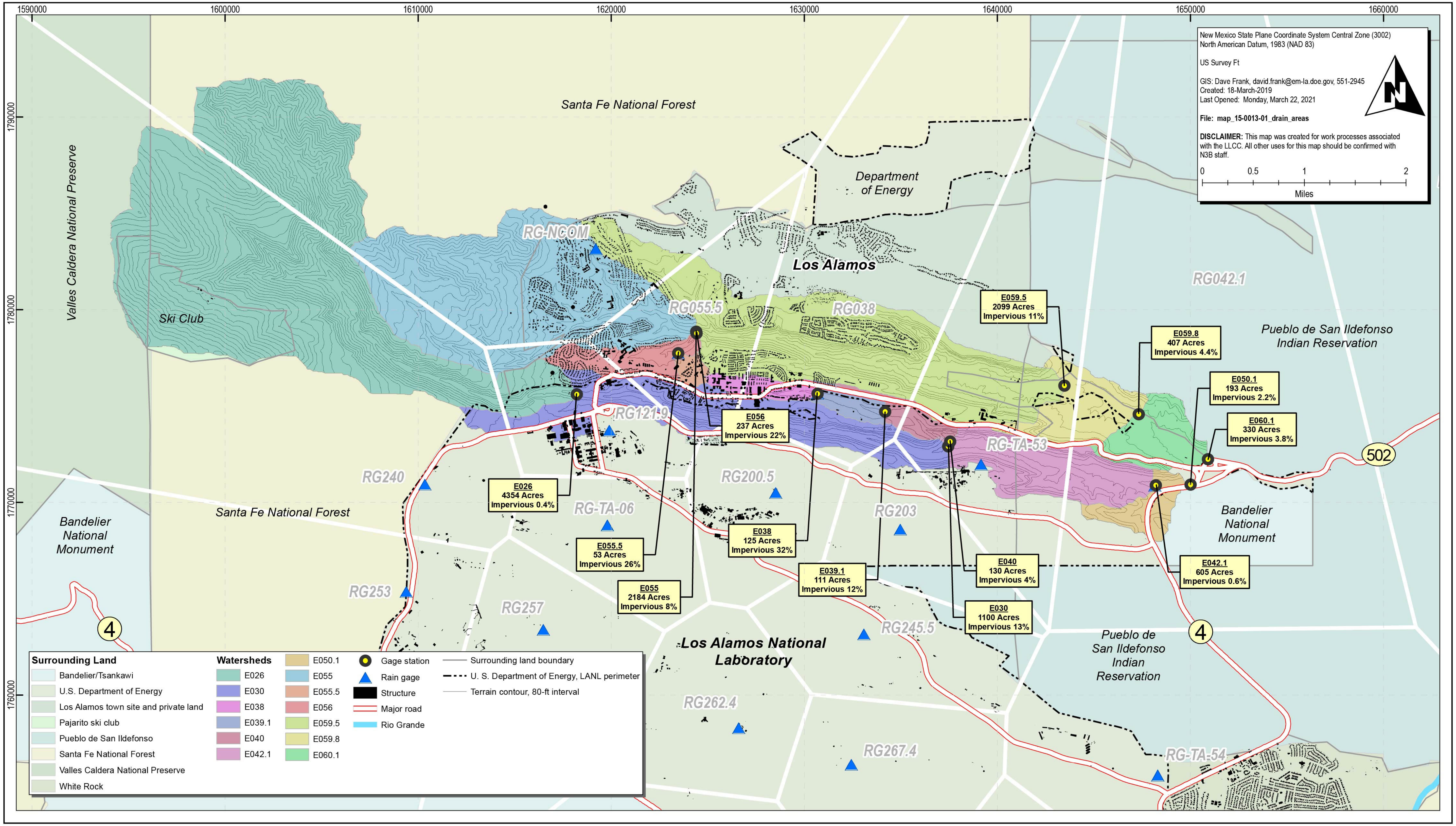


Figure 2.1-4 LA/P watershed showing drainage areas for each stream gaging station and associated rain gages and Thiessen polygons

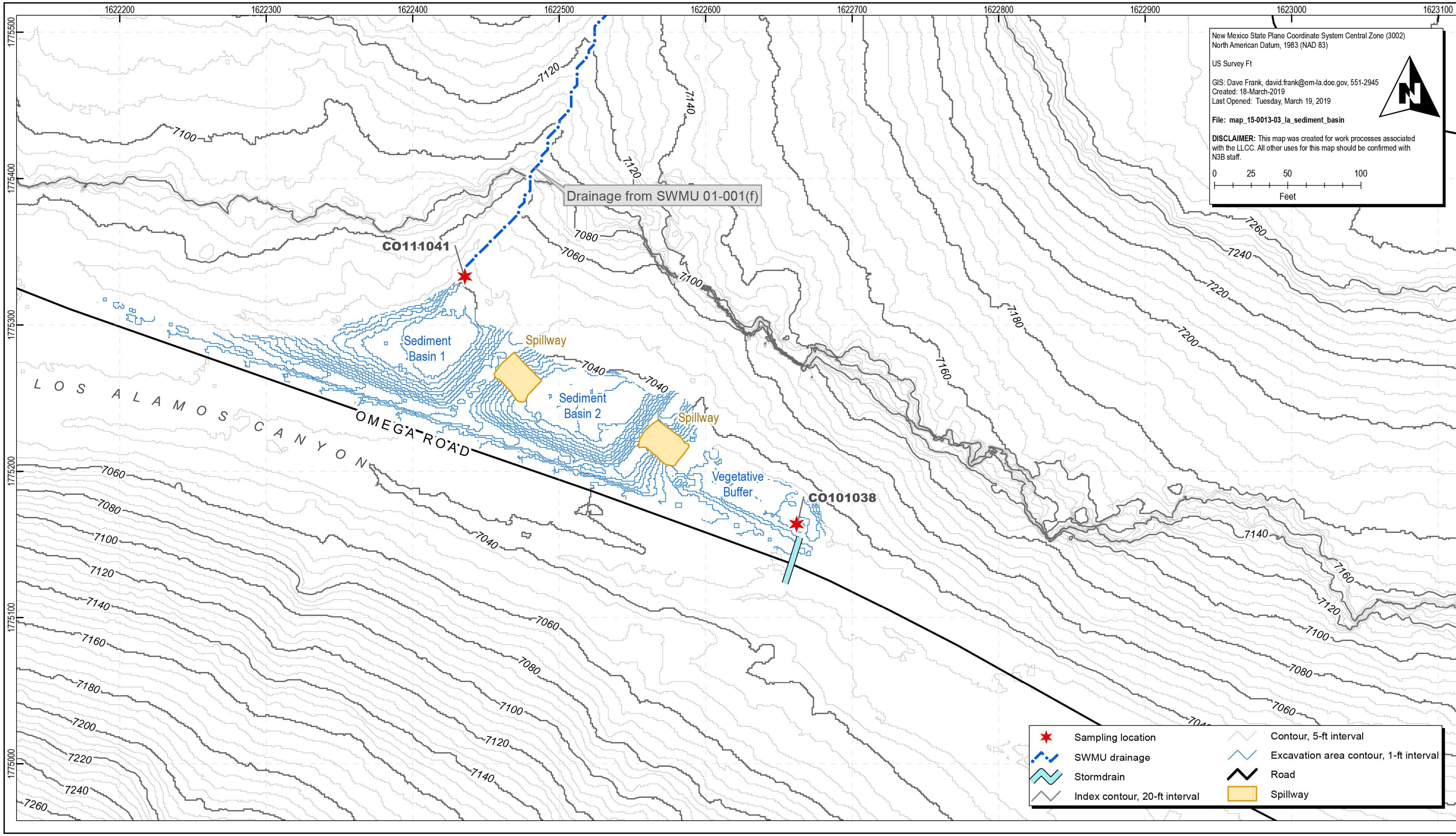


Figure 2.2-1 Upper Los Alamos Canyon sediment detention basins and sampling locations below the SWMU 01-001(f) drainage

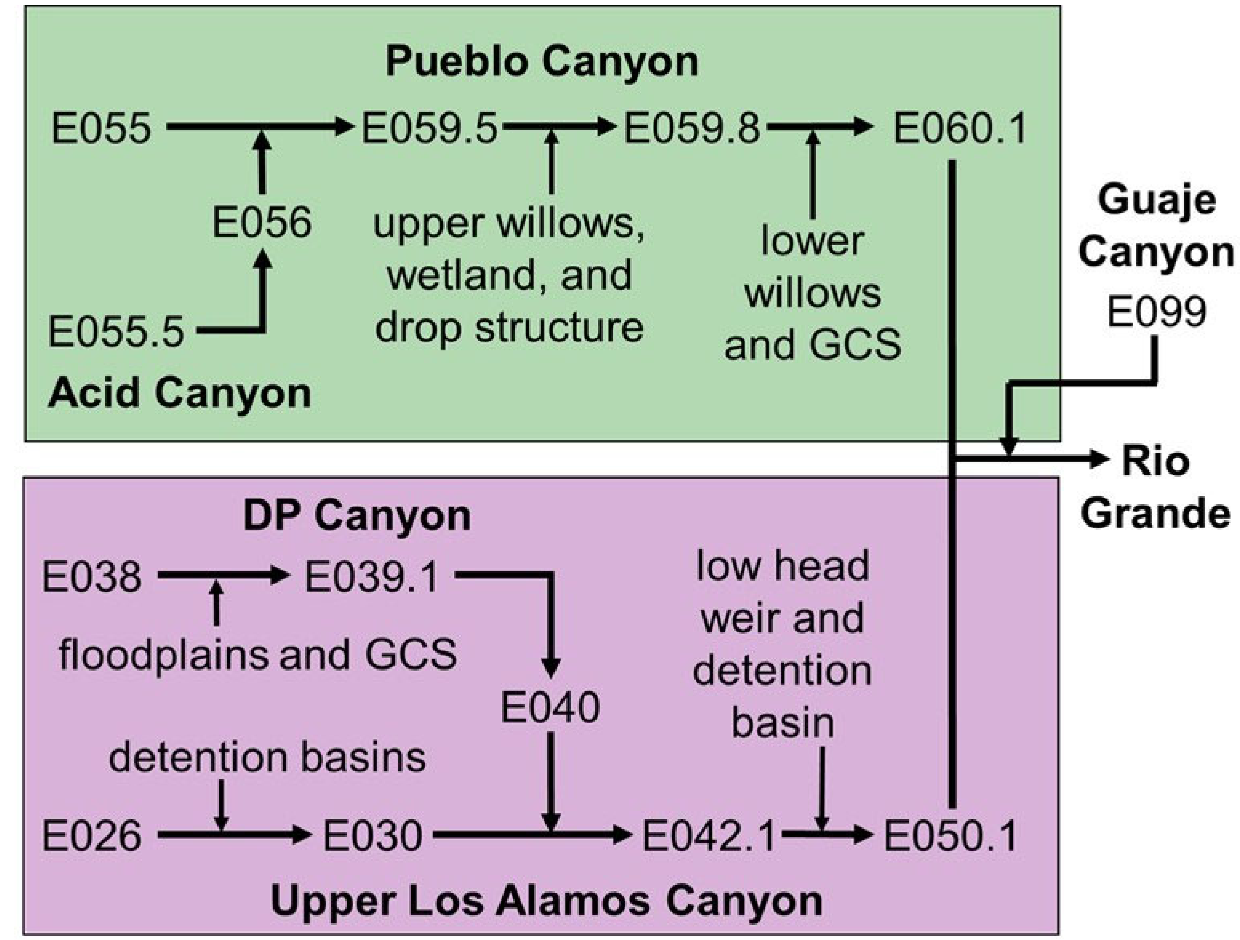
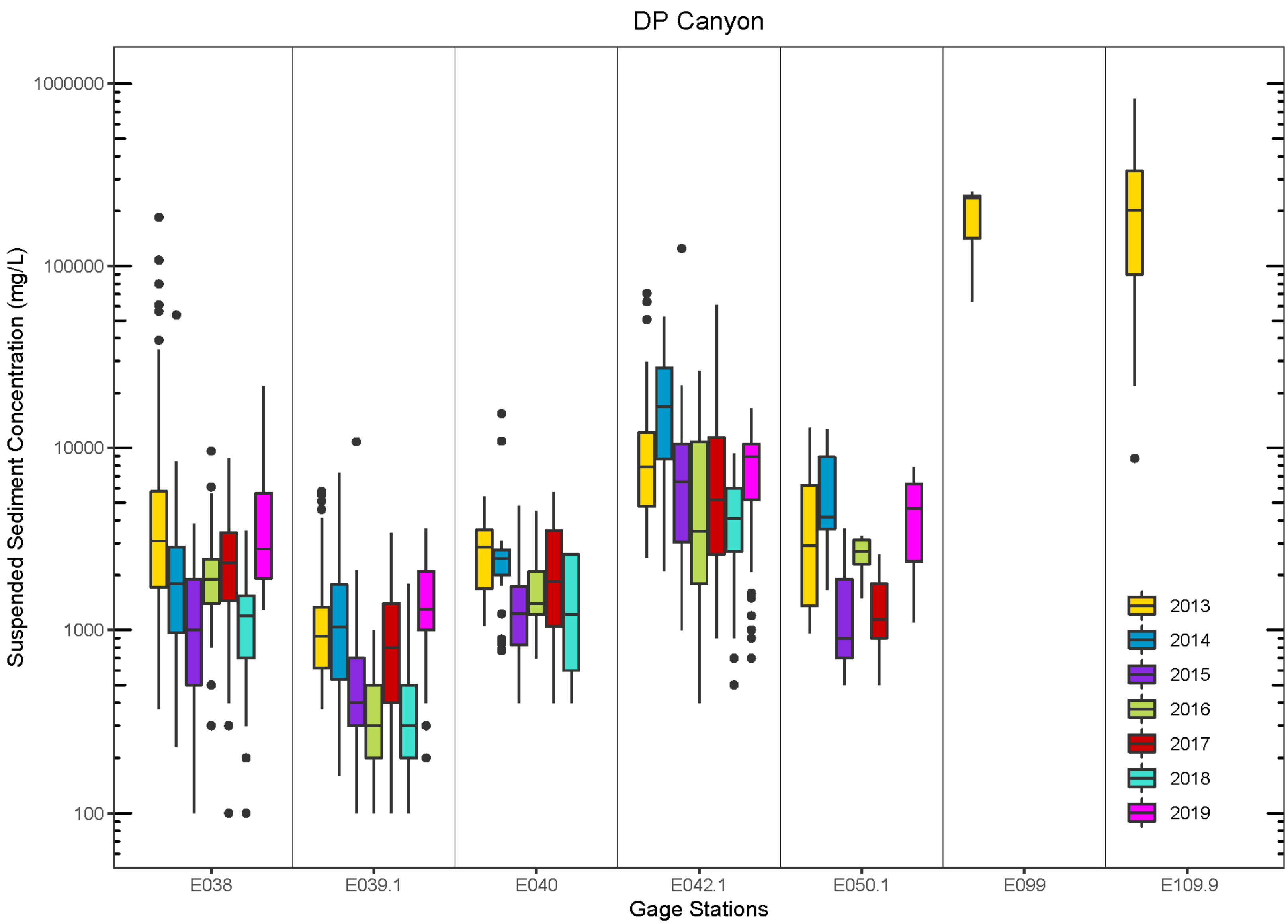
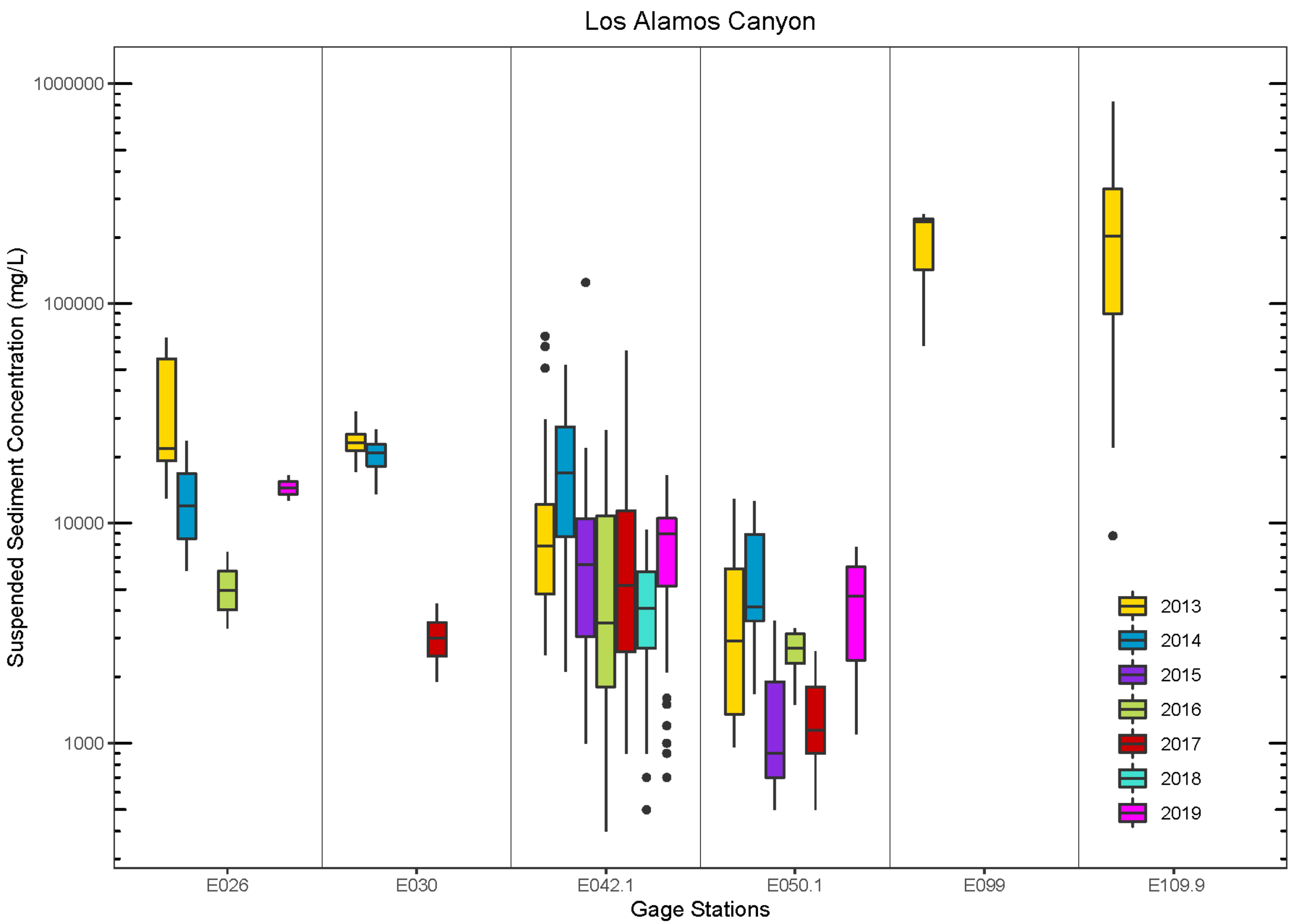


Figure 3.2-1 Flow diagram of gaging stations and sediment transport mitigation sites in the LA/P watershed



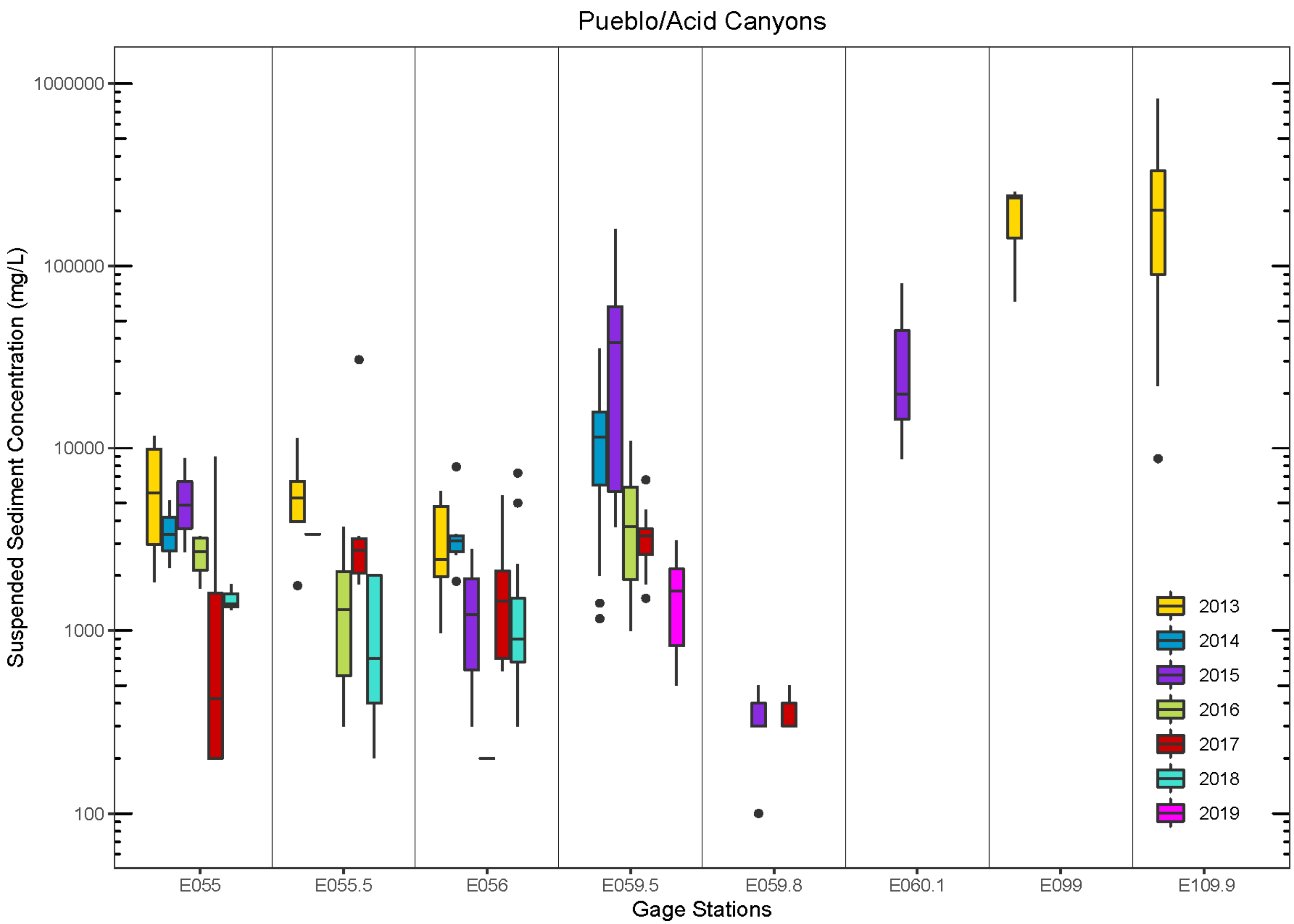
Note: Black dots represent outliers.

Figure 3.2-2 Box-and-whisker plots of SSC for all gaging stations in the LA/P watershed over the 7 yr of monitoring from 2013 to 2019



Note: Black dots represent outliers.

Figure 3.2-2 (continued) **Box-and-whisker plots of SSC for all gaging stations in the LA/P watershed over the 7 yr of monitoring from 2013 to 2019**



Note: Black dots represent outliers.

Figure 3.2-2 (continued) **Box-and-whisker plots of SSC for all gaging stations in the LA/P watershed over the 7 yr of monitoring from 2013 to 2019**

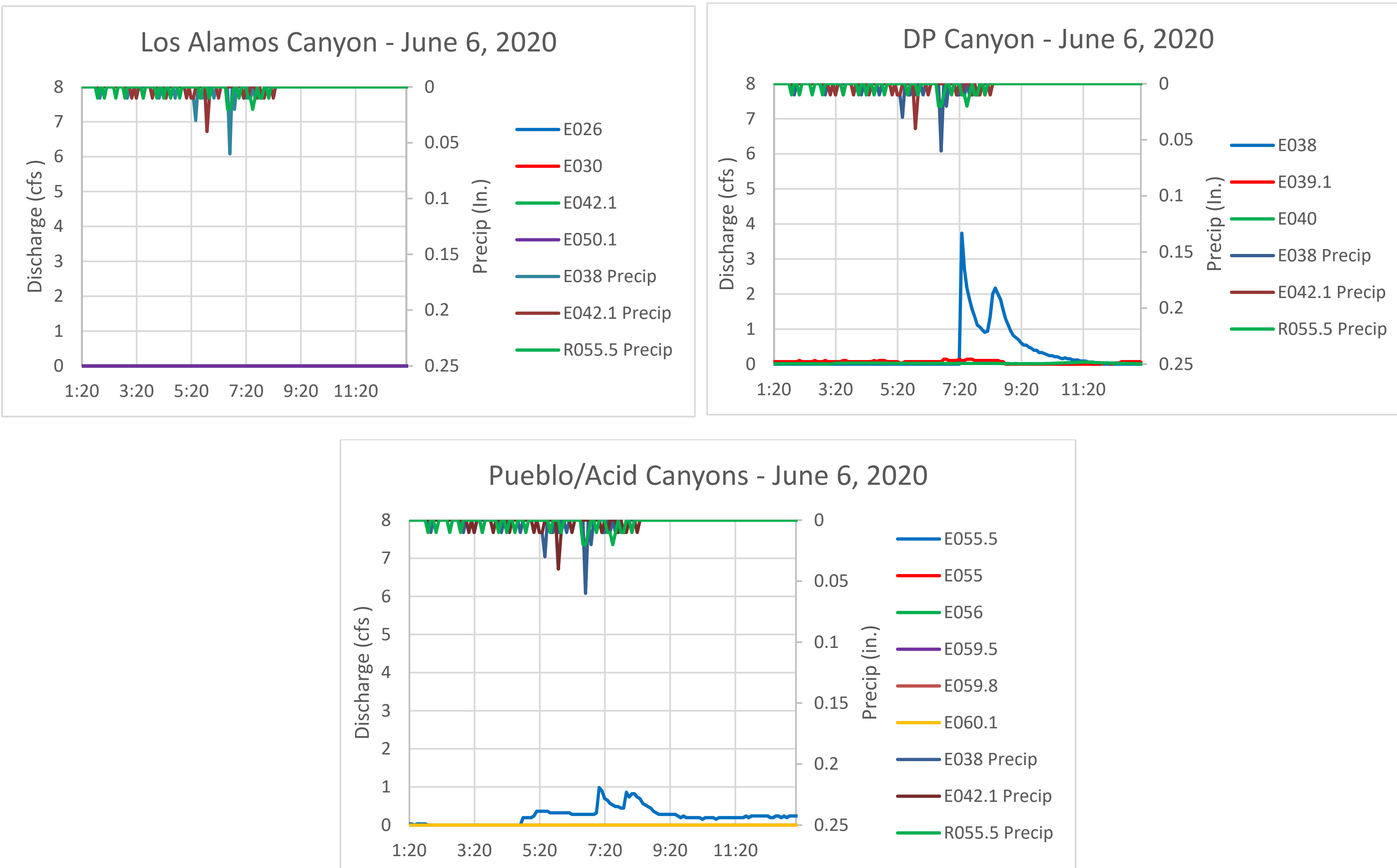
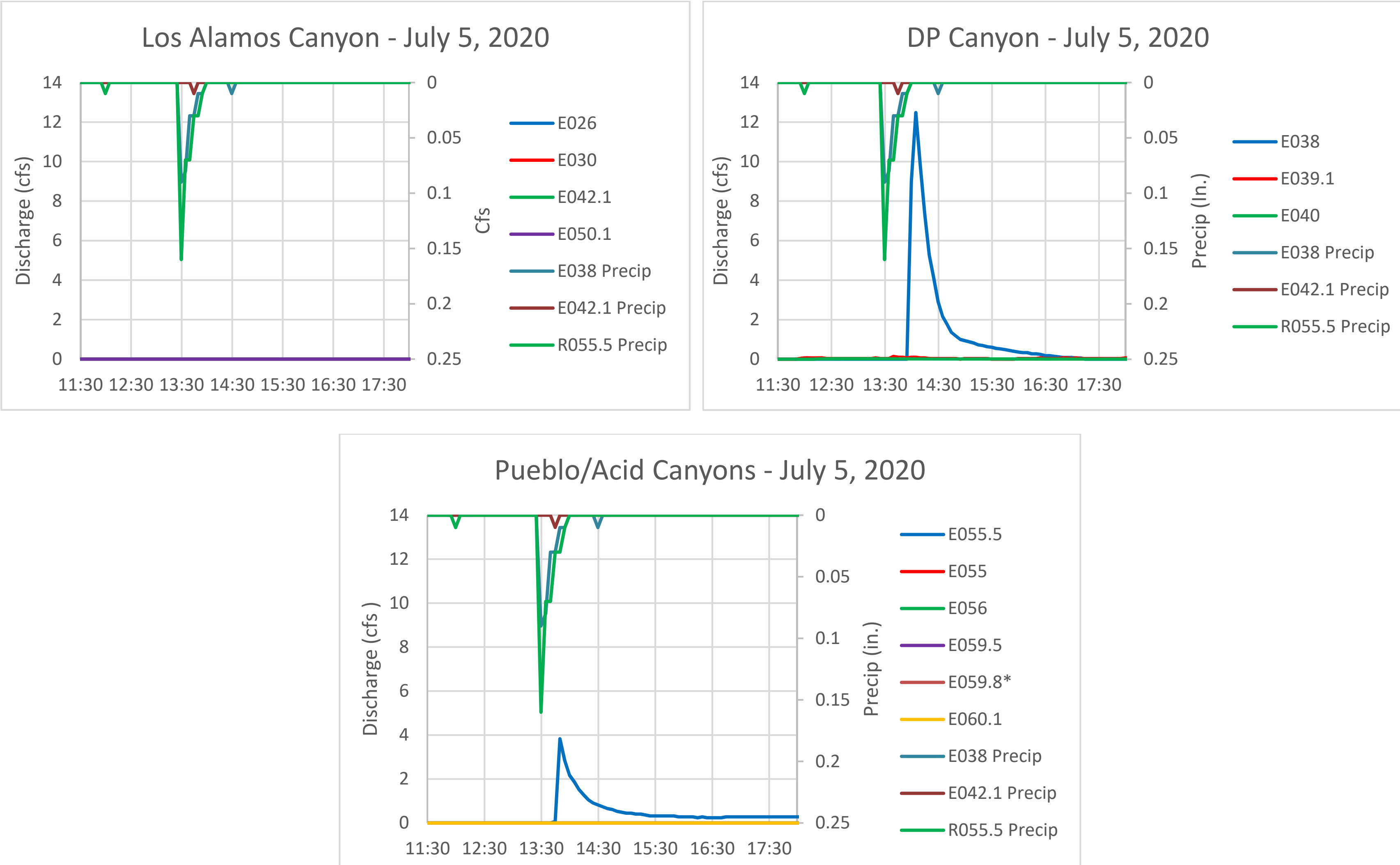
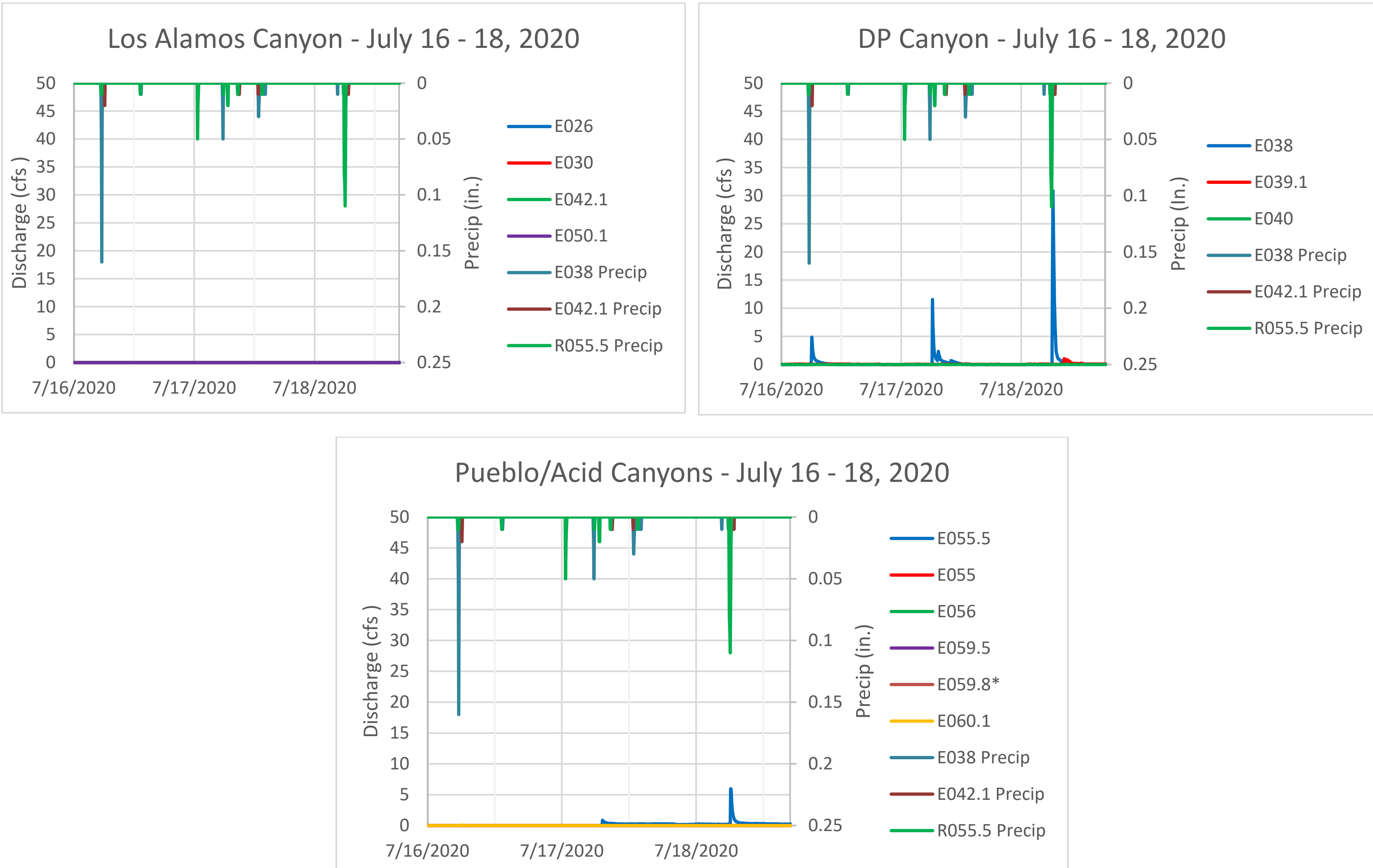


Figure 3.2-3 **Hydrographs during each runoff event with 24-hr precipitation 0.25 in. or greater for each canyon from upstream to downstream reaches**



* E059.8 sensor was malfunctioning during this time.

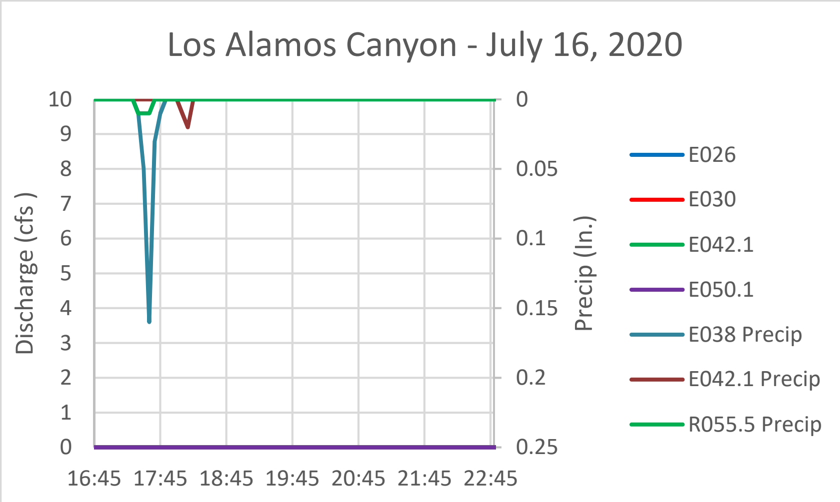
Figure 3.2-3 (continued) Hydrographs during each runoff event with 24-hr precipitation 0.25 in. or greater for each canyon from upstream to downstream reaches

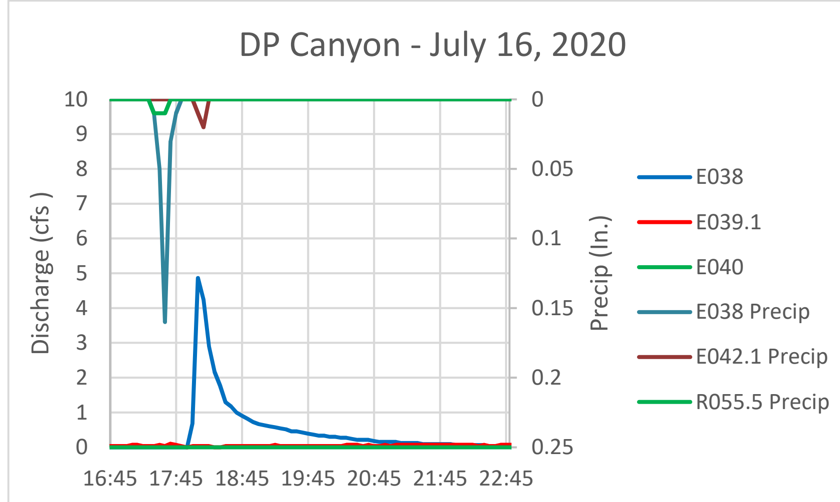


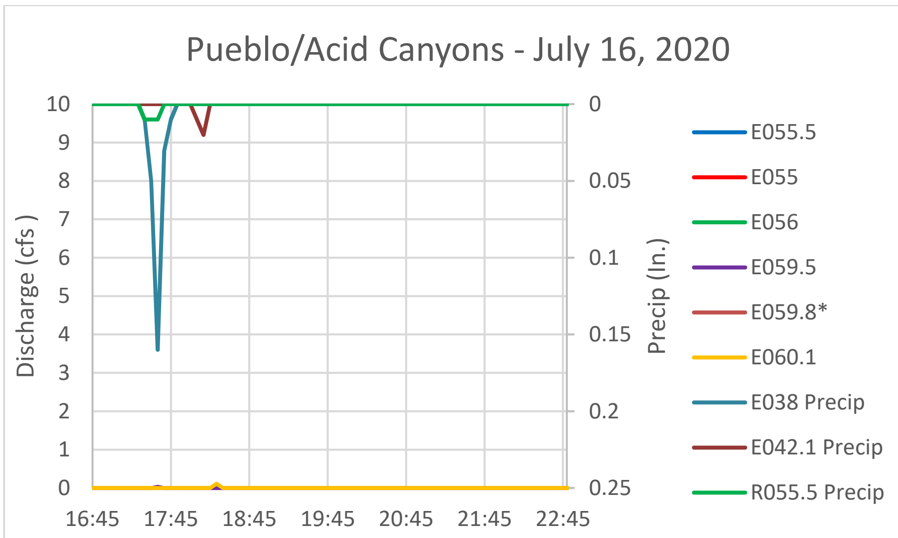
Note: The storms on July 16 and 18 exceeded the 0.25 in. of precipitation in 24 hr; however, the storm on July 17 did not.

* E059.8 sensor was malfunctioning during this time.

Figure 3.2-3 (continued) Hydrographs during each runoff event with 24-hr precipitation 0.25 in. or greater for each canyon from upstream to downstream reaches

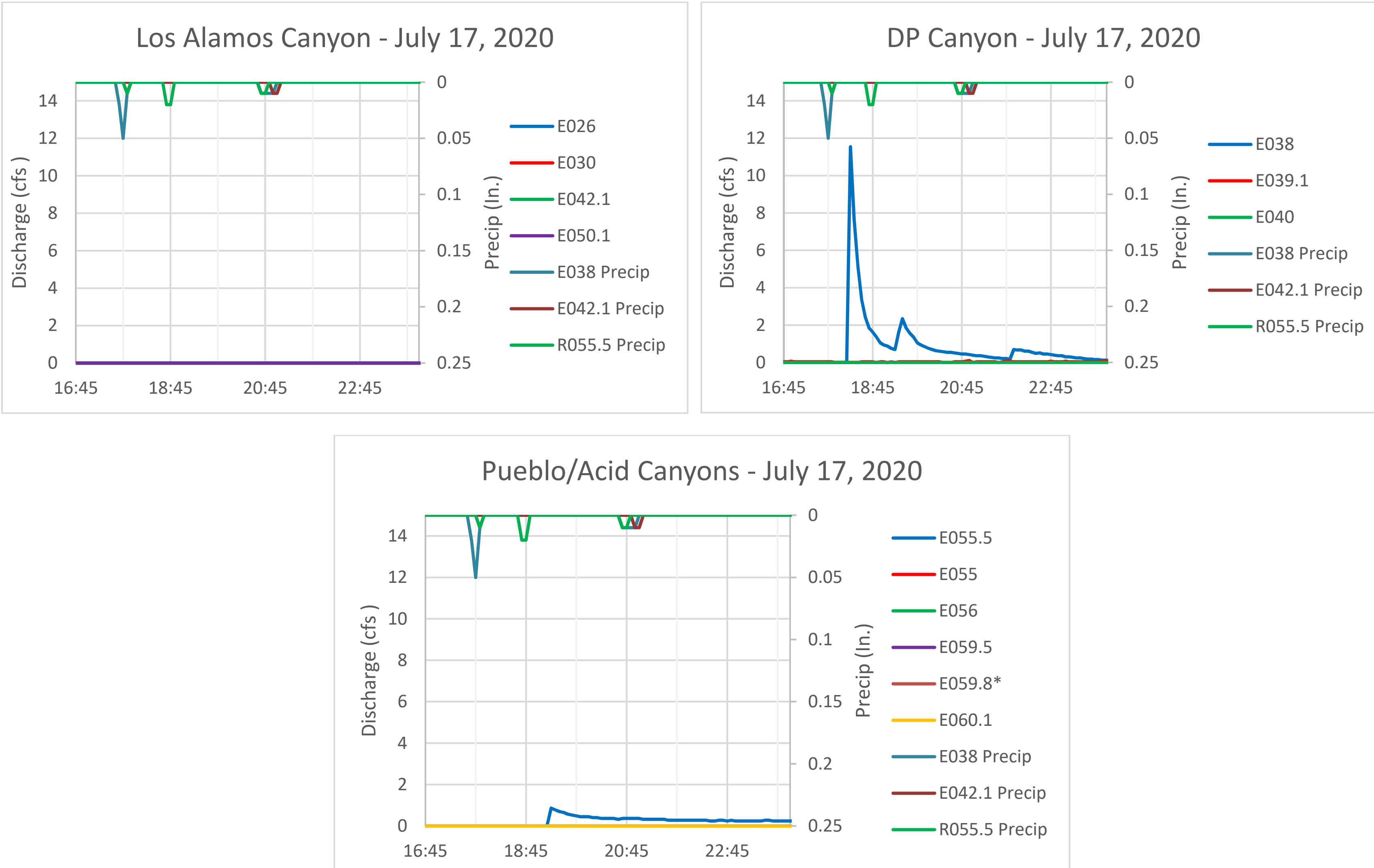






* E059.8 sensor was malfunctioning during this time.

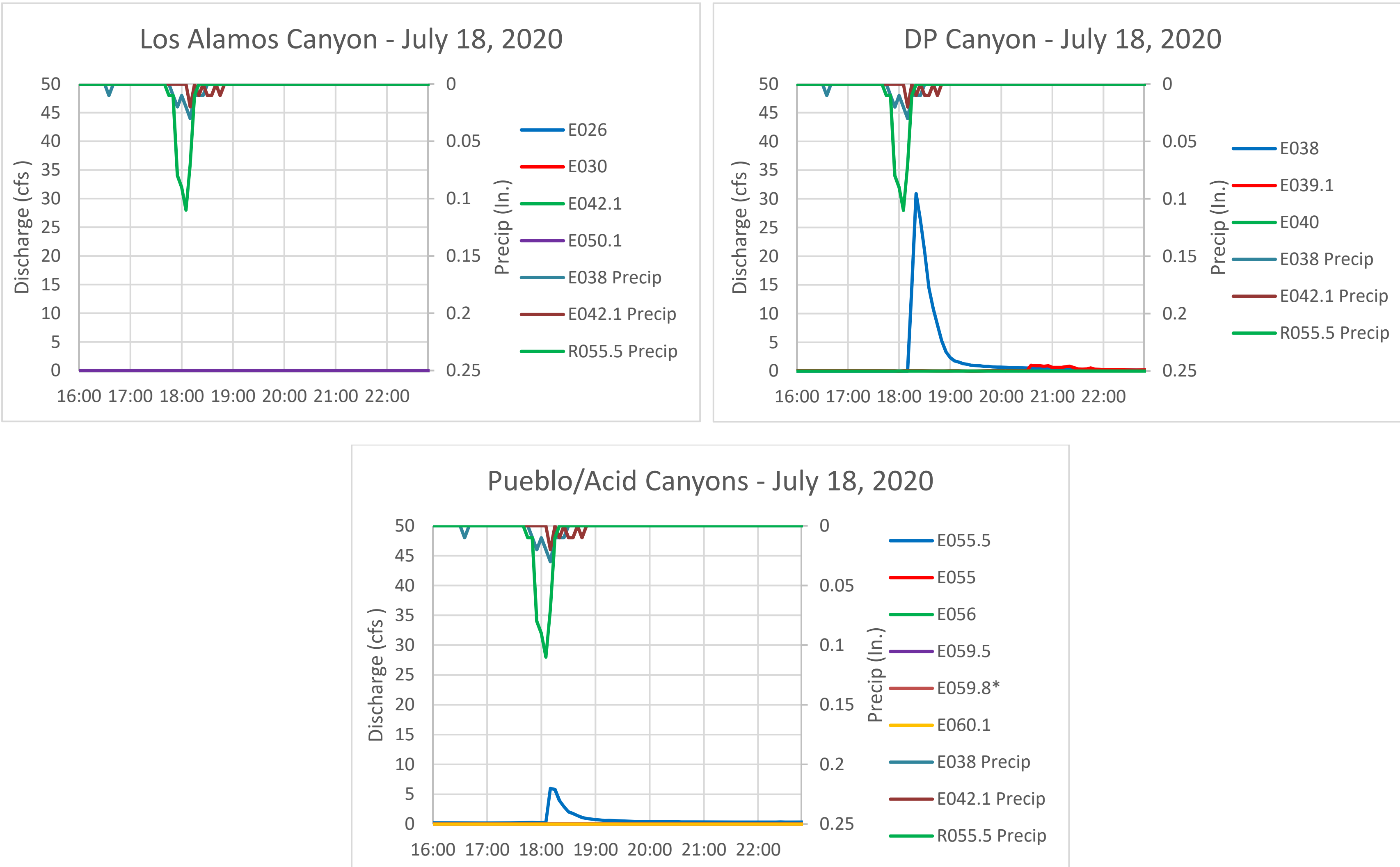
Figure 3.2-3 (continued) Hydrographs during each runoff event with 24-hr precipitation 0.25 in. or greater for each canyon from upstream to downstream reaches



Note: The July 17 storm did not exceed 0.25 in. precipitation in 24 hr.

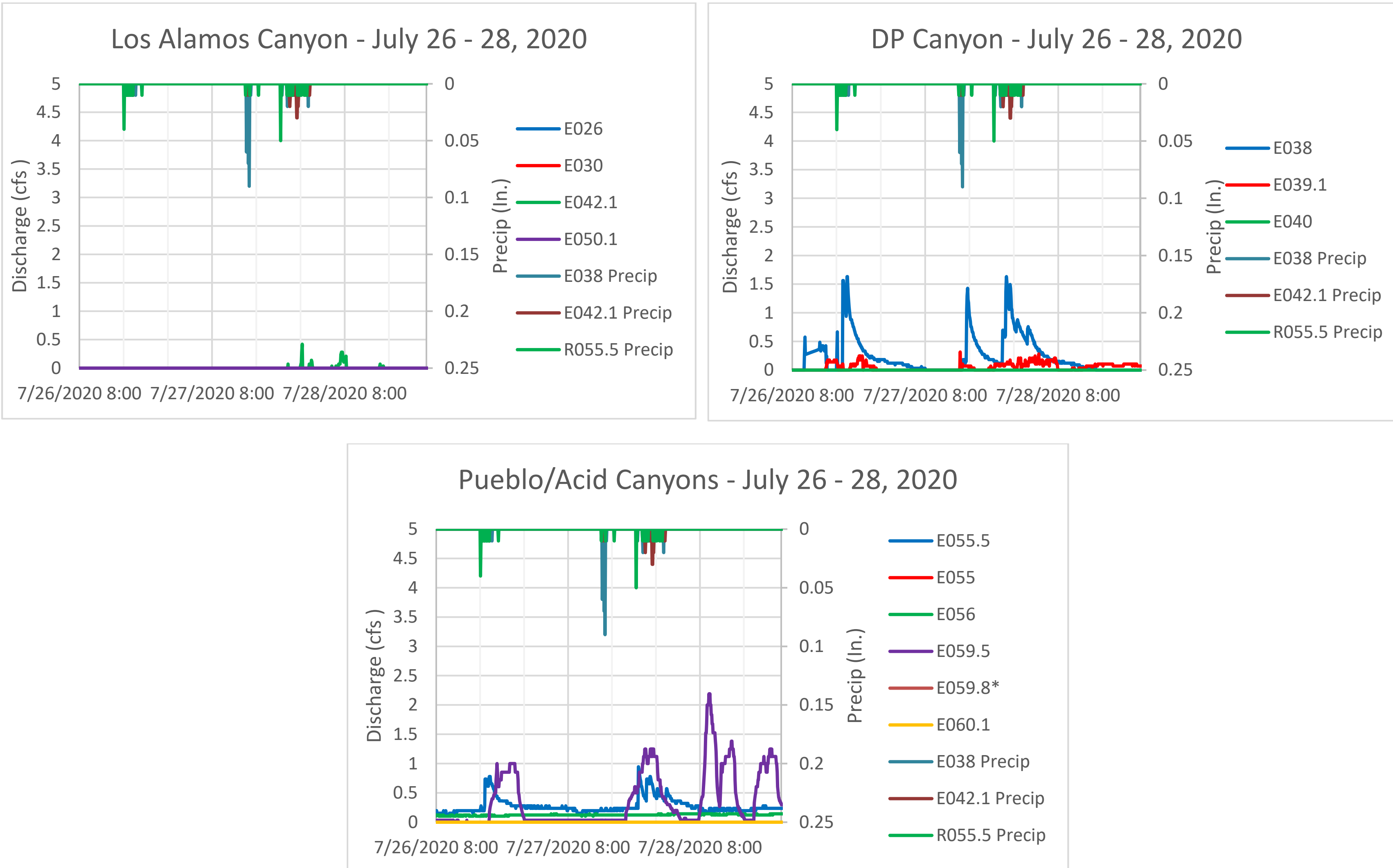
* E059.8 sensor was malfunctioning during this time.

Figure 3.2-3 (continued) Hydrographs during each runoff event with 24-hr precipitation 0.25 in. or greater for each canyon from upstream to downstream reaches



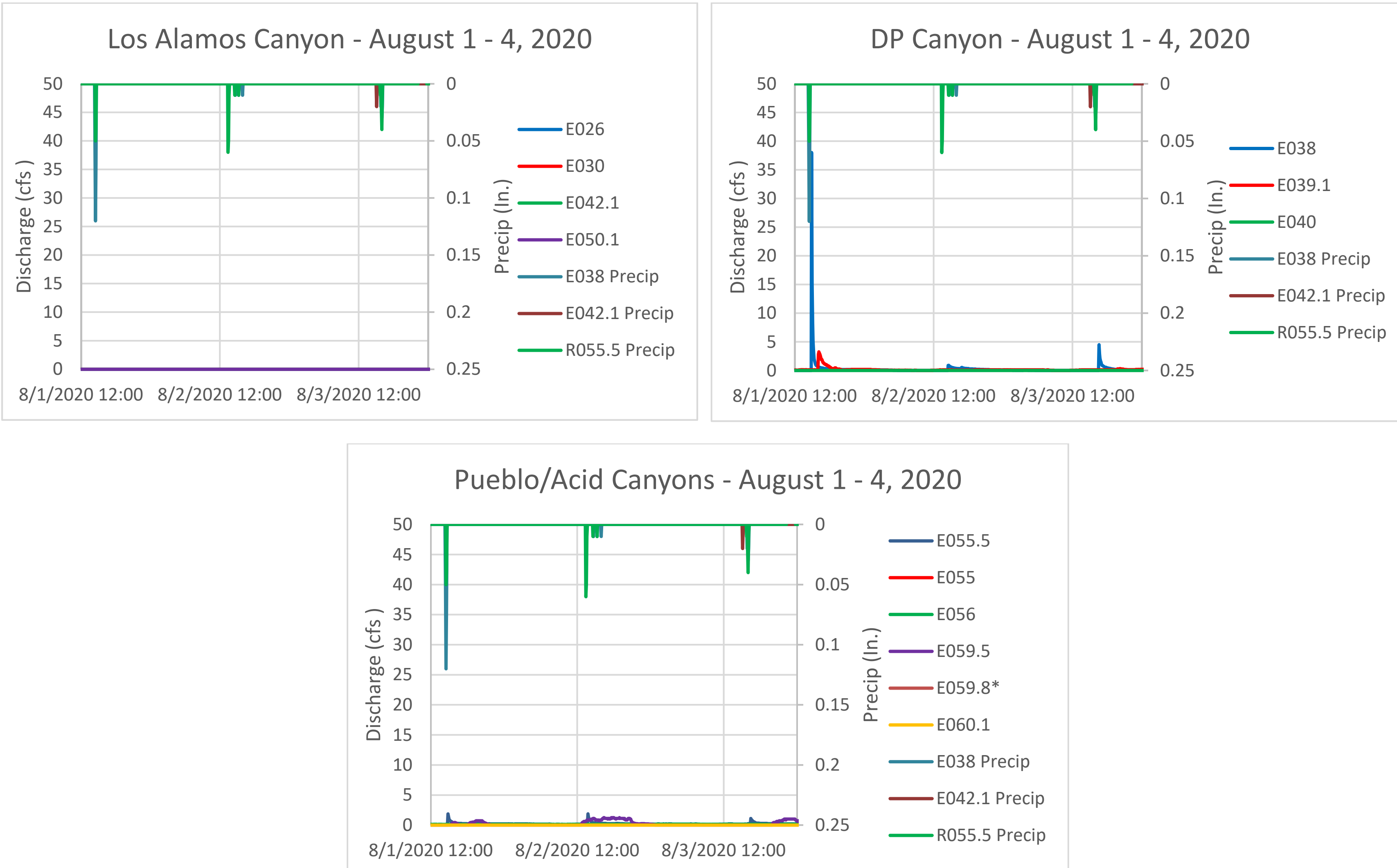
* E059.8 sensor was malfunctioning during this time.

Figure 3.2-3 (continued) **Hydrographs during each runoff event with 24-hr precipitation 0.25 in. or greater for each canyon from upstream to downstream reaches**



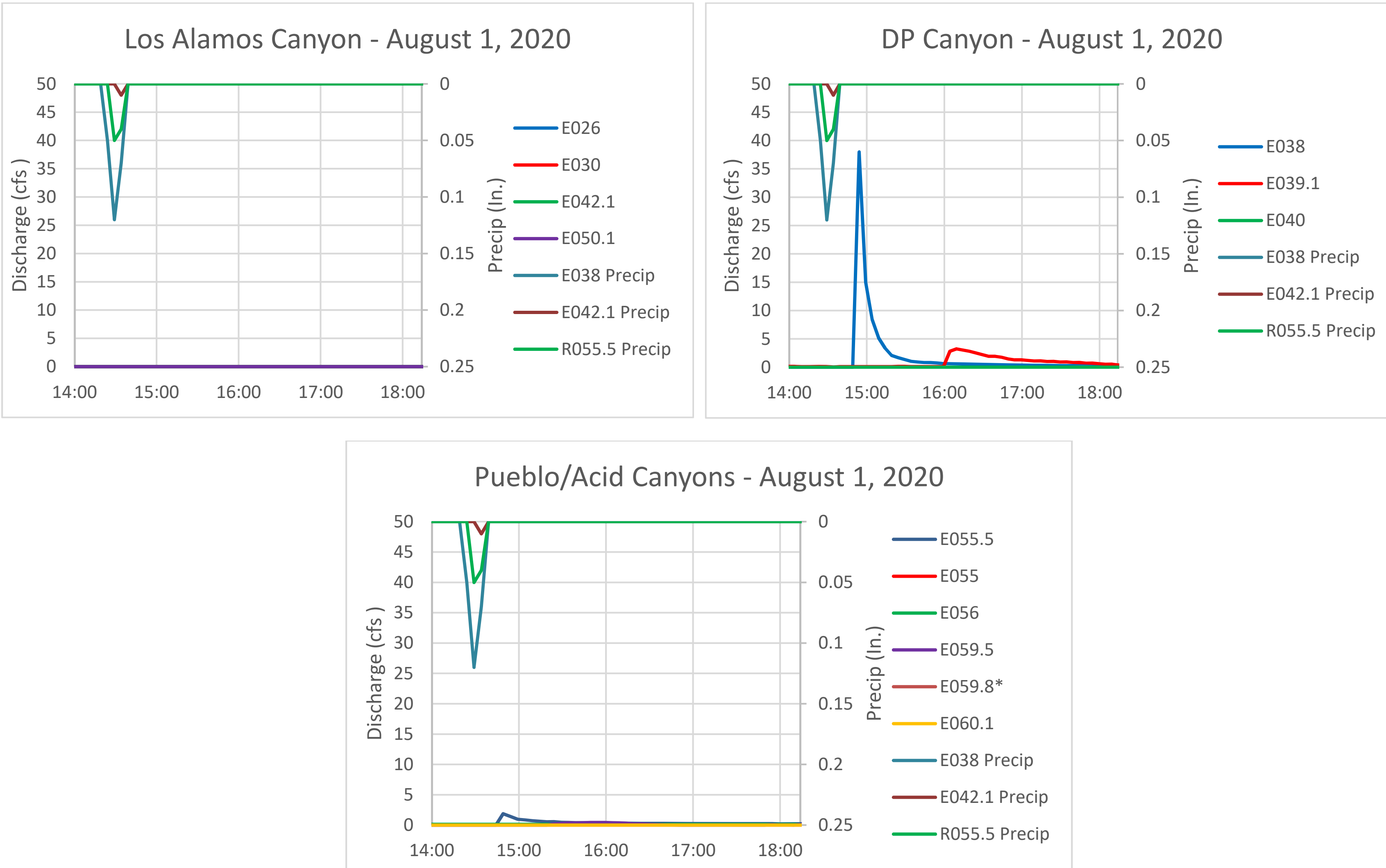
* E059.8 sensor was malfunctioning during this time.

Figure 3.2-3 (continued) **Hydrographs during each runoff event with 24-hr precipitation 0.25 in. or greater for each canyon from upstream to downstream reaches**



* E059.8 sensor was malfunctioning during this time.

Figure 3.2-3 (continued) **Hydrographs during each runoff event with 24-hr precipitation 0.25 in. or greater for each canyon from upstream to downstream reaches**



* E059.8 sensor was malfunctioning during this time.

Figure 3.2-3 (continued) Hydrographs during each runoff event with 24-hr precipitation 0.25 in. or greater for each canyon from upstream to downstream reaches

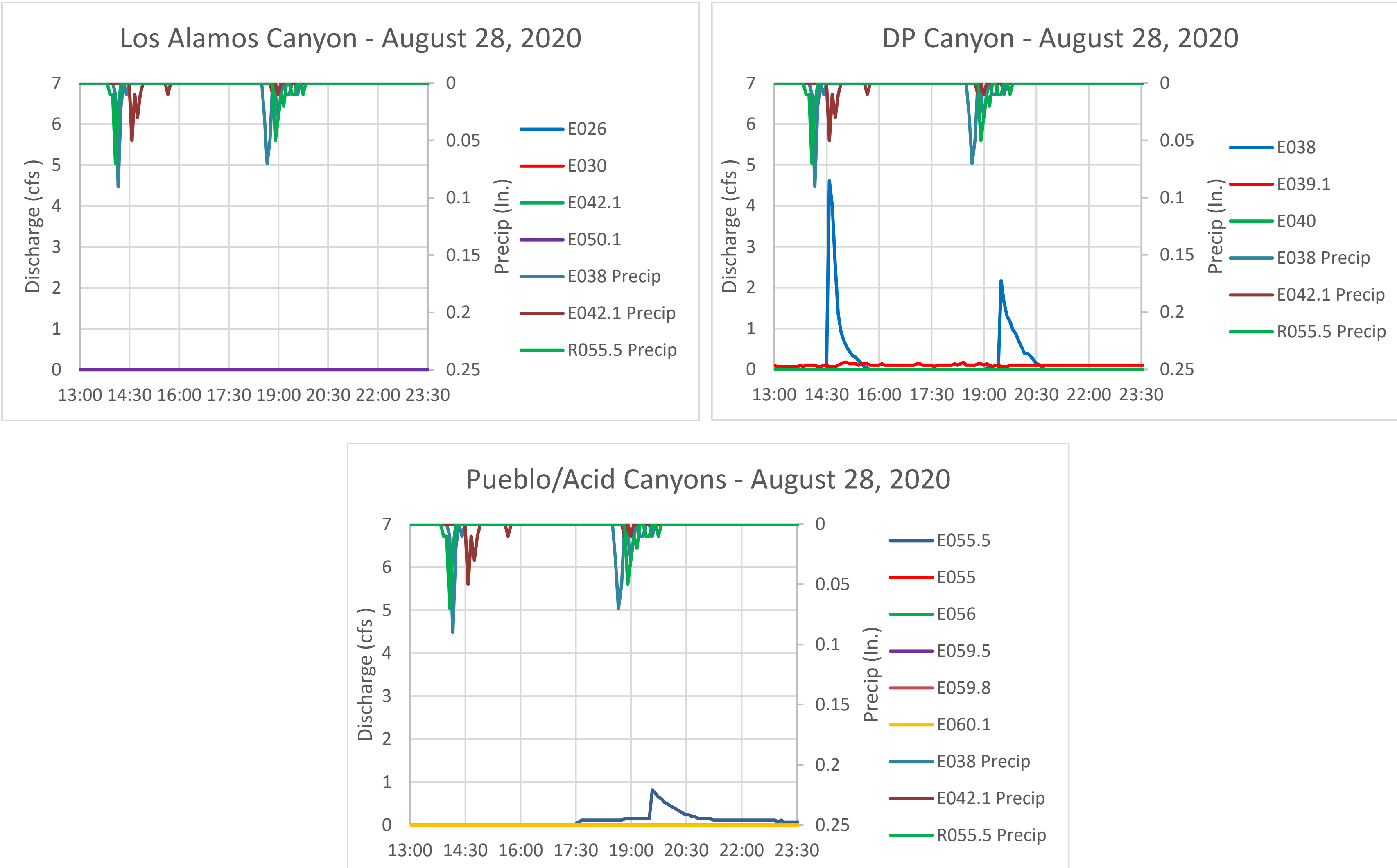


Figure 3.2-3 (continued) **Hydrographs during each runoff event with 24-hr precipitation 0.25 in. or greater for each canyon from upstream to downstream reaches**

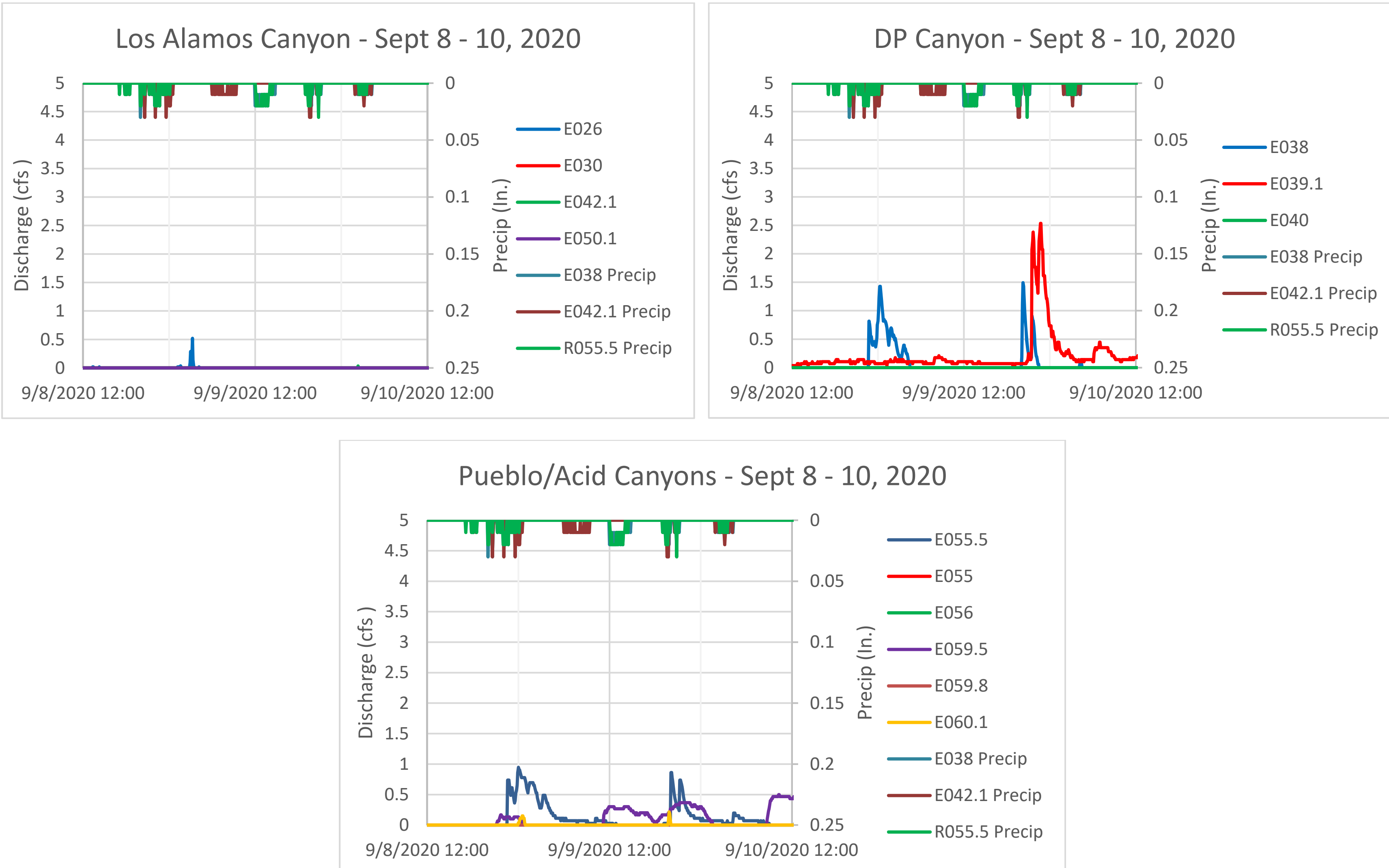


Figure 3.2-3 (continued) **Hydrographs during each runoff event with 24-hr precipitation 0.25 in. or greater for each canyon from upstream to downstream reaches**

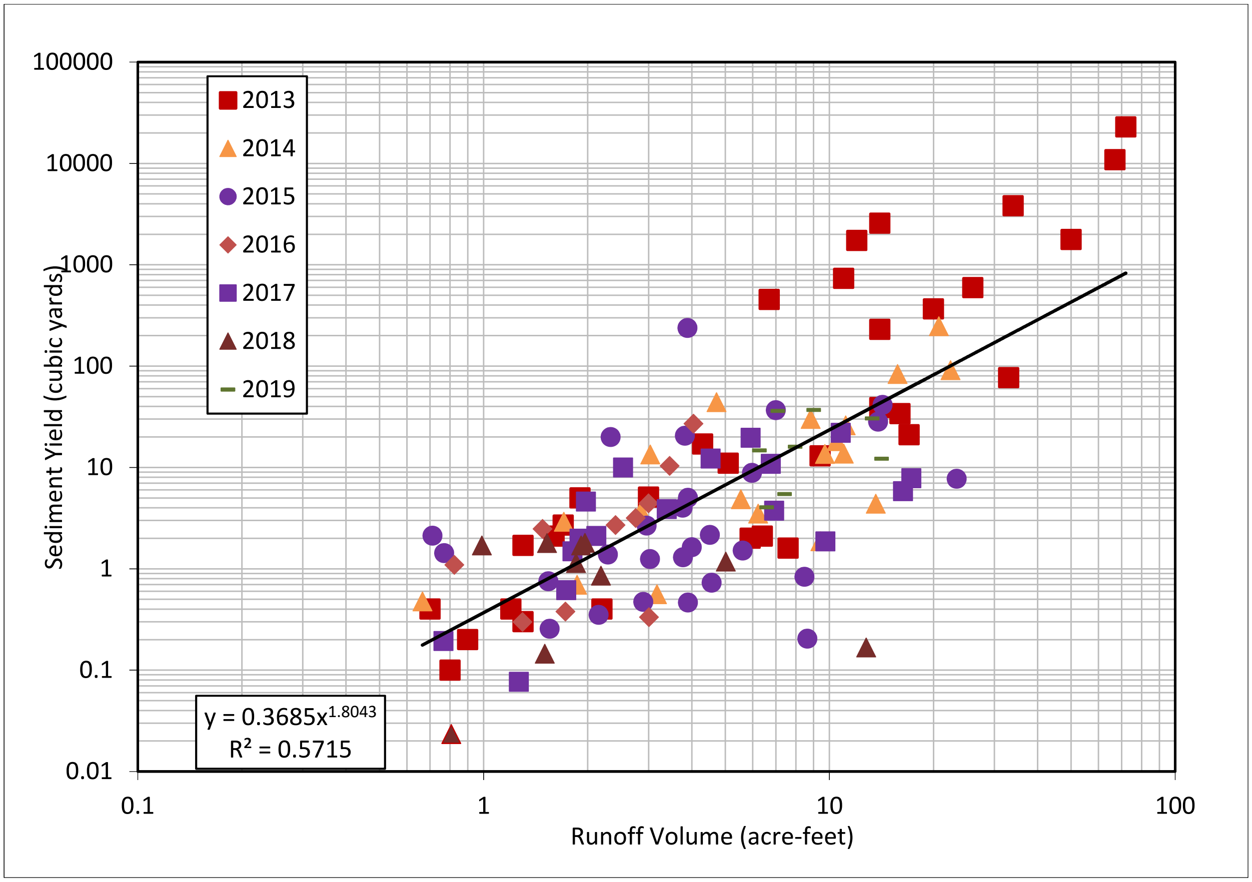


Figure 3.2-4 Relationship between SSC-based sediment yield and runoff volume over the 7 yr of monitoring from 2013 to 2019

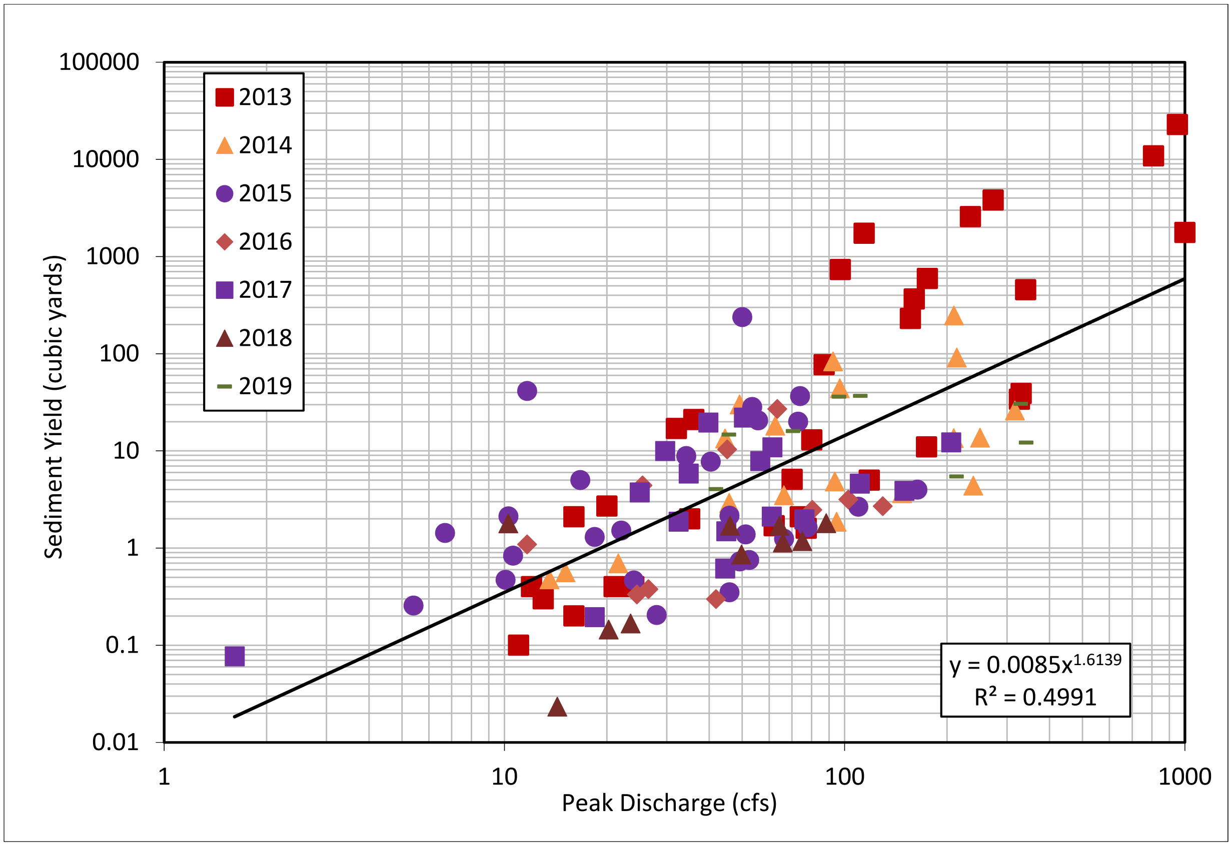
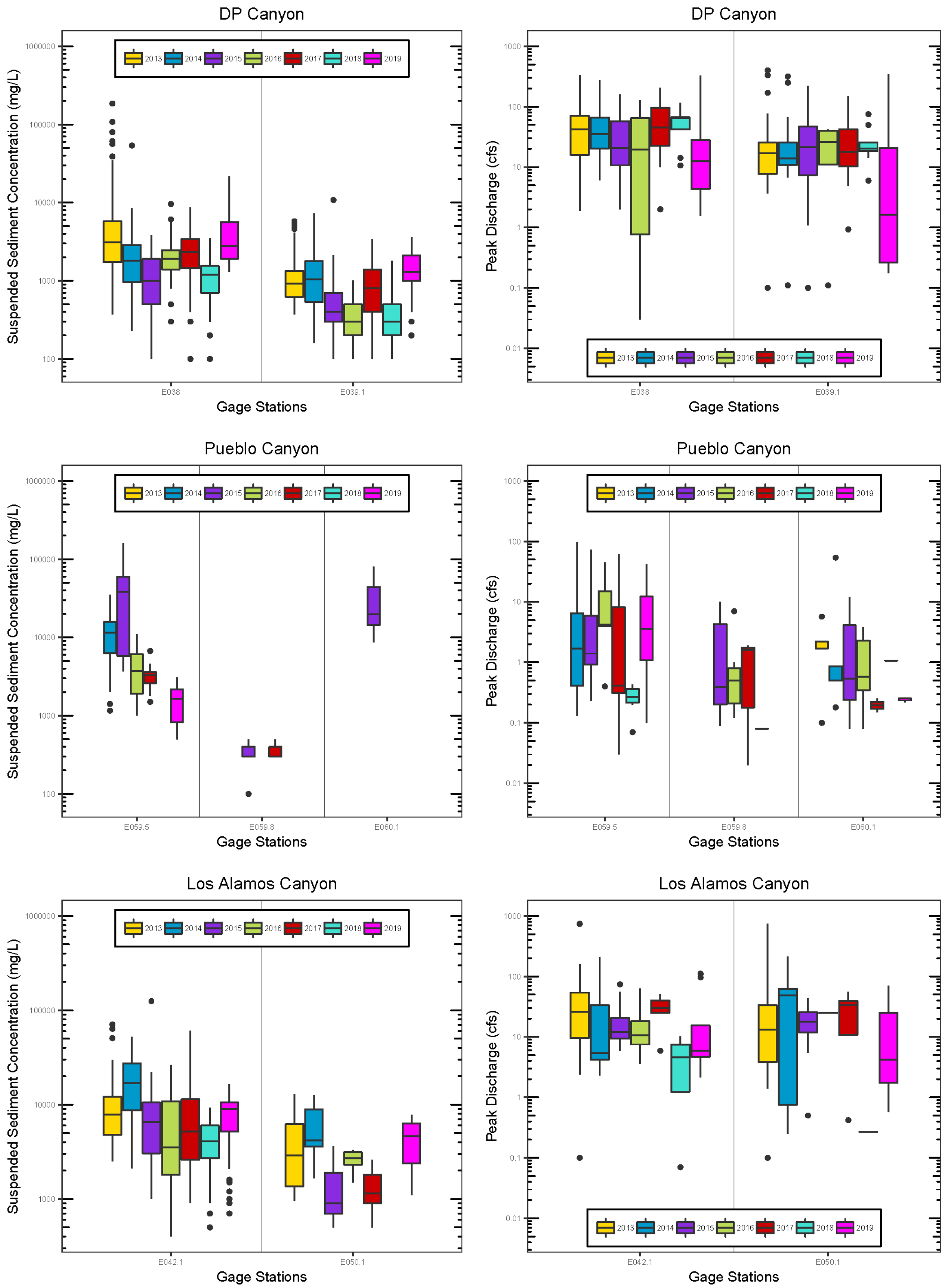


Figure 3.2-5 Linear relationship between SSC-based sediment yield and peak discharge over the 7 yr of monitoring from 2013 to 2019



Note: Black dots represent outliers.

Figure 3.4-1 Box-and-whisker plots of SSC (left) and peak discharge (right) upstream and downstream of the watershed mitigations in DP (top), Pueblo (middle), and Los Alamos (bottom) Canyons over the 7 yr of monitoring from 2013 to 2019

Table 2.1-1
Equipment Configuration at LA/P Gaging Stations

Gaging Station	Stage Measurement Sensor	Communication Method with Data Logger	Sampler Trip Level (Discharge) (cfs)	Dates Sampler Trip Level Active
E026	Radar sensor	Radio telemetry	5	Monitoring season
E030	Radar sensor	Radio telemetry	50	Monitoring season
E038	Radar sensor	Radio telemetry	100	Monitoring season
E039.1	Radar sensor	Radio telemetry	50	Monitoring season
E040	Radar sensor	Radio telemetry	50	Monitoring season
E042.1	radar sensor	Radio telemetry	50	Monitoring season
E050.1	Encoder, bubbler, radar sensor	Radio telemetry	5	Monitoring season
E055	Radar sensor	Radio telemetry	50	Monitoring season
E055.5	Radar sensor	Radio telemetry	50	Monitoring season
E056	Bubbler	Radio telemetry	50	Until 8/28/2019
E056	Radar sensor	Radio telemetry	50	After 8/28/2019
E059.5	Bubbler	Radio telemetry	5	Monitoring season
E059.8	Bubbler	Radio telemetry	5	Until 8/7/2020
E059.8	Radar sensor	Radio telemetry	5	After 8/7/2020
E060.1	Encoder, bubbler, radar sensor	Radio telemetry	5	Monitoring season

Table 2.3-1
Maximum Daily Discharge for the Largest Storm Events in the LA/P Watershed during 2020

Date	Los Alamos/Pueblo												
	DP Canyon			Los Alamos Canyon				Acid Canyon		Pueblo Canyon			
	E038	E039.1	E040	E026	E030	E042.1	E050.1	E055.5	E056	E055	E059.5	E059.8	E060.1
6/6/2020	3.7 BT[a]	0.14 BT	0.06 BT	0	40	0	0	0.99 BT	0	0	0	ND[b]	0
7/5/2020	12 BT	0.14 BT	0.03 BT	0	0	0	0	3.8 BT	0	0	0	ND	0
7/16/2020	4.9 BT	0.10 BT	0	0	0	0	0	0	0.06 BT	0	0.03 BT	ND	0.11 BT
7/18/2020	30 BT	1.02 BT	0	0	0	0	0	6.0 BT	0.08 BT	0	0	ND	0
7/27/2020	1.6 BT	0.32 BT	0	0	0	0.07 BT	0	0.95 BT	0.14 BT	0	1.2 BT	ND	0
8/1/2020	38 BT	3.25 BT	0	0	0	0	0	1.9 BT	0.16 BT	0	0.72 BT	ND	0
8/28/2020	4.6 BT	0.18 BT	0	0	0	0	0	0.82 BT	0	0	0	0	0
9/8/2020	0.82 BT	0.14 BT	0	0.02 BT	0	0	0	0.95 BT	0	0	0.17 BT	0	0.04 BT
9/9/2020	1.5 BT	2.53 BT	0	0.52 BT	0	0	0	0.95 BT	0	0	0.37 BT	0	0.22 BT

Note: Units are cubic feet per second.

[a] BT = Below gaging station triggering threshold; no sample collected.

[b] ND = No data; site equipment malfunctioned and did not record flow.

Table 2.3-2
Sampling Operational Issues during the 2020 Monitoring Year

Gaging Station	Date	Peak Discharge (cfs)	Reason	Comment
n/a*	n/a	n/a	n/a	No sampler operational issues in 2020. No flows above sampler trigger levels. No samples collected.

* n/a = Not applicable.

Table 2.4-1
Factors Contributing to Analytical Suite Prioritization

Gage	Priority	Analytical Suite	Glass Bottle	Polyethylene Bottle	Minimum Volume Required (L)
DP Canyon Gages					
E038, E039.1, E040	1	PCBs	Yes	No	1
	2	Gamma spectroscopy[a] and gross alpha	Yes	Yes	1
	3	Isotopic radionuclides	Yes	Yes	1
	4	Strontium-90	No	Yes	1
	5	Dioxins and furans	Yes	No	1
	6	TAL metals[b] (F[c]/UF[d])	Yes	Yes	0.25/0.25
	7	BLM suite[e]	Yes	No	1
	8	Particle size and SSC	Yes	Yes	1
Upper Los Alamos Canyon Gages					
E026, E030	1	PCBs	Yes	No	1
	2	Gamma spectroscopy and gross alpha	Yes	Yes	1
	3	Isotopic radionuclides	Yes	Yes	1
	4	Strontium-90	No	Yes	1
	5	Dioxins and furans	Yes	No	1
	6	TAL metals (F/UF)	Yes	Yes	0.25/0.25
	7	BLM suite	Yes	No	1
	8	Particle size and SSC	Yes	Yes	1
Upper Pueblo Canyon and Acid Canyon Gages					
E055, E055.5, E056	1	PCBs	Yes	No	1
	2	Gamma spectroscopy and gross alpha	Yes	Yes	1
	3	Isotopic radionuclides	Yes	Yes	1
	4	TAL metals (F/UF)	Yes	Yes	0.25/0.25
	5	BLM suite	Yes	No	1
	6	Particle size and SSC	Yes	Yes	1

Table 2.4-1 (continued)

Gage	Priority	Analytical Suite	Glass Bottle	Polyethylene Bottle	Minimum Volume Required (L)
Lower Los Alamos Canyon Gages					
E042.1	1	PCBs	Yes	No	1
	2	Gamma spectroscopy and gross alpha	Yes	Yes	1
	3	Isotopic radionuclides	Yes	Yes	1
	4	Strontium-90	Yes	Yes	1
	5	Dioxins/furans	Yes	No	1
	6	TAL metals (F/UF)	Yes	Yes	0.25/0.25
	7	BLM suite	Yes	No	1
	8	Particle size and SSC	Yes	Yes	1
E050.1	1	PCBs	Yes	No	1
	2	Gamma spectroscopy and gross alpha	Yes	Yes	1
	3	Isotopic radionuclides	Yes	Yes	1
	4	Dioxins/furans	Yes	No	1
	5	Strontium-90	Yes	Yes	1
	6	TAL metals (F/UF)	Yes	Yes	0.25/0.25
	7	BLM suite	Yes	No	1
	8	Gross beta	Yes	Yes	0.25
	9	Radium-226/radium-228	Yes	Yes	1
	10	Particle size and SSC	Yes	Yes	1
Lower Pueblo Canyon Gages					
E059.5, E059.8	1	PCBs	Yes	No	1
	2	Gamma spectroscopy and gross alpha	Yes	Yes	1
	3	Isotopic radionuclides	Yes	Yes	1
	4	Dioxins/furans	Yes	No	1
	5	Strontium-90	Yes	Yes	1
	6	TAL metals (F/UF)	Yes	Yes	0.25/0.25
	7	BLM suite	Yes	No	1
	8	Particle size and SSC	Yes	Yes	1

Table 2.4-1 (continued)

Gage	Priority	Analytical Suite	Glass Bottle	Polyethylene Bottle	Minimum Volume Required (L)
E060.1	1	PCBs	Yes	No	1
	2	Gamma spectroscopy and gross alpha	Yes	Yes	1
	3	Isotopic radionuclides	Yes	Yes	1
	4	Dioxins/furans	Yes	No	1
	5	Strontium-90	Yes	Yes	1
	6	TAL metals (F/UF)	Yes	Yes	0.25/0.25
	7	BLM suite	Yes	No	1
	8	Gross beta	Yes	Yes	0.25
	9	Radium-226/radium-228	Yes	Yes	1
	10	Particle size and SSC	Yes	Yes	1
Detention Basin and Vegetative Buffer below the SWMU 01-001(f) Drainage					
CO111041, CO101038	1	PCBs	Yes	No	1
	2	TAL metals (F/UF)	Yes	Yes	0.25/0.25
	3	BLM suite	Yes	No	1
	4	Gross alpha	Yes	Yes	1
	5	Particle size and SSC	Yes	Yes	1

[a] Gamma spectroscopy = Actinium-228, beryllium-7, bismuth-212, bismuth-214, cesium-134, cesium-137, cobalt-60, gross gamma, iodine-131, lead-212, lead-214, potassium-40, protactinium-234m, sodium-22, thallium-208, and thorium-234.

[b] TAL Metals = Ag, Al, As, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Na, Ni, Pb, Sb, Se, Tl, V, and Zn; hardness is calculated from calcium and magnesium, components of the TAL list.

[c] F = Analyses of filtered sample.

[d] UF = Analyses of unfiltered sample.

[e] BLM suite = Biotic ligand model suite: alkalinity, dissolved organic carbon, and pH.

Table 2.4-2
Analytical Requirements for Storm Water Samples

Analytical Suite	Method	BDD[a] Monitoring	Detention Basins and Wetland Below the SWMU 01-001(f) Drainage	DP Canyon Gages	Fire-Affected Lower Watershed Gages	Lower Pueblo Canyon Gages	Upper Los Alamos Canyon Gages	Upper Pueblo Canyon and Acid Canyon Gages
Alkalinity	EPA:310.1	X	X[b]	X	X	X	X	X
Americium-241	HASL-300:AM-241	X	—[c]	—	X	X	—	X
Dioxins/furans	EPA:1613B	X	—	—	X	X	X	—
Dissolved organic carbon	SW-846:9060	X	X	X	X	X	X	X
Gamma spectroscopy	EPA:901.1	X	—	X	X	X	X	X
Gross alpha	EPA:900	X	X	X	X	X	X	X
Gross beta	EPA:900	X	—	—	—	—	—	—
Hardness[d]	SM:A2340B	X	X	X	X	X	X	X
Isotopic plutonium	HASL-300:ISOPU	X	—	X	X	X	X	X
Isotopic uranium	HASL-300:ISOU	X	—	—	—	—	—	—
Mercury	EPA:245.2	X	X	X	X	X	X	X
Particle size	ASTM:C1070-01	X	X	X	X	X	X	X
PCBs	EPA:1668C	X	X	X	X	X	X	X
pH	EPA:150.1	X	X	X	X	X	X	X
Radium-226/radium-228	EPA:903.1/904	X	—	—	—	—	—	—
SSC	ASTM:D3977-97	X	X	X	X	X	X	X
Strontium-90	EPA:905.0	X	—	X	X	X	X	—
TAL metals	EPA:200.7/200.8	X	X	X	X	X	X	X

[a] BDD = Buckman Direct Diversion gaging stations E050.1 and E060.1.

[b] X = Monitoring planned.

[c] — = Monitoring not planned.

[d] Hardness is calculated from filtered calcium and magnesium, components of the TAL metals list.

Table 2.5-1
Sample Collection and Sample Retrieval Working-Day Interval

Location Alias	Date Sample Collected	Date Sample Retrieved	Working Days between Collection and Retrieval	Comment
n/a*	n/a	n/a	n/a	No samples collected during 2020 monitoring season.

* n/a = Not applicable.

Table 2.5-2
Gaging Station Operational Issues during the 2020 Monitoring Year

Gaging Station	Reason	Issue Date	Repair Date	Working Days from Issue to Repair	Potential Missed Discharge above Trigger	Peak Discharge (cfs)
E059.8	Bubbler malfunction	6/4/2020	8/7/2020	62	0	ND*

* ND = No discharge data recorded.

Table 3.1-1
Drainage Area and Impervious Surface Percentage in the Los Alamos Canyon Watersheds

Canyon	Gaging Station	Drainage Area (acres)	Impervious Surface (%)
Acid	E055.5	53	26
Acid*	E056	237	22
Acid	Acid Canyon above E056	290	23
Pueblo	E055	2184	8.0
Pueblo	E059.5	2099	11
Pueblo	E059.8	407	4.4
Pueblo*	E060.1	330	3.8
Pueblo	Pueblo Canyon above E060.1	5310	9.5
DP	E038	125	32
DP*	E039.1	111	12
DP*	E040	130	4.0
DP	DP Canyon above E039.1	236	23
DP	DP Canyon above E040	366	16
LA	E026	4354	0.4
LA*	E030	1100	13
LA*	E042.1	605	0.6
LA*	E050.1	193	2.2
LA*	E109.9 (including Guaje Canyon)	27,000	1.2
LA	Los Alamos Canyon above E050.1	6250	2.7
LA	Los Alamos, Pueblo, and Guaje Canyons above E109.9	37,760	2.6
LA*	Los Alamos Canyon between E050.1, E060.1, and E109.9	5240	2.4
Guaje	E099	21,000	0.9

* Drainage areas marked by an asterisk do not extend to head of watershed above gaging station; unmarked drainage areas extend from the gaging station to the head of the watershed.

Table 3.2-1
Travel Time of Flood Bore, Peak Discharge, Increase or Decrease in Peak Discharge, and Percent Change in Peak Discharge from Upstream to Downstream Gaging Stations for 2020 Runoff Events across the Watershed Mitigations

Date (2020)	Travel Time from E038 to E039.1 (min)	Peak Discharge (cfs)		+/−[a]	%[b]	Travel Time from E042.1 to E050.1 (min)	Peak Discharge (cfs)		+/−	%
		E038	E039.1				E042.1	E050.1		
6/6	10	3.7	0.14	-	96	—[c]	0	0	—	—
7/5	0	12	0.14	-	99	—	0	0	—	—
7/16	75	4.9	0.07	-	99	—	0	0	—	—
7/18	105	31	1.0	-	97	—	0	0	—	—
7/27	135	1.6	0.21	-	87	—	0.42	0	-	100
8/1	80	38	3.3	-	91	—	0	0	—	—
8/28	30	4.6	0.18	-	96	—	0	0	—	—
9/8	95	1.4	0.14	-	90	—	0	0	—	—
9/9	150	1.5	2.5	+	40	—	0	0	—	—
Min	0	1	0	—	40	—	0	0	—	100
Mean	76	11	1	—	88	—	—	0	—	—
Max	150	38	3	—	99	—	0.42	0	—	100
Date (2020)	**Travel Time from E059.5 to E059.8 (min)**	**Peak Discharge (cfs)**		**+/−**	**%**	**Travel Time from E059.8 to E060.1 (min)**	**Peak Discharge (cfs)**		**+/−**	**%**
		E059.5	**E059.8**				**E059.8**	**E060.1**		
6/6	—	0	ND[d]	—	—	—	ND	0	—	—
7/5	—	0	ND	—	—	—	ND	0	—	—
7/16	—	0.03	ND	—	—	—	ND	0.11	—	—
7/18	—	0	ND	—	—	—	ND	0	—	—
7/27	—	1.2	ND	—	—	—	ND	0	—	—
8/1	—	0.72	ND	—	—	—	ND	0	—	—
8/28	—	0	0	—	—	—	0	0	—	—
9/8	—	0.17	0	-	100	—	0	0.15	+	100
9/9	—	0.37	0	-	100	—	0	0.22	+	100
Min	—	0	0	—	100	—	0	0	—	100
Mean	—	0.28	0	—	100	—	—	0.05	—	100
Max	—	1	0	—	100	—	0	0.22	—	100

[a] + = Increase; − = decrease

[b] % = percent change in peak discharge.

[c] — = Result not applicable.

[d] ND = No data available because of equipment failure at the site.

Table 3.2-2
SSC-Based Sediment Yield and Runoff Volume for Sampled 2013 to 2020 Runoff Events

Gaging Station	Date	Sediment Yield (tons)	Sediment Yield (yd^3)[a]	Runoff Volume (acre-ft)	Peak Discharge (cfs)
2013 Runoff Events					
E038	6/14/2013	11	5.1	3.0	70
E038	6/30/2013	11	5.0	1.9	120
E038	7/12/2013	87	39	14	330
E038	7/28/2013	4.7	2.1	1.6	74
E038	8/5/2013	25	11	5.1	170
E038	8/9/2013	3.8	1.7	1.3	62
E039.1	6/14/2013	0.6	0.3	1.3	13
E039.1	6/30/2013	0.3	0.1	0.8	11
E039.1	7/12/2013	75	34	16	330
E039.1	7/28/2013	0.8	0.4	1.2	24
E039.1	8/4/2013	0.8	0.4	0.7	12
E039.1	8/9/2013	0.5	0.2	0.9	16
E039.1	9/10/2013	4.4	2.0	5.9	35
E039.1	9/12/2013	3.6	1.6	7.6	77
E039.1	11/5/2013	0.9	0.4	2.2	21
E042.1	7/12/2013	817	366	20	160
E042.1	8/5/2013	29	13	9.4	80
E042.1	9/10/2013	48	21	17	36
E050.1	7/12/2013	39	17	4.3	32
E050.1	8/5/2013	6.1	2.7	1.7	20
E050.1	9/10/2013	4.6	2.1	6.4	11
E050.1	9/12/2013	171	77	33	87
E099	7/12/2013	5748	2574	14	230
E099	8/5/2013	1015	455	6.7	340
E109.9	7/8/2013	3880	1737	12	110
E109.9	7/12/2013[b]	1326	594	26	180
E109.9	7/20/2013[b]	24,305	10,883	67	810
E109.9	7/25/2013	1639	734	11	100
E109.9	7/26/2013[b]	515	230	14	160
E109.9	8/3/2013	51,060	22,862	72	950
E109.9	8/5/2013b	3955	1771	50	1000
E109.9	8/9/2013	8524	3816	34	270

Table 3.2-2 (continued)

Gaging Station	Date	Sediment Yield (tons)	Sediment Yield (yd^3)[a]	Runoff Volume (acre-ft)	Peak Discharge (cfs)
2014 Runoff Events					
E038	7/8/2014	6.5	2.9	1.7	46
E038	7/27/2014	7.9	3.5	2.9	148
E038	7/29/2014	11	4.8	5.5	94
E039.1	7/8/2014	1.1	0.5	0.7	14
E039.1	7/15/2014	1.3	0.6	3.2	15
E039.1	7/15/2014	58	26	11	317
E039.1	7/27/2014	1.6	0.7	1.9	22
E039.1	7/29/2014	7.8	3.5	6.2	66
E039.1	7/31/2014	31	14	11	250
E040	7/29/2014	4.2	1.9	9.4	95
E040	7/31/2014	9.8	4.4	14	239
E042.1	7/29/2014	186	83	16	92
E042.1	7/31/2014	551	247	21	210
E050.1	7/15/2014	67	30	8.8	49
E050.1	7/29/2014	41	18	11	63
E050.1	7/31/2014	204	91	22	214
E059.5	7/29/2014	30	13	3.0	44
E059.5	7/31/2014	98	44	4.7	97
2015 Runoff Events					
E038	06/26/2015	9.0	4.0	3.8	163
E038	07/20/2015	3.7	1.6	4.0	78
E038	07/31/2015	6.0	2.7	3.0	110
E038	08/08/2015	1.7	0.8	1.5	52
E039.1	05/21/2015	1.0	0.5	3.9	24
E039.1	06/26/2015[b]	2.8	1.3	3.0	66
E039.1	07/03/2015	3.1	1.4	2.3	51
E039.1	07/07/2015	4.8	2.2	4.5	46
E039.1	07/29/2015	1.6	0.7	4.6	49
E039.1	08/08/2015	0.8	0.4	2.1	46
E039.1	10/21/2015	0.5	0.2	8.6	28
E042.1	07/03/2015	4.7	2.1	0.7	10
E042.1	07/07/2015	63	28	14	53
E042.1	07/20/2015	46	21	3.8	56
E042.1	07/31/2015	82	37	7.0	74
E042.1	10/21/2015	11	5.0	3.9	17
E050.1	07/07/2015	17	7.8	23	40
E050.1	07/20/2015	20	8.9	6.0	34

Table 3.2-2 (continued)

Gaging Station	Date	Sediment Yield (tons)	Sediment Yield (yd^3)[a]	Runoff Volume (acre-ft)	Peak Discharge (cfs)
E050.1	07/29/2015	3.4	1.5	5.6	22
E050.1	08/08/2015	1.9	0.8	8.5	11
E050.1	10/21/2015	2.9	1.3	3.8	18
E050.1	10/23/2015[b]	0.6	0.3	1.6	5.4
E059.5	07/03/2015	533	239	3.9	50
E059.5	07/31/2015	44.8	20	2.3	73
E059.8	10/21/2015	1.1	0.5	2.9	10
E060.1	07/02/2015[b]	93	42	14	12
E060.1	07/20/2015	3.2	1.4	0.8	6.7
2016 Runoff Events					
E038	8/19/2016	5.5	2.5	1.5	80
E038	8/24/2016	6.0	2.7	2.4	129
E038	8/27/2016	7.1	3.2	2.8	103
E039.1	8/3/2016	0.8	0.4	1.7	27
E039.1	9/6/2016	0.7	0.3	1.3	42
E039.1	11/5/2016	0.7	0.3	3.0	25
E042.1	8/27/2016	60	27	4.0	63
E042.1	11/6/2016	2.4	1.1	0.8	12
E050.1	8/27/2016	9.9	4.4	3.0	25
E059.5	8/27/2016	23	10	3.5	45
2017 Runoff Events					
E038	7/8/2017	9327	4.6	2.0	110
E038	7/26/2017	24,828	12.3	4.5	205
E038	7/29/2017	3016	1.5	1.8	45
E038	8/7/2017	4013	2.0	1.9	76
E039.1	7/8/2017	4273	2.1	2.1	60
E039.1	7/26/2017	7881	3.9	3.4	150
E039.1	7/29/2017	1247	0.6	1.7	45
E039.1	8/7/2017	394	0.2	0.8	18
E042.1	7/26/2017	20,223	10.0	2.5	30
E042.1	9/27/2017	7583	3.7	6.9	25
E042.1	9/29/2017	44,574	22.0	10.8	51
E042.1	10/4/2017	39,745	19.6	5.9	40
E050.1	9/27/2017	3781	1.9	9.7	32
E050.1	9/29/2017	15,899	7.8	17.3	56
E050.1	10/4/2017	11,842	5.8	16.3	35
E059.5	9/29/2017	22,036	10.9	6.8	61
E059.8	10/5/2017[b]	156	0.1	1.3	1.6

Table 3.2-2 (continued)

Gaging Station	Date	Sediment Yield (tons)	Sediment Yield (yd^3)[a]	Runoff Volume (acre-ft)	Peak Discharge (cfs)
2018 Runoff Events					
E038	08/02/2018	2.5	1.1	1.8	66
E038	08/10/2018	4.0	1.8	2.0	88
E038	08/15/2018	3.8	1.7	1.9	64
E038	09/03/2018	3.8	1.7	1.0	46
E039.1	08/02/2018	0.4	0.2	13	24
E039.1	08/10/2018	1.9	0.9	2.2	50
E039.1	08/15/2018	0.3	0.1	1.5	20
E039.1	09/03/2018	0.1	0.0	0.8	14
E039.1	09/04/2018	2.6	1.2	5.0	75
E042.1	09/04/2018	4.0	1.8	1.5	10
2019 Runoff Events					
E038	08/07/2019	68.0	30.5	13.3	329[c]
E039.1	07/26/2019	12.2	5.5	7.4	213
E039.1	08/07/2019	27.2	12.2	14.2	342
E042.1	07/26/2019	80.7	36.1	7.1	96
E042.1	08/07/2019	82.5	36.9	9.0	111
E050.1	07/26/2019	32.9	14.7	6.3	46
E050.1	08/07/2019	35.8	16.0	8.0	71
E059.5	08/07/2019	9.0	4.0	6.6	42
2020 Runoff Events					
No samples were collected in 2020.					

Notes: Sediment yield and runoff volume were calculated only from sampled events with reliable hydrographs and sedigraphs; hence, the 09/12/2013 sampling at E026 and E109.9 was excluded.

[a] Volumetric sediment yield was computed using a soil bulk density of 2650 kg/m^3 and volume = mass/density.

[b] Samples were not collected throughout the entire hydrograph (see Figures 3.2-3 and 3.2-4); hence, sediment yields may be underestimated.

[c] At E038 the peak stage during the 08/07/2019 flow event exceeded the rating curve. The peak discharge value was calculated using a best-fit equation for the rating curve.

Appendix A

Acronyms and Abbreviations

A-1.0 ACRONYMS AND ABBREVIATIONS

AAL	acute aquatic life
ASTM	American Society for Testing and Materials
BDD	Buckman Direct Diversion
BDDB	Buckman Direct Diversion Board
BLM	biotic ligand model
CAL	chronic aquatic life
cfs	cubic foot per second
Consent Order	Compliance Order on Consent
DEM	digital elevation model
DOE	Department of Energy (U.S.)
DP	Delta Prime
EPA	Environmental Protection Agency (U.S.)
F	filtered
GCS	grade-control structure
GIS	geographic information system
GPS	global positioning system
HEC-RAS	Hydrologic Engineering Center River Analysis System (model)
HH-OO	human health–organism only
IMWP	Interim Measure Work Plan to Mitigate Contaminated Sediment Transport in Los Alamos and Pueblo Canyons
Individual Permit	National Pollutant Discharge Elimination System Permit No. NM0030759
Laboratory	Los Alamos National Laboratory
LANL	Los Alamos National Laboratory
LA/P	Los Alamos and Pueblo (watershed)
LiDAR	light-detecting and ranging
LW	livestock watering
MDA	minimum detectable activity
MDL	method detection limit
MOU	memorandum of understanding
N3B	Newport News Nuclear BWXT-Los Alamos, LLC
NDVI	normalized difference vegetation index
NMAC	New Mexico Administrative Code

NMED	New Mexico Environment Department
NPDES	National Pollutant Discharge Elimination System
PCB	polychlorinated biphenyl
PQL	practical quantitation limit
RPD	relative percent difference
redox	oxidation reduction
RMSE	root-mean-squared error
SIMWP	Supplemental Interim Measures Work Plan to Mitigate Contaminated Sediment Transport in Los Alamos and Pueblo Canyons
SSC	suspended sediment concentration
SWMU	solid waste management unit
T2S	Tech2Solutions
TA	technical area
TAL	target analyte list (EPA)
TCDD[2,3,7,8]	2,3,7,8 tetrachlorodibenzo-p-dioxin
TOC	total organic carbon
TRM	turf-reinforcement mat
UF	unfiltered
VNIR	visible and near-infrared
WH	wildlife habitat
WWTF	wastewater treatment facility

Appendix B

2020 Geomorphic and Wetland Vegetation Changes at Sediment Transport Mitigation Sites in the Los Alamos/Pueblo Watershed

B-1.0 INTRODUCTION

This appendix establishes baseline data obtained through aerial methodology and evaluates geomorphic and wetland vegetation changes that occurred at sediment transport mitigation sites in the Los Alamos/Pueblo (LA/P) watershed during the 2019 monsoon season. Data were collected with the use of aerial hyperspectral imaging and light detection and ranging (LiDAR) imaging over the specified area of interest within the LA/P watershed, a methodology outlined in the “2018 Monitoring Report for Los Alamos/Pueblo Watershed Sediment Transport Mitigation Project” (N3B 2019, 700419). The aerial-derived data sets for 2019, compared with previous survey data derived from the global positioning system (GPS) in 2018 and baseline data sets from 2013, depict seasonal variation and enhance evaluation of the stability of the LA/P sediment transport mitigation sites within Los Alamos National Laboratory (LANL or the Laboratory).

Vegetation surveys are performed to monitor health and success of willow plantings. Coyote willows (*Salix exigua*) were planted in Pueblo Canyon to aid in surface stabilization, reduce flow velocity, and encourage sediment accumulation (LANL 2016, 601433; LANL 2017, 602343). The vitality of wetland species is a good indicator of oxidation reduction (redox) and saturation conditions over a spatial distribution that cannot be easily measured by other point data techniques such as alluvial well/piezometer monitoring. Specifically, the presence of obligate wetland vegetation implies persistent saturation.

Results from this aerial survey are presented in this appendix, representing geomorphic and vegetation change in the 2020 monsoon season and across the current and previous survey methodology.

B-2.0 AIRBORNE-BASED SURVEY METHODS OF THE LOS ALAMOS/PUEBLO WATERSHED

In 2019, new aerial survey techniques replaced previously implemented ground-based GPS survey methods. Tetra Tech was contracted to survey the LA/P sediment transport mitigation project area of interest using airborne hyperspectral and LiDAR equipment to collect geomorphic and vegetation data. A baseline LiDAR aerial survey was performed in 2018, during which points were measured at a density at least equivalent to the 2016 LiDAR data set (18–24 points per m^2). The LiDAR surveys provided a detailed digital elevation model (DEM) of the entire active channel within the wetland area, allowing comparison with historic ground-based geomorphic survey data.

Vegetation features were surveyed using an AISA EAGLE II visible and near-infrared (VNIR) hyperspectral imaging sensor system affixed to a Cessna 172 Skyhawk. A total of 128 spectral bands for the VNIR were collected, producing a ground sampling distance of 0.5m. Location and altitude data were collected by an Oxford Technical Solutions, Ltd., 2+ second-generation GPS.

Upon completion of airborne survey efforts, ground truthing was performed to identify reed canary grass, willow, and cattail. These data were used to develop a classification algorithm for the analysis of the hyperspectral data. Analysis resulted in seven target vegetation classes: reed canary grass, willow, cattail, mixed reed canary grass and willow, other vegetation, surface water, and non-vegetated (Figure B-2.0-1).

B-3.0 HYDROLOGIC EVENTS DURING THE 2020 MONSOON SEASON

No sample-triggering discharge events occurred during the 2020 monsoon season.

B-4.0 MONITORING RESULTS

The monsoon season of 2020 resulted in minor annual changes to morphology of monitored features and caused no significant geomorphic changes within the watershed monitored area. While minor changes occurred during the 2020 monsoon season, increased precision through new monitoring techniques will provide a more accurate and robust baseline data set for both geomorphic and vegetation data. Spatial data generated through new aerial methodology had a confidence level greater than 85%, exceeding the industry standard. Future data sets will be collected on a triennial survey basis.

B-4.1 Thalweg and Stream Bank

In 2018, the channel thalweg and stream banktop profile was surveyed by GPS in numerous segmented sections: a total length of 6491 ft and 9035 linear ft for the thalweg and banktop, respectively. In 2013, the entire thalweg and banktop were surveyed by GPS to establish baseline conditions. The total length was established at 7431 ft for the thalweg and 12,400 linear ft for the banktop.

LiDAR data were collected at the end of 2018 and used to produce a DEM. Data were not available for analysis for the 2018 report but were analyzed and used in this 2019 report. Analysis from the DEM contours in 2019 facilitated the determination of thalweg and banktop within the area of interest. The DEM identified the entire thalweg at 9981 ft and the banktop at 14,524 ft—increases of 53 and 61 percent, respectively—in linear length identified from the 2018 methodology. The DEM contour proved advantageous in identifying both the thalweg and banktop. While the GPS survey was unable to identify a clear thalweg because of diffused flow or vegetation, the extent of the DEM-identified thalweg and banktop could be continued (Figures B-4.1-1, B-4.1-2, and B-4.1-3).

Both the 2013 and 2018 GPS-surveyed thalwegs aligned very accurately with the DEM thalweg profile. Polylines generated from high-density LiDAR-generated DEM proved to be as accurate, if not more so, in capturing the thalweg and banktop elevation profile, especially in areas of diffused flow, braided channels, or heavy vegetation.

B-4.2 Wetland Vegetation

There was ample variation between the 2017 GPS wetland survey and the 2019 VNIR survey data sets. Data from 2017 focused solely on willow, grouping vegetation into five communities based on plant height and spatial distribution, while the 2019 data set defines individual species and their distribution. Within the area of interest, the 2019 Tetra Tech survey identified two willow group species (willow and mix [willow mixed with reed canary grass]) along with vegetation in the other vegetated and non-vegetated classes.

Variation of willow vegetation determined from each survey method was significant (the 2017 survey quantified 1.89 acres; the 2019 survey identified 0.22 acres). Variation is primarily a function of differences between survey methodology (Figure B-4.2-1, Table B-4.2-1). The 2019 data do not suggest that willow abundance has decreased 89 percent between 2017 and 2019. Rather, the detail and distribution of wetland species are much finer in the 2019 data set. The capability to extract non-riparian species or non-vegetated areas is an excellent tool to prevent overestimation of wetland area and also to quantify potential triennial expansion or reduction of willow vegetation distribution within the watershed.

Further, with data collected in the 2019 survey, it was possible to generate a normalized difference vegetation index (NDVI) (Figure B-4.2-2), essentially a surface reflectance, for the vegetation in the LA/P watershed. These data are used to produce a wetland plant health matrix that can then be compared across triennial survey data, quantifying the vigor of individual plant species throughout the wetland. Additional vegetation metrics of height and density were collected and used in the production and analysis of the species distribution algorithms and species distribution (Figures B-4.2-3 and B-4.2-4).

B-5.0 CONCLUSIONS AND RECOMMENDATIONS

In 2020, storm water peak discharge did not alter geomorphologic stability or willow distribution attributes with the LA/P watershed. No sample-triggering discharge events occurred during the 2020 monsoon season.

Comparison of data between 2018 survey methods and 2019 survey methods produces variation that is not attributable to hydrologic effects. Regardless, vegetative and geomorphic variation from 2018 to 2019 suggests that the LA/P watershed is stable and functioning properly.

The processed LiDAR data will be field-verified to ensure that geomorphic changes shown in a DEM comparison represent actual geomorphic changes. Additional ground-truth efforts may occur to improve species distribution data sets and expand for potentially occurring additional riparian obligate species in the LA/P watershed complex.

If no large storm events occur creating significant geomorphic change, aerial LiDAR surveys will be performed every third year, with the next survey scheduled for 2022. Additional ground-truthing efforts and data analysis will improve and refine the existing 2019 data set as well as the 2022 effort.

B-6.0 REFERENCES AND MAP DATA SOURCES

B-6.1 References

The following reference list includes documents cited in this report. Parenthetical information following each reference provides the author(s), publication date, and ERID, ESHID, or EMID. This information is also included in text citations. ERIDs were assigned by the Laboratory's Associate Directorate for Environmental Management (IDs through 599999); ESHIDs were assigned by the Laboratory's Associate Directorate for Environment, Safety, and Health (IDs 600000 through 699999); and EMIDs are assigned by Newport News Nuclear BWXT-Los Alamos, LLC (N3B) (IDs 700000 and above). IDs are used to locate documents in N3B's Records Management System and in the Master Reference Set. The New Mexico Environment Department (NMED) Hazardous Waste Bureau and N3B maintain copies of the Master Reference Set. The set ensures that NMED has the references to review documents. The set is updated when new references are cited in documents.

LANL (Los Alamos National Laboratory), April 2016. "2015 Monitoring Report for Los Alamos/Pueblo Watershed Sediment Transport Mitigation Project," Los Alamos National Laboratory document LA-UR-16-22705, Los Alamos, New Mexico. (LANL 2016, 601433)

LANL (Los Alamos National Laboratory), April 2017. "2016 Monitoring Report for Los Alamos/Pueblo Watershed Sediment Transport Mitigation Project," Los Alamos National Laboratory document LA-UR-17-23308, Los Alamos, New Mexico. (LANL 2017, 602343)

N3B (Newport News Nuclear BWXT-Los Alamos, LLC), April 2019. "2018 Monitoring Report for Los Alamos/Pueblo Watershed Sediment Transport Mitigation Project," Newport News Nuclear BWXT-Los Alamos, LLC, document EM2019-0106, Los Alamos, New Mexico. (N3B 2019, 700419)

B-6.2 Map Data Sources

Paved Road; Los Alamos National Laboratory, FWO Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 29 November 2010.

Structures; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 29 November 2010.

Fences; Los Alamos National Laboratory, IFPROG, As published, Oracle Spatial Database; GISPUBPRD1/PUB.Infrastructure/PUB.fences_arc, 2020.

Gage Stations: N3B/T2S, As published, GIS projects folder; \\n3b-fs01\n3b-shares) (Q: GIS DATA) Project: 15-0080; project_data.gdb; point feature dataset; gage_stations feature class; 2020

2018 Species Distribution; N3B/T2S, As published, GIS projects folder; \\n3b-fs01\n3b-shares) (Q: GIS DATA) Project: 19-0056; project_data.gdb; poly feature dataset; species_distribution_2018 feature class; 2020.

2019 Aerial Thalweg; N3B/T2S, As published, GIS projects folder; \\n3b-fs01\n3b-shares) (Q: GIS DATA) Project: 19-0056; project_data.gdb; line feature dataset; thalweg_2016_derived_data feature class; 2020.

Hillshade; N3B/T2S, As published, GIS projects folder; \\n3b-fs01\n3b-shares) (Q: GIS DATA) 2014; BareEarth; BareEarth_DEM_Mosaic_Overviews; BareEarth_DEM_Mosaic.gdb

Sandia Wetlands 2019 Boundary; Sandia 2019 Wetlands Vegetation Density; N3B/T2S, As published, GIS projects folder; \\n3b-fs01\n3b-shares) (Q: GIS DATA) Project: 19-0056; project_data.gdb; sandia_density raster dataset; 2020.

Sandia NDVI; N3B/T2S, As published, GIS projects folder; \\n3b-fs01\n3b-shares) (Q: GIS DATA) Project: 19-0056; project_data.gdb; sandia_NDVI_extract raster dtaset; 2020.

Contours, 20 and 2-ft interval; N3B/T2S, As published, GIS projects folder; \\n3b-fs01\n3b-shares) (Q: GIS DATA) Project: 19-0056; project_data.gdb; line feature dataset; site_contour feature class; 2020.

Sandia 2019 Wetlands Vegetation Density; N3B/T2S, As published, GIS projects folder; \\n3b-fs01\n3b-shares) (Q: GIS DATA) Project: 19-0056; project_data.gdb; sandia_density raster dataset; 2020.

Sandia 2019 Wetlands Vegetation Height; N3B/T2S, As published, GIS projects folder; \\n3b-fs01\n3b-shares) (Q: GIS DATA) Project: 19-0056; project_data.gdb; sandia_height_extract raster dataset; 2020.

2017 GPS Thalweg; N3B/T2S, As published, GIS projects folder; \\n3b-fs01\n3b-shares) (Q: GIS DATA) Project: 19-0056; project_data.gdb; line feature dataset; T2017_Sandia_Thalweg_ln feature class; 2020.

2019 Aerial plunge pool; N3B/T2S, As published, GIS projects folder; \\n3b-fs01\n3b-shares) (Q: GIS DATA) \LANL Hyperspectral Data\Species_Distribution\West_AOI\W_Surface_Water.shp 2020.

2019 Banktop; N3B/T2S, As published, GIS projects folder; \\n3b-fs01\n3b-shares) (Q: GIS DATA) Project: 19-0056; project_data.gdb; line feature dataset; T2018_Sandia_Canyon_BankTops_Line feature class; 2020.

2019 Plunge Pool; 3B/T2S, As published, GIS projects folder; Q:\LANL Hyperspectral Data\Species_Distribution\West_AOI\W_Surface_Water.shp 2020.

Surrounding Land: As published; N3B GIS project folder: Q:\16-Projects\16-0033\project_data.gdb\polygon\pline_lab_county; October 2019.

TA Boundary: As published; Triad SDE Spatial Geodatabase: GISPUBPRD1\PUB.Boundaries\PUB.Tecareas; October 2019.

Major Road: As published; Q:\16-Projects\16-0033\project_data.gdb\line\major_road; October 2019.

Drainage: As published; Q:\16-Projects\16-0033\project_data.gdb\line\drainage_features; October 2019.

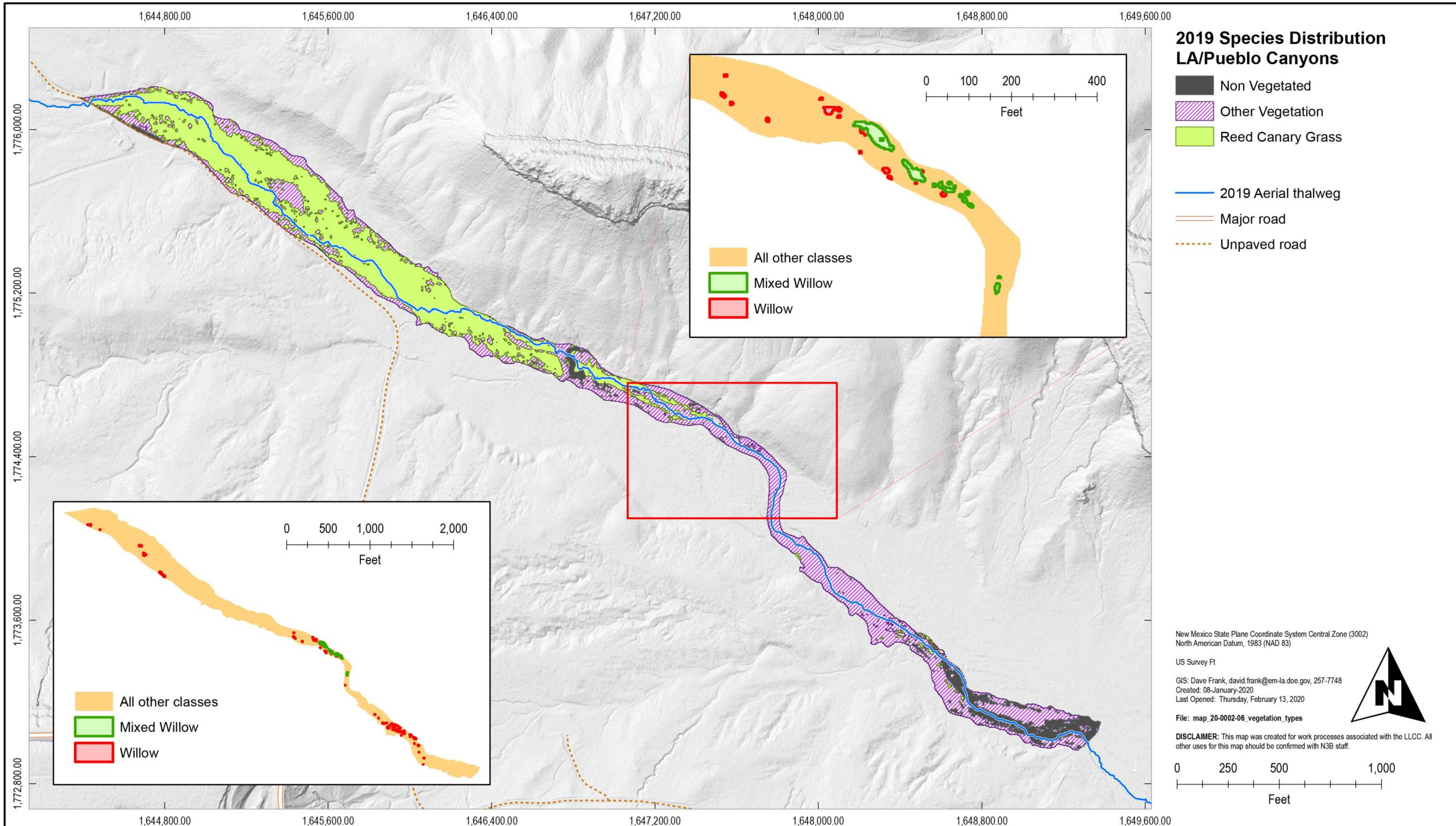


Figure B-2.0-1 LA/P 2019 species distribution, gage stations, and thalweg

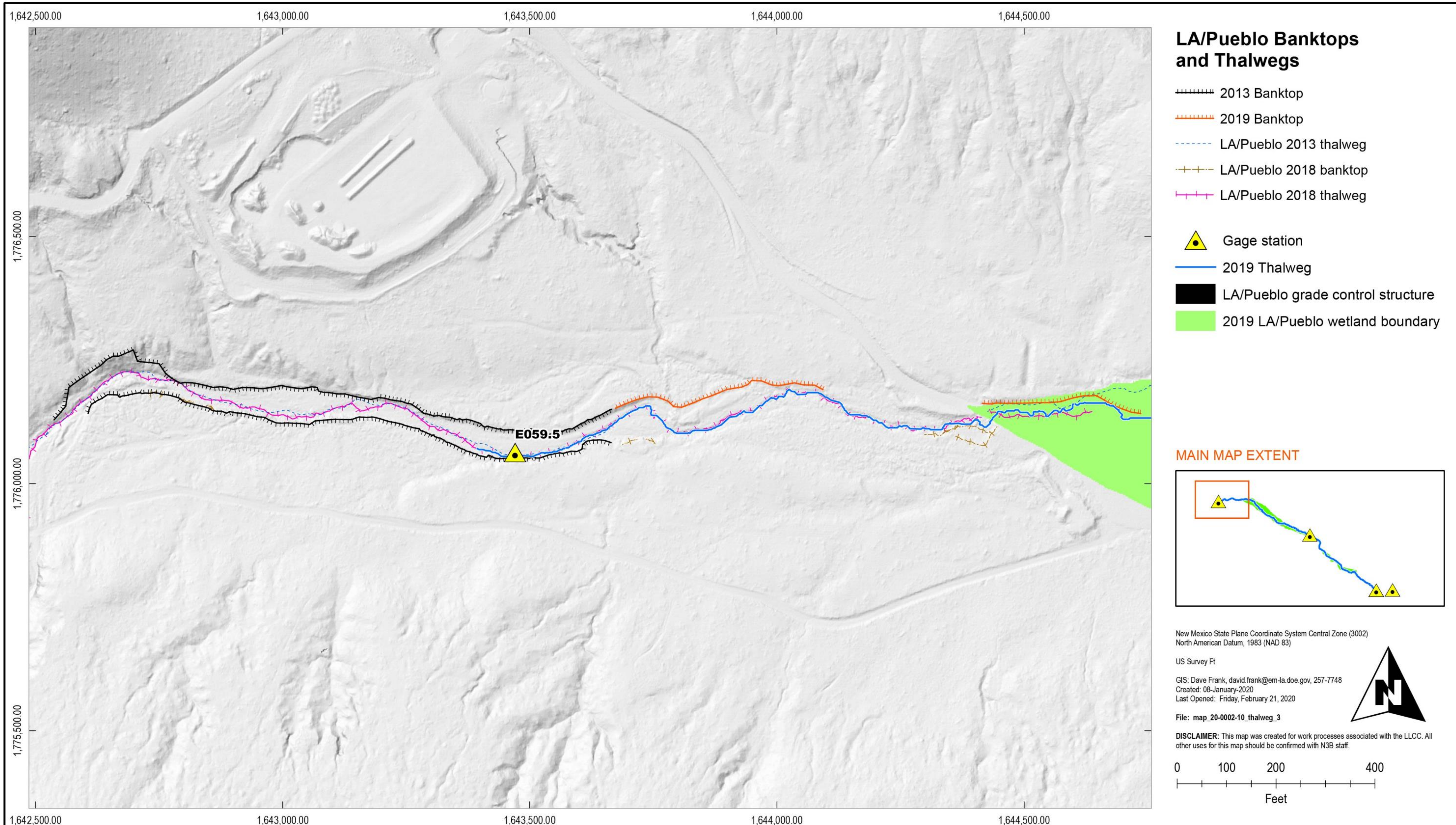


Figure B-4.1-1 Comparison of thalweg and banktop surveys near gage station E059.5

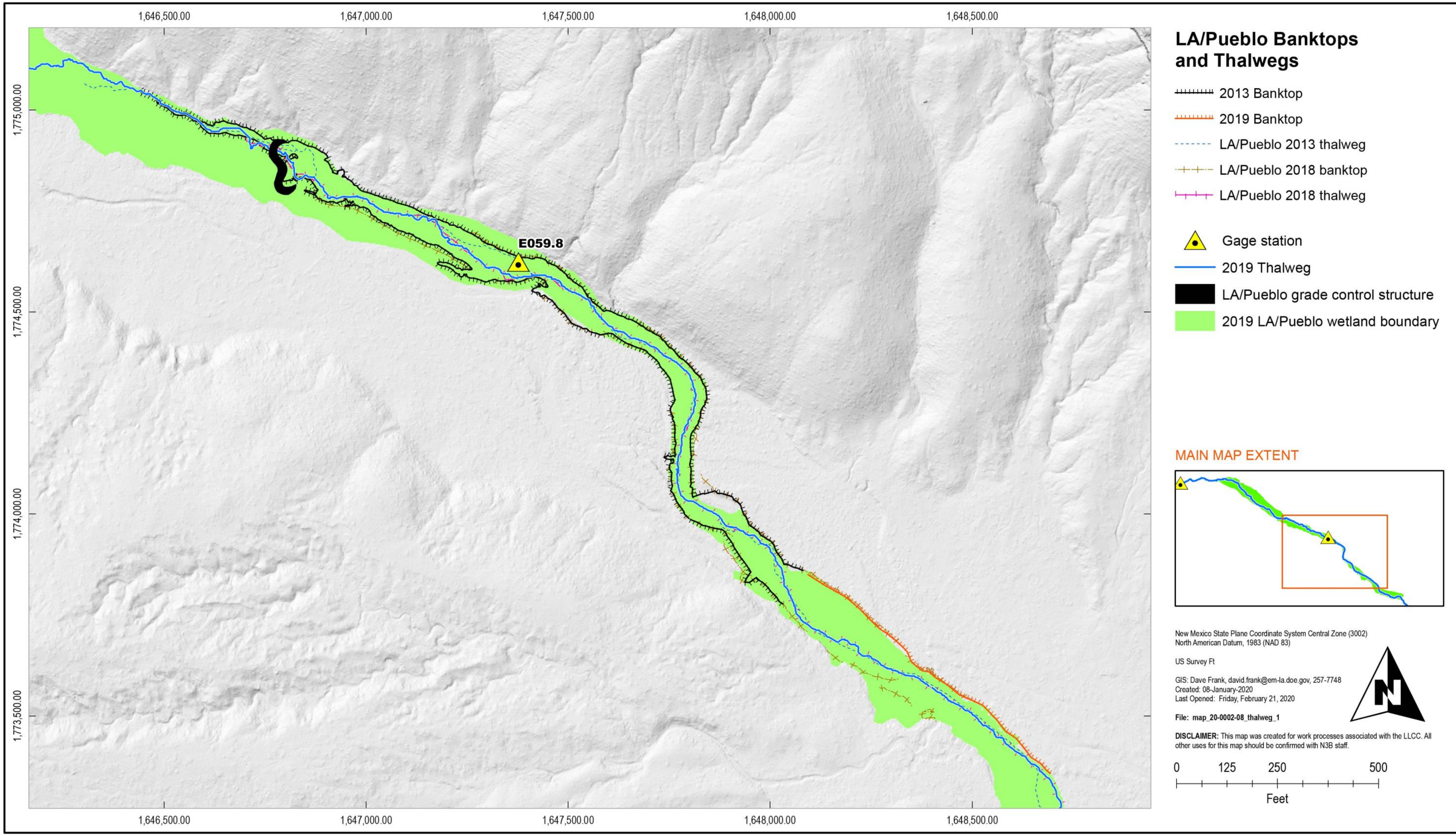


Figure B-4.1-2 Comparison of thalweg and banktop surveys near gage station E059.8

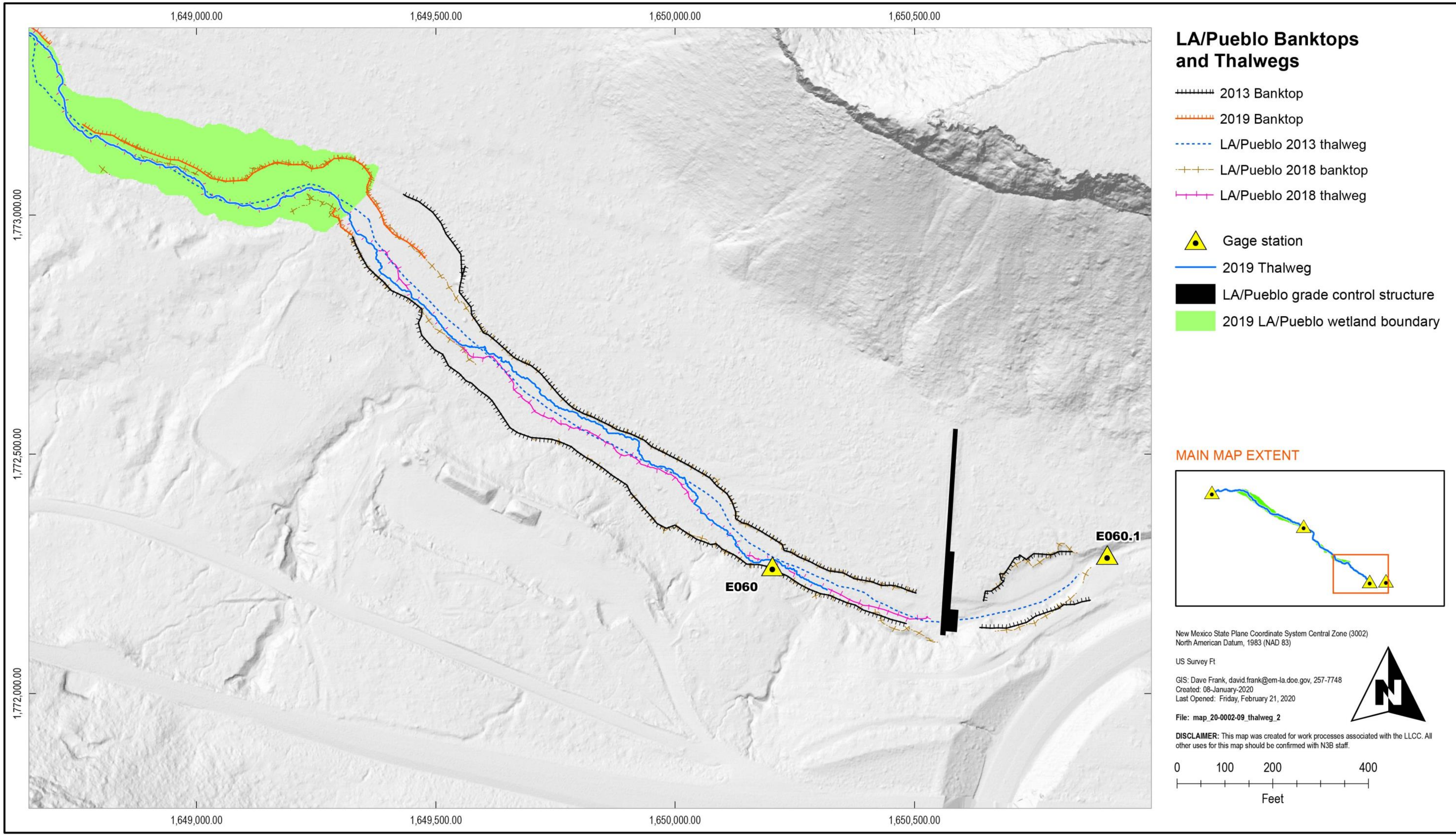


Figure B-4.1-3 Comparison of thalweg and banktop surveys near gage station E060.1

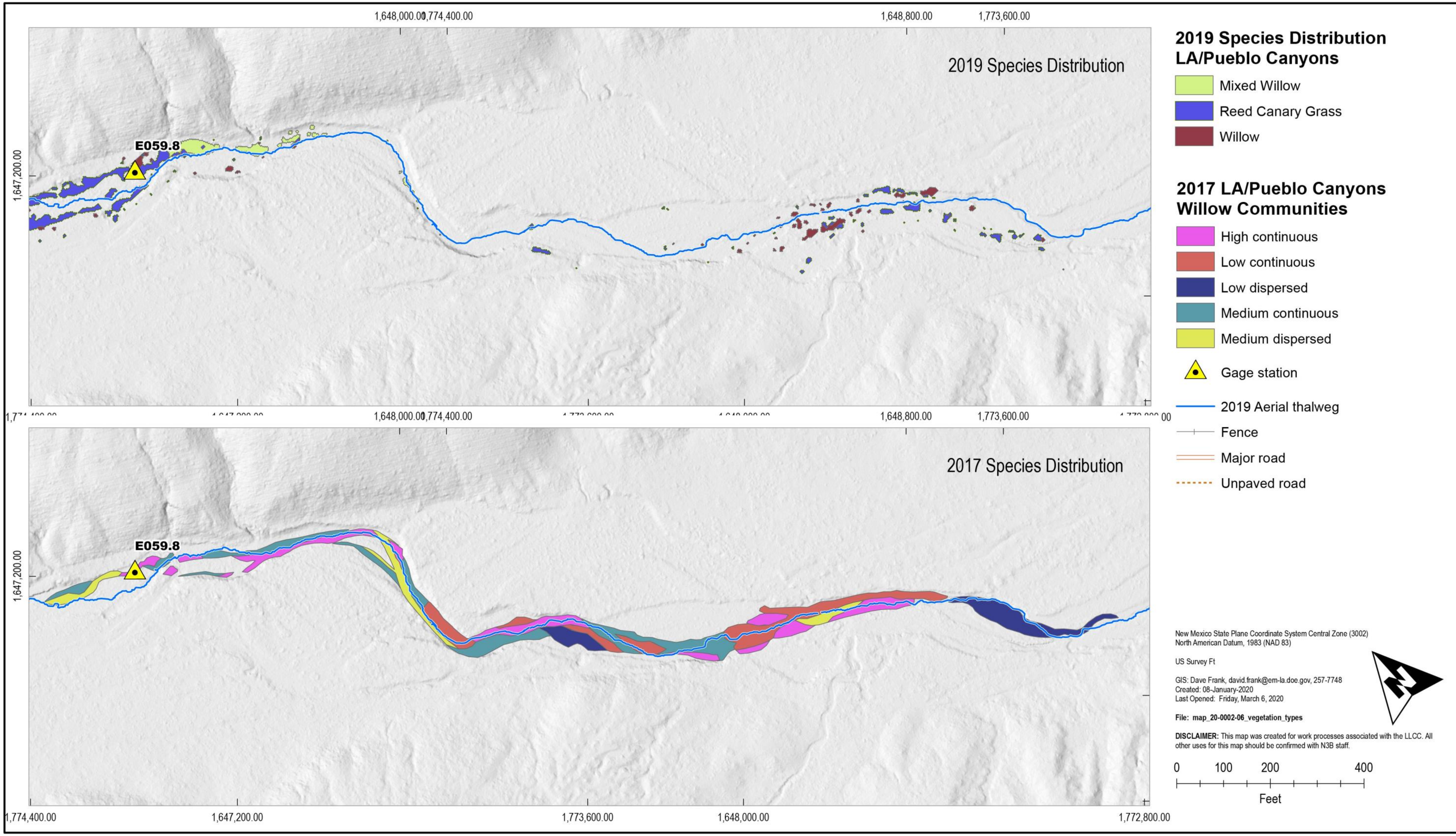


Figure B-4.2-1 Comparison of willow distribution across 2017 GPS survey and 2019 aerial survey methods in LA/P watershed

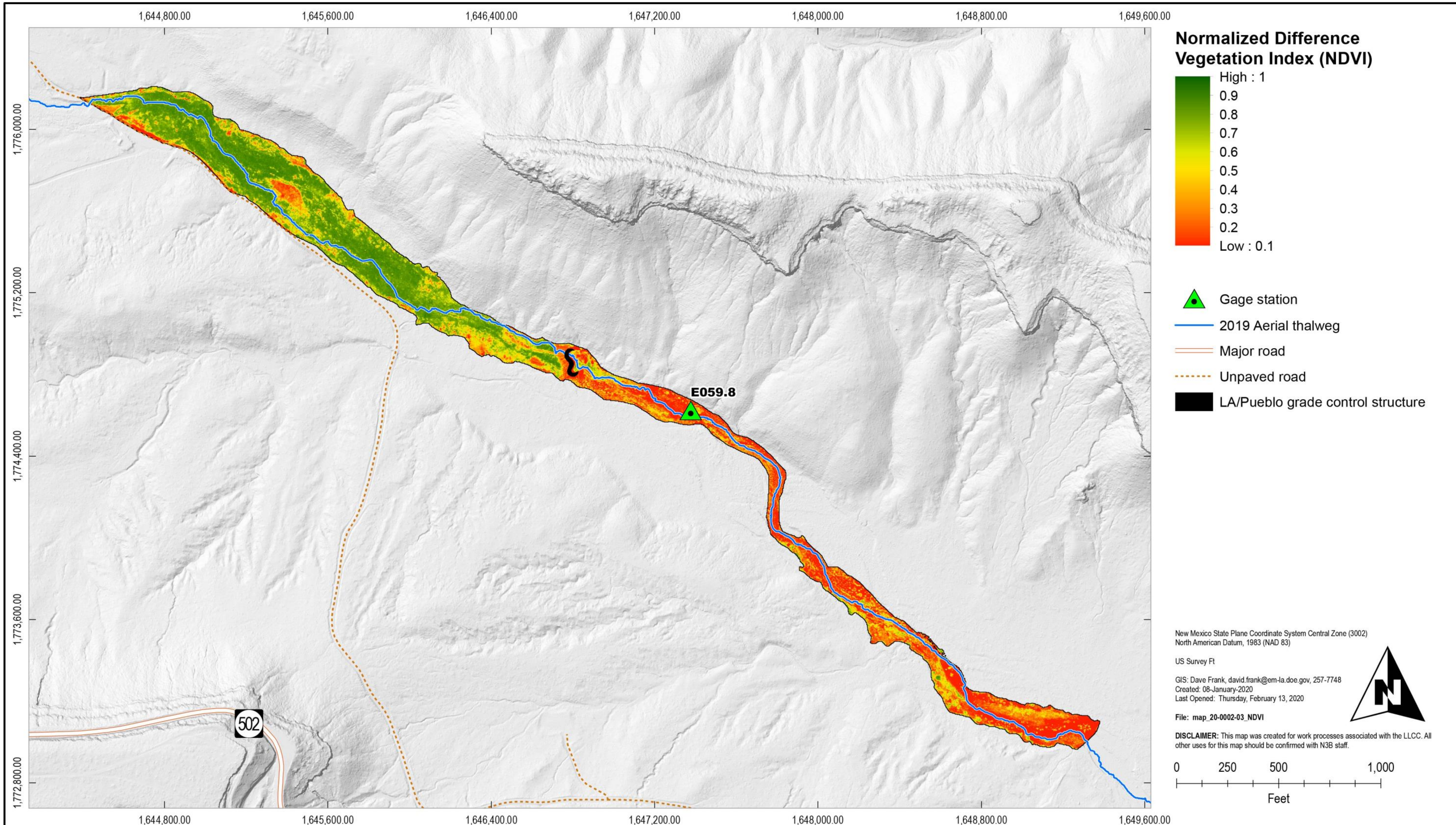


Figure B-4.2-2 2019 aerial-derived normalized difference vegetation index of LA/P watershed

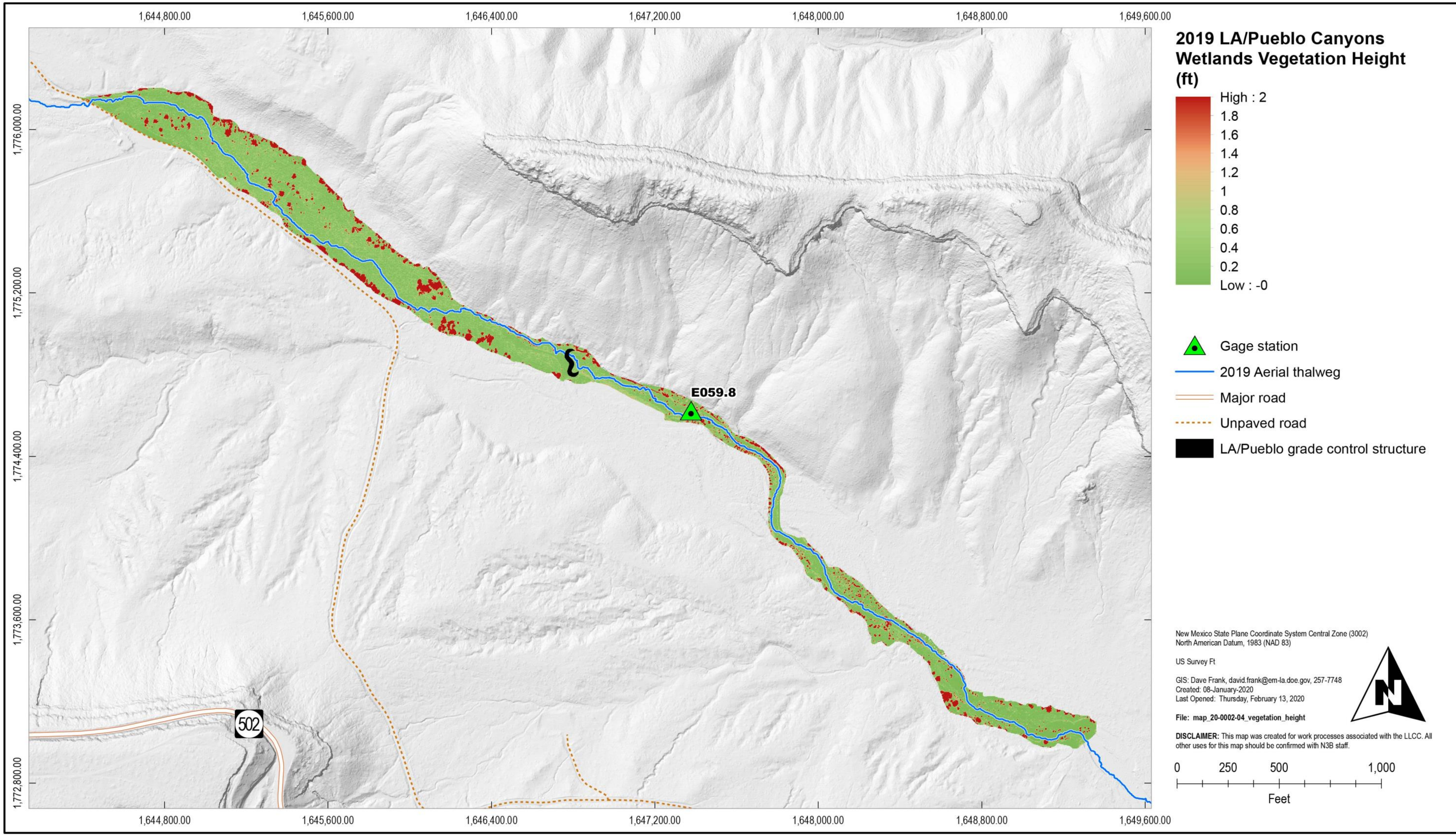


Figure B-4.2-3 2019 aerial-derived LA/P watershed vegetation height

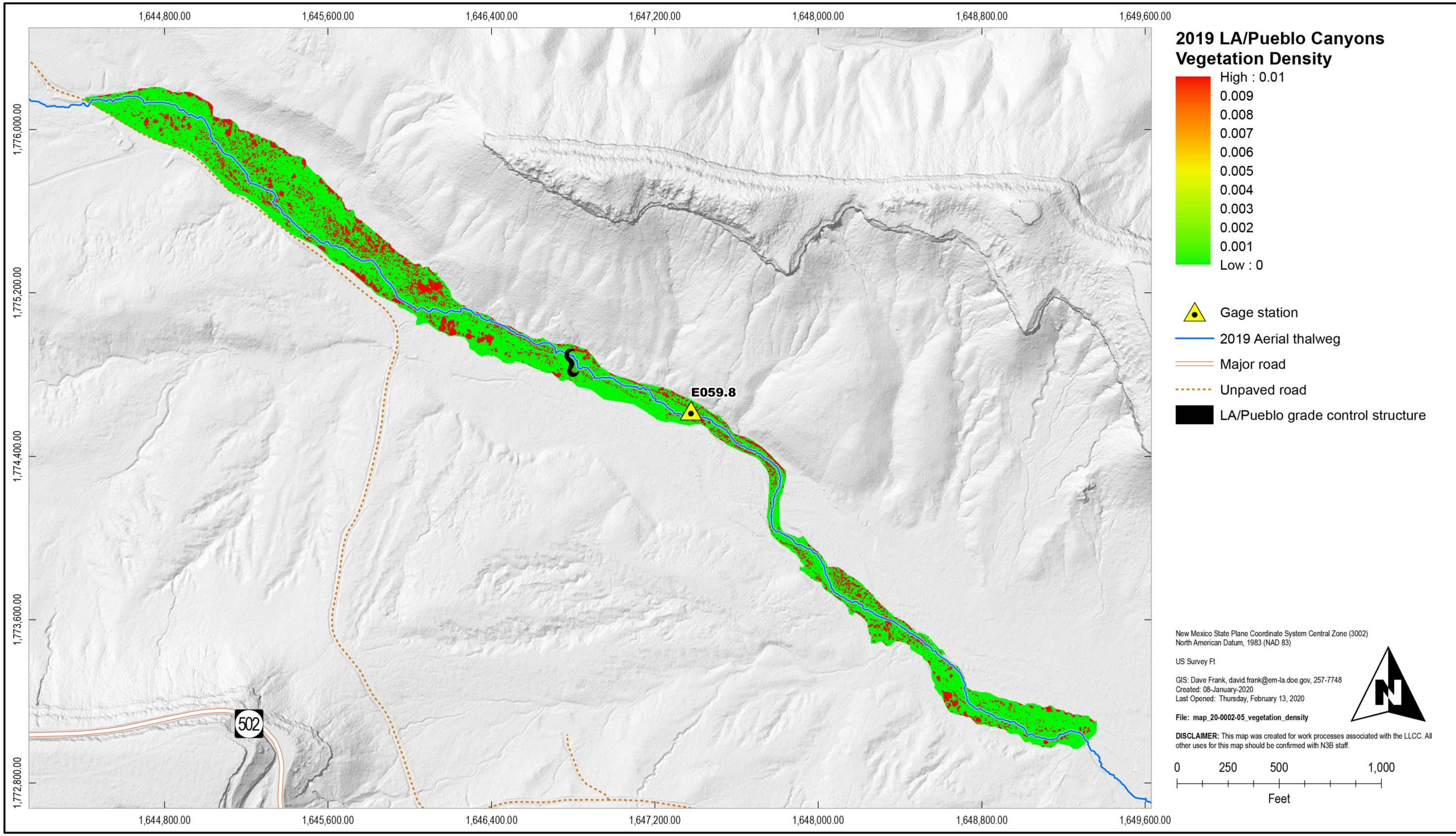


Figure B-4.2-4 2019 aerial-derived LA/P watershed vegetation density

Table B-4.2-1
Willow Distribution
from 2017 GPS Survey and 2019 Aerial Survey

Survey Year	Willow	Mixed Willow/Grass	Total Area
2017	82,425	n/a*	82,425
2019	5613	4317	9930

Note: Units are square feet.
* n/a = Not applicable.

Appendix C

2020 Watershed Mitigation Inspections

C-1.0 INTRODUCTION

Watershed storm water controls and grade-control structures (GCSs) are inspected on a routine basis and after significant flow events (greater than 50 cubic feet per second [cfs]). These inspections are completed to ensure the watershed mitigations are functioning properly and to identify if maintenance may be required. Examples of items evaluated during inspections include the following:

- Debris/sediment accumulation that could impede operation
- Water levels behind retention structures
- Physical damage to structure or failure of structural components
- Undermining, piping, flanking, settling, movement, or breeching of structure
- Vegetation establishment and vegetation that may negatively impact structural components
- Rodent damage
- Vandalism
- Erosion

The photographs in this appendix depict annual or significant flow-event-driven storm water inspections of watershed mitigations in Los Alamos and Pueblo Canyons. Each group of photographs is associated with a specific feature (e.g., standpipe, weir, upstream, downstream) that has the potential to develop issues. The photographs are presented in chronological order and depict the feature in 2020. Photographs of features were taken to mirror previous inspection photographs as closely as possible. Due to delays associated with the COVID-19 pandemic, the first set of inspections was conducted in August and September 2020 and the second set in October 2020. No storm event inspections were conducted in 2020.

C-2.0 DP CANYON GRADE-CONTROL STRUCTURE

C-2.1 Embankment

Photo C-2.1-1 September 2020—Embankment is stable and operating as designed. Well established vegetation with no erosion occurring from hillslope.

Photo C-2.1-2 October 2020—Embankment is stable and operating as designed. Well established vegetation with no erosion occurring from hillslope.

C-2.2 Overflow Weir Structure

Photo C-2.2-1 September 2020—upslope face of weir, looking east. Weir is functioning; no deteriorating joints or bulging gabion baskets.

Photo C-2.2-2 September 2020—piping occurring at upslope face of weir. Continue to monitor.

Photo C-2.2-3 **October 2020—upslope face of weir, looking south. Recommend trash pickup.**

Photo C-2.2-4 **October 2020—piping occurring at upslope face of weir. Recommend placing rock from nearby and on-site round riprap pile within the two voids upslope of weir near the north abutment.**

C-2.3 Crest of Weir Structure

Photo C-2.3-1 September 2020—crest of weir structure looking upslope. No deteriorated joints present on upslope side of weir. Gabion basket is structurally intact and in stable condition.

Photo C-2.3-2 October 2020—weir structure looking upslope. No significant change since last inspection.

C-2.4 Downstream Face of Overflow Weir Structure

Photo C-2.4-1 September 2020—downstream face of weir. Continue to monitor bulging gabion baskets. No evidence of cracking or spalling; area is clear of debris.

C-2.5 GCS Standpipe

Photo C-2.5-1 September 2020—standpipe. Sediment level is approximately 1 ft below wood board stop. No significant change since last inspection. Will continue to monitor.

Photo C-2.5-2 September 2020—standpipe. Tire is present within standpipe. No action recommended.

Photo C-2.5-3 October 2020—standpipe. No significant change since last inspection.

Photo C-2.5-4 September 2020—standpipe. Recommend removal of tire.

C-2.6 GCS Spillway

Photo C-2.6-1 September 2020—spillway alignment. Spillway operating as designed. No sign of improper alignment or deterioration. No trash encountered.

C-2.7 GCS Outlet

Photo C-2.7-1 September 2020—outlet. Evidence of corrosion noted in 2018. Pond level was at approximately 6 in. above the bottom of the outlet culvert at time of inspection. Will continue to monitor.

Photo C-2.7-2 October 2020—outlet. Cloud pool downslope of weir.

C-3.0 UPPER LOS ALAMOS CANYON SEDIMENT DETENTION PONDS

C-3.1 Lower Basin Embankment and Pond

Photo C-3.1-1 September 2020—lower basin. No breaching/slides/cracks/sloughs present on embankment or pond. No erosion occurring on slope. No trash or debris present in control. Rodent burrows not encountered. Recommend removal of vegetation on the maintenance access path on the pond bank north of the Canyon Road.

Photo C-3.1-2 October 2020—lower basin. Basin dry. No rodent burrows encountered.

C-3.2 Upper Basin Embankment and Pond

Photo C-3.2-1 **September 2020—upper basin. Sloughing on south bank of the Upper Pond above where TRM was installed. Sides are retained by concrete jersey barrier at edge of road. Continue to monitor.**

Photo C-3.2-2 **October 2020—upper basin. Basin dry. Sloughing on south side of basin above where TRM was installed. Sides are retained by concrete jersey barrier at north road edge. Continue to monitor.**

C-3.3 Lower Basin Spillway

Photo C-3.3-1 September 2020—lower basin spillway. No signs of erosion occurring on or near spillway. Spillway is maintaining alignment and stability.

Photo C-3.3-2 October 2020—lower basin spillway. No significant change since last inspection.

C-3.4 Upper Basin Spillway

Photo C-3.4-1 September 2020—upper basin spillway. No signs of erosion occurring on or near spillway. Spillway is maintaining alignment and stability.

Photo C-3.4-2 October 2020—upper basin spillway. No change since last inspection.

C-3.5 Wetland and Culvert

Photo C-3.5-1 September 2020—wetland vegetation. Wetland vegetation is green and ranges from 6 to 8 ft in height. Vegetation coverage is uniform within the wetland pond.

Photo C-3.5-2 October 2020—wetland vegetation. Wetland vegetation is dormant with height ranging from 6 to 8 ft. Vegetation coverage is uniform within the wetland pond.

Photo C-3.5-3 October 2020—culvert inlet. Culvert inlet is buried under twigs and pine needles. No action recommended.

C-3.6 Upstream Pipeline and Appurtenances

Photo C-3.6-1 September 2020—pipeline headwall. Needle cast debris blocking portion of pipe inlet grate. Blockage removed 9/10/2020. Recommend replacement of trash rack with one that is not in line with pipe inlet.

Photo C-3.6-2 October 2020—pipeline headwall. No deficiency found.

Photo C-3.6-3 September 2020—pipeline headwall. Rebar sticking up on headwall is a tripping hazard. Recommend removal.

Photo C-3.6-4 September 2020—pipeline cable support. No significant change since last inspection.

Photo C-3.6-5 October 2020—pipeline cable support. No significant change since last inspection.

Photo C-3.6-6 September 2020—beam trolley support. Caster gouging and degradation of coating due to skewed support on beam trolley support 15. Continue to monitor gouging on pipe support beam trolleys.

Photo C-3.6-7 October 2020—beam trolley support. Caster gouging and degradation of coating due to skewed support on beam trolley support 15. Continue to monitor gouging on pipe support beam trolleys.

Photo C-3.6-8 September 2020—fallen tree on pipeline. Recommend relocation of fallen tree and repair of bridge.

Photo C-3.6-9 October 2020—pipeline. Fallen tree relocated from off of pipeline.

Photo C-3.6-10 October 2020—bridge. Recommend repair of bridge.

C-3.7 Upstream Pipeline Vacuum Breaker

Photo C-3.7-1 September 2020—pipeline vacuum breaker. Control is operating as designed with no apparent issues to structure.

Photo C-3.7-2 October 2020—pipeline vacuum breaker. Control is operating as designed with no apparent issues to structure.

C-3.8 Upstream Pipeline Bridge Structure

Photo C-3.8-1 September 2020—pipeline bridge structure. Control is operating as designed with no apparent issues to structure.

Photo C-3.8-2 October 2020—pipeline bridge structure. Control is operating as designed with no apparent issues to structure.

C-3.9 Pipeline Outlet and Energy Dissipater

Photo C-3.9-1 September 2020—pipeline outlet, energy dissipater, and gabion overflow structure. Control is operating as designed with no apparent issues to structure.

Photo C-3.9-2 October 2020—pipeline outlet, energy dissipater, and gabion overflow structure. Control is operating as designed with no apparent issues to structure.

Photo C-3.9-3 September 2020—pipeline outlet. No deficiency found.

Photo C-3.9-4 October 2020—pipeline outlet. No deficiency found.

Photo C-3.9-5 September 2020—discharge culvert north of Los Alamos Canyon Road. Riprap area is steep and any size riprap presents a falling hazard. Area should stabilize naturally. No action recommended.

Photo C-3.9-6 October 2020—discharge culvert north of Los Alamos Canyon Road. No action recommended.

C-4.0 LOS ALAMOS CANYON WEIR AND DETENTION PONDS

C-4.1 Weir Embankment Upstream Slope

Photo C-4.1-1 **September 2020—upstream northern embankment slope. Vegetation is dormant. Area is dry. No deficiency found.**

Photo C-4.1-2 **October 2020—upstream northern embankment slope. Vegetation is dormant. Area is dry. No deficiency found.**

Photo C-4.1-3 September 2020—upstream southern embankment slope.

Photo C-4.1-4 October 2020—rodent activity. Holes encountered on south bank upstream of Los Alamos Canyon Weir.

C-4.2 Weir Embankment Abutment

Photo C-4.2-1 September 2020—abutment looking south. No significant change since last inspection.

Photo C-4.2-2 October 2020—abutment looking south. No change since last inspection.

C-4.3 Weir Embankment Downstream Slope

Photo C-4.3-1 September 2020—downstream southern embankment slope. No deficiency found.

Photo C-4.3-2 October 2020—downstream southern embankment slope. No deficiency found.

Photo C-4.3-3 **September 2020—downstream northern embankment slope. Sediment deposited from runoff coming from dirt roads upgradient of the north side gabion embankment. Recommend placement of gravel bags at top of gabion on north bank downstream of the Los Alamos Canyon Weir.**

Photo C-4.3-4 **October 2020—downstream northern embankment slope. Sediment deposited from runoff coming from dirt roads upgradient of the north side gabion embankment. Recommend placement of gravel bags at top of gabion on north bank downstream of the Los Alamos Canyon Weir.**

C-4.4 Upper Pond

Photo C-4.4-1 September 2020—Los Alamos Pond 1 (upper) looking downstream. Pond has been breached and has no sediment capacity. No action recommended.

Photo C-4.4-2 October 2020—Los Alamos Pond 1 (upper) looking downstream. No significant change since last inspection.

C-4.5 Middle Pond

Photo C-4.5-1 September 2020—Los Alamos Pond 2 (middle) looking downstream. Pond has been breached and has no sediment capacity. No action recommended.

Photo C-4.5-2 October 2020—Los Alamos Pond 2 (middle). No significant change since last inspection.

C-4.6 Lower Pond

Photo C-4.6-1 September 2020—Los Alamos Pond 3 (lower). Pond is dry. No significant change since last inspection.

Photo C-4.6-2 October 2020—Los Alamos Pond 3 (lower). No significant change since last inspection.

C-4.7 Upslope Face and Crest of Overflow Weir Structure

**Photo C-4.7-1 September 2020—upstream weir face.
No significant change since last inspection.**

Photo C-4.7-2 September 2020—weir crest. Recommend repair of holes in gabion basket.

Photo C-4.7-3 September 2020—broken gabions on north end of crest. Recommend repair of holes in gabion basket.

Photo C-4.7-4 September 2020—broken gabion wires on south end of weir crest. Recommend repair.

Photo C-4.7-5 October 2020—weir crest. No significant change since last inspection.

Photo C-4.7-6 October 2020—broken gabions on north end of crest. Recommend repair of holes in gabion basket.

Photo C-4.7-7 October 2020—broken gabion wires on south end of weir crest. Recommend repair.

C-4.8 Downstream Face of Overflow Weir Structure

Photo C-4.8-1 October 2020—downstream weir face. Continue to monitor bulging baskets and joints.

C-4.9 Weir Standpipe

Photo C-4.9-1 September 2020—standpipe. Sediment and debris level at 4.6 ft on staff gage upstream of the weir.

Photo C-4.9-2 October 2020—standpipe. No significant change since last inspection.

C-4.10 Weir Outlet

Photo C-4.10-1 September 2020—weir outlet. Erosion occurring in sediments deposited on top of gabion mattress apron. Rilling does not extend beyond the end of the gabion mattress apron. Sediment deposits on top of gabion mattress are approximately 1 in. below the bottom of the outlet invert. No action recommended.

Photo C-4.10-2 October 2020—weir outlet. No significant change since last inspection.

C-4.11 Borrow Pit Runoff Control Berm

Photo C-4.11-1 September 2020—borrow pit and berm. Rilling noted on 2019 inspections has sedimented naturally. Continue to monitor.

Photo C-4.11-2 September 2020—vegetation on earthen berm. Vegetation is not well established. Continue to monitor. Damage to north end of berm that occurred during county construction remains. No action recommended.

Photo C-4.11-3 September 2020—borrow pit. Well construction materials from Los Alamos County project remain. Recommend notifying Los Alamos County to have materials removed.

Photo C-4.11-4 October 2020—borrow pit and berm. Grass is dormant and 3 in. to 1 ft in height. Native brush is 3 in. to 2 ft in height. Vegetation coverage is uniform in soils placed upgradient of the berm.

Photo C-4.11-5 **October 2020—borrow pit and berm. Vegetation is not well established on earthen berm. Damage to north end of berm occurred during Los Alamos County construction in 2019. Will continue to monitor.**

Photo C-4.11-6 **October 2020—borrow pit. Well construction materials from Los Alamos County project remain. Recommend notifying Los Alamos County to have materials removed.**

C-5.0 PUEBLO CANYON GRADE-CONTROL STRUCTURE

C-5.1 Upstream Embankment

Photo C-5.1-1 August 2020—south embankment, looking west. Well established vegetation on embankment. No signs of erosion or undermining.

Photo C-5.1-2 October 2020—south embankment, looking west. No significant change since last inspection.

C-5.2 Embankment Abutment

Photo C-5.2-1 August 2020—embankment abutment from north side of channel, looking south. Well established vegetation surrounding control. No presence of trash or debris.

Photo C-5.2-2 October 2020—embankment abutment from north side of channel, looking south. Well established vegetation surrounding control. No presence of trash or debris.

C-5.3 Downstream Embankment and Outlet

Photo C-5.3-1 August 2020—downstream south embankment, looking west. Control is operating as designed. No buckling of embankment observed. Riprap functioning as designed. Vegetation established and no evidence of erosion.

Photo C-5.3-2 October 2020—downstream south embankment, looking east. No significant change since last inspection.

C-5.4 Crest of Overflow Weir Structure and Spillway

Photo C-5.4-1 August 2020—weir crest and flow-way, looking north. Recommend removal of tall vegetation located on upstream side of spillway.

Photo C-5.4-2 August 2020—weir crest and flow-way, looking south. Tree has fallen over overflow weir structure. Recommend removal of tree.

Photo C-5.4-3 October 2020—weir spillway and flow-way, looking north. Recommend removal of tall vegetation located on upstream side of spillway.

Photo C-5.4-4 October 2020—weir crest and flow-way, looking north. Recommend removal of fallen tree.

C-5.5 Downstream Face of Overflow Weir Structure Showing Outlet and Spurs

Photo C-5.5-1 August 2020—Redi-Rock spurs, looking east. Well established vegetation along all hillslopes. No erosion apparent along slopes or near turf-reinforcement mat. All structures functioning as designed.

Photo C-5.5-2 August 2020—Redi-Rock spurs, looking west. No deficiency found.

Photo C-5.5-3 October 2020—Redi-Rock spurs, looking east

Photo C-5.5-4 October 2020—Redi-Rock spurs, looking west

C-6.0 PUEBLO CANYON WETLAND STABILIZATION STRUCTURE

C-6.1 Upper, Middle, and Lower Pueblo Wetland Structure

Photo C-6.1-1 August 2020—Redi-Rock block structure, looking north. Redi-Rock structure shows no evidence of displacement or settling. Vegetation well established.

Photo C-6.1-2 August 2020—Redi-Rock block structure, looking southeast. Redi-Rock structure shows no evidence of displacement or settling. Vegetation well established.

Photo C-6.1-3 **August 2020—Redi-Rock block structure. Noted void between block 13 and 14 (as counted from north end of structure). Filled void with on-site rocks based on recommendation from 2019 Q4 inspection.**

Photo C-6.1-4 **October 2020—Redi-Rock block structure, looking north. No deficiency found.**

Photo C-6.1-5 October 2020—Redi-Rock block structure, looking southeast. No deficiency found.

C-6.2 Wetland North Bank

Photo C-6.2-1 August 2020—wetland north bank, looking northeast. Slope is stable with no evidence of erosion where riprap is located. Structure is functioning as designed with established vegetation.

Photo C-6.2-2 October 2020—wetland north bank, looking east. No deficiency found.

C-6.3 Wetland South Bank

Photo C-6.3-1 August 2020—south bank, looking south. Riprap (Class B) has fallen down to toe of steep slope on south bank. South bank is susceptible to erosion. Loose soil in voids where riprap was placed. Recommend placement of jute erosion-control matting, wire-enclosed riprap using on-site riprap, or brush barriers using on-site fallen trees to stabilize soil on steep slopes downstream of grade-control structure. Continue to monitor.

Photo C-6.3-2 October 2020—south bank, looking west. South bank is susceptible to erosion. Loose soil in voids where fallen riprap was placed. Recommend placement of jute erosion-control matting, wire-enclosed riprap, or brush barriers at toe of slope on south bank downstream of Pueblo Canyon Wetland grade-control structure.

C-6.4 Downstream South Bank

Photo C-6.4-1 August 2020—south bank berm, looking northeast. Berm is stable. No noted erosion or breaching, slides, or cracks in berm.

C-6.5 Upstream Area of Wetland

Photo C-6.5-1 August 2020—upstream pond, looking upstream. No deficiency found.

Photo C-6.5-2 October 2020—upstream pond, looking upstream. No deficiency found.

Appendix D

Instantaneous (5-min) Gaging Station Stage and Discharge Data for the Los Alamos/Pueblo Watershed (on CD included with this document)