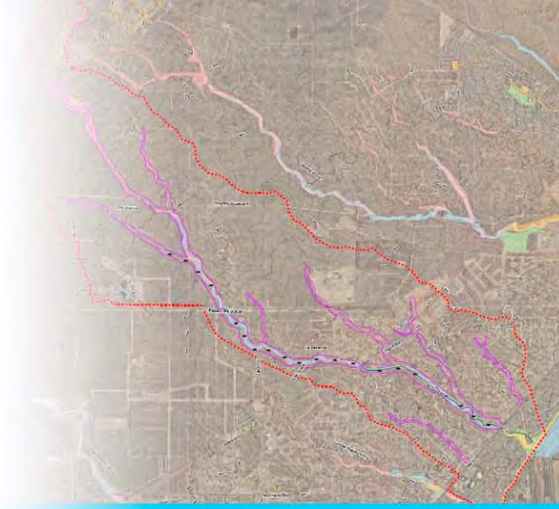
A Comprehensive Management Strategy for Arroyo Corridors



Sandoval County, New Mexico

November 2010

Prepared for:

Southern Sandoval County Flood Control Authority

1041 Commercial Drive SE

Rio Rancho, NM 87124

Prepared By:

Bohannan ▲ Huston Inc.

ENGINEERING ▲

SPATIAL DATA ▲

ADVANCED TECHNOLOGIES ▲

COMPREHENSIVE MANAGEMENT STRATEGY
FOR ARROYO CORRIDORS

SANDOVAL COUNTY, NEW MEXICO

PREPARED FOR:

Southern Sandoval County Arroyo Flood Control Authority
1041 Commercial Drive SE
Rio Rancho, NM 87124

NOVEMBER 2010

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COMPREHENSIVE MANAGEMENT STRATEGY FOR ARROYO CORRIDORS NOVEMBER 2010

The technical material and data contained in this document were prepared under the supervision and direction of the undersigned, whose seal as a Professional Engineer, licensed to practice in State of New Mexico, is affixed below:

Scott Armstrong, PE Engineer of Record License No. 15782

This is a planning document. Nothing herein constitutes any commitment by SSCAFCA to construct any project, study any area, acquire any right of way or enter into any contract. This report does not obligate SSCAFCA in any way. Drainage facility alignments, corridors, locations, treatments and cost estimates are conceptual only, and may be altered or revised based upon future project analysis, changed circumstances or otherwise. Land uses in this document were assumed for the basis of hydrologic modeling only.

Drainage facility alignments, conveyance treatments, corridors, locations, rights-of way and cost estimates are conceptual only, and may be altered or revised based upon future project analysis, changed circumstances or otherwise. This document does not provide adequate detail for construction of the recommendation in this report.

Land uses included in this document were assumed for the basis of hydrologic modeling only. This document does not grant "free discharge" from any proposed or existing development. Naturalistic channel treatments and piped storm drains are used for flood control conveyance, unless otherwise authorized by SSCAFCA.

The Comprehensive Management Strategy for Arroyo Corridors dated November, 2010 was accepted by SSCAFCA on 11/12/10.

By: _____ Date: March 16, 2011
David Stoliker, P.E. Executive Engineer

INTRODUCTION

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I. INTRODUCTION

A. Project Purpose

The Southern Sandoval County Arroyo Flood Control Authority (SSCAFCA) values open space and the natural attributes of ephemeral arroyos and wants to protect them. Therefore, SSCAFCA developed this project to take a "high level" look at what can be done to preserve the natural features of the ephemeral arroyos found within SSCAFCA's jurisdiction. This report, the Comprehensive Management Strategy for Arroyo Corridors (Strategy Report), documents the results of this project. As stated in the Scope of Services the project was scoped to "evaluate the potential for a 'naturalistic' system"; and to identify and evaluate constraints that may need to be addressed, and the techniques that may be needed to achieve this goal. As with most projects of this nature, the overall project purpose and goals were updated and refined as the project progressed. That effort resulted in the Project Vision and Goals (see1.C & D).

B. Project Team

In order to achieve the purpose, SSCAFCA assembled a project team with a diverse background. The Team included the individuals and the entities described below. In addition, some information is provided regarding the role and previous experience of the entities involved.

- SSCAFCA – lead agency; contracting authority. David Stoliker, Trevor Alsop.
- US Army Corps of Engineers (USACE) – regulatory authority. Eddie Paulsgrove, Lesley McWhirter, Allan Steinle.
- City of Rio Rancho (CoRR) – regulatory authority. Randall Carroll, Scott Sensanbaugher.
- Bohannan Huston, Inc. (BHI) – lead consultant; previous geomorphologic studies (in cooperation with Tetra Tech, Inc.). Howard Stone, Scott Armstrong.
- Tetra Tech, Inc. (TTI) – expert fluvial geomorphologist; experience with ephemeral systems. Bob Mussetter.
- Terracon Consultants, Inc. (TCI) – geotechnical services. Mike Anderson.
- WH Pacific (WHP) – consultant with extensive hydrology model development experience for the Barranca Watershed. Clint Dodge, Sharon Procopio.
- Huitt Zollars Inc. (HZI) – consultant with extensive development experience within SSCAFCA's jurisdiction. Kim Kemper, Jarrod Likar.

The project team met several times throughout the beginning phases of the project. In addition to the preliminary engineering investigation and analysis, these efforts concentrated on developing the project vision and goals described below. Brief summaries of these meetings were prepared and are included in Appendix A.

C. Project Vision

During discussions of arroyo corridor preservation, several objectives were established. These objectives have been incorporated into the following Project Vision:

1. To establish arroyo corridors that allow for:
    - Protection of the public from the damaging effects of flooding and the associated sediment erosion and deposition,
    - Managing erosion and deposition by maintaining the balance, not by prevention,
    - Recognition of development pressures; but resisting the resulting pressure to minimize drainage corridor width, which would result in hard-lined concrete trapezoidal channels to convey flood flows.
2. To preserve:
    - Habitat for flora and fauna, including preservation of vertical banks,
    - Sandy bed condition, which will provide opportunities for groundwater recharge,
    - Naturalistic character of the corridor, to provide a richer experience for people using the area for multi-use benefits,
    - Open spaces and view sheds.
3. To enhance:
    - Recreational facilities,
    - Storm water quality,
    - Other uses (e.g. economic development).

D. Project Goals

1. Goals

In accordance with the project purpose and vision, the main goal of the project is to develop recommendations which can be implemented to preserve the natural or naturalistic character of all arroyos in SSCAFCA's jurisdiction (beginning with the Barranca Arroyo) and to develop the framework and background analysis necessary to support development of a new Comprehensive Management Strategy for Arroyo Corridors.

While the Barranca Arroyo was used as the case study for this report, from the beginning, the overall goal was to use the information obtained from this study, as well as previously published reports for the Barranca Watershed, to define recommendations that could be applied to all arroyos and watersheds within SSCAFCA's jurisdiction.

2. Definitions

As the project progressed, it became apparent that in order to meet this goal it would be necessary to define both a natural and naturalistic arroyo. Through several discussions and

revisions these definitions were developed by the project team and are included below. For comparison an engineered channel is also defined.

a) Natural Arroyo

A natural arroyo is defined as:

an ephemeral drainage way, typically having a sloping, movable bed with steep or vertical erodible banks, which have not been directly altered by human intervention.

b) Naturalistic Arroyo

A naturalistic arroyo corridor is defined as:

an ephemeral drainage way, typically having a sloping, movable bed with steep or vertical erodible banks, which have been directly altered by human intervention and in which non-continuous or limited erosion protection measures have been installed to prevent damage to infrastructure while maintaining the natural bed and bank materials, with the objective of maintaining the natural character of the corridor to the maximum extent practicable such that it can continue to be used by wildlife and offer other multi-use benefits.

c) Engineered Channel

An engineered channel is defined as:

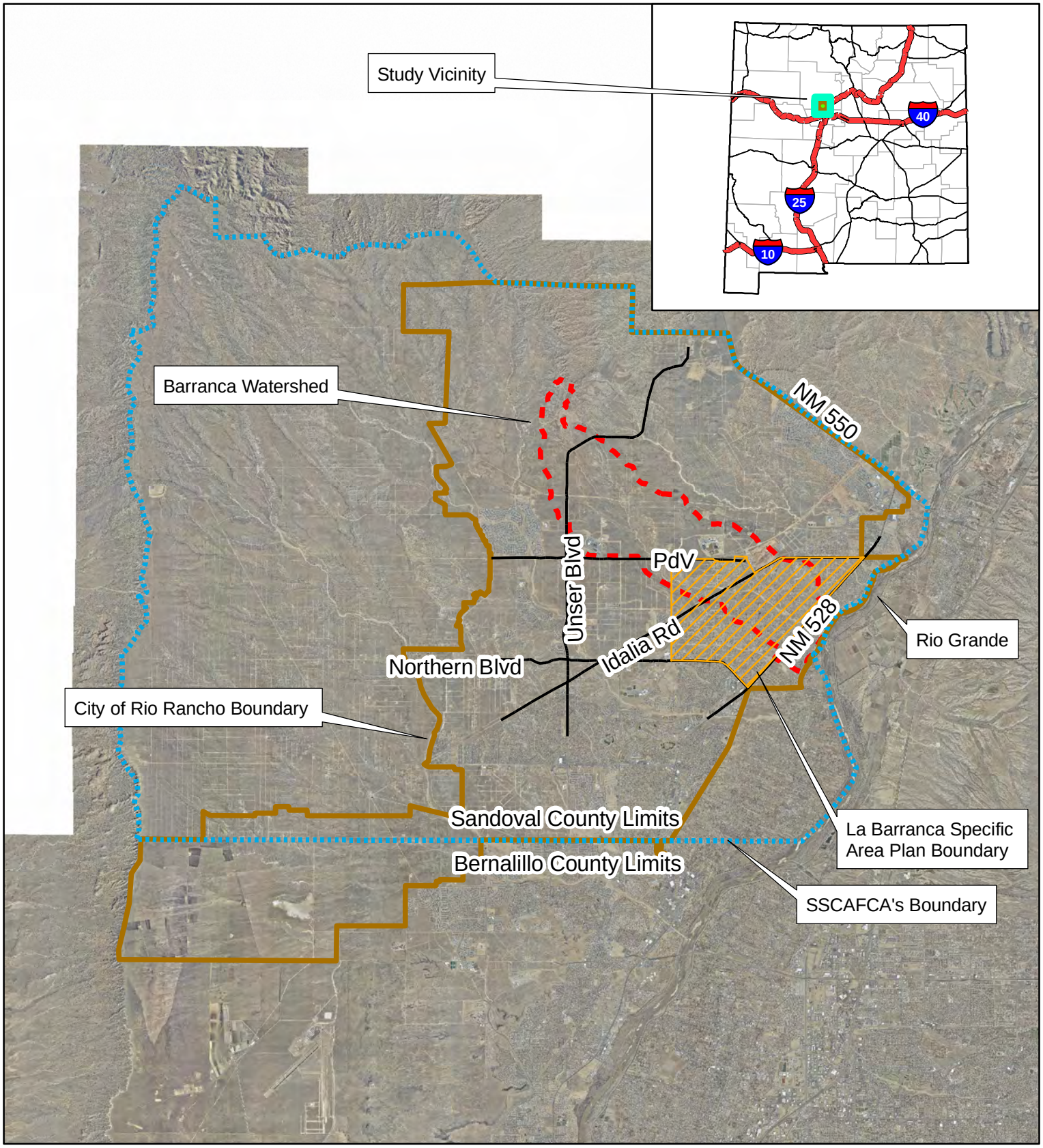
an engineered facility to convey flows using mostly man-made treatments. An engineered channel typically limits, but does not preclude the use of the arroyo corridor for use by wildlife and other multi-use alternatives.

E. Report Organization

To assist the reader, this Strategy Report has been divided into three distinct portions. The first portion includes basic background information for the report, as well as a literature review. This information is provided in Sections I and II, respectively. The second portion of the report presents the Barranca Watershed Example Study, included in Sections III through VII. The final portion of the report is the SSCAFCA Jurisdiction Wide Comprehensive Management Strategy. This information is presented in Section VIII. Section IX provides a bibliography for the development of this Strategy Report.

F. Project Area Description

SSCAFCA's jurisdictional boundary is shown on Figure 1, along with the Barranca watershed boundary. The Barranca Watershed is located primarily in the northeastern portion of SSCAFCA's jurisdiction. The upper limits of the watershed begin west of Unser Boulevard in the Mariposa



N

0 7,500 15,000 30,000 Feet

1 inch = 15,000 feet

FIGURE 1
SSCAFCA's JURISDICTIONAL BOUNDARY AND THE BARRANCA WATERSHED VICINITY MAP

NOVEMBER 2010

Bohannan Huston

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development. Over most of its length the watershed ranges between 1 and 1.5 miles wide and extends southeastward to the Rio Grande. The overall drainage area encompasses approximately 11 square miles. The main branch of the arroyo is approximately 9 miles long. The watershed ranges in elevation from approximately 6,060' at the headwaters to 5,040' at the Rio Grande. As a result, the arroyo has an approximate slope of 2%.

Approximately 20% of the watershed area is currently developed, which at present is less than the percentage of development within other watersheds in SSCAFCA's jurisdiction. By comparison the Montoyas Arroyo Watershed is approximately 25% developed, and the Black Arroyo Watershed is over 50% developed. East of NM 528 the watershed contains some existing arroyo improvements, such as grade control structures. In addition, there are culvert crossings at most of the larger roadways, especially in the lower portion of the watershed.

II. LITERATURE REVIEW

There have been several reports previously published that provide information related to areas within the Barranca Watershed. The following section provides some of the highlights of those reports. In addition, there are several existing guidance documents and regulations that will impact the development of SSCAFCA's Comprehensive Management Strategy regarding the preservation of arroyo corridors and these are also summarized below.

A. Draft Barranca Arroyo Watershed Management Plan

The Draft Barranca Arroyo Watershed Management Plan Version 2.0 (BAWMPv2.0) (WH Pacific, 2010) was prepared to evaluate existing conditions, indicate critical problems and establish long range planning goals for drainage management in the Barranca Watershed. The original BAWMP was prepared and accepted in 2006. The recent Draft provided in February 2010 was used for this review. The revisions included in BAWMPv2.0 are a technical update to convert hydrology models from AHYMO to HEC-HMS (as required by the SSCAFCA DPM) and to include recent development into the plan. Major changes are included in the Version 2.0 update are the V. Sue Cleveland High School, the Guadalajara Storm Drain and the City Center Development.

The BAWMPv2.0 lists all the pertinent watershed characteristics including physical properties, existing facilities, environmental qualities and the general soil types found in the Barranca Watershed. Section III below provides a summary of information from the BAWMPv2.0 (and other sources) that is pertinent to the analysis presented in this Strategy Report.

The BAWMPv2.0 provides updated hydrology models that were prepared for three development conditions.

- Existing Conditions – present development conditions.

- Developed Conditions (referred to as DEVEX08) - assumes full build out of the watershed with existing drainage facilities as of 2008 (i.e. no new dams, ponds, etc.) This condition is used to indicate critical problems in the watershed.
- Ultimate Conditions – Full build out of the watershed with all proposed drainage facilities built.

The plan addresses the development of the City Center Area. Historically the drainage from this area could potentially flow to the east into the Barranca watershed or to the south into the Lomitas Negras watershed. The BAWMPv2.0 ultimate conditions hydrology includes the City Center flow within the Barranca Watershed and adjusts the basin area accordingly.

The BAWMPv2.0 also included a summary of the SSCAFCA Quality of Life Master Plan and recommended use of naturalistic arroyos as well as a Watershed Park.

B. La Barranca Specific Area Plan

The La Barranca Specific Area Plan (BASAP) (CoRR, March 2010) is a planning document prepared by the City of Rio Rancho as part of their Vision 2020 – Integrated Comprehensive Plan. The BASAP will help "guide and manage the physical development within the planning area." The BASAP was accepted by the CoRR City Council in March, 2010. The BASAP area contains approximately 4,536 acres and is bounded by Paseo del Volcan and Idalia Rd. to the north, NM 528 to the east, Northern Blvd. to the south, and Loma Colorado Blvd. to the west. This area is shown on Figure 1.

The BASAP lists the existing conditions within the planning area including land use, zoning, public facilities, capital improvements, transportation and utility infrastructure. There is a description referring to the challenges that have emerged due to platting of the area without regard to drainage corridors and other public infrastructure needs. The BASAP lists the policies and goals to help solve the problems and ensure that there is adequate infrastructure for future development.

There are two specific policies within the BASAP that will affect drainage within the watershed. Goal L2 - *Encourage residential lot consolidation* and Policy I2 - *Ensure adequate drainage facilities are in place prior to completion of new development projects*, are both in line with SSCAFCA's goals and objectives to proactively prevent future drainage problems that will help protect the public from the damaging effects of flooding.

C. Applicable Guiding Documents

1. SSCAFCA Vision and Mission Statement

To assure the recommendations from this Strategy Report are in agreement with SSCAFCA's charter, SSCAFCA's Vision and Mission are restated below.

Vision – Flood control today, for a safe tomorrow.

Mission - Protect citizens and property by implementing proven flood control solutions that:

- manage our watersheds prudently for future generations
- enhance the quality of life

- create the most appealing multi-use facilities
- set an example of quality, integrity, leadership, and professionalism
- educate the public concerning flood hazards
- administer public funds prudently

3. Development Process Manual (DPM)

In July 2009, SSCAFCA adopted a Development Process Manual (DPM) based on Chapter 22 of the City of Albuquerque's (COA) DPM. SSCAFCA revised the COA DPM to meet the needs and desires of the SSCAFCA Board. The current version of the SSCAFCA DPM was revised in April 2010.

The procedures for hydrologic analysis and design of public and private drainage control, flood control and erosion control facilities are outlined in the DPM. In addition, the DPM includes criteria for hydraulic design of open channels and closed conduits, as well as guidelines for the following: channel treatment selection, grading and erosion control design, and rights-of-way, easements and covenants required for the design. The analyses presented in this Strategy Report were performed using procedures in accordance with the DPM.

In addition, the DPM provides information regarding ownership of lands within an arroyo corridor. Specifically, the DPM states that "Land necessary for permanent drainage, flood control, erosion control or major arroyos must be dedicated in fee simple to SSCAFCA." There are other provisions that allow drainage easements or covenants, but it is clear that SSCACFA policy requires fee simple public ownership. Information provided in the DPM related to land ownership was utilized to help set the framework for development of this Comprehensive Management Stategy regarding the preservation of arroyo corridors.

4. Sediment and Erosion Design Guide

In November 2008, SSCAFCA published the Sediment and Erosion Design Guide (SED Guide). The SED Guide describes the basic geomorphic and watershed processes that are prevalent in the SSCAFCA area. The SED Guide also provides guidance for the analysis of various sediment transport / geomorphologic phenomena within arroyos in the SSCAFCA jurisdictional area. One example is identification of the methodology for establishing a lateral erosion envelope (LEE). The SED Guide defines the LEE line as the maximum lateral migration distance of an arroyo that can be expected over the next 30 to 50 years. The procedures outlined in the SED Guide were used for this Strategy Report as described in Section V.

5. Quality of Life Master Plan

SSCAFCA and its constituents place a high value on multi-use facilities. Therefore, as part of its stormwater management mission, SSCAFCA recognizes its opportunity to encourage other

agencies or entities to utilize its land for multiple, value-added purposes. This may include a network of multi-purpose pathways and bike routes to maximize use and enjoyment of lands within or adjacent to SSCAFCA holdings, as well as other benefits. With input from landowners, developers, neighborhood groups and interested individual citizens, SSCAFCA developed its Quality of Life Master Plan. The plan includes recommendations and an implementation program for the enhancement of SSCAFCA's drainage corridors.

The Quality of Life Master Plan suggests that flood control facilities can be blended into existing and future neighborhoods, softening the hard edge of channel treatments. The Quality of Life Master Plan addresses the entire SSCAFCA service region with its varying environmental conditions, land use and jurisdictional policies. The environmental conditions discussed include physical characteristics, habitat, plant communities, archaeological considerations, and soils. Planning concepts for turning flood management rights-of-way into value added assets are discussed. Recommended amenities include campgrounds, parks, golf courses, "disc-golf" areas, commercial joint-uses, off-road venues, interpretive areas, x-treme game sites, and wildlife corridors. The Quality of Life Master Plan offers amenity recommendations for each arroyo.

The plan was reviewed to verify recommendations provided in this Strategy Report are in agreement with the overall Quality of Life Master Plan.

6. Utility Guidance

One use of arroyo corridors within SSCAFCA's jurisdiction is for conveying sanitary sewer trunk lines to downstream treatment facilities. In addition to sanitary sewer lines, several other utilities utilize portions of arroyo corridors throughout SSCAFCA's jurisdiction. In some locations, the lateral migration of the arroyo and/or degradation of the bed have led to sanitary sewer lines being exposed and even broken in some cases. As a result, SSCAFCA has included guidelines for utilities within an arroyo corridor in the DPM.

Regardless, given its current jurisdiction and authority, all proposed uses of an arroyo corridor for utilities must be coordinated with SSCAFCA to ensure the primary function of the natural / naturalistic arroyos are not compromised.

7. CoRR Parks and Recreation Plans

One vision in the Quality of Life Master Plan is the concept of a linear parkway, or Watershed Park, along drainage ROW's. The CoRR Parks and Recreation Department fully supports this concept. SSCAFCA has adopted the CoRR Trails Master Plan on all arroyos within their jurisdiction. As discussed below, there is a large portion of the platted right-of-way that covers the Barranca Arroyo, which has been dedicated to SSCAFCA. Therefore this is an opportunity for the CoRR to expand their trail system within the watershed using public lands.

D. Applicable Guiding Regulations

This report was prepared so that the recommendations will be in compliance with all applicable tribal, State of New Mexico and local regulations, statutes, policies, and standards for conserving the environment; and environmental resources such as water and air quality; endangered plants and animals; and cultural resources. In order to achieve that requirement a general review of the most relevant laws was performed to verify the report is compliant with those laws. The list below provides a partial list of the most applicable laws.

- National Environmental Policy Act (NEPA) of 1969, as amended (42 U.S.C. 4321 et seq.)
- Clean Air Act of 1970, as amended (42 U.S.C. 7401 et seq.)
- Clean Water Act of 1972, as amended (33 U.S.C. 1251 et seq.)
- Endangered Species Act of 1973, (ESA) as amended (16 U.S.C. 1531 et seq.)
- Migratory Bird Treaty Act of 1918 (16 U.S.C 703, et seq.)
- National Historic Preservation Act of 1966, as amended (16 U.S.C. 470a et seq.)
- Floodplain Management (Executive Order 11988)
- Protection of Wetlands (Executive Order 11990)
- Protection of Historic and Cultural Properties (36 CFR 800 et seq.)
- Bald and Golden Eagle Protection Act (16 U.S.C. 668a-d)

BARRANCA WATERSHED EXAMPLE STUDY

III. EXISTING CONDITIONS

As discussed above, the BAWMPv2.0 provides a comprehensive review of the existing conditions within the watershed. Other Watershed Management Plans developed by SSCAFCA provide similar information for the remaining watersheds within their jurisdiction. The information provided below is meant to be a short summary description of the existing conditions. More detailed information can be found in the BAWMPv2.0.

A. Area Soils and Geology

The arroyos within SSCAFCA's jurisdictional area, including the Barranca, drain portions of the Santa Fe formation that are underlain by poorly consolidated sedimentary rocks of the Santa Fe Group, and most of the area is covered by large expanses of aeolian sand and alluvium associated with the arroyo systems that drain generally southeasterly into the Rio Grande (Personius et al., 1999). The beds of most of the arroyos in this area are composed of loose sands, with a small amount of silt and fine gravel. Outcrops of the weakly-cemented Santa Fe formation rocks occur in isolated locations in the bed and banks of active arroyos. These outcrops are composed primarily of sandstone and mudstone, with minor amounts of silt/clay and gravel.

The outcrops are erosion-resistant, but are erodible when subjected to high velocity flows. This erosion-resistant material provides a measure of temporary vertical and lateral stability. As part of this Strategy Report, 8 grab samples of bed material were collected and analyzed. In addition, data from 5 previous sampling sites were reviewed. This information, including a map showing the location of the sample locations is included in Appendix B. As will be discussed in more detail in a later section of this report, the results indicate that the bed material in the Barranca contains a substantial amount (20% to 30%) of gravel that will affect the future behavior of the arroyo if it continues to downcut due to watershed development and other factors. Alluvial materials on the surface in the overbank areas generally contain sufficient gravel-sized particles to produce a desert pavement that inhibits overland erosion during rainstorm events that are of sufficient intensity and duration to cause sheet flow.

B. Geomorphology

The main branch of Barranca Arroyo extends approximately 9.5 miles from the confluence with the Rio Grande upstream to the watershed divide, and the portion of the reach that is of primary interest in this evaluation extends approximately 6.2 miles from Rio Rancho Drive (U.S. Highway 528) upstream to Progress Boulevard as shown on Exhibit 1. With the exception of local reaches immediately downstream from Progress and Idalia Roads, the arroyo is relatively un-incised, with relatively steep erodible banklines that are only a few feet high, except where the arroyo is in contact with the bounding Santa Fe Formation terraces. The incision below Progress and Idalia Roads results from a combination of upstream sediment trapping, confinement by the bounding terraces (or road opening) and the typical incision that occurs in erodible materials downstream from hardpoints in the channel bed. Progress Road is an unpaved dip

crossing and the total drop in the bed across the crossing is in the range of 6 to 8 feet (Figure 2). The arroyo passes under Idalia Road through a series of four 4-foot high corrugated metal (CMP) arch culverts. The total drop from the culvert invert to the downstream arroyo bed is over 6 feet (Figure 3). At the time of this report, the drop across Paseo del Volcan, which consists of a series of 4 10'W X 10'H concrete box culverts with concrete bottom, is only about 2 feet (Figure 4). Based on the observed incision at the other crossings, the incision downstream from this crossing will continue to increase from future runoff events. Additional grade control exists due to the construction of concrete encased utility crossings of the arroyo just downstream of major culverts.

The slope of the primary reach is relatively uniform, with an average gradient of approximately 1.6 percent (about 84 feet per mile) (Figure 5). As shown on this figure, a significant concavity (bowl shaped depression) occurs in the profile between about 40th Street and 38th Avenue, and a minor convexity occurs in the profile from about 0.4 miles upstream from Idalia Road to about 0.4 miles upstream from 40th Street. These profile features would typically indicate degradation (convexity) and aggradation (concavity); however, in this case, they appear to be controlled by the local geology and underlying soil structure. The area in which the concavity occurs is un-incised, with channel widths generally in the 50 to 60 foot range and relatively low banks (Figure 6 – Figure 7). The area of the convexity is also relatively un-incised, but the width between the higher Santa Fe formation terraces is somewhat less and the channel tends to be narrower than in the previously described upstream reach (40- to 50-foot range) (Figure 8). The overall orientation of the primary project reach generally follows the northwest to southeast trend of the Rio Grande valley fill on the west side of the river, but the portion of the reach between Idalia and 40th Street runs essentially west to east.

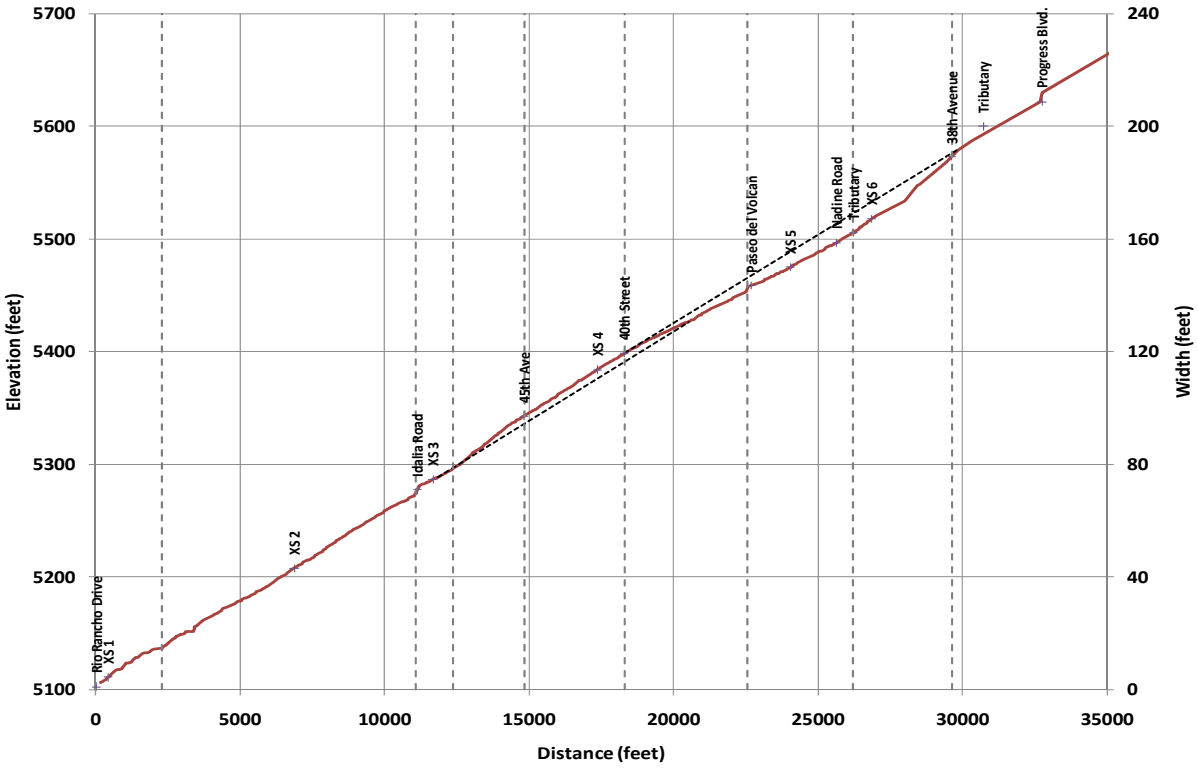
As expected, the channel width varies significantly along the reach, with a general trend of increasing width with increasing drainage area (Figure 7). In the portion of the primary reach upstream from 38th Avenue, where the drainages area is in the range of 2 to 2.5 mi^2, the channel averages about 40 feet wide. As discussed in the previous paragraph, the average width through the reach from 38th Avenue downstream to about 45th Street averages about 50 feet, with a slight trend of decreasing width in the downstream direction in spite of the significant increase in drainage area from about 2.5 mi^2 to about 5 mi^2. Between 45th Street and approximately 0.4 mi downstream from Idalia Road, the average width increases to about 60 feet, and the width continues to increase in the downstream direction to about 110 feet in the approximately 0.5 mile reach upstream from Highway 528.

Figure 2 - Barranca Arroyo looking downstream from Progress Road

Figure 3 - Looking upstream at Idalia Road. The person in the photo is 6'-3" tall

Figure 4 - Looking upstream at the 10'W x 10'H box culverts under Paseo del Volcan

Figure 5 - Longitudinal profile of the Barranca arroyo active channel bed 38th Ave.

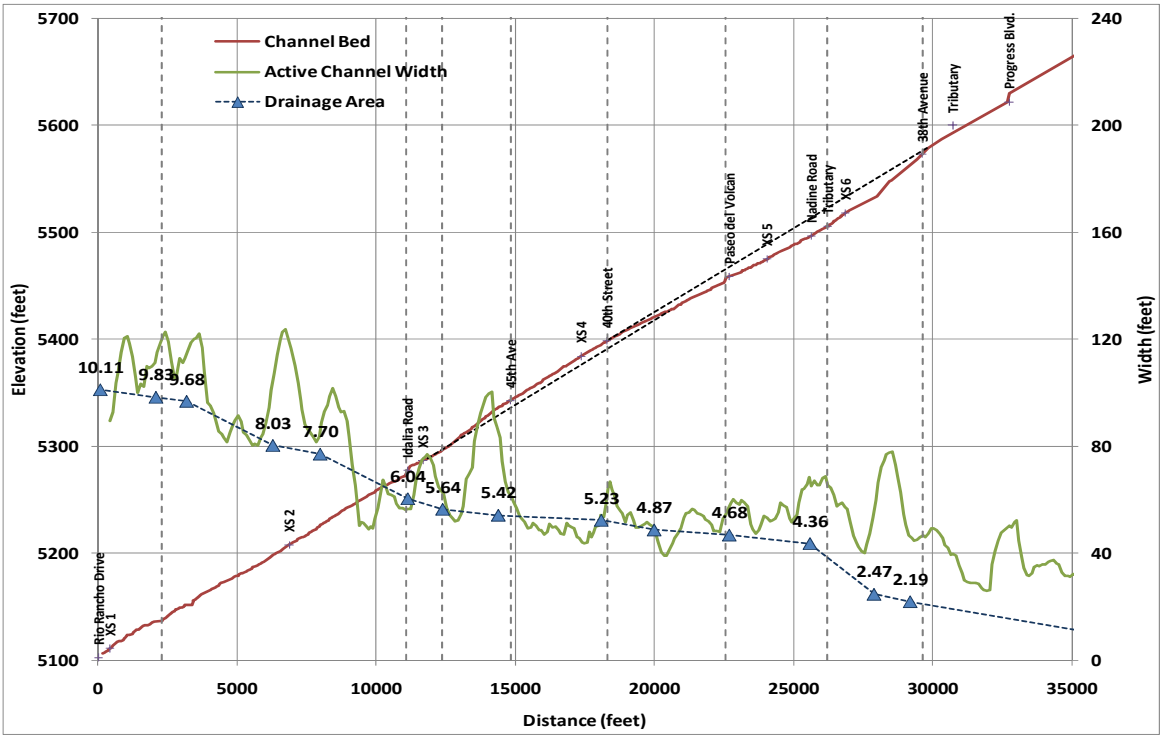


Note: Based primarily on a GPS survey conducted by BHI in Fall 2009 and supplemented upstream from 38th Ave. with data from the County contour mapping

Figure 6 - Typical section of the Barranca Arroyo from Paseo del Volcan to Nadine Rd.

Note: View looking upstream from Station 243+00, approximately 800 feet upstream from Paseo del Volcan.

Figure 7 – Barranca Longitudinal profile superimposed with the moving-average active channel width



Note: Over 1000-foot increments from the 2006 aerial photography and the drainage area at the AHYMO analysis points along the reach

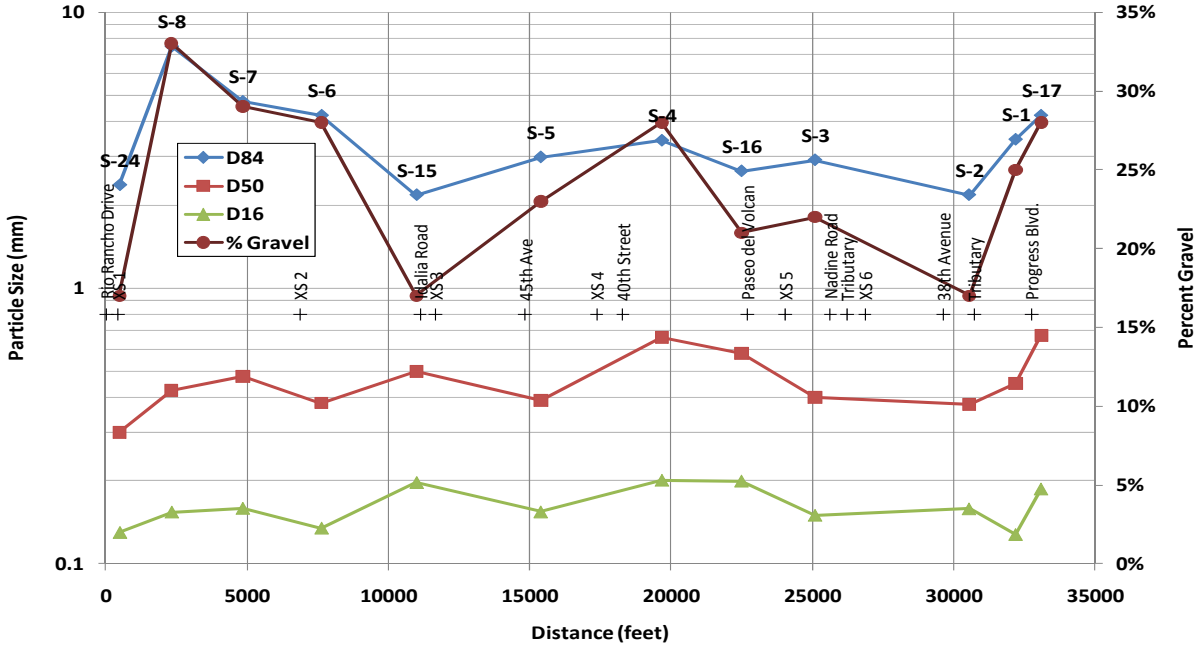
Figure 8 - Barranca Arroyo typical section in reach between Idalia Road to 40th Street.

Note: View looking downstream from 40th Street

Like most arroyos, the Barranca has relatively low sinuosity (ratio of the channel length to the down valley length measured using aerial photography) throughout most of the reach, averaging about 1.14 between Highway 528 and Progress Road. The sinuosity tends to be somewhat higher in the upstream portion of the reach, with a maximum value of 1.24 in the approximately 0.5 mile reach just downstream from Progress Road and 1.19 in the previously described concave reach that generally falls between Idalia Road and 38th Avenue.

The bed material in the Barranca Arroyo is primarily sand, with median size in the 0.4 to 0.5 mm range throughout most of the reach, with a modest fining trend in the downstream direction (Figure 9). Although most of the material is in the sand range, the bed material matrix also includes a significant amount of gravel, ranging from approximately 15 percent to as high as 30 percent. Although the bulk of this material is transportable under essentially the entire range of flows that can occur in the arroyo, the coarser material will influence the degradational behavior as the arroyo incises under future development conditions due to selective transport, in which the finer sand is transported at a higher rate than the gravels, leaving behind a coarse surface layer that will progressively limit the transport capacity over time.

Figure 9 - Median (D50), D15 and D84 particle sizes of bed material samples



Note: Collected by Mussetter Engineering, Inc. (MEI, 2008) (S-15, 16, 17 and 24) and by Terracon in 2009 (S-1 through S-8). The "D" refers to the grain size, or apparent diameter, of the soil particles and the number, e.g. 50 denotes the percent of all particles smaller than the apparent diameter.

C. Property Ownership / Land Use

A majority of the land in the watershed was platted in the 1960's and is in the original Rio Rancho Estates Subdivision. Most of the parcels in this platted area are privately owned. Over time SSCAFCA has

acquired several parcels that have been dedicated for the arroyo. However, the publicly owned right-of way (ROW) width is variable and in many locations does not provide adequate ROW for the arroyo. In addition, there are areas where the ROW does not coincide with the current alignment of the arroyo or the mapped floodplain. There are also areas (such as the stretch between Paseo del Volcan and 40th St.) where there is no dedicated land for the Barranca Arroyo. The current SSCAFCA owned ROW and drainage easements are shown on Exhibit 1. Exhibit 2 through Exhibit 8 provides a more detailed view of this information.

D. Topography

The topography for the area is shown on Exhibit 1. This information was derived from a computer generated digital terrain model surface produced for Sandoval County in 2003. The accuracy was sufficient to produce 4 ft. contours. Land in the Barranca Watershed generally slopes from the northwest to the southeast. Using this coarse data the BAWMPv2.0 estimated the average main branch slope as approximately 2%. Using more detailed survey information obtained for this Strategy Report, the average slope was found to be approximately 1.6%. Using data presented on Figure 7 the minimum slope, located near Paseo del Volcan, was determined to be approximately 1.3% and the maximum slope, located near 38th Ave., was determined to be approximately 2.7%.

E. Hydrology

The BAWMPv2.0 converts the hydrology developed in the 2006 BAWMP from AHYMO to HEC-HMS. Table 1 provides a comparison of the 100 year – 24 hr flow at four analysis points calculated with both methods. In addition, the table provides data for 3 conditions: existing development with existing infrastructure; developed conditions with anticipated future infrastructure in place (ultimate condition); and DEVEX – which assumes fully developed conditions within the watershed (based on existing platting and zoning) without anticipated future drainage infrastructure. In general, the difference in flow between AHYMO and HEC-HNS is minor, typically less than 10%, which can be attributed to routing variations and different unit hydrograph methods. The LEE line analysis discussed in Section V.A was completed before the BAWMPv2.0 was finalized and therefore used the hydrology developed with AHYMO and presented in the original BAWMP. However, the minor differences in flow are insignificant given the empirical nature of the LEE line investigation and therefore use of the AHYMO flows is sufficient for that purpose.

Table 1 – Comparison of Flows Derived Using AHYMO vs. HEC-HMS

La Barranca 100-yr Flows Source: WH Pacific Compiled by: Bohannan Huston, Inc. Date: February 24, 2010							
WMP AP ID	Road Crossing	Existing		Developed		DEVEX	
		AHYMO	HMS	AHYMO	HMS	AHYMO	HMS
		cfs	cfs	cfs	cfs	cfs	cfs
13	528 Highway	4040	3830	870	830	9270	8080
24	Idalia Road	2790	2890	920	920	5890	5560
30	Paseo Del Volcan	2440	2780	360	240	5210	5210
56a	Unser Blvd.	320	450	770	770	820	820

F. FEMA Floodplains

The Federal Emergency Management Agency has developed Flood Insurance Rate Maps (FIRMs) for the Barranca that show areas anticipated to be inundated by a 100-year flood. The limits of this floodplain are shown on Exhibit 1.

G. Storm Water Quality

Due to the mostly undeveloped conditions of the Barranca watershed it is likely that there are fewer man-made contaminants (e.g. oils, asphalt) in the runoff than compared to more densely developed watersheds in the area. However, it is well documented that in arid environments with sandy arroyos (such as found in SSCAFCA's jurisdiction) during the first flush of runoff events the water quality typically has a very high sediment concentration.

The BAWMPv2.0 lists the Environmental Protection Agency (EPA) requirements for a National Pollutant Discharge Elimination System (NPDES) Phase II General Permit. SSCAFCA has applied for a NPDES permit and water quality is being addressed. As future development occurs, it will be necessary to implement Best Management Practices (BMPs) to maintain water quality and meet the anticipated, more stringent regulatory requirements. The major BMPs recommended in the BAWMPv2.0 for the Barranca watershed are to treat the runoff from a 0.6" 6-hour storm event, incorporate water quality facilities into proposed flood control ponds and dams, and require commercial & industrial developments to provide on-site treatment.

In addition, the currently unapproved BAWMPv2.0 also recommends micro water quality ponds/parks that use "clean grey water" which can be used to provide treatment for low flows, and wildlife habitat and educational opportunities.

IV. FUTURE CONDITIONS AND IMPACTS

A. Arroyo Evolution

In order to properly evaluate other alternatives to achieve the project goals, it is important to evaluate the ramifications of a 'no action' alternative. As described herein, the no action alternative is relative to actions that SSCAFCA would implement. It is important to note that under this scenario, although SSCAFCA would not implement any of the actions described below, changes will surely occur in the watershed. For example, it is anticipated that development will continue throughout the watershed even in a no action scenario. With or without this development, under the no action scenario the arroyo will continue to migrate laterally and the arroyo bed will continue to degrade.

A no action alternative could not only severely limit SSCAFCA's ability to preserve an adequate corridor width, but also would increase the risk for property damage and threat to life. Therefore, taking 'no action' at this time would likely force SSCAFCA into implementing more emergency actions in the future to protect structures from imminent danger; or may require implementation of tighter regulatory initiatives in the future to control the amount and frequency of runoff carried in the receiving arroyo.

B. Future Development

At the time of this report, Huitt-Zollars is in the process of developing a Facility Plan for the Rio Rancho City Center. The purpose of that plan is to establish the facilities necessary to convey stormwater runoff from the City Center development and to convey the off-site stormwater runoff through the site. Currently three options have been explored for the proposed drainage infrastructure to convey the stormwater runoff. The first option includes a naturalistic arroyo and a storm drain. The second option includes a hard lined channel and a storm drain. The third option includes an offsite Progress Dam and a storm drain. All three options redirect flow from the Lomitas Negras watershed into the Barranca watershed.

Additional recent developments in the Barranca watershed include the V. Sue Cleveland High School and the Guadalajara Storm Drain. The high school development revised the sub-basin configuration from the previous BAWMP; however the discharge locations conform to the 2006 BAWMP. Furthermore, the PDV Crossing 'E' pond proposed in the 2006 BAWMP was incorporated into the school development and the site drainage matches historic flows. The Guadalajara storm drain was constructed to collect local flows after the damaging 2006 storm season.

The anticipated effects of these and other future developments have been accounted for in the hydrology developed for the BAWMPv2.0.

C. Proposed Sanitary Sewer

As a part of the Paseo Gateway Subdivision, a new sanitary sewer line is proposed in the Barranca Arroyo. Based on information provided by Huitt-Zollars the line is proposed to extend from the existing wastewater treatment facility (located north of the outlet of the Barranca to the Rio Grande) to Idalia Road.

The proposed SAS profile is 8 ft to 20 ft below the arroyo invert between the treatment facility and approximately 500 ft southeast of NM528. From here the line is proposed to be nominally 9 ft below the arroyo invert until it reaches Idalia Road. The proposed sewer line is 30" diameter from the treatment facility to NM528 and 28" diameter from NM528 to Idalia Road. Exhibit 1 shows the location of the proposed sewer line. If this line is constructed, it could have effects on the integrity of the existing arroyo stability that would require mitigation during construction.

V. EXAMPLE ARROYO ANALYSIS

To help achieve the project objectives, the analysis described below was performed to support development of a Comprehensive Management Strategy. The results of the analyses are presented in Section VI; and the recommendations derived from these analyses specific for the Barranca Arroyo are presented in Section VII, while the recommendations that are extrapolated to the entire SSCAFCA jurisdiction are presented in Section VIII.B.

A. LEE Line Analysis

The LEE line analysis performed as part of this Strategy Report extended along the main branch of the Barranca Arroyo from NM528 to approximately ½ mile north of Paseo del Volcan. At this point, the analysis then followed a tributary upstream of the City Center area. The analysis presented in this report was performed for the existing and ultimate conditions, as defined in the BAWMP. A DEVEX LEE line analysis was previously performed by WH Pacific as part of the 2006 BAWMP.

The intent of this investigation is to use the results of the LEE line analysis to identify lands that could potentially be used as a set back from the arroyo, within which development could be regulated. Since this approach would have impacts on existing lands, the investigation also evaluated the impacts on existing private property. That analysis is described in Section V.B below.

The existing (Table 2) and ultimate (Table 3) conditions flows used for this study were obtained from the 2006 BAWMP. Analysis locations corresponded to analysis points (AP) provided in the document at crossing structures, arroyo junctions and downstream of proposed dams. The procedures described in Section 3.4.5.3 of the SED Guide were used to determine the Down Valley Length (Lv) and the Total Erosion Width (LEE). These values are calculated using two input parameters: Q100 and average arroyo slope.

Table 2 summarizes the results of the LEE line analysis for the existing conditions. The road crossings listed on the table are shown on Exhibit 1. The existing condition LEE lines were calculated using the existing conditions 100-year, 24 hour storm event flows.

Table 2 – LEE Line Flows and Widths – Existing Conditions

AP	Approx Station	Road Crossings	Q100 (cfs)	Qd (cfs)	S (ft/ft)	Down Valley Length (feet)	Total Erosion Width (feet)	Comments
13	11+10	528 Highway NE	4,040	808	0.0179	416	472	
11	34+70	Saratoga Dr NE	4,020	804	0.0157	415	482	
21	89+60	Tributary Intersection	2,790	558	0.0145	345	399	
24	116+40	Idalia Road	2,790	558	0.0169	340	395	
26	118+50	Junction	2,600	520	0.0163	327	383	
29	183+00	Tributary Intersection	2,570	514	0.0140	332	382	
46	230+10	Paseo Del Volcan	2,400	480	0.0131	324	383	
47	257+50	Junction	2,300	460	0.0140	313	371	
50	262+90	Junction	990	198	0.0114	207	250	
56	337+10	38th Ave NE	510	102	0.0268	146	168	LEE line on northern bank from Sta. 317+50 to 322 +50 was modified based on field erosion patterns.

AP - References Analysis Point in the Barranca Watershed Management Plan

Table 3 summarizes the results of the analysis for ultimate conditions with proposed improvements (e.g. dams) in place. In some cases the LEE line was modified due to field evidence. The lower flows resulting from the proposed future dams would change the character of the sinusoidal pattern over time in response to cleaner, i.e., sediment free water discharging from each dam outlet. Over time, we anticipate the lower flows would decrease the potential for long-term lateral movement in the arroyo.

The higher flows resulting from the DEVEX (without future dams) analysis presented in the 2006 BAWMP resulted in a LEE line that is wider than either the existing conditions or ultimate conditions LEE line presented in this report. This confirms what would be expected, i.e., the higher flows would increase the potential for long-term lateral movement.

Through discussions with the Project Team, it was decided that the biggest benefit for preservation of the arroyo corridor could be achieved by using the maximum LEE line width defined for the 3 hydrologic conditions analyzed. As discussed above, the DEVEX lee line typically provided the widest limits. However, in a few isolated locations the existing conditions or ultimate conditions LEE line actually extended outside the DEVEX LEE line due to minor differences of implementing the methodology. Therefore, for purposes of further analysis a LEEMAX line was derived from the widest of the three LEE lines at any given location. The line is shown on the Exhibits.

Table 3 – LEE Line Flows and Widths – Ultimate Conditions

AP	Approx Station	Road Crossings	Q100 (cfs)	Qd (cfs)	S (ft/ft)	Down Valley Length (feet)	Total Width (LEE)	Comments
13	11+10	528 Highway NE	870	174	0.0179	181	219	LEE line on south bank was adjusted from approx. STA 26+00-STA 29+50 based on existing erosion patterns.
11	34+73	Saratoga Dr NE	920	184	0.0160	189	229	
16	38+82	Saratoga Dam	920	184	0.0157	190	229	Due to short reach length downstream flow of 920 cfs was used rather than 520 cfs outflow from dam.
21	89+62	Junction	1,180	236	0.0145	218	262	
24	116+41	Idalia Road	920	184	0.0169	187	226	Northern & southern LEE lines were modified to match LEE lines for the existing condition to better represent multiple flow path areas from STA 140+00 to STA 146+25.
26	148+54	Junction	270	54	0.0163	119	144	
29	183+00	Junction	360	72	0.0140	136	165	LEE lines for south & north bank were adjusted from Sta. 183+00 to STA 189+65 based on existing erosion patterns.
46	230+14	Paseo Del Volcan	2,300	460	0.0114	326	386	
31_ BA_ 51D	237+00	PDV Dam	2,300	460	0.0135	315	373	
47	257+50	Junction	2,300	460	0.0140	313	371	
50	262+92	Junction	1,040	208	0.0157	200	242	
55	316+97	Upper SLO Dam	380	76	0.0160	136	164	LEE lines for south & north bank were adjusted from Sta. 316+80 to 318+85 based on existing erosion patterns.
56	337+06	Trib Intersection	1,060	212	0.0299	198	220	
25_ BA_ 75S	344+05	38th Ave NE	890	178	0.0246	183	219	LEE lines for south & north bank were adjusted from Sta. 317+50 to 322+50 based on existing erosion patterns.

AP - References Analysis Point in the Barranca Watershed Management Plan

B. Property Ownership Evaluation

As discussed above, the LEEMAX line anticipates the widest future long-term lateral movement of the arroyo compared to the existing or developed conditions LEE lines. Therefore this is the line that will be used for future planning for the arroyo. The LEEMAX line is shown on Exhibit 1 and shown in more detail on Exhibits 2 through 8.

Using the LEEMAX line and available landownership data, GIS tools were then utilized to determine the number of parcels that intersected the LEEMAX Line. This was done in order to evaluate the impact of implementing a management strategy that would prohibit development within the LEEMAX. Any parcel within the CoRR database which intersected or is found to be completely within the LEEMAX Line was identified. The parcel data was then divided into two categories: parcel area inside and parcel area outside the LEEMAX Line.

The purpose of this excise was to determine the acreage of land not currently in SSCAFCA's ownership that falls within the LEEMAX line limits. The results of the analysis are presented in Section VI.A.

C. Equilibrium Slope Analysis

Urbanization in the Barranca watershed has increased the peak flows and runoff volumes and decreased the sediment supply to the arroyo compared to the essentially undeveloped conditions that existed even a few decades ago. The arroyo is responding to these changes by incising and widening in a manner that is consistent with the Incised Channel Evolution Model (ICEM) (Schumm, et al, 1984; MEI, 2009; Mussetter and Harvey, 2005). Future development will continue to increase runoff and decrease the sediment supply, further exacerbating the incision and widening tendency. The equilibrium slope concept applies to the conditions to which a channel will tend over a long period of time.

The LEE Line analysis discussed previously relied on estimates of the amount of additional widening and changes in arroyo planform that are likely to occur over the long-term under the existing, ultimate and DEVEX conditions. In addition to providing an appropriate lateral erosion buffer and/or suitable erosion protection, it will also be necessary to provide vertical controls to prevent excessive incision that can affect infrastructure adjacent to, or buried beneath the arroyo (such as the proposed sanitary sewer line between Highway 528 and Idalia Road). Therefore an equilibrium slope analysis was performed in accordance with the SED Guide to assess the potential magnitude of the degradation under both existing and DEVEX (worst case) conditions, and the results were then used to estimate the number and spacing of grade controls that will eventually be required. The analysis is described below, and the results are presented in Section VI.B.

The equilibrium slope for existing hydrology conditions was estimated based on the existing conditions hydrology presented in the 2006 BAWMP and the reduction in sediment supply associated with

the distribution of land treatment types in the hydrology model input files. This methodology requires an estimation of the dominant discharge for the arroyo. Dominant discharge for perennial arroyos can be estimated as the peak discharge of the storm event that would deliver the average annual sediment load. For arroyos in SSCAFCA's jurisdiction, based on Equation 3.46 of the SED Guide ($Q_D=0.2Q_{100}$), the dominant discharge under existing conditions varies from ~113 cfs at Progress Road to ~587 cfs at Highway 528 (Figure 10), and the dominant width varies from ~35 feet at Progress Road to ~68 feet at Highway 528 (Figure 11).

Figure 10 - Estimated dominant discharge under Existing and DEVEX conditions.

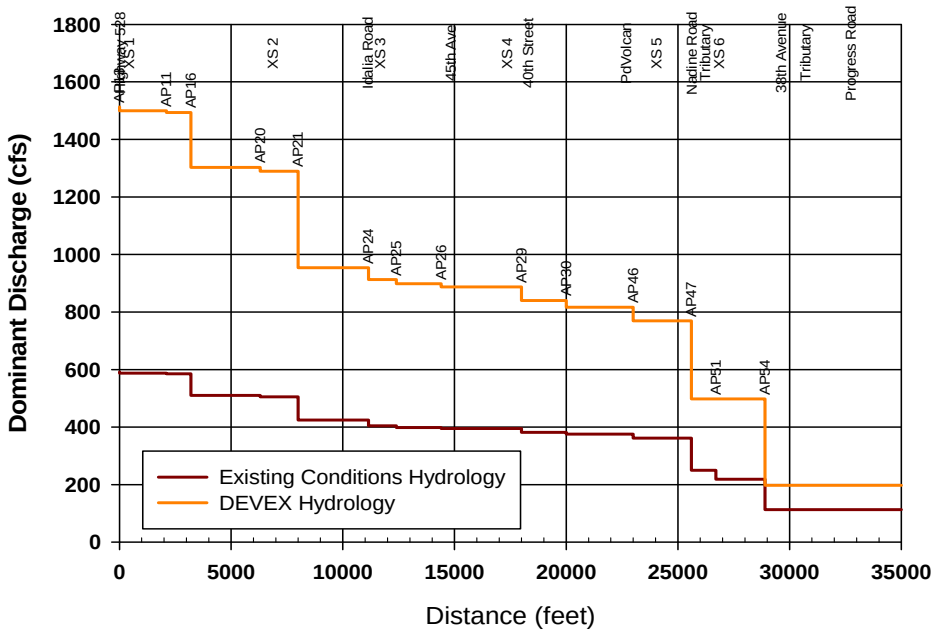
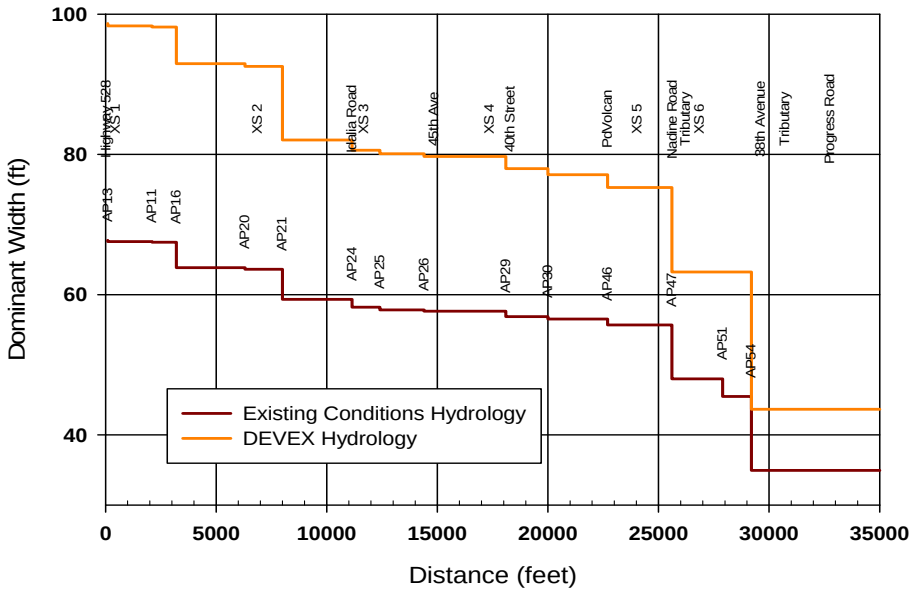
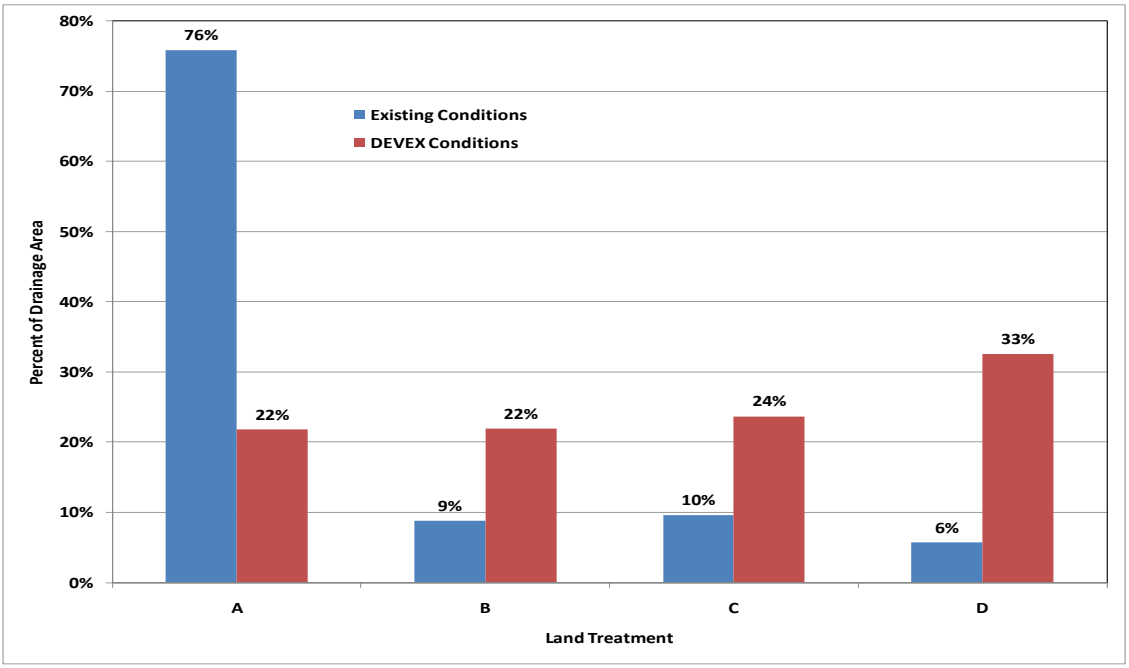


Figure 11 - Estimated dominant channel width under Existing and DEVEX conditions.



Based on the hydrology model input files, the overall Barranca watershed upstream from Highway 528 has the following distribution of Land Treatment Types: A - 76%, B – 9%, C – 10% and D – 6% (Figure 12). As described in Section 2 of the DPM 22, areas in Land Treatment Type A have soils that are uncompacted by human activities, with minimal disturbance to grading, ground cover and infiltration capacity. These areas are in a relatively undisturbed state, and the sediment supply is consistent with undeveloped conditions. Areas in Land Treatment Type B include irrigated lawns, parks, etc. with significant vegetative cover. While they may be subject to minor amounts of erosion, the sediment supply from these areas is relatively minor. Areas in Land Treatment Type C have soils that are compacted by human activity, such as unpaved parking lots, roads, and trails with minimal vegetation. These areas are typically erosion-resistant, but they can deliver substantial amounts of sediment to the arroyos during intense runoff events. Finally, Land Treatment Type D consists of the impervious areas such as pavement and roofs that do not contribute to the watershed sediment supply to the arroyos.

Figure 12 - Relative area of land treatment types in the Barranca Watershed under Existing and DEVEX conditions.



Based on Dr. Bob Mussetter's broad experience with the sediment yields throughout the Albuquerque / Rio Rancho area, these land treatment types have the following relative weightings with respect to the sediment yield that would occur under completely undeveloped conditions: A – 1.0, B – 0.2, C – 0.5, and D – 0. Based on these weightings, the area-weighted, sediment yield factor under existing conditions relative to fully undeveloped conditions is about 0.85 at Progress Road and decreases to about 0.82 at Highway 528 (Figure 13). Using Equation 3.30 from the SED Guide and assuming that the median (D_{50}) bed material size will increase to 0.7 mm due to winnowing of the fines (as shown on Figure 14) the estimated equilibrium slope is:

- approximately 80 percent (0.014 ft/ft) of the existing slope at Progress Road (0.0175 ft/ft),
- approximately 90 percent (0.014 ft/ft) of the existing slope in the reach downstream from 45th Avenue (0.016 ft/ft), and
- approximately 60 percent (0.009 ft/ft) of the existing slope at Highway 528 (0.0165).

Using this information, a determination was made of the average spacing of grade control structures that would be required to accommodate this anticipated future channel degradation (based on existing conditions hydrology). The results of the analysis are described in Section VI.B.

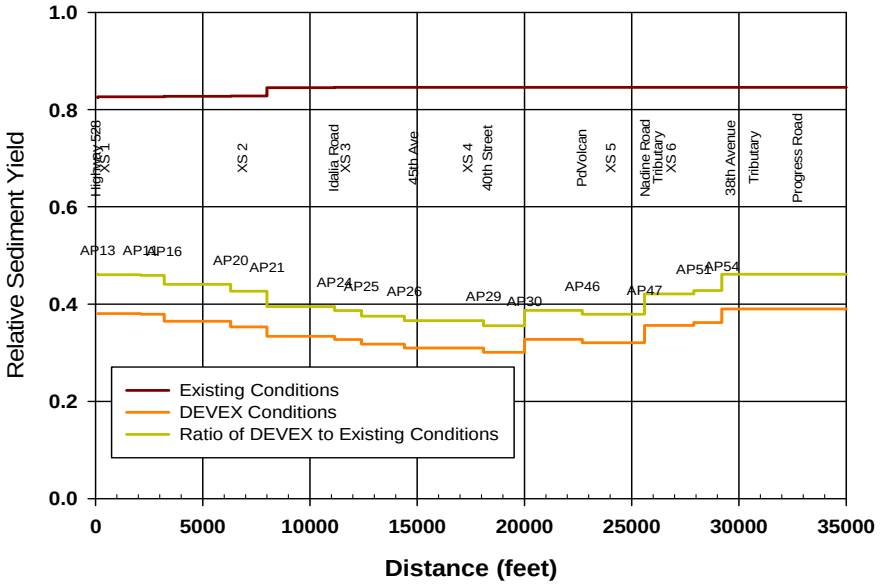
In addition, an analysis was performed to determine the equilibrium slope under DEVEX conditions using the procedures discussed above. Under DEVEX conditions, the dominant discharge varies from ~197 cfs at Progress Road to ~1,500 cfs at Highway 528 and the dominant channel width will range from ~44 feet to ~99 feet at these two locations (Figure 10 and Figure 11). Based on the DEVEX AHYMO input

files, about 22 percent of the watershed will be in Land Treatment Type A, 22 percent will be in Land Treatment Type B, 24 percent will be in Land Treatment Type C and about 33 percent of the watershed will be in Land Treatment Type D (Figure 12). The area-weighted, relative sediment yield under these conditions vary from ~0.39 at Progress Road to a minimum value of ~0.31 upstream from 40th Avenue, and then increases back to ~0.39 upstream from Highway 528 (Figure 13). Based on the change in sediment supply indicated by these results (as shown on Figure 14) the equilibrium slope under DEVEX conditions varies as follows:

- approximately 40 percent (0.0075 ft/ft) of the existing slope (0.0175 ft/ft) at Progress Road to
- approximately 34 percent (0.0065 ft/ft) of the existing slope in the reach between 45th Avenue and Idalia Rd. (0.019 ft/ft), and
- approximately 39 percent (0.0065 ft/ft) of the existing slope upstream from Highway 528 (0.0165).

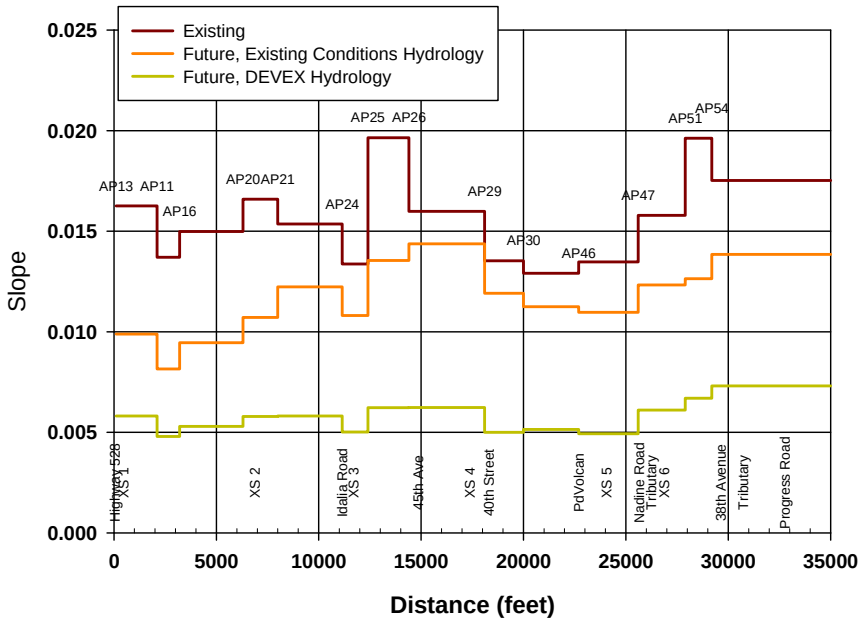
Similar to the analysis performed for the existing conditions hydrology, this information was used to estimate the average spacing of grade control structures that would be required to accommodate this anticipated future channel degradation based on the DEVEX hydrology. The results of this analysis are described in Section VI.B.

Figure 13 - Relative sediment as a percentage of completely undeveloped watershed upstream from each analysis point (AP) for Existing and DEVEX conditions.



Note: Also shown is the DEVEX sediment as a percentage of the Existing Conditions yield.

Figure 14 - Estimated equilibrium slope under Existing and DEVEX conditions.



VI. RESULTS AND CONCLUSIONS – BARRANCA WATERSHED EXAMPLE STUDY

A. LEE Line / Property Ownership Evaluation

This evaluation was performed to support the requirement of the DPM, which says that all lands within an arroyo corridor must be in SSCAFCA's control. The results of the analysis to identify land within the limits of the LEEMAX line which are not currently reserved for the arroyo are summarized on Table 4. The individual parcel information is shown geographically on Exhibit 2 through Exhibit 8.

The parcels within the LEEMAX shown on the exhibits and included on Table 4, exclude lands owned fee simple by SSCAFCA as well as lands held in easement by SSCAFCA. Within the Barranca Arroyo, SSCAFCA holds easements on parcels at the extreme upstream and downstream portions of the arroyo (as shown on Exhibit 1). These lands are outside the defined limits of the LEEMAX. In addition, any parcels identified in any of the data sets by any of the following attributes were also excluded from the results: 1) public ownership (i.e. CoRR); 2) land use code of arroyo or flood control channel; 3) legal description indicating arroyo or drainage; 4) lot description indicating arroyo or drainage; or a 5) feature description of 'drn', pond, ROW, or park.

As shown on the figures, some of the parcels with a portion of their area within the LEEMAX line are fairly large, e.g., the Paseo Gateway area. In these cases it was assumed that SSCAFCA would only acquire the portion of the parcel within the LEEMAX line. However, if given affected parcel is less than 1 acre, then for planning purposes, if any portion of the parcel is within the LEEMAX line, it is recommended that SSCAFCA acquire the entire parcel. This would allow an even greater buffer area for habitat and recreational amenities along the arroyo corridor.

Some of the parcels with at least a portion of their area within the LEEMAX line currently have some development. Preliminary analysis indicates that between NM 528 and Idalia Rd, there are 11 parcels with at least a portion of the lot within the LEE line that already have some structural improvements. Between Idalia Rd and 28th Ave (Paseo del Volcan), there are 2 such parcels. North of Paseo del Volcan none of the parcels within the LEE line contain structures.

It should be noted that this analysis was performed using a variety of data sources (e.g. ownership information from SSCAFCA, CoRR parcel information, Sandoval Co. parcel information). In some cases these data sets provide contradictory or missing information relative to the land ownership, and in most locations the data sets have minor shifts in their spatial locations. In order to rectify these inconsistencies, engineering judgment was used to make the most logical decision regarding location relative to, or ownership of lands within, the LEEMAX line. Where available, preference was given for information provided by SSCAFCA.

Table 4 – Property Ownership Evaluation Results

	# of Parcels or Area (acres)
Total number of parcels completely within leemax line	35
Total number of parcels partially within leemax line	652
Total area of parcels completely within leemax line	36.6
Total area of portions of parcels within leemax line	380.3
Total number of parcels affected	687
Total amount of land to acquire	569.5

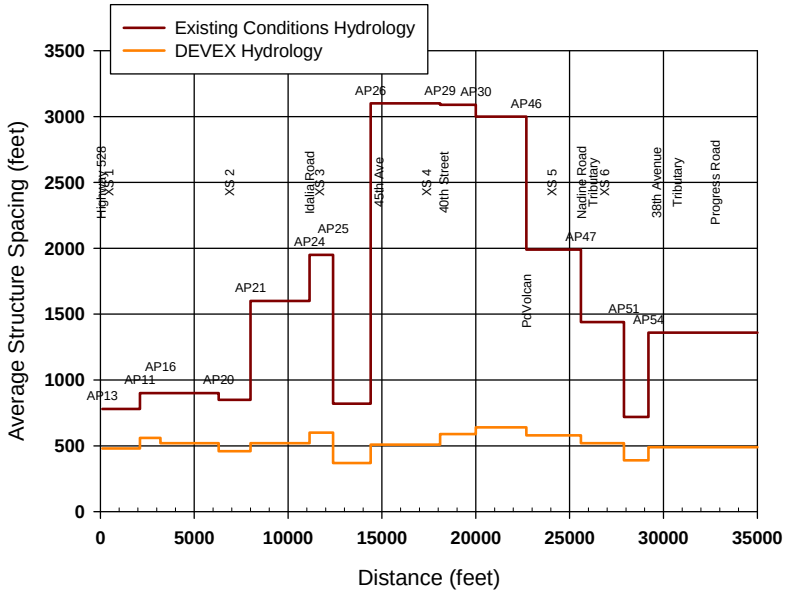
Note: Analysis only includes lands within the limits of the LEEMAX not currently reserved for the arroyo.

B. Equilibrium Slope Evaluation

Using the approach described in Section V.C, and based on the estimated equilibrium slopes for the existing conditions hydrology (between 0.009 and 0.014 ft/ft) (Figure 14), the average spacing of grade control structures for maximum drop heights at individual structures of 5 feet ranges from 610 feet just downstream from 38th Ave. to over 3,000 feet between 45th Avenue and Paseo del Volcan (Figure 15).

Given the estimated equilibrium slopes based on the DEVEX hydrology (between 0.0065 and 0.0075 ft/ft), the average spacing of grade control structures for a maximum drop height of 5 feet, is anticipated to vary from a minimum of about 320 feet (upstream from Idalia Road to 530 feet downstream from Paseo del Volcan (Figure 15)).

Figure 15 - Average spacing of grade controls at the estimated equilibrium slope for maximum drop heights of 5 feet under Existing and DEVEX conditions.



C. Costs

The main recommended actions from this Strategy Report, which require direct capital costs, are associated with the acquisition of parcels within the LEEMAX line overlay and the grade controls discussed above. As shown on Table 4, there are approximately 570 acres that would need to be acquired. While it is anticipated that these lands could be obtained using various, less expensive methods, for planning purposes the assumption included in this report is that these lands would be purchased in fee simple. Assuming an average cost of $5 / square foot of land value, the overall capital costs for this recommendation is $124 million. Table 5 below provides the anticipated capital costs for the grade control structures which totals approximately $4.5 million. It is important to note that these costs can be planned and implemented over a period of several years.

In addition, implementation of these two recommendations should be considered simultaneously because the effects of one action will likely reduce the quantity needed for the other action. For example, if a sufficient amount of land within the LEEMAX is acquired, and policies will prohibit this land from being encroached upon by development, fewer grade control structures will be needed. Similarly, if grade controls are constructed as part of on-going developments or roadway projects, the LEEMAX line will be affected in that local area. Using the technical guidelines presented in the SED Guide, the LEEMAX line would be less in this location – which could limit the acreage of lands to be acquired. This phenomenon will have to be balanced with the needs for other uses of the arroyo corridor.

Table 5 – Grade Control Structure Cost Estimate

Barranca Watershed Grade Control Structure Cost Estimate								
Reach	Begin AP	End AP	Downstream Description	Station	Dominant Width	Quantity	Cost per LF width	Estimate Amount
1	13	24	Hwy 528	1+00	66	11	$2,600	$1,890,000
2	24	46	Idalia Road	111+50	58	7	$2,600	$1,060,000
3	46	47	Paseo del Volcan	227+00	57	1	$2,600	$ 150,000
4	47	54	Nadine Rd	256+00	50	11	$2,600	$1,430,000
Total								$4,530,000

VII. RECOMMENDATIONS - BARRANCA WATERSHED EXAMPLE STUDY

The recommendations presented in this Section are limited to the isolated Barranca Watershed Example Study analysis presented in this Strategy Report. Beyond these watershed specific recommendations, the SSCAFCA Jurisdiction Wide Comprehensive Management Strategies presented in Section VIII should also be implemented for this watershed.

A. Barranca LEE Line Overlay

It is recommended that SSCAFCA officially adopt a policy regulating future development on parcels identified on Exhibit 2 through Exhibit 8 that are within or partially within the LEEMAX line. In addition, it is recommended that SSCAFCA aggressively pursue acquisition of those parcels through dedication, donation, or outright purchase. From a practical standpoint, if a parcel size is less than 1 acre, but only a portion of the lot is within the LEEMAX line, it is recommended that the entire lot be acquired. Conversely, if a portion of a large lot is within the LEE line, it is recommended that actions be undertaken to divide the parcel into areas within and area outside the LEE line, and acquisition target only the area within the LEE line. Priority should be given to the area between Paseo del Volcan and 40th St., based on the fact that at this time there are no parcels defined for the arroyo corridor in this section of the arroyo.

If this recommendation is to be implemented, a review of the potential legal ramifications should be investigated in order to limit SSCAFCA's potential liability.

B. Engineering Controls

The primary recommended engineering control for the Barranca is the implementation of grade control structures. At first thought, construction of grade control structures may seem counter-intuitive to maintaining a naturalistic arroyo. However, as development continues in the watershed, without some form

of horizontal and vertical control, the arroyo will continue to evolve into an even more incised channel and threaten existing and future structures.

The equilibrium slope / grade control spacing analysis presented in Sections V.C and VI.B, discuss anticipated future spacing based on both the existing conditions hydrology and the DEVEX hydrology. Since it is recommended that the analysis is periodically updated, preliminary recommendations have been prepared for locating grade control structures based on the existing conditions hydrology. The locations of the structures recommended are shown on Exhibit 1. As the flows increase due to future development the analysis can be updated and the spacing revisited.

The spacing of the grade control was approximated based on the information provided in Section VI.B which assumes a 5' maximum drop, as well as currently established vertical controls locations (NM 528, Idalia Road, and Paseo del Volcan). It should be noted that the recommendation for grade control does not require all structures to be in place simultaneously. They can be planned over a long-term project implementation time-frame.

SSCAFCA JURISDICTION WIDE COMPREHENSIVE MANAGEMENT STRATEGY

VIII. ARROYO CORRIDOR GOALS AND COMPREHENSIVE MANAGEMENT STRATEGY

This section presents a set of goals desired to be achieved by this Comprehensive Management Strategy for Arroyo Corridors.

A. SSCAFCA Vision and Mission

The goals were derived from SSCAFCA's approved vision and mission statements as follows:

- SSCAFCA Vision - Flood Control Today - for a Safe Tomorrow
- SSCAFCA Mission - Protect citizens and property by implementing proven flood control solutions that:
    - Manage our watersheds prudently for future generations,
    - Enhance the quality of life,
    - Create the most appealing multi-use facilities,
    - Set an example of quality, integrity, leadership, and professionalism,
    - Educate the public concerning flood hazards, and
    - Administer public funds prudently.

B. Goals to Be Achieved

The following are the goals to be achieved by this Strategy Report.

1. Establish Naturalistic Floodplain for Public Safety and protection of privately held property,
2. Establish Erosion Setback Limits for Public Safety and protection of privately held property, including:
    - Establish playa policy for public safety,
    - Establish LEE line policy for public safety,
3. Protect Flora, Fauna, and Their Associated Habitat to enhance the quality of life now and for future generations,
4. Protect and Enhance Quality of Life / Cultural Amenities, now and for future generations, including:
    - Preserve archeological / cultural resource sites,
    - Promote recreation / trails / connectivity,
    - Create bosque reserve,
    - Promote educational enhancements to educate the public regarding flood hazards,
    - Provide pet owner amenities to enhance quality of life,

- Promote integration of artistic features to create the most appealing multi-use features,

5. Preserve Arroyos in Naturalistic State for future generations,
6. Create a Natural Arroyo Corridor / Upland Preserve for future generations,
7. Maintenance and Improvement of Water Quality recognizing the value of drinking water and storm water run-off's connection to it, including:
    - Surface water
    - Ground water
    - Ground water recharge areas
8. Construction of Sustainable Facilities Through Prudent Administration of Public Funds.

The goals listed above, and the means to achieve these goals, will comply with all local, state, regional, and federal regulations to set an example of quality, integrity, leadership and professionalism.

In order to achieve the goals listed above, the project team identified and evaluated several different alternatives as shown on Table 6. For discussion purposes, these alternatives have been divided into the classes listed below:

1. Public Education and Outreach;
2. Right-of-Way / Easement Acquisition;
3. Regulatory / Zoning / Policy Options;
4. Floodplain Mapping; and
5. Engineering Solutions.

A discussion of each alternative strategy is provided in the following section.

Table 6
Comprehensive Management Strategy for Arroyo Corridors

Arroyo Corridor Goals - To Be Achieved	Arroyo Corridor Preservation Strategies - How to Achieve Goals (Alternatives)			
	1. Note: Public Education and Outreach is a Component of All Strategies			
	2. ROW / Easement Acquisition	3. Regulatory / Zoning / Policy Decisions	4. Floodplain Mapping	5. Engineering Solutions
1. Establish Naturalistic Floodplain for Public Safety	ROW	FEMA	FEMA	
2. Establish Erosion Setback Limits for Public Safety				
Establish LEE Line Policy for Public Safety	X	SSCAFCA Policy	X	X
Establish Playa Policy for Public Safety	X	CoRR / SSCAFCA Policy		
3. Protect Flora, Fauna, and Their Associated Habitat	ROW	X		X
4. Protect and Enhance Quality of Life / Cultural Amenities				
Preserve Archeological / Cultural Resource Sites	X	USACE / SHPO		X
Promote Recreation / Trails / Connectivity (no vehicles)	X		X	X
Create Bosque Reserve	X	X	X	
Promote Educational Enhancements		X		X
Provide Pet Owner Amenities	X	X		X
Promote Artistic Features for Multi-Use Facilities	X	X		X
5. Preserve Arroyos in Naturalistic State	X	X	X	X
6. Creation of a Natural Arroyo Corridor / Upland Preserve	ROW	X	X	
7. Maintenance and Improvement of Water Quality				
Surface Water / Water Harvesting	X	X	X	X
Ground Water	X	X		X
Ground Water Recharge Areas	X	X	X	X
8. Construction of Sustainable Facilities Through Prudent Administration of Public Funds	X	X	X	X

X - indicates multiple approaches and jurisdictions

C. Discussion of Alternative Strategies

1. Public Education and Outreach

Educating the public needs to be a vital component of creating a naturalistic arroyo corridor. A successful education campaign can influence everything from voters who exercise control over bond sales, which ultimately finance SSCAFCA projects; to future generations who may learn the value of naturalistic arroyos and make daily decisions to avoid degradation of the water quality within a watershed. In fact, public education and outreach should be a part of any and all management alternatives. The effect of this alternative could impact the success of the Comprehensive Management Strategy at several levels.

A specific example of this alternative includes public service announcements promoting the good work that has been completed using funding from past bond cycles. Another example is educating the public by providing "interpretive" plaques along the arroyo corridors to increase the public awareness of drainage facilities, arroyo geomorphology, riparian areas, flora, fauna, and environmental affects. Through these efforts the true value of open space arroyo corridors can be realized. This will ultimately lead to support for the various management alternatives listed below.

2. ROW / Easement Acquisition

The existing platting created in the 1960's throughout most of SSCAFCA's jurisdiction has made it much more difficult to control how development proceeds. This platting creates two impediments to achieving the arroyo corridor goals stated above:

- diverse ownership of numerous individual lots; and
- the lack of lands dedicated for drainage / arroyo corridors

Numerous individual lot owners are allowed to develop these properties since the existing platting is "grandfathered" in. Over the past few decades, this less than ideal situation, has led to construction of a water supply well and sewer leach field on individual small lots. This can lead to negative impacts on flora and fauna, existing archeological sites, water quality degradation, and reduced ground water recharge.

The lack of dedicated lands for drainage, along with landowner's lack of knowledge of the potential damage from flooding and arroyo evolution, can potentially damage existing structures. This ultimately becomes a public safety concern.

An alternative that can be used to offset these effects is the acquisition of land within the arroyo corridors through either right-of-way or easements. The active pursuit of these lots within or next to the arroyo would allow protection of development in these areas to help preserve arroyo corridors. Public ownership through fee simple ROW acquisition is preferred when more public safety is desired.

3. Regulatory / Zoning / Policy Decisions

The use of government regulations through the enactment of zoning ordinances or adoption of policies is another alternative for achieving the stated goals. These can work toward arroyo preservation by a diverse approach. For example regulations may be adopted that attempt to minimize the erosive impact of continued development within naturalistic arroyo corridors; minimize the impact of development on water quality or flora and fauna; or seek to ensure adequate land area is reserved for flood control, which will help preserve arroyo corridors in their naturalistic state.

4. Floodplain Mapping

Another alternative that can be used to accomplish some of the goals of the Comprehensive Management Strategy is to utilize the protections provided by Special Flood Hazard Areas (SFHA), which are mapped by the National Flood Insurance Program administered by FEMA. These areas provide protection for developments that can occur within their boundaries. It should be noted that FEMA legally has jurisdiction not only on existing mapped floodplains, but can also manages lands outside of mapped floodplains, if erosion concerns are probable. This fact makes the use of this alternative more advantageous.

For many relatively undeveloped areas, such as exist in much of SSCAFCA's jurisdiction, FEMA studies document SFHA's using approximate methods. While this does place some limitations on the level of development that can occur, a more detailed Flood Insurance Study (FIS), which provides Base Flood Elevations (BFE's) for a given arroyo, would provide even more protection of development. This alternative has a greater benefit for arroyo corridor preservation and should be pursued for all arroyos.

5. Engineering Solutions

The engineering solutions alternatives presented here are intended to preserve the character of the arroyo (sandy bed, vertical banks, sinusoidal lateral patterns, etc.) and existing habitat; and therefore do not include concrete trapezoidal channel type solutions. In essence, all the tools described below provide non-contiguous engineered structures intended to control the arroyo at fixed points. Controlling the arroyo at fixed points has several advantages when trying to maintain or create a naturalistic arroyo:

- Construction of fixed point controls can be programmed out over several years,
- The location of structures can be modified based on field review of the arroyo movement over time and increased understanding of the geomorphology,
- Fixed point controls have proven to reduce the ability of the arroyo to migrate laterally within the corridor.

a) Bank Protection

In a naturalistic arroyo, bank protection can be applied where continued arroyo lateral migration cannot be allowed due to a fixed control such as an adjacent roadway, major utility, existing structure or the height of the bank is such that it is highly unstable and could pose a risk to property or life.

Bank protection can be done by itself in isolated situations but is often more successful when constructed in combination with bed protection, to help control further down cutting at the base of the vertical bank.

A variety of materials can be used for bank protection including: colored shotcrete, wire-tied riprap, colored concrete, or gabions. Soil cement or cement treated base are also alternatives but usually need to be of sufficient size to justify the expense of setting up a processing mill on-site, as there are no local sources of such materials at the existing concrete plants. All of these solutions can be modified to minimize the intrusion on the naturalistic features of the arroyo, while still maintaining the function.

In addition to utilizing bank protection for ensuring the integrity of existing infrastructure, bank protection measures can also be applied to protect known habitat. This is true even if the bank itself is providing the habitat, e.g. a vertical bank used by burrowing owls or bank swallows. In this case, the implemented bank protection measures must be very carefully designed. This is especially critical where species actually require a sloughing bank for their habitat.

b) Bed Protection

Bed protection, when not done with a contiguous channel, has normally limited application. Within naturalistic arroyos it is typically limited to discrete reaches where existing constraints prevent further bed lowering. In these situations, bank protection is also required in order to prevent the migration of the arroyo away from the bed protection. Typical materials for construction are similar to the materials described under Bank Protection.

c) Grade Control Structures

Grade control structures have proven to be one of the more successful means of controlling naturalistic arroyos. With a grade control structure, the arroyo is confined both vertically and horizontally at a fixed location. Existing roadway crossings are good examples of grade control. Within SSCAFCA's jurisdiction, there are numerous roadway crossings over arroyos using circular or box culverts or bridges.

These crossings, like other grade control structures, are effective in that they induce a flatter slope between structures. Properly designed and located, these structures will have the effect of moving the arroyo slope toward the equilibrium slope. Therefore, these structures not only reduce the energy of the runoff, but the energy can also be isolated at the grade control structure and can then be better managed and controlled.

Grade control structures need to be designed with great care in order to prevent the arroyo from either circumventing the drop structure by lateral bank migration or by insufficient downstream control whereby runoff can expose the downstream toe protection and undermine the structure. Typical materials are similar to the materials described under Bank Protection.

d) Detention Facilities

Higher flows resulting from increased development produce larger shear stresses on the existing arroyos. These higher flows may then require hard lined channels to prevent the potential damaging effects of large flood events. Detention facilities (dam and ponds) provide a great way to reduce the peak flow in the arroyo, thereby minimizing the need for hard lined channels to control the effects of higher magnitude flows.

However, detention facilities have consequences that also require mitigation downstream of the facility. The runoff from a detention facility, although reduced in peak flow, provides discharge for a much longer period of time than would naturally occur. In addition, this outflow is devoid of sediment that is captured upstream of the facility and, therefore, more prone to erode the downstream arroyo in order to maintain the sediment balance.

Several regional detention facilities have been proposed in the Watershed Management Plans for various arroyos within SSCAFCA's jurisdiction. Some of these are proposed to release flows that are well below the historic discharge for the arroyo segment downstream of the facility. If these facilities are implemented, the effects of this approach should be closely monitored to evaluate the impact on preserving the arroyo corridor in a naturalistic setting.

D. Examples of Strategy Implementation

1. Establish Naturalistic Floodplain for Public Safety

Several alternatives can be implemented to help achieve this goal. The most protective may be the outright purchase of ROW to be preserved as a naturalistic arroyo corridor. As stated

elsewhere in this report, and as shown on Table 6, purchase of ROW may simultaneously help achieve several goals. However, protection of floodplains for public safety is paramount.

2. Establishment of Erosion Setback Limits for Public Safety

a) LEE line Policy

One of the most promising alternatives for establishing erosion setback limits is within the regulatory / zoning / policy category, as shown on Table 6. With this idea, regulation of development within or adjacent to the LEE line would be possible. Owners of lots adjacent to the LEE line should be encouraged to dedicate lands currently within the LEE line for arroyo corridor purposes. Dedication of these lands (as well as additional areas required for the anticipated bank sloughing / angle of repose of the bank soils) can help achieve all of the stated goals. This would require that SSCAFCA develop and pursue polices to provide incentives which encourage implementation of this alternative.

b) Playa Policy

The creation and implementation of a playa policy is another example of how regulatory / zoning / policy decisions can help establish erosion setback limits for public safety. A joint CoRR / SSCAFCA policy should be prepared and used to regulate development in these sensitive areas to help prevent or mitigate flooding and erosion problems.

3. Protection of Flora and Fauna and Associated Habitat

An alternative to help maintain naturalistic arroyos within SSCAFCA's jurisdiction to protect flora, fauna and their habitat is to develop habitat overlays (which include foraging areas, where possible). As shown on Table 6, there are several alternatives that could be implemented to help achieve this goal. Habitat overlays fall into the regulatory / zoning / policy decision category. Once these overlays are developed, SSCAFCA could implement a policy that manages the impacts of development on the lands within these overlay areas. These overlays would be derived in consultation with local experts to define geographic areas that may contain suitable habitat for specific species of concern (both wildlife and vegetation).

Preliminary discussions have noted that both bank swallow and burrowing owl habitat is contained within portions of the Barranca watershed and likely in other watersheds within SSCAFCA's jurisdiction as well. Bank swallows in the area may require habitat up to a maximum distance of approximately 7 miles to foraging areas (e.g., along the Rio Grande riparian corridor). Typically north facing banks are better for bank swallow habitat. Burrowing owls establish foraging

areas in upland regions adjacent to their burrows. This overlay approach is consistent with recommendations provided by the USACE for "preserving existing habitat to the extent possible".

The USACE has noted that the New Mexico Department of Game and Fish have published criteria for creating artificial habitat for the burrowing owl, and that the NM Avian Conservation Partners note that artificial nesting banks may be utilized by bank swallows. Therefore, in agreement with the USACE, this alternative would require that SSCAFCA researches the potential effectiveness of artificial habitat for both species in the event habitat loss is unavoidable. If the creation of artificial habitat is proven to be successful, different levels of habitat overlays should be derived. For example, a strict 'no development' overlay may be reserved for the highest quality habitat, while other, less restrictive overlay zones, for areas of lesser quality habitat can be implemented. These less restrictive overlay areas may allow certain types of development, provided that the project facilitates the creation of suitable artificial habitat.

4. Protect and Enhance Quality of Life / Cultural Amenities

SSCAFCA should collaborate with the CoRR Parks and Recreation Department to promote the enhanced use of arroyo corridors within their jurisdiction. The steps to accomplish this include:

- Hold coordination meetings with CoRR Parks and Recreation to identify priority watersheds.
- Identify potential recreational enhancement features for each priority area.
- Pursue acquisition of property that can have a multi-use aspect for both drainage and recreational features.
- Pursue acquisition of property adjacent to road crossings:
    - Since the LEE lines constrict at roadway crossings, additional areas outside of the LEEMAX should be acquired in these locations for use as trailheads.
    - Priorities should be for areas currently under the most development pressure.
    - For the Barranca Arroyo this includes near NM528, Paseo del Volcan, and Idalia road in that order.

The steps presented above will help preserve archeological and cultural resource sites; promote recreation; create a bosque reserve, promote educational enhancements, provide pet owner amenities, and promote artistic features for multi-use facilities. As shown on Table 6, the steps listed above span the range of alternative categories.

5. Preservation of Arroyos in a Naturalistic State

Preservation of arroyos in a naturalistic state can be pursued through the use of the following five alternatives shown on Table 6:

- Public education and outreach,
- ROW / easement acquisition,
- Regulatory, zoning, policy decisions,
- Floodplain mapping, and
- Engineering solutions.

6. Creation of a Natural Arroyo Corridor / Upland Preserve

It has been stated that once all the available private lands are developed, the only areas of remaining open space in SSCAFCA's jurisdiction will be CoRR parks and SSCAFCA arroyo corridors. Along those lines, in order to preserve a large area to represent the current natural state of the upper portions of watersheds, SSCAFCA should identify and protect a 'Preserve' in the upper portion of a watershed. This area could be used for future education efforts, to demonstrate how true natural watersheds function, while simultaneously achieving several of the other goals listed on Table 6. This can be accomplished using all of the alternatives listed.

7. Maintenance and Improvement of Water Quality

c) Surface Water / Water Harvesting

Federal regulations of storm water contaminants are becoming more restrictive and exposure to potential for violations makes it imperative for SSCAFCA to adopt policies to improve water quality in the watershed. In addition to arroyo-level water quality improvement techniques (such as small ponds), more source controls could be implemented such as water quality manholes, pet waste clean-up stations at parks, and water quality inlets for storm drain systems.

Additionally, education can play a vital part in increasing the awareness of trash and other contaminants that can reach our arroyos and, more importantly, the Rio Grande. Educational efforts at the school level and through public service announcements (PSA's) have proven particularly effective in raising the awareness of our environment and it is recommended that SSCAFCA continue their involvement with these approaches.

It is recognized that cost of master planned storm water facilities, such as large regional dams, are becoming more expensive to construct due to a variety of reasons such as: more restrictive governmental legislation, difficulty of finding available land, rising costs of operations and maintenance and the preference to apply natural land

form techniques so the dam looks less like an engineered structure. Therefore, determining ways of mitigating the affects of runoff from impervious surfaces is vital in helping to control the need for and cost of downstream master planned facilities. If the need for these facilities can be reduced, additional monies can be made available for other initiatives that can promote preservation of arroyo corridors.

One way to help mitigate the effects of the increase in impervious surfaces from development, is to control the amount (both volume and rate) of water that is allowed to leave a development site. The tools to accomplish this are referred to as 'water harvesting', 'source control' or Low Impact Development (LID) and may include the following:

- Require all new development to install rain collection systems to store all of the water that falls on roofs, which can then be reused on the developed site to water the drought tolerant plants which could be required as part of the site landscaping.
- Alternately require all developments to store all the water on site by means of a depressed landscaped area. These areas can either be required to retain all water or detain and discharge using a controlled outlet.

Both options would require that SSCAFCA officially adopt and enforce policies requiring the infrastructure described above. These policies would need to be written to avoid ambiguity and be prescriptive in their requirements for sizes of drainage infrastructure installed. Since implementation of these types of policies is fairly new, and it would likely require a case study to be performed to document the effects of such policies.

One known requirement of this option would be the creation of an on-going enforcement program to ensure all new developments are in compliance with the policies, and in addition, that all on-site drainage infrastructure is functioning and maintained.

d) Ground Water

Since ground water impacts can be difficult to remedy, prevention of ground water pollution is of primary importance. Therefore public education is key to achieving this goal. Other alternatives can also be used such as engineering solutions to promote ground water recharge as described below.

e) Ground Water Recharge Areas

Areas that are most beneficial to promoting ground water recharge can be identified and these areas should be targeted for protection. This can be achieved through the use of all of the alternatives presented in Table 6.

8. Construction of Sustainable Facilities

It is recognized that preservation of some arroyo corridors in a naturalistic state will likely require some structural modifications. These modifications should be designed and constructed with as minimal impact on the surrounding areas as possible. In all cases these designs should incorporate sustainable attributes to assure the prudent use of public funds, while working to simultaneously achieve additional goals listed on Table 6.

E. Operations and Maintenance of Recommended Actions

As with all public agencies, Operation and Maintenance (O&M) of existing facilities is an on-going challenge for SSCAFCA. It is recommended that any new infrastructure resulting from this Strategy Report incorporate an O&M Plan for future care of the facility. SSCAFCA should pursue operation agreements with other agencies for facilities that are jointly developed and implemented to reduce their financial burden for future O&M. Furthermore, and most importantly, SSCAFCA should appropriate funds for O&M during future budgeting cycles.

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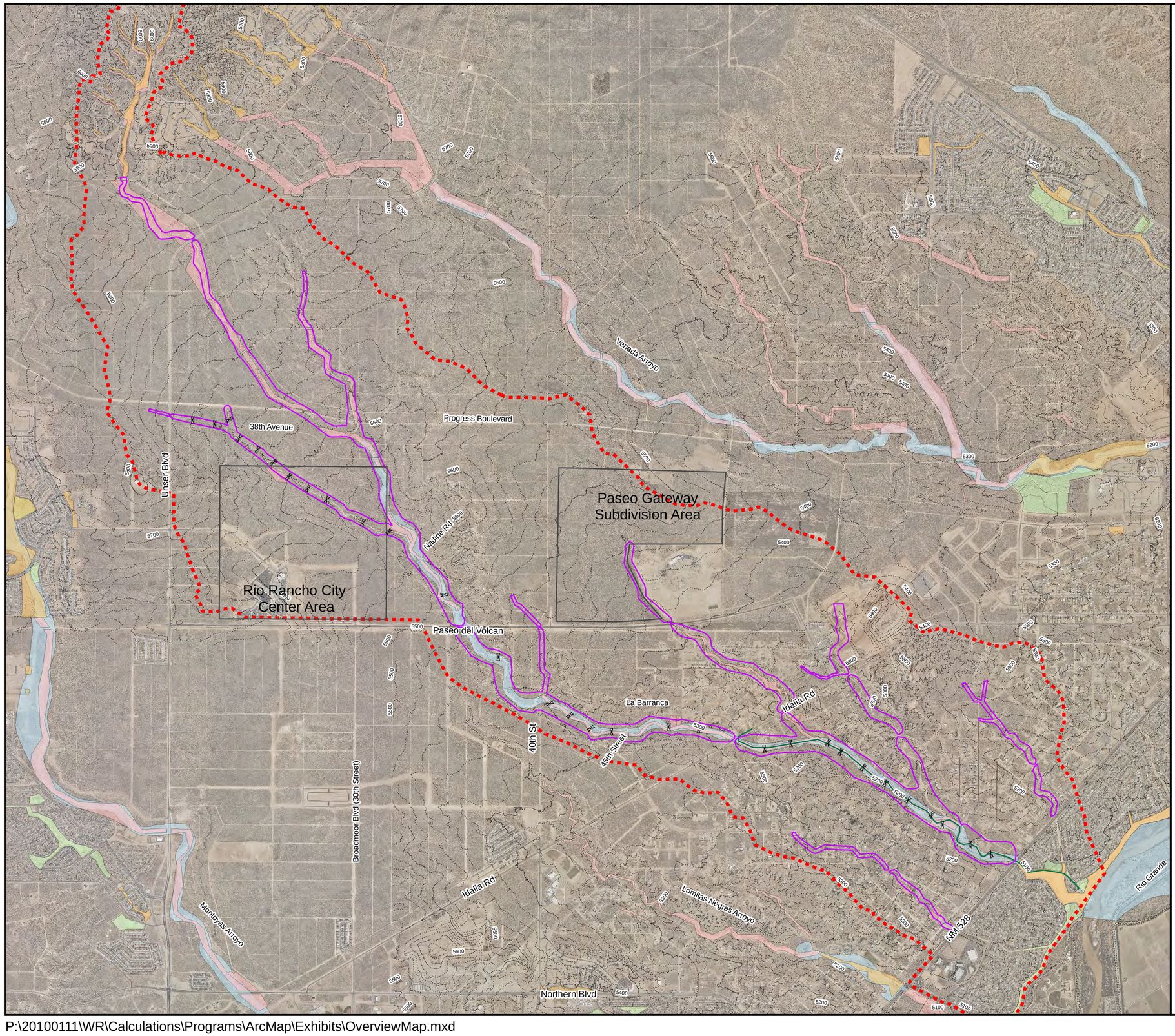
EXHIBIT 1

BARRANCA WATERSHED OVERVIEW



Legend

- Proposed 5 ft Grade Control Structure
- Barranca Watershed Boundary
- LEEMAX Lee Line
- Proposed Sewer Line
- SSCAFCA Easements
- SSCAFCA Fee Simple Land
- Parks and Trails
- SPECIAL FLOOD HAZARD AREA ZONE A
- 20 ft Contours

SOUTHERN SANDOVAL COUNTY ARROYO FLOOD CONTROL AUTHORITY

Bohannan Huston Inc.

Courtyard I 7500 Jefferson St. NE Albuquerque, NM 87109-4335

ENGINEERING • SPATIAL DATA • ADVANCED TECHNOLOGIES

EXHIBIT 1
LA BARRANCA WATERSHED OVERVIEW MAP

0 1,500 3,000 6,000 Feet

1 inch = 1,500 feet

N

THE IMAGE ON THIS MAP WAS PRODUCED BY MRCOG IN 2008

THE CONTOURS ON THIS MAP ARE FROM A 4 FT SURFACE PRODUCED IN 2003 BY SANDOVAL COUNTY

NOVEMBER 2010

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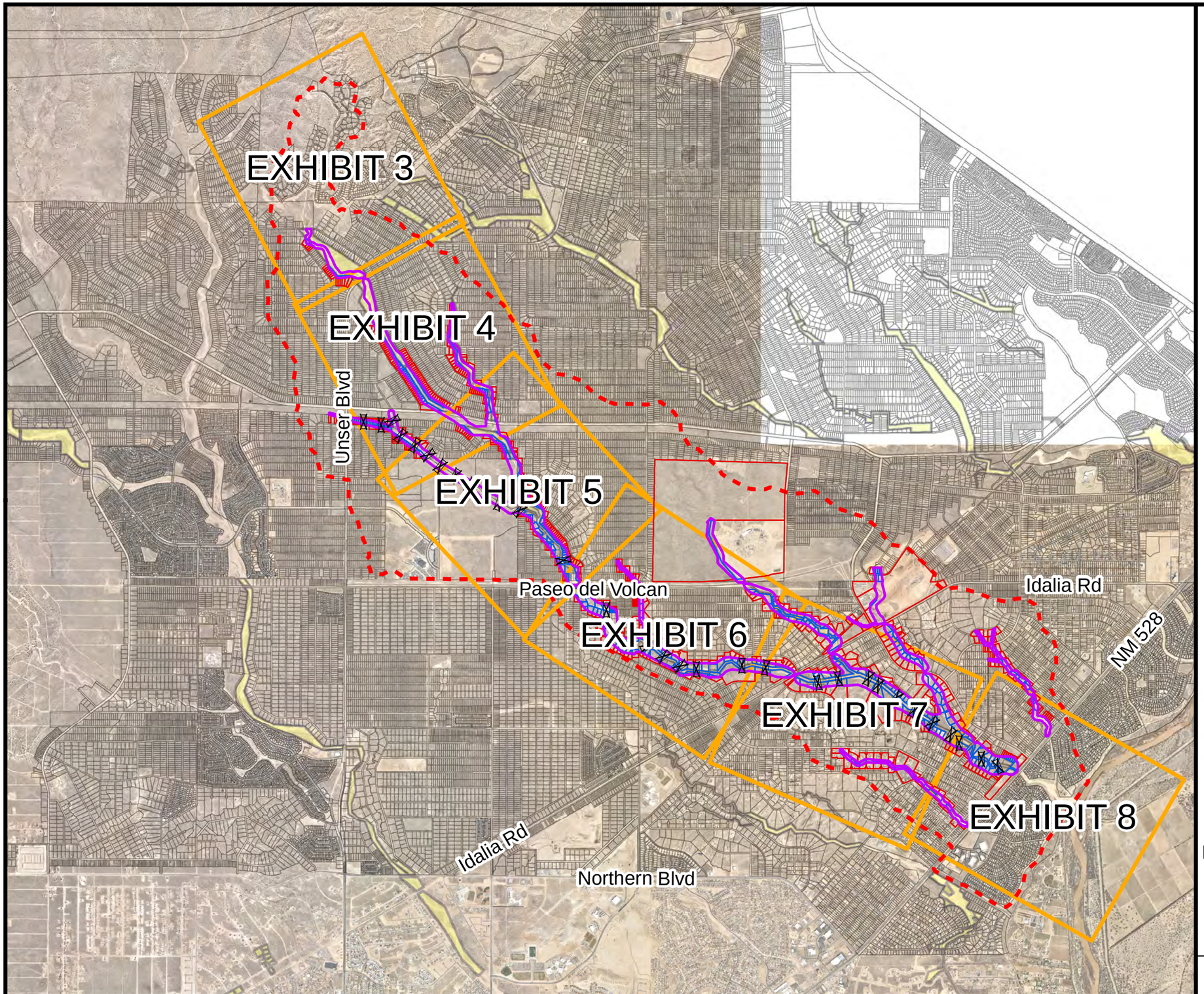
EXHIBIT 2

PROPERTY OWNERSHIP EVALUATION KEY MAP



Legend

- GRADE CONTROL STRUCTURE
- LEEMAX
- BARRANCA WATERSHED BOUNDARY
- 1 in to 750 Ft Grid
- SSCAFCA FEE SIMPLE LAND
- SSCAFCA Easements
- PARCELS

PARCELS AFFECTED BY LEEMAX LINE

- PORTION OF PARCEL INSIDE LEEMAX LINE
- PORTION OF PARCEL OUTSIDE LEEMAX LINE

SOUTHERN SANDOVAL COUNTY ARROYO FLOOD CONTROL AUTHORITY

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EXHIBIT 2

LA BARRANCA WATERSHED
PROPERTY OWNERSHIP EVALUATION
KEY MAP

N

0 2,000 4,000 8,000
Feet

1 inch = 4,000 feet

NOVEMBER 2010

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EXHIBITS 3 THRU 8

PROPERTY OWNERSHIP EVALUATION MAPS

Unser Blvd

Legend

- GRADE CONTROL STRUCTURE
- LEEMAX
- BARRANCA WATERSHED BOUNDARY
- SSCAFCA EASEMENTS
- SSCAFCA FEE SIMPLE LAND
- PARCELS

PARCELS AFFECTED BY LEEMAX LINE

- PORTION OF PARCEL INSIDE LEEMAX LINE
- PORTION OF PARCEL OUTSIDE LEEMAX LINE

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EXHIBIT 3

LA BARRANCA WATERSHED
PROPERTY OWNERSHIP EVALUATION

0 375 750 1,500 Feet

1 inch = 750 feet

NOVEMBER 2010

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Unser Blvd

Progress Blvd

Legend

- GRADE CONTROL STRUCTURE
- LEEMAX
- BARRANCA WATERSHED BOUNDARY
- SSCAFCA EASEMENTS
- SSCAFCA FEE SIMPLE LAND
- PARCELS

PARCELS AFFECTED BY LEEMAX LINE

- PORTION OF PARCEL INSIDE LEEMAX LINE
- PORTION OF PARCEL OUTSIDE LEEMAX LINE

SOUTHERN SANDOVAL COUNTY ARROYO FLOOD CONTROL AUTHORITY

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EXHIBIT 4

LA BARRANCA WATERSHED
PROPERTY OWNERSHIP EVALUATION

0 375 750 1,500 Feet

1 inch = 750 feet

N

NOVEMBER 2010

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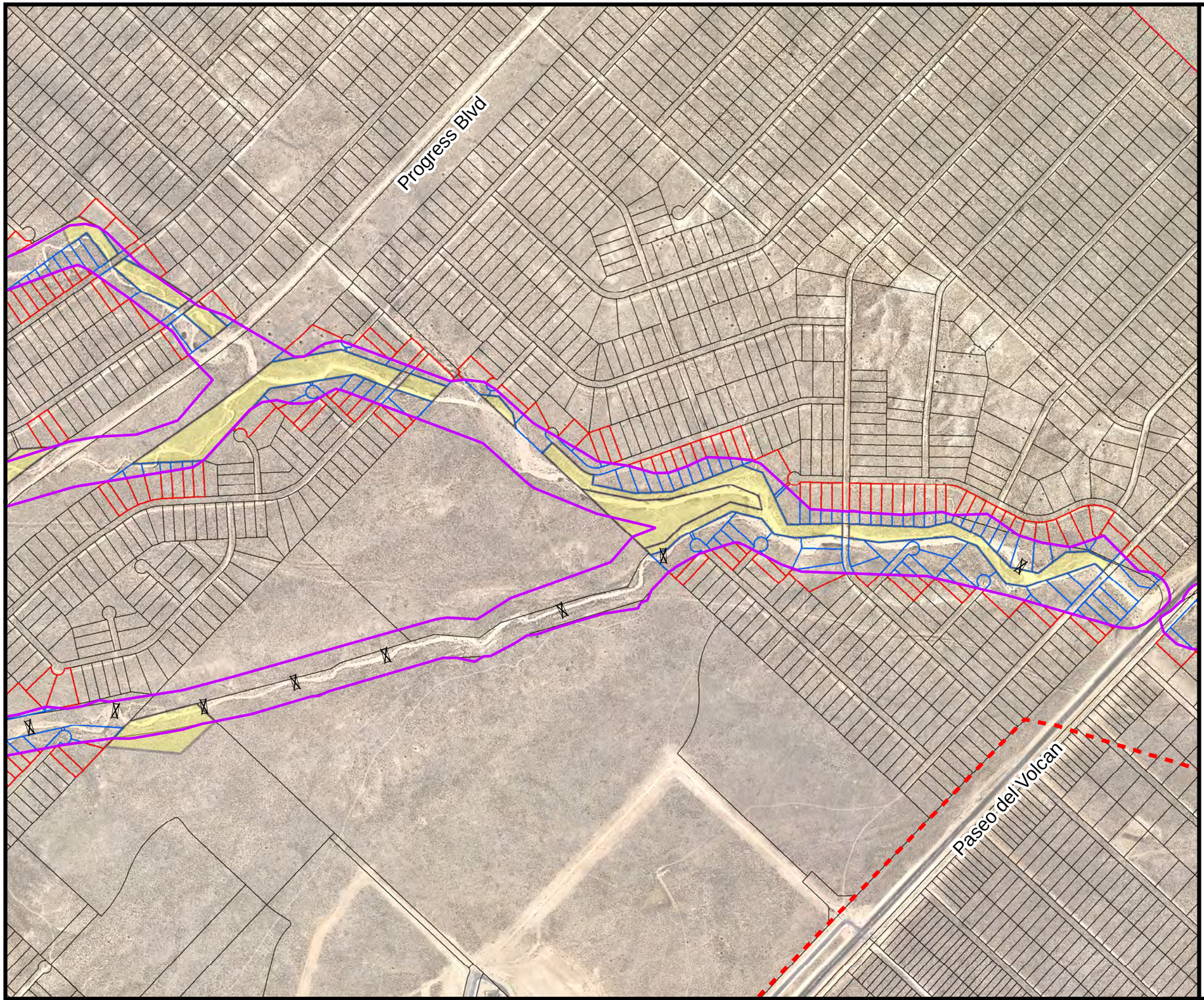

Legend

- GRADE CONTROL STRUCTURE
- LEEMAX
- BARRANCA WATERSHED BOUNDARY
- SSCAFCA EASEMENTS
- SSCAFCA FEE SIMPLE LAND
- PARCELS

PARCELS AFFECTED BY LEEMAX LINE

- PORTION OF PARCEL INSIDE LEEMAX LINE
- PORTION OF PARCEL OUTSIDE LEEMAX LINE

SOUTHERN SANDOVAL COUNTY ARROYO FLOOD CONTROL AUTHORITY

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EXHIBIT 5

LA BARRANCA WATERSHED
PROPERTY OWNERSHIP EVALUATION

0 375 750 1,500 Feet

1 inch = 750 feet

NOVEMBER 2010

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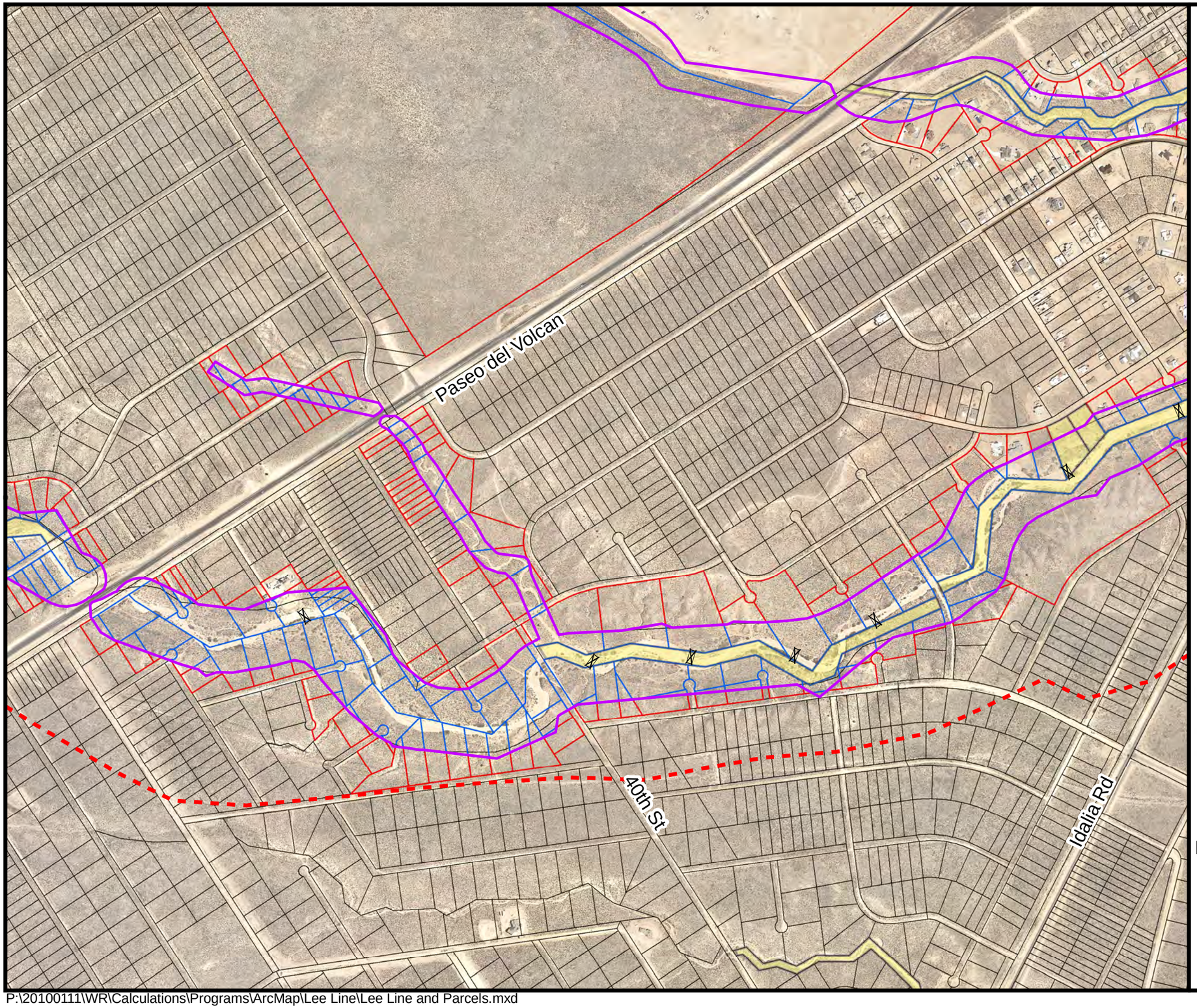

Legend

- GRADE CONTROL STRUCTURE
- LEEMAX
- BARRANCA WATERSHED BOUNDARY
- SSCAFCA EASEMENTS
- SSCAFCA FEE SIMPLE LAND
- PARCELS

PARCELS AFFECTED BY LEEMAX LINE

- PORTION OF PARCEL INSIDE LEEMAX LINE
- PORTION OF PARCEL OUTSIDE LEEMAX LINE

SOUTHERN SANDOVAL COUNTY ARROYO FLOOD CONTROL AUTHORITY

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EXHIBIT 6

LA BARRANCA WATERSHED
PROPERTY OWNERSHIP EVALUATION

0 375 750 1,500 Feet

1 inch = 750 feet

NOVEMBER 2010

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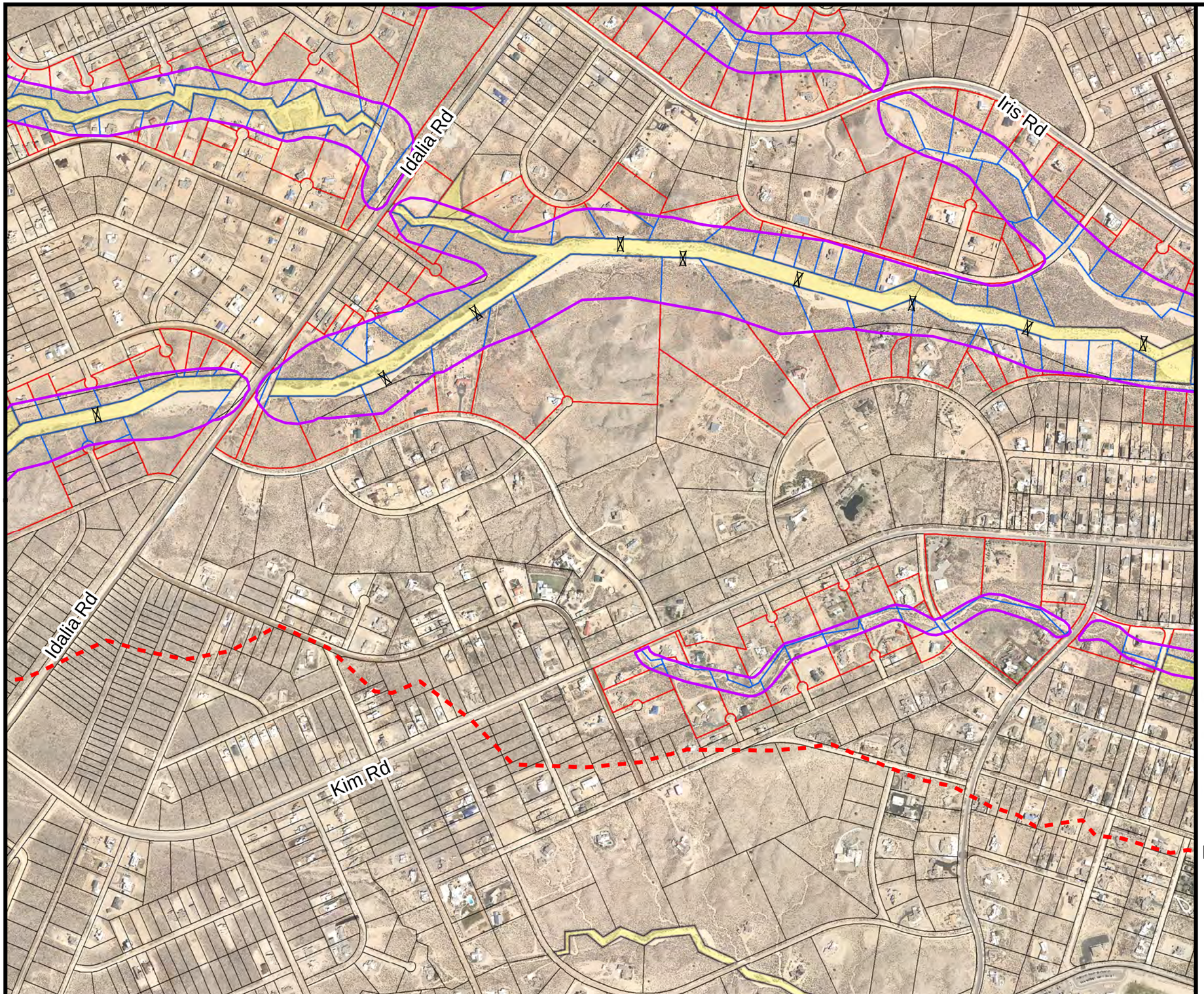

Legend

- GRADE CONTROL STRUCTURE
- LEEMAX
- BARRANCA WATERSHED BOUNDARY
- SSCAFCA EASEMENTS
- SSCAFCA FEE SIMPLE LAND
- PARCELS

PARCELS AFFECTED BY LEEMAX LINE

- PORTION OF PARCEL INSIDE LEEMAX LINE
- PORTION OF PARCEL OUTSIDE LEEMAX LINE

SOUTHERN SANDOVAL COUNTY ARROYO FLOOD CONTROL AUTHORITY

Bohannan Huston INC.
Courtyard I 7500 Jefferson St. NE Albuquerque, NM 87109-4335
ENGINEERING SPATIAL DATA ADVANCED TECHNOLOGIES

EXHIBIT 7

LA BARRANCA WATERSHED
PROPERTY OWNERSHIP EVALUATION

0 375 750 1,500 Feet

1 inch = 750 feet

N

NOVEMBER 2010

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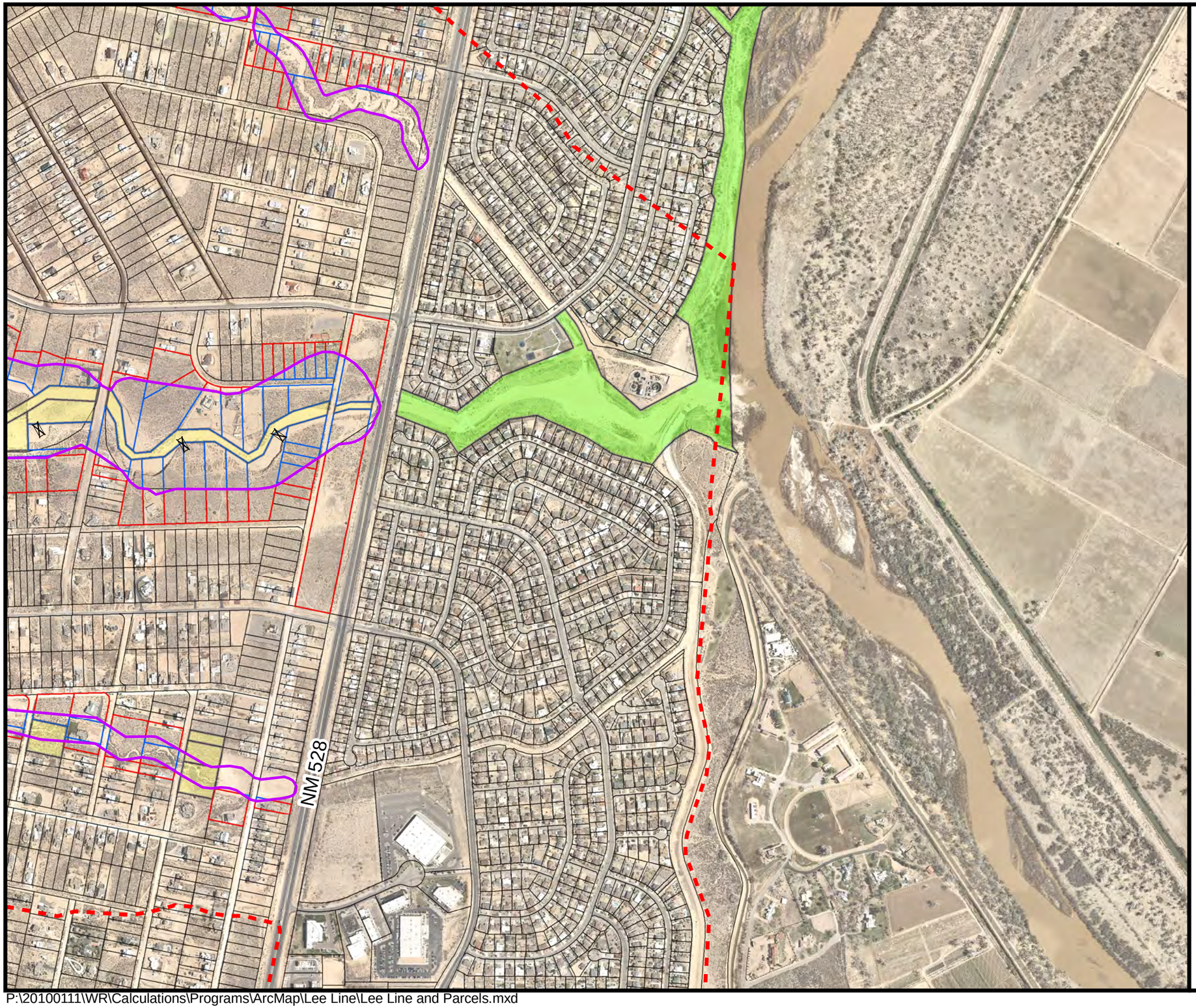

Legend

- GRADE CONTROL STRUCTURE
- LEEMAX
- BARRANCA WATERSHED BOUNDARY
- SSCAFCA EASEMENTS
- SSCAFCA FEE SIMPLE LAND
- PARCELS

PARCELS AFFECTED BY LEEMAX LINE

- PORTION OF PARCEL INSIDE LEEMAX LINE
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SOUTHERN SANDOVAL COUNTY ARROYO FLOOD CONTROL AUTHORITY

Bohannan Huston Inc.
Courtyard I 7500 Jefferson St. NE Albuquerque, NM 87109-4335
ENGINEERING · SPATIAL DATA · ADVANCED TECHNOLOGIES

EXHIBIT 8

LA BARRANCA WATERSHED
PROPERTY OWNERSHIP EVALUATION

0 375 750 1,500 Feet

1 inch = 750 feet

NOVEMBER 2010

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APPENDIX A

PROJECT TEAM MEETING SUMMARIES

Summary Notes from
Project Kick off and Field Visit Coordination Meeting
La Barranca Arroyo Study
August 27, 20009

1. Introductions

Attendees:	Company/Agency	E-mail
David Stoliker	SSCAFCA	dstoliker@sscafca.com
Ralph Montoya	SSCAFCA	rmontoya@sscafca.com
Steve Gardner	SSCAFCA	sgardner@sscafca.com
Trevor Alsop	SSCAFCA	talsop@sscafca.com
Randall Carroll	City of Rio Rancho	rcarroll@ci.rio-rancho.nm.us
Howard Stone	BHI	hstone@bhinc.com
Scott Armstrong	BHI	sarmstrong@bhinc.com
Bob Mussetter	TetraTech	bob.mussetter@tetratech.com
Kim Kemper	Huitt-Zollars	krkemper@huitt-zollars.com
Clint Dodge	WH Pacific	cdodge@whpacific.com
Mike Anderson	Terracon	meanderson@terracon.com

2. Project Objectives - Round Table Discussions
   - David - how to keep arroyos natural, while also keeping them from eroding?
     - Some examples of erosion protection measures include:
       - lining the arroyos
       - reducing flows to 0.5 cfs/acre
   - Bob - noted that it is not practicable to keep arroyos from eroding;
     - The goal should be to manage erosion, not stop it.
     - Ultimately, you can't eliminate having some protection measures in arroyos.
   - David
     - Storm water quality needs to be included. (Should we treat first ¼"? first ½" of runoff?)
     - Money is not a limitation on this project, wants this project to be very unique
     - This will be his last new venture.
     - David pointed out that after development takes its toll, the only place Mother Nature is left is in arroyos that SSCAFCA can preserve.
   - Kim - cost has to be a factor (for developers)
     - David has asked Kim to represent the Developer voice.
   - David – keep list of Action Items and Purposes
     - Action Items – see below
     - Project Purposes:
       - Address erosion / sediment transport
       - Water Quality
       - Cost
       - Runoff volume control
   - David – address OSE / water rights issues
     - What are implications of water harvesting?
     - Trevor to coordinate with Brad Bingham

- Trevor
  - Need to address volume of water, not just peak flows. This will become an EPA mandate.
  - Trevor will be the lead on water quality and conservation.

- David – Report deliverables
  - Policy statement
  - Toolbox to achieve goals / policy

- Purpose Statement
  - Develop tools to protect arroyos within an urban environment in a natural state.
  - Apply tools to La Barranca and analyze long term effects

  - Bob asked: What is the definition of a natural state?
  - Group identified some qualities of a natural arroyo:
    - Contains quality of life amenities
    - An arroyo that is living and active

3. Potential Toolbox Items / Report topics
   - Policy Statement
   - Bob posed the following question: what is the content? Why are we here?
     - Development caused the volume of runoff to go up, & the sediment supply to go down.
     - Now, the equilibrium is out of whack.
     - Challenge - how to allow development, while also allowing equilibrium to reestablish.
     - Sediment transport issues need to be addressed in report
       - Quantify what will happen with each alternative
   - Howard – need to investigate infiltration issue in the report
   - Mike – possibly use geotextile? Other surface options?
   - Kim – look at C/I sites 1st flush; could develop tools and polices from that information
   - Randall
     - Volume control –Metering at discharge point. (i.e. 2 yr, 5 yr, 10 yr flows) per CoRR policy written by Robert Schulz.
     - Underground storage of rainwater – previously allowed by CoRR
   - Trevor
     - In order to reduce the volume, backyard ponds bounded by walls could be placed.
     - Credit could be taken for playas. A rule/regulation should be written to protect playas.
   - Ralph
     - Quality of life issues need to be included;
     - Arroyos are natural corridors to river with possible connection to bosque trail.
     - Incorporate SSCAFCA Quality of Life Master Plan into Study.
   - Steve
     - Protection of public (e.g. how does 30' high bank affect public safety)
     - Look at changing the way developed flows are discharged to the La Barranca,
       - i.e. instead of discharging at historic rates via "sheet flow", the current paradigm involves collecting developed flows, detaining, and discharging at historic rates through a single discharge point.

- Can we try to discharge in a way that more closely mimics nature?

- David
  - Property ownership – Sandoval Co. has 139 lots on auction block; could obtain land to preserve natural state
  - Could mandate cisterns (large volume)
  - Road crossings: have huge impact (as noted in field); How to address??
  - Storm water quality Costs Water rights issues

4. Misc. Information
   a. Sanitary Sewer criteria - sewer in arroyos: 2' below scour depth
   b. Study Limits
      i. David – stop at NM 528???
      ii. Howard suggests extending to Rio Grande
      iii. David indicated that the arroyo below NM528 is controlled, and so is not a candidate for "natural" arroyo
      iv. Proposed limits – NM528 to upper end of arroyo, west of Unser Blvd- ~ 8.5 miles
   c. Available Mapping / Surface Info.
      i. BHI has 2008 imagery
      ii. BHI has 4' surface from ~ 8yrs. ago
   d. ROW / ownership
      i. Need accurate ROW maps
      ii. Per Randal – CoRR has some easements on private lots
      iii. HZ has plat information – they will provide to BHI
   e. CoRR Parks and Rec
      i. Trevor – City may not have Park facility plan along arroyo, but does want trails
      ii. Randal – will provide a) Planning Overlays, and b) facility plans to BHI
   f. Schedule:
      i. Report / Deliverable due Dec 2009
      ii. Monthly meetings - ~ 3 or 4 for duration of 2009
5. Action Items
   a. City Center Drainage Plan
      i. Kim to provide ~ Nov. 15th
      ii. Coordination with WHP required for upper SLO hydrology
      iii. UNM is included – but not official
   b. Design Details - Outlet works / restrictions
      i. Per David, Clint to look at reducing velocities from outfalls to the arroyo
   c. OSE Water rights issues
      i. Trevor to check w/ Brad Bingham at COA
   d. Ownership / Easement information
      i. Kim to provide plats to BHI – COMPLETED
      ii. Randall to provide Planning Overlays to BHI
      iii. Randall to provide facility plans to BHI
   e. Share Point: - Trevor / Kim to investigate setting up a site for this project
   f. Arroyo Profile
      i. BHI to cut profile w/ available 4' contour data.
      ii. Bob requested that we run a vertical profile down the thalweg to compare to the 8 year old mapping.

g. Geotech:
    i. Bob to provide previous soil sample results to Group – COMPLETED
    ii. Bob to suggest locations for samples to be collected by Terracon – COMPLETED
    iii. Mike to provide analysis at next meeting
h. Next Meeting:
    i. BHI to set up meeting
    ii. Agenda:
        1. Throw tools on the table
        2. Get Howard / Bob to run scenarios to describe effects of those options

Meeting Summary from November 19, 2009
SSCAFCA / BHI Project Update

Original Agenda Items in Bold
New information – un-bold
Action Items – highlighted in red

1. City of Rio Rancho Mural
    a. Draft – presented to David
    b. CoRR Parks and Rec – awaiting data on schools
    c. Will finalize mural
    d. Coordinate w/ SSCAFCA, CoRR to present Final copies
        i. BHI to coordinate schedules w/ Jay Hart, Richard Jiminez, Trevor, David, Gerhard

2. La Barranca Arroyo Study
    a. LEE line status
        i. BHI to send to Clint or add Clint's DEVEX LEE line analysis to our results for comparison
        ii. Use LEE line as PR – to preserve arroyos
            1. be conservative with line work – bigger LEE line – more area preserved
        iii. David to invite USACE to next meeting – enlist their help with preserving arroyos
        iv. BHI / TetraTech to emphasis to USACE about SSCAFCA's history of protecting arroyos
    b. Soil sample data
    c. Natural Arroyo definition
        i. An ephemeral drainage way, typically having a flat, movable bed and steep or vertical erodible banks, which have not been directly altered by human intervention.
        ii. Need to add statement about intended use: - used by wildlife, supports habitat, used by recreationalists
    d. Naturalistic Arroyo definition
        i. An arroyo in which erosion protection measures have been installed to prevent damage to infrastructure while maintaining the natural boundary materials, with the objective of maintaining the natural character of the channel to the maximum extent possible.
        ii. BHI needs to develop a Vision / Goal
    e. Next Steps
        i. Incorporate City Center affects
            1. BHI to obtain analysis, results from HZ
        ii. Final product
            1. Provide more specific recommendations on how to treat arroyos in future
            2. Develop Policy statements
    f. Schedule
        i. Jan / Feb. 2010 - provide report

3. Montoyas Arroyo Watershed Management Plan Update
    a. Developments w/ No Report – list provided to SSCAFCA
        i. Original list provided 10/8/09
        ii. BHI to resend list to Ralph – entire team
        iii. Ralph / BHI to coordinate on CoRR CIP projects – to obtain info. on developments

1. East of Unser?
2. West of Broadmoor – Chestman?

b. Existing Conditions Premise –
   i. All developments with approved drainage reports - modeled as 2009 "Existing" condition
   ii. Regardless of what is actually constructed on the ground
   iii. This was confirmed by Team
   iv. BHI to define this in the MA WMP Update Report
   v. Report to Define who is responsible for future infrastructure

c. Ponds
   i. BHI to send our current pond criteria to SSCAFCA indicating which ponds will be modeled and which will be ignored

d. Corrales Parcels
   i. BHI to inquire with WH Pacific if they have parcel data

e. Schedule
   i. Draft Existing conditions model in 60 days - ~ Jan 22, 2010

4. Additional Projects
   a. BHI to coordinate w/ Jennifer to get grant for wetlands at inlet to HJC
   b. BHI to coordinate on 2nd potential project from Sportsplex all the way to Rio Grande

   c. DPM
      i. WH Pacific to finalize
      ii. BHI to review

Meeting Summary
December 10, 20009 Coordination Meeting
La Barranca Arroyo Study
(Note: Original Agenda items noted in Bold font)

1. **Introductions** – see attached sign in sheet

2. **Review Project Purpose**
   a. **Preserve arroyos (use LEE line to secure arroyo corridor as open space)**
      i. Bob – a detailed study would convert from floodplain into floodway;
         1. this may provide better protection for arroyo corridor than a floodplain
      ii. Howard – will add current FEMA A zone maps to report
   b. **Preserve burrowing owls / habitat**
      i. David
         1. Also concerned about bank swallows
         2. Would like to define a applicable bank swallow habitat as a planning overlay
         3. Landscape architects say soap sage is endangered; may be present in area
      ii. Eddie – north facing banks are better for bank swallow habitat
      iii. Eddie – burrowing owls need habitat w/in 3 miles of bosque (beyond that little habitat)
   c. **Proposed Project Vision Statement:** ***To establish arroyo corridors that allow for the safe passage of stormwater flows. These arroyo corridors also allow for the preservation of flora and fauna than can coexist with appropriate human activities such as recreational facilities. In addition, these arroyos corridors are also intended to protect the public from the damaging effects of flooding and associated sediment erosion and deposition.***
      i. David – want to negate impacts of development
      ii. Bob – goal to 'investigate' potential impacts of development and work with them
      iii. Leslie – need to maintain balance between erosion / deposition
      iv. Scott S. – probably don't want to say 'negate' impacts of development; state we want to 'recognize development pressures'
      v. David – really only 1 goal – natural arroyo from river to Mariposa

3. **Discuss and Promote SSCAFCA's Past record of stewardship**
   a. As follow up to meeting, 'team' visited SSCAFCA Environmental Mitigation Area
   b. Discussed Frisbee Golf Course plans for Lomitas Negras area

4. **Review Definitions**
   a. **Natural Arroyo definition**
      i. ***An ephemeral drainage way, typically having a flat, movable bed and steep or vertical erodible banks, which have not been directly altered by human intervention.***
   b. **Naturalistic Arroyo definition**
      i. ***An arroyo*** *corridor* ***in which*** *non-continuous or limited* ***erosion protection measures have been installed to prevent damage to infrastructure while maintaining the natural*** ~~***boundary***~~ *bed and bank* ***materials, with the objective of maintaining the***

natural character of the ~~channel~~ *corridor* ***to the maximum extent ~~possible~~*** *practicable.*

ii. Group edits shown in highlighted area above
iii. Scott S. – would be helpful to add examples to definitions
iv. David – want to preserve the attributes of arroyo corridors

c. Per 11/19/09 meeting

i. **Need to add intentions for arroyo use – e.g. "use by wildlife, recreationist"**
ii. **Need to modify to include arroyo 'corridor' – not just arroyo**

5. Discuss Analysis

a. Soils Data

i. Mike
1. has a geologic map that he can provide
2. area characterized by light aeolian (wind blown) sands; little cohesive soils
3. options for preserving naturalistic arroyos – vegetation or soil erosion mats
4. Challenge is vertical banks – therefore could use 'harder' concepts, but more expensive

ii. David – at this point don't let cost rule out alternatives; include all options in evaluation

b. Arroyo profile – preliminary review of profile provided and discussed

c. LEE Line

i. Review results – existing, developed, DEVEX
1. Want to use widest LEE line – most protective
2. What are legal ramifications of LEE line policy?
3. Leslie – didn't think property ownership guaranteed right to highest and best use; doesn't think defining a LEE line would be considered a 'taking'

ii. Discuss geologic formation affecting LEE line

iii. Parcel data review

iv. ID problem areas if we are to leave arroyo alone
1. Discussion noted locations of lots w/in LEE lines
2. SSCAFCA stance is NOT to use SSCAFCA $$ to protect a single house
3. Howard / Bob – do need to treat these locations as boundary conditions
4. Bob – solution is to define LEE line and let natural channel evolution occur
5. David – ultimate solution has to be to purchase those lots; ROW is a big issue, SSCAFCA has $ for infrastructure, but ROW purchase is probematic

d. Discuss outstanding data

i. City Center analysis

6. Next Steps

a. Defining an Arroyo Corridor for drainage, riparian life, and recreational uses.

i. SSCAFCA has adopted CoRR Trail plans on all arroyos

b. Palate of protections for naturalistic arroyos

i. Use widest LEE line
ii. Include amenities in planning – e.g. reveg work, recreational features, outside LEE line
iii. Hard treatments, e.g. wire-tied riprap, dumped riprap

c. Finalize recommendations

i. Need to use holistic approach
ii. Educate realtors not to buy / sell property next to arroyos
iii. Educate children – arroyos need to move, migrate
iv. Safety of public
v. Minimize CoRR and SSCAFCA's liability

d. Create Policy

7. Develop Remaining Project Schedule

a. Present Draft report at next meeting

La Borrance Arroyo

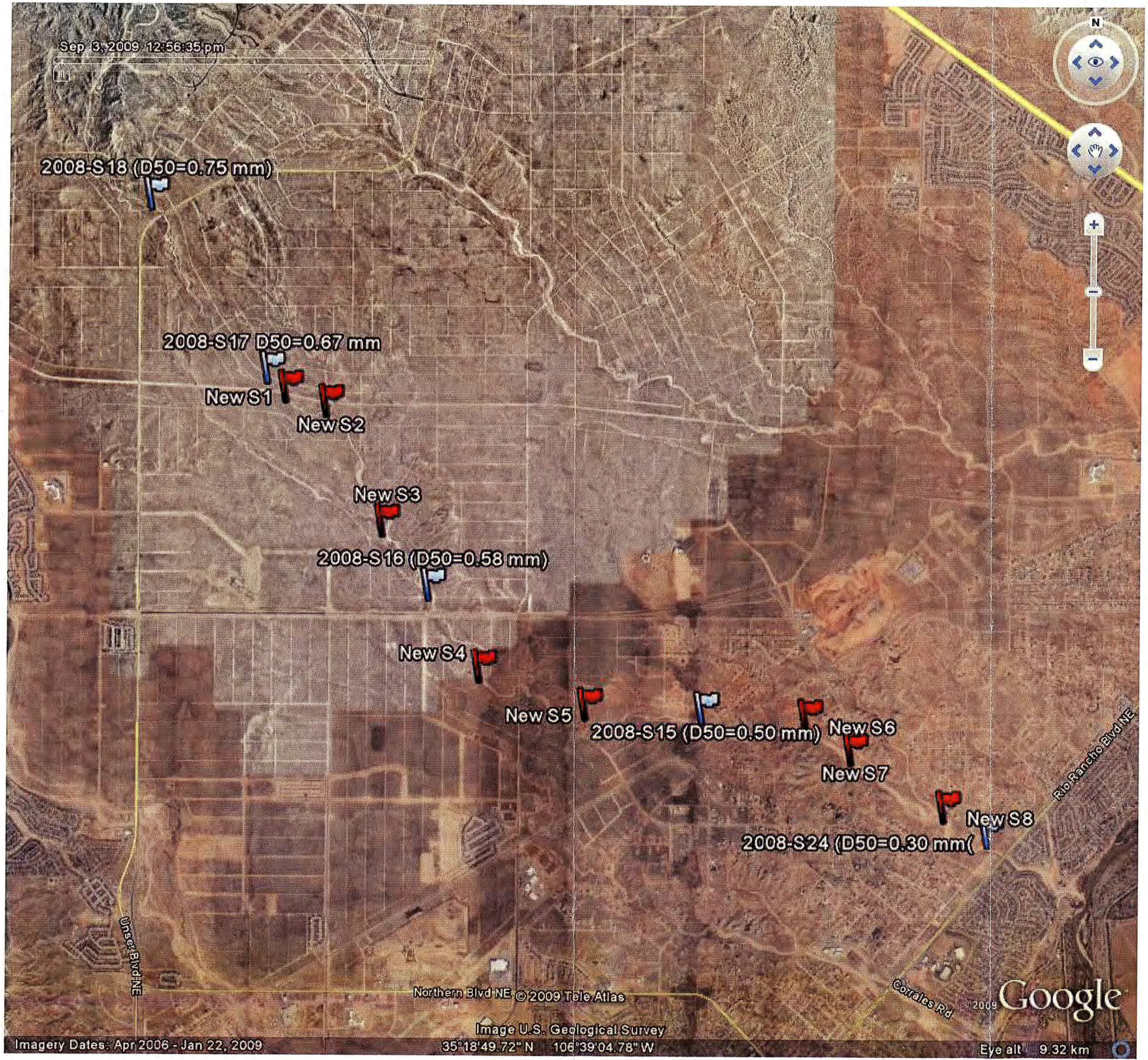
Study

Dec. 10, 2009

Name	Organization	phone
Howard Stone	BHI	798-7829
Scott Armstrong	BHI	798-7832
Trevor Alsop	SSCAFCA	892-7246
Bob Mussetter	Tetra Tech	970-223-9600
Lesley McWhirter	USACE	342-3678
Eddie Paulsgrove	USACE	342-3279
Ralph Montoya	SSCAFCA	892-7246
Allan Steinle	USACE	342-3282
MIKE ANDERSON	TERRACON	797-4287
Sharon Procopio	WHPacific	348-5227
Clint Dodge	WHPacific	247-0294
DAVID STOLLER	SSCAFCA	892-5266
KIM KEMPER	HUITT-ZOLLARS	892-5141
Scott Sensanbaugher	City of RR	896-8736

APPENDIX B

BARRANCA ARROYO SOILS DATA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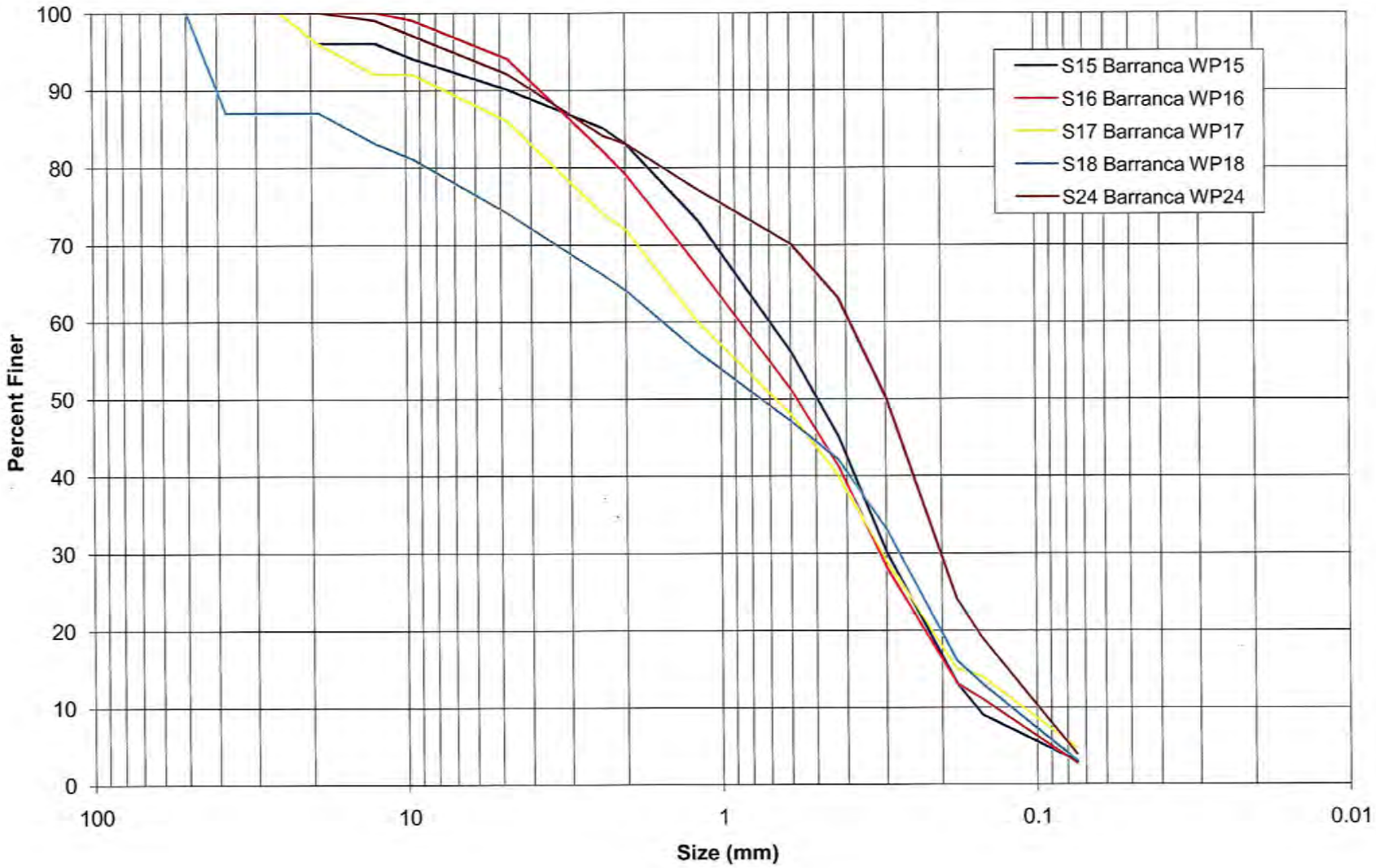
2008-S17 D50=0.67 mm
New S1
New S2
New S3
2008-S16 (D50=0.58 mm)
New S4
New S5
2008-S15 (D50=0.50 mm)
New S6
New S7
New S8
2008-S24 (D50=0.30 mm(
Rio Rancho Blvd NE
Unser Blvd NE
Northern Blvd NE
Corales Rd
© 2009 Tele Atlas
Image U.S. Geological Survey
Imagery Dates: Apr 2006 - Jan 22, 2009
35°18'49.72" N 106°39'04.78" W
Eye alt 9.32 km
2009 Google

Sieve	Size (mm)	S15 Barranca WP15	S16 Barranca WP16	S17 Barranca WP17	S18 Barranca WP18	S24 Barranca WP24
2"	50				100	
1-1/2"	37.5	100	100	100	87	100
1"	25	100	100	100	87	100
3/4"	19	96	100	96	87	100
1/2"	12.5	96	100	92	83	99
3/8"	9.5	94	99	92	81	97
#4	4.75	90	94	86	74	92
#8	2.36	85	82	74	66	84
#10	2	83	79	72	64	83
#16	1.18	73	67	60	56	77
#30	0.6	56	51	48	47	70
#40	0.425	45	41	40	42	63
#50	0.3	30	28	29	33	50
#80	0.18	13	13	15	16	24
#100	0.15	9	11	14	13	19
#200	0.075	2.9	2.6	4.7	3.0	3.8
D84		2.17	2.65	4.23	13.88	2.36
D16		0.20	0.20	0.19	0.18	0.13
D50		0.50	0.58	0.67	0.75	0.30
%>2 mm		17	21	28	36	17
G		3.45	3.74	4.95	11.32	5.08

La Barranca 2008 Sediment Samples



P:\20100111\Archive\Received\From Tetra Tech\La Barranca 2008 Sediment Samples, Plot

9/8/2009

Smft
Bobm - via email 11/19/09
20100111
HCS - via email

Terracon
Consulting Engineers & Scientists

4905 Hawkins NE
Albuquerque, New Mexico 87109
Phone 505.797.4287
Fax 505.797.4288
www.terracon.com

November 4, 2009

Bohannan Huston, Inc.
7500 Jefferson Street
Courtyard I
Albuquerque, NM 87109

Attn: Mr. Scott Armstrong

Re: La Barranca Arroyo Study
Downstream of the City Center
Rio Rancho, New Mexico
Terracon Project No. 66095031

Dear Mr. Armstrong:

Terracon Consultants, Inc. (Terracon) has completed our geotechnical engineering exploration and lab testing for the evaluation of the soils exposed at the floor of the existing arroyo located downstream of the City Center in Rio Rancho, New Mexico. The purpose of these services is to provide data and geotechnical parameters to assist in the design of the improvements for La Barranca Arroyo.

Proposed Construction: Based on the provided information, it is our understanding that improvements may be considered for a section of the existing arroyo located downstream of the City Center to the Rio Grande located in Rio Rancho, New Mexico.

Scope of Services: The scope of the services performed for this project included site reconnaissance by a Terracon representative, a subsurface exploration program, and laboratory testing.

Eight (8) hand auger borings were drilled to a depth of about one foot below existing site grade along the floor of the existing arroyo, as shown on the attached Sample Location Diagram, Figure 1. The auger borings and sample locations were designated by Tetratech.

Selected soil samples were tested for the following engineering properties:

- Water Content
- Atterberg Limits
- Sieve Analysis

Subsurface Conditions: As presented in the test results, poorly graded sand with varying amounts of silt and gravel (SP, SP-SM) were encountered in all the borings.

Groundwater was not encountered in the test borings at the time of field exploration, nor when checked immediately upon completion of hand auger operations.

GENERAL COMMENTS

The analysis and test data presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either expressed or implied, are intended or made. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the data contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies the data in this report in writing.

We have appreciated being of service to you if you have any questions concerning this report or any of our testing, inspection, design and consulting services, please do not hesitate to contact us.

Sincerely,

TERRACON CONSULTANTS, INC.,

Meagan J. Duneman, E.I.
Staff Engineer

MICHAEL E. ANDERSON
NEW MEXICO
12132
PROFESSIONAL ENGINEER

Michael E. Anderson, P.E.
Principal/Office Manager

Attachments: Figure 1- Sample Location Diagram
Grain Size Distribution
Lab Summary
General Notes
Unified Soil Classification System

Copies to: Addressee (4) – 3 hard copies and 1 by PDF

● **S-1**

Sample Location

Project Mngr:	MJD
Drawn By:	
Checked By:	MEA
Approved By:	MEA

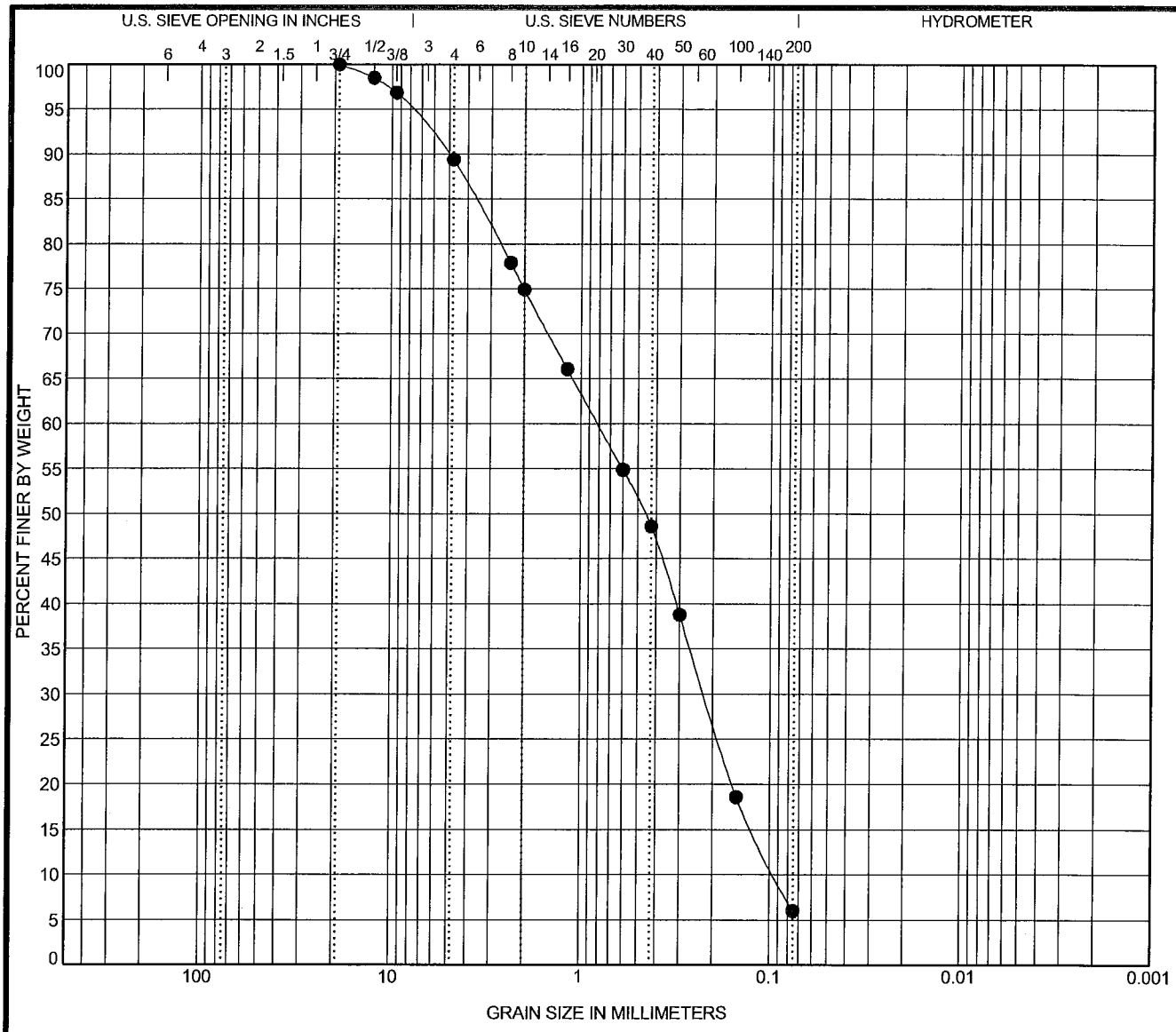
Project No.	66095031
Scale:	NTS
File No.	
Date:	11/2009

Terracon
Consulting Engineers and Scientists
4905 Hawkins St. NE
Albuquerque, New Mexico 87109
Phone: 505.797.4287 Fax 505.797.4288

SAMPLE LOCATION DIAGRAM

La Barranca Arroyo Study
Downstream of the City Center
Rio Rancho, New Mexico

FIG. No. 1



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	**S-1**	**1.0ft**	**POORLY GRADED SAND with SILT(SP-SM)**	**NP**	**NP**	**NP**	**0.64**	**8.73**

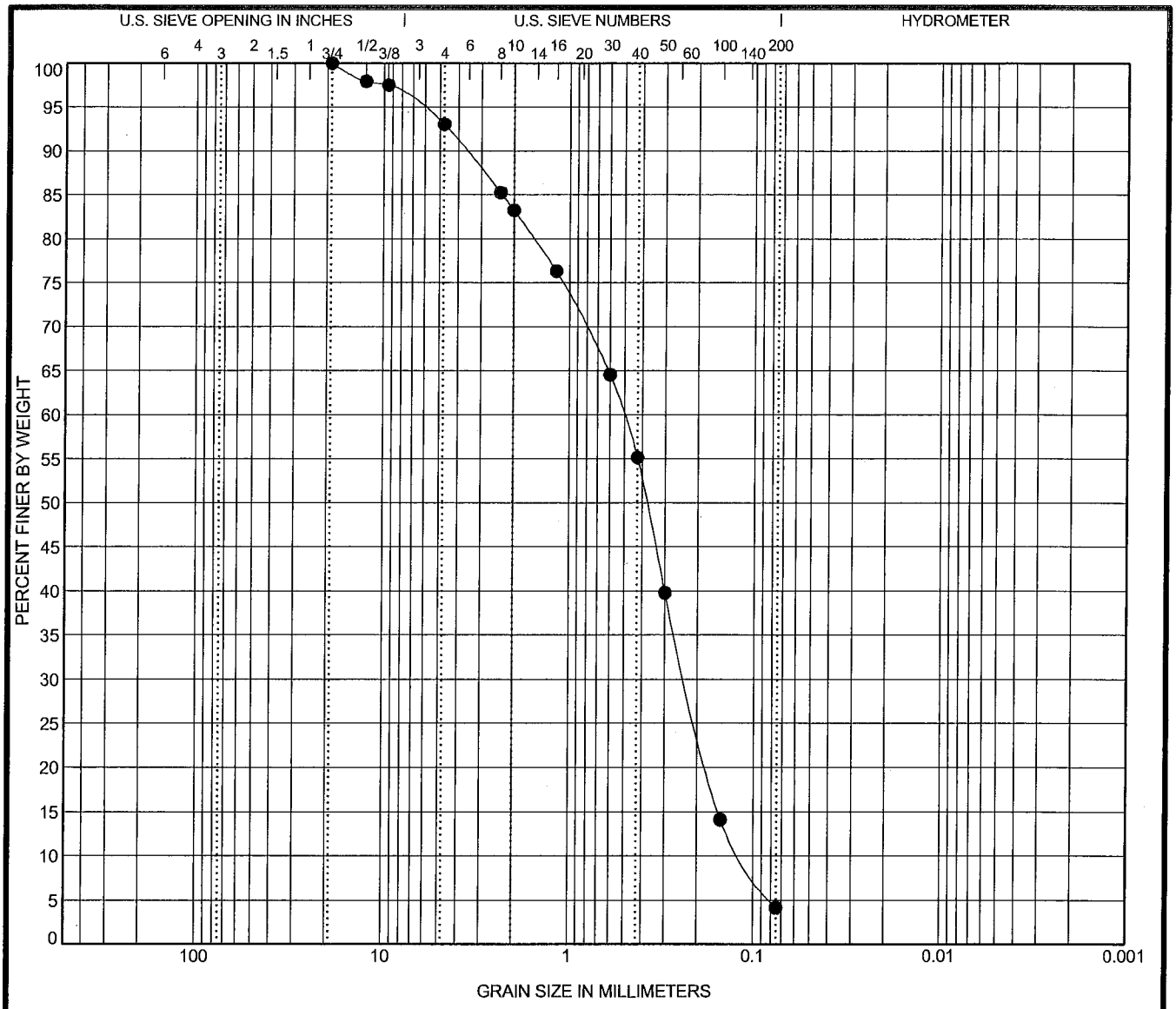
	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**S-1**	**1.0ft**	**19**	**0.817**	**0.222**	**0.094**	**10.6**	**83.4**	**6.0**	

Terracon

GRAIN SIZE DISTRIBUTION

Project: La Barranca Arroyo
Site: Rio Rancho, NM
Job #: 66095031
Date: 11-4-09

TC GRAIN SIZE 66095031.GPJ TERRACON.GDT 11/4/09



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	**S-2**	**1.0ft**	**POORLY GRADED SAND(SP)**	**NP**	**NP**	**NP**	**0.93**	**4.49**

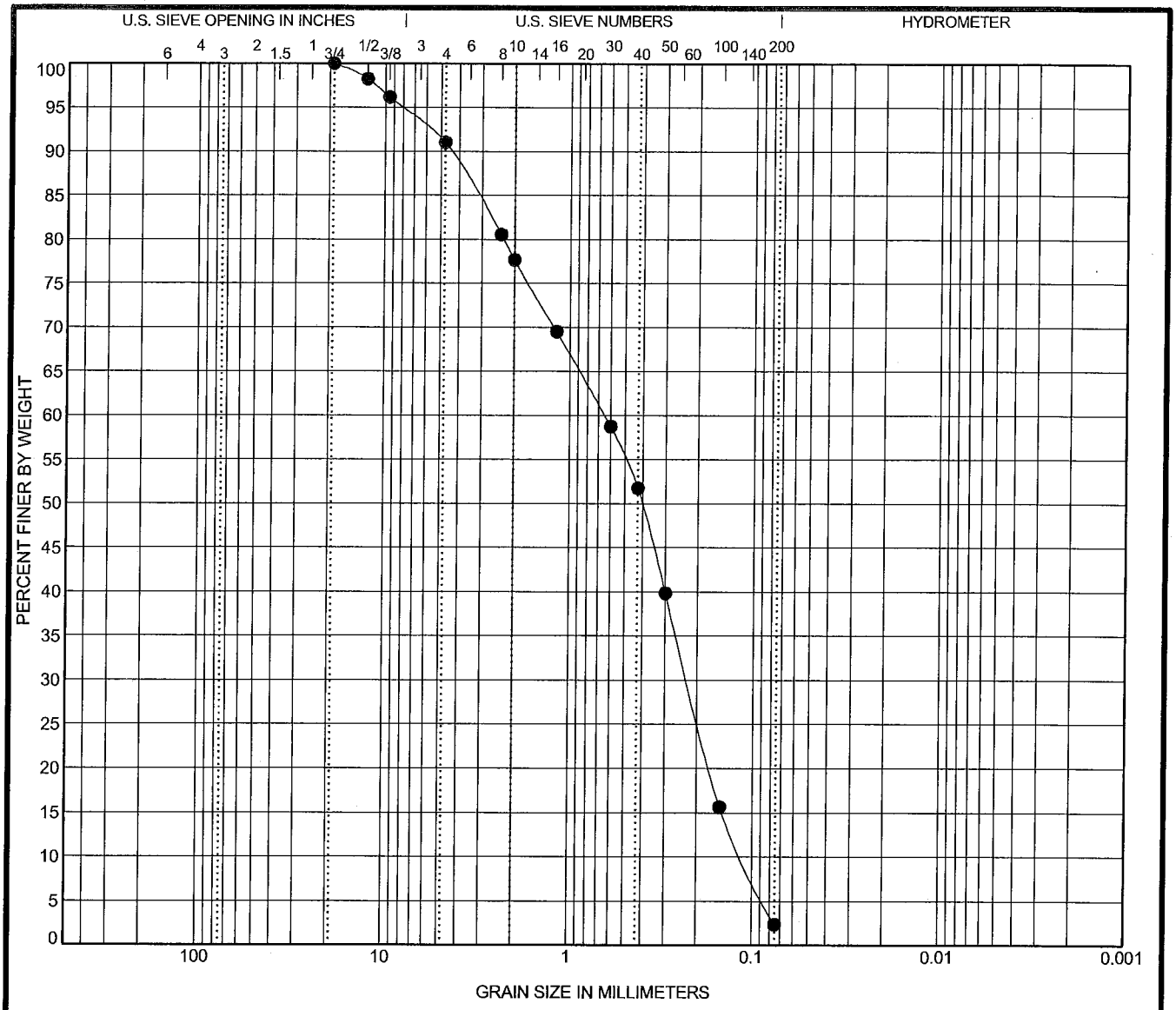
	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**S-2**	**1.0ft**	**19**	**0.508**	**0.23**	**0.113**	**7.0**	**88.9**	**4.1**	

Terracon

GRAIN SIZE DISTRIBUTION

Project: La Barranca Arroyo
Site: Rio Rancho, NM
Job #: 66095031
Date: 11-4-09

TC_GRAIN SIZE_66095031.GPJ_TERRACON.GDT 11/4/09



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	**S-3**	**1.0ft**	**POORLY GRADED SAND(SP)**	**NP**	**NP**	**NP**	**0.71**	**5.80**

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**S-3**	**1.0ft**	**19**	**0.649**	**0.226**	**0.112**	**9.0**	**88.7**	**2.3**	

Terracon

GRAIN SIZE DISTRIBUTION

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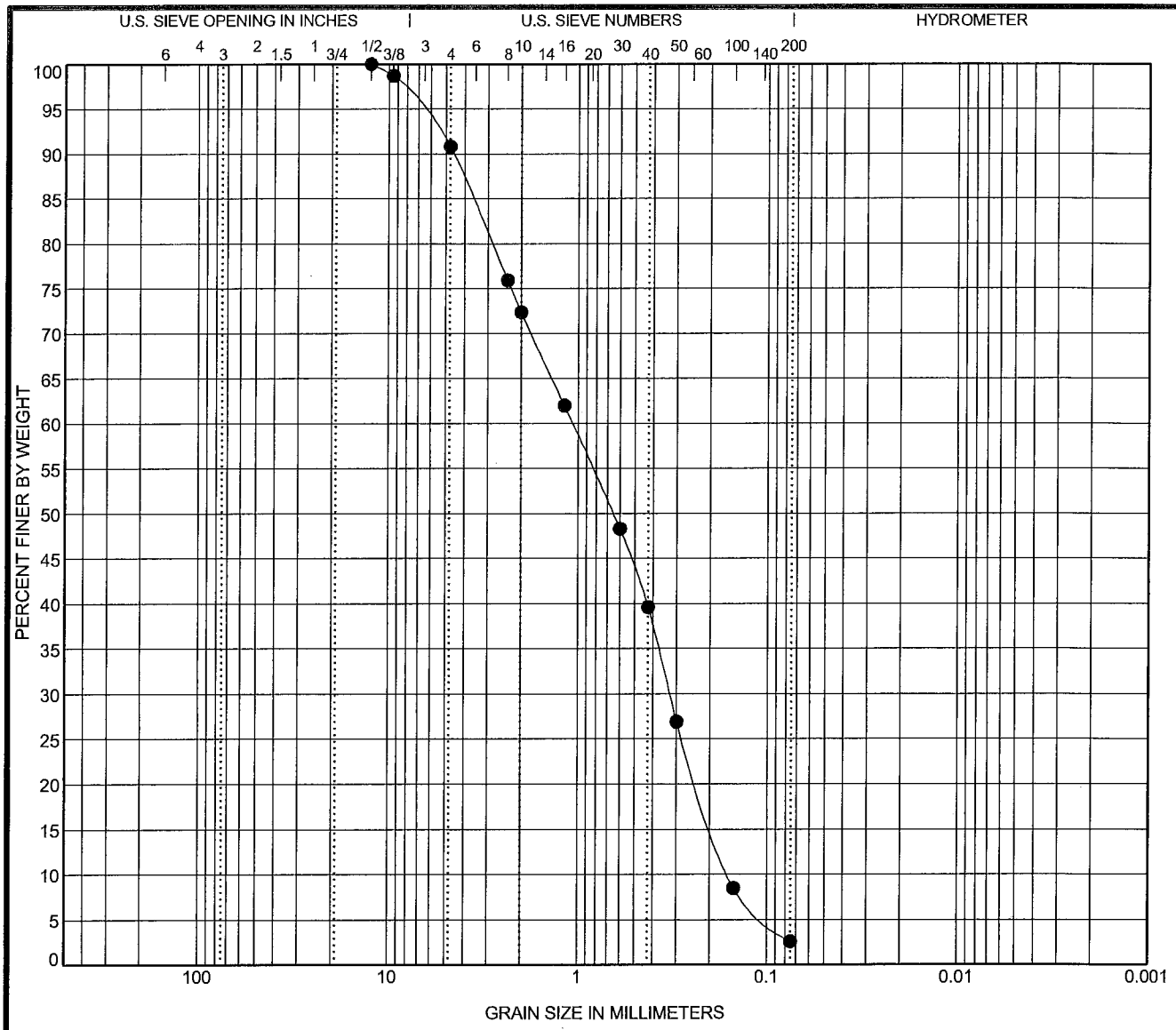
Job #: 66095031
Date: 11-4-09

TC GRAIN SIZE 66095031.GPJ TERRACON.GDT 11/4/09



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification	Classification	LL	PL	PI	Cc	Cu
●	**S-4 1.0ft**	**POORLY GRADED SAND(SP)**	**NP**	**NP**	**NP**	**0.63**	**6.73**

	Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**S-4 1.0ft**	**12.5**	**1.07**	**0.327**	**0.159**	**9.2**	**88.3**	**2.5**	

Terracon

GRAIN SIZE DISTRIBUTION

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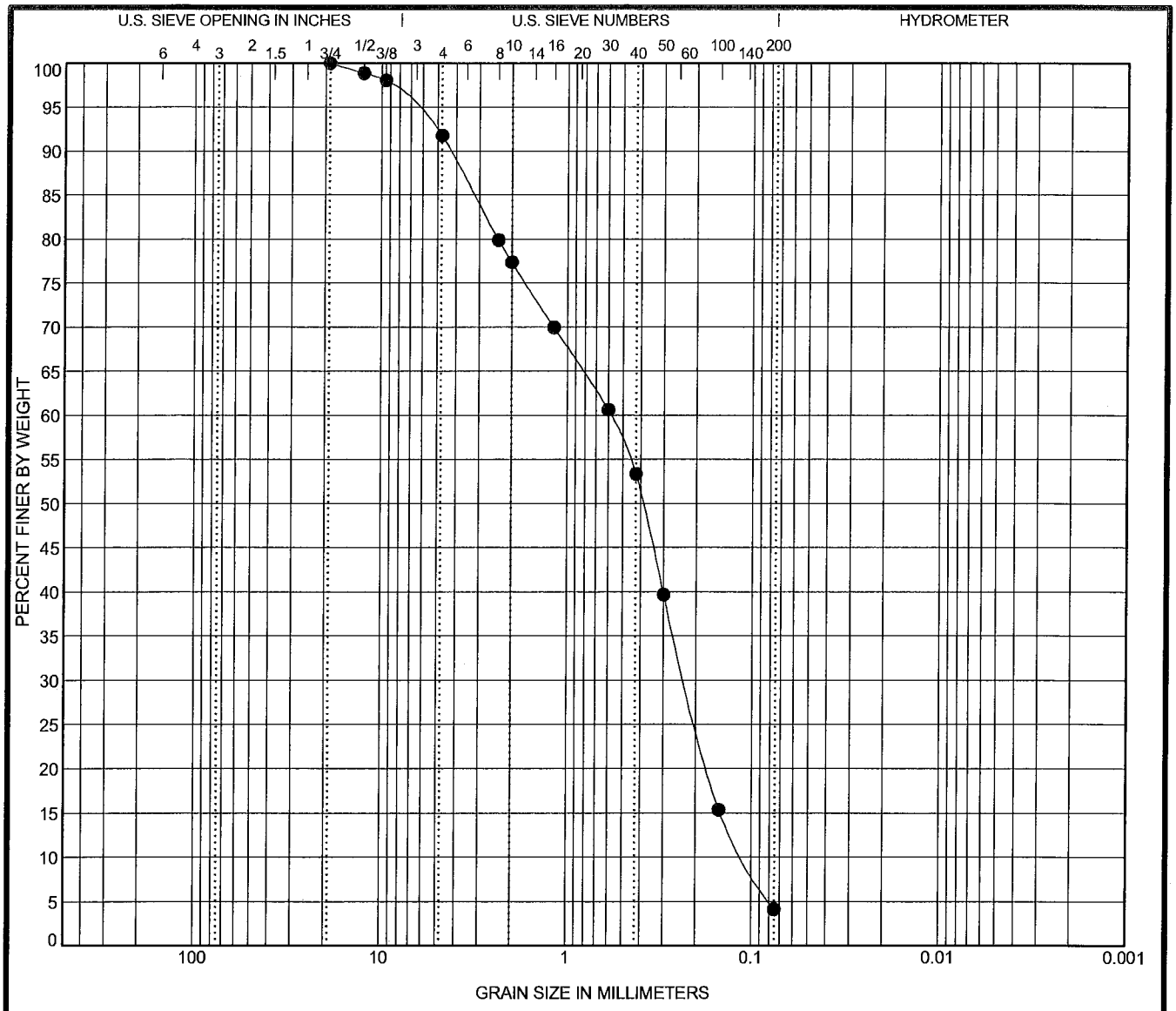
Site: Rio Rancho, NM
Job #: 66095031
Date: 11-4-09

TC GRAIN SIZE 66095031.GPJ TERRACON.GDT 11/4/09



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	**S-5**	**1.0ft**	**POORLY GRADED SAND(SP)**	**NP**	**NP**	**NP**	**0.83**	**5.40**

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**S-5**	**1.0ft**	**19**	**0.582**	**0.228**	**0.108**	**8.2**	**87.7**	**4.1**	

Terracon

GRAIN SIZE DISTRIBUTION

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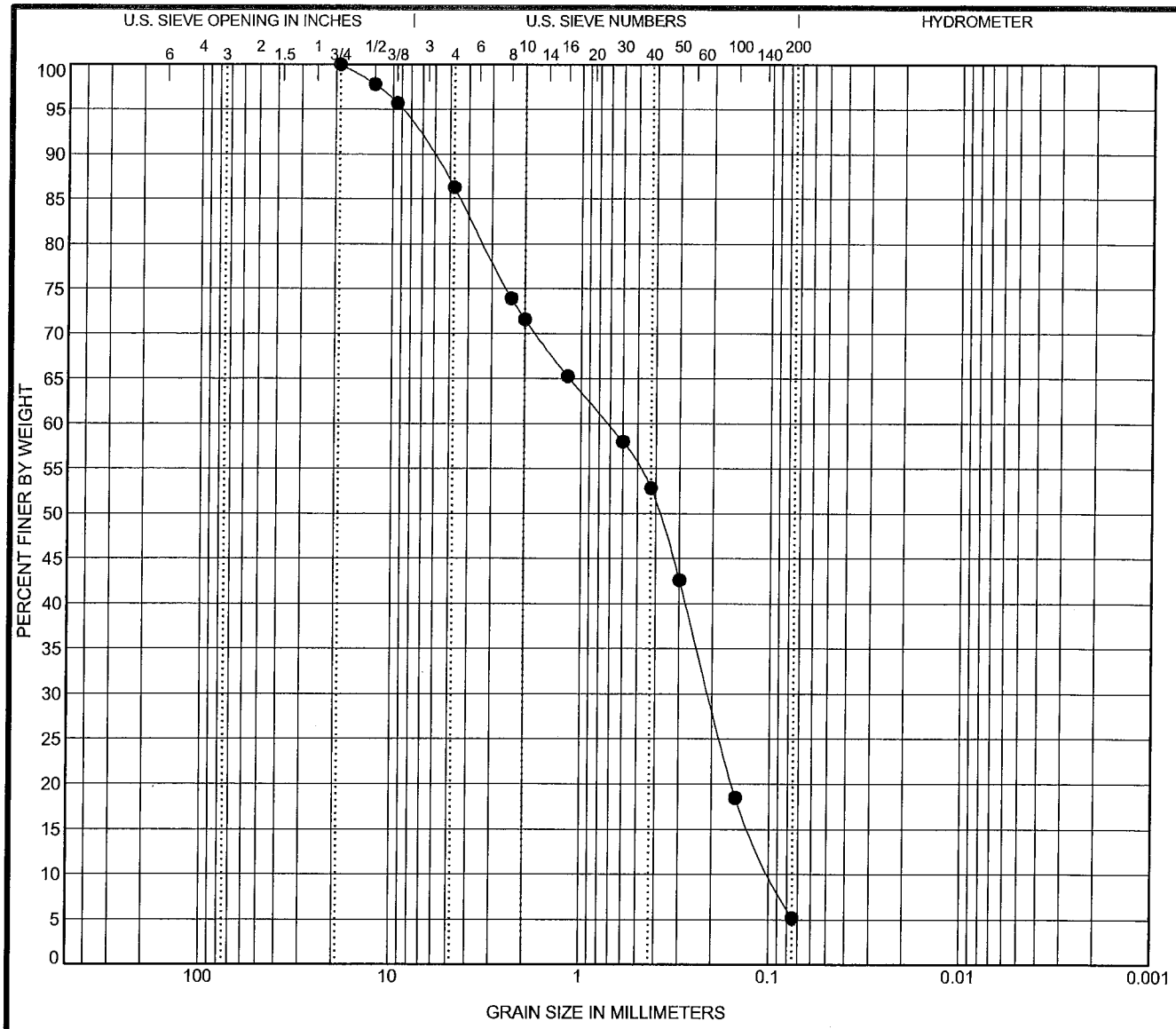
Site: Rio Rancho, NM
Job #: 66095031
Date: 11-4-09

TC GRAIN SIZE 66095031.GPJ TERRACON.GDT 11/4/09



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	**S-6**	**1.0ft**	**POORLY GRADED SAND with SILT(SP-SM)**	**NP**	**NP**	**NP**	**0.63**	**7.48**

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**S-6**	**1.0ft**	**19**	**0.722**	**0.209**	**0.097**	**13.7**	**81.2**	**5.1**	

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GRAIN SIZE DISTRIBUTION

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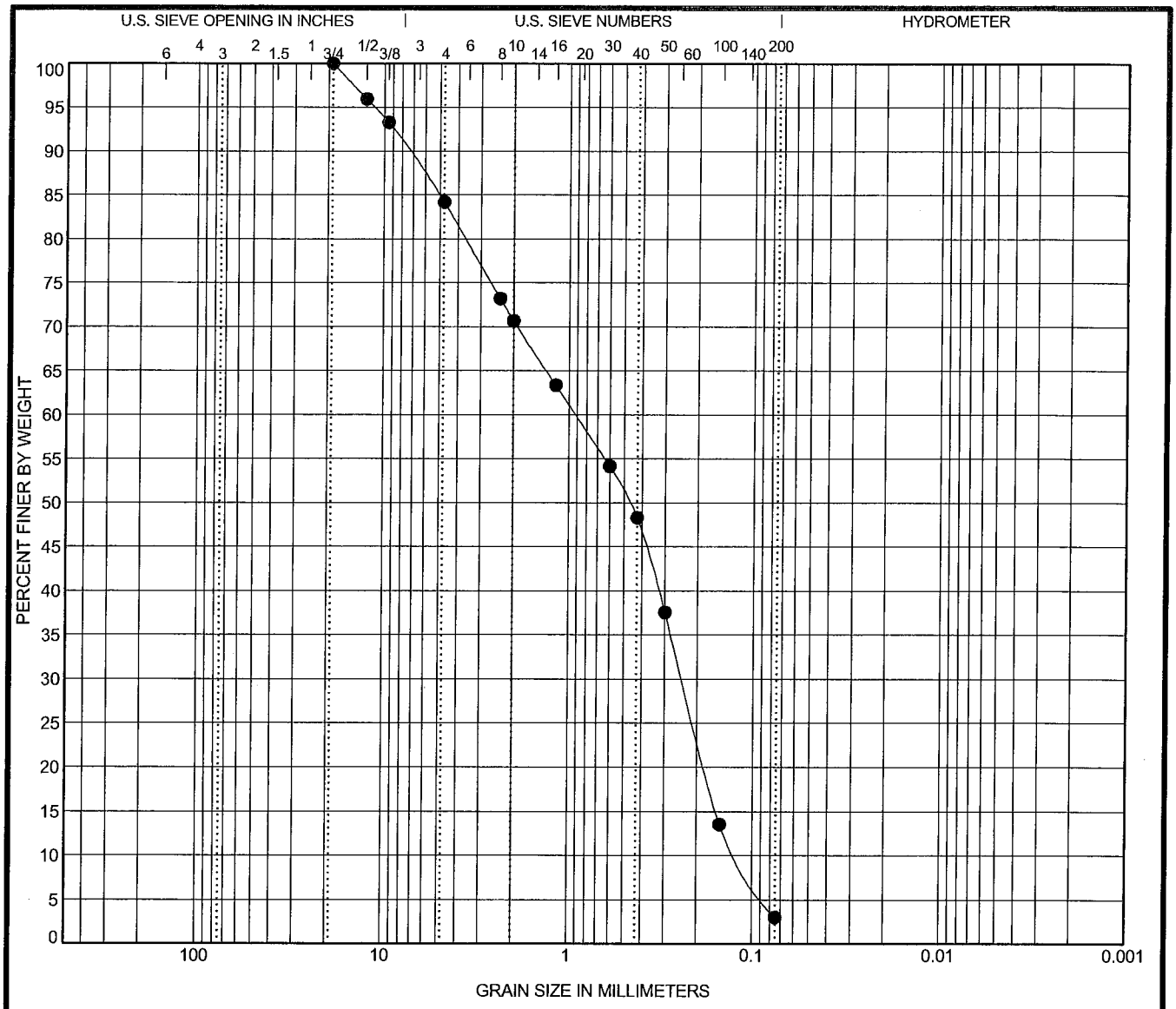
Job #: 66095031
Date: 11-4-09

TC GRAIN SIZE 66095031.GPJ TERRACON.GDT 11/4/09



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	S-7	1.0ft	POORLY GRADED SAND with GRAVEL(SP)	NP	NP	NP	0.53	7.75

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	S-7	1.0ft	19	0.921	0.241	0.119	15.8	81.2	3.0	

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GRAIN SIZE DISTRIBUTION

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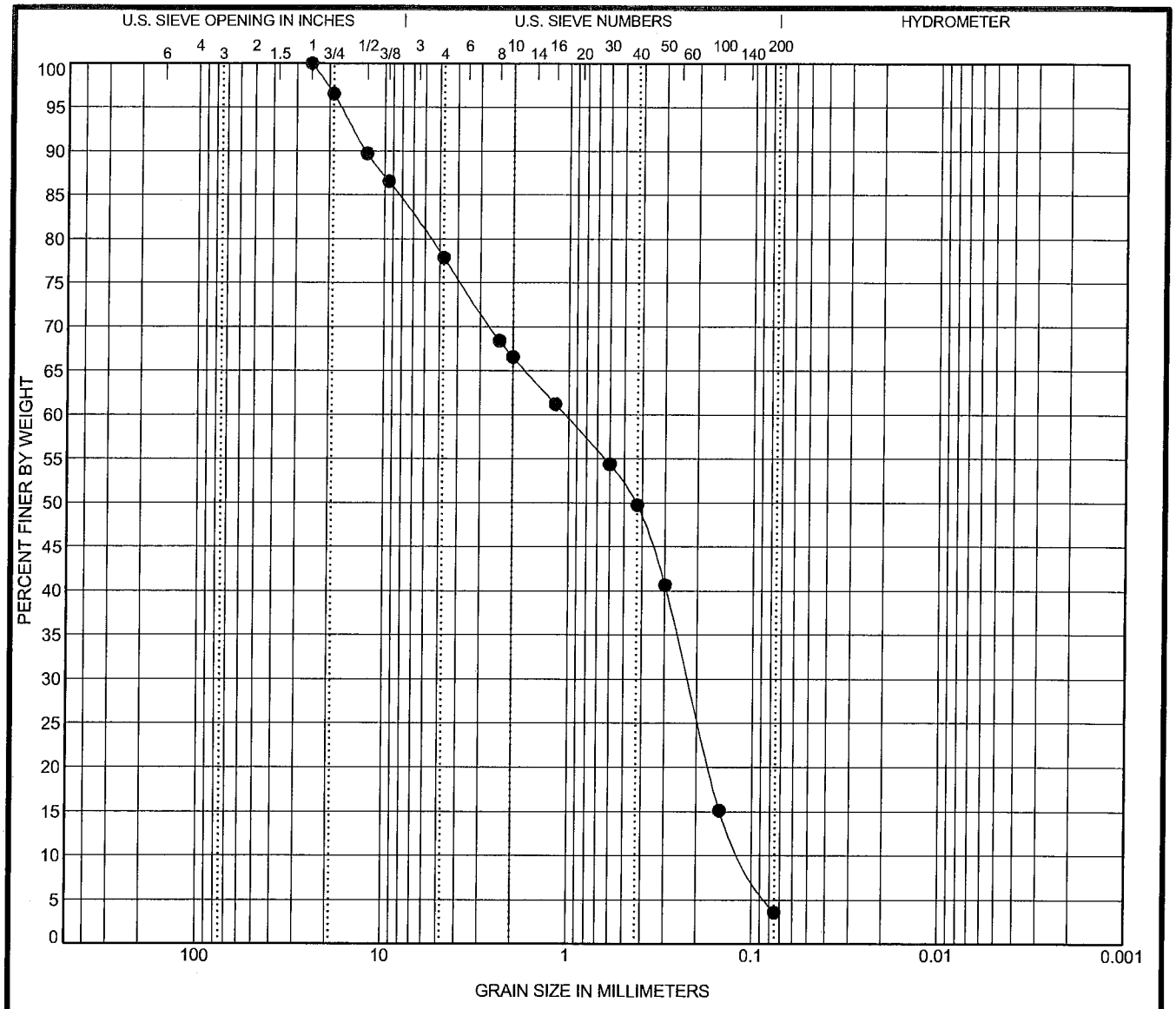
Date: 11-4-09

TC GRAIN SIZE 66095031.GPJ TERRACON.GDT 11/4/09



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	**S-8**	**1.0ft**	**POORLY GRADED SAND with GRAVEL(SP)**	**NP**	**NP**	**NP**	**0.44**	**9.46**

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**S-8**	**1.0ft**	**25**	**1.045**	**0.225**	**0.11**	**22.1**	**74.3**	**3.6**	

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GRAIN SIZE DISTRIBUTION

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Job #: 66095031
Date: 11-4-09

TC_GRAIN_SIZE_66095031.GPJ TERRACON.GDT 11/4/09

Borehole	Depth ft	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Size (mm)	%<#200 Sieve	USCS Class-ification	Water Content (%)	Dry Unit Weight (pcf)	Satur-ation (%)	Void Ratio
S-1	1.0	NP	NP	NP	19	6	SP-SM	2			
S-2	1.0	NP	NP	NP	19	4	SP	3			
S-3	1.0	NP	NP	NP	19	2	SP	1			
S-4	1.0	NP	NP	NP	12.5	3	SP	2			
S-5	1.0	NP	NP	NP	19	4	SP	2			
S-6	1.0	NP	NP	NP	19	5	SP-SM	1			
S-7	1.0	NP	NP	NP	19	3	SP	2			
S-8	1.0	NP	NP	NP	25	4	SP	2			

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SUMMARY OF LABORATORY RESULTS

Project: La Barranca Arroyo
Site: Rio Rancho, NM
Job #: 66095031
Date: 11-4-09

GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:

SS:	Split Spoon - 1-3/8" I.D., 2" O.D., unless otherwise noted	HS:	Hollow Stem Auger
ST:	Thin-Walled Tube - 2" O.D., unless otherwise noted	PA:	Power Auger
RS:	Ring Sampler - 2.42" I.D., 3" O.D., unless otherwise noted	HA:	Hand Auger
DB:	Diamond Bit Coring - 4", N, B	RB:	Rock Bit
BS:	Bulk Sample or Auger Sample	WB:	Wash Boring or Mud Rotary

The number of blows required to advance a standard 2-inch O.D. split-spoon sampler (SS) the last 12 inches of the total 18-inch penetration with a 140-pound hammer falling 30 inches is considered the "Standard Penetration" or "N-value". For 3" O.D. ring samplers (RS) the penetration value is reported as the number of blows required to advance the sampler 12 inches using a 140-pound hammer falling 30 inches, reported as "blows per foot," and is not considered equivalent to the "Standard Penetration"or "N-value".

WATER LEVEL MEASUREMENT SYMBOLS:

WL:	Water Level	WS:	While Sampling	N/E:	Not Encountered
WCI:	Wet Cave in	WD:	While Drilling		
DCI:	Dry Cave in	BCR:	Before Casing Removal		
AB:	After Boring	ACR:	After Casing Removal		

Water levels indicated on the boring logs are the levels measured in the borings at the times indicated. Groundwater levels at other times and other locations across the site could vary. In pervious soils, the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater levels may not be possible with only short-term observations.

DESCRIPTIVE SOIL CLASSIFICATION: Soil classification is based on the Unified Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

CONSISTENCY OF FINE-GRAINED SOILS

Unconfined Compressive Strength, Qu, psf	Standard Penetration or N-value (SS) Blows/Ft.	Consistency
< 500	0 - 1	Very Soft
500 – 1,000	2 - 4	Soft
1,000 – 2,000	4 - 8	Medium Stiff
2,000 – 4,000	8 -15	Stiff
4,000 – 8,000	15 - 30	Very Stiff
8,000+	> 30	Hard

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Standard Penetration or N-value (SS) Blows/Ft.	Ring Sampler (RS) Blows/Ft.	Relative Density
0 – 3	0-6	Very Loose
4 – 9	7-18	Loose
10 – 29	19-58	Medium Dense
30 – 49	59-98	Dense
> 50	> 99	Very Dense

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 – 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300mm)
Cobbles	12 in. to 3 in. (300mm to 75 mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm)
Silt or Clay	Passing #200 Sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 – 12
Modifiers	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1-10
Medium	11-30
High	> 30

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UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]					Soil Classification	
					Group Symbol	Group Name[B]
Coarse Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[E]		GW	Well-graded gravel[F]
			$Cu < 4$ and/or $1 > Cc > 3$[E]		GP	Poorly graded gravel[F]
		Gravels with Fines More than 12% fines[C]	Fines classify as ML or MH		GM	Silty gravel[F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel[F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[E]		SW	Well-graded sand[I]
			$Cu < 6$ and/or $1 > Cc > 3$[E]		SP	Poorly graded sand[I]
		Sands with Fines More than 12% fines[D]	Fines classify as ML or MH		SM	Silty sand[G,H,I]
			Fines Classify as CL or CH		SC	Clayey sand[G,H,I]
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	inorganic	PI > 7 and plots on or above "A" line[J]		CL	Lean clay[K,L,M]
			PI < 4 or plots below "A" line[J]		ML	Silt[K,L,M]
		organic	Liquid limit - oven dried / Liquid limit - not dried	< 0.75	OL	Organic clay[K,L,M,N] / Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line		CH	Fat clay[K,L,M]
			PI plots below "A" line		MH	Elastic Silt[K,L,M]
		organic	Liquid limit - oven dried / Liquid limit - not dried	< 0.75	OH	Organic clay[K,L,M,P] / Organic silt[K,L,M,Q]
Highly organic soils	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

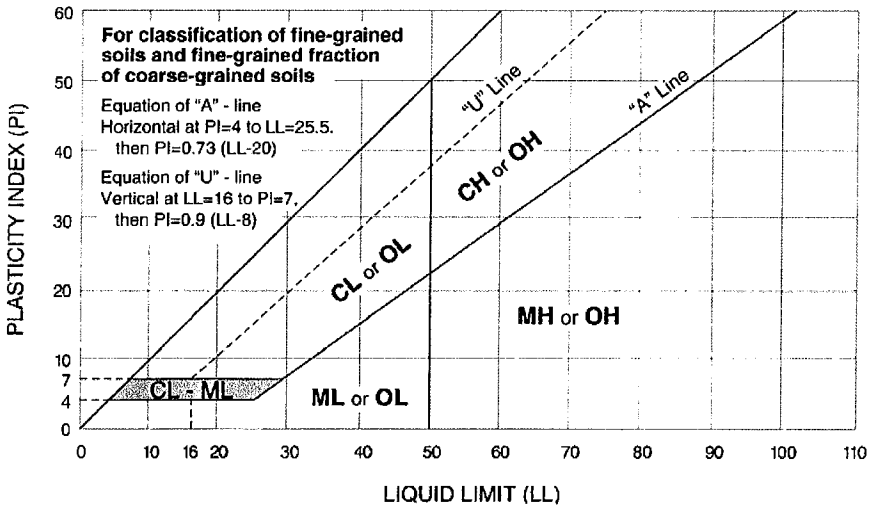
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



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