Appendix A
Cultural Resources Consultation

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Cultural Resources and Documentation of Section 106 Consultation

For the Tamaya Drainage Project, Section 106 consultation (of the National Historical Preservation Act of 1966, as amended) began with submittal of several archaeological survey reports, prepared by a Pueblo of Santa Ana contractor, to the New Mexico State Historic Preservation Officer (SHPO) in 2003. The USACE is the lead agency for the Section 106 consultation process. The SHPO requested additional documentation regarding the surveys as well as survey level, limited testing. Several of the related Pueblo of Santa Ana projects were on-hold for several years and the additional documentation has since been received. In the interim, the Pueblo of Santa Ana established their own Tribal Historic Preservation Office (THPO). Section 106 consultation has been reinitiated with the Pueblo and the Corps is recommending that copies of Section 106 consultation with the THPO and related documentation be submitted to the SHPO for their records. Copies of the Section 106 consultation were also submitted to the U.S. Bureau of Indian Affairs, Southwest Region. The USACE has been intensively coordinating planning for the project with the Pueblo. On March 28, 2013, the Pueblo’s THPO concurred with the USACE determination of no adverse effect to historic properties and that construction of the recommended project is in the best interests of the Pueblo. A copy of the consultation letter appears at the end of this Appendix.

A brief discussion of local Culture History follows.

Culture History

The project area is located on Pueblo Reservation land in the immediate vicinity of the Tamaya Village. As early as 1709, and since that time, the Pueblo has been actively re-acquiring land within the area of traditional use including the agricultural area along the Rio Grande known as Ranchiit'u (also known as El Ranchito or Ranchitos; Bayer 1994:77-84, 162-164, 203-221). The Ranchiit'u is within the Northern Rio Grande Region as archaeologically defined by Wendorf and Reed (1955) (Rodgers 1979:16; Cordell 1997:197; Penner *et al*. 2001a). The culture history of the Southwest and the project area has been chronologically generalized into several classification schemes that utilize noticeable changes in the cultural record, as seen in temporal and spatial similarities and differences, to assist in the explanation and interpretation of the cultural record. The primary Periods and their approximate dates are as follows:

PaleoIndian	ca. 13,500 B.P. - 9,500 B.P.
Archaic	ca. 9,500 B.P. - 2,000 B.P.
Puebloan	ca. 1 - 1540
Historic	1540 - Present.

These Periods are further subdivided to describe specific regional and local variations in the archaeological record (Penner *et al*. 2001a:10-14; Bayer 1994:247-264; Cordell 1997: 197-199, 1984: 106-107, 1979: 131-151; Rodgers 1979:16-24; Simmons *et al.* 1989:23-26, 32-35; Stuart and Gauthier 1984: 44-54).

The earliest cultural time periods represented in the archaeological record are the PaleoIndian and Archaic Periods that are typically identified by the presence of morphologically diagnostic projectile points. Judge (1973) has provided evidence for PaleoIndian Period human use of the central Rio Grande Valley. In New Mexico, the chronology defined by Cynthia Irwin-Williams (1973) for the Arroyo Cuervo region in northwestern New Mexico has been the most widely utilized for the Archaic Period although Huckell (1996) has recently brought together documentation for the period in the Southwest. The end of the Archaic Period is difficult to define chronologically because the mobile hunting and gathering lifestyle continued in many areas into the Historic Period.

Generally in the Rio Grande Valley, the prehistoric Puebloan Period is characterized by increasing population sizes, movement of people across the landscape, more sedentism and aggregation of people into larger villages, an increasing dependence on agriculture, and a more intense and efficient use of the environment. Small pithouse villages, larger above-ground roomblocks, and huge adobe pueblos with scattered fieldhouses are common. There is an increasing use of water control methods and local and long distance trade is important.
In the Tamaya/Ranchiit'u area, the chronological Puebloan cultural sequence includes the Rio Grande Developmental (ca. 660-1200), the Coalition period (ca. 1200-1325), the Rio Grande Classic (ca. 1325-1600), and the Historic period dating from about 1600 to present (Cordell 1997:197-199, 359-360; Rodgers 1979:18-24; Murrell and Leckman 2011). The Pueblo of Santa Ana people, who call themselves "Tamayame" and their Pueblo "Tamaya," are one of several

Keresan speaking groups that live in the middle Rio Grande area. Archaeological evidence supports their ancestral creation and migration stories (Strong 1979:404-405; Bayer 1994:1-11).

The Historic Period in the Southwest is initiated with Coronado's 1540 Spanish *entrada*. In 1598 Don Juan de Oñate arrived in the Rio Grande Valley, claiming the region for the King of Spain and began his colonization and subjugation efforts (Strong 1979:405; Bayer 1994:34-35). After years of oppression, exploitation, desecration, spiritual persecution and disease in addition to drought and resulting famine, the Tamayame actively joined with other Rio Grande Pueblos to expel the Spaniards in what has been called the Pueblo Revolt of 1680 (Strong 1979:405; Bayer 1994:63-66; Simmons 1988:65-72). In the aftermath, and as a result of the effects of the Revolt and several subsequent Spanish forays in which numerous Puebloan villages, including those of the Santa Ana people were attacked and burned, the Tamayame affiliated themselves with the Spaniards after de Vargas' Reconquest (Strong 1979:405; Bayer 1994:66-72). The Tamayame resettled in an area of traditional use, building homes and a Spanish church at Tamaya (Bayer 1994:72; Harrington 1916:519-521, Map 29, Plate 20b).

At the end of the Seventeenth Century, the Puebloan tribes received grants from the Spaniards for the land around their Pueblos. However, these areas did not include all of the areas that they had traditionally used and, located in such an arid and marginal environment as that of the Southwest, were generally not large enough to sufficiently support the Pueblo. The Tamayame soon recognized that land and water would increasingly become scarce with the influx and rapid population growth of the colonizers. In order to reestablish their claims to the areas west of Tamaya Village, Ranchiit'u, and other nearby areas, the Tamayame, in 1709, started purchasing some of the traditional use lands back (Strong 1979:398, 405; Bayer 1994:73-95; White 1942:27-28). Eventually, the majority of the Tamayame moved to, and today continue to live in, the Ranchiit'u area (Strong 1979:398, 405; Bayer 1994:223; Harrington 1916:519-521). Encroachment, trespass, fraudulent claims, and schemes continually pressed the Tamayame for their land (Bayer 1994).

In 1821 Mexico won its independence from Spain and in 1846 the United States invaded and took the Southwest. Through most of the Historic Period, the Tamayame and their neighbors farmed along the streams and rivers, grazed livestock in the upland areas, and utilized regional timber resources, and a few tribal members did some mining. Congress confirmed the land claims of the Santa Anas in 1869, and a patent for the land was issued in 1883 (White 1942:74; USGAO 2001:28). Although there was no specific date found for the Pueblo's original Spanish Colonial community land grant, Congress confirmed and patented a total of 17,360.56 acres, and Congress confirmed the El Ranchito grant in 1897 and approved the patent for 4,250.63 acres in 1909 (USGAO 2001: 17-18, 26-27, 30). The Pueblo also holds lands or portions thereof within the Rancho of Santa Ana and the Ojo del Espiritu Santo grants (USGAO 2001: 26-27, 30-31, 33-34). However, it was not until the *United States v. Sandoval*, 231 U.S. 28 (1913) case was settled in 1913 that most of the land problems were abated; but not ended (White 1942:74-75; Bayer 1994:154-167; Dozier 1970:107-108).

In the 1880s, the arrival of Atchison, Topeka, and Santa Fe (AT&SF) Railroad brought a huge and rapid influx of new residents to New Mexico (Bayer 1994:173-174; Myrick 1990). In the 1920s and 1930s, the railroads along with Fred Harvey were also bolstering Southwest tourism and helped raise philanthropist's concerns for the Pueblo peoples which instituted a Native American arts and crafts trade (Bayer 1994:173-174, 225-228; Simmons 1988:172-175; Myrick 1990:34-39). Railroad construction was almost furious in its growth as they pressed to provide access to the West's natural resources (Myrick 1990:xiii-xviii).

In 1880, the AT&SF Railroad's main line tracks were laid through Ranchiit'u as the line was pushed southward to Albuquerque and Belen (Bayer 1994:173). The construction of branch lines soon followed. The Santa Fe Northwestern Railway (SFNW) was one such branch line that, in order to reach timber resources in the Cañon de San Diego Grant and the Jemez Mountains and coal deposits further west, crossed not only the Ranchiit'u, but also the Spanish Pueblo Grant at Tamaya, and the Pueblo's traditional lands in the Ojo de Espiritu Santo Grant, as well as the Spanish Pueblo Grants at Zia and Jemez Pueblos (Bayer 1994:157-164, 212-213; Glover 1990:2-9). Initial surveys for the SFNW route to the Jemez Mountains were conducted in 1921; a construction contract was awarded on October 16, 1922. Work on the roadbed in Bernalillo began on November 8, 1922 (Glover 1990:4-7). Work on the massive, wooden Rio Grande trestle was completed early in 1923 (Glover 1990:6-7). The rights-of-way agreements with the Pueblos of Santa Ana, Zia, and Jemez were signed in March, 1926. They were legally questioned, and were reapproved on July 10, 1928 (Glover 1990:8-9; Bayer 1994:212). The SFNW ceased operations and the railroad was abandoned in 1941; today, all that remains in the Ranchiit'u area are portions of the old railroad grade bed and cut-off pieces of the old Rio Grande trestle pilings (Glover 1990:42, 57; see Photograph No. 1 in Everhart 2001).

Formation of the Middle Rio Grande Conservancy District (MRGCD) was approved in 1924 and operations began the next year to provide facilities for the efficient delivery of irrigation water, to prevent flood hazards and provide flood protection measures, to regulate the Rio Grande channel and stream flows, and to provide drains to reclaim land that had become saturated and saline from high groundwater levels (Ackerly *et al*. 1997:20-21). The development and rehabilitation work conducted by the MRGCD had impacts to the Ranchiit'u area in the form of rights-of-way for flood control structures, ditches and drains; however, these structures have also provided flood control and made irrigation of the Ranchiit'u land easier for the Tamayame (Bayer 1994:240-244). To assist in the prevention of flood hazards in the Rio Grande valley and to provide flood protection measures, USACE has also constructed flood protection structures on Pueblo Reservation lands, such as the dam (Rodgers 1979; Berry and Lewis 1997; Dodge and Santillanes 2007).

DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
4101 JEFFERSON PLAZA NE
ALBUQUERQUE NM 87109-3435

March 11, 2013

Planning, Project and Program Management Division
Planning Branch
Environmental Resources Section

Re: NM HPD Consultation Nos. 60531 and 68452

Tribal Historic Preservation Officer
Pueblo of Santa Ana
2 Dove Road
Santa Ana Pueblo, New Mexico 87004

Dear Tribal Historic Preservation Officer:

Pursuant to 36 CFR Part 800, the U.S. Army Corps of Engineers (Corps), Albuquerque District, in consultation with the Pueblo of Santa Ana (Pueblo), is submitting documentation to your office for Section 106 consultation purposes relating to two projects: (1), the Jemez River Weir and Access Road Project, and (2), the Tamaya Drainage Project; both located on lands within the Pueblo of Santa Ana Reservation, Sandoval County, New Mexico. The Corps is the lead Federal agency for Section 106 purposes for both, and we seek your concurrence with our determinations of eligibility and effect for the projects described here, one of which was constructed before Section 106 consultation was complete due to circumstances described below. In addition to documents relating to these two projects, also enclosed here is background material including a letter from the Corps to the New Mexico State Historic Preservation Office (HPD/SHPO) regarding the partial and complete evacuation of reservoir water at Jemez Canyon Dam in 2000 (HPD Consultation Log 60531) and 2001, respectively (Enclosure 1), and associated mitigation projects to protect natural and cultural resources. Also enclosed for your records is a summary report prepared by the Corps describing the overall chronology of these projects and associated reports, including those described herein (Enclosure 2).

No. 1. The Jemez River Weir and Access Road Project. Section 106 consultation for the Weir and Access Road project was originally initiated in 2003 with the SHPO, prior to the establishment of the Tribal Historic Preservation Officer (THPO) position at the Pueblo. After earlier consultation with SHPO, the Corps is now resuming Section 106 consultation with your office. For your convenience and for your records, a copy of our consultation letter (dated July 21, 2003) and the SHPO response (dated August 6, 2003; HPD Consultation Log 68452) are enclosed (Enclosures 3 and 4). At that time and subsequent to a SHPO and Corps meeting to discuss the Jemez Reservoir projects held on August 6, 2003, the SHPO concurred with a "conditional no adverse effect" for the Weir and Access Road project pending submittal of additional documentation. Following this initial consultation and while awaiting cultural resources documentation being prepared by the Pueblo's archaeological contractor, Earth Analytic, Inc., the Corps deemed (in consultation with the Pueblo) that immediate action was needed in order to prevent substantial erosion and other negative effects from reservoir evacuation; therefore, the project was constructed before Section 106 consultation with SHPO was complete. At that point, this and several other Pueblo of Santa Ana archaeological survey projects were placed on hold for several years.

Pursuant to 36 CFR 800.4, the Area of Potential Effects (APE) for the Jemez Weir and Access Road Project were 70 acres surveyed by Earth Analytic (Enclosure 5). The weir project was constructed across the Jemez River at the upstream end of the Jemez Canyon Dam and Reservoir sediment pool to prevent erosion from proceeding up the Rio Jemez. As directed by the Pueblo, the project provided improvements to the existing Access Road that included the placement of gravel over the portions of the four archaeological sites located within the existing roadway. Improvements to the existing Access Road did not include straightening of sharp corners and grading to level high-low areas as originally planned.

In the interim, Earth Analytic submitted documentation to the Pueblo for transmittal to the Corps on archaeological surveys and survey-level limited testing relating to this project, in partial fulfillment of SHPO's request for more information; copies of site forms and relevant correspondence are included here (Enclosure 6). In addition, the SHPO had also requested copies of the testing plan and the results on testing for both this project and the Tamaya Stormwater Drainage Project (described in section No. 2, below; project locations for the Jemez Weir and Access Road and the Tamaya Drainage Projects are shown in Enclosure 5). These documents are enclosed in a single bound volume entitled **Compilation of Letter Reports: The Jemez River Weir and Tamaya Storm Water Drainage System Projects** by Earth Analytic (Dorshow 2002a, b, c, and d); these four reports include the Scope of Work, a Mid-Point Summary of Findings, a Brief Project Summary of Findings, and An End of Project Summary of Findings, all dated 2002 (Enclosure 7).

The 2003 Earth Analytic report submitted to the SHPO is entitled **A Cultural Resources Assessment of Approximately 70 Acres for the Weir and Access Road at the Pueblo of Santa Ana, Sandoval County, New Mexico** (Penner, Duncan, Byszewski, and Dorshow 2003 [Earth Analytic Report No. EA66.01; NMCRIS No. 79981]; (Enclosure 8). Prior to the survey, searches of the State Register of Cultural Properties and National Register of Historic Places found that there are no known listed historic properties reported to occur within or immediately adjacent to the project area. During project planning, consultation with Pueblo of Santa Ana tribal representatives indicated that no traditional cultural properties would be affected by the project.

In keeping with the Corps' 2003 SHPO consultation letter (HPD Consultation Log 68452), we seek your concurrence with our determination of "no adverse effect to historic properties" for the construction of the Jemez Weir, and the placement of gravel over portions of the four archaeological sites and the use of the two-track Access Road. Earth Analytic recommended that New Mexico Laboratory of Anthropology (LA) sites LA 137046, LA 137047, LA 137049, and LA 137050 are eligible for inclusion to both the State and National

Registers and that LA 137048 was potentially eligible. The Corps agrees with Earth Analytic's eligibility recommendations for these sites, and we ask for your concurrence in these determinations, recognizing that such concurrence is after the fact and that the project has already been constructed.

During engineering design work on the Jemez Weir Access Road, it was determined that, in several locations, eroding arroyos may soon threaten the road, and therefore erosion control measures should be planned for. Earth Analytic conducted a cultural resources survey on April 16, 2003, covering a total of 20.7 hectares (51 acres). The cultural resources report (Enclosure 9) is entitled **Cultural Resources Assessment of Proposed Erosion Control Measures for the 2003 Rio Jemez Weir Access Road Project, An Addendum to: A Cultural Resources Assessment of Approximately 70 Acres for the Weir and Access Road at the Pueblo of Santa Ana, Sandoval County, New Mexico** (Byszewski 2003 [Earth Analytic Report EA97; NMCRIS No. 83217]). This report was also submitted to the SHPO. Subsequent to the survey, none of the proposed erosion control structures were constructed. During the survey, one archaeological site was discovered, LA 139126. Earth Analytic recommended that LA 139126 was potentially eligible for nomination to the State and National Registers. The Corps agrees that the site is potentially eligible, and we seek your concurrence in this determination.

No. 2. The Tamaya Drainage Project. With this letter, the Corps is initiating Section 106 consultation with your office regarding the proposed Tamaya Drainage Project. The Corps has been working intensively with the Pueblo's Department of Natural Resources and the Tribal Council to coordinate planning efforts and project-related studies. The proposed Tamaya Drainage Project is located immediately adjacent to the Pueblo of Santa Ana's historic village of Tamaya. Tamaya has been documented as LA 8975 and was listed on the State (HPD SR No. 165) and National Registers (NR No. 74001204) on March 13, 1970 and November 1, 1974, respectively. The Corps constructed the Santa Ana Pueblo Protection Works (levee) to protect Tamaya from the threat of flooding in the early 1950s. Subsequent to the construction of the flood protection levee, ponding developed on the landward side of the levee adjacent to the village. The ponding resulted in several problems, including the nuisance of seasonal pests such as mosquitos and other insects, odors resulting from water-level fluctuations in the ponding area, ponded water located below the effective drainage capability of the existing pumping station, and noise resulting from the existing pumping system (Enclosure 10). The proposed Tamaya Drainage Project includes placement of earthen fill material and the installation of a new pumping system on the landward side of the levee. The project is designed to reduce levels of temporary water impoundment from seepage and local interior drainage. In reducing the ponding problem, the project will also reduce the nuisance problems with pests, odors, and noise. The current ponding area does constitute a wetland that would be lost due to this project; in order to mitigate the loss of the wetland, the Project will also construct a wetland at a mitigation site located downstream of the village, near the Jemez Weir (see Enclosure 5).

Several areas of tribal concern including traditional cultural properties are known to occur in the immediate vicinity of the proposed Tamaya construction area; these would be avoided during construction. Construction vehicles would be confined to the planned travel route that primarily uses the existing levee top, and would be limited to low travel speeds, thereby reducing noise and ground vibration during construction. Construction activities and the related noise would be of short duration. Hauling of excavated earthen materials from the Tamaya ponding area for placement at the wetland mitigation site located near the Jemez Weir or for stockpiling, or hauling existing earthen fill materials stockpiled near Jemez Dam for placement at the Tamaya ponding area would result in no historic properties affected. Construction of the project would result in a positive benefit to the Pueblo's traditional use of the Tamaya village.

There are no historic properties in the vicinity of the proposed wetland mitigation site, but as noted above, portions of four archaeological sites are located within the Jemez Weir Access Road. The Corps is of the opinion that use of the access road to the proposed wetland mitigation site would result in "no adverse effect to historic properties." There would be no effect to other historic properties or traditional cultural properties known to occur on Pueblo of Santa Ana lands. The Corps is therefore of the opinion that construction of the proposed Tamaya Drainage Project would result in "no adverse effect to historic properties."

The Pueblo contracted with Earth Analytic to perform the cultural resources survey and conduct survey-level, limited archaeological testing for the Tamaya Drainage Project. The results of the survey and limited testing are presented in the 2003 Earth Analytic report entitled **A Cultural Resources Assessment of 479 Acres for the Proposed 2003 Tamaya Pueblo Pond Modification Project, Pueblo of Santa Ana Reservation, Sandoval County, New Mexico** (Penner et al. 2003b [Earth Analytic Research Report EA66.02; NMCRIS No. 80680], Enclosure 11). The Penner et al. (2003b) survey covered the eastern portion of the ancestral Tamaya village, on the landward side of the levee, and a significant area to the east of the Pueblo for a total of 194 hectares (479 acres). The survey area was defined as Area A (Enclosure 12). Two archaeological sites, LA 137629 and LA 137630, were discovered east of the village on gravel terraces above the Jemez River floodplain. No work will be conducted in the vicinity of these sites. Earth Analytic recommended that the newly recorded sites LA 137629 and LA 137630 are eligible for inclusion to both the State and National Registers. The Corps agrees that LA 137629 and LA 137630 are eligible, and we seek your concurrence with this determination.

In consultation with the Pueblo, it was agreed that survey-level, limited archaeological testing would be conducted in a smaller area along the eastern margins of the village, on the landward side of the levee (Area B; Enclosure 12). In order to define and limit the proposed construction area and avoid impacts to cultural materials, this testing sought to determine the presence or absence of cultural deposits, and the nature and extent of any subsurface deposits and their proximity to the existing flood protection levee. As determined from historic aerial photography, large portions of Area B were historically within the Jemez River floodplain or within the channel of an unnamed arroyo that flowed immediately east of the village prior to construction of the flood control levee in the early 1950s. Prior to the Corps Section 106 consultation with the SHPO on the Jemez Weir and

Access Road Project and preparation of Earth Analytic's Compilation Reports for the survey and limited testing also proposed at Tamaya, Earth Analytic proceeded and conducted the survey and survey-level limited testing between August and October, 2002. Area B, where limited testing occurred, is approximately 4.5 hectares (11.3 acres). Pursuant to 36 CFR 800.4, the Area of Potential Effects (APE) for the Tamaya Drainage Project is a portion of the 11.3 acres of Area B.

In consultation with the Pueblo, planning and analysis of the alternatives for the proposed Tamaya Drainage Project have recently been defined and are presented in the project's draft Environmental Assessment currently available for public review at the following web address:

http://www.spa.usace.army.mil/Missions/Environmental/EnvironmentalComplianceDocuments/EnvironmentalAssessmentsFONSI.aspx .

Pursuant to 36 CFR 800.2, consulting parties in the Section 106 process for the Jemez River Weir and Access Road Project and the Tamaya Drainage Project include the Corps and the your office. Since both projects are located entirely within Pueblo lands, scoping letters were not sent to other tribes. Since Section 106 consultation was initiated with the SHPO, the Corps is recommending that copies of this THPO letter and the associated documentation be submitted to the SHPO for their records. The SHPO mailing address is:

Dr. Jeff Pappas
State Historic Preservation Officer
Historic Preservation Division
Bataan Memorial Building
407 Galisteo Street, Suite 236
Santa Fe, New Mexico 87501

In summary, for the Jemez River Weir and Access Road Project, the Corps is seeking your concurrence with our determinations of "no adverse effect to historic properties" for the 2003 construction of the Jemez Weir and the placement of gravel over portions of four archaeological sites and the use of the Access Road. The Corps is also seeking your concurrence with the eligibility determinations for the six archaeological sites; that sites LA 137046, LA 137047, LA 137049, and LA 137050 are eligible for nomination to both the State and National Registers and that LA 137048 and LA 139126 are potentially eligible.

For the Tamaya Drainage Project, the Corps is seeking your concurrence with our determination of "no adverse effect to historic properties" for the construction of (1) the project that would excavate wetland materials from and place earthen materials in the existing ponded area located on the landward side of the Tamaya flood control levee and adjacent to the historic village; and (2) the construction of a wetland mitigation site near the Jemez Weir and use of the Access Road noted above. The Corps is also seeking your concurrence with the eligibility determinations for two archaeological sites; that sites LA

137629 and LA 137630 are both eligible for nomination to both the State and National Registers.

Section 106 consultation regarding the other projects noted in Enclosure 2 will be forthcoming, pending receipt of additional documentation from Earth Analytic. If you have any questions or require additional information regarding the Jemez River Weir and Access Road Project or the Tamaya Drainage Project, please contact Mr. Gregory D. Everhart, archaeologist at (505) 342-3352, or me at (505) 342-3281. You may also provide comments to the above address.

Sincerely,

Julie Alcon
Chief, Environmental Resources Section

March 28th 2013
Date

I CONCUR
PUEBLO OF SANTA ANA,
Acting TRIBAL HISTORIC
PRESERVATION OFFICER

Cf w/Enclosures:

Dr. Bruce Harrill
Regional Archaeologist
U.S. Bureau of Indian Affairs
Southwest Regional Office
Post Office Box 26567
Albuquerque, New Mexico 87125-6567

Appendix B
Clean Water Act Section 404 Compliance

This Appendix contains technical and supplementary information documenting compliance with Section 404 of the Clean Water Act.

(1) Wetland Mitigation Plan
(2) Wetland Delineation
(3) 404(b)(1) Analysis
(4) Water Quality Certification

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Mitigation Plan for the
Tamaya Drainage Project,
Sandoval County, New Mexico

Prepared by
U.S. Army Corps of Engineers
Albuquerque District
4101 Jefferson Plaza NE
Albuquerque, New Mexico 87109

April, 2012

US Army Corps
of Engineers®
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Distribution

This Mitigation Plan is being distributed as part of the Implementation Report with Integrated Environmental Assessment (IR/EA) for the Tamaya Drainage Project in compliance with the National Environmental Policy Act (NEPA). The complete Distribution List appears in the IR/EA. This Mitigation Plan has been prepared in coordination and consultation with the Pueblo of Santa Ana, and distributed as follows:

Pueblo of Santa Ana Natural Resources Department

Pueblo of Santa Ana Tribal Historic Preservation Office

Pueblo of Santa Ana Office of the Governor

USACE, Albuquerque District Regulatory Program

Bureau of Indian Affairs

USFWS, New Mexico Ecological Services Field Office

USEPA

USDA NRCS

Table of Contents

1. Brief description of overall project:

The Tamaya Drainage Project is proposed by the U.S. Army Corps of Engineers (Corps), Albuquerque District, to provide a solution to the ponding of water within the Santa Ana Pueblo levee adjacent to the historic village of Tamaya. The proposed drainage project would fill the ponded area, which has developed into a wetland over the years. The purpose of this mitigation plan is to identify a mitigation alternative for the filled wetland that is technically feasible, economically practicable, environmentally sound, and acceptable to the Pueblo. The Pueblo of Santa Ana supports the proposed drainage project and this proposed mitigation plan to eliminate the nuisance and hazard of standing water adjacent to Tamaya Village and to compensate for unavoidable loss of aquatic resources when the pond is filled.

1.1. History:

During the design of Jemez Canyon Dam it was determined that Tamaya Village would be vulnerable to inundation during a large flood event or periods of high pool stages in Jemez Canyon Reservoir. The Santa Ana Pueblo levee was constructed around the village to prevent potential flooding. Since the levee was completed in 1954, seepage and elevated groundwater levels on the landward side of the levee have created a permanent wetland (pond) in close proximity to the village. Since the levee acts as a barrier, the pond does not drain naturally. The pond is considered to be an undesirable feature by the Pueblo due to stagnant water, unpleasant smells associated with anaerobic conditions, breeding mosquitoes, and the presence of a potential safety hazard adjacent to the historic village. An existing pump system is used as needed to drain the pond to prevent water from encroaching on structures within the village, during flood events, or at the request of the Pueblo. Also at the request of the Pueblo, spraying to control mosquitoes is done before important cultural events are held at Tamaya Village. The Pueblo has long desired a permanent and lower-maintenance solution to these issues. The Corps proposes to fill the pond using native material derived from either the excavated mitigation area, or sediments previously removed from the reservoir. The filled pond area would be planted with native trees and shrubs to provide riparian habitat and an aesthetically pleasing area adjacent to the village.

1.2. Description of Mitigation Area:

A. Wetland Creation

The proposed compensatory mitigation would have two components, wetland creation and preservation. The first component wound entail the creation of a new 1.65-acre wetland near the Jemez weir, 1.75 miles downstream from Tamaya Village and pond (the impact site). Figure 1 shows the spatial relationship of these areas. The created wetland mitigation site would be located 500 feet upstream of the Jemez River weir and 100 feet from the channel in an area currently dominated by a monoculture of decadent saltcedar. The mitigation wetland would be created by excavating approximately 4-10 feet to reach groundwater, and 3 feet below the water table to obtain a depth of 3 feet in the deepest part of the wetland. Groundwater would supply permanent water. The created wetland would be planted with species that occur in the impact area to create a similar plant community, with the addition of other species as suitable and available. Because of its location far from developed areas, it would provide wildlife habitat that is well connected to both the riparian corridor and the adjacent floodplain and uplands. The sides of the excavation away from the river would be sloped gently (10:1) to allow easy access to water for all types of wildlife. Because the Jemez River is not perennial in this reach, the permanent water source would be of great value to wildlife.

B. Herbaceous Wetland Preservation

The second component of the proposed mitigation is the preservation of 13.2 acres of wet sedge meadow on the right bank of the Jemez River, across the river from Tamaya Village. The sedge meadow is an emergent wetland community with saturated soils at a shallow depth (2" to 9" to groundwater on 3/23/12). Preservation would entail control of any encroaching invasive species, particularly salt cedar, and agreement by the Pueblo to leave the meadow in its current state.

The herbaceous wetland plant communities that have been mapped at this location in the past include:

Pre-weir map (ca. 2003)

ID	Vegetation Type	Acres
0	cattail strip on right bank	2.4
2	wet (sedge) meadow	26.1
3	wet meadow- downstream 1	5.4
4	wet meadow- downstream 2	9.4
Total right bank herbaceous wetlands at or near current sedge meadow		**43.3**

2005 map by New Mexico Natural Heritage Program (NMNHP)

ID	NMNHP Class	Acres
2	Threesquare Bulrush-Inland Saltgrass	11.4
3	Threesquare Bulrush - Common Spikerush	6.1
5	Inland Saltgrass Monotype	3.2
6	Common Spikerush - Juncus - Yerba Mansa	23.5
13	Narrowleaf cattail	1.7
Total right bank herbaceous wetland at current sedge meadow		**45.9**

In March 2012, Corps biologists delineated a wet meadow of approximately 64 acres in this area (see Figure 1 and Figure 3). The 2003 and 2005 vegetation maps included a patch of saltcedar-inland saltgrass community in the area that is currently wet meadow. Saltcedar is no longer a dominant species at this location due to removal efforts by the Pueblo of Santa Ana. This accounts for much of the difference in size of the herbaceous wetlands at this site. However, it is also possible that aggradation and a local rise in water table have increased the wetland acreage here. The pre-weir map considered part of the current wet meadow as upland.

2. Objectives

The objectives of this wetland mitigation plan are:

A) to construct and establish a wetland of similar structure and function to the resource that will be lost, the Tamaya Village pond. The mitigation wetland would be in-kind (replacement of the same wetland type) and on-site (in the same segment of the Jemez River as the impact site).

B) to preserve the wet meadow in its current state, managing the meadow to keep saltcedar out and maintain it as herbaceous wetland.

The Tamaya drainage project impacts are not within the service area of an approved mitigation bank or in-lieu-fee program; therefore, appropriate credits are not available for purchase. Compensatory mitigation will be accomplished by the Corps as described in this plan.

2.1. Description of Impact Site (Tamaya Pond).

Wetland delineation of the pond was performed by Corps biologists and Regulatory personnel twice. In 2002, the wetland area was delineated as 2.5 acres. In July 2011, the wetland was delineated as 3.3 acres. Wetland determinations and field forms are provided in Enclosure A. The impact area can be classified under the Cowardin system as a Palustrine emergent wetland. Part of the area is permanently flooded; however, the area of water fluctuates due to water management (pumping) as described above. Plants observed at the pond are reported in Table 1. The central area of the wetland is a cattail (*Typha*) community with a mix of cattail and approximately 40% open water. The wet edges and shallow water that ring the pond support bulrushes, spikerushes, Baltic rush, and yerba mansa. Wetland functions of the pond, as described in the Mitigation Ratio Checklist (Enclosure B) include surface water storage, dissipation of energy from runoff, cycling of nutrients, removal of elements and compounds, retention of particulates, and maintenance of plant and animal communities.

2.2. Mitigation Ratio

A mitigation ratio of 1:1 for the constructed wetland and 8:1 for the preservation of the wet meadow was derived using the Corps, South Pacific Division Regulatory Program checklist (Enclosure B). Using this ratio and mitigating for half the acreage with each method, the required mitigation area for the 3.3 acre impact site is a 1.65-acre constructed wetland plus 13.2 acres of wet meadow preserved. Table 2 summarizes the characteristics of the impact and mitigation areas.

2.3. Description of Mitigation Site

The mitigation site footprint has been planned to remove invasive saltcedar and to avoid impact to native cottonwoods. The shape of the saltcedar area, the need to intercept groundwater within a practical excavation depth, and the technical requirements of keeping a safe distance from the river channel and the weir resulted in an irregular area being outlined for the mitigation. (see Figure 2). Groundwater hydrology was investigated and mapped in the project area to guide the development of this mitigation plan.

Prior to selection of the recommended mitigation area, several other mitigation alternatives were considered and rejected due to unsuitable depth to groundwater, technical infeasibility, or prohibitive expense. In-kind mitigation alternatives considered but rejected included: constructing an upland wildlife pond with pumped groundwater; re-excavating the existing dry swale at the weir; or establishing wetlands on the Rio Grande (off-site). A mitigation approach relying exclusively on wetland creation was proposed but rejected because the cost of the excavation required for a wetland this large would be prohibitive. An out-of-kind alternative, rehabilitation of areas of the wet meadow that still contain invasive saltcedar, was rejected due to its large mitigation ratio, which would have required a project area larger than the available habitat. None of these alternatives were determined to be viable or cost-effective, per correspondence between the Corps and the Pueblo.

Table 1: Tamaya Pond plant species and indicator status

Scientific name	Common names	Origin	Wetland indicator status
Anemopsis californica	yerba mansa	Native	OBL
Typha domingensis	cattail	Native	OBL
Juncuc arcticus var. balticus	baltic rush	Native	OBL
Eleocharis sp	spikerush	Native	OBL
Schoenoplectus pungens	common threesquare bulrush	Native	OBL
Muhlenbergia asperifolia	scratchgrass/ alkali muhly	Native	FACW-
Hordeum jubatum	foxtail barley	Native	FACW-
Elaeagnus angustifolia	Russian olive	Introduced	FACW-
Populus deltoides ssp. wislizenii	Rio Grande cottonwood	Native	FACW-
Tamarix sp.	saltcedar/ tamarisk	Introduced	NI
Sphaerophysa salsula	Swainsonpea	Introduced	NI
Xanthium strumarium	cocklebur	Introduced	NI
Melilotus alba	white sweet clover	Introduced	FACU
Distichlis spicata	inland saltgrass	Native	FACW

Table 2: Sedge meadow plant species and indicator status

Distichlis spicata	inland saltgrass	Native	FAC
Eleocharis sp	spikerush	Native	OBL
Juncuc arcticus var. balticus	baltic rush	Native	FACW
Schoenoplectus pungens	common threesquare bulrush	Native	OBL
Typha sp	cattail	Native	OBL
Tamarix sp.	saltcedar/ tamarisk	Introduced	NI
Anemopsis californica	yerba mansa	Native	OBL
Triglochin maritima	Seaside arrowgrass	Native	OBL

Table 3: Impact and Mitigation Area Comparison

Site	Before (existing) or after (proposed)?	Area non-wetland WoUS	Area wetland WoUS	Buffer	Non-aquatic mitigation (acres)	Hydrologic regime/ source	Vegetation type	Habitat type	Mitigation type	Cowardin system and classification
Impact	Before	0	3.3 ac	n/a	n/a	Ground-water	Cattail-bulrush-	pond	-	Palustrine emergent
Creation	After	0	1.65 ac	n/a	n/a	Ground-water	Cattail-bulrush	pond	Establish-ment	Palustrine emergent
Preservation	After	0	64 ac; 13.2 ac used for mitigation	n/a	n/a	Ground-water	Spikerush-saltgrass-bulrush	Wet meadow	Preser-vation	Palustrine emergent

Figure 1: Location of impact and mitigation areas

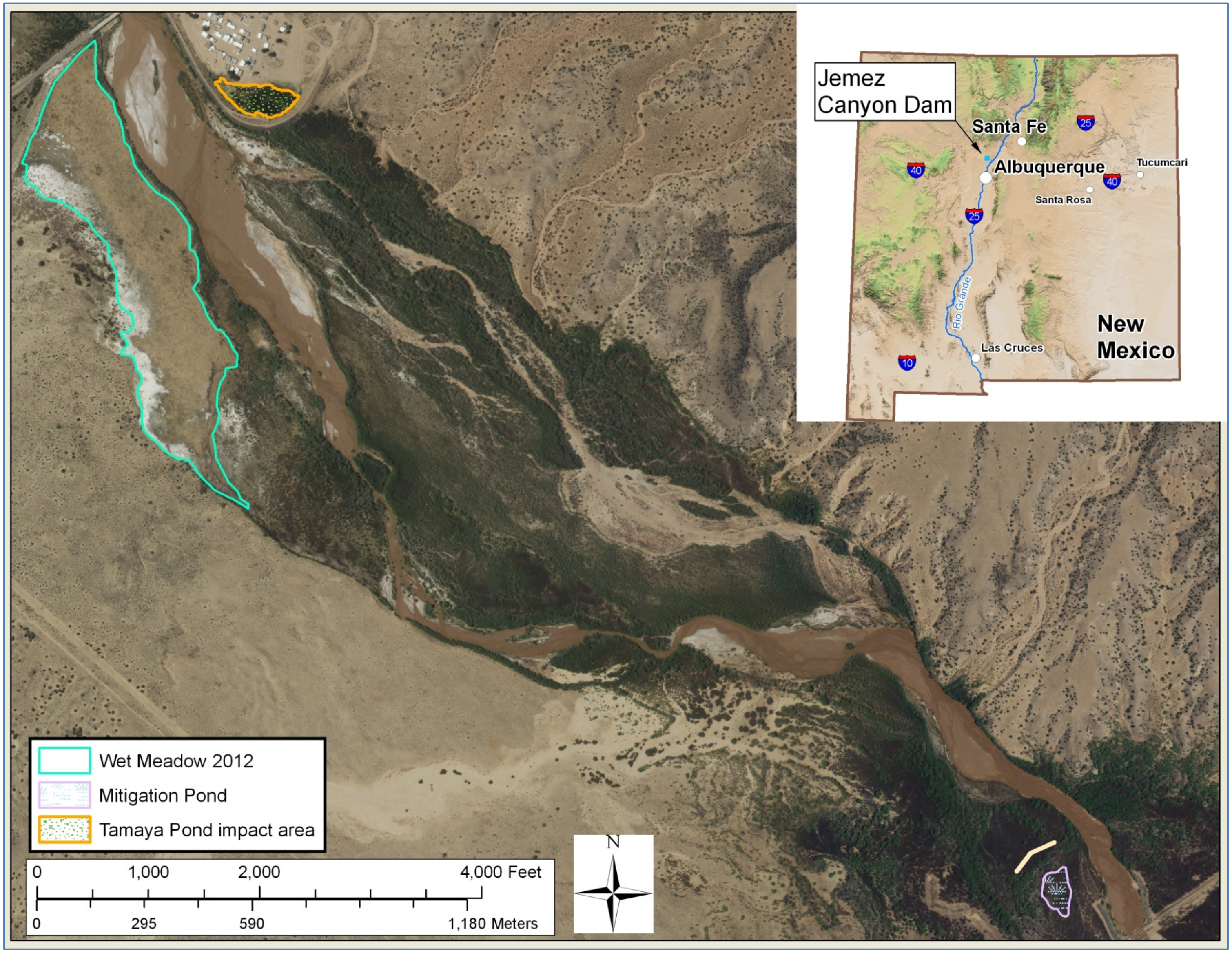


Figure 2: Created Wetland Mitigation area showing approximate depth to groundwater

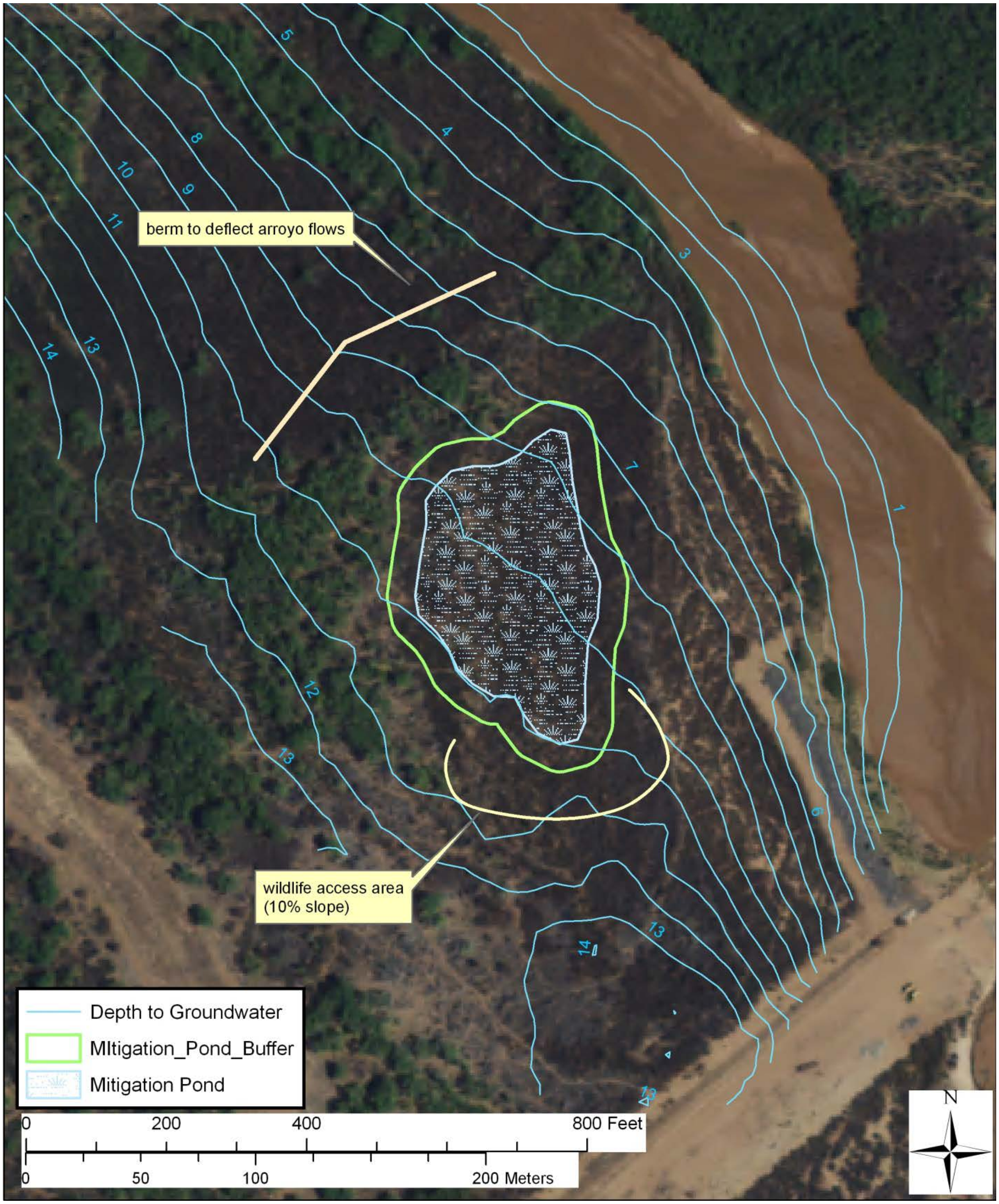
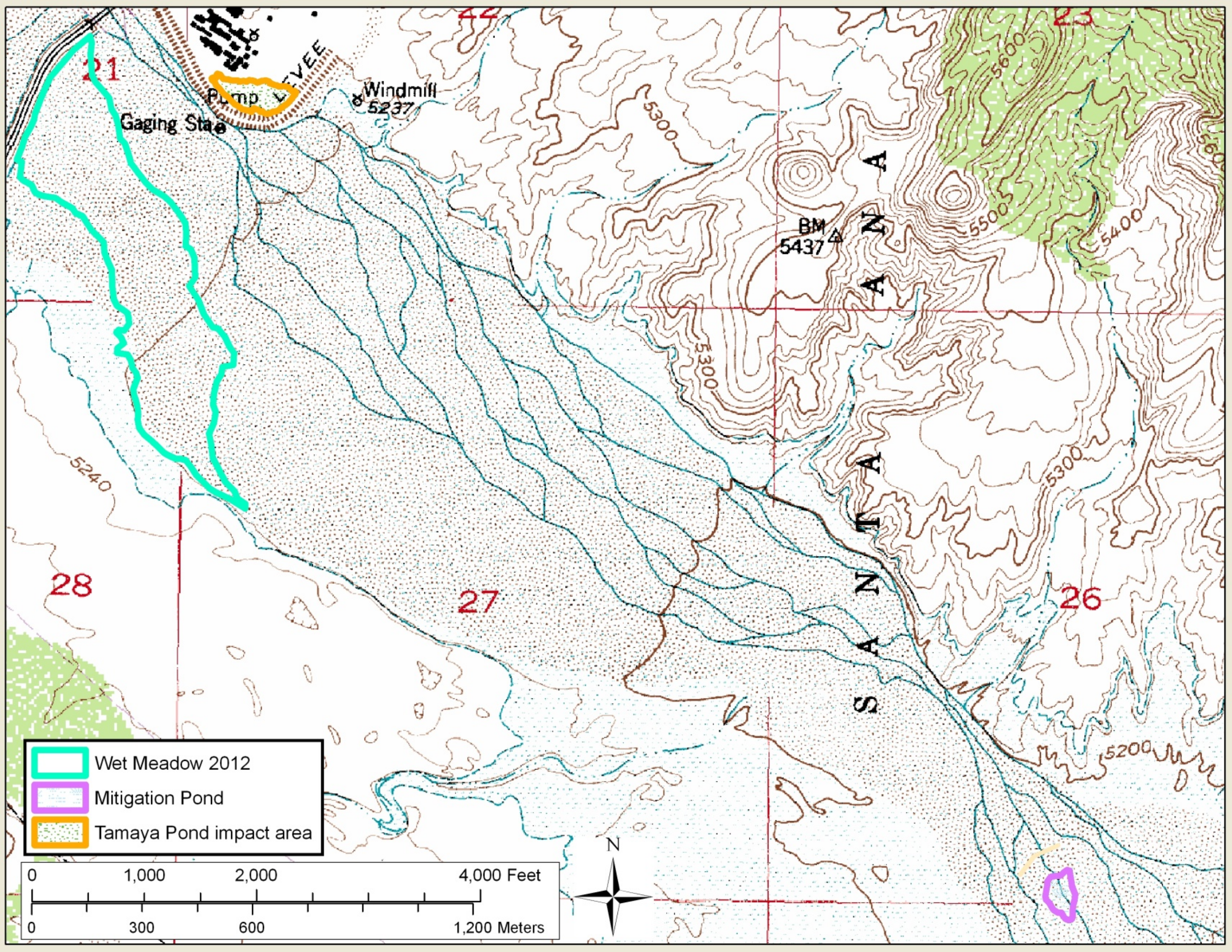


Figure 3: Wetland Preservation Mitigation area (wet meadow)

Figure 4: Impact and Mitigation Areas topographic map



3 Description of site selection criteria

3.1 Watershed Overview:

The proposed location of mitigation sites are along the Jemez River. The wetland creation site is 1.75 miles downstream from the impact site. This is considered an "on-site" mitigation because the mitigation site is in the same watershed and river segment as the impact site. The preservation area is directly across the river from Tamaya Village and the impact site. The watershed is primarily undeveloped. All land within the project area belongs to the Pueblo of Santa Ana. Tamaya Village land use is residential and ceremonial. The surrounding land is managed primarily for wildlife, with some grazing. At Zia Pueblo, approximately 9 river miles upstream from Tamaya Village, agricultural land use is important in the historic floodplain, although the surrounding upland landscape is still native vegetation. Agriculture is also an important land use in the small community of San Ysidro, located about five miles upstream from Zia Pueblo at the confluence of the Jemez River and the Rio Salado, and another five miles upstream at Jemez Pueblo. Apart from these small communities and their surrounding agricultural areas, the watershed is undeveloped or lightly developed.

Tamarisk or saltcedar (*Tamarix* sp.) is found throughout the lower Jemez River watershed from Jemez Pueblo downstream to the confluence with the Rio Grande. The saltcedar leaf beetle (*Diorhabda* sp.) has come into the area and is defoliating the saltcedar, beginning in 2011 at Jemez Canyon Reservoir and expanding its area in 2012 as far upstream as Jemez Pueblo. Tamarisk is present at both the impact and the mitigation areas; the mitigation wetland creation site is located in a large patch of defoliated tamarisk.

3.2 Landscape Setting and Position:

The following information is quoted from the Jemez Watershed Restoration Action Strategy (Jemez Watershed Group 2005). The Jemez River watershed is defined as Hydrologic Unit Area (HUA) #13020202. The contributing watershed to the Jemez River is approximately 1,034 square miles and the total length of the Jemez River is approximately 65 miles to its confluence with the Rio Grande. The watershed is dominated by both forest and rangeland on mostly USDA Forest Service, Tribal, and private land. The Jemez watershed is almost entirely in Sandoval County. It includes the villages of San Ysidro, Jemez Springs, unincorporated areas surrounding them, as well as the Pueblos of Zia, Jemez, and some Santa Ana tribal lands.

The Jemez River watershed divide is over 10,600 feet in elevation, dropping to about 5,100 feet at the Jemez Canyon Dam (Massong, 2008). Hydrologic characteristics of the watershed are described in detail in Section 2.4 of the Implementation Report and Environmental Assessment (IR/EA). Due to irrigation water withdrawals, the Jemez River below San Ysidro is intermittent. The primary ecological needs in the lower Jemez watershed are restoring native riparian species and providing permanent water sources for wildlife.

The mitigation site is within the riparian corridor and is located as close to the river channel as is technically feasible. Connectivity with the surrounding riparian habitat is therefore high. All lands surrounding the mitigation site are open space. Therefore, there is no need for a buffer.

3.3 Site-specific information:

All lands associated with the Jemez Canyon Dam and Reservoir Project (about 6,711 acres), including all lands within the project impact and mitigation areas, are held either in trust by the United States for the benefit and use of the Pueblo of Santa Ana, a federally recognized Native American Tribe, or by the Pueblo in restricted fee title. There is no potential for any change in ownership in the foreseeable future.

The Department of the Army and the Pueblo signed a Memorandum of Understanding in 1952 which established a perpetual right and privilege for the construction, operation, and maintenance of the Jemez Canyon Dam and Reservoir Project, including the Santa Ana Pueblo levee, which created the wetland at the impact site.

Hydrologic inputs for the created mitigation wetland will be from passive ‘daylighting’ of groundwater in the excavated mitigation area. A water right is not needed to implement the mitigation project. Significant hydrologic changes are not anticipated due to the stabilizing effect of the weir located 200 ft. downstream. Depth to groundwater has been determined for the mitigation project in a preliminary investigation (see Figure 2 and Groundwater Hydrology sections and Appendix D of IR/EA). During the design phase of the project, a more detailed groundwater investigation would be completed. Water levels in the wetland are expected to fluctuate with river stage. During unusually high flows, the Jemez River is known to overbank onto the floodplain, including the mitigation area.

Existing habitat in the footprint of the created wetland is a monoculture of tamarisk. Because of the density of tamarisk, there is essentially no understory. In 2011, the saltcedar leaf beetle (*Diorhabda* sp.) arrived in the area and defoliated the tamarisk completely. Defoliation was repeated in 2012. The standing defoliated or dead tamarisk presents a fire hazard and provides essentially no wildlife habitat. A few isolated mature cottonwoods are present within the footprint. Loss of these trees would be compensated by planting of cottonwoods and native riparian vegetation within the filled pond (impact site).

The preservation site is a groundwater-fed wet meadow. Vegetation along the upslope side is primarily saltgrass with increasing cover of Baltic rush and bulrush towards the river. This community grades into an almost pure stand of spikerush in the areas with shallowest groundwater. The saltgrass portion of the meadow has been cleared of saltcedar by the Pueblo. In March 2012, the soil was moist even in areas with prominent salt crust.

4 Baseline information

4.1 Historic and existing plant communities

The Tamaya Village pond (impact site) prior to construction of the Jemez Canyon Dam and Santa Ana Pueblo levee was part of the Jemez River floodplain and was sparsely vegetated or unvegetated due to the flashy, dynamic nature of the sand bed river. Since construction of the levee, the site has come to support a wetland plant community dominated by cattail (*Typha domingensis*) throughout the deeper, frequently-inundated areas. The cattails provide dense cover; open water covers approximately 25% of the site. A variety of wetland species grow on the margins of the pond in the transition from wetland to upland, including: saltgrass (*Distichlis* *spicata*), alkali muhly (*Muhlenbergia asperifolia*), Yerba mansa (*Anemopsis californica*), threesquare bulrush (*Schoenoplectuss pungens*.), spikerush (*Eleocharis* spp.), knotweed (*Polygonum* sp.), alkali yellowtops (*Flaveria campestris)*, annual rabbitfoot grass (non-native) (*Polypogon monspeliensis*) and foxtail barley (*Hordeum jubatum*). Woody species along the levee side of the pond included Russian olive (*Elaeagnus angustifolia*) and Tamarisk or saltcedar (*Tamarix* sp.), which are exotic, invasive species.

4.2 Historic and existing hydrology

The Corps modeled groundwater hydrology in the Tamaya Pond area as part of the drainage project planning process and determined that the pond is primarily fed by groundwater (USACE 2012). The impact site also collects surface runoff from Tamaya Village. The levee prevents this runoff from draining, so the water level is managed by pumping as needed. Details regarding site hydrology are presented in the Hydrology section of the IR/EA and Appendix C.

The mitigation site would also be groundwater-fed. The site is within the Jemez River floodplain, but not within the active channel or high-flow channel. The area is only rarely inundated by high flows. The last observed inundation of the swale was in August 2006. Surface and groundwater hydrology in the mitigation area are controlled by the weir, which constrains the channel, prevents incision, and supports the groundwater level. A shallow groundwater well is in place at the swale and groundwater hydrology at the swale has been monitored by the Pueblo.

Groundwater depth at the mitigation site was determined by boring, courtesy of the USGS (see Groundwater Hydrology, Appendix D). Due to difficulty in accessing the site, only four bore holes were completed. The Corps then modeled groundwater depth contours in the mitigation area. The mitigation wetland will be excavated three feet deeper than the groundwater surface to provide an area of open water. A more detailed groundwater investigation would be performed in the design phase of the project.

Soil conditions at the site are described in the IR/EA. Tamaya Village and most of the pond fall within the Harvey-Cascajo soil map unit. The levee and lower edge of the pond are mapped within Riverwash. Observations from the wetland delineation indicate that hydric soils have developed in the wetland. Harvey-Cascajo are not hydric soils and the soil map resolution is not detailed enough to show the hydric soil at the wetland. Riverwash soils are classified as hydric. Soils at the wet meadow are in the Trail loamy sand map unit. These soils are derived from eolian deposits over stream alluvium and are not classified as hydric; however, delineation identified hydric soils on site.

Field observations confirm that soils at both the impact and the mitigation sites are sandy and derived from river alluvium. The hydric soil at the existing pond developed from very similar soil to that found at the mitigation site, and is known to support a wetland. Therefore, we can be confident that the mitigation site will also develop hydric soil over time and will have no difficulty supporting a wetland plant community. The sandy alluvial soils at the mitigation site are appropriate for a groundwater-fed wetland

4.3 Geomorphology, Sediment and Geology

The Jemez River from above the weir upstream to its confluence with the Rio Salado has a broad sandy channel with a very shallow braided flow pattern. Review of historic aerial photos shows shifts in the active channel (within the floodplain); however, there has been little change in the active floodplain (see Figure 5 and Figure 6). As described in the IR/EA, the Jemez River channel near Tamaya Village is perched with a limited carrying capacity within the active channel. Conditions within the river channel near and upstream of the village indicate channel instabilities. Evaluation of sediment range data indicate that the mean active elevations have generally fluctuated both up and down. In the vicinity of the village, a modest aggradational trend is suggested at one of the four rangelines examined. At the created wetland mitigation site, neither aggradation nor degradation is occurring because the weir maintains the current channel elevation.

A description of geology is included in the IR/EA. No formations are present which would limit restoration activities.

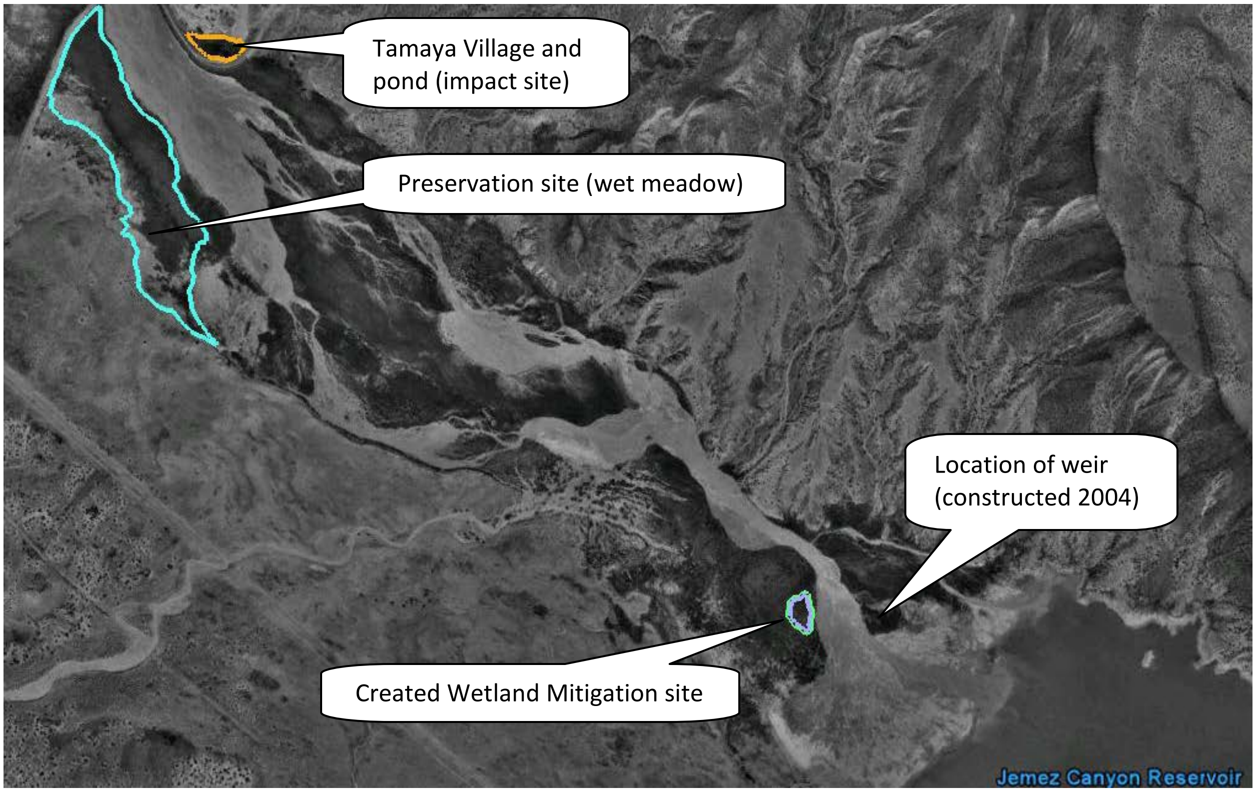


Figure 5: 1996 aerial photo of project area

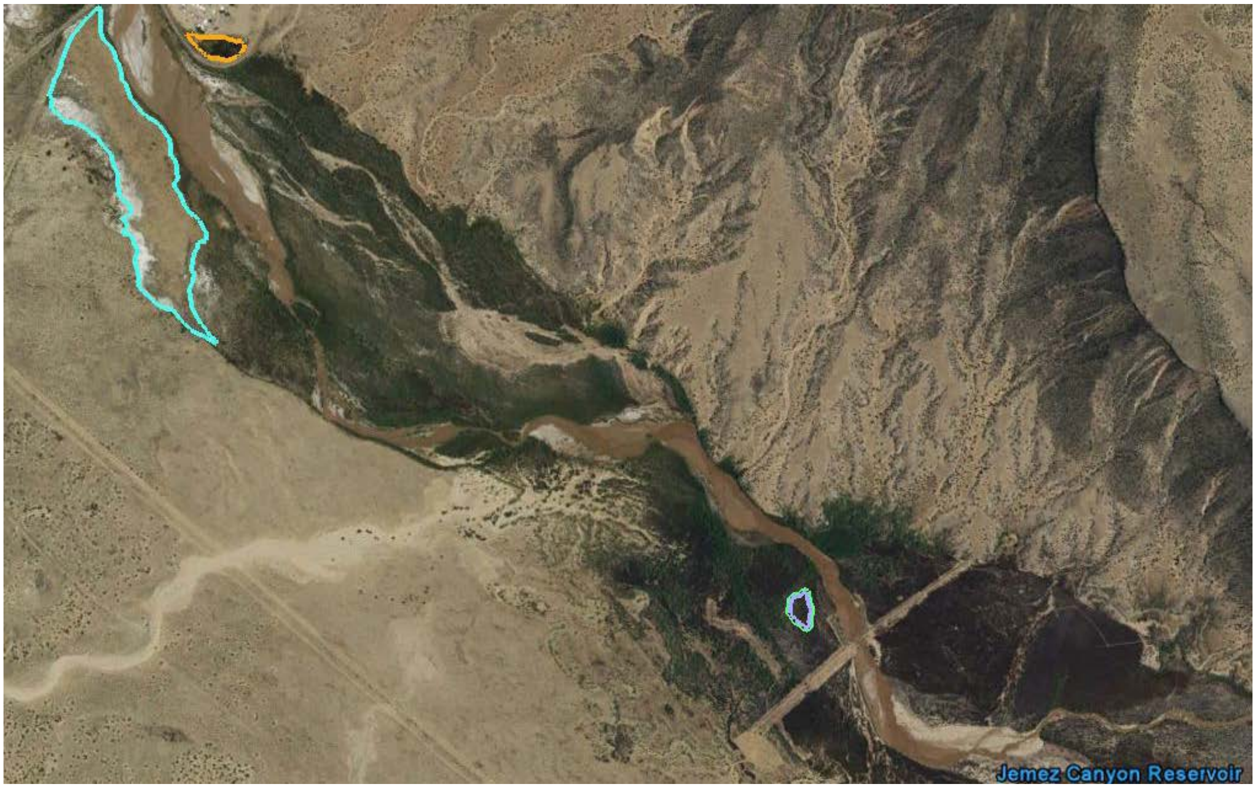


Figure 6: 2011 aerial photo of project area

4.4 Species of concern

As described in the IR/EA, there are no federal or state threatened or endangered species present at the mitigation site. The Southwestern Willow Flycatcher may occur in a variety of riparian habitat types along the Jemez River during spring or fall migration periods. However, suitable habitat is not present at Tamaya Pond. The Pueblo of Santa Ana conducts surveys of the riparian area and has documented areas that are used by flycatchers. The mitigation area falls outside the area that is visited by migrating flycatchers and does not contain suitable habitat due to the dense monoculture of salt cedar which has been defoliated by the *Diorhabda* beetle.

As stated in the IR/EA, surveys for the candidate species, New Mexico meadow jumping mouse, will be conducted during the design phase of the project. Jumping mouse is unlikely to occur at the pond but may occur at the preservation site. No construction would occur at the preservation site and there would be no effect to jumping mouse; however, a baseline would be needed to inform management of the preservation area. If this species is detected at the pond, consultation with the USFWS would be initiated.

5. Mitigation work plan

5.1 Construction Methods

The created wetland would be constructed by clearing and grubbing to remove the saltcedar and excavating to groundwater. The proposed grading and elevations would follow the design drawings as shown in Figure 7 Erosion control measures would include using geotextile on slopes steeper than 1:4 and planting and reseeding with native species. Because the project is over one acre in size, a Stormwater Pollution Prevention Plan (SWPPP) under the US Environmental Protection Agency's National Pollutant Discharge Elimination System (NPDES) permit program would be required.

5.2 Implementation Schedule

The project would take place in 2014, outside the nesting season, dependent on availability of funds. The mitigation wetland would be excavated prior to beginning the fill project.

The proposed sequence of work is as follows:

1- prepare access as needed;
2- remove saltcedar;
3- excavate;
4- stabilize slopes with geotextile as needed;
5- dewater pond (impact site);
6-dig and transplant material to mitigation site;
7- planting of nursery stock and seeding in and around mitigation site;
8- fill impact site
9- revegetate impact site

The project may be phased if sufficient funding is not allocated for the entire project. In this case, the mitigation wetland would be created prior to filling the impact site. .

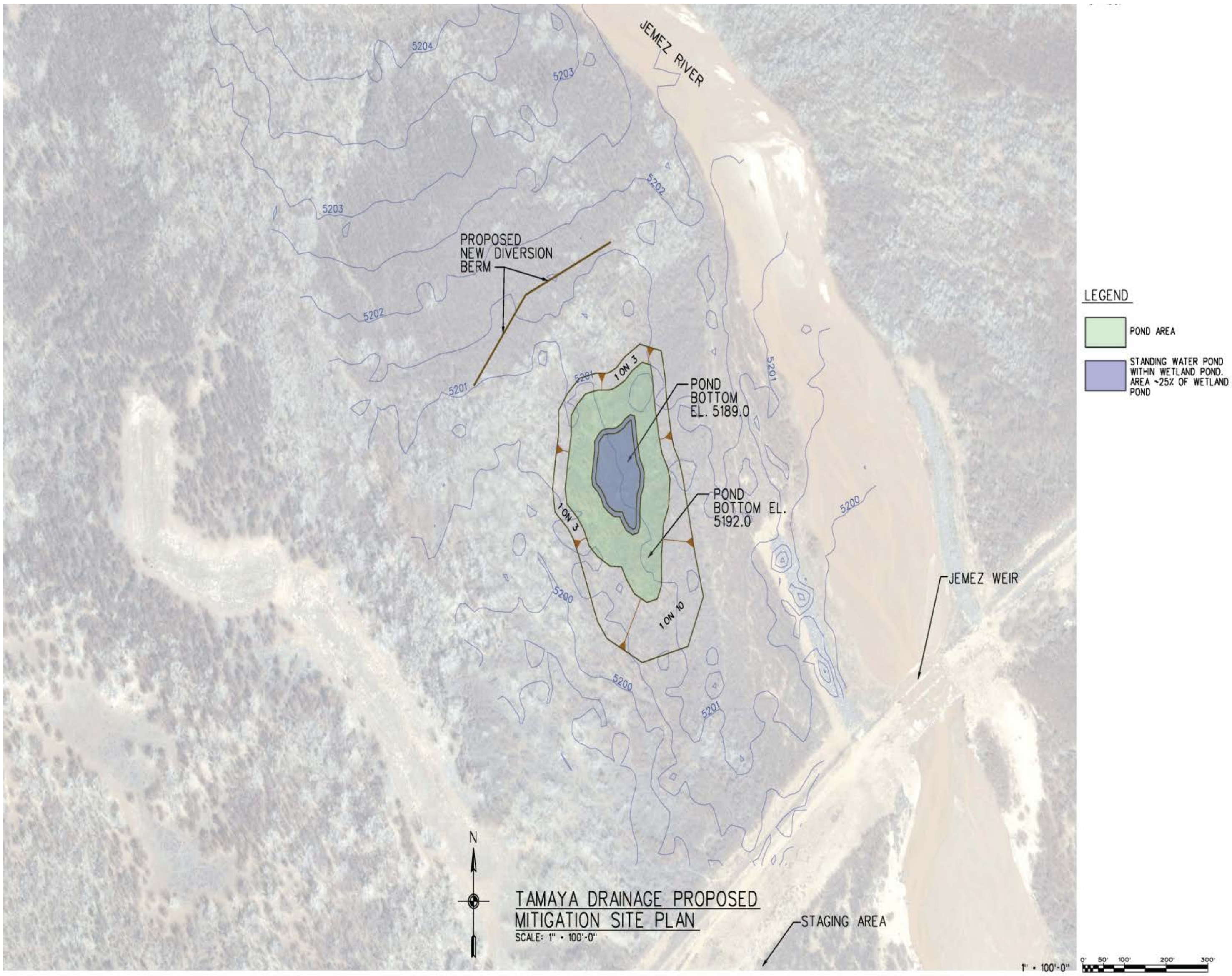


Figure 7: Mitigation Wetland Design

5.3 Methods for establishing the desired plant community

Wetland sod would be transplanted from the impact site to the mitigation site using a front-end loader to cut blocks of sod or similar mechanized digging. Nursery-grown plants would be used to supplement the wild material. Cattails and bulrushes would be transplanted by rhizomes obtained from the impact site. Riparian shrubs from nursery stock would be planted using long-stem transplants with the root systems placed into the capillary fringe. Willow cuttings would be planted at the edge of the moist soil. Similar riparian shrubs and cottonwoods would be planted at the impact site. Portions of the site that have elevations too high above groundwater for riparian plantings will be seeded to native grasses, per Table 4 below.

Table 4: Plant species proposed for constructed wetland mitigation and indicator status

Scientific name	Common names	Wetland indicator status
Anemopsis californica	yerba mansa	OBL
Typha domingensis	cattail	OBL
Juncuc arcticus var. *balticus*	baltic rush	OBL
Eleocharis rostellata	spikerush	OBL
Schoenoplectus pungens	common threesquare bulrush	OBL
Muhlenbergia asperifolia	scratchgrass/ alkalai muhly	FACW
Hordeum jubatum	foxtail barley	FAC
Distichlis spicata	inland saltgrass	FAC
Salix exigua	Coyote willow	OBL
Shrubs for slopes outside wetland:		
Rhus aromatica subsp. *trilobata*	Three-leaved sumac	FACU
Ribes aureum	Golden currant	FAC
Forestiera pubescens	New Mexico Olive	FACU
Lycium torreyi	Wolfberry	-
Baccharis salicina	Baccharis / seepwillow	FACW
Grasses for slopes outside wetland:		
Sporobolus airoides	Alkali sacaton	FAC
Sporobolus cryptandrus	Sand dropseed	FACU
Sporobolus flexuosus	Mesa dropseed	FACU
Sporobolus contractus	Spike dropseed	-
Achnatherum hymenoides	Indian ricegrass	UPL
Pleuraphis jamesii	Galleta	-
Elymus elymoides	bottlebrush squirreltail	FACU

5.4 Invasive species control

Saltcedar would be removed from the mitigation site as the first step in construction. Re-invasion would be monitored and the need for control would be evaluated annually, along with the presence of the *Diorhabda* beetle. If beetle defoliation does not keep tamarisk within acceptable levels, re-invasion would be controlled using selective methods such as cut-stump herbicide treatment.

Best Management Practices that would be followed during construction to prevent the introduction of invasive species include:

- All construction equipment would be cleaned with a high-pressure water jet before entering and upon leaving the project area to prevent introduction or spread of invasive plant species.
- Equipment that was previously used in a waterway or wetland would be disinfected to prevent spread of aquatic disease organisms such as chytrid fungus. Disinfection water shall be contained in a tank or approved off-site facility and shall not be allowed to enter water ways or to be discharged prior to being treated to remove pollutants. Waste water would be disposed following all federal, state, and local regulations.
- Weeds and salt cedar resprouts would be controlled during the construction period and as a component of maintenance and management of the created wetland mitigation site.

5.5 Avoidance measures:

Measures to be taken to avoid any aquatic resources or other sensitive resources within the mitigation site would include flagging and fencing to keep equipment out of cottonwood root zones. Work would take place outside of the migratory bird nesting season.

6. Budget and Cost Effectiveness/Incremental Cost Analysis

6.1 Budget for preferred mitigation alternative

The initial estimated budget for mitigation by creating wetlands was as follows:

Item	Cost
Clearing and Grubbing	24,888.31
Construct Temporary Access Roadway	18,967.60
Wetland Excavation	408,042.94
Dewatering during Excavation below Groundwater	17,945.63
Hauling to berm	22,704.88
Hauling to spoil area	520,689.57
Place & Compact Berm	31,803.06
Temporary Fencing	17,393.25
Seeding	5,054.18
Plantings, including transplanting	245,862.42
Total---	1,313,351.84

Due to the expense of mitigating the impact exclusively by creating wetlands, the current preferred plan for mitigation using a combination of wetland creation and preservation was proposed. The revised budget, which was subsequently calculated as Plan G, is as follows:

Item	Cost
Clearing and Grubbing	12,444.16
Construct Temporary Access Roadway	18,967.60
Wetland Excavation	260,453.35
Dewatering during Excavation below Groundwater	12,053.15
Place & Compact Berm	20,695.55
Temporary Fencing	8,696.62
Seeding	3,032.51
Plantings, including transplanting	122,644.78
Total---	458,987.72

6.2 Cost Effectiveness and Incremental Cost Analysis

Corps regulations (ER 1105-2-100, Appendix C) require completion of an incremental cost analysis (ICA) for mitigation plans to demonstrate that the most cost effective mitigation measure(s) has been selected. Mitigation analysis shall be presented in an analytical framework commensurate with other project benefits and costs. The least cost mitigation plan that provides full mitigation of losses specified in mitigation planning objectives, and which is unconstrained except for required legal and technical constraints, shall always be identified and displayed

The following mitigation alternatives were analyzed initially for the Tamaya Drainage project:

A. 4 Acre Wetland in Preferred Location	1,313,351.84
B. 5 Acre Wetland in Preferred Location	1,668,177.45
C. 6 Acre Wetland in Preferred Location	2,040,451.57
D. 4 Acre Wetland Farther From River	1,590,741.21
E. 4 Acre Wetland, lined with pumped water	1,719,040.73
F. 4 Acre Wetland Closer to River	1,173,777.50

Alternative F, a 4-acre wetland constructed closer to the river than the preferred location, is the least cost alternative because a location in closer proximity to the river channel would require less excavation to reach groundwater. On preliminary CE/ICA analysis, this was the lowest-cost Best Buy plan. However, this alternative was determined by the PDT to be technically infeasible because its proximity to the river would entail unacceptable risk both to the mitigation feature and to the weir during expected high flows.

For a second round of CE/ICA, Alternative F was excluded from analysis. Alternatives A, B, and C were determined to be Best Buy plans. Alternative A was selected as the lowest-cost plan that meets mitigation requirements.

Table 5: CE/ICA results including Plan F

Name	Cost	Output (acres)	Cost Effective?
No Action	0	0	Best Buy
A	1313351	4	No
B	1668177	5	Yes
C	2040452	6	Best Buy
D	1590741	4	No
E	1719041	4	No
F	1173778	4	Best Buy

Figure 8: CE/ICA results including Plan F

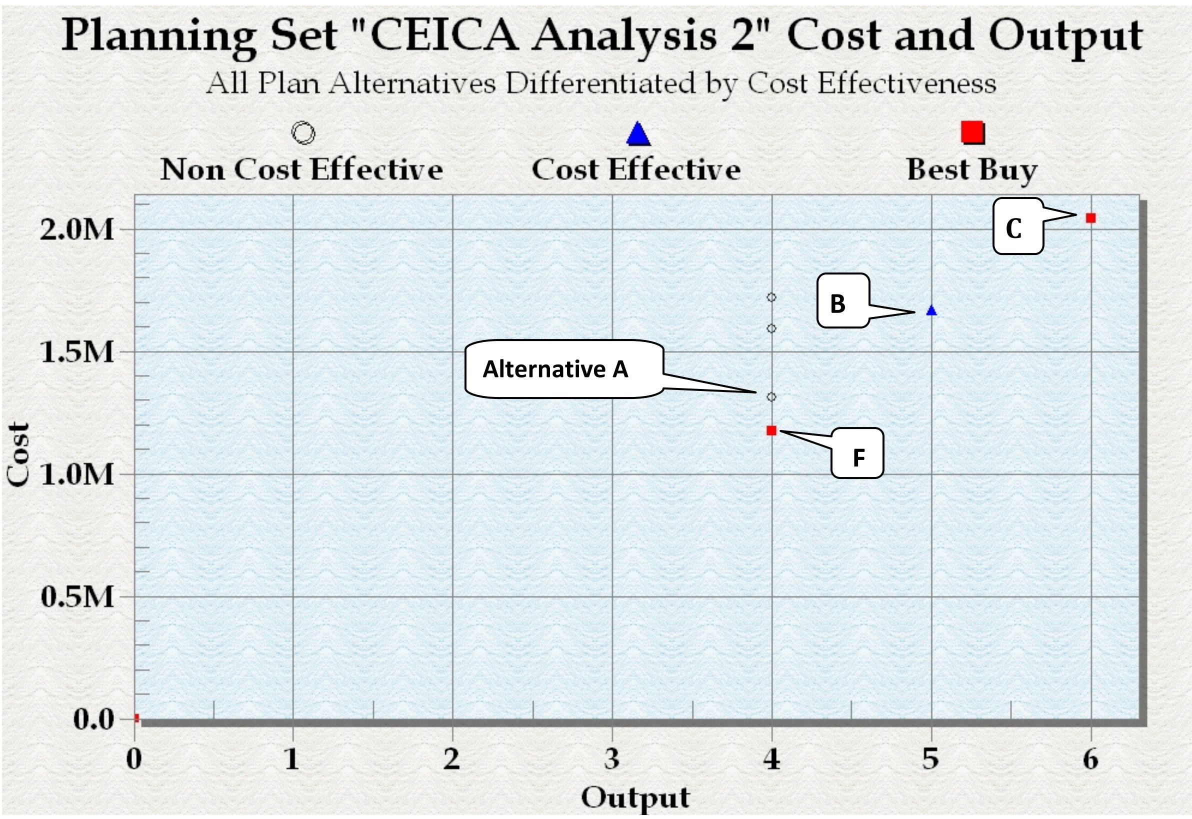
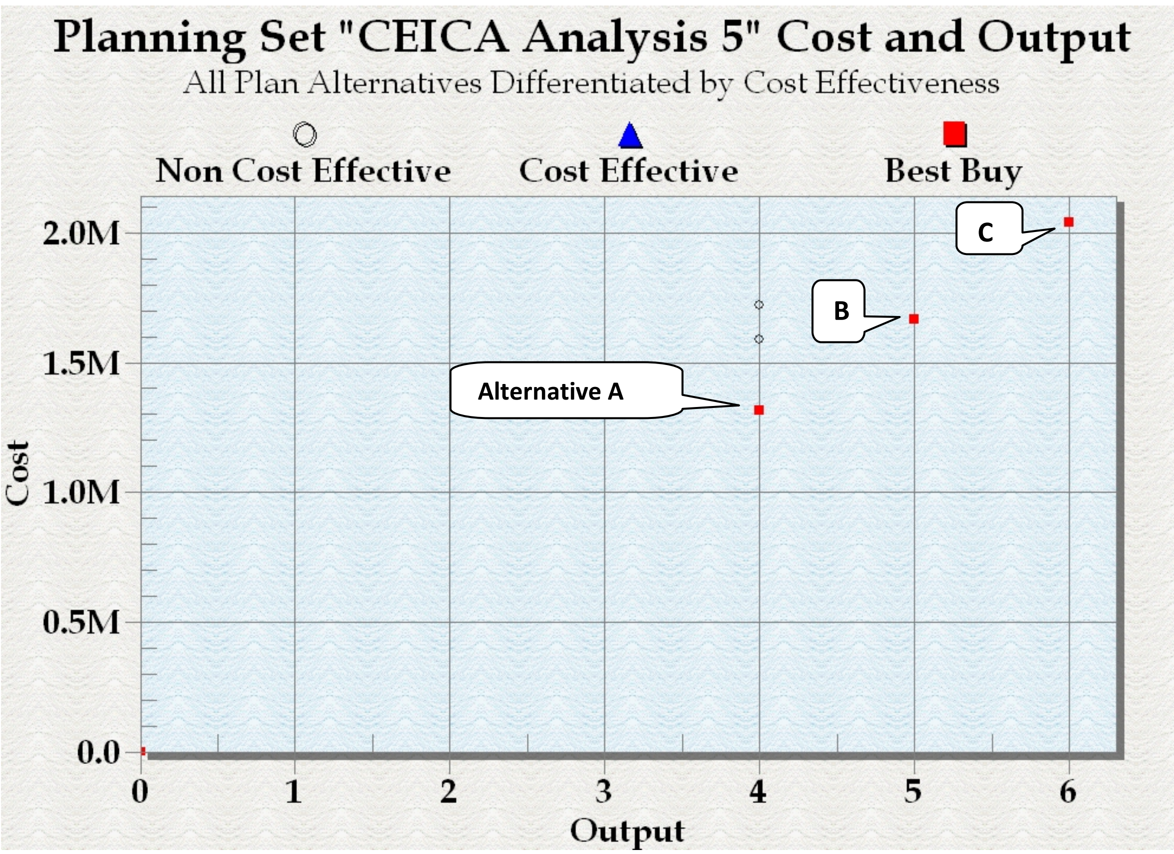


Table 6: CE/ICA results without Plan F

Name	Cost	Output (acres)	Cost Effective?
No Action	0	0	Best Buy
A	1313351	4	Best Buy
B	1668177	5	Best Buy
C	2040452	6	Best Buy
D	1590741	4	No
E	1719041	4	No

Figure 9: CE/ICA results without Plan F



Based on the CE/ICA results above, Plan A was selected for implementation. However, due to the high estimated construction cost of creating a wetland for mitigation, options for decreasing the amount of created wetland were discussed with the Corps' Regulatory Division. Prior to the construction of the Jemez weir, the Corps' Environmental Assessment contained the statement:

> "The proposed action [construction of the weir] is related to mitigation for the evacuation of the Jemez Canyon Reservoir sediment pool and to the future action of draining the Tamaya Pond (inadvertently created from past levee construction)…" (USACE, 2003).

The weir EA did not, however, analyze wetland functions of the pond or allocate wetland acreage preserved to mitigation for the pond vs. the delta riparian vegetation. For the present

analysis, only similar wetland types in proximity to the pond were considered. As described in Section 1.2B, herbaceous wetlands were mapped in about 2003 and 2005. The sedge meadow appears to have increased in size by approximately 14 acres. Preservation of this increase would mitigate for half the wetland impact (13.2 acres to mitigate for 1.65 acres, or half the pond, at a ratio of 8:1).
Because permanent water sources are rare in the Jemez River watershed below the confluence with the Rio Salado, it was determined that the remaining 1.65 acres of impact would be mitigated by constructing an in-kind wetland pond. The preservation portion of the mitigation may not be increased or decreased due to Regulatory requirements; therefore, CE/ICA is not required for this part of the mitigation.

7. Maintenance Plan

The mitigation wetland is designed to require little or no maintenance because its source of water is groundwater. Barring a major event that inundates the mitigation area, maintenance is expected to be minimal, consisting mainly of control of invasive species, and should decrease each year. A major flood event may deposit silt in the wetland; the need for removal would be evaluated after such an event.

The need for management of vegetation, such as replacing dead plants or removal of saltcedar, other invasive plants, or excessive cattail growth, would be evaluated at each monitoring visit. After the initial 3- to 5-year monitoring during the establishment period, inspection and monitoring would be conducted annually along with the inspection of the weir.

8. Ecological performance standards

The success of mitigation activities for the Tamaya Drainage Project will be determined by survival and growth of planted riparian and wetland vegetation, the presence of wetland indicators, and the use of the mitigation area by wildlife. Criteria should be met within the 3-5 year monitoring period. If not, adaptive management measures would be implemented and monitoring continued until criteria are met.

Cottonwood pole and riparian shrub plantings: The objective for this project is a mean survival rate of 80% for the riparian tree and shrub planting areas for five years following planting. Shrubs should show an increase in height or canopy spread each year until reaching mature size.

Wetland (Hydrophytic) plants: Native wetland plant species diversity should be equal to or greater than the number of species planted. Cover by obligate or facultative wetland plants (OBL or FACW) should reach 80% in the shallow water zone (moist soil to 1 ft. deep) by the end of the 3-5 year monitoring period. The overall cover of bulrushes and cattails in deeper water areas (1-3ft) should be at least 20%, with cattail cover not more than 60%.

Wetland hydrology: the mitigation wetland should contain standing water or other indicators of wetland hydrology.

Hydric Soils: Hydric soil indicators require time to develop. By the end of the monitoring period, soils in the wetland should show evidence of semi-permanent saturation or other hydric indicators.

Native Species: Native species should dominate vegetative cover. The relative percent cover by exotic species should decline over time and should be less than 25% by the end of the 3-5 year monitoring period.

Wildlife: The site should show evidence of wildlife use including at least three of the following: Evidence of large mammal use (tracks, scat, grazing/browsing); visual or auditory observations of riparian birds or waterfowl during site visits; presence of aquatic herptiles (turtles, native frogs, or salamanders); presence of wetland or aquatic invertebrates such as dragonflies.

9. Monitoring requirements

Monitoring will be scheduled as follows:

- during the excavation and planting of the mitigation area during implementation
- three times per year (spring, summer and fall) in the first two years post-construction
- annually thereafter until success criteria have been met and it has been determined that the wetland is functioning as intended.

The presence of surface water will be assessed visually. Depth to groundwater will be monitored with one or more piezometers that are planned to be installed outside the wetland footprint prior to construction. Extent of surface water, vegetative cover by native and non-native species, saltcedar invasion, and any geomorphic changes such as silt deposition will be noted. Additionally, vegetation will be monitored and wildlife observations will be noted as per appropriate sections of the field data forms (Enclosure C).

9.1 Vegetation monitoring:

Following construction, the wetland perimeter would be mapped using handheld GPS. The perimeter of the wetland would be stratified into five segments. Five permanent points would be selected at each mitigation wetland cell. At the filled pond, five monitoring points would be established using a stratified random sample (Figure 10). This would ensure that sample points are distributed throughout wetland border or filled pond area. Monitoring points would be positioned along the wetland edge at the time planting is complete and marked with rebar. This would allow ready assessment of surface water conditions and whether water is rising or receding over time.

At each sample point, photos would be taken in four directions. A 1-m radius circular plot would be used to evaluate herbaceous vegetation (Figure 11). Species, percent cover, and wetland indicator values would be recorded at each monitoring point. An additional circular plot would be established in the upland zone outside the shrub planting area to record grass species and percent cover.

A 10-m2 rectangular plot with its short axis centered on the monitoring point would extend 4m to the approximate edge of the shrub planting area. Size will be adjusted if needed to obtain more individual shrubs for monitoring. Shrub percent survival, height or canopy spread will be recorded.

At each monitoring visit, a general walk-through will be done through each mitigation area to observe potential problem spots, weeds, and invasive species. Any weeds or invasive species will be qualitatively noted and described. General photos of the areas will be taken and described. Example field monitoring data sheets are included as Enclosure A.

9.2 Anticipated Cost of Monitoring and Reporting Activities

It is estimated that annual monitoring and reporting activities for the mitigation project associated with the Tamaya Drainage Project will be approximately $10,000. This assumes three weeks total of field monitoring, data analysis, and reporting time for one biologist. Costs incurred for replanting wetland and riparian species or treating invasive species are not included in this estimate.

Figure 10: Vegetation Monitoring Point Layout (example).

Actual points will be determined following construction and wetland mapping.

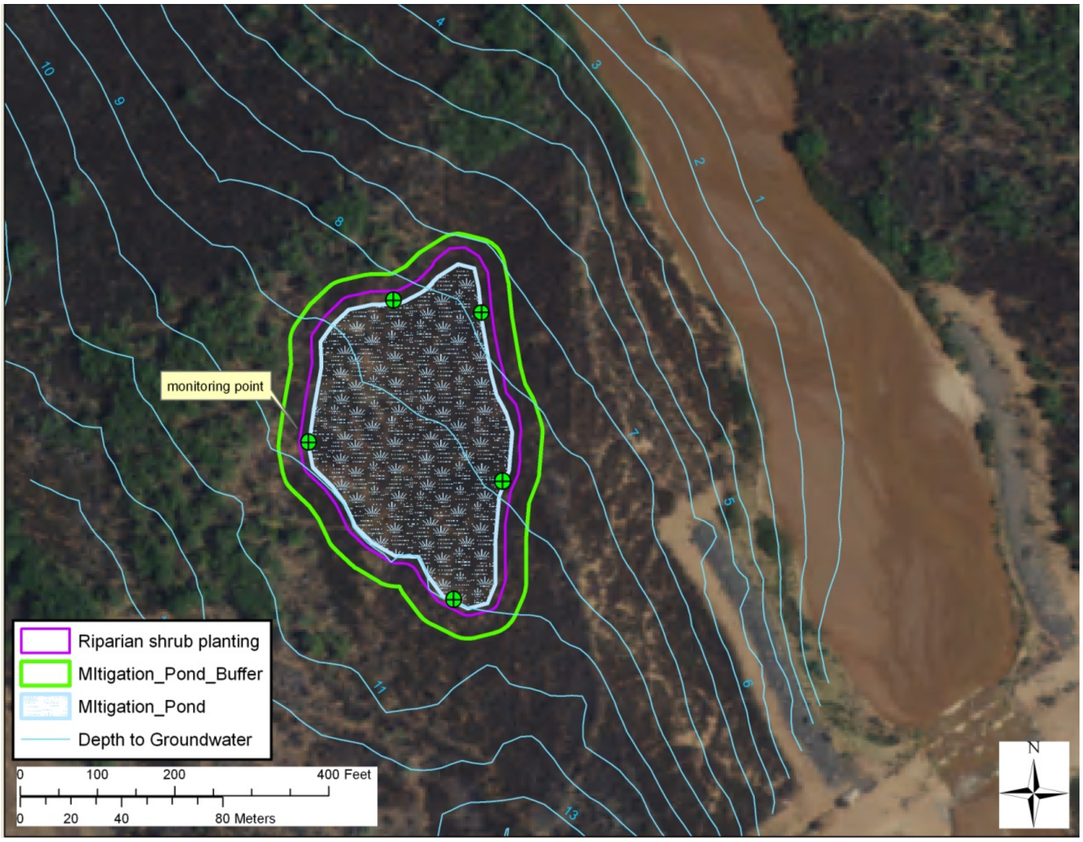
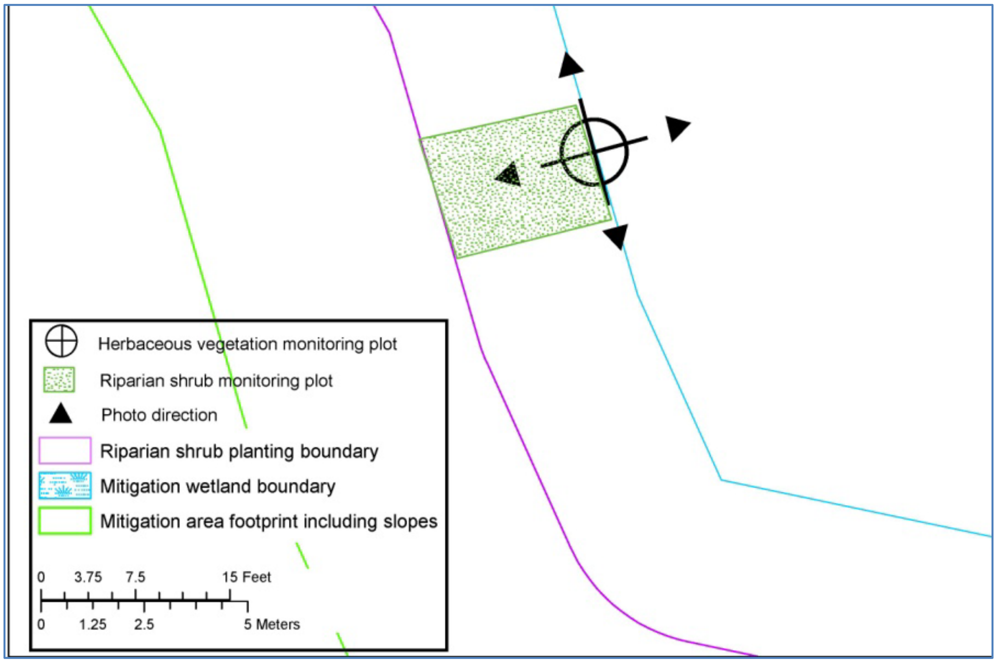


Figure 11: Monitoring Point Detail



10. Long-Term Management Plan

Long-tern management of the mitigation wetland would become part of the Jemez Canyon Dam project's O&M operations. Inspection and qualitative monitoring would be conducted annually by a qualified biologist along with the inspection of the weir by Corps personnel. The presence of surface water would be assessed visually. When there is concern that a significant change may have occurred, the wetland perimeter would be mapped by walking around each wetland feature using a handheld GPS receiver. The extent of surface water, vegetative cover by native and non-native species, saltcedar invasion, and any geomorphic changes such as silt deposition will be noted.

Funding for routine inspection and adaptive management would be obtained from the Operations budget each year.

11. Adaptive Management Plan

Adaptive management is a systematic approach for improving resource management by learning from management outcomes. It promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process (Williams, Szaro, and Shapiro. 2009).

Monitoring and reporting activities will inform the Corps and the Pueblo of Santa Ana whether or not mitigation activities have been successful to date and whether a change in management is needed. Adaptive management measures for the mitigation wetland could include, but are not limited to:

- Re-grading or removing sediment from part or all of the created wetland site (there may be a trade-off between keeping the wetland vegetation and possibly needing to remove sediment). Re-grading of wetland, if needed, would be based on as-built plans submitted by the contractor just after excavation of the mitigation area to ensure grading has been performed per contracting plans.
- Maintaining the berm, possibly by adding sediment removed from the created wetland.
- Replanting or reseeding part of the created wetland site to improve species cover or diversity, or to re-establish vegetation after a major flood event or re-grading/sediment removal.
- Invasive species control at the created wetland or preservation sites.
- Installation of new or replacement fencing;
- Soil testing or amendment, if soils are an issue for plant growth in the created wetland.

Should the ecological performance standards not be met during any given year, the reasons for failure to meet standards will be evaluated and appropriate management actions taken. Each year, the Corps in consultation with the Pueblo of Santa Ana will investigate why plantings were not successful, what could be done differently to improve success rates, what environmental factors could be contributing to a decline in success, whether there have been unacceptable structural changes such as sediment accumulation, and what actions are recommended to improve success or remedy an unacceptable situation. For example, if plantings fail, the cause would be evaluated before planting new plants to replace those that die. Did the depth to water table change so the plants' roots failed to reach water? Was herbivory or disease a factor? Was the soil too saline or otherwise unsuitable? Any replacement plants will be monitored for the duration of the monitoring period.

References

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Massong, T.M. 2008. Jemez River Watershed Hydrologic Assessment, Final Report May 2008. U.S. Army Corps of Engineers, Albuquerque District, Hydrology and Hydraulics Section, Albuquerque, NM. 34+ pages.

U.S. Army Corps of Engineers (USACE). 2003. Final Environmental Assessment for the Proposed Construction of a Low-Head Weir, Rio Jemez, the Pueblo of Santa Ana, New Mexico. U.S. Army Corps of Engineers Albuquerque District, Albuquerque, New Mexico. August 2003.

U.S. Army Corps of Engineers (USACE). 2012. Final Letter Report, Tamaya Pond Groundwater Modeling Update for Revised Grading Plan and Revised Passive Drain with Sump. U.S. Army Corps of Engineers, Seattle District, Seattle, Washington.

Williams, B. K., R. C. Szaro, and C. D. Shapiro. 2009. Adaptive Management: The U.S. Department of the Interior Technical Guide. Adaptive Management Working Group, U.S. Department of the Interior, Washington, DC.

Enclosures

Enclosure A: Wetland Delineation Field Forms and Map

Enclosure B: Mitigation Ratio Setting Checklist

Enclosure C: Monitoring Data Sheets

Enclosure A: Wetland Delineation Field Forms and Map

2002 Wetland Delineation

2011 Wetland Delineation

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: Tamaya	Date: July 2, 2002
Applicant/Owner: Santa Ana Pueblo	County: Sandoval
Investigator: Ernie Gehnke, Patty Phillips	State: New Mexico
Do Normal Circumstances exist on the site? Yes (No)	Community ID:
Is the site significantly disturbed (Atypical Situation)? (Yes) No	Transect ID:
Is the area a potential Problem Area? Yes (No) (If needed, explain on reverse.)	Plot ID:

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Typha latifolia		OBL	9.		
2.			10.		
3.			11.		
4.			12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 100%

Remarks: Cattail Marsh Drought year

HYDROLOGY

___ Recorded Data (Describe in Remarks):
- ___ Stream, Lake, or Tide Gauge
- ___ Aerial Photographs
- ___ Other

√ No Recorded Data Available

Field Observations:

- Depth of Surface Water: — (in.)
- Depth to Free Water in Pit: 8 (in.)
- Depth to Saturated Soil: 1 (in.)

Wetland Hydrology Indicators:

Primary Indicators:
- ✓ Inundated
- ✓ Saturated in Upper 12 Inches
- ___ Water Marks
- ___ Drift Lines
- ___ Sediment Deposits
- ___ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):
- ___ Oxidized Root Channels in Upper 12 Inches
- ___ Water-Stained Leaves
- ___ Local Soil Survey Data
- ___ FAC-Neutral Test
- ___ Other (Explain in Remarks)

Remarks:

SOILS

Map Unit Name
(Series and Phase): ______________________ Drainage Class: ________
Field Observations
Taxonomy (Subgroup): ______________________ Confirm Mapped Type? Yes No

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.
0-6		10YR 8/2	N/A	N/A	Sandy
6 +		10yr 4/2	N/A		Sandy

Hydric Soil Indicators:

- ___ Histosol
- ___ Histic Epipedon
- ___ Sulfidic Odor
- ___ Aquic Moisture Regime
- ___ Reducing Conditions
- ✓ Gleyed or Low-Chroma Colors
- ___ Concretions
- ___ High Organic Content in Surface Layer in Sandy Soils
- ___ Organic Streaking in Sandy Soils
- ___ Listed on Local Hydric Soils List
- ___ Listed on National Hydric Soils List
- ___ Other (Explain in Remarks)

Remarks:

WETLAND DETERMINATION

Hydrophytic Vegetation Present?	(Yes) No (Circle)	
Wetland Hydrology Present?	(Yes) No	
Hydric Soils Present?	(Yes) No	Is this Sampling Point Within a Wetland? (Circle) (Yes) No

Remarks:

Approved by HQUSACE 3/92

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: Tamaya Applicant/Owner: Santa Ana Pueblo Investigator: Ernie Gahnke, Patty Phillips	Date: July 2, 2002 County: Sandoval State: New Mexico
Do Normal Circumstances exist on the site? Yes No Is the site significantly disturbed (Atypical Situation)? Yes No Is the area a potential Problem Area? Yes No (If needed, explain on reverse.)	Community ID: Transect ID: Plot ID:

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Scirpus americana		OBL	9.		
2. Distichlis spicata		NI	10.		
3. Rabbitfoot Polypogon monspeliensis		FACW	11.		
4. Knotweed Polygonaceae			12.		
5. Yerba mansa Anemopsis		OBL	13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-).

Remarks: Area dominated by Scirpus

HYDROLOGY

___ Recorded Data (Describe in Remarks): ___ Stream, Lake, or Tide Gauge ___ Aerial Photographs ___ Other √ No Recorded Data Available	Wetland Hydrology Indicators: Primary Indicators: ___ Inundated ✓ Saturated in Upper 12 Inches ___ Water Marks ___ Drift Lines ___ Sediment Deposits ___ Drainage Patterns in Wetlands
Field Observations: Depth of Surface Water: 0 (in.) Depth to Free Water in Pit: 0 (in.) Depth to Saturated Soil: 0 (in.)	Secondary Indicators (2 or more required): ___ Oxidized Root Channels in Upper 12 Inches ___ Water-Stained Leaves ___ Local Soil Survey Data ___ FAC-Neutral Test ___ Other (Explain in Remarks)

Remarks:

SOILS

?

Map Unit Name
(Series and Phase): ______ Drainage Class: ______
Field Observations
Taxonomy (Subgroup): ______ Confirm Mapped Type? Yes No

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.
0-3	—	10yr 4/1	N/A	N/A	coarse sandy

Hydric Soil Indicators:

- ___ Histosol
- ___ Histic Epipedon
- ___ Sulfidic Odor
- ___ Aquic Moisture Regime
- ___ Reducing Conditions
- ✓ Gleyed or Low-Chroma Colors
- ___ Concretions
- ___ High Organic Content in Surface Layer in Sandy Soils
- ___ Organic Streaking in Sandy Soils
- ___ Listed on Local Hydric Soils List
- ___ Listed on National Hydric Soils List
- ___ Other (Explain in Remarks)

Remarks:

WETLAND DETERMINATION

Hydrophytic Vegetation Present? (Yes) No (Circle)
Wetland Hydrology Present? (Yes) No
Hydric Soils Present? (Yes) No

Is this Sampling Point Within a Wetland? (Circle) (Yes) No

Remarks: area pond formed by levee
1953 - 1954 - levee construction

Approved by HQUSACE 3/92

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: Tamaya Applicant/Owner: Santa Ana Pueblo Investigator: Ernie Jahnke, Patty Phillips	Date: July 2, 2002 County: Sandoval State: New Mexico
Do Normal Circumstances exist on the site? Yes (No) Is the site significantly disturbed (Atypical Situation)? (Yes) No Is the area a potential Problem Area? Yes (No) (If needed, explain on reverse.)	Community ID: Transect ID: Plot ID:

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. ~~knotweed~~ Yerba mansa		OBL	9.		
2. Distichlis spicata		NI	10.		
3. Scirpus ~~americanus~~ pungens		OBL	11.		
4. foxtail Hordeum jubatum		FACW-	12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-).

Remarks: Yerba Mansa (Anemopsis californica) Community

HYDROLOGY

___ Recorded Data (Describe in Remarks): ___ Stream, Lake, or Tide Gauge ___ Aerial Photographs ___ Other ✓ No Recorded Data Available	Wetland Hydrology Indicators: Primary Indicators: ___ Inundated ✓ Saturated in Upper 12 Inches ___ Water Marks ___ Drift Lines ___ Sediment Deposits ___ Drainage Patterns in Wetlands
Field Observations: Depth of Surface Water: 0 (in.) Depth to Free Water in Pit: 0 (in.) Depth to Saturated Soil: 0 (in.)	Secondary Indicators (2 or more required): ___ Oxidized Root Channels in Upper 12 Inches ___ Water-Stained Leaves ___ Local Soil Survey Data ___ FAC-Neutral Test ___ Other (Explain in Remarks)

Remarks:

SOILS

Map Unit Name
(Series and Phase): ______ Drainage Class: ______
Field Observations
Taxonomy (Subgroup): ______ Confirm Mapped Type? Yes No

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.
0-36		10yr 2/1			sandy loam
~~6-~~		10yr 3/2			fine sand

Hydric Soil Indicators:

- ___ Histosol
- ___ Histic Epipedon
- ___ Sulfidic Odor
- ___ Aquic Moisture Regime
- ___ Reducing Conditions
- ✓ Gleyed or Low-Chroma Colors
- ___ Concretions
- ___ High Organic Content in Surface Layer in Sandy Soils
- ✓ Organic Streaking in Sandy Soils
- ___ Listed on Local Hydric Soils List
- ___ Listed on National Hydric Soils List
- ___ Other (Explain in Remarks)

Remarks: redox features present

WETLAND DETERMINATION

Hydrophytic Vegetation Present?	(Yes) No (Circle)	
Wetland Hydrology Present?	(Yes) No	
Hydric Soils Present?	(Yes) No	Is this Sampling Point Within a Wetland? (Circle) (Yes) No

Remarks:

Approved by HQUSACE 3/92

T1

WETLAND DETERMINATION DATA FORM – Arid West Region

Project/Site: Tamaya Pond City/County: Sandoval County Sampling Date: 28 July 11
Applicant/Owner: Santa Ana Pueblo State: NM Sampling Point: T1
Investigator(s): Eddie Paulsgrove Section, Township, Range:
Landform (hillslope, terrace, etc.): Basin Local relief (concave, convex, none): concave Slope (%): 0
Subregion (LRR): Lat: Long: Datum:
Soil Map Unit Name: NWI classification:
Are climatic / hydrologic conditions on the site typical for this time of year? Yes ___ No X (If no, explain in Remarks.)
Are Vegetation ___, Soil ___, or Hydrology X significantly disturbed? Are "Normal Circumstances" present? Yes ___ No X
Are Vegetation ___, Soil X, or Hydrology X naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present? Yes X No ___	Is the Sampled Area within a Wetland?	Yes X
Hydric Soil Present? Yes X No ___		
Wetland Hydrology Present? Yes X No ___		

Remarks: Drought season

Sect: 22
Township: 14N
Range 3E
35.4261
-106.617
2003-00207

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: ___)	Absolute % Cover	Dominant Species?	Indicator Status
1. Typha angustifolia			
2. domingensis			
3.			
4.			
		= Total Cover	
Sapling/Shrub Stratum (Plot size: ___)			
1.			
2.			
3.			
4.			
5.			
		= Total Cover	
Herb Stratum (Plot size: ___)			
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
		= Total Cover	
Woody Vine Stratum (Plot size: ___)			
1.			
2.			
		= Total Cover	

% Bare Ground in Herb Stratum ___ % Cover of Biotic Crust ___

Dominance Test worksheet:
Number of Dominant Species That Are OBL, FACW, or FAC: ___ (A)
Total Number of Dominant Species Across All Strata: ___ (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: ___ (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ___	x 1 = ___
FACW species ___	x 2 = ___
FAC species ___	x 3 = ___
FACU species ___	x 4 = ___
UPL species ___	x 5 = ___
Column Totals: ___ (A)	___ (B)

Prevalence Index = B/A = ___

Hydrophytic Vegetation Indicators:
- ___ Dominance Test is >50%
- ___ Prevalence Index is ≤3.0[1]
- ___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ___

Remarks:

US Army Corps of Engineers Arid West – Version 2.0

T 1

Sampling Point: ______

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	%	Redox Features Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0-4	10YR 3/3	97	10YR 6/8	3	CS/C	PL/M	Sandy	8% organic – [illegible]
4-14	2.5Y 3/3	65	10YR 4/2	35	D	M	Sandy	matrix organic root structure [illegible] sandy/loss [illegible]
14+	cobble material (angular)							

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Stratified Layers (A5) (LRR C)
___ 1 cm Muck (A9) (LRR D)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)
___ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

___ 1 cm Muck (A9) (LRR C)
___ 2 cm Muck (A10) (LRR B)
___ Reduced Vertic (F18)
___ Red Parent Material (TF2)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):
Type: ______
Depth (inches): ______

Hydric Soil Present? Yes ____ No ____

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
X Water Marks (B1) (Nonriverine)
X Sediment Deposits (B2) (Nonriverine)
___ Drift Deposits (B3) (Nonriverine)
X Surface Soil Cracks (B6)
X Inundation Visible on Aerial Imagery (B7)
X Water-Stained Leaves (B9)
___ Salt Crust (B11)
___ Biotic Crust (B12)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
X Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Thin Muck Surface (C7)
___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

X Water Marks (B1) (Riverine)
X Sediment Deposits (B2) (Riverine)
___ Drift Deposits (B3) (Riverine)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Crayfish Burrows (C8)
___ Saturation Visible on Aerial Imagery (C9)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ____ No ____ Depth (inches): ______
Water Table Present? Yes ____ No ____ Depth (inches): ______
Saturation Present? (includes capillary fringe) Yes X No ____ Depth (inches): <17 in

Wetland Hydrology Present? Yes ____ No ____

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

US Army Corps of Engineers Arid West – Version 2.0

WETLAND DETERMINATION DATA FORM – Arid West Region

Project/Site: Tamaya T.2   City/County: Sandoval County   Sampling Date: 28 July 11

Applicant/Owner: Santa Ana Pueblo   State: NM   Sampling Point: BT2

Investigator(s): Eddie Paulsgrove   Section, Township, Range: ______

Landform (hillslope, terrace, etc.): Basin   Local relief (concave, convex, none): Concave   Slope (%): 5

Subregion (LRR): ______ Lat: ______ Long: ______ Datum: ______

Soil Map Unit Name: ______ NWI classification: ______

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ______ No ______ (If no, explain in Remarks.)

Are Vegetation ______, Soil ______, or Hydrology ______ significantly disturbed? Are "Normal Circumstances" present? Yes ______ No ______

Are Vegetation ______, Soil ______, or Hydrology ______ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present? Yes Y No ___	Is the Sampled Area within a Wetland?	Yes ___ No X
Hydric Soil Present? Yes Y No ___		
Wetland Hydrology Present? ? Yes ___ No X		

Remarks: Need to check aerial photos for inundation – for now, calling this a transition zone just outside wetland boundary.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: ______)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	= Total Cover		
Sapling/Shrub Stratum (Plot size: ______)			
1.			
2.			
3.			
4.			
5.			
	= Total Cover		
Herb Stratum (Plot size: 1m x 2m)			
1. Juncus balticus	65	Y	OBL
2. Scirpus pungens	30	Y	OBL
3. Muhlenbergia asperifolia	10	N	FACW
4. Polypogon monspeliensis	~2	N	FACW
5. Plantago major	~2	N	FACW
6. Xanthium strumarium	~2	N	NI
7. Sphaerophysa salsula	~2	N	NI
8. Melilotus alba	~2	N	NI
	115 = Total Cover		
Woody Vine Stratum (Plot size: ______)	50% = 57.5 20% = 23		
1.			
2.			
	= Total Cover		

% Bare Ground in Herb Stratum ______ % Cover of Biotic Crust ______

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: ______ (A)

Total Number of Dominant Species Across All Strata: ______ (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: ______ (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	______	x 1 = ______
FACW species	______	x 2 = ______
FAC species	______	x 3 = ______
FACU species	______	x 4 = ______
UPL species	______	x 5 = ______
Column Totals:	______ (A)	______ (B)

Prevalence Index = B/A = ______

Hydrophytic Vegetation Indicators:

- __ Dominance Test is >50%
- __ Prevalence Index is ≤3.0[1]
- __ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- __ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ______

Remarks:

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SOIL

Sampling Point: ______

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-1.5	10YR 3/2	80	roots - no redox features				sandy loam	dense roots
1.5-[illegible]	10YR 5/4	80	10YR 5/8	20	CS	M	loam	moist w/ gravel
[illegible] 12								m
12-	14-14 in T1							

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

__ Histosol (A1)
__ Histic Epipedon (A2)
__ Black Histic (A3)
__ Hydrogen Sulfide (A4)
__ Stratified Layers (A5) (**LRR C**)
__ 1 cm Muck (A9) (**LRR D**)
__ Depleted Below Dark Surface (A11)
__ Thick Dark Surface (A12)
__ Sandy Mucky Mineral (S1)
__ Sandy Gleyed Matrix (S4)
__ Sandy Redox (S5)
__ Stripped Matrix (S6)
__ Loamy Mucky Mineral (F1)
__ Loamy Gleyed Matrix (F2)
__ Depleted Matrix (F3)
__ Redox Dark Surface (F6)
__ Depleted Dark Surface (F7)
__ Redox Depressions (F8)
__ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

__ 1 cm Muck (A9) (**LRR C**)
__ 2 cm Muck (A10) (**LRR B**)
__ Reduced Vertic (F18)
__ Red Parent Material (TF2)
__ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes ______ No ______

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

__ Surface Water (A1)
__ High Water Table (A2)
__ Saturation (A3)
__ Water Marks (B1) (**Nonriverine**)
__ Sediment Deposits (B2) (**Nonriverine**)
__ Drift Deposits (B3) (**Nonriverine**)
__ Surface Soil Cracks (B6)
__ Inundation Visible on Aerial Imagery (B7)
__ Water-Stained Leaves (B9)
__ Salt Crust (B11)
__ Biotic Crust (B12)
__ Aquatic Invertebrates (B13)
__ Hydrogen Sulfide Odor (C1)
__ Oxidized Rhizospheres along Living Roots (C3)
__ Presence of Reduced Iron (C4)
__ Recent Iron Reduction in Tilled Soils (C6)
__ Thin Muck Surface (C7)
__ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

__ Water Marks (B1) (**Riverine**)
__ Sediment Deposits (B2) (**Riverine**)
__ Drift Deposits (B3) (**Riverine**)
__ Drainage Patterns (B10)
__ Dry-Season Water Table (C2)
__ Crayfish Burrows (C8)
__ Saturation Visible on Aerial Imagery (C9)
__ Shallow Aquitard (D3)
__ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ______ No X Depth (inches): ______
Water Table Present? Yes ______ No X Depth (inches): ______
Saturation Present? (includes capillary fringe) Yes ______ No X Depth (inches): ______

Wetland Hydrology Present? Yes ______ No X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

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WETLAND DETERMINATION DATA FORM – Arid West Region

Project/Site: Tamaya Pond City/County: Sandoval County Sampling Date: 28 July 2009

Applicant/Owner: Santa Ana Pueblo State: NM Sampling Point: T3

Investigator(s): Eddie Paulsgrove Section, Township, Range: ______

Landform (hillslope, terrace, etc.): Basin Local relief (concave, convex, none): Concave Slope (%): ______

Subregion (LRR): ______ Lat: ______ Long: ______ Datum: ______

Soil Map Unit Name: ______ NWI classification: ______

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ____ No X (If no, explain in Remarks.)

Are Vegetation ____, Soil ____, or Hydrology X significantly disturbed? Are "Normal Circumstances" present? Yes ____ No X

Are Vegetation ____, Soil X, or Hydrology ____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____	Is the Sampled Area within a Wetland? Yes ____ No X
Hydric Soil Present?	Yes ____ No X	
Wetland Hydrology Present?	Yes X No ____	

Remarks: Negative test hole. area has had sufficient moisture for wetland plants but has not developed wetland soil.

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: ______)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	= Total Cover		
Sapling/Shrub Stratum (Plot size: ______)			
1.			
2.			
3.			
4.			
5.			
	= Total Cover		
Herb Stratum (Plot size: ______)			
1. Muhlenbergia asperifolia	25	Y	FACW
2. Polypogon monspeliensis	20	Y	FACW
3. Typha domingensis	15		OBL
4. Juncus balticus	10		OBL
5. Scirpus pungens	5		OBL
6.			
7.			
8.			
	80 = Total Cover		
Woody Vine Stratum (Plot size: ______)	50% = 40		% cover
1.	20% = 16		% cover
2.			
	= Total Cover		

% Bare Ground in Herb Stratum ______ % Cover of Biotic Crust ______

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: ______ (A)

Total Number of Dominant Species Across All Strata: ______ (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: ______ (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	______	x 1 = ______
FACW species	______	x 2 = ______
FAC species	______	x 3 = ______
FACU species	______	x 4 = ______
UPL species	______	x 5 = ______
Column Totals:	______ (A)	______ (B)

Prevalence Index = B/A = ______

Hydrophytic Vegetation Indicators:

- ___ Dominance Test is >50%
- ___ Prevalence Index is ≤3.0[1]
- ___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks:

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SOIL

Sampling Point: ____________

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-1"	10YR 4/3	90	none				sand	sandy, dry, 10% roots
	~~roots~~		→				fine sand	with gravels, loose, dry
1"-6"	10YR 3/3	90	→					10% gravel
6"-12"							~~coarse sand~~	, loose, moist @ 12"
								Sandy gravel

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.) None

- __ Histosol (A1)
- __ Histic Epipedon (A2)
- __ Black Histic (A3)
- __ Hydrogen Sulfide (A4)
- __ Stratified Layers (A5) (**LRR C**)
- __ 1 cm Muck (A9) (**LRR D**)
- __ Depleted Below Dark Surface (A11)
- __ Thick Dark Surface (A12)
- __ Sandy Mucky Mineral (S1)
- __ Sandy Gleyed Matrix (S4)
- __ Sandy Redox (S5)
- __ Stripped Matrix (S6)
- __ Loamy Mucky Mineral (F1)
- __ Loamy Gleyed Matrix (F2)
- __ Depleted Matrix (F3)
- __ Redox Dark Surface (F6)
- __ Depleted Dark Surface (F7)
- __ Redox Depressions (F8)
- __ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- __ 1 cm Muck (A9) (**LRR C**)
- __ 2 cm Muck (A10) (**LRR B**)
- __ Reduced Vertic (F18)
- __ Red Parent Material (TF2)
- __ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ______________________

Depth (inches): ______________________

Hydric Soil Present? Yes ______ No ______

Remarks: Dead hydrophytic vegetation - dominated by FACW

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply) none except dead hydro. vegetation

- __ Surface Water (A1)
- __ High Water Table (A2)
- __ Saturation (A3)
- __ Water Marks (B1) (**Nonriverine**)
- __ Sediment Deposits (B2) (**Nonriverine**)
- __ Drift Deposits (B3) (**Nonriverine**)
- __ Surface Soil Cracks (B6)
- __ Inundation Visible on Aerial Imagery (B7)
- __ Water-Stained Leaves (B9)
- __ Salt Crust (B11)
- __ Biotic Crust (B12)
- __ Aquatic Invertebrates (B13)
- __ Hydrogen Sulfide Odor (C1)
- __ Oxidized Rhizospheres along Living Roots (C3)
- __ Presence of Reduced Iron (C4)
- __ Recent Iron Reduction in Tilled Soils (C6)
- __ Thin Muck Surface (C7)
- __ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- __ Water Marks (B1) (**Riverine**)
- __ Sediment Deposits (B2) (**Riverine**)
- __ Drift Deposits (B3) (**Riverine**)
- __ Drainage Patterns (B10)
- __ Dry-Season Water Table (C2)
- __ Crayfish Burrows (C8)
- __ Saturation Visible on Aerial Imagery (C9)
- __ Shallow Aquitard (D3)
- __ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes _____ No _____ Depth (inches): ___________

Water Table Present? Yes _____ No _____ Depth (inches): ___________

Saturation Present? (includes capillary fringe) Yes _____ No _____ Depth (inches): ___________

Wetland Hydrology Present? Yes ______ No ______

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

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WETLAND DETERMINATION DATA FORM – Arid West Region

Project/Site: Tamaya Pond City/County: Sandoval County Sampling Date: 28 JUL 11
Applicant/Owner: Santa Ana Pueblo State: NM Sampling Point: T5
Investigator(s): Eddie Paulsgrove Section, Township, Range: ______
Landform (hillslope, terrace, etc.): Basin Local relief (concave, convex, none): Concave Slope (%): ______
Subregion (LRR): ______ Lat: ______ Long: ______ Datum: ______
Soil Map Unit Name: ______ NWI classification: ______
Are climatic / hydrologic conditions on the site typical for this time of year? Yes ______ No X (If no, explain in Remarks.)
Are Vegetation ______, Soil ______, or Hydrology X significantly disturbed? Are "Normal Circumstances" present? Yes ______ No X
Are Vegetation ______, Soil X, or Hydrology X naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present? Yes X No ______		Is the Sampled Area within a Wetland? Yes X No ______
Hydric Soil Present? Yes X No ______		
Wetland Hydrology Present? Yes X No ______		

Remarks: Extended Drought; surface water ponded, being pumped beneath level.

VEGETATION – Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: ______)			
1.			
2.			
3.			
4.			
= Total Cover			
Sapling/Shrub Stratum (Plot size: ______)			
1.			
2.			
3.			
4.			
5.			
= Total Cover			
Herb Stratum (Plot size: 2 x 2m)			
1. Scirpus pungens	75	Y	
2. Juncus balticus	25		
3. Bidens or Flaveria sp.	20		
4. Muhlenbergia asperifolia	20		
5. Polypogon	5		
6. grass sp. 2 (w. wheat?)	5		
7.			
8.			
= Total Cover	150		
	50% = 75, 20% = 30		
Woody Vine Stratum (Plot size: ______)			
1.			
2.			
= Total Cover			

% Bare Ground in Herb Stratum ______ % Cover of Biotic Crust ______

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: ______ (A)

Total Number of Dominant Species Across All Strata: ______ (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: ______ (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	______	x 1 = ______
FACW species	______	x 2 = ______
FAC species	______	x 3 = ______
FACU species	______	x 4 = ______
UPL species	______	x 5 = ______
Column Totals:	______ (A)	______ (B)

Prevalence Index = B/A = ______

Hydrophytic Vegetation Indicators:

- ___ Dominance Test is >50%
- ___ Prevalence Index is ≤3.0[1]
- ___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ______ No ______

Remarks:

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SOIL

Sampling Point: 1

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0 – 2	10YR 3/1	70					Clay	silty, 30% veg moist
2 – 9	10YR 4/2	90					fine sand,	some silt 10% veg moist
9 – 16	10YR 4/2	85					Sand, medium,	15% gravel moist

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR C**)
- ___ 1 cm Muck (A9) (**LRR D**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- X Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR C**)
- ___ 2 cm Muck (A10) (**LRR B**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes X No ___

Remarks: Somewhat problematic (sand content), 6 inches (sulfide odor starts)

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1) (**Nonriverine**)
- ___ Sediment Deposits (B2) (**Nonriverine**)
- ___ Drift Deposits (B3) (**Nonriverine**)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Biotic Crust (B12)
- ___ Aquatic Invertebrates (B13)
- X Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water Marks (B1) (**Riverine**)
- ___ Sediment Deposits (B2) (**Riverine**)
- ___ Drift Deposits (B3) (**Riverine**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ___	No ___	Depth (inches): ___
Water Table Present?	Yes ___	No ___	Depth (inches): ___
Saturation Present? (includes capillary fringe)	Yes ___	No ___	Depth (inches): ___

Wetland Hydrology Present? Yes X No ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks: Problem soil, not a lot of surface variability

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WETLAND DETERMINATION DATA FORM – Arid West Region

Project/Site: Tamaya Pond City/County: Sandoval County Sampling Date: 28 July 11
Applicant/Owner: Santa Ana Pueblo State: NM Sampling Point: T4
Investigator(s): Eddie Paulsgrove Section, Township, Range: ____
Landform (hillslope, terrace, etc.): Basin Local relief (concave, convex, none): Concave Slope (%): ____
Subregion (LRR): ____ Lat: ____ Long: ____ Datum: ____
Soil Map Unit Name: ____ NWI classification: ____
Are climatic / hydrologic conditions on the site typical for this time of year? Yes ____ No X (If no, explain in Remarks.)
Are Vegetation ____, Soil ____, or Hydrology ____ significantly disturbed? Are "Normal Circumstances" present? Yes ____ No X
Are Vegetation ____, Soil ____, or Hydrology ____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X No ____	**Is the Sampled Area within a Wetland?**	**Yes** X **No** ____
Hydric Soil Present?	Yes X No ____		
Wetland Hydrology Present?	Yes X No ____		

Remarks: 22" below surface - wet blackened gravel (w/ organic matter) Litter - stems of dead Scirpus — covering ground. Drought

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: ____)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
	____ = Total Cover		
Sapling/Shrub Stratum (Plot size: ____)			
1.			
2.			
3.			
4.			
5.			
	____ = Total Cover		
Herb Stratum (Plot size: ____)			
1. Scirpus acutus	30	Y	OBL
2. Xanthium strumarium	20	Y	NI
3. Polypogon monspeliensis	<1		
4. Muhlenbergia asperifolia	5		FACW
5.			
6.			
7.			
8.			
	55 = Total Cover		
	50% = 22.5 20% = 11		
Woody Vine Stratum (Plot size: ____)			
1.			
2.			
	____ = Total Cover		

% Bare Ground in Herb Stratum ____ % Cover of Biotic Crust ____

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: ____ (A)
Total Number of Dominant Species Across All Strata: ____ (B)
Percent of Dominant Species That Are OBL, FACW, or FAC: ____ (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	____	x 1 = ____
FACW species	____	x 2 = ____
FAC species	____	x 3 = ____
FACU species	____	x 4 = ____
UPL species	____	x 5 = ____
Column Totals:	____ (A)	____ (B)

Prevalence Index = B/A = ____

Hydrophytic Vegetation Indicators:

- ___ Dominance Test is >50%
- ___ Prevalence Index is ≤3.0[1]
- ___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes X No ____

Remarks:

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Sampling Point: ______

SOIL

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	%	Redox Features Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0-1"	10YR 4/3	90					Sandy, fine	10% root, dry
1-22	10YR 4/3	95%					Sand, coarse	5% gravel
22-	7.5YR 2/0	95%					gravel, blackish	5% organics

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR C**)
- ___ 1 cm Muck (A9) (**LRR D**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR C**)
- ___ 2 cm Muck (A10) (**LRR B**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes ______ No ______

Remarks: concave, red parent, problematic sandy soils, levee toe slop

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1) (**Nonriverine**)
- X Sediment Deposits (B2) (**Nonriverine**)
- ___ Drift Deposits (B3) (**Nonriverine**)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- X Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Biotic Crust (B12)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water Marks (B1) (**Riverine**)
- ___ Sediment Deposits (B2) (**Riverine**)
- ___ Drift Deposits (B3) (**Riverine**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ______ No X Depth (inches): ______

Water Table Present? Yes ______ No ______ Depth (inches): ______

Saturation Present? (includes capillary fringe) Yes ______ No ______ Depth (inches): ______

Wetland Hydrology Present? Yes ______ No ______

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks: Concave setting, w/ levee toe slope, problematic sandy soils w/ red parent material

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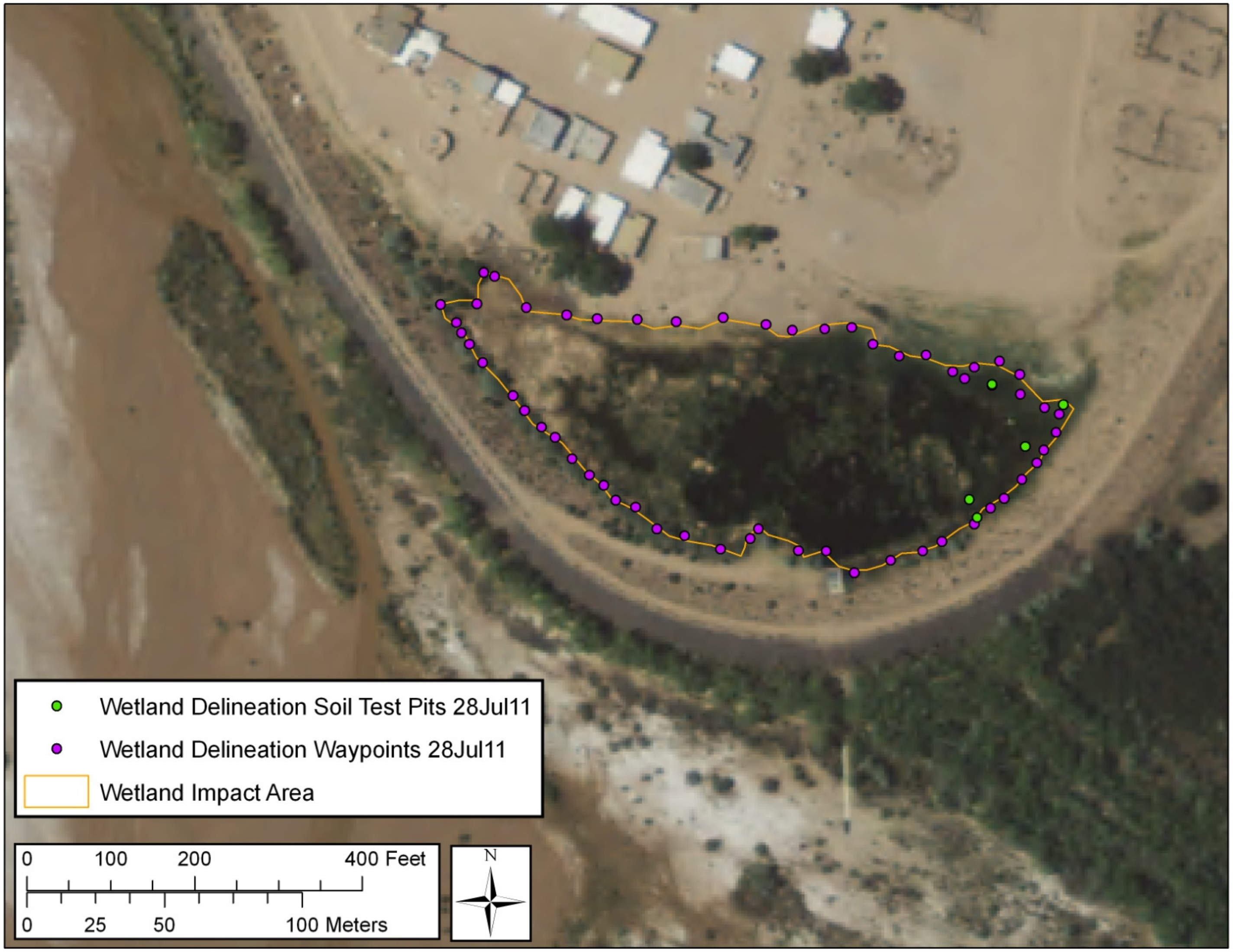
Tamaya Pond Wetland Delineation Map, 28 July 2011



Enclosure B: Wetland Mitigation Ratio Determination

SPD mitigation ratio setting checklist

<table>
<tr><td rowspan="2">1</td><td colspan="4">Date: ___25 Sept 2012_______ Corps file no.: ____________________ Project Manager: __D. Price__________________

Impact site name: ____ Tamaya Pond ____ ORM impact resource type: ____________________
Impact Cowardin or HGM type: ___ P EM ____________ Impact area (acres): ___3.3_____________ Impact distance (linear feet): ____________________</td></tr>
<tr><td>P EM = Palustrine, emergent wetland, persistent, permanently (interior) to semipermanently (periphery) flooded, impounded. NOTE: wetland created by levee; water levels manipulated by pumping. Perennial, obligate wetland vegetation is present in deeper interior zone whereas periphery has mix of obligate and facultative species.</td><td>Column A:
Mitigation site name: __Sedge Meadow__
Mitigation type: Compensatory Mitigation; Preservation, on-site, out of kind
Resource type: _Wet sedge meadow_
Cowardin/HGM type: _ Palustrine persistent emergent, seasonally/ intermittently flooded _</td><td>Column B (optional):
Mitigation site name: _ New wetland pond excavated to groundwater
Mitigation type: Compensatory Mitigation, on site, in kind _
Resource type: Emergent wetland
Cowardin/HGM type: Palustrine persistent emergent, permanently to semipermanently flooded</td><td></td></tr>
</table>

2	**QUALITATIVE impact-mitigation comparison:** Has a Corps-approved functional/condition assessment been obtained? If not, complete step 2; otherwise, complete step 3. Yes ☐ No ☒ a. Short/long-term surface water storage b. Subsurface water storage c. Moderation groundwater flow/discharge d. Dissipation of energy e. Cycling of nutrients f. Removal of elements and compounds g. Retention of particulates h. Export of organic carbon i. Maintenance of plant and animal communities	Note: steps 2 and 3 are mutually exclusive. If step 2 is used, then complete the rest of the checklist (steps 4-10). Starting ratio: 1:1 Ratio adjustment: _+5__ Baseline ratio: _6:1_ PM justification: **a: +0** Surface water storage in mitigation area is by overbanking and is transient in nature, whereas surface water storage at impact site is semi-permanent. However, impact site has managed hydrology (impounded; pumped to draw down water). **b and c: 0**. Soils at both sites are sandy alluvium and both sites are similarly able to store subsurface water and moderate groundwater flow. **d: +1** Both sites would dissipate energy, but under different circumstances. Mitigation site is connected to river channel and able to dissipate energy from high flows, whereas impact site dissipates energy from storm flows through the village. **e: +1.** Impact site likely performs more nutrient cycling due to permanent surface water and concentration of wildlife. **f: +3.** Impact site likely removes compounds from surface runoff in vicinity of Tamaya Pueblo. Mitigation site is not positioned to perform this function. **g & h: 0.** Both sites able to retain particulates and export carbon. **i: +0.** Although qualitatively different, both sites maintain native plant communities that in turn support wildlife. Permanent water makes impact site valuable; however, this value is detracted from by the proximity to human habitation, grazing, burning, trash, and invasives.	Starting ratio: 1:1 Ratio adjustment: _-0.5_ Baseline ratio: _0.5:1_ PM justification: This wetland would be excavated to a depth such that groundwater would be present year-round. It is expected that this created wetland will function very similarly to the impacted site. Stressors (managed hydrology, human impacts) present at impact site **a: -0.5** Surface water storage potential at mitigation site is potentially greater than impact site because it is connected to the floodplain. Impact site has managed hydrology (impounded; pumped to draw down water). **b and c: 0.** Soils at both sites are sandy alluvium and both sites are similarly able to store subsurface water and moderate groundwater flow. Groundwater flow would not change significantly due to excavation for mitigation site. Impact area would lose some water storage capacity but due to sandy fill would still retain some ability to store water. **d: 0.** **e: 0** Mitigation area would have similar vegetation and similar ability to cycle nutrients as impact area. **f: +0.5** (would remove compounds, but not from water near inhabited area) **g, h: 0** **i: -0.5.** The constructed wetland would have greater wildlife benefits than the impact area because it would not be adjacent to an inhabited area. The impact site is subject to grazing, trash, and unplanned burning. It also has invasive species that are not being managed.	

3	**QUANTITATIVE impact-mitigation comparison:** Use step 3 if a Corps-approved functional/condition assessment has been obtained. Use Before-After-Mitigation-Impact (BAMI) spreadsheet (attachment 12501.4) (if a district-approved functional/condition method is not available, use step 2 instead). See example in attachment 12501.2.	Note: steps 2 and 3 are mutually exclusive. If step 3 is used, steps 3 and 5 may also be mutually exclusive. If a functional/ condition assessment method is used that explicitly accounts for area (such as HGM), steps 3 and 5 are mutually exclusive; however, if a method is used that does *not* explicitly account for area (such as CRAM), then both steps should be used. Complete the rest of the checklist (steps 4-10 or steps 4 and 6-10, as appropriate). Baseline ratio from BAMI procedure (attached): __:__	Baseline ratio from BAMI procedure (attached): __:__	
4	**Mitigation site location:**	Ratio adjustment: +0 PM justification: Mitigation site is in same segment of the Rio Jemez.	Ratio adjustment:+0 PM justification: Mitigation site is in same segment of the Rio Jemez.	
5	**Net loss of aquatic resource surface area:**	Ratio adjustment: +1 PM justification: Preservation	Ratio adjustment: +0 PM justification: Establishment (creating new wetland habitat)	
6	**Type conversion:**	Ratio adjustment: +1 PM justification: Mitigation area is a different habitat type from impact site. Both are rare habitat types in the watershed; however, presence of permanent water in a seasonally dry watershed gives the impact area higher value.	Ratio adjustment: +0 PM justification: This created wetland habitat would be designed to be very similar to the impacted site; emergent vegetation with a shrub fringe.	
7	**Risk and uncertainty:**	Ratio adjustment: **+0** PM justification: (**+0.5**) Likely need for long-term maintenance - exotic species (Tamarisk) removal. Pueblo of Santa Ana has already accomplished extensive Tamarisk control at this site. (- 0.5) Impact site is a public health risk due to proximity to human habitation, presence of mosquitoes and offensive odors associated with stagnant water.	Ratio adjustment: **0** PM justification: (**+0.5**) Mitigation site did not formerly support targeted aquatic resources; possible need for long-term maintenance including exotic species removal or removing sediment. (- 0.5) Impact site is a public health risk due to proximity to human habitation, presence of mosquitoes and offensive odors associated with stagnant water.	

8	**Temporal loss:**	Ratio adjustment: +0 PM justification: Herbaceous wetland already exists; benefits are immediate.	Ratio adjustment: +0.5 PM justification: Construction of wetland would occur concurrently with impact; however, time would be required for vegetation (shrubs and herbaceous) to become established. Using +0.5 because - most of the vegetation will be herbaceous and willows from whips, which establish quickly. - vegetation and soil will be transplanted from impact site, and would rapidly establish the new wetland community..	
9	**Final mitigation ratio(s):**	Column A: 1. Baseline ratio from step 2 or 3 = _6:1_ 2. Total adjustments = _+2_ 3. Final ratio: **_8 : 1__** Proposed impact (total): _1.65acre (note—half of the 3.3-acre impact site) ___ linear feet to Resource type: _cattail-bulrush pond___ Cowardin or HGM: _ emergent wetland, permanently/semipermanently flooded _ Required mitigation: _26.4_ acre ___ linear feet of Mitigation type: _preservation, on-site, out-of-kind____ Resource type: _sedge meadow ______ Cowardin or HGM: _ emergent wetland , seasonally/ intermittently flooded_	Column B: 1. Baseline ratio from step 2 or 3 = **0.5:1** 2. Total adjustments = +0.5 3. Final ratio: _1 : 1_ Remaining impact: __1.65acre (note—half of the 3.3-acre impact site) Required mitigation: _1.65_ acre ___ linear feet of Mitigation type: _establishment, on-site, in-kind_ Resource type: cattail-bulrush pond__ Cowardin or HGM: _ emergent wetland, permanently/ semipermanently flooded Additional PM comments: This situation is unusual because the Corps is mitigating for past federal actions that impact the Pueblo of Santa Ana and Tamaya Village.	

10	**Final compensatory mitigation requirements:**	PM summary: Proposed mitigation is a combination of establishment and preservation. Sufficient acreage exists to mitigate entirely with preservation; however, this would not replace the permanent water source that is an important resource in the watershed. Therefore, half the acreage will be mitigated by establishing a permanent emergent wetland with ~25% open water for wildlife. The remainder will be mitigated by preservation of the wet sedge meadow , including maintenance removal of saltcedar as required. Establishment of in-kind, on-site, permanently flooded emergent wetland : 1.65 acre Preservation of wet sedge meadow, including ongoing saltcedar control: 13.2 acres

Enclosure C: Data Forms

Cottonwood and shrub monitoring (filled pond and mitigation area slopes)

Herbaceous species monitoring (created wetland, including grasses on slopes, and preservation area)

Cottonwood and Riparian Shrub Monitoring Field Data
Tamaya Drainage Wetland Mitigation Project

Planting Location (select one):	Sample Unit (select one):	Field Crew:	Date:	Time:
☐ Tamaya Village ☐ Mitigation Created Wetland	☐ 1 ☐ 4 ☐ 2 ☐ 5 ☐ 3			

Photo Log (note photo numbers, directions and descriptions here):

1

2

3

4

Plant ID refers to the unique number on each tree tag.

Plant Condition is healthy, stressed, or dead.

DBH is the diameter of the tree at 1.4 m from the ground.

Shrub height to nearest 0.1m if below 2m, then to nearest 0.5m

Plant ID	Plant Condition	DBH (trees) / Height (shrubs)	Comments

Are weeds or invasive species present? ☐ Yes ☐ No

If so, what species?

Estimated percent cover: ☐ 0-25% ☐ 26-50% ☐ 51-75% ☐ 76-100%

Wildlife Observations:

Signs of mammal use present? ☐ Yes ☐ No

If so, what signs observed?

Riparian Birds present? ☐ Yes ☐ No

If so, what species?

Waterfowl present? ☐ Yes ☐ No

If so, what species?

Aquatic Herptiles present? ☐ Yes ☐ No

If so, what species?

Aquatic Invertebrates present? ☐ Yes ☐ No

If so, what taxa?

General comments, notes, site descriptions.

Herbaceous Species Monitoring Field Data
Tamaya Drainage Wetland Mitigation Project

Planting Location (select one):	Sample Unit (select one):	Field Crew:	Date:	Time:
☐ Tamaya Village ☐ Mitigation Created Wetland ☐ Mitigation Preservation Area (Wet Meadow)	☐ 1 ☐ 4 ☐ 2 ☐ 5 ☐ 3			

Photo Log (note photo numbers, directions and descriptions here):

1

2

3

4

Genus-species	Common name	Cover %	Wetland Indicator Status and Comments

Percent cover in general area: ☐ 0-25% ☐ 26-50% ☐ 51-75% ☐ 76-100%

Are weeds or invasive species present? ☐ Yes ☐ No

If so, what species?

Estimated percent cover: ☐ 0-25% ☐ 26-50% ☐ 51-75% ☐ 76-100%

Wetland Indicator Observations:

Hydric soil indicators present? ☐ Yes ☐ No
If so, what indicators observed?

Wetland hydrology indicators present? ☐ Yes ☐ No
If so, what indicators observed?

Wildlife Observations:

Signs of mammal use present? ☐ Yes ☐ No
If so, what signs observed?

Riparian Birds present? ☐ Yes ☐ No
If so, what species?

Waterfowl present? ☐ Yes ☐ No
If so, what species?

Aquatic Herptiles present? ☐ Yes ☐ No
If so, what species?

Aquatic Invertebrates present? ☐ Yes ☐ No
If so, what taxa?

General comments, notes, sites descriptions.

Section 404 (b) (1) Evaluation – Tamaya Drainage Project

I. Project Description

The Tamaya Drainage Project is proposed by the U.S. Army Corps of Engineers (Corps), Albuquerque District, to eliminate the ponding of water within the Santa Ana Pueblo protection works (levee) adjacent to the historic village of Tamaya. The proposed action would fill the ponded area, which has developed into a wetland over the years. Mitigation for the loss of this 3.3-acre wetland is proposed to consist of creation of a 1.65 acre permanent wetland and preservation of 13.2 acres of wet meadow. A mitigation plan has been formulated and is included as part of Appendix B of the Draft Implementation Report and Environmental Assessment (IR/EA) for the project.

a. Location

The proposed action area is located in Sandoval County, New Mexico on Pueblo of Santa Ana trust lands (Figure 1). The action area includes the pond, levee, access road (BIA route 74) and two mitigation areas: 1) the wet meadow preservation area located on the right bank of the Jemez River, across the river from Tamaya Village, and 2) the created wetland mitigation site, located near the Jemez Weir 1.75 miles downstream from the village. The pond is located at approximate coordinates 35°25’35”N, 106°37’00”W and the created wetland mitigation site is located at approximate coordinates 35°24’27”N, 106°35’32”W.

b. General Description

The pond would be filled to approximate elevation 5233’ using 32,000 cubic yards of fill material from two potential sources: 1) sediment excavated from the mitigation wetland creation site and 2) sediment that was previously removed from the Rio Grande as part of a Section 1135 ecosystem restoration project and has been stored near the Jemez Canyon Dan spillway. The fill would be sloped to 0.8%. A correspondingly sloped passive groundwater collecting network and drainage pipe would be installed to direct subsurface flow to a central vault for active pumping for management of excess surface water or groundwater. The fill elevation and haul route would be adjusted as needed to avoid cultural resources.

c. Authority and Purpose

Authorization

The U.S. Army Corps of Engineers, Albuquerque District (Corps), in cooperation with and at the request of the Pueblo of Santa Ana (Pueblo), would conduct the proposed action under its Operations authority for the Jemez Canyon Dam and Reservoir Project (JCDR). Detailed information about the history and authorized purposed of the JCDR is provided in the Environmental Assessment, Section 1.

Purpose and Need

The fundamental purpose of the project is human health and safety. The pond is considered to be an undesirable feature by the Pueblo due to stagnant water, unpleasant smells associated with anaerobic conditions, breeding mosquitoes, and the presence of a potential safety hazard adjacent to the historic village. The Pueblo has long sought a remedy for these issues. A detailed history is provided in the Environmental Assessment.

Based on these problems, a number of key purpose and needs of the Proposed Action were developed and include:

- Eliminate breeding area for disease-carrying mosquitoes
- Eliminate drowning hazard adjacent to village
- Preserve cultural and historical resources
- Improve aesthetics by replacing stagnant, anaerobic water with native riparian vegetation and grasses
- Provide, through the creation of a mitigation wetland, a water source for wildlife in a location removed from human use
- Reduce populations of invasive plants, such as saltcedar
- Provide pedestrian access from Tamaya Village to the river
- Protect and manage the wet meadow to prevent further invasion of saltcedar.
- Develop and implement a long-term monitoring and adaptive managment plan.

d. General Description of Dredged or Fill Material

(1) General Characteristics of Material (grain size, soil type)
Fill material would originate from two sources. First, excavated soils from the created wetland would be used to the extent practicable. The created wetland site is situated within the Riverwash soil map unit. This is a sandy to sandy loam soil derived from alluvium. It is somewhat poorly drained with slopes of one to three percent. Riverwash is a nonsaline soil with calcium carbonate content below one percent.

The second source of fill would be sediments excavated form the Santa Ana Section 1135 Ecosystem Restoration Project on the Rio Grande. This material has a hydraulic conductivity value of a well to poorly sorted sand (26 and 62 feet/day respectively). It has been tested and found to be free of contaminants or toxic substances (see Appendix E of the Draft IR/EA

(2) Quantity of Material (cu. yds.)
The approximate quantify of material to be removed from the mitigation site would be 25,155 cubic yards. The quantity neded to fill the pond is approximately 32,000 cubic yards. .

(3) Source of Material
See above.

e. Description of the Proposed Discharge Site(s)

(1) Location (map) See Figure 1.
(2) Size: 3.3 acres
(3) Type of Site: confined by levee and adjacent high ground
(4) Type(s) of Habitat: Palustrine emergent wetland with managed hydrology (water level controlled by pumping).
(5) Timing and Duration of Discharge
Construction would occur outside the migratory bird nesting season. Approximately 50 days of hauling and placing fill would be required.

f. Description of Disposal Method (hydraulic, drag line, etc.)

This material would be removed from the mitigation site by excavator and trucked to the pond site. Excess material is not expected; however, if there is excess, it would be hauled off site and deposited at an approved upland location.

II. Factual Determination

There would be permanent loss of 3.3-acres of wetland. This loss would be mitigated by creation of a 1.65-acre wetland with similar structure and function, as well as preservation of 13.2 acres of wet meadow.

a. Physical Substrate Determinations

(1) Substrate Elevation and Slope – Substrate elevation at the pond (impact site) is 5230-5240'. The pond would be filled to approximate elevation 5233'. The fill would not be of uniform elevation but would be sloped towards a groundwater collection sump. The elevation at the mitigation site is approximately 5196'. The mitigation site would be excavated up to. 10 ft. below the current surface to reach groundwater, and three feet below this level to create a groundwater-fed wetland.

(2) Sediment Type – Sediments to be excavated form the mitigation site and used in filling the pond are those described in d.(1). Existing sediments in the impact site vary, with sandy material at the edges and fine-grained mucky material in the permanently flooded cattail part of the wetland.

(3) Dredged/Fill Material Movement - Material excavated from the mitigation site would be removed by an excavator and placed directly into a dump truck to be used in filling the pond. Material from the sediments stockpile near the Jemez Canyon Dam spillway would be loaded into trucks and transported to the impact site. Approximately 5,000 square feet of soil and sediment from the edges of the impact site would be moved to the mitigation site when transplanting wetland plants.

(4) Physical Effects on Benthos (burial, changes in sediment type, etc.) – Benthos that currently exists at the pond would buried. Some of the organisms would be

salvaged along with plant material that would be removed for transplanting. Creation of the mitigation wetland would provide a substrate for colonization by similar benthic organisms.

(5) Other Effects – Mosquitofish (*Gambusia affinis*) that were previously introduced into the pond would be affected by filling the pond. These fish are not native to the Jemez River. Tiger salamanders *(Ambystoma tigrinum)* would also be affected. This is an unavoidable impact. Due to the mucky substrate it would be very difficult to capture them for salvage. Salamanders colonized the pond naturally without human assistance, and are also expected to colonize the mitigation wetland in time.

(6) Actions Taken to Minimize Impacts –

- A wetland mitigation plan has been formulated and is included in this Appendix to the Draft IR/EA.
- Construction would take place outside the migratory bird nesting season
- Sediment and erosion controls would be during the construction period and before the created wetland slopes or banks are permanently stabilized. A Storm-Water Pollution Prevention Plan is required is required for this action.
- All fuels and lubricants would be stored outside of the 100-year floodplain of the Jemez River and construction equipment would be inspected daily and monitored during operation to prevent leaking fuels or lubricants from entering surface water.
- All construction equipment would be cleaned with a high-pressure water jet before entering and upon leaving the project area to prevent introduction or spread of invasive species. Equipment that was previously used in a waterway or wetland would be disinfected to prevent spread of aquatic disease organisms such as chytrid fungus. Disinfection water shall be contained in a tank or approved off-site facility and shall not be allowed to enter water ways or to be discharged prior to being treated to remove pollutants.
- Following construction, the soil at the filled pond site would be stabilized and revegetated with appropriate native plant species including riparian grasses, shrubs and trees. The wetland mitigation site would be planted to wetland species and riparian shrubs. Grasses would be planted in the upland disturbed areas surrounding the mitigation wetland.

b. Water Circulation, Fluctuation and Salinity Determinations

There would be no impact to the water within the channel of the Jemez River. Water within the pond would be eliminated. The created wetland would fill with groundwater.

(1) Water – The pond (impact) site where water currently exists would be filled and drained. The mitigation site, which is currently dry, would fill with groundwater. There would be no change to the wet meadow preservation area. Normally this site has saturated soil but no surface water. Water levels at the mitigation site would be monitored visually, as surface water is expected to be present year-

round. If the water level in the mitigation wetland drops below the surface, monitoring wells would be installed and the Adaptive Management Plan would be implemented (see Mitigation Plan). No changes in the following water quality parameters are expected, unless noted below:

(a) Salinity
(b) Water Chemistry (Ph, etc.)
(c) Clarity
(d) Color
(e) Odor – The odors associated with stagnant water at the pond would be eliminated.
(f) Taste
(g) Dissolved Gas Levels – DO levels may change over time in the created wetland as the vegetation and biota develop.
(h) Nutrients – Nutrient levels may change over time in the created wetland.
(i) Eutrophication – Eutrophication would be monitored at the created wetland.
(j) Others as Appropriate

(2) Current Patterns and Circulation – Does not apply, except as noted. There is no circulation of water at the pond, nor would there be at the mitigation site; both are fed by groundwater.

(a) Current Patterns and Flow –.
(b) Velocity –.
(c) Stratification –.
(d) Hydrologic Regime – Hydrologic regime at the pond is currently manipulated but there is permanent water in parts of the pond. Hydrologic regime of the created wetland would be a permanent wetland.

(3) Normal Water Level Fluctuations (tides, river stage, etc.) - There is no normal fluctuation at the pond because the water level is manipulated by pumping. Normal fluctuations based on river stage and depth to groundwater would occur at the created wetland.
(4) Salinity Gradients – NA.

(5) Actions That Will be taken to minimize impacts:
- A more detailed groundwater investigation would be conducted before construction of the created wetland. Presence of surface water would be monitored after the mitigation wetland is complete.
- .Sediment and erosion controls would be used during the construction period and before wetland banks are permanently stabilized, as described above under a(6).

c. Suspended Particulate/Turbidity Determinations

For the following discussion, only the created wetland mitigation site was considered. Because the pond will be filled, the following parameters would not be relevant to the impact site. For example, after the pond is filled there would be no turbidity because there would be no water.

(1) Expected changes in suspended particulates and turbidity levels in vicinity of disposal site – Suspended particulates and turbidity at the created wetland would be present after construction but are expected to decrease over time as the wetland develops.

(2) Effects –The above would not have significant effects to biota since organisms that are suited to the site conditions would colonize the created wetland.

(a) Light Penetration – Light penetration would increase following construction as the banks stabilize and turbidity decreases, but may decrease over time as the wetland develops and fills with organisms.

(b) Dissolved Oxygen – Dissolved oxygen (DO) would likely be low initially since the water source is groundwater. As wetland plants develop, DO levels are expected to improve.

(c) Toxic Metals and Organics – Toxic metals and organics are not anticipated to occur. The Rio Grande sediment to be used in filling the pond has been tested (see Appendix E). Sediment excavated from the created wetland mitigation site would also be used to fill the pond, and would contain only those constituents naturally present in the existing soils at the mitigation site. For the same reason, toxic metals and organics are not anticipated to occur. in the created wetland.

(d) Pathogens – NA.

(e) Aesthetics – Aesthetics would be altered for a short time during construction. Aesthetics at the pond would improve as stagnant water is eliminated. Aesthetics at the mitigation site would improve as standing dead/defoliated saltcedar is removed and replaced with a diverse wetland.

(f) Others as Appropriate

(3) Effects on Biota – Macroinvertebrates, microinvertebrates, amphibious and/or fish species would be affected by filing the pond. Until the created wetland is fully developed and functional, the following factors would be temporarily be affected:
(a) Primary Production, Photosynthesis
(b) Suspension/Filter Feeders
(c) Sight Feeders

(4) Actions taken to minimize impacts: See actions listed under Section II.a(6).

d. Contaminant Determinations - Contaminants would not be increased due to construction of this project. Sediments used for fill would originate either from the same river segment, or from the previously-tested Rio Grande sediments. Therefore, the required determinations pertaining to the presence and effects of contaminants can be made without additional testing.

e. Aquatic Ecosystem and Organism Determinations - Since there is no anticipated addition of contaminants due to construction, the following would not be affected by construction of the project due to contaminants.

(1) Plankton
(2) Benthos
(3) Nekton
(4) Aquatic Food Web
(5) Special Aquatic Sites
   (a) Sanctuaries and Refuges – Not applicable.
   (b) Wetlands – As described, a wetland would be filled and mitigated. Refer to the mitigation plan.
   (c) Mud Flats – Not applicable.
   (d) Vegetated Shallows - Not applicable.
   (e) Coral Reefs – Not applicable.
   (f) Riffle and Pool Complexes – Not applicable.

(6) Threatened and Endangered Species - Refer to Section 5.2.3 of the Draft IR/EA. The Corps has determined that there would be no effect to listed species or critical habitat due to the proposed action.

(7) Other Wildlife – As stated in Section 5.2.2 of the Draft IR/EAthe proposed action would result in unavoidable short-term impacts to wildlife. During construction, waterfowl and riparian birds would be displaced. Non-native aquatic animals inhabiting the pond (mosquito fish and bullfrogs) would perish. Native tiger salamanders are expected to colonize the mitigation wetland following construction.

(8) Actions to Minimize Impacts – See actions listed under Section II.a(6). Actions to minimize impacts as described in the Draft IR/EA would be implemented, including the following:
   - Construction would take place outside the migratory bird nesting season
   - All fuels and lubricants would be stored outside of the 100-year floodplain of the Jemez River and construction equipment would be inspected daily and monitored during operation to prevent leaking fuels or lubricants from entering surface water.
   - All construction equipment would be cleaned with a high-pressure water jet before entering and upon leaving the project area to prevent introduction or spread of invasive species.
   - Following construction, the soil at the filled pond site would be stabilized and revegetated with appropriate native plant species including riparian grasses, shrubs and trees. The wetland mitigation site would be planted to wetland

species and riparian shrubs. Grasses would be planted in the upland disturbed areas surrounding the mitigation wetland.

f. Proposed Disposal Site Determinations – It is anticipated that all excavated material would be used for placement of fill. If this is not practicable, an upland disposal site would be identified.

(1) Mixing Zone Determination – Not applicable.

(2) Determination of compliance with applicable water quality standards –The Environmental Protection Agency (EPA) administers Section 401 Water Quality Certification (WQC) for tribes that do not have water quality certifying authority, including the Pueblo of Santa Ana. The Draft IR/EA and this 404(b)(1) analysis are being provided to the EPA with a request for review.

(3) Potential effects on human use characteristic – Human use would be improved by the proposed project.

(a) Municipal and private water supply – The proposed project is not within or adjacent to municipal or private water supplies.

(b) Recreational and commercial fisheries - Not applicable.

(c) Water related recreation – No recreational resources would be affected by the proposed project.

(d) Aesthetics – There would be short-term affects during construction. As discussed above, aesthetics would improve in the long term when stagnant water is eliminated from the vicinity of Tamaya Village.

(e) Parks, National and Historic Monuments, National Seashores, Wilderness Areas, Research Sites, and similar preserves – The proposed project is not within any such areas.

g. Determination of Cumulative Effects on the Aquatic Ecosystem – Cumulative effects on the ecosystem would be minimal over the long term due to implementation of the mitigation and monitoring plan.

h. Determination of Secondary Effects on the Aquatic Ecosystem - Secondary effects would be minimal and are expected to be beneficial. .

III. Findings of Compliance or Non-Compliance with the restrictions on discharge

a. Adaptation of the Section 404(b) (1) Guidelines to this Evaluation – Not applicable (the guidelines were not adapted).

b. Evaluation of Availability of Practicable Alternatives to the Proposed Discharge site which would have less adverse impact on the aquatic ecosystem

There is no feasible alternative that would accomplish the project purpose. Alternatives that have been analyzed are presented in Section 4 of the EA..

c. Compliance with applicable state water quality standards

The proposed action is on Tribal land and is not within state jurisdiction. Concurrence (and a 401 water quality certificate, if required) from the USEPA would be obtained prior to start of construction.

d. Compliance with applicable toxic effluent standard or prohibition under Section 307 of the Clean Water Act

Not applicable.

e. Compliance with Endangered Species Act of 1973

The proposed project is in compliance with the Endangered Species Act of 1973. Effects on listed species have been determined and are discussed in Section 5.2.3 of the Draft IR/EA. The Corps has determined that there would be no effect to listed species by the proposed project.

f. Compliance with specified protection measures for marine sanctuaries designated by the Marine Protection, Research and Sanctuaries Act of 1972

Not applicable.

g. Evaluation of Extent of Degradation of the Waters of the United States

(1) Significant adverse effects on human health and welfare – No significant adverse effects on human health or welfare would occur due to the proposed project.

(a) Municipal and private water supplies – No effect to municipal or private water supplies would occur from the proposed project.

(b) Recreation and commercial fisheries – No effect to recreation or commercial fisheries would occur from the proposed project.

(c) Plankton – Plankton would not be affected by the proposed project.

(d) Fish – Only non-native fish species would be affected.

(e) Shellfish – Shellfish would not be affected by the proposed project.

(f) Wildlife – Only short-term affects to wildlife would occur during construction. There would be a long-term benefit because a water source that is not adjacent to human habitation would be created.

(g) Special Aquatic sites – No applicable.

(2) Significant adverse effects on life stages of aquatic life and other wildlife dependent on aquatic ecosystems – There would be temporary adverse effects on life stages of aquatic life and other wildlife dependent on aquatic ecosystems until the mitigation site is fully developed.

(3) Significant adverse effects on aquatic ecosystem diversity, productivity and stability - There would be temporary adverse effects on aquatic ecosystem diversity, productivity and stability.

(4) Significant adverse effects on recreational, aesthetic, and economic values - There would not be significant adverse effects on recreational, aesthetic, and economic values.

h. Appropriate and practicable steps taken to minimize potential adverse impacts of the discharge on the aquatic ecosystem – All of the actions to minimize potential adverse impacts of the proposed project as listed above include:

- A wetland mitigation plan has been formulated and is included in this Appendix to the Draft IR/EA.
- Construction would take place outside the migratory bird nesting season
- Measures to be taken to avoid any aquatic resources or other sensitive resources within the mitigation site would include flagging and fencing to keep equipment out of cottonwood root zones.
- Sediment and erosion controls would be during the construction period and before the created wetland slopes or banks are permanently stabilized. A Storm-Water Pollution Prevention Plan is required is required for this action.
- All fuels and lubricants would be stored outside of the 100-year floodplain of the Jemez River and construction equipment would be inspected daily and monitored during operation to prevent leaking fuels or lubricants from entering surface water.
- All construction equipment would be cleaned with a high-pressure water jet before entering and upon leaving the project area to prevent introduction or spread of invasive species. Equipment that was previously used in a waterway or wetland would be disinfected to prevent spread of aquatic disease organisms such as chytrid fungus. Disinfection water shall be contained in a tank or approved off-site facility and shall not be allowed to enter water ways or to be discharged prior to being treated to remove pollutants.

- Following construction, the soil at the filled pond site would be stabilized and revegetated with appropriate native plant species including riparian grasses, shrubs and trees. The wetland mitigation site would be planted to wetland species and riparian shrubs. Grasses would be planted in the upland disturbed areas surrounding the mitigation wetland.

i. On the basis of the guidelines, the proposed disposal site(s) for the discharge of dredged or fill material is:

(2) Specified as complying with the requirements of these guidelines, with the inclusion of appropriate and practical conditions to minimize pollution or adverse effects on the aquatic ecosystem.

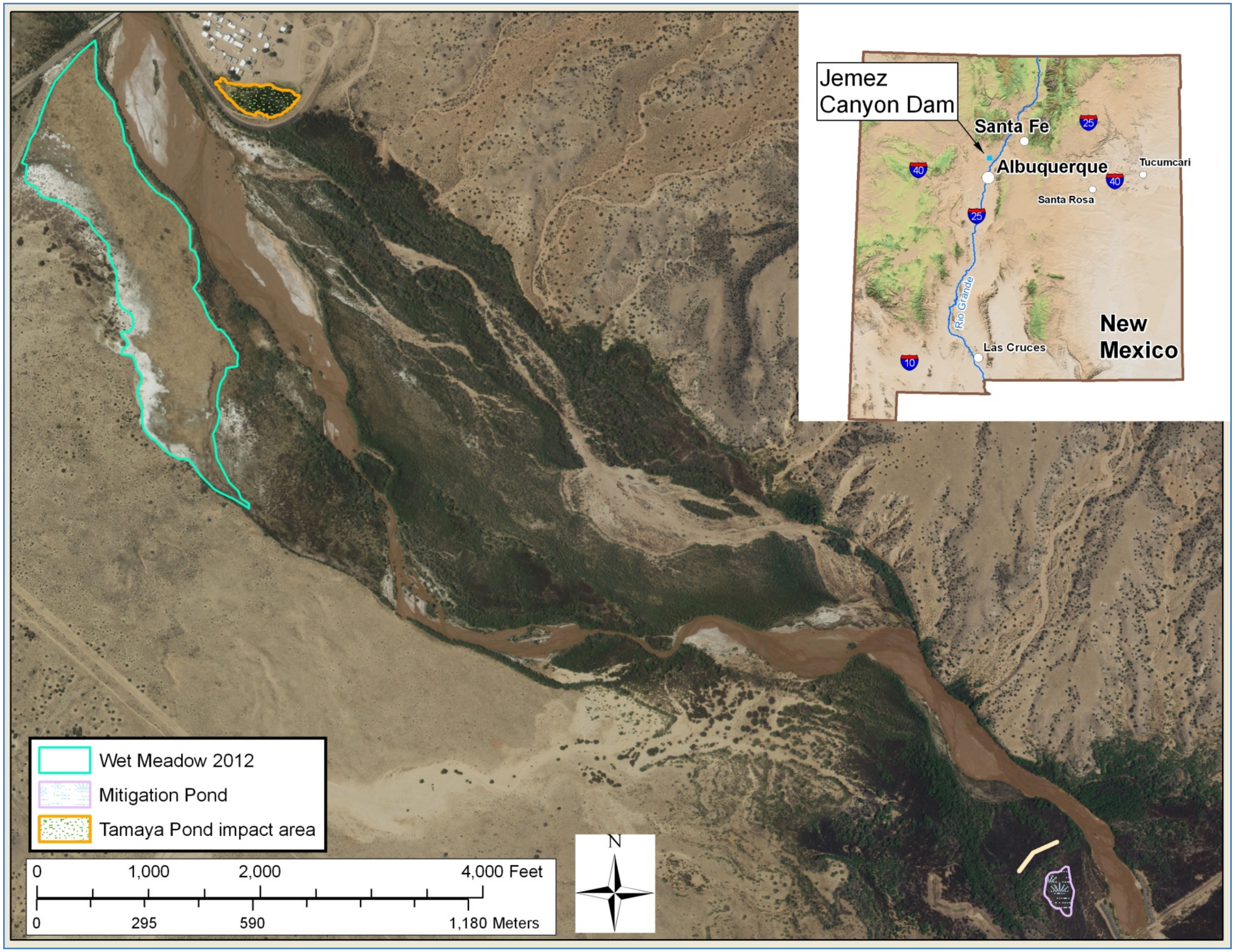


Figure 1: Location of impact and mitigation areas

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 6
1445 ROSS AVENUE, SUITE 1200
DALLAS TX 75202-2733

MAR 11 20[illegible]

Julie Alcon
Chief, Environmental Resources Section
Albuquerque District Corps of Engineers
4101 Jefferson Plaza NE
Albuquerque, NM 87109-3435

RE: Clean Water Act §401 Water Quality Certification for Pueblo of Santa Ana, Tamaya Drainage Project, Sandoval County, New Mexico

Dear Ms. Alcon:

The Wetlands Section of the Environmental Protection Agency, Region 6 (EPA) has reviewed the authorization documentation for the project indicated above under §404 and §401 of the federal Clean Water Act. The project involves pond modification and mitigation near the Tamaya Village. The U.S. Army Corps of Engineers (USACE) is conducting the action under its Operations Authority for the Jemez Canyon Dam and Reservoir Project.

EPA understands that a wetland area will be filled to address health, safety and aesthetic concerns, and that mitigation for unavoidable impacts has been proposed. At this time, the Pueblo of Santa Ana has not adopted water quality standards under the federal Clean Water Act. Water quality standards have been adopted by the state of New Mexico, which apply to nearby areas within this watershed. Although the state's standards do not apply to Pueblo of Santa Ana waters, these standards can provide a technical basis for evaluation of potential projects. To see the complete list of state water quality standards, please refer to the *State of New Mexico Standards for Interstate and Intrastate Surface Waters,* adopted by the New Mexico Water Quality Control Commission (Title 20, Chapter 6. Part 4 of the New Mexico Administrative Code). These standards are available at the following address: http://www.nmenv.state.nm.us/swqb/Standards/index.html.

EPA has coordinated with Pueblo of Santa Ana to determine the appropriateness of the following requirements for certification of this project. The Tribal staff concurred with EPA's approach for §401 certification of the project.

Section 401 Water Quality Certification with Conditions:

Pursuant to §404 of the Clean Water Act, EPA hereby issues §401 Water Quality Certification for this project. This certification is subject to conditions to ensure that the project will comply with water quality standards and the Antidegradation Policy.

Therefore, this Certification is not valid unless the following conditions are adhered to:

1. The Corps has prepared a list of steps to follow to minimize potential adverse impacts associated with this project. Located in the draft Environmental Assessment for the project, Appendix B, Clean Water Act Section 404 Compliance, III.h. Appropriate and practicable steps taken to minimize potential impacts of the discharge on the aquatic ecosystem. That list is incorporated herein in its entirety.

2. Prior to commencement of the project, the Corps shall contact the Pueblo of Santa Ana to obtain a list of emergency response personnel. The Corps shall provide this list to all project specific staff, contractors and subcontractors.

3. The Corps shall notify the Pueblo emergency response personnel of any accidental discharges, or any significant problems with or changes to the project plans that may affect water quality. This applies to both the pond modification and mitigation portions of the project.

A copy of this §401 certification must be kept at the project site during all phases of construction. All contractors involved in this project must be provided a copy of this certification and made aware of the conditions prior to starting construction.

EPA reserves the right to amend or revoke this §401 certification at any time to ensure compliance with water quality standards. If you have any questions regarding this §401 Water Quality Certification please feel free to contact Tom Nystrom of my staff at (214) 665-8331. Thank you for your cooperation in maintaining the water quality of the Pueblo of Santa Ana.

Sincerely,

Jane B. Watson, PhD.
Associate Director
Ecosystems Protection Branch

cc: Mr. Alan Hatch, Director
Department of Natural Resources
Pueblo of Santa Ana
2 Dove Rd.
Santa Ana Pueblo, NM 87004

Appendix C

Hydrology, Hydraulics and Sedimentation

Hydrology, Hydraulics and Sedimentation

Supplemental Technical Information

The following information describes the technical information developed to support description of existing conditions, as well as engineering alternative designs and their respective effects. This information provides the basis for the related surface water-related summaries provided within the main report.

1. Existing Conditions and Affected Environment

The Rio Jemez originates in the Jemez Mountains of New Mexico, converges with the Rio Grande north of Bernalillo, and is entirely situated in Sandoval County, NM. (The Rio Guadalupe, a tributary of the Rio Jemez and part of the watershed, extends into adjacent Rio Arriba County.) The Rio Jemez flows in a generally southeasterly direction with a total length of approximately 65 miles. Elevation ranges from over 11,000 ft. at the headwaters of the watershed to 5,075 at the confluence with the Rio Grande. The river is perennial in the upper reach and ephemeral in the lower reach above the Jemez Canyon Reservoir due to irrigation diversion upstream. The Rio Jemez in the proposed project area has a sand-bedded, low gradient channel with an elevation of 5,237 ft. at the upstream, northern end of the levee and 5,233 ft. at the downstream, southern end of the levee.

Over the first two and a half decades of the project (as well as currently) Rio Jemez flows typically pass through Jemez Canyon Dam with little, if any, regulation. Reservoir releases are typically restricted to not exceed, in combination with upstream releases, the maximum non-damaging capacity of the downstream channel of the Rio Grande, as measured at Albuquerque, up to 7,000 cfs (USACE 1994). When the passage of inflow to the reservoir has exceeded the channel capacity constraints on the Rio Grande downstream, flood control storage has been initiated. Flood waters have been stored only for the duration needed to evacuate the water as rapidly as downstream conditions permit. Operation of Jemez Canyon Dam for flood control is coordinated with Cochiti and Galisteo Dams in order to regulate for the maximum safe flow at Albuquerque.

In the spring of 1979, the Corps and the New Mexico Interstate Stream Commission (NMISC) established a sediment retention pool of about 2,000 acre-feet at Jemez Canyon Reservoir using water exchanged from the San Juan-Chama Project. The Corps and the NMISC storage agreement expired on December 31, 2000. The NMISC decided not to extend the agreement for sediment pool storage, citing significantly increased demands on available water in the region, its increasing cost, and the need for increased sediment loading to the currently degrading Rio Grande channel as factors in this decision. A partial evacuation of the pool began on September 20, 2000. The pool at Jemez Canyon Reservoir was finally evacuated by October 2001. Since the pool's evacuation, approximately 190 acre-feet of sand-sized material passes through the dam annually. The Corps currently is investigating measures to maintain the passage of sediment through the dam. Subsequent to evacuation of the pool, the Corps and the Pueblo of Santa Ana formulated a mitigation plan to address the resulting onset of channel incision of the Rio Jemez. A low-head weir was constructed in 2004 (Corps, 2003) to prevent further incision and loss of riparian vegetation.

Surface Water Hydrology

The surface water hydrologic needs of the current study included characterization of the surface water conditions to help define the environment, as well as to serve as boundary conditions in support of the groundwater modeling. The scope of surface water evaluations described in this study consist of topographic, hydrologic, hydraulic and sedimentation conditions and variables within the study area for both the Jemez River, as well as some of the ephemeral tributary arroyos adjacent to the Village.

Surface water hydrologic information used for this study came from two primary sources. A watershed hydrologic assessment on the Jemez River above the dam was completed in 2008 by USACE to update frequency discharges at specific locations through numerical modeling using HEC-HMS (Massong, 2008). In addition, estimates of localized hydrologic peak discharges over the Village and a select number of adjacent tributary arroyos near the levee were also prepared in anticipation of alternative formulation. The anticipated alternatives included proposed realignment of the levee, removal or repositioning of the interior pond water in the vicinity of the Village, and alignment and design of flow channels to convey intercepted tributary flows around and away from the Village. These two sources comprise the majority of surface water hydrologic information used in development of this report.

a. Topography

   The drainage area upstream from Jemez Canyon Dam is just over 1,000 square miles with a watershed divide of over 10,600 feet in elevation, but dropping to about 5,100 feet at the dam (Massong, 2008). Figure C-1 shows the overall watershed. During the winter months, heavy snowfall occurs in the upper mountainous areas of the watershed, with much lighter snow over the lower basin. Snow remains in the mountainous areas above elevation 7,000 feet, NGVD from December into April. Below 7,000 feet, NGVD snow seldom stays on the ground more than a few days. The average annual snowfall varies from ten inches at Jemez Canyon Dam to over 100 inches in the mountains.

Runoff response to precipitation is very rapid due to steep slopes in most of the basin. This results in floods with very high peak flows. Flood volumes are usually small due to the storm areal extent. The mountain streams are narrow and steep so flow rises very rapidly and falls rapidly after the peak passes. The Rio Salado channel in the lower reaches and the Jemez River channel below the Rio Salado confluence are wide and sandy with a shallow braided flow pattern that results in rapid attenuation of floods with high peaks and small volumes. The mountains, due to the vegetal cover, have relative high loss rates and significant depression storage in the valleys that greatly reduce runoff. The mesas have flatter slopes, grass and herbal cover with large playas that reduce runoff. The area generally below 6,000 feet, NGVD is covered by semi-desert vegetation and has the lowest loss rates due to the scarcity of vegetation and soils with high clay content (USACE, 1994).

b. Jemez River

Summer thunderstorms with their very high intensity precipitation and short duration often result in 80 percent or greater runoff from this area. Spring runoff from snowmelt during March through June produces most of the annual runoff volume.

Frequency peak discharge values from the Jemez River Watershed Hydrologic Assessment (2008) were adopted for the current study. Those peak values are associated with summer rainstorm events, as opposed to spring snowmelt runoff, and typically exhibit short-duration, low-volume, and high-peak characteristics. Although the largest volume of water passing this gage originates as snowmelt during the spring, the highest peak flows are derived from summer rainstorm events, and were judged to represent a more critical river boundary condition for the subsequent groundwater modeling. A comparison of peak flow data with the mean daily discharge data found that only two of the top ten peak flow events included runoff from snowmelt: 1958 and 1973 (Massong).

The Jemez River gage near Jemez, NM has recorded several large peak flow events since 1936 (Figure C-2), with the largest flow of almost 6,000 cfs in 1958. Although the two largest flows occurred prior to 1965, the top ten flows occur throughout the period of record, with the third and fourth largest flows occurring in the 1980s and 1990s. A review of daily data found that spring flows from snowmelt in the Jemez River Watershed usually occurred in April and May, while rain-only flows occurred after May. Typically the rainstorm-driven floods are characterized as a small increase in the mean daily discharge above base flow which ranges from 30-60 cfs. Also, these summer events last for only one day, although a notable exception to this single-day trend occurred in 1967, when over ten days are recorded with daily flows significantly above base flow (100-200 cfs) (Massong, 2008).

Sixteen specified hyetographs were created from eight frequency storm events using HEC-HMS: eight high elevation hyetographs and eight low elevation hyetographs. Then each sub-basin was assigned either a high or a low elevation input hyetograph. Initially, loss rate parameters were assigned based on values from other hydrologic models in the area (Massong and Beach 2008, Massong 2007). However, the simple designation of high versus low elevation was not sufficient in this watershed to create a calibrated model. Initially, each sub-basin was identified based on elevation, but in addition to the high versus low elevation category, two additional categories were incorporated for assigning loss values: middle elevation and canyon sub-basins. Loss parameter adjustment was used for further model calibration (Massong, 2008).

c. Interior Drainage

The interior hydrology for both pond conditions and adjacent tributary flows were derived using the Tamaya watershed hydrologic models, described below, as a basis. HMS models were created to establish the peak discharge frequency and flood hydrographs of four arroyos that drain directly into or near the Tamaya Village. These four ephemeral flow paths drain the adjacent bluff of the Jemez Mesa just to the northwest of the village. In addition, the frequency peak flows and volumes of rainfall within the village and levee were computed to support groundwater modeling efforts

The USGS 7.5 Minute Topographic Quadrangle Map for Santa Ana Pueblo (35106-D5) was used as the primary map for this analysis, with additional digital mapping files such as aerial photographic (.tif) images also used. Data and parameters obtained from the digital mapping included, but were not limited to: delineation of sub-basins and outlet points, identification of sub-basin centroids and flow paths, computation of sub-basin areas and channel slopes, time of concentration and lag time parameters, aerial distribution of vegetation, etc.

The four sub basins of interest contributing to the Jemez River near Tamaya Village were un-gaged watersheds, so the Regional Flood Frequency Equations (RFFE) were selected for use as calibration targets for the sub-basins. The RFFE were obtained from the USGS Water Resources Investigation Report 96-4112 “Analysis of the Magnitude and Frequency of Peak Discharges and Maximum Observed Peak Discharge in New Mexico” (Waltemeyer, 1996). The RFFE selected were for statewide small basins, 10 square miles or less and less than 7500 feet mean basin elevation. The rainfall data used for this hydrologic analysis was obtained from NOAA Atlas 14, accessed on the NOAA’s Precipitation Frequency Server (http://hdsc.nws.noaa.gov/hdsc/pfds/sa/nm_pfds.html).

HMS Version 3.0.0 was used in this analysis. In consultation with senior engineers, and through sensitivity trials, the adopted modeling used the Initial-Constant Loss method to account for losses, and Snyder's Method to transform the unit hydrograph. The final method and run selected to relatively match the RFFE's and best represent the hydrologic conditions, was the Snyder's Method with 0.8 in. initial and 0.3 in./hr. constant loss parameter values.

The methodology used for the interior area was to directly apply the runoff depths from the adjacent watersheds to the village area. The runoff depths and the methodology were judged as applicable because of the consistent conditions - the proximity of the drainage areas to each other, and the similarity in the soil types and infiltration rates. The runoff depths for each frequency event were obtained from the HMS output. This depth was then multiplied by the interior basin area to determine the runoff volume. To account for the impervious areas in the pueblo due to structures, the resulting runoff volumes were increased by 10%. This runoff volume computation was carried out for both the existing levee and for an anticipated realigned levee alternative.

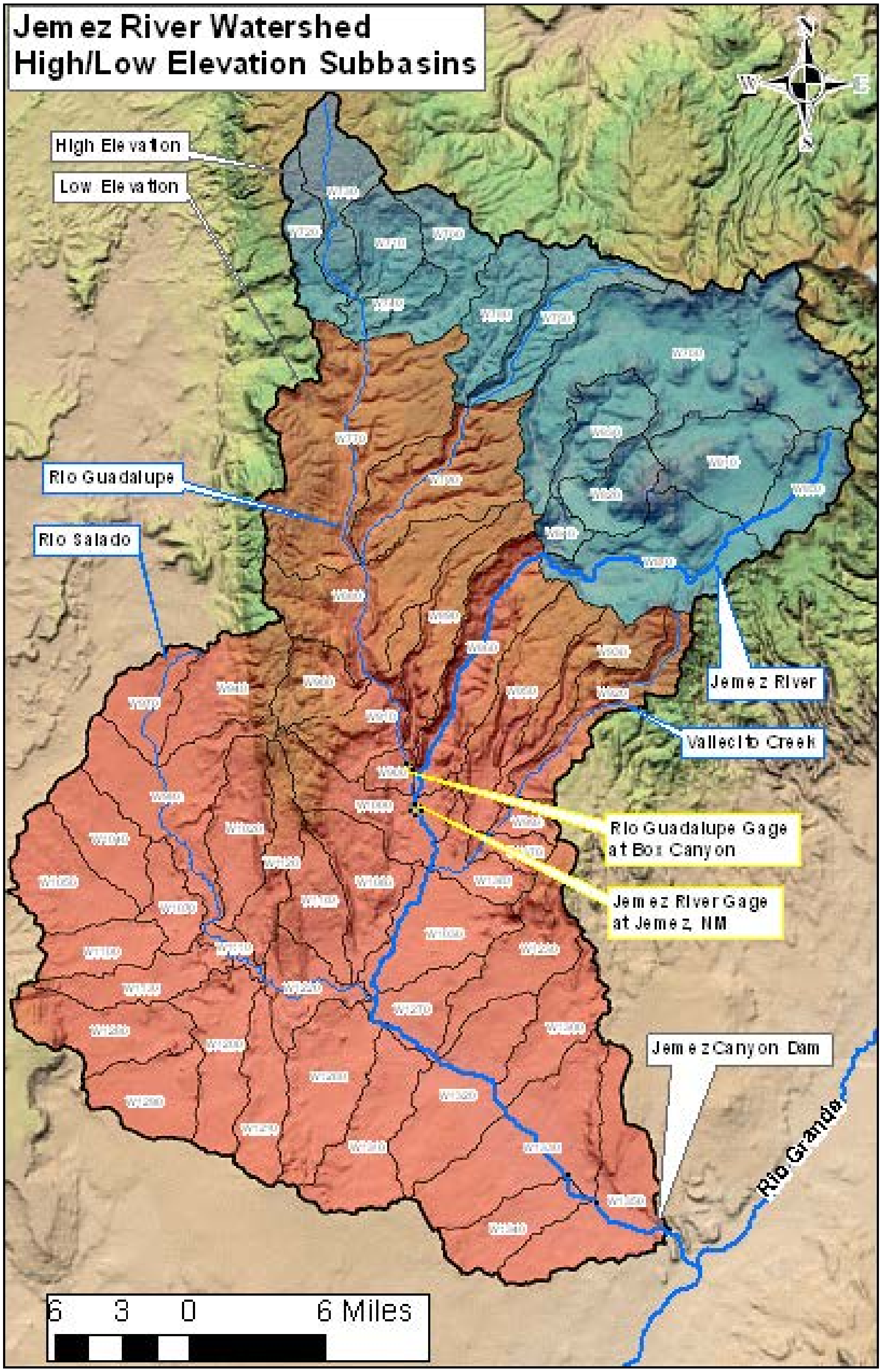


Figure C - 1: Jemez Watershed

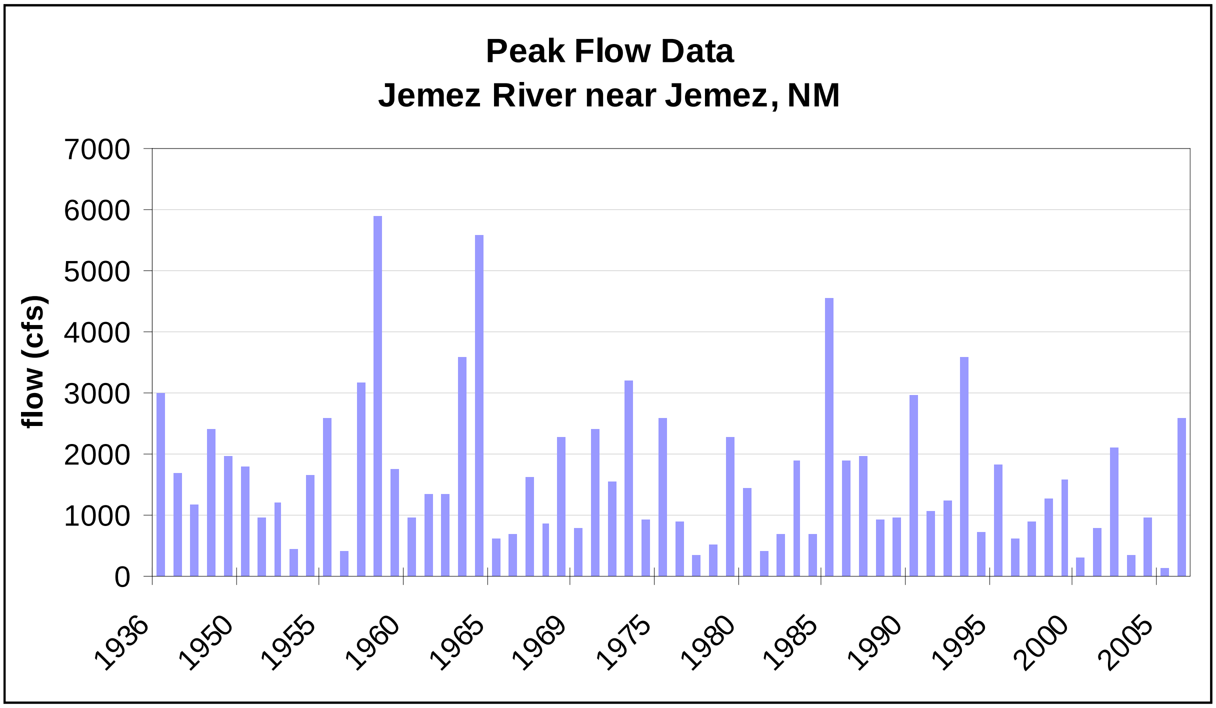


Figure C-2: Peak Flow Data, Jemez River gage near Jemez, NM

d. Hydrologic Conclusions

JEMEZ RIVER - The frequency-discharge data used for the RAS Modeling of the Tamaya Reach on the Jemez River were obtained from the Jemez River Hydrology Report. The peak discharges used for the Tamaya Reach were those generated for the Jemez Reservoir Weir, as shown in Table C.1, below.

INTERIOR AREAS - For the volumetric runoff for frequency storms over the village, the runoff depths for each frequency event were obtained from the HMS output. This depth was then multiplied by the interior basin area to determine the runoff volume. To account for the impervious areas in the pueblo due to structures, the resulting runoff volumes were increased by 10%. Results of these computations are shown in Table C.2, below.

ADJACENT TRIBUTARIES - The resulting frequency peak discharges used for HEC-RAS modeling of the adjacent tributary arroyos are shown in Table C-3, below.

Table C.1 From *Jemez River Hydrology Report* – Model Output at Points of Interest

Return Period	% Chance Event	Jemez Reservoir Weir (cfs)	Flow at Dam (cfs)	Volume at Dam (acre-feet)
500 yr	0.2	28,700	27,700	18,750
200 yr	0.5	21,000	20,700	14,100
100 yr	1	14,730	14,500	10,370
50 yr	2	14,100	13,900	9,690
20 yr	5	8,060	7,900	6,010
10 yr	10	6,400	6,200	4,620
5 yr	20	2,200	2,000	1,400
2 yr	50	1,900	1,700	1,060

Table C.2 Village interior frequency runoff volumes.

$V_{0.50}$ (ac ft)	$V_{0.20}$ (ac ft)	$V_{0.10}$ (ac ft)	$V_{0.05}$ (ac ft)	$V_{0.02}$ (ac ft)	$V_{0.01}$ (ac ft)	$V_{0.002}$ (ac ft)
0.49	1.34	2.36	3.49	4.32	5.23	7.58

Table C-3: Frequency peak discharges of adjacent tributary arroyos

Arroyo Basin ID	$Q_{0.50}$ (cfs)	$Q_{0.20}$ (cfs)	$Q_{0.10}$ (cfs)	$Q_{0.04}$ (cfs)	$Q_{0.02}$ (cfs)	$Q_{0.01}$ (cfs)	$Q_{0.002}$ (cfs)
1	38	103	180	263	324	387	534
2	29	76	132	194	238	284	386
3	62	168	289	422	519	618	844
4	10	28	49	71	86	101	135

Surface Water Hydraulic Conditions

Ground survey data was acquired by the Pueblo and submitted to SPA in the various requested formats. This data included station-elevation and coordinate-elevation data along each established cross section line (XSL). The data also included ground surface descriptions of the channel and overbanks. Field data was also acquired for the measurements of the Tamaya Bridge (BIA 74). This ground survey along the active channel was conducted in February 2008.

In 2002, LiDAR mapping was acquired for the surrounding areas around the Tamaya Village. This 2002 LiDAR mapping was obtained by the Pueblo of Santa Ana and has been used in various activities of the Jemez Canyon Dam Mitigation Project. Because the LiDAR was anticipated for use as a reference surface for various products under this study, it was used as the base datum for the current mitigation analysis.

An HEC-RAS Model was first built for the active channel geometry from the Ground Survey Data only. Aerial images from the USGS 2005 DOQQ along with the ground cover descriptions from the ground survey were used to assign the Manning's roughness "n" values along the active channel. They ranged from 0.035 in the main channel to 0.1 in the dense salt cedar of the overbanks. This model was then calibrated to the actual observed water surface elevations (WSE). Stream gauge records were retrieved from the USGS website for the dates of the ground survey (1Feb08-19Feb08) at the Jemez River near Jemez NM stream gauge (USGS 08324000). The WSE at the time of the ground survey were observed and recorded. The Manning's n values were adjusted accordingly in the main channel and several iterations were rerun until the resulting WSE closely matched the observed WSE within an average of 0.10 feet.

A second HEC-RAS Model was then configured from the Extended Overbank topography merged with the Active Channel Model. A DWG file of the plan view layout of the Ground Survey XSL was provided by the Pueblo of Santa Ana. The XSLs were displayed in ArcMap 9.1. HEC-GeoRAS Version 4 was used to layout and extract the cross sectional ground terrain data. This data was extracted from the 2002 LiDAR TIN Surface that was configured and provided by the Santa Ana Pueblo. The XSL were drawn from left overbank (LOB) to right overbank (ROB), looking downstream. The XSLs were confirmed to catch high ground at both the LOB and ROB. The extended XSLs were carefully drawn over the exact layout of the Ground Survey Active Channel XSLs. This was done to assure accurate comparison between the ground survey data and the LiDAR data and to properly merge the two. Once the extended XS data was extracted from the 2002 LiDAR TIN using GeoRAS, it was imported as a new project in HEC-RAS. The Ground Survey XSLs were then compared with the LiDAR TIN Extended XSL to determine the average difference in shape and elevation between the two data sets. The comparison points were chosen to be at fixed locations with low probability of change between the two survey dates (2002 and 2008), such as along the top of the levee and the bridge abutments. It was determined that the average vertical shift was about +1.15 feet (from Ground Survey to LiDAR). Once the average vertical datum shift was determined, the active channel geometry was then shifted up in the vertical direction to match the 2002 LiDAR datum. Once the ground survey data set was shifted in the vertical direction, it was then merged with the extracted 2002 LiDAR Overbank Geometry. This merging required a horizontal shift in the RAS stationing for most of the XSL. The data sets were merged using Microsoft Excel. The Manning roughness values were then assigned for the overbank areas using the aerial images from the USGS 2005 DOQQ along with the ground cover descriptions from the ground survey. The n values for the channel were copied from the Active Channel RAS Model. All n values ranged from 0.035 in the main channel to 0.1 in the dense salt cedar in the overbanks. Table C-4 lists 'n' values used in the model construction. This second Overbank/Active Channel RAS Model was again calibrated to the observed WSEs on the dates of the ground survey, using the same method and data as before.

The frequency discharges used for the Tamaya Reach were obtained from the Jemez River Hydrology Report. The Jemez Reservoir Weir location was selected to obtain the frequency discharge data. The return period of analysis were the 2, 5, 10, 20, 50, 100, 200 and 500 yr. Additional discharges were also analyzed and these included the 35 cfs for calibration, 300 cfs to represent average spring runoff and 700 cfs which represent the average active channel capacity. Once the Overbank/Active Channel RAS Model was finalized, the models were run for each specific storm event as steady-state, peak discharges. Upon analyzing the output of the runs, it was determined that the geomorphic and hydraulic conditions would require that an overflow analysis be conducted.

Table C-4: Manning's Roughness Value "n" for ground covers in Tamaya Drainage project area

Ground Cover Description	Manning's Roughness Value "n"
River Bottom	0.03 – 0.04
Very Low Density Vegetation	0.035
Braided Channels	0.038
Roadway Embankment	0.03 – 0.05
Grass	0.04
Bluff Mesa	0.045
Cattails	0.05
Low-Med Dense Vegetation in Watershed	0.055
Med Dense Salt Cedar and Vegetation	0.07-0.075
Rip Rap	0.07
High Density Salt Cedar	0.1
High Density Russian Olive	0.1
High Density Cottonwood	0.1

The active channel of the Jemez River DS of the BIA 74 Tamaya Bridge has aggraded and become a perched reach. Just downstream of the bridge, the ROB is characterized by a swale about 3 to 4 feet lower than the channel invert. The LOB is controlled by the levee protecting the Tamaya Village. The levee extends about 1700 feet downstream of the bridge. Downstream of the levee, the LOB is also characterized by a swale about 3 to 4 feet lower than the channel invert. These RAS Models end about 5700 feet downstream of the bridge.

The perched channel and lower overbank swales DS of the bridge give rise to complex channel and overbank hydraulics. The intricate hydraulics required that an overflow analysis be conducted for the majority of the flood events. The overflow analysis results more accurately reflects shared and divided flows between the channel, LOB and ROB, and provides a better representation of the prototype WSEs in each conveyance flow path.

The capacity of the main active channel was determined to be about 700 cfs. All flows above 700 cfs overtop the right bank just DS of the bridge and enter into the ROB. The large flow events (500-, 200-, 100- & 50-yr) flow combined in the main active channel and ROB up to RS 5600 (see Figure C-3, below). At RS 5600, the flows split, with 700 cfs flowing down the main active channel and the remainder flowing down the ROB. At about RS 2600 the ROB flow re-enters the main active channel and then immediately overtops the left channel bank and enters the LOB. About 5900 cfs will continue DS along the combined main channel and ROB. All flows above 5900 cfs will enter the LOB at this location. At the far DS RS 1000, the channel capacity is only about 1000 cfs, with all higher flows overtopping the left bank and entering the LOB. At this lower end, the entire conveyance area, including the main active channel and the floodplain overbanks turn in an eastward direction.

Locations were selected for the extraction of stage-discharge data, to be used as input data for the ground water model to characterize surface water boundary conditions and analyze the interaction between the surface water and the ground water. Stage-Discharge data was determined at the following specified locations (RS 7000, RS 6300, RS 5200, and RS 3000). The data was tabulated individually for the three conveyance areas: main active channel, ROB & LOB.

The downstream boundary of the ground water model was selected at the Jemez Weir. An additional surface water hydraulic model (HEC-RAS) for the Jemez River - Tamaya Reach was configured from an existing HEC-2 model assembled by SPA in 2000 for earlier mitigation studies. This model was imported into HEC-RAS 3.1.1, reviewed and adjusted to assure successful execution and correct data. The Pueblo of Santa Ana also obtained ground survey data just US and DS of the Jemez Weir in the 2008 survey. The ground data for the US and DS XSL were adjusted horizontally to match the RAS XSL stationing of the HEC2 Model and was adjusted vertically to match the datum of the 2002 LiDAR. The vertical datum shift at this location of the weir was previously determined by SPA engineers during the original study to be about +2.52 feet (from Ground Survey to LiDAR).

Sedimentation

The Jemez River above its confluence with the Rio Salado at San Ysidro has a drainage area of about 600 square miles. From sediment sampling records between February 1937 and June 1941, suspended sediment passing San Ysidro was approximately 400 acre-feet per year and the average concentration for all months of record was 0.46 percent sediment by weight. Some sediment was diverted into irrigation ditches at San Ysidro. No sediment samples have been secured from this location since 1941.

The Rio Salado has a drainage area of about 251 square miles, which is mostly plateau, with rough, broken and hilly terrain, and is easily eroded. For about three miles above San Ysidro, the streambed is wide and sandy. Sediment sampling on this stream at that time indicated that the sediment carried was about 150 acre-feet per year including 15 acre-feet of bed load. Records of sediment sampling from the Jemez River at Zia, about five miles below the Jemez-Rio Salado confluence, showed that the average annual suspended sediment load passing Zia was about 500 acre-feet per year.

Below San Ysidro, the characteristics of Jemez River change suddenly. The slope becomes flatter and the streambed becomes wider and is plugged with sand and fine material, which is washed into the river from tributaries and eolian deposition. The 183 square miles of drainage area between Jemez Canyon Dam and San Ysidro produces about one-half of the total sediment entering the reservoir area. Most of the sediment comes from the south side of the Jemez River where the Santa Fe formation is exposed or is covered with a mantle of wind-blown alluvium. The area is sparsely vegetated. The terrain is rolling hills cut by numerous steep-sided arroyos. Near the river the dunes are extensive and have advanced to the edge of the stream in many places. Runoff from this area discharges large quantities of sediment into the river. The suspended sediment load entering the reservoir area was estimated at that time to be about 910 acre-feet per year, with the bed load assumed at about ten percent of the suspended load for a total of about 1,000 acre-feet per year. Approximately 60 percent of the total yearly runoff occurs during the spring runoff period and about 70 percent of the total suspended sediment load occurs during this period. (USACE 1994)

Sediment Monitoring -- The transport and deposition of sediment, which affects the operation of Jemez Canyon Reservoir, are monitored by the measurement of suspended sediment concentrations of reservoir outflow and by periodic ground and hydrographic surveys of the reservoir area. There are 13 sediment ranges located within the reservoir area and 14 degradation ranges located in the channel below the dam. Initial capacity allocations were 73,000 acre-feet for flood control and 44,000 acre-feet for sediment deposition. Table C-5, below, from the 1994 Water Control Manual (USACE) shows area and capacity for initial conditions and subsequent surveys through 1991. It should be noted that the data presented in this table represent pre-dam modification conditions.

Table C-5. Jemez Canyon Dam capacity changes prior to dam modification.

Changes in Reservoir Area and Capacity									
Original				1975		1983		1991	
Feature	Elevation (ft., NGVD)	Area (ac.)	Capacity (ac-ft)	Area (ac.)	Capacity (ac-ft)	Area (ac.)	Capacity (ac-ft)	Area (ac.)	Capacity (ac-ft)
Top of Dam	5257.5	4440	210,082	4373	198,200	4373	194,800	4373	192,573
Max WS	5252.3	4147	187,752	4062	176,200	4062	172,800	4062	170,615
Spwy Crest	5232.0	2895	117,213	2877	106,100	2870	102,700	2954	100,485

The following additional historic information was also available to support this project:

(1) Suspended Sediment Sampling. Collection of suspended sediment samples below the dam was discontinued in 1993. Samples below the dam were collected for approximately 45 years. In the past a description of the suspended sediment and environmental conditions was recorded on SWA Form 38, Sediment Collectors Log. These logs were sent to the Reservoir Control Section (RCS), District Office, at monthly intervals for inspection and recording. Approximately once per year, suspended sediment samples were shipped from the project office to the Southwestern Division Laboratory for analysis of suspended sediment concentrations and grain size gradation determination. Results from the samples collected are available from the RCS.

(2) Reservoir Sedimentation Ranges. Thirteen transverse sediment ranges were installed in Jemez Canyon Reservoir in 1952 and marked with concrete monuments. Each range was numbered and profiled. Ranges 10 through 13 are located above the maximum water surface of the reservoir for the purpose of determining channel changes and aggradation or degradation of the river channel. Ranges 1 through 9 are used to determine the amount of sediment deposition that has taken place in the reservoir area. Reservoir sedimentation and degradation ranges are shown on Plate C-1. Sedimentation resurveys are normally scheduled on a five to seven year basis, though intervals have grown recently in response to budget constraints. Resurveys at Jemez Canyon Reservoir were made in August 1959, December 1965, January 1975, December 1983, June 1991, June 1998, and October 2009.

Geomorphology

The Jemez River rises in the Jemez Mountains and flows southeasterly for about 65 miles. It is perennial in the upper reach and ephemeral in the lower reach due to irrigation diversions. The total area drained by the river is 1,038 square miles, with 1,034 square miles above the dam. The watershed is about 65 miles long with a maximum width of 30 miles. The terrain rises from elevation 5,120 feet, NGVD at the dam to over 11,000 feet, NGVD in the mountainous region of the headwaters. The stream channel in the upper reach is confined within narrow canyons. The stream meanders through a broad sandy valley in the lower reaches and through the reservoir area, which is several hundred feet wide without well-defined banks. Below the dam the river enters a narrow canyon, which extends to the confluence with the Rio Grande. Stream slopes vary from 18 feet per mile at the dam to more than 250 feet per mile in the mountains (USACE, 1994).

The principal mountain tributary is the Rio Guadalupe, which enters the Jemez River about 26 miles above the dam. It rises in the Jemez Mountains and is perennial. Coniferous forest of pine, fur and spruce with interspersed groves of aspen covers the watershed above 7,000 feet, NGVD. Vegetal cover in the lower elevations is piñon, juniper and oak brush with very sparse grasses and herbs. The upper area is characterized by steep slopes varying from 250 feet per mile to 130 feet per mile, which results in rapid runoff (USACE, 1994).

The principal tributary in the lower basin is the Rio Salado, an ephemeral stream, which drains the southwest portion of the Jemez River Basin. It rises in the lower mountain region and flows through the highly erodible, low-lying plateau area of the watershed. Vegetal cover is sparse and consists of short grass and desert shrubs. Slopes in this area vary from about 130 feet to 18 feet per mile in the vicinity of the dam. Because of the nature of the soils and plant cover, the lower area is much more conducive to runoff than the upper area. The Rio Salado-Jemez River confluence is about 17 miles above the dam, near San Ysidro (USACE, 1994).

The Jemez River, above the weir, to the confluence with the Rio Salado is a broad sandy channel with a very shallow braided flow pattern. The Rio Salado channel is very similar to the Jemez River channel for the lower one third of its length. The higher stream channels of both the Jemez River and Rio Guadalupe are steep, narrow and well armored (USACE, 1994).

Conditions within the river channel near and upstream of the village indicate a dynamic channel that continues to adjust to watershed and environmental perturbations. The Jemez River within the Zia Pueblo, the upstream neighbor of Santa Ana, has experienced significant incision and deposition. In 2007, while visiting Zia Pueblo, an account of a sand plug forming in the channel near the downstream pueblo boundary was relayed. Further upstream, an abandoned irrigation diversion facility has left two sheet-pile grade features across the river with a grade difference estimated on the order of 10-12 ft. between the upstream and downstream streambed. In addition, the BIA 74 bridge was constructed around 199/2000 to replace the previous timber trestle structure leading to the village. Based on temporal photographic evidence obtained within Google Earth Pro, the new bridge imposed a significant constraint on the channel width when it was constructed. The south abutment was apparently extended out into the meander width such that it reduced the available conveyance width by one-third to one-half. This has likely led to some significant channel adjustments since. Finally, the recent Las Conchas fire burned parts of the upper watershed, and is expected to deliver higher-than-normal sediment loadings to the reach over the next several years.

As described under the hydraulic conditions, the Jemez River channel near the village is perched with a limited carrying capacity within the active channel. Flows in excess of this capacity spill into the lower-elevation areas adjacent to the active channel. It is hypothesized that this perched channel condition may be, at least in part, associated with the replacement of the BIA 74 Bridge. Photo 1, below, shows a historic flood photograph from 1958 in which the flow width between the BIA 74 timber bridge's abutments was roughly half again as wide as the current bridge opening. The wetland area that has formed south of the current active channel (opposite the village levee) lies in the 'flow shadow' created by the newer bridge abutment/approach. The perched nature of the channel in this area suggests some long-term aggradation. As will be described below, however, there is not a clear indication of long-term aggradation, but rather oscillation, of the mean channel bed elevation in the vicinity of the village. The perched low-flow channel adjacent to the village will in all likelihood avulse at some point in the future (when there is a sufficient event) into the lower elevation flood plain area and form a new channel.

An analysis of the 1975 through 2009 reservoir sediment range surveys was undertaken to quantify the more recent channel responses in order to characterize the current conditions and to assess the likely future conditions. Four of the reservoir rangeline data sets were evaluated by comparing the average elevations within assumed ranges to represent fluvial responses. The four rangelines selected for evaluation were S-6, S-7, S-8, and S-9. They are shown below, as

Plates C-2 through C-5. For orientation purposes, S-8 is aligned just downstream of the BIA 74 bridge into the village, with S-9 located upstream and S-7 and S-6 downstream. The average elevations for the 1975, 1983, 1991, 1998, and 2009 re-surveys were computed in two ways; 1) by arithmetic averaging of the values below a specified elevation judged to capture the active river portions, and 2) by arithmetic averaging of the values between two specified stations judged to capture the majority of typical river flows. Though the resulting values differed somewhat between the two methods, the comparative results were quite similar.

Results of this evaluation indicate that the mean active elevations have generally fluctuated both up and down throughout the evaluation period. If we assume that the mean values are representative of the population, and that it is more-or-less uniformly distributed, it is difficult to determine a clear vertical directional trend overall.

Sediment Range 6 shows mean elevation values ranging from 5211.58 ft. to 5220.04 ft. when screened for values below 5240 ft. The lowest mean elevation comes from the 1983 re-survey, with the highest for the 1998 re-survey. The current (2009) mean value is 5216.54 ft., which is lower than the 1998 re-survey, within one standard deviation of the mean periodic average (5216.46 ft.), and well within two standard deviations. Similarly, looking at point elevations between stations 20+00 and 52+00, the mean results range from 5209.85 ft. (1975) to 5215.33 ft. (2009), with the two values just slightly outside the period average (5212.61 ft.) plus-one-standard-deviation bounds, and within two standard deviations. Though the bounding values are, perhaps coincidently, associated with the ends of the evaluation period, directional changes within the intervening periods, for both evaluation methods, suggest a clear aggradational trend may not be at work here.

Sediment Range 7 does suggest a directional trend of aggradation, with values increasing over time, though the amounts are relatively modest, peaking at around 0.13 ft./yr. over the two comparison methods. The lowest mean elevation comes from the 1975 re-survey at 5221.42 ft., and the highest for the 2009 re-survey at 5223.88 ft., for the screening below elevation 5240 ft. Similarly, the 1975 value, screening between stations 10+00 and 50+00, is 5221.24 ft., while the 2009 mean value is 5223.77 ft. These two range bounds are just outside the plus/minus-one-standard-deviation limits of the overall period mean (5222.49/5222.51 ft.), and within two standard deviations. This is the only sediment range that suggests a clear temporal trend.

Sediment Range 8, nearest the village, suggests more of a condition with periodic values fluctuating around a population mean. The yearly rates between intervals are dissimilar to the rates of the preceding range (S-7), peaking at around 0.2 ft./yr. over the elevation-screening comparison method (less than 5250 ft.), but less than 0.04 ft./yr. when comparing results for point averages between stations 12+00 and 36+00. The lowest mean elevation comes from the 1983 re-survey at 5234.86 ft., and the highest for the 1998 re-survey at 5237.24 ft., for the screening below elevation 5250 ft. These values both lay just beyond the period mean (5235.86 ft.) plus-or-minus-one-standard-deviation limits, and within the two-standard-deviations limits. Screening between stations 12+00 and 36+00, the 1983 value is 5231.98 ft., while the 1998 mean value is 5236.88 ft. These two range bounds are also just outside the plus/minus-one-standard-deviation limits of the overall period mean (5235.19 ft.), and within two standard deviations.

The digitized periodic re-survey data available for Sediment Range 9, upstream of the village, covers a shorter evaluation period, from 1991 through 2009. It, too, suggests more of a condition with periodic values fluctuating around a population mean. The lowest mean elevation comes from the middle (1998) re-survey at 5243.34 ft. when screening below elevation 5250 ft, while the highest is from the 2009 re-survey at 5245.01 ft.,. The 2009 value lies just beyond the period mean (5244.02 ft.) plus-one-standard-deviation limit, and within two standard deviations. However, when screening between stations 16+00 and 47+00, the extremes come from different re-surveys, with the lowest (1998) value at 5243.79 ft., and the highest elevation (1991) mean value at 5245.99 ft. This lower average elevation value (1998) is just outside the minus-one-standard-deviation limit of the overall period mean (5245.05 ft.), and within two standard deviations.

In summary, the up and down fluctuations of the channel elevations throughout the numerous evaluation periods do not indicate a clear vertical trend for the river reach. While there is no clear evidence of a long-term aggradation trend, the shifts in the vertical direction quantified above should be planned for and accommodated as possible in any feature designs. The information above, and more fully described within Appendix C, provides insight into the range of variability that can be expected.

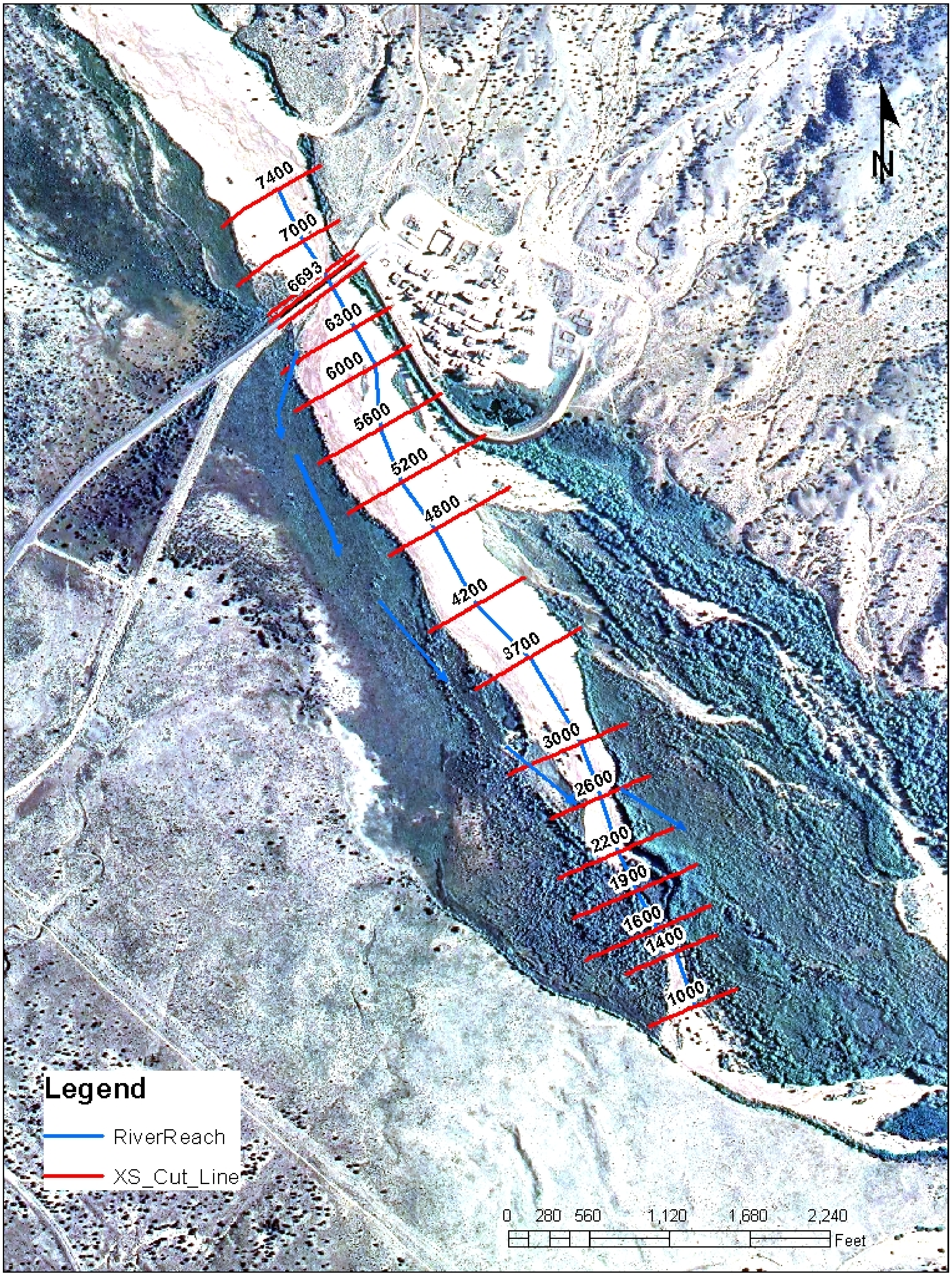


Figure C-3: Orientation graphic for channel capacity discussion.

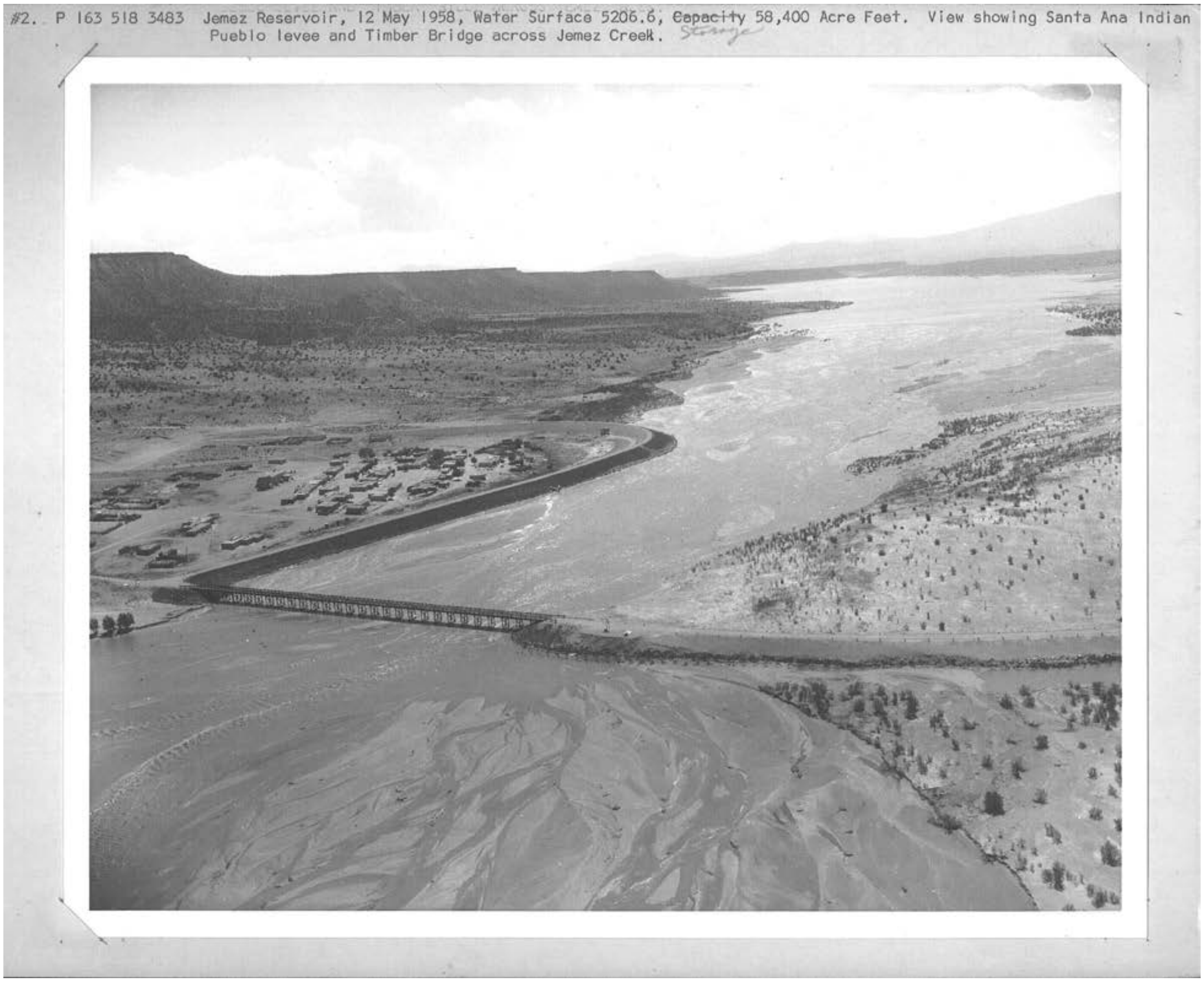
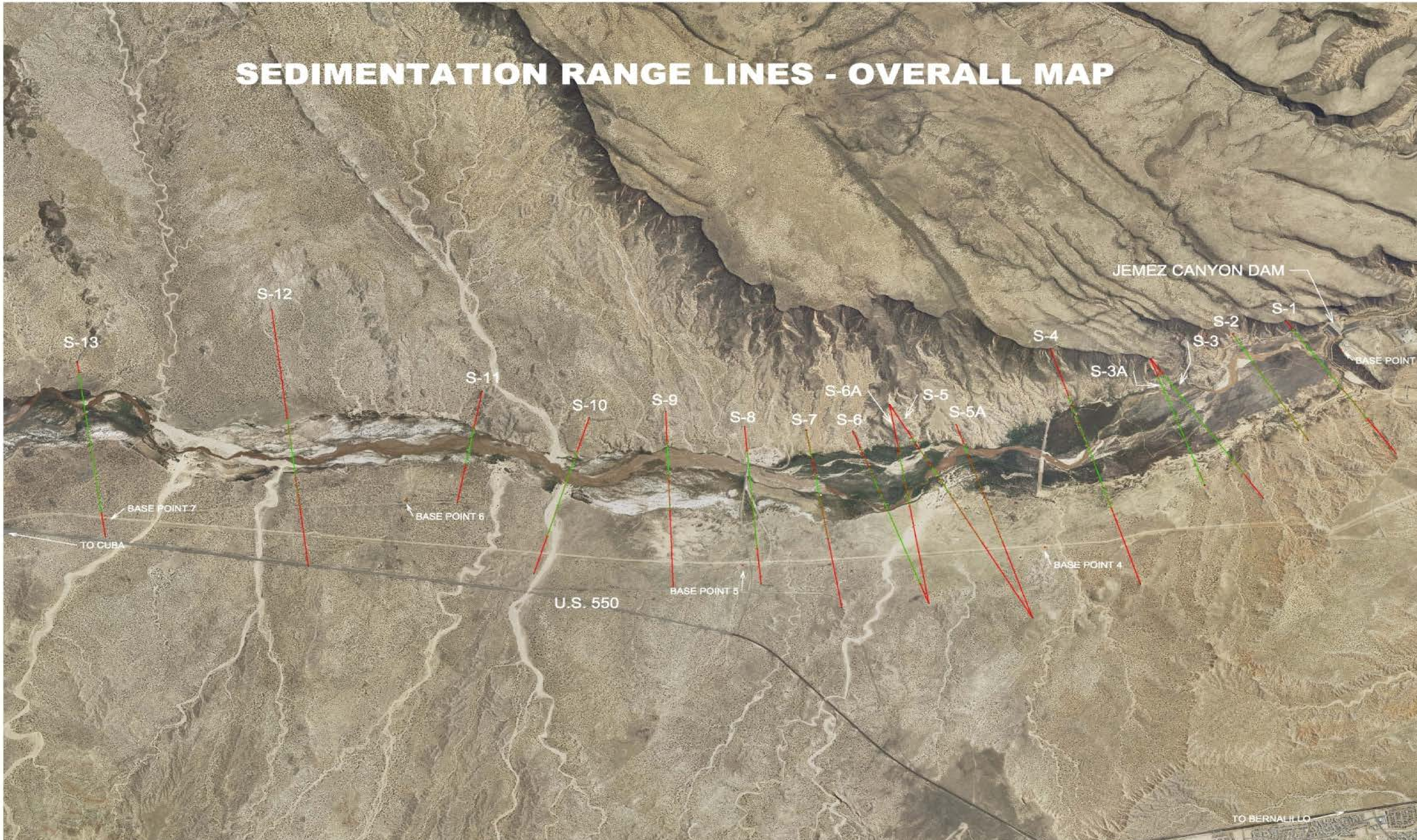


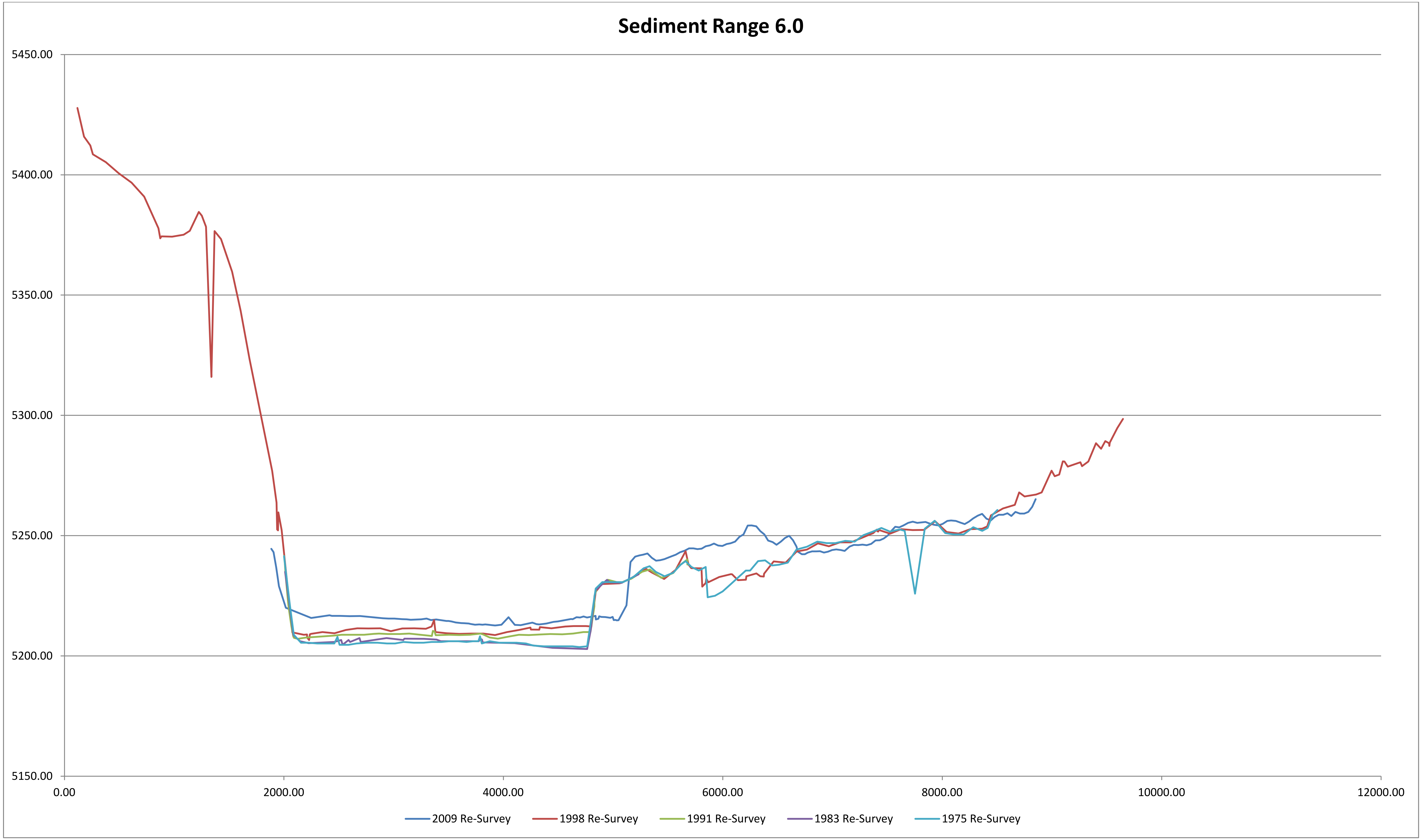
Photo 1: BIA 74 Bridge, May 1958

Plate C-1



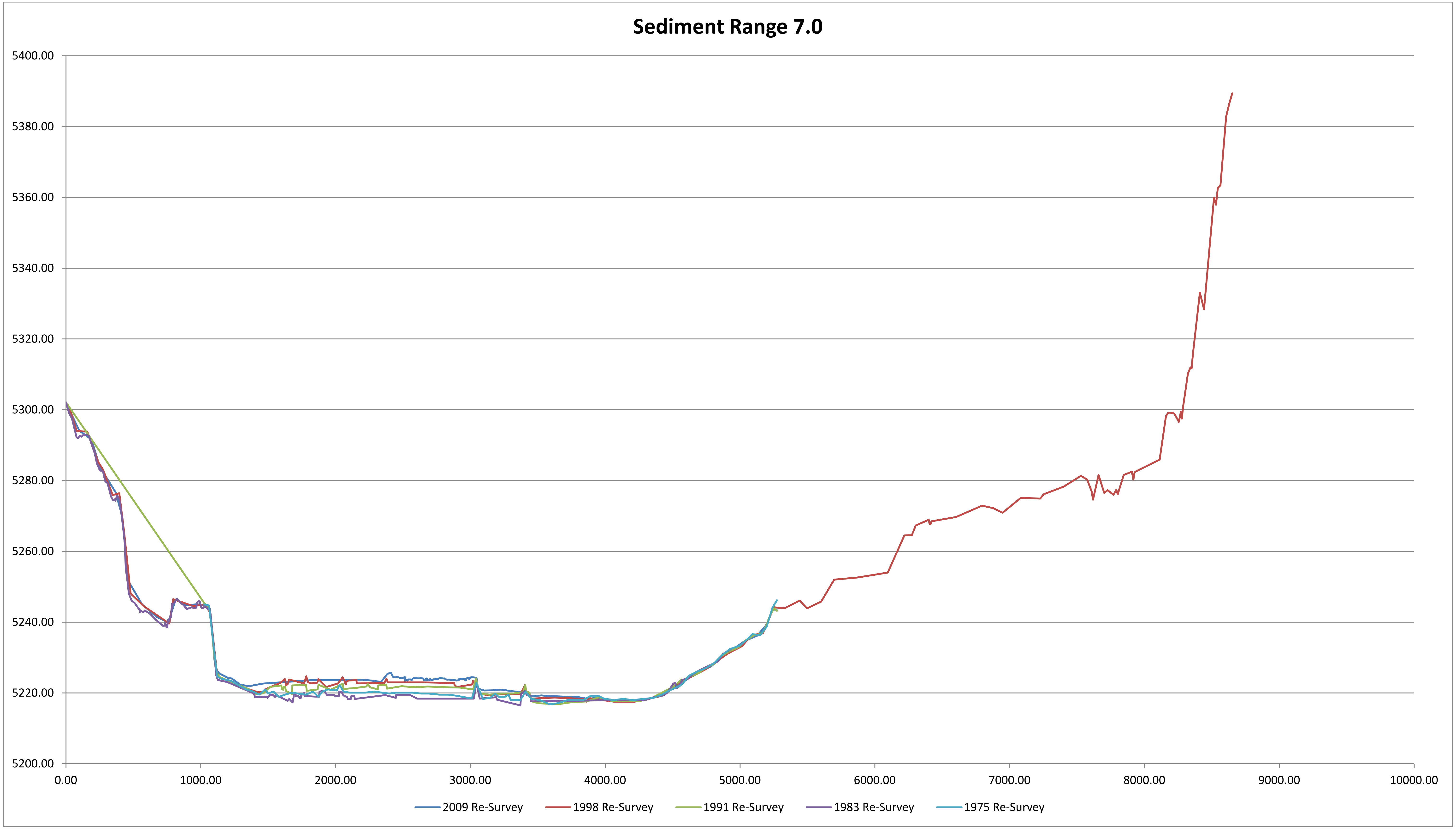
SEDIMENTATION RANGE LINES - OVERALL MAP
JEMEZ CANYON DAM
S-1
S-2
S-3
S-3A
S-4
S-5
S-5A
S-6A
S-6
S-7
S-8
S-9
S-10
S-11
S-12
S-13
BASE POINT 3
BASE POINT 4
BASE POINT 5
BASE POINT 6
BASE POINT 7
TO CUBA
U.S. 550
TO BERNALILLO

Plate C-2



Sediment Range 6.0
5450.00
5400.00
5350.00
5300.00
5250.00
5200.00
5150.00
0.00
2000.00
4000.00
6000.00
8000.00
10000.00
12000.00
2009 Re-Survey
1998 Re-Survey
1991 Re-Survey
1983 Re-Survey
1975 Re-Survey

Plate C-3



Sediment Range 7.0
5400.00
5380.00
5360.00
5340.00
5320.00
5300.00
5280.00
5260.00
5240.00
5220.00
5200.00
0.00
1000.00
2000.00
3000.00
4000.00
5000.00
6000.00
7000.00
8000.00
9000.00
10000.00
2009 Re-Survey
1998 Re-Survey
1991 Re-Survey
1983 Re-Survey
1975 Re-Survey

Plate C-4

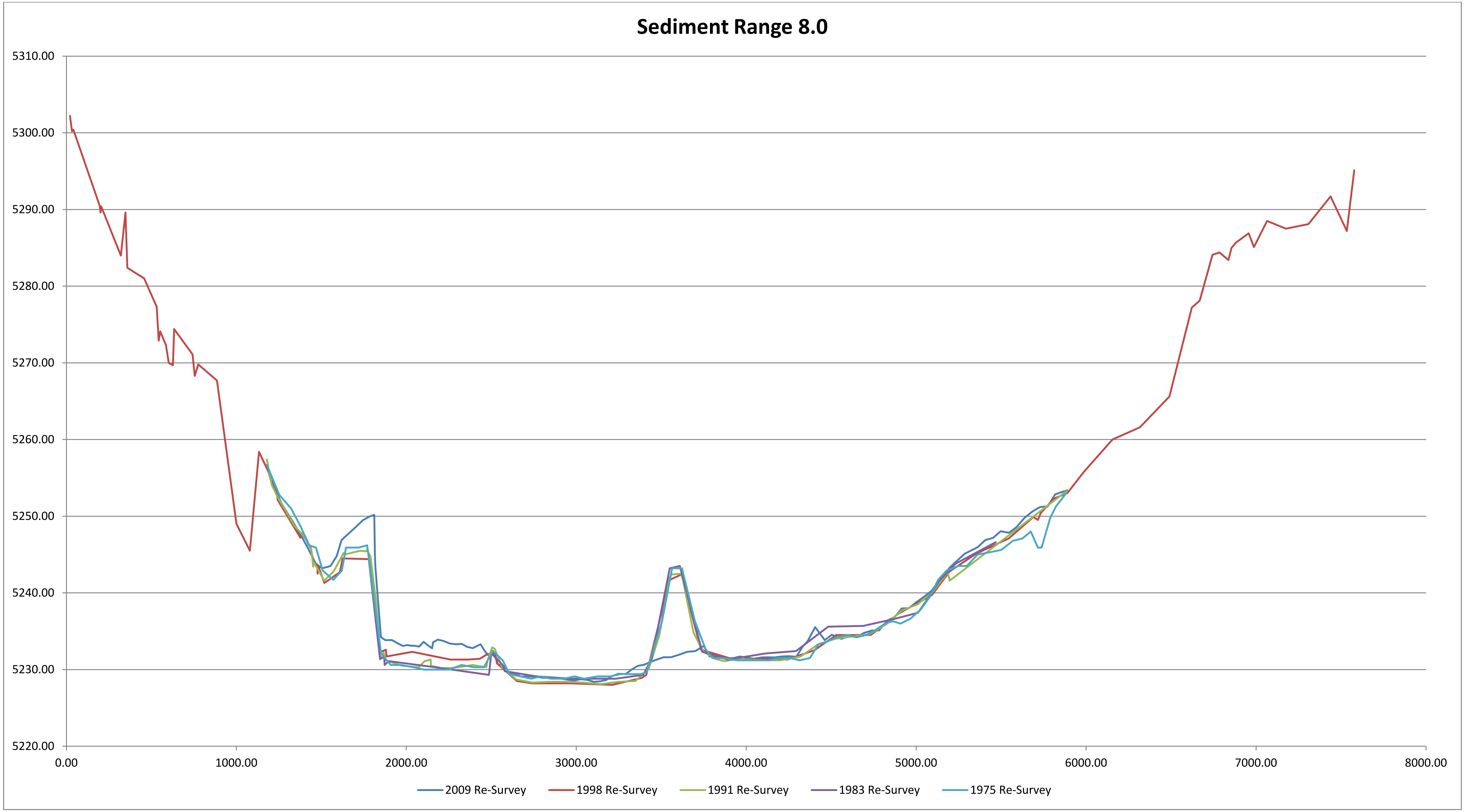
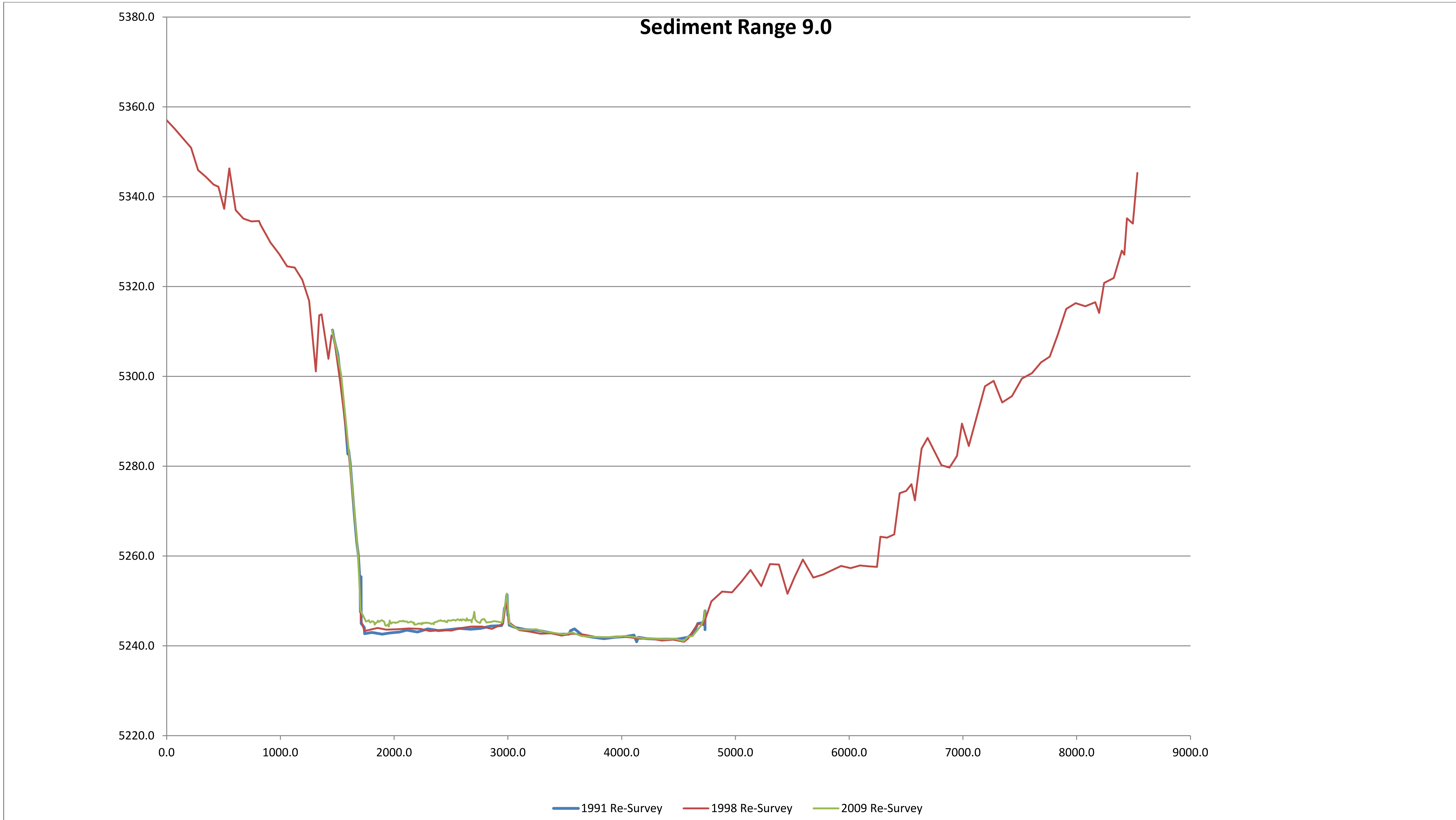

Sediment Range 8.0
5310.00
5300.00
5290.00
5280.00
5270.00
5260.00
5250.00
5240.00
5230.00
5220.00
0.00
1000.00
2000.00
3000.00
4000.00
5000.00
6000.00
7000.00
8000.00
2009 Re-Survey
1998 Re-Survey
1991 Re-Survey
1983 Re-Survey
1975 Re-Survey

Plate C-5



Sediment Range 9.0
5380.0
5360.0
5340.0
5320.0
5300.0
5280.0
5260.0
5240.0
5220.0
0.0
1000.0
2000.0
3000.0
4000.0
5000.0
6000.0
7000.0
8000.0
9000.0
1991 Re-Survey
1998 Re-Survey
2009 Re-Survey

2. Future Without Project Conditions and Effects of the No-Action Alternative

Surface Water Hydrology

With the exception of more temporary changes associated with watershed fires, such as the recent Las Conchas fire, the hydrologic parameters that control runoff within the study area are not expected to change significantly within the future. Also, climate change impacts were not evaluated as part of this study.

Hydraulic Conditions

As with the future hydrology, the channel hydraulics are not anticipated to change significantly in the future, with a few caveats described below. Because the channel near the village has exhibited a tendency to vary its geometry, as described under the Geomorphology section, there will be variations in the water surface elevation and related hydraulic variables associated with these channel adjustments. Though there is not sufficient evidence to predict definite vertical trends, it is reasonable to anticipate some vertical increase in the river's stage. Given the perched nature of the current active channel near the village, it is likely that the river stage will both rise and drop over time periodically, as the channel aggrades and then avulses to lower adjacent areas.

Sediment

As described previously, it is difficult to predict with certainty the future state of the Jemez River as it responds to sedimentation. However, because the Jemez River channel is confined within the Tamaya Village area, both by the available width between the bridge abutments as well as on the north side by the JCD project levee protecting the village, there is some limitation to the channel's ability to lower itself. There is, therefore, a higher likelihood of an increase in the channel bed and river stage near the village.

Geomorphology

There is quantitative evidence of changes in the channel bed's mean elevation which translates to the corresponding surface water elevations, and these have certainly exhibited aggradational behavior on numerous occasions. Thus, this long-term state cannot be ruled out. Since this is also the evolution most typically provided anecdotally by tribal members, DNR staff and SPA operations personnel, it lends further confidence in continuation in a modest aggradational trend over the long term. Continued monitoring of the sediment ranges will facilitate future management.

3. **Expected Future With-Project**

The alternatives being considered for alleviation of the ponding condition at the village overwhelmingly are intended to affect groundwater. They do involve collection of some amount of groundwater and return as surface water into the Jemez River. However, the volumes involved, within the context of normal Jemez River surface flows, are insignificant. Therefore, future conditions following implementation of any of the proposed alternatives would not be expected to materially affect the conditions anticipated for the future under existing conditions.

<u>Surface water hydrology</u>

As described above, changes in the surface water hydrology would be inconsequential under with-project condition, due to the relative magnitude of the water affected by an alternative. Surface runoff from within the interior of the village, for example, would primarily be returned to the Jemez River through pumping, as it currently is. Likewise, small amounts of groundwater would be pumped to the river, as they no doubt are currently to some degree, but the overall volume is insignificant in comparison to the base flow estimated upstream of the project area of some 30 to 60 cfs. For comparison, the estimated high rate for temporary pumping to lower groundwater under adverse conditions for Alternative 1, a less efficient alternative than the one being recommended, was 57 gallons per minute (GPM), or about 0.12 cfs.

<u>Surface water hydraulics</u>

As with the surface water hydrology, changes in river hydraulics associated with the groundwater discharges contemplated for the alternatives would not be expected. Indeed, it would be difficult to attribute any changes in the river stage response in the future to the relatively low range of flows associated with operation of the recommended alternative.

<u>Sedimentation</u>

As described in the previous **Future Without Project Conditions** discussion, there remains some uncertainty in the future state of the Jemez River as it responds to sedimentation. However, the future state of the river, for the reasons cited about, would not be anticipated to be the result of operation of the recommended alternative.

<u>Geomorphology</u>

With the expectation of continued morphological channel adjustments for the Jemez River, including within the vicinity of the village, the performance of the proposed alternative could be affected. The current groundwater modeling indicates an efficient engineering formulation that minimizes conditions when pumping would be required. Changes in river stage, as well as planform, could affect the volume and duration of pumping. The height and proximity of surface flows serve as one, of many, boundary conditions that influence groundwater response. The current surface flow conditions were modeled and used to estimate surface water boundary conditions. These conditions are expected to change in the future. As described previously, the changes are expected to be moderate on the basis of historical response. Given that these changes could occur in either direction (*i.e.,* higher or lower river stage, closer or farther active river channel), the current conditions are assumed to be representative. Some measure of performance robustness for proposed pond alternatives can be built into the groundwater modeling to account for this through boundary sensitivity study. In addition, continued monitoring of the sediment ranges will facilitate future management of any implemented alternative.

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Appendix D
Groundwater Hydrology

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Groundwater Hydrology
Supplemental Technical Information for Tamaya Drainage Project

This Appendix contains four sections:

1) Draft Memorandum for Record, Subject: Conceptual Site Model Technical Memorandum, Tamaya Pond Project, 25 April 2008. This Memorandum describes the data sources and conditions that were used in the groundwater modeling process by the Corps of Engineers, Seattle District.

2) Draft Groundwater Modeling Report, Tamaya Pond Project, Historic Tamaya Village, Santa Ana Pueblo, Sandoval County, New Mexico,16 October 2009. This is the groundwater modeling report prepared by the Corps of Engineers, Seattle District, for the Corps' Albuquerque District and the Pueblo of Santa Ana. This report analyzes the effects of the proposed alternatives for filling and draining the pond at Tamaya Village.

3) Tamaya Pond Groundwater Modeling Update for Revised Grading Plan and Revised Passive Drain With Sump, 24 January 2012. This is an updated groundwater modeling report prepared by the Corps of Engineers, Seattle District. This report updates the analysis of fill and drainage alternatives by incorporating revised pond topography and fill elevation, and a reconfigured passive drain.

4) Wetland Mitigation Geoprobe Trip Report. 10 July 2012. This report summarizes the findings of a groundwater investigation conducted by the Corps and USGS in July 2012 for the purpose of determining the depth and flow o fgroundwater in the area of the proposed wetland mitigation site.

DRAFT MEMORANDUM FOR RECORD

SUBJECT: Conceptual Site Model Technical Memorandum, Tamaya Pond Project, Historic Tamaya Village, Santa Ana Pueblo, Sandoval County, New Mexico

PREPARED BY: Jefferey Powers and Amy Ebnet, Seattle District, U.S. Army Corps of Engineers

Date: 25 April 2008

Introduction and Purpose.
The Seattle District, U.S. Army Corps of Engineers (USACE) is assisting the Albuquerque District USACE and the Pueblo of Santa Ana with the groundwater modeling component of the Tamaya Pond Project, a component of the Rio Jemez Mitigation Project. As outlined in the *Draft Groundwater Modeling Plan* (USACE, 18 April 2008), a technical memorandum concerning details of the conceptual site model (CSM) is required in order that stakeholders and reviewers are kept apprised of significant components of the groundwater model and to obtain consensus early on and throughout the project.

A CSM is a detailed representation of the groundwater flow system, the nature of which will determine the dimensions of the numerical model, the design of the grid, boundary conditions, stratigraphic units, and hydrostratigraphic parameters. The purpose of building a CSM is to simplify complex field stratigraphy and hydrogeology so that the system can be analyzed more readily. The intent of the technical memoranda is for issues that present a concern to be resolved to the extent practicable so that unresolved issues will not be further propagated throughout the modeling process.

Data Sources Utilized.
- USGS 7.5-minute Topographic Map, Santa Ana Pueblo, NM Quadrangle (USGS, 1990),
- Various boring logs for Tamaya Village wells and Rio Jemez mitigation wells,
- Time-varying head data files for several Tamaya Village wells,
- Lidar data and bathymetry data for Rio Jemez near the Tamaya Village site,
- Report on Updated USGS Regional Groundwater Model (McAda and Barrol, 2002),
- Ayres Rio Jemez Mitigation Model (Ayres, 2001), and
- Observations and notes from Site Visit conducted by Seattle District modeling personnel on 8 May 2007.

Model Dimensions.
The *Draft Groundwater Modeling Plan* stated the overall Tamaya Groundwater Modeling Project model domain would be no more than 25 square miles, and based on Figure 3 of the Plan showed anticipated lateral extents to be no more than 5 miles on each side. Model dimensions and boundaries selected have been further reduced which, in turn, will allow computer computational resources to focus more detail on the area of interest (i.e., that of the pond and immediate vicinity). Based on preselection of the horizontal extents of the model as described under the *Boundary Conditions* section below, the refined lateral model dimensions are on

average 10,100 feet in the northeast-southwest direction by 13,500 feet in the northwest-southeast direction (about 4.9 square miles). At this scale, resolution and accuracy of the area of interest should be improved and computational run times should be kept to a manageable level.

Numerical Model Grid Design.

As stated in the *Draft Groundwater Modeling Plan*, MODFLOW is based on the concept of partitioning the domain into numerous block-centered grid cells both in the lateral and vertical dimensions. Groundwater flow is computed between each cell and its adjacent, active cells. Grid cell size will be smaller in the immediate area of the pond and will gradually increase away from the pond towards the model boundaries. For computational stability, each successive larger grid row or column will be no more than 50 percent larger than the previous. See Figure 1 for an illustrative example of this variable grid spacing approach. Because each model run iteratively solves for the best-fit solution at all cells, run time is directly related to number of active cells. Therefore, this step-wise, non-uniform grid size approach will better balance increased accuracy of calculations in the area of interest while minimizing run times due to the large outer grid cell dimensions.

The model will contain 10 vertical layers with approximately uniform thickness unless excessive computational run times dictate fewer layers. The model layers will not be defined to represent a particular hydrologic unit, rather the hydrologic properties will be assigned to individual grid cells based on the modeled stratigraphy to better simulate relatively thin, low permeability units which are not laterally continuous.

Boundary Conditions.

Numerical models require boundary conditions, such that the hydraulic head or groundwater flux must be specified along all the outer edges of the system and any internal cells to which conditional head values must be determined (i.e., extraction well cells, river cells). Boundary conditions are mathematical statements specifying the dependent variable (hydraulic head) or the derivative of the dependent variable (flux), or a combination of the two in the case of general head boundaries, at the edges of the problem domain. Table 1 explains the location of all model boundaries, their respective boundary types, and rationale for selection.

The lateral boundaries of the Tamaya Pond Groundwater Model are referenced with respect to the predominant groundwater and surface water drainage direction which is to the southeast. The boundary hydraulically upgradient of Tamaya Village will run predominantly perpendicular to groundwater flow and will be a general head boundary. A general head boundary combines a specified flux or flow boundary (sometimes referred to as a Neumann condition) in the form of a conductance term within limits placed on the boundary by a maximum specified head (Dirichlet condition). For the initial, steady-state model this will be a constant, averaged flux boundary; however, as seasonal varying recharge from up-valley snowmelt is simulated, the boundary will be time varying for the transient model. The flow in or out of a general head cell is proportional to the computed difference in head and the constant of proportionality is the conductance. The boundaries to the northeast and southwest of the site, roughly paralleling Santa Ana Mesa and State Route 44, respectively, will also be general head boundaries. The model boundary along the Santa Ana Mesa was chosen along the 5,400 foot contour while the boundary roughly paralleling State Route 44 was chosen along the 5,300 foot contour. During transient simulations, surface water recharge to groundwater from the arroyos originating on the mesa will be modeled with increased flux. All three aforementioned general head boundaries will be predominantly adding groundwater to the model. The boundary hydraulically downgradient of the Village will also be of general head and will be the primary means for groundwater exiting the model domain.

In addition to lateral boundaries, the two vertical boundaries must be defined. The upper model boundary will be the water table surface, the elevation of which will vary with time in the transient simulation. This boundary is a specified flux boundary and will simulate the combined effects of recharge of groundwater by precipitation infiltration and evapotranspiration. The model's lower boundary will be the base of the lower-most modeled water-bearing unit. This is also to be a specified flux boundary; however, the specified flux shall be zero to simulate the lack of significant vertical flow in the highly stratified alluvial units. See Figure 2 for a conceptual block diagram of site model boundaries.

Stratigraphic Units.

The geologic information from the various Tamaya Village and vicinity boring and well logs, sieve analysis results, and former modeling reports (USGS, 2002; Ayres, 2001) will be used to construct site stratigraphy. The majority of the subsurface within the model domain is characterized by fine to coarse, permeable sands and occasional gravels of the post Santa Fe Group and given Unified Soils Classification Symbols of SW (well-graded sand), SP (poorly-graded sand), GM (silty gravel), and SM (silty sand). While thin horizontally deposited silt and/or clayey sand units exist beneath the site, no large-scale continuous confining units are believed to exist within the shallow alluvium modeled (above 150 feet below ground surface). The small-scale silt and/or clayey sand units will be modeled with lower conductivity values relative to the predominant fine sands beneath the site that make up the majority of the subsurface, hence these small-scale units will impede but not prevent vertical flow between the sandy, more permeable soils.

Hydrostratigraphic Parameters.

Hydraulic information from interpretation of the geologic strata, regional aquifer testing (USGS, 2002; Ayres, 2001), and proposed site slug testing will be used as input for the groundwater model's hydrostratigraphic parameters. These parameters include hydraulic conductivity and leakance of each modeled stratigraphic unit, specific yield (water table, or unconfined layer) and storativity (confined layers). Hydraulic conductivity is the most important of these parameters, and estimates for the post-Santa Fe Group deposits vary from as low as 0.2 to 325 ft/day. Given the relatively low hydraulic gradient magnitude of the Rio Jemez valley near Tamaya Village, these values translate to groundwater velocities on the order of 0.003 to 5 ft/day. A value similar to that used in the USGS and Ayres models will be used as a starting point (at the low end of the range); however, adjustments based on the proposed slug testing results and during the calibration process will likely increase overall modeled hydraulic conductivity values.

Table 1. Summary of Boundary Conditions

Boundary Physical Location and Description	**MODFLOW Boundary Package and Boundary Condition (BC) Type**	**BC Type Rationale**
Hydraulically upgradient of Tamaya Village	General Head Package/Specified conductance and maximum head	Means of Rio Jemez up-valley groundwater inflow to model domain
Hydraulically downgradient of Tamaya Village	General Head Package/Specified conductance and maximum head (except at Jemez Weir, see below)	Means of Rio Jemez down-valley groundwater outflow from model domain
Northeast of and parallel to Rio Jemez (Santa Ana Mesa)	General Head Package/Specified conductance and maximum head	Recharge from side-gradient mesa
Southwest of and parallel to Rio Jemez (State Route 44)	General Head Package/Specified conductance and maximum head	Recharge from side-gradient uplands
Top of modeled domain (water table plane)	Recharge Package/Specified flux	Input competing effects of precipitation recharge and evapotranspiration
Bottom of modeled domain (Base of lowest-elevation modeled hydrostratigraphic unit)	Basic Package/Specified flux (zero flux, a.k.a. “no flow”	Predominant groundwater flow is horizontal, not vertical because of horizontal deposition of alluvium.
Rio Jemez from hydraulic upgradient to downgradient boundaries	River Package/Specified head	To utilize output from HEC-RAS surface water model at points upstream and downstream of the Village.
Tamaya Village Groundwater Extraction Well	Well Package/Specified flux	Optimal method for simulating extraction well
Rio Jemez Weir; makes up portion of boundary hydraulically downgradient of Village	Drain Package/Specified head	Water removed from model only when water surface is above specified elevation

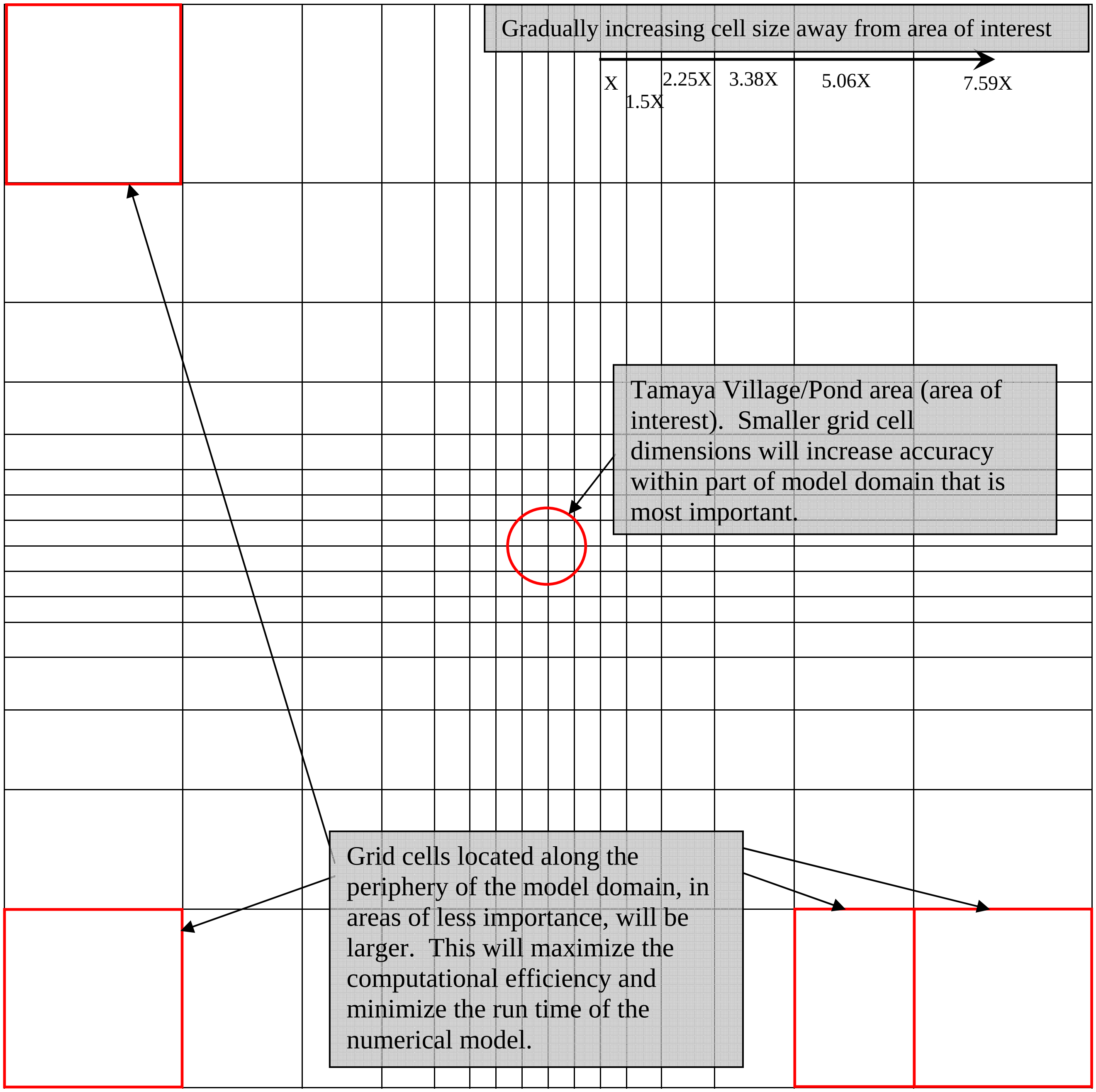

Figure 1. Variable Spacing Concept for Numerical Model Grid Design

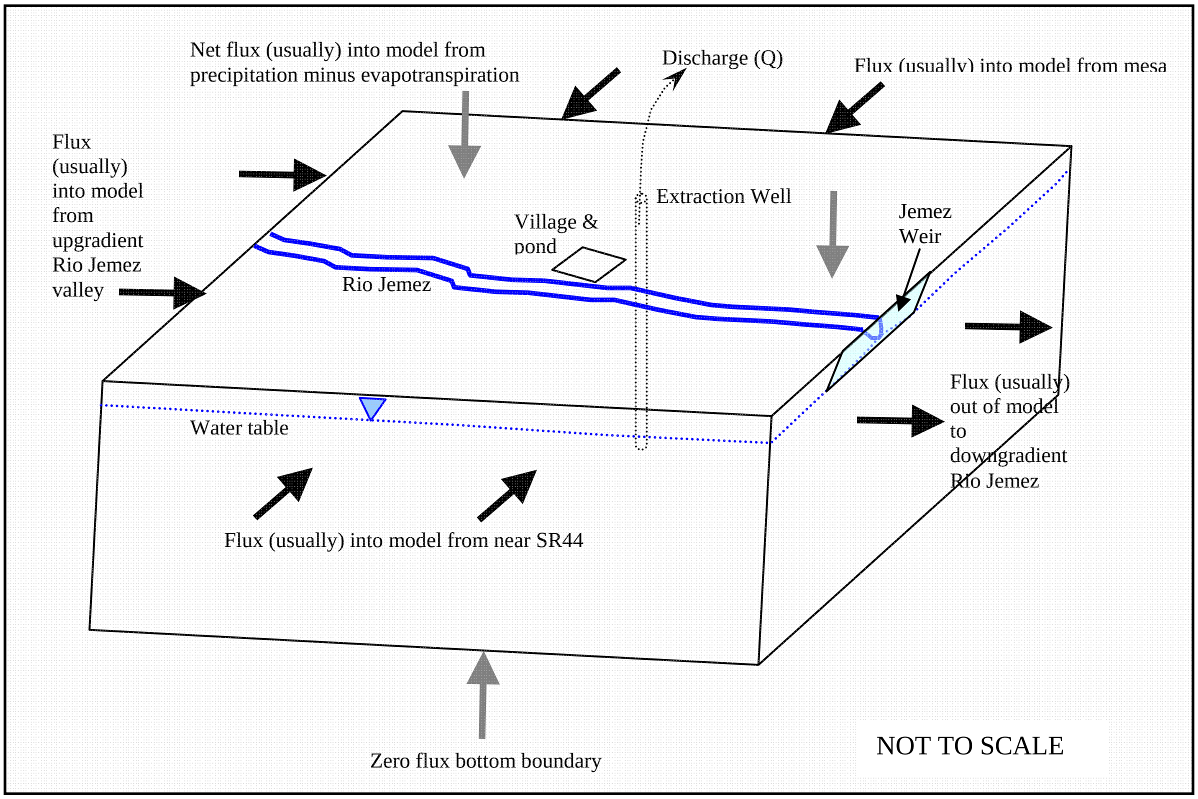

Figure 2. Conceptual Site Model Block Diagram

DRAFT
GROUNDWATER MODELING REPORT

Tamaya Pond Project
Historic Tamaya Village, Santa Ana Pueblo
Sandoval County, New Mexico

Prepared for:

US Army Corps of Engineers, Albuquerque District

and

Pueblo of Santa Ana

Prepared by:
Department of the Army

US Army Corps of Engineers
Seattle District

16 October 2009

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GROUNDWATER MODELING REPORT

Tamaya Pond Project
Historic Tamaya Village, Santa Ana Pueblo
Sandoval County, New Mexico

1.0 BACKGROUND AND OBJECTIVES

Tamaya Village is in the Pueblo of Santa Ana (PSA), located in Sandoval County, approximately 20 miles north of Albuquerque, New Mexico (Figure 1). Tamaya is the ancestral village for the Pueblo which has been continuously occupied for more than 700 years. The village is located adjacent to the Rio Jemez (Jemez River), which discharges to the Rio Grande about eight miles downstream of the village. The Jemez Canyon Dam, constructed approximately five miles below the village, began operations in 1953. The dam impounded water for sediment retention and flood control in a reservoir, the back waters of which would periodically reach to the limits of the village. A ring levee was built around approximately one-half of Tamaya Village as part of the Jemez Canyon Dam project in order to protect the village from inundation. The pond, just inside the southern portion of the ring levee, is believed to have formed as a result of gradual aggradation and subsequent raised groundwater levels associated with the pooled water of the reservoir and modified river channel hydraulics. The pond is an undesirable feature which periodically threatens to partially inundate the historic village.

The modeling project has consisted of developing a numerical groundwater flow model that incorporates local site geologic, hydrologic, and hydrogeologic conditions to accurately reproduce site conditions. Results of groundwater flow model simulations were then evaluated to provide input with regard to the most effective and feasible alternatives at eliminating the standing water in the pond. These results will be incorporated into an Albuquerque District Alternatives Report. The results of the groundwater model, including that of several remedial alternatives, will be presented to the Pueblo's Tribal Council for a decision on which remedy is most appropriate.

There were several objectives developed for the Tamaya Pond groundwater model prior to initiation of the project. These objectives included:

- Assimilate relevant site data into a comprehensive hydrogeologic conceptual and mathematical model framework,
- Adequately represent the current site groundwater conditions,
- Quantitatively evaluate up to four proposed remedial alternatives for effectiveness of pond removal, and qualitatively evaluate for feasibility and cost (the number of scenarios subsequently increased by one, from four to five),
- Help identify gaps in available site hydraulic data, and

- Provide an updatable and transferable tool (i.e., the model in electronic form, with related documentation such as this report) for future site groundwater management.

The overarching purpose for implementing a groundwater model was to assist the Pueblo of Santa Ana in evaluating and selecting the best remedial alternative for permanent elimination of the pond.

The Tamaya Pond groundwater flow model was developed and executed by the U.S. Army Corps of Engineers (USACE), Seattle District in concert with Jemez River hydraulic modeling by the USACE, Albuquerque District, on behalf of USACE Albuquerque District and the Pueblo of Santa Ana.

2.0 CONCEPTUAL MODEL

Real world geologic and hydrogeologic systems can be very complex. A conceptual model in its simplest form is a description of how a system works. It may consist of descriptive text, figures, tabular information, or any combination of these tools to represent the system. In this case a CSM is a representation of the groundwater flow system, the nature of which will determine the dimensions of the numerical model, the design of the grid, boundary conditions, stratigraphic units, and hydrostratigraphic parameters. The purpose of building a CSM is to simplify complex field stratigraphy and hydrogeology so that the system can be analyzed more readily.

2.1 Hydrostratigraphy

The aquifer system in the Middle Rio Grande Basin consists of the Santa Fe Group and post Santa Fe Group alluvial deposits. The Santa Fe Group and post-Santa Fe Group deposits are divided into four hydrostratigraphic units: the lower, middle, and upper parts of the Santa Fe Group and the post-Santa Fe Group (Thorn et al, 1993). The primary water bearing units are in the post Santa Fe Group alluvial deposits and the upper and middle part of the Santa Fe Group (Thorn et al, 1993). The Santa Fe Group varies in thickness from 2,400 ft near the margins of the basin to 14,000 ft in the center of the basin (Thorn et al, 1993). The lower part of the Santa Fe Group is composed of piedmont-slope, eolian, and basin-floor playa deposits. Sediments in the middle part of the Santa Fe Group consist of piedmont-slope deposits, fluvial basin-floor deposits and basin-floor playa deposits, and the upper part of the Santa Fe Group is composed of interlayered piedmont-sloped and fluvial basin-floor deposits (McAda and Barroll, 2002). The post Santa Fe Group is several miles wide and up to 120 ft thick and is composed of highly permeable sands and gravels interbedded with less permeable silts and clays (Thorne et al, 1993). The Tamaya groundwater model domain consists wholly of the post-Santa Fe Group.

2.2 Hydrologic Properties

Hydraulic conductivity estimates for the post-Santa Fe Group deposits vary from as low as 0.2 ft/day to 325 ft/day. Hydraulic conductivities in the upper Santa Fe Group have been estimated to be from 4 to 150 ft/day. The middle Santa Fe Group has been estimated to have hydraulic conductivities ranging from 4 to 11 ft/day (McAda and Barroll, 2002). The USGS model used 1.5 ft/day for the hydraulic conductivity value for the post Santa Fe Group and the upper and middle Santa Fe Group (McAda and Barrol, 2002). The interbedded low permeability layers give the aquifer a large vertical anisotropy (McAda and Barrol, 2002).

Hydraulic conductivities were estimated from grain size distribution data for soil samples collected between 6 and 75 ft below ground surface in the vicinity of Tamaya Village (Parametrix, 2002). The resulting hydraulic conductivity values were analyzed and incorporated into the conceptual site model.

Specific yields in the sediments in the Middle Rio Grande Basin range for 0.1 to 0.25 and specific storage is about 1.2x10-6 per ft (McAda and Barroll, 2002).

Albuquerque District obtained additional hydraulic conductivity data for the shallow alluvial aquifer on site through the implementation of a slug testing program (USACE, 2008). Eleven existing piezometers were tested in May 2008, the data from which were analyzed by the Bouwer and Rice Method and incorporated into the conceptual site model for inclusion into the groundwater flow model. Hydraulic conductivity values obtained from slug testing ranged from 0.8 to 123.4 ft/day, with a mean value of 50 ft/day.

2.3 Groundwater Flow

The horizontal component of groundwater flow in the Jemez River Drainage is primarily from the northwest to the southeast. This is because the aquifer in the Jemez River Drainage is recharged from surface runoff infiltrating into the shallow portion of the aquifer from the mountains to the north as well as from subsurface flow from the adjacent basin to the northwest (McAda and Barroll, 2002). The Jemez River is hydraulically connected to the groundwater over most of its length in the basin and is a source of recharge in some locations (McAda and Barroll, 2002). A small quantity of groundwater is withdrawn from the aquifer from a pumping well east of Tamaya Village. Groundwater is also lost from the aquifer through evapotranspiration from riparian vegetation along the Jemez River.

3.0 COMPUTER CODE

MODFLOW 2000, a finite difference groundwater modeling software, was utilized for the flow model (Harbaugh et al., 2000). MODFLOW is a public domain code developed by the U. S. Geological Survey and has the widest user-base of all numerical groundwater flow modeling programs. The acronym “MODFLOW” stands for MODular Three-Dimensional Finite-Difference Ground-Water FLOW Model.

MODFLOW has a modular structure that allows it to be easily modified to adapt the code for a particular application. MODFLOW has been updated several times, each adding new capabilities to the original version. MODFLOW 2000 is the latest version which simulates steady and nonsteady flow in an irregularly shaped flow system in which aquifer layers can be confined, unconfined, or partially confined simulating a combination of the two. Flow from external stresses such as flow to wells, areal recharge, evapotranspiration, flow to drains, and flow through river beds can be simulated. Hydraulic conductivities (or transmissivities under confined conditions) for any layer may differ spatially and be anisotropic, and the storage coefficient may be heterogeneous. Specified head and specified flux boundaries can be simulated, as can a head-dependent flux across the model’s outer boundary that allows water to be supplied to a boundary block in the modeled area at a rate proportional to the current head difference between a “source” of water outside the modeled area and the boundary block.

Department of Defense Groundwater Modeling System (GMS) (EMRL, 2005) was used as the software platform and graphical-user interface for the flow model. GMS provides a seamless platform for MODFLOW and is available along with technical support, free of charge to Government agencies and contractors. Version 6.5 of GMS was utilized. The combined use of widely available software such as GMS and MODFLOW will insure that the groundwater model can be used in the future by any agency or consultant, with minimal expense for model training, software purchases, or technical support.

4.0 GROUNDWATER MODEL DESIGN

4.1 Domain

Based on preselection of the horizontal extents of the model as described under the *Boundaries* section below, the refined lateral model dimensions are on average 10,100 feet in the northeast-southwest direction by 13,500 feet in the northwest-southeast direction (about 4.9 square miles). At this scale, resolution and accuracy of the area of interest was maximized, and computational run times were kept to a manageable level.

4.2 Grid

MODFLOW is based on the concept of partitioning the domain into numerous block-centered grid cells both in the lateral and vertical dimensions. Groundwater flow is computed between each active cell and its adjacent active cells. Grid cell size was made smaller in the immediate area of the pond (10 x 10 ft square cells) and was gradually increase away from the pond towards the model boundaries to increase computational efficiency. Because each model run iteratively solves for the best-fit solution at all cells, run time is directly related to number of active cells.

Therefore, this step-wise, non-uniform grid size approach better balanced increased accuracy of calculations in the area of interest with minimized run times due to the large outer grid cell dimensions. The model contains a total of 309,420 grid cells.

The model contains 10 vertical layers with approximately uniform thickness. The hydrologic properties were assigned to individual grid cells based on the modeled stratigraphy to better simulate relatively thin, low permeability units which are not laterally continuous.

The model grid was rotated 45 degrees so that the principal direction of groundwater flow – to the southeast – corresponded with one of the two horizontal grid axes. This was to maximize computational efficiency and to prevent model inaccuracies and non-convergence issues.

4.3 Boundaries

Numerical models require boundary conditions, such that the hydraulic head or groundwater flux must be specified along all the outer edges of the system and any internal cells to which conditional head values must be determined (i.e., extraction well cells, river cells). Boundary conditions are mathematical statements specifying the dependent variable (hydraulic head) or the derivative of the dependent variable (flux), or a combination of the two in the case of general head boundaries, at the edges of the problem domain. Table 1 explains the location of all model boundaries, their respective boundary types, and rationale for selection.

The lateral boundaries of the Tamaya Pond Groundwater Model are referenced with respect to the predominant groundwater and surface water drainage direction which is to the southeast. The lateral boundaries were specified flux and represented using the MODFLOW well package to either input or extract water from the edges of the model domain. The boundary hydraulically upgradient of Tamaya Village, predominantly perpendicular to groundwater flow, was made a specified flux boundary. The boundaries to the northeast and southwest of the site, roughly paralleling Santa Ana Mesa and State Route 44, respectively, were also specified flux. The model boundary along the Santa Ana Mesa was chosen along the 5,400 foot contour while the boundary roughly paralleling State Route 44 was chosen along the 5,300 foot contour. During some transient simulations, surface water recharge to groundwater from the principal arroyo near Tamaya Village from off the mesa was modeled with increased flux through the river package. All three aforementioned boundaries were predominantly adding groundwater to the model. The boundary hydraulically downgradient of the Village was also of specified flux and was the primary means for groundwater exiting the model domain.

The upper model boundary was the water table surface, the elevation of which will vary with time in the transient simulation. This boundary is a specified flux boundary and simulated the combined effects of recharge of groundwater by precipitation infiltration and evapotranspiration. The model's lower boundary was the base of the lower-most modeled water-bearing unit. This was also modeled as a specified flux boundary; however, the specified flux was zero to simulate the lack of significant vertical flow in the highly stratified alluvial units with depth.

4.4 Sources and Sinks

The Jemez River is incorporated into the model using the MODFLOW river package. Required inputs for each designated river cell are river stage and streambed conductance. River stage was supplied at four points along the river by the results of the Albuquerque District HEC-RAS modeling; river stage at other points along the river was linearly interpolated. Conductance to the CSM polygon defining the river cells was assigned a value of 0.05 $ft^2/d/ft^2$ which was then interpolated within GMS to provide proportional conductance based on differing grid cell dimensions. At times when there was no flow in the river, conductance was set to zero to prevent unwanted infiltration into the shallow aquifer.

The Pueblo's water supply well, located approximately 2,500 ft northeast of the village, was simulated using the MODFLOW well package. Lacking more complete data, the well was assigned a low, continuous assumed pumping rate of 715 cubic ft/day (3.7 gpm). Withdrawal occurs from Layer 9 which corresponds to an elevation of 5,108 ft (240 ft below ground surface or "bgs"). Because the well is screened deep and pumps only a small amount of groundwater, its affects are not seen in shallow groundwater in the upper layers in vicinity of the pond.

4.5 Materials

The geologic information from the various Tamaya Village and vicinity boring and well logs, sieve analysis results, and former modeling reports (USGS, 2002; Ayres, 2001) was used to construct site stratigraphy. The majority of the subsurface within the model domain is characterized by fine to coarse, permeable sands and occasional gravels of the post Santa Fe Group and given Unified Soils Classification Symbols of SW (well-graded sand), SP (poorly-graded sand), GM (silty gravel), and SM (silty sand). While thin horizontally deposited silt and/or clayey sand units exist beneath the site, no large-scale continuous confining units are believed to exist within the shallow alluvium modeled (above 150 feet below ground surface). The small-scale silt and/or clayey sand units will be modeled with lower conductivity values relative to the predominant fine sands beneath the site that make up the majority of the subsurface, hence these small-scale units will impede but not prevent vertical flow between the sandy, more permeable soils. See Section 2.2 for ranges of hydraulic conductivity values used to represent the various materials.

4.6 Other Model Parameters

Hydraulic information from interpretation of the geologic strata, regional aquifer testing (McAda and Barroll, 2002; Bexfield and McAda, 2003; Ayres, 2001), and site slug testing (USACE, 2008) were used as input for the groundwater model's hydrostratigraphic parameters. These parameters include hydraulic conductivity and leakance of each modeled stratigraphic unit, specific yield (water table, or unconfined layer) and storativity (confined layers). Hydraulic conductivity is the most important of these parameters, and estimates for the post-Santa Fe Group deposits vary from as low as 0.2 to 325 ft/day. Given the relatively low hydraulic gradient magnitude of the Rio Jemez valley near Tamaya Village, these values translate to groundwater velocities on the order of 0.003 to 5 ft/day. A value similar to that used in the USGS and Ayres models was used as a starting point (at the low end of the range); however, adjustments based on the slug testing results and during the calibration process necessitated an increase in overall modeled hydraulic conductivity values compared to what has been used on previous larger-scale models.

5.0 CALIBRATION

The purpose of model calibration is to establish that the model can reproduce field-measured hydraulic heads and flows. During the calibration process, a set of values for aquifer parameters and stresses was found that approximated field-measured heads and flows. Calibration was performed by the automated parameter estimation method, as opposed to the trial-and-error method, for model parameters. A sensitivity analysis was then conducted on calibration parameters to evaluate what influence each parameter has on the modeled hydraulic heads. The predictive scenarios were subsequently run using the calibrated model as the base platform.

Pertinent Model Simulation Settings.

1. Flow simulated using Layer Property Flow (LPF) Package
2. Rewetting of dry cells turned off
3. For recharge and evapotranspiration, flow terms are assigned to the top face of applicable cells
4. For recharge (except as noted on steady-state sensitivity Run 1), flow assigned to uppermost active cell
5. No horizontal anisotropy
6. Preconditioned Conjugate Gradient (PCG2) Solver Package utilized
7. 0.1 foot head change convergence criterion used in PCG2
8. The following boundary condition packages were utilized: river (for Jemez and arroyo), well (for specified boundary flux, supply well, and extraction wells for select predictive scenarios), drain (for Jemez weir, and pond drain in select scenarios), recharge, lake (for pond recharge), and evapotranspiration (ET)
9. English units are used (feet and day)

5.1 Steady-State Model

The first step in model calibration is to apply averaged but representative parameter values to the boundary conditions, sources, and sinks defined in the conceptual site model (CSM) in order to represent steady-state conditions. Representative groundwater elevations from multiple observation points were then used as a basis for adjusting the parameter values such that modeled hydraulic heads at those observation points reflected similar values. The observation points utilized included wells TP-2, TP-5, TP-6, P-18S, P-18D, P-23, and BIANW in the Tamaya Village and pond (village/pond) area, and P-4, P-5, P-6, HW-4, and HW-6 in the downgradient area near the Jemez weir (weir area). The calibration parameters for the steady state model were Jemez river stage, river conductance, aquifer horizontal hydraulic conductivity (Kh), vertical anisotropy (Kh/Kv, also referred to as horizontal to vertical K ratio), specified flux at model boundaries, recharge due to precipitation, and evapotranspiration. Representative values of aquifer specific yield, specific storage, and porosity were included in the steady-state model but were not considered calibration parameters. Specific yield and specific storage do not affect time-independent (steady-state) solutions. See Tables 2 and 3 for a summary of calibrated model parameters.

The steady-state model simulated average late winter/early spring time conditions, and incorporated the Jemez River HEC-RAS surface water model results provided by USACE, Albuquerque District for the week ending 25 March 2006. March 2006 was simulated for the steady-state model to maximize observation data for calibration. River stage in each model cell was linearly interpolated by Groundwater Modeling System (GMS) software based on the following HEC-RAS output values: River Station (RS)7000, 5238.98 ft; RS6300, 5236.51 ft; RS5200, 5232.79 ft; RS3000, 5225.82 ft, Weir Upstream, 5198.93, and Weir Downstream, 5190.01 ft. This time period reflected a weekly average river flow of about 35 cubic feet per second (cfs). The original plan was to calibrate the steady-state model to April 2003 observed values due to the abundance of observational data for that time period; however, large residuals in observed versus computed heads in the southern portion of the model (near the weir area) led to the determination that the weir, constructed beginning in August 2003, was not being simulated correctly. This led to the decision to calibrate to the 2006 data set and allowed for a better-calibrated model, especially in the southern end.

The Kh values for the calibrated model ranged from 0.1 to 62 ft/d, with a mean Kh of 7 ft/d. For comparison, the range in Kh values estimated from the spring 2008 slug testing program at wells near the village and pond was 0.5 to 350 ft/d, with a mean Kh of 24 ft/d. The range of calibrated Kh values is in general agreement with the slug testing results, and with that used by Ayres (Ayres, 2001) in the previous groundwater model.

The supply well northwest of the village/pond area was used to develop lithology for the lower model layers, and was modeled with a small constant discharge of 715 ft^3/d (3.7 gpm) from Layer 9, which had negligible effect on gradient near the village or pond.

The calibration target, or maximum difference between observed and simulated groundwater elevations, for wells near the village/pond area was 1.0 ft. For the lower priority, downgradient area near the weir, the calibration target was 5.0 ft. The targets were met for all but P-18S, a shallow well northwest of the village and pond and adjacent to the river, in which the final calibrated value was 1.5 ft lower than the observed value. P-18S is clustered with P-18D, a well with a deeper screen in which the calibrated value was only 0.5 ft lower than observed. The fact that groundwater elevations were observed to be one foot apart in these two wells, located in the same horizontal position with only a 20-ft difference in screen elevations makes it difficult to calibrate. However, the calibrated model did correctly predict a downward vertical gradient at this well cluster.

Overall, steady-state calibration produced an average difference of only -0.13 feet considering all seven village/pond area observation wells. Table 4 shows observed versus computed groundwater elevations at observation wells for the steady-state model. For the observation wells near the weir ("priority 2"), the average difference for the calibrated model was 2.77 feet.

No arroyos were explicitly included in this model; however, specified flux from lateral model boundaries, including the mesa to the north of the village, were included to simulate both overland flow down the slope which infiltrates the ground, and mountain-derived groundwater recharge.

The run time of the steady-state model was less than one minute.

A component of model calibration is a sensitivity analysis of the calibrated model to determine which parameters are most influential in model outcomes.

A sensitivity analysis is conducted for the purpose of quantifying the uncertainty in the calibrated model caused by uncertainty in the estimates of aquifer parameters, stresses, and boundary conditions, and is an important component of the groundwater flow model process. During a sensitivity analysis, calibrated values are systematically changed, in this case one at a time, within a plausible range for each value. The magnitude of change in heads from the calibrated steady-state solution (reported as average difference in Table 6) is a measure of the sensitivity of the solution to that particular parameter. For the steady-state model, a total of 14 sensitivity runs were simulated testing for sensitivity to the following parameters: recharge, river stage, evapotranspiration, river conductance, Kh, Kh/Kv ratio, and specified flux at model boundaries. See Table 6 for a summary of these sensitivity results.

Based on the sensitivity results, the model appears most sensitive to Kh, particularly when lowered, followed by adjustments to river stage. Due to the slug testing program of wells at or near the pond, and the generally good agreement between slug testing results and modeled permeabilities, the Kh values modeled in this area are believed to be representative of actual conditions. Additionally, there is reasonable confidence in interpretations made based on HEC-RAS surface water modeling of the river. The third most sensitive parameter is recharge. The model appears least sensitive to the Kh/Kv ratio.

5.2 Transient Model

A transient calibration is optimal to ensure the model can adequately simulate time-varying stresses and conditions, and ultimately in order to successfully simulate the predictive scenarios. As such, an ideal transient simulation would contain at least one fairly significant stress, such as a large ramping up and down of river stage. Stresses which typically vary with time, and which were incorporated into the transient model include river stage, recharge, and evapotranspiration. Parameters that have the potential to influence hydraulic conditions over time include the storativity terms of specific storage and specific yield. As discussed above, a 2003 data set was originally targeted due to the large amount of transient observation data during that period; however, the final transient model was calibrated to a January to June 2006 data set. A total of 25 stress periods were simulated, one for each week between 31 December 2005 and 24 June 2006. Although river stage decreased after mid-April (the Jemez actually went dry) subsequent to a very steady, modest stage starting 31 December, there was no significant ramping of river stages during the 2006 data set. There was also only modest precipitation during this period which did not lead to a significant recharge-related stress. Therefore calibration of the transient model was fairly straightforward. As such, some uncertainty remains with respect to the accuracy of time-varying predicted heads.

Table 5 shows the HEC-RAS surface water model outputs that were used as groundwater model inputs to interpret river stage at every river cell during each stress period. This table also provides the transient evapotranspiration (ET) data set as well as the historical recharge data set for the 2006 time period modeled. Calibration of recharge led to the conclusion that the transient model could be adequately calibrated with a constant zero recharge value. This is because recharge occurred in only six of 25 stress periods, and all weekly totals were less than the corresponding weekly total ET values, which countered recharge by removing water from the upper layer of the model.

The run time of the transient model was approximately 14 minutes.

A sensitivity analysis for a transient calibrated model is conducted to evaluate the uncertainty in the calibrated model caused by uncertainty in the estimates of applied stresses. During the transient sensitivity analysis, the stresses of time-varying river stage, river conductance, evapotranspiration, recharge, specific yield, and specific storage were systematically varied to determine the magnitude of change in heads from the calibrated solution. Also, because Kh was a sensitive parameter in the steady-state model, this parameter was doubled and halved in two separate transient sensitivity runs. See Table 7 for a qualitative summary of transient sensitivity results. The results indicated the model was most sensitive to increasing river stage, followed by increasing recharge, and decreasing ET.

6.0 PREDICTIVE SIMULATIONS

Five base predictive scenarios were set up and run using the calibrated transient Tamaya groundwater model. All scenarios involved infilling the existing pond to an even elevation of 5235 ft., with permeable soils of similar properties to the shallow sand currently present. These base scenarios included the four original scenarios of 1) place fill only with no dewatering, 2) fill with active pumping from newly installed wells, 3) fill with a realigned, extended levee and an arroyo interceptor channel with no dewatering, 4) fill with realigned levee and arroyo interceptor channel with pumping, plus one additional scenario which consisted of 5) fill with removal of groundwater via a passive drain and sump with pump, utilizing a passive drain constructed below land surface in the pond area. While not explicitly modeled in the latter scenario, groundwater collected in the drain would be removed by active pumping from a sump located at the downgradient (southern) end of the drain. For each base scenario, predictive runs were conducted under the January-June 2006 flow conditions, a 100-yr Jemez River stage event, and a worst-case scenario where the Jemez stage rises to within three feet of the top of the existing levee at the location of the Jemez bridge and remains constant for eight weeks. See Table 8 for a matrix depicting each modeled scenario and Table 9 for a list of the GMS file names for each modeled scenario.

6.1 Scenario 1: Existing levee alignment, pond filled in to 5235 ft.

The Scenario 1 setup left the levee configuration unchanged from its existing condition. This consists of a semicircular ring levee around the southern portion of the village and in particular surrounding the existing Tamaya Pond, the bottom of which occurs at an elevation of approximately 5227 ft (Figure 2). The land surface of the area in and immediately around the pond was raised to an elevation of 5235 ft, meaning parts of the pond were filled in as much as 8 ft (Figure 3). Emplaced fill material was assumed to exhibit the same soil properties as the existing materials found in this area (sands of SP and SW USCS classification, modeled hydraulic conductivity of 62 and 26 ft/day, respectively). To reflect the addition of soil in the pond area, the top of the uppermost model layer was simply raised in any cell which originally had a top elevation below 5235 ft. Scenario 1a was as described above and using the 2006 Jemez River stage dataset to simulate the river. The duration of the 2006 stage scenario was 25 weeks (corresponding to the modeled time period 12/31/05-6/23/06). Scenario 1b, instead of using the 2006 dataset, used a slightly higher 100-yr Jemez River stage provided by the HEC-RAS model conducted by Albuquerque District. The final hydraulic head levels of the 2006 simulation (corresponding to 6/23/06) were used as starting head conditions for the 100-yr stage scenario. The 100-yr river stage scenario intended to represent higher-stage Jemez conditions of a flashy, summer storm event; therefore, it was reasonable to assume groundwater conditions which occurred in June of 2006 as a starting point for this scenario. The duration of the 100-yr stage scenario was five weeks (6/24-8/1/06). Lastly, Scenario 1c utilized the conditions described herein except the Jemez stage was constructed to peak at three feet below the top of the levee in the vicinity of the Jemez River bridge leading to the village (about elevation 5243 ft., whereas the top of levee is approximately 5246 ft) and remain constant for a period of eight weeks. The time period simulated for this third scenario was 18 weeks (6/24-10/29/06), with the Jemez rising rapidly to maximum height on 7/1/06 and declining rapidly to a dry river bed on 8/30/06.

6.2 Scenario 2: Existing levee alignment, pond filled in to 5235 ft., active pumping

Scenario 2 also left the levee alignment and elevation as it currently exists and filled the pond area in to an elevation of 5235 with fill of similar properties as the existing shallow soil. Active pumping via three groundwater extraction wells was included in this scenario (Figure 4). The wells were approximately equally spaced in a linear trend from NW to SE within the topographically lowest areas of the existing pond, with pump elevations of about 5233 or 5234 ft, corresponding to the mid-elevation of the Layer 1 model cell in which they were located. The mid-screen elevation corresponded to about 11 to 12 ft bgs. As before, Scenario 2a was with the 2006 Jemez stage hydrograph, Scenario 2b was with the 100-yr stage hydrograph, and Scenario 2c was with the Jemez within three feet of the top of the levee near the bridge.

6.3 Scenario 3: Existing levee alignment, pond filled in to 5235 ft., passive drain with active sump

Scenario 3 also left the levee alignment and elevation as it currently exists and filled the pond area in to an elevation of 5235 with in kind material. Passive drainage via an approximate 600-ft long buried drain was included in this scenario (Figure 5). The drain was a single, linear feature which trended from NW to SE beneath the lowest areas of the existing pond, with a uniform drain elevation of 5230 ft (5 ft below the new ground surface). Since the drain was within the fill material, it was within SP and SW USCS-classified materials which are relatively permeable. The conductance of the passive drain, a term used to represent relative ease of drainage from aquifer to drain, was 1,200 ft/d. For Scenario 3c the conductance was defined slightly differently, using a value of 200 ft^2/d per foot in a GIS arc and mapped to the MODFLOW grid, resulting in average conductance of about 1,500 ft/d. Since site topography is such that the drain could not flow water by gravity from inside the levee to outside to the river, an active sump with pump or pumps would be required to remove water from the passive drain. These pumps were not simulated, as the drain automatically removes water entering it from the model. As before, Scenario 3a was with the 2006 Jemez stage hydrograph, Scenario 3b was with the 100-yr stage hydrograph, and Scenario 3c was with the Jemez within three feet of the top of the levee near the bridge.

6.4 Scenario 4: Levee extension with arroyo interceptor channel, pond filled in to 5235 ft.

Scenario 4 involved realigning the eastern third of the existing ring levee by extending the levee to the south and east to encompass a larger undeveloped area behind the levee. Approximately 520 ft of the existing levee was removed in the model by lowering the surface elevation to nearby ground surface and assigning the closest native soil type to that of the former levee. Additional levee was modeled by raising ground surface (and the top elevations of Layers 1 and 2) to the design height of the levee extension as provided in CADD form by Albuquerque District (approximately 5245-5246 ft), and by converting Layer 1 material type from existing ground surface (either SP or SW) to the low-permeability levee material type. Figure 7 shows the realigned levee configuration whereas Figure 6 shows the existing conditions. As part of the levee realignment design, an arroyo interceptor channel was incorporated which runs north and east of the realigned levee in order to contain and pass arroyo flows safely around and outside the levee. This was modeled by adjusting the ground surface to that in the CADD design drawing and reconfiguring the assignment of river cells to match the arroyo channel. In this scenario, the pond area was also filled in to an elevation of 5235 ft with in kind material. Scenario 4a was with the 2006 river stage, Scenario 4b was with the 100-yr stage hydrograph, and Scenario 4c was with the Jemez within three feet of the top of the levee near the bridge.

6.5 Scenario 5: Levee extension with arroyo interceptor channel, pond filled in to 5235 ft., active pumping

In this scenario the pond infilling and levee and arroyo interceptor channel alignments were adjusted as described in Section 6.4, Scenario 4, above. In addition, the three groundwater extraction wells within the pond area described in Section 6.2, Scenario 2, were added to the predictive simulation. Scenario 5a was with the 100-yr stage hydrograph, and Scenario 5b was with the Jemez within three feet of the top of the levee near the bridge.

7.0 RESULTS

7.1 Scenario 1: Existing levee alignment, pond filled in to 5235 ft.

<u>1a Result (2006 River Stage):</u> Groundwater in the pond area never rose above the 5235 ft ground surface during the entire predictive run. The maximum elevation of groundwater was 5,233.2 ft at the northwestern edge of the pond area, and 5,231.4 ft in the center of the current footprint of the pond, on 4/19/06. On the last time step of the model (6/23/06), groundwater in the center of the current footprint of the pond was 5228.5 ft, or about 6.5 ft below ground surface. See Figure 8 for a groundwater contour map showing the maximum groundwater elevations simulated in the pond for this scenario.

<u>1b Result (100-Yr River Stage):</u> Groundwater levels in the pond area did not rise above the 5235 ft ground surface elevation during the entire simulation. The maximum groundwater elevation in the pond area was 5229.6 ft on 7/23/06. During the last time step of the model (8/1/06), groundwater in the pond area was 5229.5 ft, or about 5.5 ft below ground surface. See Figure 12 for a groundwater contour map showing the maximum groundwater elevations simulated in the pond for this scenario.

<u>1c Result (Levee minus 3 ft River Stage):</u> In the pond area it took 14 days (simulation date of 7/15/06) for groundwater to begin to pool above the 5235 ft ground surface from the time the Jemez peaked to 3 ft below the top of the levee at the Jemez bridge. It took 11 days from the time the river stage began to recede for all pooled water in the pond area to dissipate to below ground surface (simulation date of 9/10/06). The maximum flooded area within the ring levee/former pond was estimated to be 181,000 ft^2 (just over 4 acres). See Figure 14 for a groundwater contour map showing the maximum groundwater elevations simulated in the pond for this scenario.

7.2 Scenario 2: Existing levee alignment, pond filled in to 5235 ft., active pumping

<u>2a Result (2006 River Stage):</u> Groundwater in the pond area never rose above the 5235 ft ground surface during the entire predictive run without pumping wells simulated, therefore this scenario was not needed to keep the pond area from flooding. However, as a practical exercise the scenario was run using three extraction wells pumping, from west to east, 25, 25, and 35

gpm, with modest drawdown results and with the middle well pumping dry on 6/1/06. On the last time step of the model (6/23/06), groundwater in the center of the current footprint of the pond was 5228.5 ft (6.5 ft bgs). See Figure 9 for a groundwater contour map showing the maximum groundwater elevations simulated in the pond for this scenario.

<u>2b Result (100-Yr River Stage):</u> Similarly to the 2a Scenario, groundwater in the pond area never rose above the 5235 ft ground surface during the whole predictive run. Therefore, as before, extraction wells in the pond area were not required. The maximum groundwater elevation in the pond area was 5229.4 ft on 7/23/06. During the last time step of the model, groundwater in the pond area was 5228.8 ft, or about 6.2 ft below ground surface.

<u>2c Result (Levee minus 3 ft River Stage):</u> The 3 extraction wells, having been turned on once the Jemez rose to peak stage on 7/1/06, required pumping rates of 45, 25, and 25 gpm (west to east, respectively) in order for no flooding to occur during the simulation. It is known from Scenario 1c it would take 14 days beyond 7/1/06 for flooding to occur if the wells were not in operation. The shallowest depth to groundwater, with wells pumping, was 0.5 ft below ground surface to the northwest of the westernmost extraction well. The shallowest depth to groundwater in the center of the pond area was 2 ft bgs (5233 ft) on the last day of elevated river stage (8/30/06). See Figure 15 for a groundwater contour map showing the maximum groundwater elevations simulated in the pond for this scenario.

7.3 Scenario 3: Existing levee alignment, pond filled in to 5235 ft., passive drain with active sump

<u>3a Result (2006 River Stage):</u> Groundwater in the pond area never rose above the 5235 ft ground surface during the entire predictive run. The highest elevation groundwater rose in the center of the pond area was 5230.5 on 12/31/05 (resulting from the initial starting condition). The drain was actively receiving groundwater between 12/31/05 and 6/9/06; with a maximum flow rate of 57 gpm at the start of the simulation. On the last time step of the model (6/23/06), groundwater in the center of the current footprint of the pond was 5228.6 ft (6.4 ft bgs). See Figure 10 for a groundwater contour map showing the maximum groundwater elevations simulated in the pond for this scenario.

<u>3b Result (100-Yr River Stage):</u> Groundwater in the pond area never rose above the 5230 ft, the elevation the drain was set to; therefore the drain did not receive any groundwater during this simulation. The reason the 100-yr event produced lower groundwater elevations in the pond area compared to the 2006 scenario was due to the lower initial starting groundwater elevation of the simulation. On the last time step of the model (6/23/06), groundwater in the center of the current footprint of the pond was 5229.5 ft (5.5 ft bgs).

<u>3c Result (Levee minus 3 ft River Stage):</u> With the drain in place at a constant elevation of 5230 ft, 5 ft below ground surface, the drain worked well and never allowed groundwater in the pond area to rise above 5230.7 ft (4.3 ft bgs). The drain was actively receiving groundwater between 7/3/06 to 10/12/06. These dates correspond to two days after the rise to peak Jemez stage (7/1/06) and 43 days after the last day of elevated Jemez stage (8/30/06). The maximum rate of

flow into the drain was 153 gpm on the last day of elevated Jemez stage. This date (8/30/06) also corresponded to the maximum groundwater elevation of 5230.7 ft during the simulation. By the last time step (10/29/06), groundwater in the pond vicinity was at an elevation of 5228.2 ft, below the elevation of the drain. See Figure 16 for a groundwater contour map showing the maximum groundwater elevations simulated in the pond for this scenario.

7.4 Scenario 4: Levee extension with arroyo interceptor channel, pond filled in to 5235 ft.

4a Result (2006 River Stage): Groundwater did not rise above elevation 5235 ft within the pond area during the entire simulated period; therefore no flooding occurred. In the center of the pond area, groundwater rose as high as 5231.5 ft (3.5 ft bgs). See Figure 11 for a groundwater contour map showing the maximum groundwater elevations simulated in the pond for this scenario.

4b Result (100-Yr River Stage): With the levee realignment and extension, arroyo interceptor channel, and current pond filled to 5235 ft with like material, and utilizing the 100-yr Jemez River stage, no cell flooding was observed inside the levee. The highest groundwater elevation attained within the center of the pond area was at the beginning of the simulation at 5230.6 ft (4.4 ft bgs). The shallowest depth to groundwater within the area bounded by the new levee realignment was about 2.5 ft bgs (reported as depth below ground surface and not elevations in this instance because ground surface varied within this portion of the model). See Figure 13 for a groundwater contour map showing the maximum groundwater elevations simulated in the pond for this scenario.

4c Result (Levee minus 3 ft River Stage): Under this scenario, with no active extraction of groundwater, flooding of cells occurred 11 days after the Jemez River peaked on 7/1/06. The first cells to flood were those located along the northwestern perimeter of the current pond area and beyond to the northwest, closest to where the river bottom elevation is highest. The maximum height groundwater rose within the center of the existing pond area during the simulation was to 5234.9 ft, on the last day of peak river stage (8/30/06). This corresponds to groundwater at just 0.1 ft below ground surface. The reason for flooding to the northwest of the center of the pond area and not in the center of the pond area itself is because the corresponding river stage elevation adjacent to the cells to the northwest was higher. Because MODFLOW is not a surface water model, it did not transfer water from the flooded cells to other areas of the pond of equal ground surface elevation. Flooding of nearly all cells within the area bounded by the newly realigned levee occurred because the ground surface was not raised in this area. The total estimated flooded area within the pond area and to the northwest was approximately 95,000 ft^2. It took 7 days from the time the river stage began to recede for all pooled water in the pond area to dissipate to below ground surface (simulation date of 9/7/06). See Figure 17 for a groundwater contour map showing the maximum groundwater elevations simulated in the pond for this scenario.

7.5 Scenario 5: Levee extension with arroyo interceptor channel, pond filled in to 5235 ft., active pumping

<u>5a Result (100-Yr River Stage):</u> Under this scenario active extraction of groundwater is not necessary to prevent the pond area from flooding. However, with three extraction wells evenly distributed as before within the pond area pumping 45, 25, and 25 gpm respectively from west to east, groundwater on average in the pond area is lowered about 4 ft compared to the similar scenario without active pumping (Scenario 4a). Groundwater elevation in the center of the pond area at the end of the simulation was 5226.4 ft (8.6 ft bgs) and 5228.7 (6.3 ft bgs) near the westernmost extraction well.

<u>5b Result (Levee minus 3 ft River Stage):</u> Under this scenario, with active pumping using three extraction wells withdrawing 45, 25, and 25 gpm respectively from west to east, no flooding occurred inside the levee during the entire simulated period at locations raised to a height of 5235 ft. Nearly the entire new area within the realigned levee did flood because the ground surface was not raised in this area (elevations generally ranged from about 5226 to 5230 ft). The extraction wells were turned on once the river stage peaked (7/1/06) and kept on throughout the remainder of the simulation. On day 1 of active pumping during the simulation (7/1/06), groundwater elevation in the center of the pond was 5230.4 ft (4.6 ft bgs). The maximum height attained during the simulation in the center of the pond area was 5232.1 (2.9 ft bgs) on the last day of the elevated river stage (8/30/06). After 8/30/06, groundwater elevation dropped slowly but steadily through the end of the simulated period, and was lowered to 5226.8 ft (8.2 ft bgs). See Figure 18 for a groundwater contour map showing the maximum groundwater elevations simulated in the pond for this scenario.

Time series groundwater elevation data for a cell located in the center of the pond for the 2006 Spring Flow, 100 Year, and Levee Minus 3 ft River Stage transient simulations are plotted in Figure 19, Figure 20, and Figure 21 respectively.

8.0 DATA GAPS

Through the modeling process, several data gaps were identified. These included: lack of detailed water supply well usage records and pumping rates; uncertainty regarding survey accuracy and water levels in downgradient/weir wells; lack of stratigraphic detail and groundwater observation points beyond the immediate area of interest; uncertainty associated with recharge from rainfall collection off of village structures; and basin-wide water inputs and outputs along the model boundaries. The only data gap which affects uncertainty within the Tamaya Village and pond area of interest is recharge from village structures. No other data gaps were identified in the immediate area of the Tamaya Pond; therefore results in this main area of interest are believed to be fairly accurate due to the more rigorous data set and better calibration in this region of the model.

9.0 MODEL USE AND LIMITATIONS

The base MODFLOW model used to set up the predictive scenarios is based on best available geologic and hydrogeologic data at the time of model development. Site conceptual models may change over time as new information becomes available. If any of the CSM assumptions or parameter values utilized in the groundwater model are determined to be inaccurate based on new data or data otherwise unavailable to the modeling team, predictive results may likewise be affected. If the model is to be utilized for future predictive purposes within the area of the historic village or pond, updates to the CSM and numerical model may be warranted. The model as it is currently configured may not accurately predict water levels near the edges of the domain; therefore caution should be used if attempts are made to use the model for predictive purposes outside the immediate area around the village or pond.

10.0 CONCLUSIONS AND RECOMMENDATIONS

The groundwater modeling results can be used to assist the Pueblo of Santa Ana in evaluating and selecting the best remedial alternative for permanent elimination of the pond. The Tamaya model individual objectives, as listed in Section 1, were achieved. Relevant site data was assimilated into a detailed hydrogeologic and mathematical model framework, current site groundwater conditions are believed to be adequately represented. Five remedial alternatives were set up, run, and evaluated for effectiveness of pond removal. Existing site hydraulic data gaps have been identified. The model, in its electronic form, is updatable and transferable for future groundwater management.

The reason the 100-yr river stage scenario appears to not significantly affect water levels around the pond area is because the starting groundwater elevations simulated on 6/24/06 have a significant influence of how high groundwater elevations reach due to the high river stage. In this case groundwater on 6/24/06 was approximately 5228 ft below ground surface in the pond area, and although the river stage caused groundwater to rise, it was only by a modest amount. Rise in river stage was not enough for water to begin to pool above the 5235 ft land surface. Starting hydraulic heads for the 100-yr river stage scenario were resultant elevations determined on the final time step of the 2006 model; therefore, if the vicinity had experienced more recharge than it did in the first half of 2006, the 100-yr scenario would have experienced higher resultant groundwater elevations.

Based on the results of this groundwater modeling project, including consideration of results of the calibrated transient 2006 model, it appears the most benefit will be obtained by raising the existing ground surface elevation in and around the existing pond to 5235 ft. Dewatering of the pond would likely be required to keep the infilling construction project in the dry; however, once completed, under most seasonal conditions the model predicts the daylighting of groundwater above ground surface (which forms the current pond) to be eliminated. Only under extremely high Jemez flows – and for generally short durations – would additional measures be required to prevent pooling of water above ground surface in the pond area.

If additional protective measures were desired to keep the pond area from flooding during extremely high stage and long duration river flows, either of the groundwater withdrawal options (3 extraction wells or a passive drain with active sump pump) would work adequately to provide this protection. A cost analysis was not performed as part of the groundwater modeling project; therefore costs for construction and operation & maintenance should be evaluated if either of these measures were to be instituted. The 3 extraction well pumps and piping, if utilized, should be sized such that they are within the peak portion of the efficiency rating curve from about 25-45 gpm. Several configurations may be considered when designing for groundwater removal from a passive drain sump, either by using a combination of smaller and larger pumps which could be used under smaller and larger inflows to the sump, or a single larger pump capable of handling smaller inflows as well.

If shallow groundwater extraction wells are to be installed, the screened intervals should be installed deeper than represented in the model scenarios which included active pumping. The scenarios with the three extraction wells had pump intake and hence screen interval represented at elevations of 5,223 to 5,224 ft, which is 11 to 12 feet bgs. Placing the screen bottoms at about 25 feet below ground surface would allow more flexibility in operating the wells since the wells would be less susceptible to being pumped dry.

The reconfigured levee alignment appears to hasten entry of river-induced floodwaters to areas within the levee (14 days without versus 8 days with levee realignment, utilizing non-pumping scenarios). The total flooded area and volume of water is vastly reduced, however, when the levee is realigned (181,000 ft^2 versus 16,000 ft^2) and the reconfigured levee allows about 25 percent of ponded water to occur farther away from the current location adjacent to the village. It should be pointed out, however, that flooding inside the ring levee only occurred under the worst-case scenario modeled, that being the Jemez stage at three feet below the existing levee at the Jemez bridge held constant for an extended eight-week period. The levee, either in its current configuration or in the realigned option, has no low-permeability layer to tie into; therefore groundwater above the bottom elevation of the levee will flow underneath the base of the levee through relatively permeable soils if allowed sufficient time. Because the levee realignment would likely be the most complex and costly option to construct, it may be the least preferred. However, unlike the pumping options, no power is required once constructed to operate.

11.0 REFERENCES

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TABLES

Table 1. Summary of Boundary Conditions

Boundary Physical Location and Description	**MODFLOW Boundary Package and Boundary Condition (BC) Type**	**BC Type Rationale**
Hydraulically upgradient of Tamaya Village	Well Package/Specified flux	Means of Rio Jemez up-valley groundwater inflow to model domain
Hydraulically downgradient of Tamaya Village	Well Package/Specified flux (except at Jemez Weir, see below)	Means of Rio Jemez down-valley groundwater outflow from model domain
Northeast of and parallel to Rio Jemez (Santa Ana Mesa)	Well Package/Specified flux	Recharge from side-gradient mesa
Southwest of and parallel to Rio Jemez (State Route 44)	Well Package/Specified flux	Recharge from side-gradient uplands
Top of modeled domain (water table plane)	Recharge Package/Specified flux	Input competing effects of precipitation recharge and evapotranspiration
Bottom of modeled domain (Base of lowest-elevation modeled hydrostratigraphic unit)	Basic Package/Specified flux (zero flux, a.k.a. "no flow")	Predominant groundwater flow is horizontal, not vertical because of horizontal deposition of alluvium.
Rio Jemez from hydraulic upgradient to downgradient boundaries	River Package/Specified head	To utilize output from HEC-RAS surface water model at points upstream and downstream of the Village.
Tamaya Village Groundwater Extraction Well	Well Package/Specified flux	Optimal method for simulating extraction well
Rio Jemez Weir; makes up portion of boundary hydraulically downgradient of Village	Drain Package/Specified head	Water removed from model only when water surface is above specified elevation

Table 2. Summary of Calibrated Model Parameters, Steady-State Model

Parameter	**Calibrated Value**
Horizontal hydraulic conductivity (Kh, ft/d)	0.025 to 62.2 ft/d (see Table 3 for Kh detailed by stratigraphic unit)
Vertical anisotropy (Kh/Kv ratio)	6.5
River stage (ft)	Varies (see Table 4, Stress period #8 row)
River conductance (ft/d/ft)	0.05
Specified flux boundary condition (ft3/d)	SW: 2,500
	NW: 47,000
	NE: 2,500
	SE: -52,000
Recharge (ft/d)	0.00048
Evapotranspiration (ET) rate (ft/d)	0.0137
ET extinction depth (ft)	10
Specific yield	0.12
Specific storage (1/ft)	$1.2x10^{-6}$
Porosity	0.3

Table 3. Summary of Calibrated Kh Values

Hydrologic Unit	**Model Material ID**	**Material Symbol**	**Calibrated Value (ft/d)**
Inorganic CLAY	3	CL	4.1
SILT and/or fine SAND	8	ML	0.1
SILT and/or fine SAND	9	ML	2.98
Clayey SAND	10	SC	25.3
Lower alluvium1	11	SCG	25.3
Silty SAND	12	SM	5.9
Poorly-graded silty SAND	19	SP-SM	50
Poorly-graded SAND	16	SP	62.2
Poorly-graded SAND with gravel	17	SPG	62.2
Well-graded SAND	21	SW	26.3
Well-graded SAND with gravel	22	SWG	26.3
Well-graded silty SAND	23	SW-SM	1.0
Well-graded silty SAND with gravel	24	SW-SMG	1.0
Well-graded GRAVEL	6	GW	3.1
Well-graded GRAVEL with sand	7	GWS	3.1
SILT and/or CLAY	25	Levee	0.025
Silty SAND, poorly-graded	14	SM-SP	5.1
Lower alluvium2	20	SP-SMG	5.1

Notes:
In some cases, automated parameter estimation resulted in materials manually classified as less permeable to have greater Kh values than those classified as more permeable (i.e., Kinorganic clay > Ksilt/fine sand). Kh values, however, remain within reasonable range.

Table 4. Steady-State Simulated Groundwater Elevations at Observation Points

Model node (i, j, k)	Observation Well ID	Area of model	Water level (WL) observed (ft), March 2006	WL simulated at node (ft)
80, 126, 1	TP-2	Pond	5232.019	5232.149
35, 97, 1	TP-5	Pond	5233.661	5233.882
25, 109, 1	TP-6	Pond	5234.713	5235.650
21, 72, 1	P-18S	Pond	5238.752	5237.252
21, 72, 2	P-18D	Pond	5237.579	5237.067
53, 54, 1	P-23	Pond	5232.885	5232.913
103, 84, 1	BIANW	Pond	5230.800	5230.625
154, 17, 1	P-4	Weir	5212.400	5212.685
158, 111, 1	P-5	Weir	5204.220	5207.260
158, 51, 1	P-6	Weir	5204.440	5205.299
159, 73, 1	HW-4	Weir	5200.730	5203.815

Table 5. Summary of Calibrated Time-varying Parameters, Transient Model

Stress Period (Start date)	River Stage (ft) RS7000	River Stage (ft) RS6300	River Stage (ft) RS5200	River Stage (ft) RS3000	Evapo-Transpiration ET (ft/d)	Recharge (ft/d)
0 (12/31/05)	5238.96	5236.48	5232.54	5225.44	0.006	0.0
1 (12/31/05)	5238.96	5236.48	5232.54	5225.44	0.006	0.0
2 (1/7/06)	5238.96	5236.49	5232.63	5225.58	0.006	0.0
3 (1/14/06)	5238.97	5236.50	5232.69	5225.67	0.006	0.0
4 (1/21/06)	5238.96	5236.49	5232.62	5225.56	0.006	0.0
5 (1/28/06)	5238.97	5236.50	5232.75	5225.75	0.006	0.000238
6 (2/4/06)	5238.97	5236.50	5232.71	5225.69	0.006	0.000952
7 (2/11/06)	5238.97	5236.50	5232.71	5225.69	0.006	0.0
8 (2/18/06)	5238.97	5236.50	5232.73	5225.73	0.006	0.0
9 (2/25/06)	5238.97	5236.50	5232.73	5225.73	0.006	0.0
10 (3/4/06)	5238.96	5236.49	5232.64	5225.59	0.006	0.0
11 (3/11/06)	5238.97	5236.50	5232.72	5225.70	0.006	0.0
12 (3/18/06)	5238.98	5236.51	5232.79	5225.82	0.006	0.003214
13 (3/25/06)	5238.96	5236.49	5232.58	5225.51	0.006	0.000476
14 (4/1/06)	5238.95	5236.48	5232.41	5225.25	0.006	0.0
15 (4/8/06)	5238.99	5236.53	5232.89	5225.97	0.006	0.0
16 (4/15/06)	5238.97	5236.51	5232.75	5225.75	0.006	0.0
17 (4/22/06)	dry	dry	dry	dry	0.006	0.0
18 (4/29/06)	dry	dry	dry	dry	0.006	0.0
19 (5/6/06)	dry	dry	dry	dry	0.007	0.00619
20 (5/13/06)	dry	dry	dry	dry	0.009	0.0
21 (5/20/06)	dry	dry	dry	dry	0.013	0.0
22 (5/27/06)	dry	dry	dry	dry	0.018	0.0
23 (6/3/06)	dry	dry	dry	dry	0.023	0.0
24 (6/10/06)	dry	dry	dry	dry	0.024	0.004167
25 (6/17/06)	dry	dry	dry	dry	0.025	0.0

Notes:
Calibrated transient recharge was 0 for all stress periods due to cancellation effect from ET; however, historical recharge shown above based on precipitation for period of record.
Beginning 4/22/06, dry river simulated by setting conductance to 0.

Table 6. Steady-State Calibration Sensitivity Analysis Summary

	RUN # "GMS file" Description	RUN 1 "steady sensitivity1" (recharge to top layer)	RUN 2 "st.sens.2" (+1 Ft river stage)	RUN 3 "st.sens.3" (Halve ET)	RUN 4 "st.sens.4" (Double ET)	RUN 5 "st.sens.5" (Double river conductance)	RUN 6 "st.sens.6" (Triple river conductance)	RUN 7 "st.sens.7" (Double recharge)
Village/ Pond Observation Points	Average Difference, Calibrated vs. Sensitivity Run (ft)	-0.79	0.92	0.74	0.23	0.25	0.35	0.84
	Standard Deviation (ft)	0.34	0.04	0.39	0.33	0.03	0.05	0.39
Down gradient/ Weir Observation Points	Average Difference, Calibrated vs. Sensitivity Run (ft)	-0.95	0.74	0.53	1.28	0.04	0.26	0.84
	Standard Deviation (ft)	0.91	0.82	0.77	1.7	0.59	0.79	0.6
	RUN # "GMS file" Description	RUN 8 "st.sens.8" (Halve recharge)	RUN 9 "st.sens.9" (Double Kh)	RUN 10 "st.sens. 10" (Halve Kh)	RUN 11 "st.sens. 11" (Double Kh/Kv ratio)	RUN 12 "st.sens. 12" (Halve Kh/ Kv ratio)	RUN 13 "st.sens. 13" (Double boundary specified flux)	RUN 14 "st.sens. 14" (Halve boundary specified flux)
Village/ Pond Observation Points	Average Difference, Calibrated vs. Sensitivity Run (ft)	-0.46	-0.4	1.08	-0.18	0.09	0.12	-0.37
	Standard Deviation (ft)	0.18	0.25	0.6	0.14	0.08	0.22	0.09
Down gradient/ Weir Observation Points	Average Difference, Calibrated vs. Sensitivity Run (ft)	-0.2	0.02	1.39	0.34	0.17	-1.43	-1.03
	Standard Deviation (ft)	0.77	0.55	0.75	0.45	0.47	1.67	1.31

Notes:
Village/Pond Observation Points: TP-2, TP-5, TP-6, P-18S, P-18D, P-23, BIANW.
Downgradient/Weir Observation Points: P-4, P-5, P-6, HW-4, HW-6.

Table 7. Transient Calibration Sensitivity Analysis Summary

Parameter and amount varied	Simulation file name	Result near pond compared with calibrated model
+1 Ft. river stage	TransientSensitivity Stage.gpr	Groundwater elevations at observation points except P-18S and P-18D significantly affected upward
Double river conductance	TransientSensitivity Conductance.gpr	Less impact than increasing stage, all groundwater elevations at wells slightly upward
Triple river conductance	TransientSensitivity Conductance2.gpr	Little difference between doubling and tripling conductance
Double ET	Transientsensitivity4.gpr	Lower overall model mean error but due in large part to weir-area wells; unrealistically high ET
Halve ET	Transientsensitivity5.gpr	Post-dry river slope too shallow compared to observation hydrographs
Double recharge	Transientsensitivity6.gpr	Excessive spike in groundwater elevations at highest recharge stress period (SP19)
Double Sy	Transientsensitivity7.gpr	Post-dry river slope too shallow compared to observation hydrographs
Double Ss	Transientsensitivity8.gpr	Very little difference compared to calibrated
Double Kh	Transientsensitivity9.gpr	Groundwater elevations slightly upward; Post-dry river slope too steep
Halve Kh	Transientsensitivity10.gpr	Post-dry river slope too shallow for TP-5, TP-6 and BIANW, too steep for P-23; approaching lower limits of realistic Kh values

Table 8. Predictive Scenarios and Results Summary

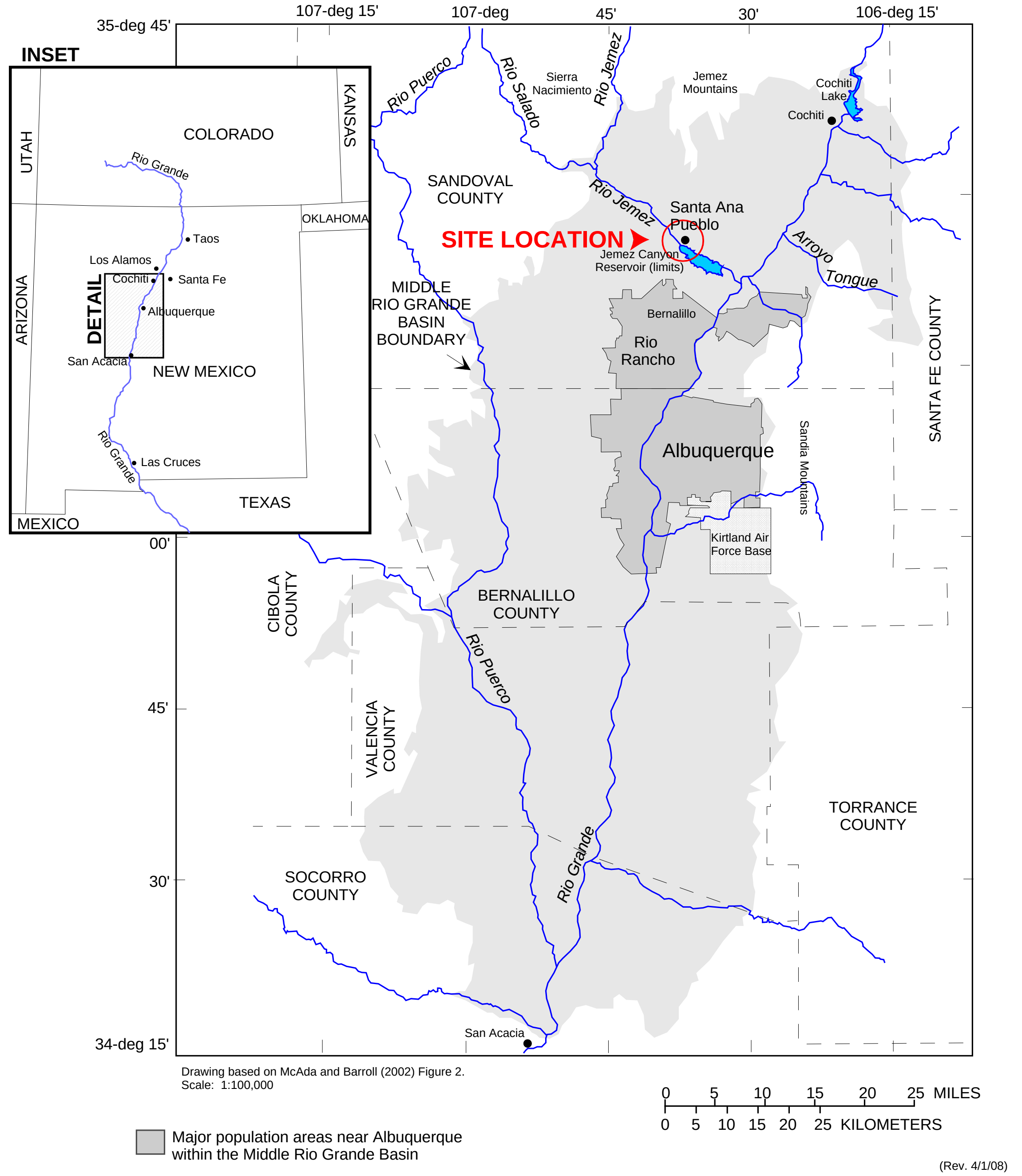
Base Scenario No.	**2006 River Stage**	**100-Year River Stage**	**Exist Levee minus 3 ft River Stage**
1. Existing levee, pond filled to 5235	**1a** Result: Ponded water eliminated	**1b** Result: Ponded water eliminated	**1c** Result: Ponding water begins 14 days after peak river stage
2 Existing levee, pond filled to 5235, active pumping	**2a** Result: Ponded water eliminated	**2b** Result: Ponded water eliminated	**2c** Result: 3 wells pumping 45, 25, 25 gpm eliminates ponding of water
3. Existing levee, pond filled to 5235, passive drain	**3a** Result: Ponded water eliminated	**3b** Result: Ponded water eliminated	**3c** Result: drain with max flow of 153 gpm eliminates ponding of water
4. Levee extension w/ arroyo interceptor channel, pond filled to 5235	**4a** Result: Ponded water eliminated	**4b** Result: Ponded water eliminated	**4c** Result: Ponding water begins 11 days after peak river stage
5. Levee extension w/ arroyo interceptor channel, pond filled to 5235, active pumping	NA	**5a** Result: Ponded water eliminated	**5b** Result: 3 wells pumping 45, 25, 25 gpm eliminates ponding of water

NA – Not applicable

Table 9. Predictive Scenario GMS File Names on the Pueblo Groundwater Modeling Workstation

Scenario ID	Scenario Description	GMS File Name
1a	Existing levee alignment Pond filled to 5235 ft 2006 river stage	2006Transient4_Fill1.gpr
1b	Existing levee alignment Pond filled to 5235 ft 100-yr river stage	2006Transient4_Fill3.gpr
1c	Existing levee alignment Pond filled to 5235 ft Existing levee top minus 3 ft river stage	3ft_Below_Levee_Fill1.gpr
2a	Existing levee alignment Pond filled to 5235 ft Active pumping 2006 river stage	2006Transient4_Pump1.gpr
2b	Existing levee alignment Pond filled to 5235 ft Active pumping 100-yr river stage	100Transient4_Pump1.gpr
2c	Existing levee alignment Pond filled to 5235 ft Active pumping Existing levee top minus 3 ft river stage	3ft_Below_Levee_Pump1.gpr
3a	Existing levee alignment Pond filled to 5235 ft Passive drain 2006 river stage	2006Transient4_Drain1.gpr
3b	Existing levee alignment Pond filled to 5235 ft Passive drain 100-yr river stage	100Transient4_Drain1.gpr
3c	Existing levee alignment Pond filled to 5235 ft Passive drain Existing levee top minus 3 ft river stage	3ft_Below_Levee_Drain1.gpr
4a	Reconfigured levee with arroyo interceptor channel Pond filled to 5235 ft 2006 river stage	2006Transient4_levee5.gpr
4b	Reconfigured levee with arroyo interceptor channel Pond filled to 5235 ft 100-yr river stage	100Yr_Levee2.gpr
4c	Reconfigured levee with arroyo interceptor channel Pond filled to 5235 ft Existing levee top minus 3 ft river stage	3ft_Below_Levee_Levee2.gpr
5a	Reconfigured levee with arroyo interceptor channel Pond filled to 5235 ft Active pumping 100-yr river stage	100Yr_Levee2_Pump1.gpr
5b	Reconfigured levee with arroyo interceptor channel Pond filled to 5235 ft Active pumping Existing levee top minus 3 ft river stage	3ft_Below_Levee_Pump2.gpr

FIGURES



U.S. ARMY CORPS OF ENGINEERS
SEATTLE DISTRICT

Tamaya Groundwater Modeling Project
Site Location Map

Tamaya Groundwater Modeling Report

Santa Ana Pueblo	**Figure 1**	New Mexico

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FINAL LETTER REPORT
TAMAYA POND GROUNDWATER MODELING UPDATE
FOR REVISED GRADING PLAN AND REVISED PASSIVE DRAIN WITH SUMP

Prepared by U.S. Army Corps of Engineers, Seattle District

January 24th, 2012

Introduction and Model Set-Up

In 2009 a numerical groundwater flow model was developed for the Tamaya Pond Project for the purpose of assisting the Pueblo of Santa Ana in evaluating and selecting the best remedial alternative for permanent elimination of the pond. A detailed groundwater modeling report was written to document all aspects of the modeling conducted at that time (USACE 2009[1]). See the previous report for details regarding the original groundwater model utilized for this update.

In December 2011 Albuquerque District requested that the Seattle District groundwater modeling team evaluate additional predictive scenarios that would reflect the latest project design criteria. Two components of the revised design criteria included re-graded surface topography of the pond area and a revised passive drain design.

Surface topography not previously incorporated into the 2009 models included a grading plan for the Tamaya Pond vicinity that was generally lower in elevation and was sloped downward by 0.8% toward the southeast to provide surface drainage toward a grouping of centralized beehive grates. The revised elevations varied from 5240 feet northwest of the pond area down to 5232.5 feet along a linear transect connecting the beehive grates in what is now the center of the pond. In predictive scenarios developed in 2009, the Tamaya Pond was in-filled with in-kind material to a uniform elevation of 5235 feet. The reconfigured land surface incorporated into this modeling update is intended to preserve historical cultural features to the north of the pond area, and to improve surface drainage. See design drawing Sheet C-101 for the proposed site and drainage plan.

After development of the updated base models incorporating revised pond topography, a reconfigured passive drain was also incorporated. In predictive scenarios developed in 2009 that included passive drains, the drain was modeled as a linear feature about 600 feet in length, with a uniform elevation of 5230 feet. The newly revised drain configuration, however, consists of nine shorter, parallel drain segments feeding into a single collector trunk drain, as depicted on design drawing Sheet C-102. For the first set of predictive model runs, all cells representing the drain segments were set to a uniform elevation of 5231 feet. For the second set of runs, the drain elevations were set to be 1.5 feet below the 0.8% sloped land surface, and corresponded to a range of between 5233.4 to 5231.2 feet. Drain conductance, the term used to represent relative ease of water flow from aquifer to drain, was set to a relatively high value of 1200 feet per day

[1] US Army Corps of Engineers, Seattle District. Groundwater Modeling Report, Tamaya Pond Project, Historic Village of Tamaya, Santa Ana Pueblo, Sandoval County, New Mexico. Prepared for US Army Corps of Engineers, Albuquerque District and Pueblo of Santa Ana, December 4, 2009.

(the same value used in 2009 models containing drains) to allow for groundwater to exit the model easily once it encountered the drain.

Updated groundwater modeling included the use of two Jemez River flow scenarios – one in which the river rises to within three feet of the top of the ring levee surrounding Tamaya Village at the bridge (abbreviated as "three feet below levee") and one newly constructed scenario for this work which reflected the 2010 Jemez River estimated stage data from January 1st to June 25th. The three feet below levee scenario represents an extreme loading condition as would result from an extended-duration reservoir pool held by Jemez Canyon dam that extended up-canyon to the vicinity of Tamaya Village. The elevated stage is held constant for an eight-week period. While a specific recurrence interval is not associated with this scenario, it is believed to be greater than the Jemez River stage resulting from a 500 year event, with a corresponding Jemez River flow above the dam of approximately 40,000 cubic feet per second (cfs). Conversely, the 2010 scenario is believed to represent a fairly typical spring runoff event, with a weekly-averaged peak flow of 590 cfs at the US Geological Survey (USGS) gage below the dam.

An attempt was made to also model the 1% exceedance probability event (originally developed in 2009); however, there was uncertainty in the accuracy of this model due to the incorporation of the MODFLOW Lake Package to simulate precipitation runoff from village structures. The 1% exceedance event equates to a 100 year flood event. Since the results of this scenario would be bracketed by the 2010 and three feet below levee results, predictive runs for this scenario were not carried to completion.

A total of six predictive model runs were executed. Three were based on the 2010 Jemez River estimated stage boundary conditions and consisted of a base case without drain, a case in which the drain was set to a uniform elevation of 5231 feet., and a case in which the drain was set to correspond to 1.5 feet. below the 0.8% sloped ground surface. Likewise, there were three predictive models set up based on the three feet below levee river stage boundary conditions consisting of a base case without drain, a uniform drain at 5231 feet, and a sloped drain set to 1.5 feet below the 0.8% sloped ground surface.

Results

2010 Estimated Stage with No Drain Present:

In order to predict what future ambient groundwater conditions would be like in the vicinity of Tamaya Pond under the 2010 Jemez River estimated stage conditions, the base case model was run in which the pond was in-filled with a 0.8% sloped surface and no drain was installed. Results of the base case predictive scenario indicated that groundwater would come within approximately one foot of ground surface for this scenario but would not rise above ground surface. See Figure 1 for predicted maximum groundwater elevations for this scenario.

Three Feet Below Levee Stage with No Drain Present:

The base case, no drain scenario was also set up and run for the three feet below levee river stage condition. Under this very high Jemez River flow condition, the entire re-graded pond area would be underwater for approximately 65 days. See Figure 4 for predicted maximum groundwater elevations for this scenario.

2010 Estimated Stage and Drain Set to Elevation 5231 feet:

The results indicated that groundwater never reached ground surface during this scenario. The highest groundwater elevation in the vicinity of the pond area was 5232.4 feet on April 23rd, 2010 (six days after peak river flow), at the location of the re-graded 5236 feet ground surface contour just to the west-northwest of the current pond. The results indicated that groundwater flowed into the drain for most of the modeled period; from January 2nd until June 20th, 2010 (modeled period was January 2nd to June 25th, 2010). Maximum flow rate into the drain was 19.9 gallons per minute (gpm) on April 24th, 2010. Total flow into the drain over the entire modeled period was 363,497 cubic feet, or 2.7 million gallons. See Figure 2 for maximum groundwater elevations in the pond area during this predictive simulation. See Figure 7 for a depiction of drain flow and river stage versus time for this predictive simulation.

2010 Estimated Stage and Drain Set to 1.5 feet Below Ground Surface:

As with the previously described 2010 scenario, groundwater never reached ground surface during this modeled scenario. The highest groundwater elevation in the pond vicinity occurred on May 1st, 2010A (14 days after peak river flow), when groundwater reached 5233 feet at the location of the 5236 ground surface contour. The highest groundwater elevation within the footprint of the current pond was 1.6 feet below ground surface (bgs) (5231.3 feet) at the terminus of the lowest (easternmost) perforated drain pipe (ground surface elevation 5132.9 feet). See Figure 3 for maximum groundwater elevation contours in the pond area for this predictive simulation. Groundwater flowed into the drain from April 11th to May 23rd, 2010. Maximum flow rate into the drain was only 1.8 gpm on April 30th, 2010. Total flow into the drain over the entire modeled period was 9,572 cubic feet (71,595 gallons). By raising the drain to correspond to 1.5 feet below ground surface (as opposed to setting at a uniform 5231 feet elevation), total flow is reduced by 97%. See Figure 8 for drain flow and river stage over time for this predictive simulation.

Three Feet Below Levee Stage and Drain Set to Elevation 5231 feet:

The results of this model run indicated groundwater never reached ground surface. The highest groundwater elevation occurred on August 30th, 2006 (the final day of elevated river stage; elevated river stage occurred over an eight week period July 1st to August 30th, 2006), in which groundwater is at 5234.2 feet at the location of the re-graded 5236 feet ground surface contour to the west-northwest of the current pond. See Figure 5 for maximum groundwater elevation contours in the pond area for this predictive simulation. The drain received groundwater during most of the modeled period; from July 6th to October 2nd, 2006 (modeled period was June 24th to October 29th, 2006). Maximum flow rate into the drain was 99.0 gpm on August 30th, 2006 (the last day of peak river stage). Total flow into the drain over the entire modeled period was 1.04 million cubic feet (7.78 million gallons). See Figure 9 for drain flow and approximate river stage over time for this simulation.

Three Feet Below Levee Stage and Drain Set to 1.5 feet Below Ground Surface:

As with the previously described three feet below levee stage scenario, groundwater never reached ground surface during this model run. Highest groundwater occurred on August 30th, 2006, at which time groundwater was at 5235.1 feet at the location of the 5236 feet ground surface contour. See Figure 6 for maximum groundwater elevation contours during this predictive simulation. The drain received groundwater from July 8th to September 19th, 2006, with maximum flow of 73.1 gpm on August 30th, 2006 (the last day of peak river stage). Total flow into the drain over the entire modeled period was 661,177 cubic feet (4.9 million gallons). Therefore, total flow is reduced by 36% in this scenario compared to the three feet below levee with drain set to 5231 feet scenario. See Figure 10 for drain flow and approximate river stage over time for this predictive simulation.

Conclusion

It is readily apparent that much benefit in the form of reduced groundwater drain inflows can be achieved by raising the passive drain design up from a uniform 5231 feet elevation to a variable elevation consistent with placement 1.5 feet below the re-graded land surface. Because natural groundwater flow gradient direction beneath the pond area is from northwest to southeast, less water will be intercepted by a drain sloping downward with the same orientation as groundwater. Based on the re-graded topography, the sloped drain would correspond to an elevation of 5233.4 feet at its highest point in the northwestern-most drain segment to a low of 5231.2 feet in the southeastern-most drain segment (see design drawing Sheet C-102), as was modeled in the 2010 Estimated Stage with Drain Set to 1.5 feet bgs Scenario.

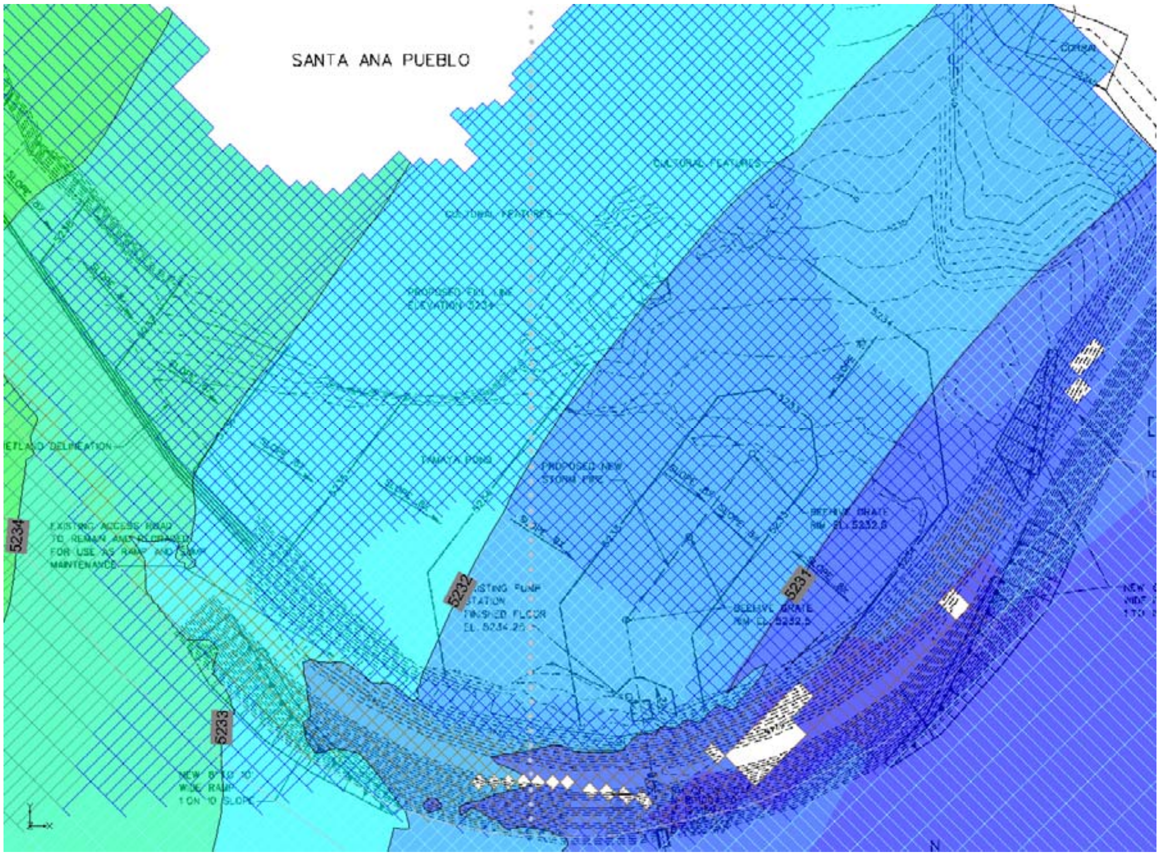

Figure 1. Model No. 2010T_RP_D0-01 (2010 river stage; no drain). Highest groundwater elevation on May 1st, 2010 (14 days after peak river flow); groundwater is within one foot of ground surface at beehive grate locations. Peak groundwater elevations are about 0.5 foot higher than experienced under 2006 river flow conditions.

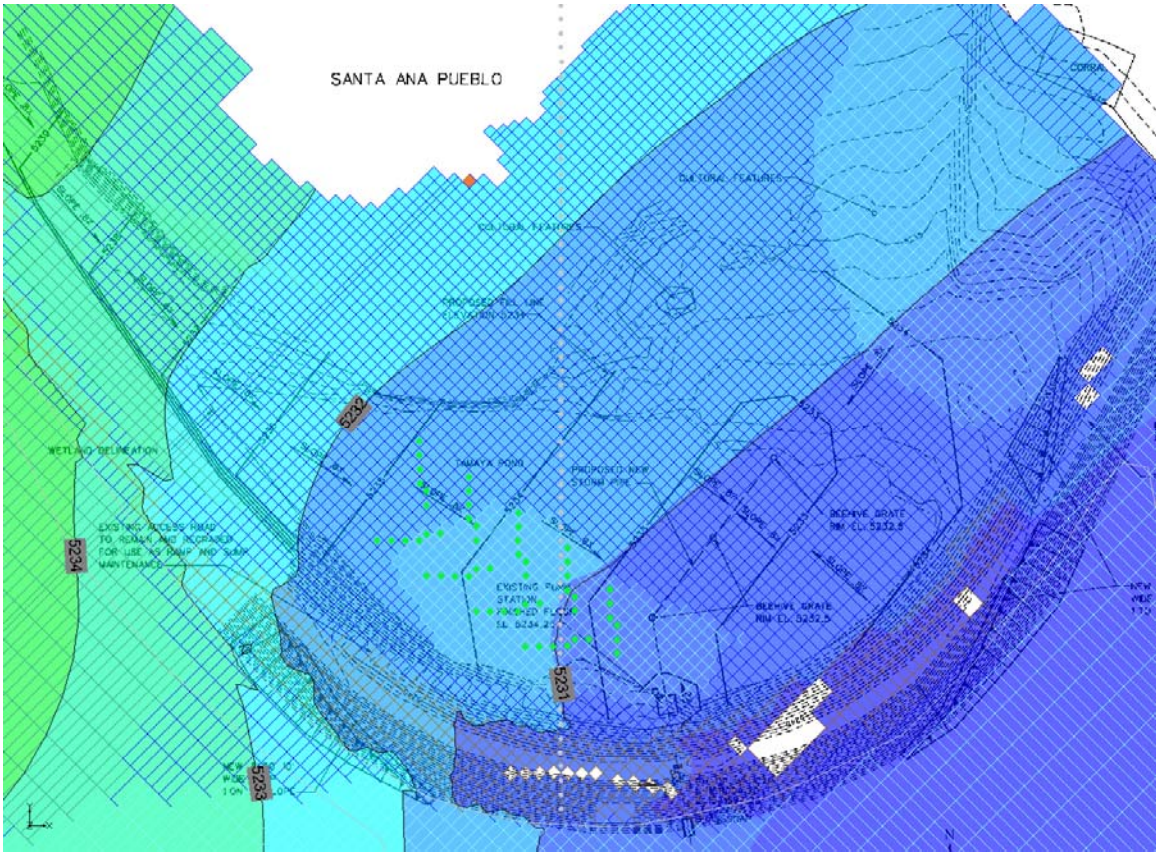

Figure 2. Model No. 2010T_RP_D1-01 (2010 river stage; drain elev. 5231 feet). Highest groundwater elevation on April 23rd, 2010 (six days after peak river flow); groundwater is 5232.4 feet at the location of the 5236 feet grade contour. Drain (cells depicted by green circles) is actively flowing water from January 2nd to June 20th, 2010. Maximum flow rate from drain is 19.9 gpm on April 24th, 2010.

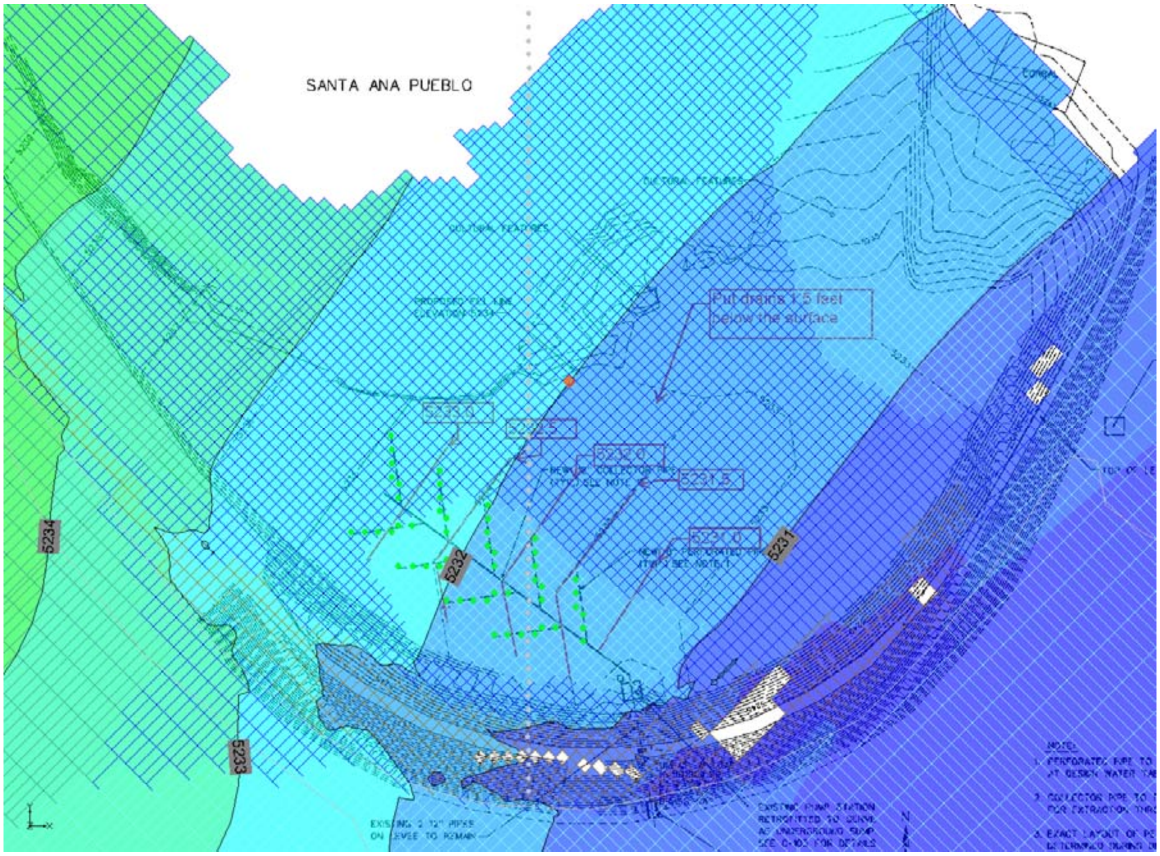

Figure 3. Model No. 2010T_RP_D2-01 (2010 river stage; sloped drain elevation 1.5 feet bgs). Highest groundwater elevation on May 1st, 2010 (14 days after peak river flow); groundwater is 5233.0 feet at the location of the 5236 feet grade contour. Shallowest groundwater in pond area is 1.6 feet bgs (5231.3 feet) at terminus of lowest perforated drain pipe (ground surf elev. 5132.9 feet). Drain (cells depicted by green circles) is actively flowing water from April 11th to May 23rd, 2010. Maximum flow rate from drain is 1.8 gpm on April 30th, 2010.

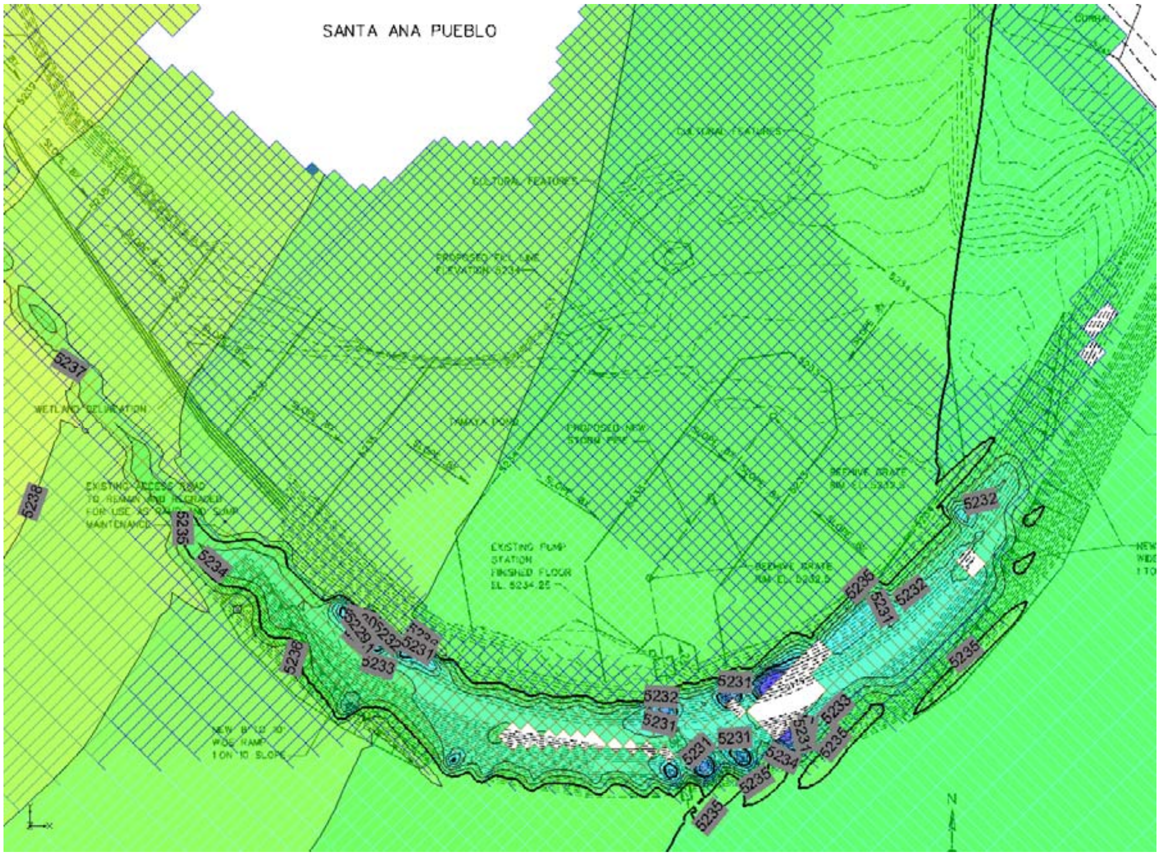

Figure 4. Model No. 003T_RP_D0-01 (three feet below levee; no drain). Highest groundwater elevation on August 30th, 2006 (first day flood stage begins receding); groundwater is above ground surface and the contour through center of pond (exiting image at top center) is 5236 feet. Low point of area begins to flood 11 days after start of flood stage; it takes 16 days after flood stage begins receding for water to dissipate below ground surface.

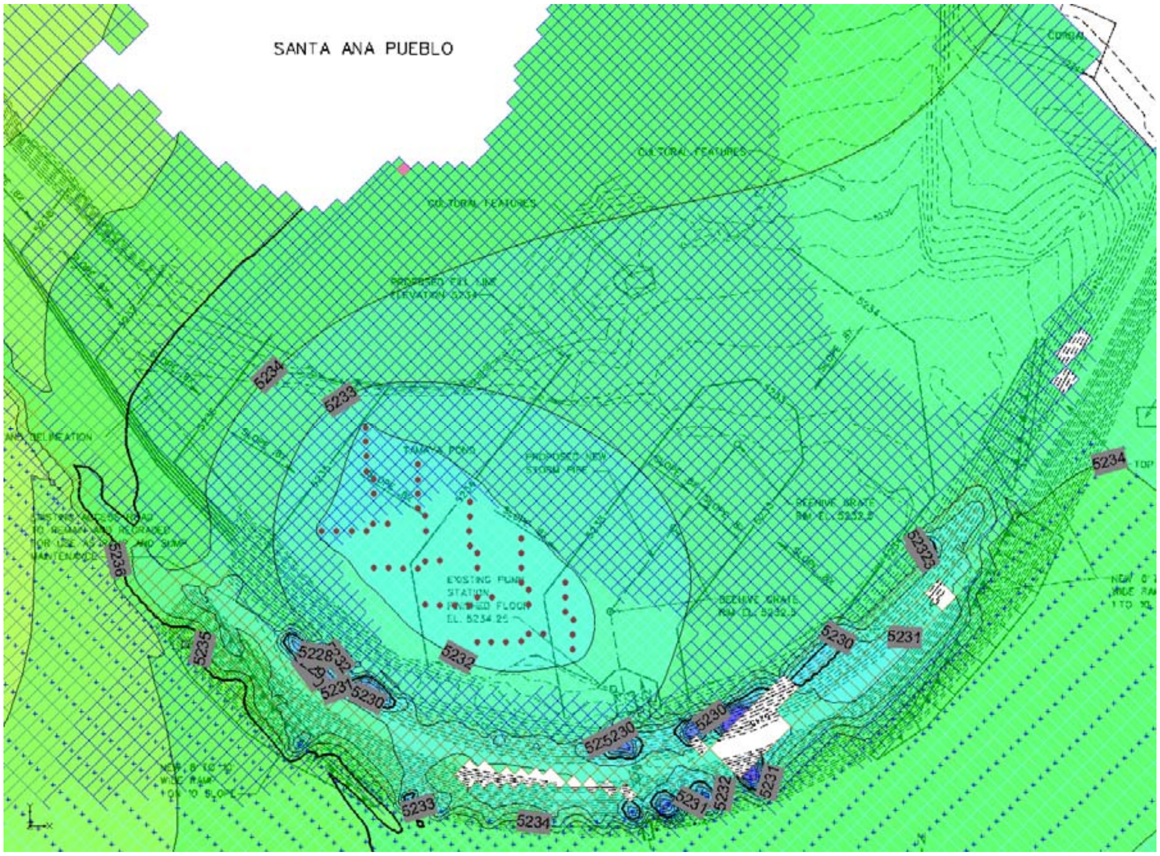

Figure 5. Model No. 003T_RP_D1-01 (three feet below levee; drain elevation 5231 feet). Highest groundwater elevation on August 30th, 2006. Groundwater never goes above ground surface with drain. Drain (cells depicted by brown circles) is actively flowing water from July 6th to October 2nd, 2006. Maximum flow rate from drain is 99 gpm on August 30th, 2006.

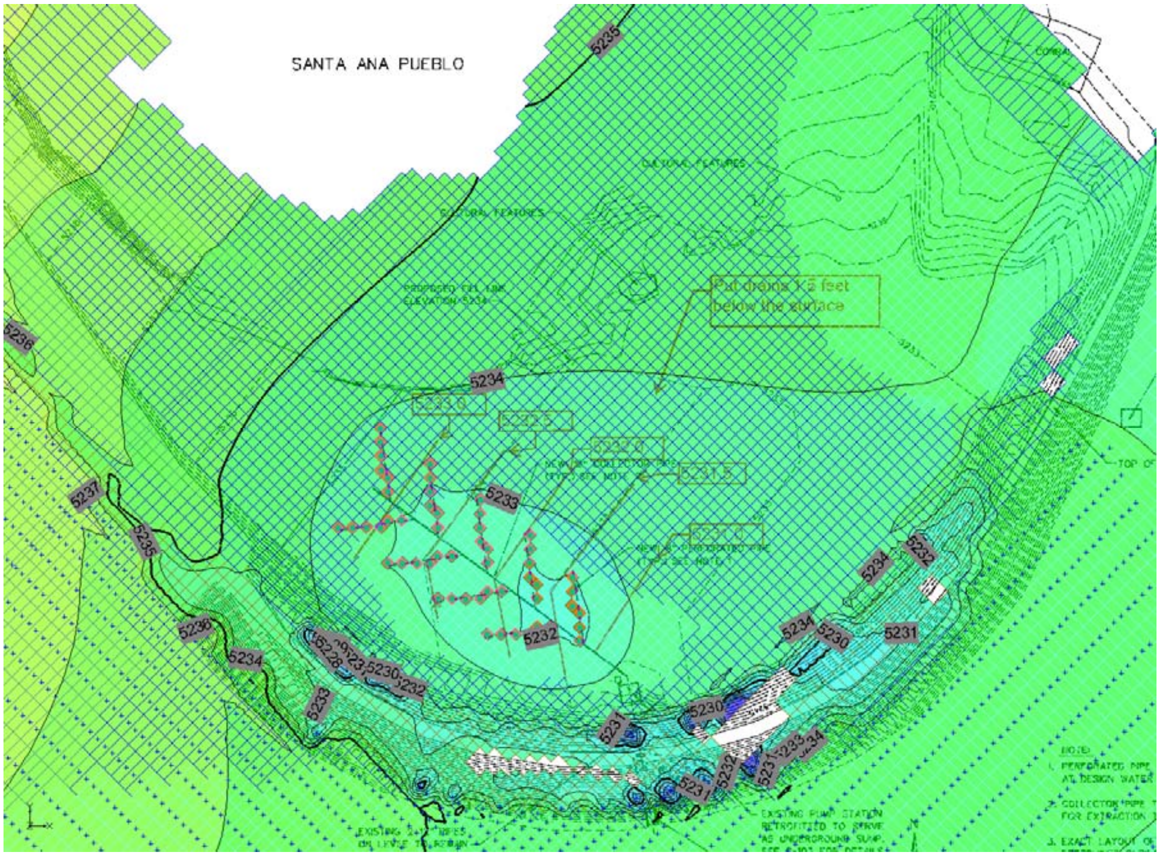

Figure 6. Model No. 003T_RP_D2-01 (three feet below levee; sloped drain elevation 1.5 feet bgs). Highest groundwater elevation on August 30th, 2006. Groundwater never goes above ground surface with drain. Drain (cells depicted by brown circles) is actively flowing water from July 8th to September 19th, 2006. Maximum flow rate from drain is 73 gpm on August 30th, 2006.

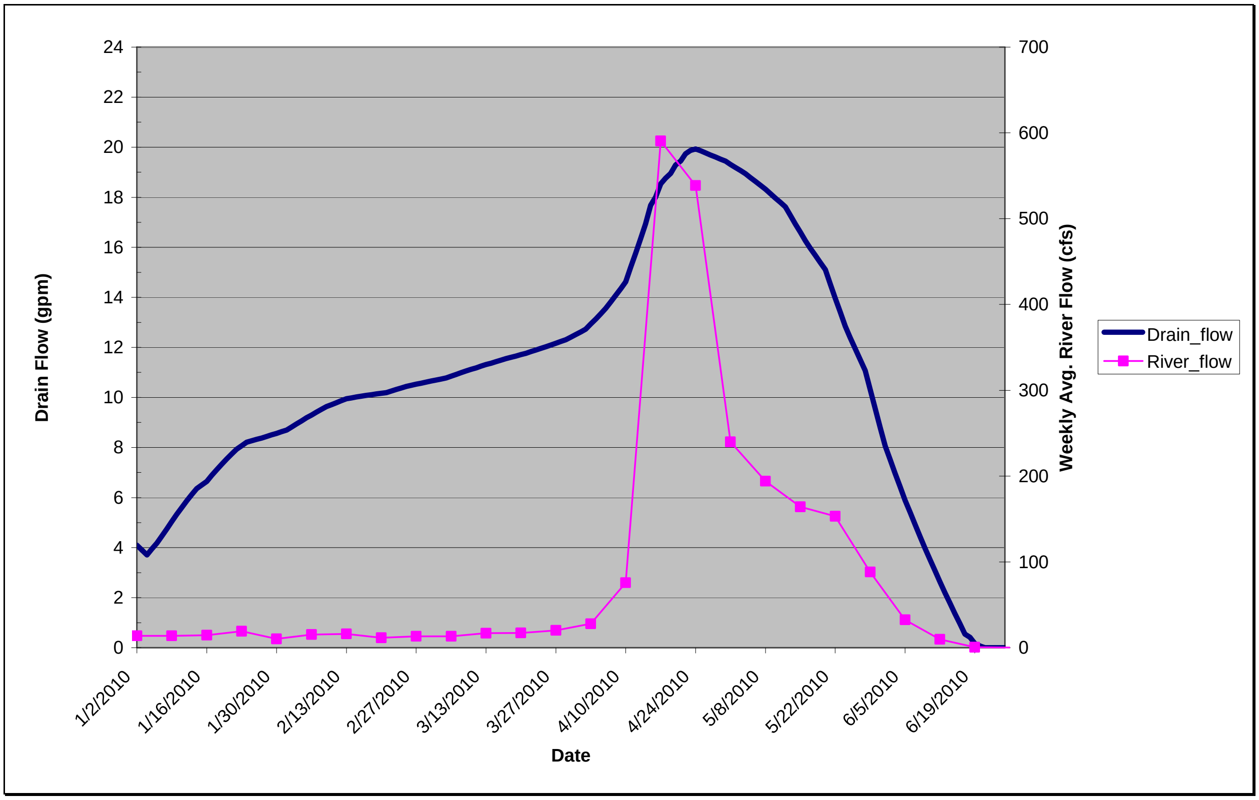

Figure 7. Tamaya Drain Flow Prediction for 2010 Estimated Stage with Drain Set to Elevation 5231 feet.

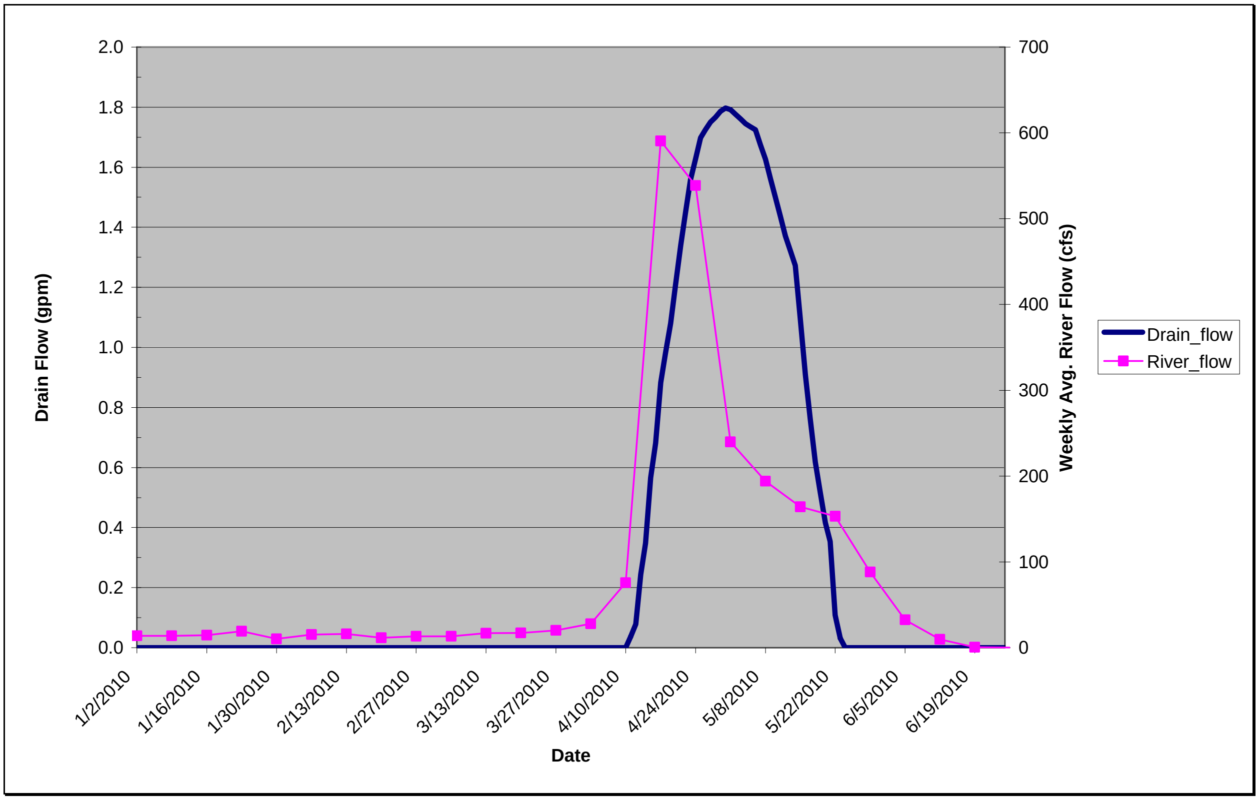

Figure 8. Tamaya Drain Flow Prediction for 2010 Estimated Stage with Drain Set to 1.5 feet below ground surface.

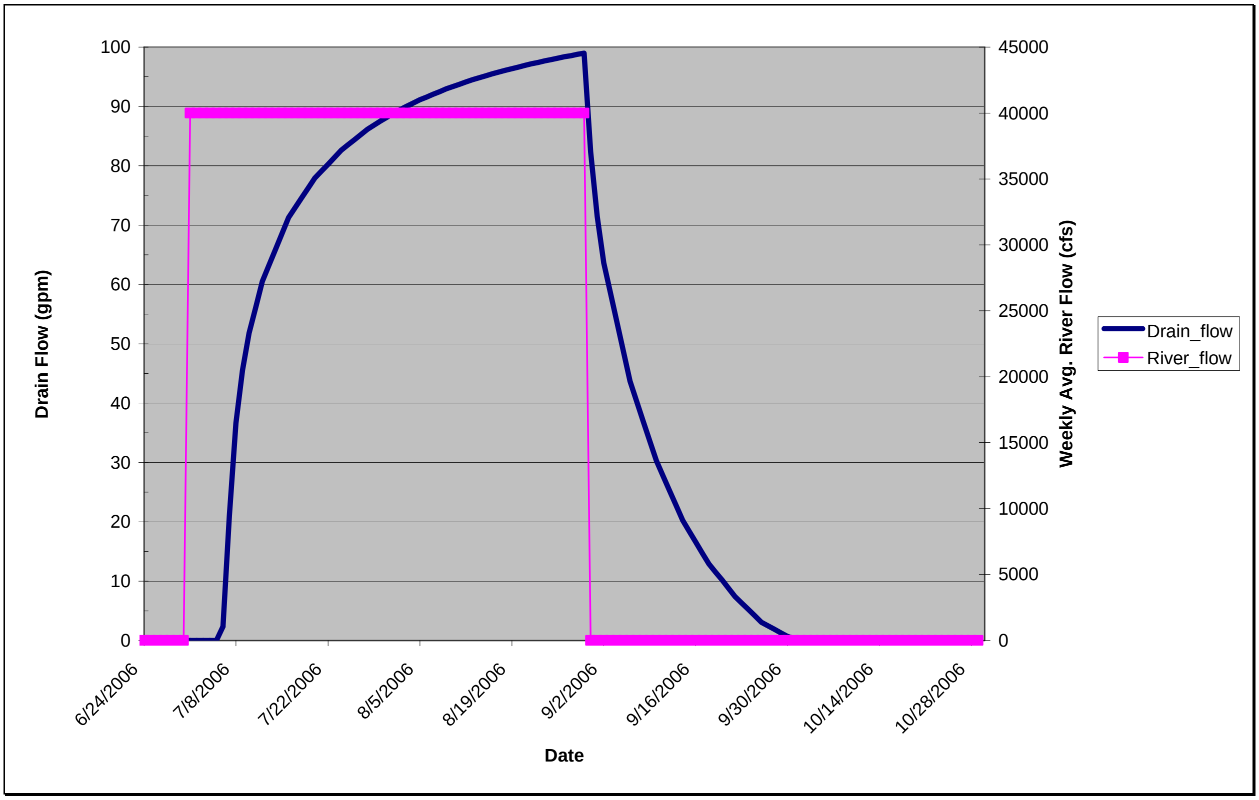

Figure 9. Tamaya Drain Flow Prediction for Three Feet Below Levee Stage with Drain Set to Elevation 5231 feet.

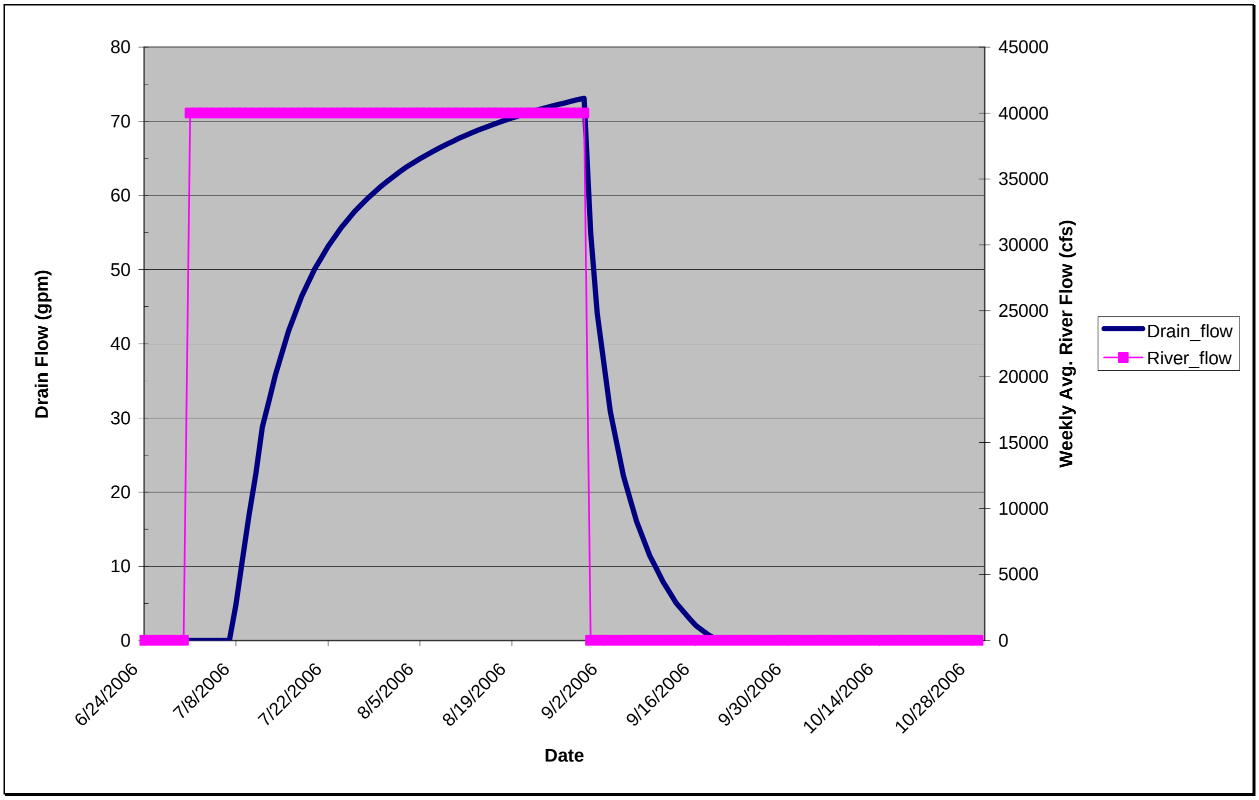

Figure 10. Tamaya Drain Flow Prediction for Three Feet Below Levee Stage with Drain Set to 1.5 feet below ground surface.

Wetland Mitigation
Jemez Weir Geoprobe Investigation
July 10, 2012

Prepared by: David Henry, Environmental Engineering
Purpose: Determine Depth and Flow of Groundwater

Four geoprobe boreholes were advanced to 8 to 16 feet below ground surface (bgs) to determine the approximate depth, direction of flow, and gradient of groundwater. The depth to groundwater presented herein is a “snap shot”. No permanent piezometers or other equipment were installed as part of this investigation. The USGS, USACE and Santa Ana Pueblo personnel were onsite during the execution of this work. The investigation area is located adjacent to the Jemez Weir. The following is a summary of each borehole advanced.

Borehole No. 1: Three 1-inch diameter cores were collected from 0 to 4 feet, 4 to 8 feet, and 8 to 12 feet below bgs. Approximately 1.9 feet of recovery was obtained from 0 to 4 feet and consisted of fine sand. From 4 to 8 feet bgs, approximately 1.9 feet of recovery was obtained, also consisting of fine sand. Moisture was noted at approximately 8 feet bgs, in the drive shoe of the core barrel. Approximately 2.75 feet of recovery was obtain in the final core, 8 to 12 feet bgs. Saturated coarse grain sand was observed at approximately 9.1 feet bgs.

Borehole No. 2: Three 1-inch diameter cores were collected from 0 to 4 feet, 4 to 8 feet, and 8 to 12 feet bgs. Approximately 2.9 feet of recovery was obtained from 0 to 4 feet and consisted of silt/fine sand. From 4 to 8 feet bgs, 100% recovery was obtained. From 4 to 6.3 feet bgs, the core consisted of clay/silt. The remaining core, to 8 feet bgs, consisted of fine sand. Approximately 2.2 feet of recovery was obtain in the final core, 8 to 12 feet bgs. Saturated coarse grain sand was observed at approximately 10.5 feet bgs.

Borehole No. 3: Two 1-inch diameter cores were collected from 0 to 4 feet and 4 to 8 feet bgs. Approximately 2.6 feet of recovery was obtained from 0 to 4 feet bgs and consisted of fine sand. From 4 to 8 feet bgs, 2.6 feet of recovery was obtained and consisted of coarse sand. Saturation was noted at approximately 7.3 feet bgs. An additional core was collected from 8 to 12 feet bgs. This core consisted of coarse sand and was saturated.

Borehole No. 4: Four 1-inch diameter cores were collected from 0 to 4 feet, 4 to 8 feet, 8 to 12 feet, and 12 to 16 feet. 2.4 feet of recovery was obtained from 0 to 4 feet and consisted of fine sand. From 4 to 8 feet bgs, 2.9 feet of recovery was obtained. From 5.1 feet bgs to 6.8 feet bgs, the core consisted of fine sand. The remainder of the core, to 8 feet bgs, consisted of clay and silt. 2.5 feet of recovery was obtain in the 8- to 12-foot core. From approximately 9.5 feet to 10.6 feet bgs, the core consisted of fine sand. From 10.6 feet to 12 feet bgs, the core consisted of coarse grain. The final core, 12 to 16 feet bgs, approximately 2.4 feet of recovery was obtained. This core consisted of coarse grain sand and was saturated at 14.5 feet bgs.

Borehole No. 3 had to be relocated. When the area was cleared, the surface was tilled, which made the surface soft. The geoprobe rig buried itself to the axel setting up on borehole No. 1. Borehole No. 3 was last borehole advanced. We attempted to travel down the path that was cleared, but the rig sank again. This is where the borehole was advanced. Coordinates and other relevant data are attached.

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U.S. Department of the Interior

Appendix E
Hazardous, Toxic, or Radioactive Waste

Tamaya Drainage Project Appendix E: Hazardous, Toxic, or Radioactive Waste

This Appendix contains supplemental technical information related to Environmental Engineering and Hazardous, Toxic, or Radioactive Waste considerations. The Appendix consists of two parts: the Environmental Engineering site visit, and the Ayres and Associates Sediment Testing Report.

Tamaya Pond
Environmental Engineering Section Site Visit

Visual inspections of the Tamaya pond have been conducted on several occasions throughout 2011 to support the due diligence requirements for draining the pond. These inspections were conducted on site visits by personnel from the US Army Corps of Engineers Albuquerque District Geotechnical and Environmental Engineering Branch who are trained in identifying the presence of and impacts from hazardous, toxic, and radioactive waste (HTRW).

Inspections have found no evidence of hazardous waste practices that would be considered detrimental to human health and/or the environment. No sign of releases of hazardous wastes, hazardous substances, or petroleum products such as distressed vegetation or soil staining have been observed; therefore, no soil sampling for chemical parameters in for this project is warranted. The only notable waste practice is from outdoor toilets. Several outdoor toilets are located north of the pond, on the outside bank of the ring levee. The outdoor toilets do not have treatment, and untreated human waste is discharged directly into the ground.

Construction and vegetation control that has been executed by the US Army Corps of Engineers within the project area for Corps of Engineers projects (such as levee maintenance) has required that all Federal, State, and Local environmental protection laws be followed. These include the Clean Water Act Stormwater Pollution Prevention requirements, the Clean Air Act and State of New Mexico Air Quality Requirements, and proper storage, use, and disposal of all petroleum products and other chemicals associated with the project. Any herbicides used for vegetation management were used as per manufacturer's instruction and thus do not pose any hazardous materials issues. Any remaining herbicide was disposed of appropriately per manufacturer's instruction and outside of the project boundaries.

Based on our observations we conclude that there are no hazardous toxic or radioactive wastes present at the Tamaya Pond site.

Following is an analysis of the sediment proposed for use in filling the pond…
The sediment originated from a Section 1135 Ecosystem Restoration Project on Pueblo of Santa Ana lands on the Rio Grande.

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September 4, 2008

AYRES ASSOCIATES

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Water Resources Division Manager
Pueblo of Santa Ana
Department of Natural Resources
02 Dove Road
Santa Ana Pueblo, New Mexico 87004

Re: Section 1135 Program – Aquatic Habitat Restoration at Santa Ana Pueblo, NM

Dear Jennifer,

On July 21, 2008, nine (9) soil samples were collected from the Rio Grande within the tribal boundaries of the Pueblo of Santa Ana. The samples were collected as part of the Sampling and Analysis Plan (SAP) for the Santa Ana 1135 Ecosystem Restoration Project, Phase 2. Five (5) samples were taken from sand bars within the river and four (4) samples were taken from the overbanks of the river.

Excavation associated with the project site was expected to have a maximum depth of five (5) feet, therefore all samples were taken by hand using a shovel, trowel, and bucket auger. Soil sampling was conducted using the methods described in EPA Standard Operating Procedure #2012, *Soil Sampling,* and #1205, *Field Sampling Guidance Document-Soil Sampling*, as provided by the EPA Region 6 web site. These procedures provided guidance on the proper collection, handling, storage, and documentation of samples, as well as equipment requirements and materials. All equipment was decontaminated between sampling locations to prevent cross-contamination using the procedures outlined in EPA Standard Operating Procedure #1230, *Sampling Equipment Decontamination*.

The samples were collected and sent to three different laboratories to complete the series of analyses outlined in the *Sediment and Soil Sampling and Analysis Plan* prepared by Ayres Associates for the U.S. Army Corps of Engineers, Albuquerque District in April of 2008. The samples were analyzed for a wide variety of analytes, of which fell into the following categories:

- Conventional and Geotechnical Analyses
- TAL Metals
- Total Petroleum Hydrocarbons
- TCL Pesticides
- TCL Semi-Volatile Organics
- TCL Volatile Organics
- TCL PCBs
- Radionuclides

The results from the sampling were received by Ayres Associates from each respective lab and evaluated under high scrutiny. The results were closely compared to Federal EPA clean up criteria and goals. Specifically they were evaluated based on the Preliminary Remediation Goals (PRG) set forth by the EPA, if available. PRGs from EPA Region 6 were used, if available, and then supplemented with PRGs from EPA Region 9. The majority of the analytes resulted in "non-detects" or values which fell below the Method Detection Limit (MDL) for the particular sample. The remaining samples that resulted in a specific concentration were compared to the PRG for each analyte, if applicable. The conventional and geotechnical analyses presented were not comparable to a PRG since the characteristics listed are the physical make up of the soil. These results are presented to indicate the morphology of the soil.

Tables 1 thru 9 below show each sample along with the respective analytes that resulted in a concentration above the MDL. As a comparison, the PRG for each analyte is listed in the table, if applicable. The results show that no analyte for any sample resulted in a concentration greater than the PRG for that analyte. One sample (Overbank Sample 2) contained an oil and grease result that was not a "non-detect." The value of 110 mg/Kg is only slightly higher than the PQL and is not considered a problem.

Table 1: Sand Bar 1 Sample Results.

Analyte	Result	Qualifier	Units	MDL	PQL	PRG (mg/Kg)	PRG (pCi/g)
Conventional and Geotechnical Analyses							
Clay	2.5	---	%	0.1	0.5	---	---
Sand	97.5	---	%	0.1	0.5	---	---
Solids, Percent	98.5	---	%	0.1	0.5	---	---
Texture Classification	Sand	---	---	---	---	---	---
TAL Metals							
Aluminum, total (3050)	2180	---	mg/Kg	3	20	77000	---
Arsenic, total (3050)	2.0	---	mg/Kg	0.3	0.5	22	---
Barium, total (3050)	78.2	---	mg/Kg	0.3	2	16000	---
Cadmium, total (3050)	0.18	B	mg/Kg	0.05	0.3	39	---
Calcium, total (3050)	3970	---	mg/Kg	20	100	N/A	---
Chromium, total (3050)	3.08	---	mg/Kg	0.05	0.3	210	---
Cobalt, total (3050)	2	B	mg/Kg	1	5	900	---
Copper, total (3050)	3	B	mg/Kg	1	5	2900	---
Iron, total (3050)	6530	---	mg/Kg	2	5	55000	---
Lead, total (3050)	2.72	---	mg/Kg	0.05	0.3	400	---
Magnesium, total (3050)	1000	---	mg/Kg	20	100	N/A	---
Manganese, total (3050)	142	---	mg/Kg	0.5	3	3500	---
Nickel, total (3050)	3	B	mg/Kg	1	5	1600	---
Potassium, total (3050)	450	---	mg/Kg	30	200	N/A	---
Selenium, total (3050)	0.08	B	mg/Kg	0.05	0.3	390	---
Sodium, total (3050)	110	B	mg/Kg	30	200	N/A	---
Thallium, total (3050)	0.24	B	mg/Kg	0.05	0.3	5.5	---
Vanadium, total (3050)	13.9	---	mg/Kg	0.1	0.5	390	---
Zinc, total (3050)	14	---	mg/Kg	1	5	23000	---
TCL Volatile Organic Compounds							
Ethylbenzene	6	J	ug/Kg	4	10	230	---
Radionuclides							
Gross Alpha	1.7	---	pCi/g	0.32	0.58	---	N/A
Gross Beta	1.5	---	pCi/g	0.78	0.64	---	N/A
Uranium 234	0.05	---	pCi/g	0.21	0.11	---	4.01 pCi/g
Uranium 235	0.14	---	pCi/g	0.21	0.18	---	0.204pCi/g
Uranium 238	0.09	---	pCi/g	0.21	0.22	---	4.46 pCi/g

Table 2: Sand Bar 2 Sample Results.

Analyte	Result	Qualifier	Units	MDL	PQL	PRG (mg/Kg)	PRG (pCi/g)
Conventional and Geotechnical Analyses							
Clay	2.5	- - -	%	0.1	0.5	- - -	- - -
Sand	97.5	- - -	%	0.1	0.5	- - -	- - -
Solids, Percent	97.6	- - -	%	0.1	0.5	- - -	- - -
Texture Classification	Sand	- - -	- - -	- - -	- - -	- - -	- - -
TAL Metals							
Aluminum, total (3050)	2330	- - -	mg/Kg	3	20	77000	- - -
Arsenic, total (3050)	2.4	- - -	mg/Kg	0.3	0.5	22	- - -
Barium, total (3050)	45.4	- - -	mg/Kg	0.3	2	16000	- - -
Cadmium, total (3050)	0.14	B	mg/Kg	0.05	0.3	39	- - -
Calcium, total (3050)	11300	- - -	mg/Kg	20	100	N/A	- - -
Chromium, total (3050)	2.94	- - -	mg/Kg	0.05	0.3	210	- - -
Cobalt, total (3050)	2	B	mg/Kg	1	5	900	- - -
Copper, total (3050)	3	B	mg/Kg	1	5	2900	- - -
Iron, total (3050)	5360	- - -	mg/Kg	2	5	55000	- - -
Lead, total (3050)	3.83	- - -	mg/Kg	0.05	0.3	400	- - -
Magnesium, total (3050)	1180	- - -	mg/Kg	20	100	N/A	- - -
Manganese, total (3050)	153	- - -	mg/Kg	0.5	3	3500	- - -
Nickel, total (3050)	3	B	mg/Kg	1	5	1600	- - -
Potassium, total (3050)	470	- - -	mg/Kg	30	200	N/A	- - -
Selenium, total (3050)	0.09	B	mg/Kg	0.05	0.3	390	- - -
Sodium, total (3050)	280	- - -	mg/Kg	30	200	N/A	- - -
Thallium, total (3050)	0.10	B	mg/Kg	0.05	0.3	5.5	- - -
Vanadium, total (3050)	19.7	- - -	mg/Kg	0.1	0.5	390	- - -
Zinc, total (3050)	12	- - -	mg/Kg	1	5	23000	- - -
TCL Volatile Organic Compounds							
Ethylbenzene	6	J	ug/Kg	4	10	230	- - -
Radionuclides							
Gross Alpha	2.1	- - -	pCi/g	0.35	0.67	- - -	N/A
Gross Beta	2	- - -	pCi/g	0.8	0.69	- - -	N/A
Uranium 234	0.07	- - -	pCi/g	0.2	0.12	- - -	4.01 pCi/g
Uranium 235	0.02	- - -	pCi/g	0.2	0.16	- - -	0.204pCi/g
Uranium 238	0.19	- - -	pCi/g	0.2	0.23	- - -	4.46 pCi/g

Table 3: Sand Bar 3 Sample Results.

Analyte	Result	Qualifier	Units	MDL	PQL	PRG (mg/Kg)	PRG (pCi/g)
Conventional and Geotechnical Analyses							
Sand	100	- - -	%	0.1	0.5	- - -	- - -
Solids, Percent	99.0	- - -	%	0.1	0.5	- - -	- - -
Texture Classification	Sand	- - -	- - -	- - -	- - -	- - -	- - -
TAL Metals							
Aluminum, total (3050)	2200	- - -	mg/Kg	3	20	77000	- - -
Arsenic, total (3050)	2.7	- - -	mg/Kg	0.3	0.5	22	- - -
Barium, total (3050)	28.5	- - -	mg/Kg	0.3	2	16000	- - -
Cadmium, total (3050)	0.14	B	mg/Kg	0.05	0.3	39	- - -
Calcium, total (3050)	9060	- - -	mg/Kg	20	100	N/A	- - -
Chromium, total (3050)	3.71	- - -	mg/Kg	0.05	0.3	210	- - -
Cobalt, total (3050)	2	B	mg/Kg	1	5	900	- - -
Copper, total (3050)	4	B	mg/Kg	1	5	2900	- - -
Iron, total (3050)	5000	- - -	mg/Kg	2	5	55000	- - -
Lead, total (3050)	3.03	- - -	mg/Kg	0.05	0.3	400	- - -
Magnesium, total (3050)	1050	- - -	mg/Kg	20	100	N/A	- - -
Manganese, total (3050)	168	- - -	mg/Kg	0.5	3	3500	- - -
Nickel, total (3050)	3	B	mg/Kg	1	5	1600	- - -
Potassium, total (3050)	400	- - -	mg/Kg	30	200	N/A	- - -
Selenium, total (3050)	0.10	B	mg/Kg	0.05	0.3	390	- - -
Silver, total (3050)	0.03	B	mg/Kg	0.03	0.1	390	- - -
Sodium, total (3050)	110	B	mg/Kg	30	200	N/A	- - -
Thallium, total (3050)	0.07	B	mg/Kg	0.05	0.3	5.5	- - -
Vanadium, total (3050)	15.1	- - -	mg/Kg	0.1	0.5	390	- - -
Zinc, total (3050)	12	- - -	mg/Kg	1	5	23000	- - -
TCL Volatile Organic Compounds							
Ethylbenzene	6	J	ug/Kg	4	10	230	- - -
Radionuclides							
Gross Alpha	1.7	- - -	pCi/g	0.32	0.57	- - -	N/A
Gross Beta	1.3	- - -	pCi/g	0.78	0.63	- - -	N/A
Uranium 234	0.17	- - -	pCi/g	0.19	0.15	- - -	4.01 pCi/g
Uranium 235	-0.15	- - -	pCi/g	0.19	0.1	- - -	0.204pCi/g
Uranium 238	0.11	- - -	pCi/g	0.19	0.22	- - -	4.46 pCi/g

Table 4: Sand Bar 4 Sample Results.

Analyte	Result	Qualifier	Units	MDL	PQL	PRG (mg/Kg)	PRG (pCi/g)
Conventional and Geotechnical Analyses							
Clay	6.3	- - -	%	0.1	0.5	- - -	- - -
Sand	85.0	- - -	%	0.1	0.5	- - -	- - -
Silt	8.8	- - -	%	0.1	0.5	- - -	- - -
Solids, Percent	86.7	- - -	%	0.1	0.5	- - -	- - -
Texture Classification	Loamy Sand	- - -	- - -	- - -	- - -	- - -	- - -
TAL Metals							
Aluminum, total (3050)	5480	- - -	mg/Kg	3	20	77000	- - -
Arsenic, total (3050)	3.6	- - -	mg/Kg	0.3	0.5	22	- - -
Barium, total (3050)	159	- - -	mg/Kg	0.3	2	16000	- - -
Beryllium, total (3050)	0.3	B	mg/Kg	0.2	1	150	- - -
Cadmium, total (3050)	0.22	B	mg/Kg	0.05	0.3	39	- - -
Calcium, total (3050)	14600	- - -	mg/Kg	20	100	N/A	- - -
Chromium, total (3050)	5.56	- - -	mg/Kg	0.05	0.3	210	- - -
Cobalt, total (3050)	3	B	mg/Kg	1	5	900	- - -
Copper, total (3050)	4	B	mg/Kg	1	5	2900	- - -
Iron, total (3050)	6700	- - -	mg/Kg	2	5	55000	- - -
Lead, total (3050)	4.52	- - -	mg/Kg	0.05	0.3	400	- - -
Magnesium, total (3050)	2390	- - -	mg/Kg	20	100	N/A	- - -
Manganese, total (3050)	168	- - -	mg/Kg	0.5	3	3500	- - -
Nickel, total (3050)	4	B	mg/Kg	1	5	1600	- - -
Potassium, total (3050)	1280	- - -	mg/Kg	30	200	N/A	- - -
Selenium, total (3050)	0.13	B	mg/Kg	0.05	0.3	390	- - -
Sodium, total (3050)	120	B	mg/Kg	30	200	N/A	- - -
Thallium, total (3050)	0.08	B	mg/Kg	0.05	0.3	5.5	- - -
Vanadium, total (3050)	15.9	- - -	mg/Kg	0.1	0.5	390	- - -
Zinc, total (3050)	17	- - -	mg/Kg	1	5	23000	- - -
TCL Volatile Organic Compounds							
Ethylbenzene	6	J	ug/Kg	4	10	230	- - -
Radionuclides							
Gross Alpha	2.3	- - -	pCi/g	0.4	0.74	- - -	N/A
Gross Beta	2.7	- - -	pCi/g	0.83	0.75	- - -	N/A
Uranium 234	0.3	- - -	pCi/g	0.19	0.18	- - -	4.01 pCi/g
Uranium 235	-0.17	- - -	pCi/g	0.19	0.09	- - -	0.204pCi/g
Uranium 238	0.19	- - -	pCi/g	0.19	0.24	- - -	4.46 pCi/g

Table 5: Sand Bar 6 Sample Results.

Analyte	Result	Qualifier	Units	MDL	PQL	PRG (mg/Kg)	PRG (pCi/g)
Conventional and Geotechnical Analyses							
Clay	1.3	---	%	0.1	0.5	---	---
Sand	98.8	---	%	0.1	0.5	---	---
Solids, Percent	97.8	---	%	0.1	0.5	---	---
Texture Classification	Sand	---	---	---	---	---	---
TAL Metals							
Aluminum, total (3050)	1890	---	mg/Kg	3	20	77000	---
Arsenic, total (3050)	1.6	---	mg/Kg	0.3	0.5	22	---
Barium, total (3050)	24.9	---	mg/Kg	0.3	2	16000	---
Cadmium, total (3050)	0.14	B	mg/Kg	0.05	0.3	39	---
Calcium, total (3050)	7500	---	mg/Kg	20	100	N/A	---
Chromium, total (3050)	2.84	---	mg/Kg	0.05	0.3	210	---
Cobalt, total (3050)	2	B	mg/Kg	1	5	900	---
Copper, total (3050)	3	B	mg/Kg	1	5	2900	---
Iron, total (3050)	4920	---	mg/Kg	2	5	55000	---
Lead, total (3050)	2.18	---	mg/Kg	0.05	0.3	400	---
Magnesium, total (3050)	1350	---	mg/Kg	20	100	N/A	---
Manganese, total (3050)	124	---	mg/Kg	0.5	3	3500	---
Nickel, total (3050)	3	B	mg/Kg	1	5	1600	---
Potassium, total (3050)	360	---	mg/Kg	30	200	N/A	---
Selenium, total (3050)	0.11	B	mg/Kg	0.05	0.3	390	---
Silver, total (3050)	0.03	B	mg/Kg	0.03	0.1	390	---
Sodium, total (3050)	90	B	mg/Kg	30	200	N/A	---
Thallium, total (3050)	0.14	B	mg/Kg	0.05	0.3	5.5	---
Vanadium, total (3050)	12.0	---	mg/Kg	0.1	0.5	390	---
Zinc, total (3050)	11	---	mg/Kg	1	5	23000	---
TCL Volatile Organic Compounds							
Ethylbenzene	6	J	ug/Kg	4	10	230	---
Radionuclides							
Gross Alpha	1.2	---	pCi/g	0.34	0.51	---	N/A
Gross Beta	0.92	---	pCi/g	0.79	0.62	---	N/A
Uranium 234	0.27	---	pCi/g	0.23	0.16	---	4.01 pCi/g
Uranium 235	-0.16	---	pCi/g	0.23	0.11	---	0.204pCi/g
Uranium 238	0.11	---	pCi/g	0.23	0.22	---	4.46 pCi/g

Table 6: Overbank 1 Sample Results.

Analyte	Result	Qualifier	Units	MDL	PQL	PRG (mg/Kg)	PRG (pCi/g)
Conventional and Geotechnical Analyses							
Clay	7.5	- - -	%	0.1	0.5	- - -	- - -
Sand	75.0	- - -	%	0.1	0.5	- - -	- - -
Silt	17.5	- - -	%	0.1	0.5	- - -	- - -
Solids, Percent	97.9	- - -	%	0.1	0.5	- - -	- - -
Texture Classification	Sandy Loam	- - -	- - -	- - -	- - -	- - -	- - -
TAL Metals							
Aluminum, total (3050)	6100	- - -	mg/Kg	3	20	77000	- - -
Arsenic, total (3050)	3.0	- - -	mg/Kg	0.3	0.5	22	- - -
Barium, total (3050)	183	- - -	mg/Kg	0.3	2	16000	- - -
Beryllium, total (3050)	0.3	B	mg/Kg	0.2	1	150	- - -
Cadmium, total (3050)	0.28	B	mg/Kg	0.05	0.3	39	- - -
Calcium, total (3050)	17100	- - -	mg/Kg	20	100	N/A	- - -
Chromium, total (3050)	7.51	- - -	mg/Kg	0.05	0.3	210	- - -
Cobalt, total (3050)	3	B	mg/Kg	1	5	900	- - -
Copper, total (3050)	6	- - -	mg/Kg	1	5	2900	- - -
Iron, total (3050)	8740	- - -	mg/Kg	2	5	55000	- - -
Lead, total (3050)	5.36	- - -	mg/Kg	0.05	0.3	400	- - -
Magnesium, total (3050)	2810	- - -	mg/Kg	20	100	N/A	- - -
Manganese, total (3050)	202	- - -	mg/Kg	0.5	3	3500	- - -
Nickel, total (3050)	5	- - -	mg/Kg	1	5	1600	- - -
Potassium, total (3050)	1430	- - -	mg/Kg	30	200	N/A	- - -
Selenium, total (3050)	0.17	B	mg/Kg	0.05	0.3	390	- - -
Silver, total (3050)	0.03	B	mg/Kg	0.03	0.1	390	- - -
Sodium, total (3050)	390	- - -	mg/Kg	30	200	N/A	- - -
Thallium, total (3050)	0.12	B	mg/Kg	0.05	0.3	5.5	- - -
Vanadium, total (3050)	20.2	- - -	mg/Kg	0.1	0.5	390	- - -
Zinc, total (3050)	20	- - -	mg/Kg	1	5	23000	- - -
TCL Volatile Organic Compounds							
Ethylbenzene	6	J	ug/Kg	4	10	230	- - -
Radionuclides							
Gross Alpha	3	- - -	pCi/g	0.48	0.93	- - -	N/A
Gross Beta	2.7	- - -	pCi/g	1	0.9	- - -	N/A
Uranium 234	0.21	- - -	pCi/g	0.2	0.15	- - -	4.01 pCi/g
Uranium 235	-0.02	- - -	pCi/g	0.2	0.15	- - -	0.204pCi/g
Uranium 238	0.21	- - -	pCi/g	0.2	0.24	- - -	4.46 pCi/g

Table 7: Overbank 2 Sample Results.

Analyte	Result	Qualifier	Units	MDL	PQL	PRG (mg/Kg)	PRG (pCi/g)
Conventional and Geotechnical Analyses							
Clay	7.5	---	%	0.1	0.5	---	---
Sand	81.3	---	%	0.1	0.5	---	---
Silt	11.3	---	%	0.1	0.5	---	---
Solids, Percent	97.0	---	%	0.1	0.5	---	---
Texture Classification	Loamy Sand	---	---	---	---	---	---
Carbon, total organic	0.2	B	%	0.1	0.5	---	---
TAL Metals							
Aluminum, total (3050)	4410	---	mg/Kg	3	20	77000	---
Arsenic, total (3050)	3.2	---	mg/Kg	0.3	0.5	22	---
Barium, total (3050)	79.4	---	mg/Kg	0.3	2	16000	---
Beryllium, total (3050)	0.3	B	mg/Kg	0.2	1	150	---
Cadmium, total (3050)	0.23	B	mg/Kg	0.05	0.3	39	---
Calcium, total (3050)	9790	---	mg/Kg	20	100	N/A	---
Chromium, total (3050)	4.89	---	mg/Kg	0.05	0.3	210	---
Cobalt, total (3050)	2	B	mg/Kg	1	5	900	---
Copper, total (3050)	5	B	mg/Kg	1	5	2900	---
Iron, total (3050)	5660	---	mg/Kg	2	5	55000	---
Lead, total (3050)	4.06	---	mg/Kg	0.05	0.3	400	---
Magnesium, total (3050)	1700	---	mg/Kg	20	100	N/A	---
Manganese, total (3050)	161	---	mg/Kg	0.5	3	3500	---
Nickel, total (3050)	4	B	mg/Kg	1	5	1600	---
Potassium, total (3050)	980	---	mg/Kg	30	200	N/A	---
Selenium, total (3050)	0.14	B	mg/Kg	0.05	0.3	390	---
Silver, total (3050)	0.03	B	mg/Kg	0.03	0.1	390	---
Sodium, total (3050)	150	B	mg/Kg	30	200	N/A	---
Thallium, total (3050)	0.09	B	mg/Kg	0.05	0.3	5.5	---
Vanadium, total (3050)	14.5	---	mg/Kg	0.1	0.5	390	---
Zinc, total (3050)	16	---	mg/Kg	1	5	23000	---
Total Petroleum Hydrocarbons							
Oil and Grease	110	---	mg/kg		100	N/A	---
TCL Volatile Organic Compounds							
Ethylbenzene	7	J	ug/Kg	4	10	230	---
Radionuclides							
Gross Alpha	3.2	---	pCi/g	0.43	0.89	---	N/A
Gross Beta	3.4	---	pCi/g	0.84	0.79	---	N/A
Uranium 234	0.22	---	pCi/g	0.19	0.16	---	4.01 pCi/g
Uranium 235	-0.09	---	pCi/g	0.19	0.13	---	0.204pCi/g
Uranium 238	0.3	---	pCi/g	0.19	0.26	---	4.46 pCi/g

Table 8: Overbank 3 Sample Results.

Analyte	Result	Qualifier	Units	MDL	PQL	PRG (mg/Kg)	PRG (pCi/g)
Conventional and Geotechnical Analyses							
Clay	5.0	- - -	%	0.1	0.5	- - -	- - -
Sand	95.0	- - -	%	0.1	0.5	- - -	- - -
Solids, Percent	98.9	- - -	%	0.1	0.5	- - -	- - -
Texture Classification	Sand	- - -	- - -	- - -	- - -	- - -	- - -
TAL Metals							
Aluminum, total (3050)	1920	- - -	mg/Kg	3	20	77000	- - -
Arsenic, total (3050)	1.9	- - -	mg/Kg	0.3	0.5	22	- - -
Barium, total (3050)	70.5	- - -	mg/Kg	0.3	2	16000	- - -
Cadmium, total (3050)	0.14	B	mg/Kg	0.05	0.3	39	- - -
Calcium, total (3050)	8100	- - -	mg/Kg	20	100	N/A	- - -
Chromium, total (3050)	2.79	- - -	mg/Kg	0.05	0.3	210	- - -
Cobalt, total (3050)	1	B	mg/Kg	1	5	900	- - -
Copper, total (3050)	2	B	mg/Kg	1	5	2900	- - -
Iron, total (3050)	3100	- - -	mg/Kg	2	5	55000	- - -
Lead, total (3050)	2.33	- - -	mg/Kg	0.05	0.3	400	- - -
Magnesium, total (3050)	770	- - -	mg/Kg	20	100	N/A	- - -
Manganese, total (3050)	107	- - -	mg/Kg	0.5	3	3500	- - -
Nickel, total (3050)	2	B	mg/Kg	1	5	1600	- - -
Potassium, total (3050)	420	- - -	mg/Kg	30	200	N/A	- - -
Selenium, total (3050)	0.08	B	mg/Kg	0.05	0.3	390	- - -
Sodium, total (3050)	110	B	mg/Kg	30	200	N/A	- - -
Vanadium, total (3050)	120	- - -	mg/Kg	1	5	390	- - -
Zinc, total (3050)	8	- - -	mg/Kg	1	5	23000	- - -
TCL Volatile Organic Compounds							
Ethylbenzene	6	J	ug/Kg	4	10	230	- - -
Radionuclides							
Gross Alpha	2.3	- - -	pCi/g	0.34	0.68	- - -	N/A
Gross Beta	2	- - -	pCi/g	0.79	0.68	- - -	N/A
Uranium 234	0.4	- - -	pCi/g	0.21	0.2	- - -	4.01 pCi/g
Uranium 235	-0.1	- - -	pCi/g	0.21	0.13	- - -	0.204pCi/g
Uranium 238	0.12	- - -	pCi/g	0.21	0.22	- - -	4.46 pCi/g

Table 9: Overbank 4 Sample Results.

Analyte	Result	Qualifier	Units	MDL	PQL	PRG (mg/Kg)	PRG (pCi/g)
Conventional and Geotechnical Analyses							
Clay	6.3	---	%	0.1	0.5	---	---
Sand	88.8	---	%	0.1	0.5	---	---
Silt	5.0	---	%	0.1	0.5	---	---
Solids, Percent	98.1	---	%	0.1	0.5	---	---
Texture Classification	Sand	---	---	---	---	---	---
TAL Metals							
Aluminum, total (3050)	3510	---	mg/Kg	3	20	77000	---
Arsenic, total (3050)	2.1	---	mg/Kg	0.3	0.5	22	---
Barium, total (3050)	49.0	---	mg/Kg	0.3	2	16000	---
Beryllium, total (3050)	0.2	B	mg/Kg	0.2	1	150	---
Cadmium, total (3050)	0.20	B	mg/Kg	0.05	0.3	39	---
Calcium, total (3050)	9720	---	mg/Kg	20	100	N/A	---
Chromium, total (3050)	3.63	---	mg/Kg	0.05	0.3	210	---
Cobalt, total (3050)	2	B	mg/Kg	1	5	900	---
Copper, total (3050)	4	B	mg/Kg	1	5	2900	---
Iron, total (3050)	4500	---	mg/Kg	2	5	55000	---
Lead, total (3050)	3.37	---	mg/Kg	0.05	0.3	400	---
Magnesium, total (3050)	1340	---	mg/Kg	20	100	N/A	---
Manganese, total (3050)	119	---	mg/Kg	0.5	3	3500	---
Nickel, total (3050)	3	B	mg/Kg	1	5	1600	---
Potassium, total (3050)	800	---	mg/Kg	30	200	N/A	---
Selenium, total (3050)	0.12	B	mg/Kg	0.05	0.3	390	---
Silver, total (3050)	0.06	B	mg/Kg	0.03	0.1	390	---
Sodium, total (3050)	210	---	mg/Kg	30	200	N/A	---
Vanadium, total (3050)	13.2	---	mg/Kg	0.1	0.5	390	---
Zinc, total (3050)	12	---	mg/Kg	1	5	23000	---
TCL Volatile Organic Compounds							
Ethylbenzene	6	J	ug/Kg	4	10	230	---
Radionuclides							
Gross Alpha	2.8	---	pCi/g	0.36	0.76	---	N/A
Gross Beta	1.7	---	pCi/g	0.81	0.68	---	N/A
Uranium 234	0.23	---	pCi/g	0.2	0.16	---	4.01 pCi/g
Uranium 235	-0.21	---	pCi/g	0.2	0.08	---	0.204pCi/g
Uranium 238	0.12	---	pCi/g	0.2	0.22	---	4.46 pCi/g

It can be concluded from the above results that no analyte was found in a significant enough quantity to warrant further investigation or action. No remediation will be needed that would be a direct result of the Sampling and Analysis Plan (SAP) for the Santa Ana 1135 Ecosystem Restoration Project, Phase 2. Therefore, there will be no need for special handling of soil from the site or special disposal protocols for soil in the project area.

I have included a CD with the job reports and results in Electronic Data Delivery format (Excel spreadsheet) for your use. If there are any questions about the SAP, or if you would like to discuss the sample results and analysis, please feel free to contact us to discuss.

Sincerely,

Ayres Associates Inc

Lyle W. Zevenbergen, PhD, PE
Manager – River Engineering

LWZ:sp

Enclosure

Appendix F
Public and Agency Review

This Appendix contains documents related to public review of the Draft Implementation Report with integrated Environmental Assessment.

(1) Notice of Availability
(2) Affidavit of Publication
(3) Public and Agency Review Letters
(4) Comment Letters Received

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<u>Notice of Availability</u>
<u>Draft Environmental Assessment for the</u>
Tamaya Drainage Project, Pueblo of Santa Ana
Sandoval County, New Mexico

Pursuant to the Council on Environmental Quality regulations that implement the National Environmental Policy Act, the U.S. Army Corps of Engineers (Corps), Albuquerque District, completed a draft Environmental Assessment (EA) and draft Finding of No Significant Impact (FONSI) for the Tamaya Drainage Project, Pueblo of Santa Ana, Sandoval County, New Mexico. The purpose of the proposed project is to alleviate health, safety, and aesthetic concerns associated with the presence of a pond of stagnant water in close proximity to Tamaya Village, the ancestral village of the Pueblo of Santa Ana (Pueblo).

The pond developed due to seepage and elevated groundwater levels on the landward side of the Santa Ana Protective Works levee, which was completed in 1954 as part of the Jemez Canyon Dam and Reservoir Project. The pond is considered an undesirable feature by the Pueblo due to the safety hazard it presents and its unaesthetic smells, poor water quality, and mosquitoes. The Corps proposes to fill the pond, coupled with a passive drainage system that would divert groundwater to a sump equipped with pumps. The filled pond area would be revegetated with native plant species. The Corps analyzed five alternatives for this project with a groundwater modeling study. Two alternatives were modified and carried forward for additional analysis. The proposed alternative provides for the best drainage scenario, the least maintenance, and would be the most cost effective.

Mitigation is required to compensate for wetland values that would otherwise be lost in filling the pond. The proposed mitigation plan has two components: preservation of a wet meadow on the opposite bank of the Jemez River across from Tamaya Village, as well as creation of a permanent wetland upstream from the Jemez weir.

Public review of the draft EA/FONSI will begin on February 15, 2013 and will run for 30 days until March 18, 203. The document will be available on the Corps web site at http://www.spa.usace.army.mil/Missions/Environmental/EnvironmentalComplianceDocuments.aspx. A hard copy will be sent upon request. Comments on the draft EA/FONSI should be sent to:

U.S. Army Corps of Engineers, Albuquerque District
Environmental Resources Section
Attn: CESPA-PM-LE (Dana Price)
4101 Jefferson Plaza NE
Albuquerque, New Mexico 87109-3435

For more information please contact Dana Price, (505) 342-3378 or dana.m.price@usace.army.mil

Paper copies of this document are also available for review at:

Santa Fe Public Library
145 Washington Street
Santa Fe, NM 87501

Bernalillo Roosevelt Public Library
134 Calle Malinche / P.O. Box 638
Bernalillo, NM 87004

Albuquerque Main Library
501 Copper NW
Albuquerque, NM 87102

Notice of Availability
Draft Environmental Assessment for the Tamaya Drainage Project, Pueblo of Santa Ana Sandoval County, New Mexico

Pursuant to the Council on Environmental Quality regulations that implement the National Environmental Policy Act, the U.S. Army Corps of Engineers (Corps), Albuquerque District, completed a draft Environmental Assessment (EA) and draft Finding of No Significant Impact (FONSI) for the Tamaya Drainage Project, Pueblo of Santa Ana, Sandoval County, New Mexico. The purpose of the proposed project is to alleviate health, safety, and aesthetic concerns associated with the presence of a pond of stagnant water in close proximity to Tamaya Village, the ancestral village of the Pueblo of Santa Ana (Pueblo).

The pond developed due to seepage and elevated groundwater levels on the landward side of the Santa Ana Protective Works levee, which was completed in 1954 as part of the Jemez Canyon Dam and Reservoir Project. The pond is considered an undesirable feature by the Pueblo due to the safety hazard it presents and its unaesthetic smells, poor water quality, and mosquitoes. The Corps proposes to fill the pond, coupled with a passive drainage system that would divert groundwater to a sump equipped with pumps. The filled pond area would be revegetated with native plant species. The Corps analyzed five alternatives for this project with a groundwater modeling study. Two alternatives were modified and carried forward for additional analysis. The proposed alternative provides for the best drainage scenario, the least maintenance, and would be the most cost effective. Mitigation is required to compensate for wetland values that would otherwise be lost in filling the pond. The proposed mitigation plan has two components: preservation of a wet meadow on the opposite bank of the Jemez River across from Tamaya Village, as well as creation of a permanent wetland upstream from the Jemez weir.

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U.S. Army Corps of Engineers,
Albuquerque District
Environmental Resources Section
Attn: CESPA-PM-LE (Dana Price)
4101 Jefferson Plaza NE
Albuquerque, New Mexico
87109-3435

For more information please contact Dana Price, (505) 342-3378 or dana.m.price@usace.army.mil

Paper copies of this document are also available for review at:

Santa Fe Public Library
145 Washington Street
Santa Fe, NM 87501

Albuquerque Main Library
501 Copper NW
Albuquerque, NM 87102

Bernalillo Roosevelt Public Library
134 Calle Malinche / P.O. Box 638
Bernalillo, NM 87004
Journal: February 15, 2013

AFFIDAVIT OF PUBLICATION

STATE OF NEW MEXICO
County of Bernalillo SS

Linda MacEachen, being duly sworn, declares and says that she is Classified Advertising Manager of **The Albuquerque Journal**, and that this newspaper is duly qualified to publish legal notices or advertisements within the meaning of Section 3, Chapter 167, Session Laws of 1937, and that payment therefore has been made of assessed as court cost; that the notice, copy of which is hereto attached, was published in said paper in the regular daily edition, for 1 times, the first publication being on the 15 day of February, 2013, and the subsequent consecutive publications on ______, 20____.

Sworn and subscribed before me, a Notary Public, in and for the County of Bernalillo and State of New Mexico this 15 day of February of 2013

OFFICIAL SEAL
Sandra B. Gutierrez
NOTARY PUBLIC
STATE OF NEW MEXICO
My Commission Expires: 2-18-13

PRICE $71.45

Statement to come at end of month.

ACCOUNT NUMBER 1009200

DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
4101 JEFFERSON PLAZA NE
ALBUQUERQUE NM 87109-3435

February 15, 2012

Planning, Project and Program Management Division
Planning Branch
Environmental Resources Section

Honorable Myron Armijo
Governor, Pueblo of Santa Ana
2 Dove Rd.
Santa Ana Pueblo, NM 87004

Dear Governor Armijo:

The U.S. Army Corps of Engineers (Corps), Albuquerque District, has prepared a draft Environmental Assessment (DEA) and draft Finding of No Significant Impact (FONSI) for the Tamaya Drainage Project, Pueblo of Santa Ana, Sandoval County, New Mexico.

Enclosed is a copy of the DEA for your review. The DEA, entitled **"Tamaya Drainage Project, Pueblo of Santa Ana, Sandoval County, New Mexico",** is also available electronically at the Albuquerque District website, http://www.spa.usace.army.mil/Missions/Environmental/EnvironmentalComplianceDocuments.aspx. The Corps is soliciting comments from Federal and local interests to comply with the National Environmental Policy Act.

Please review the enclosed DEA and provide any written comments to the above address, Attn: Ms. Dana Price, Environmental Resources Section. The Corps would appreciate receiving comments **no later than March 18, 2013,** so that comments can be addressed and revisions made to the DEA in a timely manner. You may facsimile your correspondence to (505) 342-3668 or e-mail to Dana.m.price@usace.army.mil.

If you have any questions or need additional information, please contact Ms. Dana Price, biologist, at (505) 342-3378 or e-mail at dana.m.price@usace.army.mil or Mr. Gregory Everhart, archaeologist, at (505) 342-3352 or e-mail at Gregory.D.Everhart @usace.army.mil. Thank you.

Sincerely,

Julie Alcon
Chief, Environmental Resources Section

Enclosure

Copies Furnished with Enclosure:
Mr. Alan Hatch
Mr. Walter Cristobal

DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
4101 JEFFERSON PLAZA NE
ALBUQUERQUE NM 87109-3435

February 15, 2013

Planning, Project and Program Management Division
Planning Branch
Environmental Resources Section

Mr. Wally Murphy
Field Supervisor
US Fish and Wildlife Service
New Mexico Ecological Services Field Office
2105 Osuna Road NE
Albuquerque, New Mexico 87113

Dear Mr. Murphy:

The U.S. Army Corps of Engineers (Corps), Albuquerque District, has prepared a draft Environmental Assessment (DEA) and draft Finding of No Significant Impact (FONSI) for the Tamaya Drainage Project, Pueblo of Santa Ana, Sandoval County, New Mexico. The purpose of the proposed project is to alleviate health, safety, and aesthetic concerns associated with the presence of a pond of stagnant water in close proximity to Tamaya Village, the ancestral village of the Pueblo of Santa Ana (Pueblo). See the enclosed figure for a map of the project area.

The pond developed due to seepage and elevated groundwater levels on the landward side of the Santa Ana Protective Works levee, which was completed in 1954 as part of the Jemez Canyon Dam and Reservoir Project. The pond is considered an undesirable feature by the Pueblo due to the safety hazard it presents and its unpleasant smells, poor water quality, and mosquitoes. The Corps proposes to fill the pond, coupled with a passive drainage system that would divert groundwater to a sump equipped with pumps. The filled pond area would be revegetated with native plant species. The Corps analyzed five alternatives for this project with a groundwater modeling study. Two alternatives were modified and carried forward for additional analysis. The proposed alternative provides for the best drainage scenario, the least maintenance, and would be the most cost effective.

Mitigation is required to compensate for wetland values that would otherwise be lost in filling the pond. The proposed mitigation plan has two components: preservation of a wet meadow on the opposite bank of the Jemez River across from Tamaya Village, as well as creation of a permanent wetland upstream from the Jemez weir.

The DEA, entitled **"Tamaya Drainage Project, Pueblo of Santa Ana, Sandoval County, New Mexico",** is available electronically at the Albuquerque District website, http://www.spa.usace.army.mil/Missions/Environmental/EnvironmentalComplianceDocuments.a spx . The Corps is soliciting comments from Federal, State, and local interests to comply with the National Environmental Policy Act.

The Corps has reviewed information on federally listed species and determined that no endangered or threatened species would be affected by the proposed project. We would appreciate any additional information on endangered and threatened species or species of concern within Sandoval County and the proposed project area that could be affected by the proposed project. **Please see Sections 2.3, 3.2, and 5.2 for information on Biological Resources, including Wildlife and Special Status Species. Information on Wetlands is included in Sections 2.5, 3.4, 5.4, and Appendix B.**

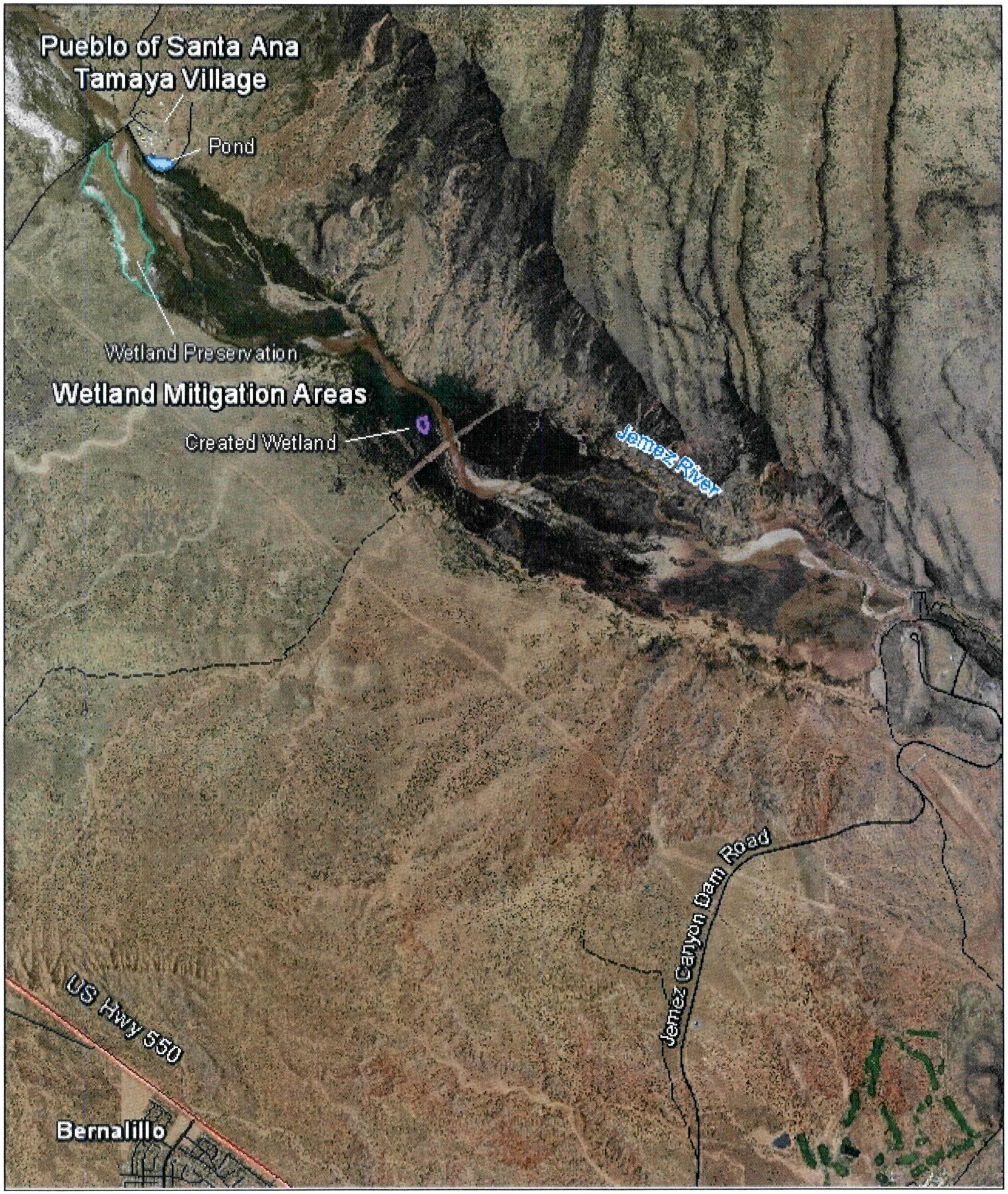
Please review the DEA and provide any written comments to the above address, Attn: Ms. Dana Price, Environmental Resources Section. Comments must be received **no later than March 18, 2013,** so that comments can be addressed and revisions made to the DEA in a timely manner. If we do not receive comments by this date, we will assume you have no concerns or have no objections to the project. You may facsimile your correspondence to (505) 342-3668 or e-mail to Dana.m.price@usace.army.mil.

If you have any questions or need additional information, please contact Ms. Dana Price, biologist, at (505) 342-3378 or e-mail at dana.m.price@usace.army.mil or Mr. Gregory Everhart, archaeologist, at (505) 342-3352 or e-mail at Gregory.D.Everhart @usace.army.mil. Thank you.

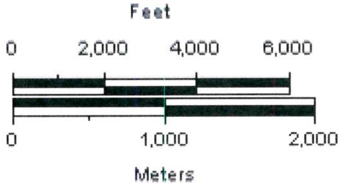
Sincerely,

Julie Alcon
Chief, Environmental Resources Section

Enclosure



Tamaya Village and Pond
Pueblo of Santa Ana



US Army Corps of Engineers ® Albuquerque District

Universal Transverse Mercator Coordinate System, Zone 13 North, 1983 North American Datum. Units meters.

Map Scale: 1:48,000
Map Date: October 9, 2012
Data Sources:
Wetland boundaries:
U.S. Army Corps of Engineers, Albuquerque District;
ortho-photography:
2011 NAIP NM County Mosaics

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DEPARTMENT OF THE ARMY
ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS
4101 JEFFERSON PLAZA NE
ALBUQUERQUE NM 87109-3435

February 15, 2013

Planning, Project and Program Management Division
Planning Branch
Environmental Resources Section

Mr. Tom Nystrom
Section 401 Water Quality Certification
US Environmental Protection Agency
Region 6
1445 Ross Avenue, Suite 1200
Dallas, TX 75202-2733

Dear Mr. Nystrom:

The U.S. Army Corps of Engineers (Corps), Albuquerque District, requests Section 401 Water Quality Certification for a proposed project on Tribal land at the Pueblo of Santa Ana, Sandoval County, New Mexico. The Corps has prepared a Section 404(b)(1) analysis as part of its draft Environmental Assessment (DEA) and draft Finding of No Significant Impact (FONSI) for the Tamaya Drainage Project, Pueblo of Santa Ana, Sandoval County, New Mexico.

The purpose of the proposed project is to alleviate health, safety, and aesthetic concerns associated with the presence of a pond of stagnant water in close proximity to Tamaya Village, the ancestral village of the Pueblo of Santa Ana (Pueblo). The pond is considered an undesirable feature by the Pueblo due to the safety hazard it presents and its unpleasant smells, poor water quality, and mosquitoes. The Corps proposes to fill the pond, coupled with a passive drainage system that would divert groundwater to a sump equipped with pumps. Mitigation is required to compensate for wetland values that would otherwise be lost in filling the pond. The enclosed mitigation plan has two components: preservation of a wet meadow on the opposite bank of the Jemez River across from Tamaya Village, as well as creation of a permanent wetland upstream from the Jemez River weir.

Concurrently with requesting Section 401 Water Quality Certification, the Corps is soliciting comments from Federal, State, and local interests to comply with the National Environmental Policy Act. The DEA, entitled **"Tamaya Drainage Project, Pueblo of Santa Ana, Sandoval County, New Mexico",** is available electronically at the Albuquerque District website, http://www.spa.usace.army.mil/Missions/Environmental/EnvironmentalComplianceDocuments.aspx .

Please review the enclosed Wetland Mitigation Plan and 404(b)(1) analysis, which comprise Appendix B of the DEA, and provide water quality certification to the above address, Attn: Ms. Dana Price, Environmental Resources Section. The Corps would appreciate receiving certification by March 18, 2013**,** so that the EA may be finalized in a timely manner. You may facsimile your correspondence to (505) 342-3668 or e-mail to Dana.m.price@usace.army.mil.

Your point of contact at the Pueblo of Santa Ana is Mr. Alan Hatch, Director of the Pueblo of Santa Ana Department of Natural Resources. Mr. Hatch may be contacted at **(505) 771-6771 or by e-mail at Alan.Hatch@santaana-nsn.gov.**

If you have any questions or need additional information, please contact Ms. Dana Price, biologist, at (505) 342-3378 or e-mail at dana.m.price@usace.army.mil. Thank you.

Sincerely,

Julie Alcon
Chief, Environmental Resources Section

Enclosures

Copies Furnished:

Ms. Marcy Leavitt
Regulatory Division
U.S. Army Corps of Engineers
Albuquerque District

Mr. Alan Hatch
Department of Natural Resources
Pueblo of Santa Ana

United States Department of Agriculture

NRCS

Natural Resources Conservation Service
6200 Jefferson NE, Room 305
Albuquerque, NM 87109
Phone: (505) 761-4402 **Fax:** (505) 761-4463
Web site: www.nm.nrcs.usda.gov

Albuquerque Field Office
6200 Jefferson NE. Room 125
Albuquerque, NM 87109
Phone: (505) 761-4499
Fax: (505) 761-5448

February 22, 2013

Dana Price
Project and Program Management Division
Environmental Resources Section
US Army, Corps of Engineers
4101 Jefferson Plaza NE
Albuquerque, NM 87109

Re: Santa Ana Response

Ms. Price:

I wished to respond to your request for written comments in compliance with NEPA for the proposed project located at Santa Ana Pueblo.

I do concur that the present shallow pool so close to the Pueblo Village does present several problems, including possible health concerns due to the mosquito populations in this area.

Our concern in these cases always is that negative impacts of altering any "wetland" area are mitigated. It appears that these concerns are adequately addressed in your mitigation plan.

Therefore, I have no objection to the project moving forward as planned.

Sincerely,

Josh Sherman
District Conservationist
NRCS/USDA