

Appendix 18.A

Baseline Channel Inventories of Pinabete Arroyo and No Name Arroyo
from 1998 and 2007 (Edited 2013)

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**BASELINE CHANNEL INVENTORIES OF PINABETE ARROYO AND NO NAME ARROYO
FROM 1998 AND 2007 (EDITED 2013)**

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**BASELINE CHANNEL INVENTORIES OF PINABETE ARROYO AND NO NAME ARROYO
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<u>18.A-2</u>	Pinabete Arroyo Cross Sections
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INTRODUCTION

Appendix 18.A includes two channel reconnaissance memos from 1998 and 2007 (edited 2013) on Pinabete and No Name Arroyos, and five exhibits with cross-section and profile information. [Exhibit 18.A-1](#) is the 1998 survey of Pinabete Arroyo with cross-sections at the upstream and downstream monitoring locations and a channel profile which was drawn between the six channel characterization sites' elevation data. The cross-sections shown on [Exhibit 18.A-2](#) documented the 2007 return to the channel characterization sites on Pinabete and re-survey of cross-sections. Two of the Pinabete Arroyo channel characterization sites, Upper Pinabete Station- B (MID) and P-6B (MID), were also resurveyed in 2008 and are presented on [Exhibit 18.A-2](#). [Exhibit 18.A-3](#) is the 1998 survey of No Name Arroyo with cross-sections at the upstream and downstream monitoring locations and a channel profile which was drawn from one mile upstream of the uppermost site, NN-7, to the confluence with the Chaco River, using elevations acquired at the seven channel characterization sites. [Exhibit 18.A-4](#) is a channel profile of lower No Name between channel characterization site NN-3 and the confluence of No Name with the Chaco River developed from aerial survey with ground truth performed to depict topography with and near the channel at a 1-foot contour interval. [Exhibit 18.A-5](#) shows cross-sections developed during the 2007 channel reconnaissance on the No Name stations.

The 1998 channel reconnaissance survey established six stations on Pinabete and seven stations on No Name to assess channel geomorphology conditions. As noted in the section titled "Channel Inventory and Evaluation for No Name Arroyo and Pinabete Arroyo 1998, Edited 2013", the survey consisted of walking one thousand-foot segments of the channel in the vicinity of the stations to generally characterize the channel. The extent of scouring and deposition along the stream, the occurrence of bedrock outcrops, bank stability and vegetative stabilization features were documented. A channel cross section was then chosen which most closely characterized the channel reach. Measurements of channel bottom width, top width and channel depth were made at the cross section using a surveyor's tape and staff gage. The upper and lower sites of each channel became established surface water monitoring locations.

The 2007 Channel Inventory and Evaluation for No Name Arroyo and Pinabete Arroyo were performed to acquire more recent geomorphologic data on Pinabete and No Name Arroyos to reflect pre-mine conditions. The evaluation included a channel stability assessment, a sinuosity evaluation, conceptual classification of bed and bank soils and the subsequent Manning's n values, and a drainage density appraisal. The survey generally returned to the 1998 stations, but many of the original survey posts were not found. A GPS unit was utilized to develop the cross-section information. A new site was established on the lower end of Pinabete (P-6) to better reflect conditions near the northwest lease boundary.

The 1998 profiles and cross sections for Pinabete and No Name ([Exhibit 18.A-1](#) and [Exhibit 18.A-3](#), respectively) include three cross sections at the uppermost and lower most channel geomorphology

stations. The locations of the crest stage gages and single stage sampler were also documented, as these stations became the surface monitoring locations.

The 2007 cross sections for the Pinabete and No Name are presented in [Exhibit 18.A-2](#) and [Exhibit 18.A-5](#), respectively. When cross sectional information for 1998 was available at the station, it was plotted on the cross section. The 1998 data appeared to be between 0.5 and 6 feet lower in elevation than the 2007 data. Rather than interpreting this as an expression of significant aggradation during the 1998-2007 time interval, best characterized as a drought, it is thought that any gross elevation differences are better described as a shift in the original datum. Substantially better channel information was acquired in 2008, when BHP Navajo Coal Company (BNCC) had the lower 4.3 miles of No Name flown for mapping at a 1-foot contour interval. The topographic map showing a 500-foot average coverage on either side of the channel is displayed on [Exhibit 18.A-4](#). A channel profile was developed from this survey which clearly identifies knickpoints at eight locations as the arroyo passes through badland topography. The largest change is seen at 18,450 feet upstream of the confluence, with a 10-foot drop in elevation. A comparison was made between the cross sections surveyed in 2007 and the ones generated by the 1-foot contour map at the Lower No Name monitoring station and NN-3, and the 2008 elevations averaged 3.5 feet higher than the cross-section information developed in 2007. Again, these differences may be the result of differences in the datum used for the surveys. The general shape of the cross sections is very similar, leading us to believe that the surveys were at approximately the same location. However, the difficulty in comparing channel surveys between the two time periods is the result of obtaining consistent information from different groups of surveyors and establishing accurate datum and permanent channel survey monuments in remote locations.

**CHANNEL INVENTORY AND EVALUATION FOR
NO NAME ARROYO AND PINABETE ARROYO
1998, EDITED 2013**

Introduction

A stream channel inventory and evaluation was conducted to describe the pre-mining conditions for the main channels of Pinabete Arroyo and No Name Arroyo in 1998. The purpose of this work was to document the channel conditions prior to mining, including the presence of bedrock outcrops, and indicators of channel instabilities such as knickpoints, channel cutbanks, and channel scour or deposition. The composition of the channel bed and bank materials, cross section dimensions, and vegetation type and density were also noted. These characteristics provide indications of the capacity of the stream channels to adjust and recover from potential changes due to mining and reclamation. This inventory also included surveys of channel cross sections and slopes and estimation of Manning roughness coefficients at surface water monitoring locations.

Methods

A stream channel inventory describes the spatial variability in a stream's characteristics at a specific point in time. Prior to the field visit, main channel profiles were plotted from topographic maps featuring 10-foot contour intervals. Locations of convex segments in the channel profile, channel knickpoints, monitoring station locations, and surface water impoundments were identified on the map. Channel inventory locations were selected to include these channel features. Inventory locations were spaced about every mile through the permit area and at a farther spacing downstream of the permit area. There is no defined channel on No Name Arroyo upstream of the permit area and the inventory did not extend beyond the upstream monitoring station on Pinabete Arroyo.

During the field inventory, a 1,000-foot segment of the channel was walked at each location to roughly characterize the channel. Features including the vegetation conditions on the channel bottom and banks, the occurrence of steep bank slopes and evidence of bank failure, extent of scouring and deposition along the stream, and the occurrence of bedrock outcrops were documented. A channel cross section was then chosen which most closely characterized the channel reach. Measurements of channel bottom width, top width and channel depth were made at the cross section using a surveyor's tape and staff gage. The composition of the channel bottom and bank were field classified in accordance with the Unified Soil Classification (USC) system. Photographs were taken to document channel conditions at each channel inventory location.

At each of the monitoring station locations, channel cross sections, crest stage gages, and single stage sediment samplers were surveyed and estimates of Manning's roughness coefficients were determined

using the procedure for small channels as described in Gray (1970). Using this procedure the value of Manning's roughness coefficient, n , is estimated from table values for component conditions which affect hydraulic roughness and resistance to flow. These conditions include channel materials, channel vegetation, surface irregularities, variations in channel shape, obstructions, and channel meandering.

The survey of channel cross-sections at the stream monitoring stations was completed on June 2, 1998, before the start of the thunderstorm runoff season, and again on November 30, 1998, at the end of the season. The surveyed sections for both dates are provided in [Exhibit 18.A-1](#) and [Exhibit 18.A-3](#). The channel profiles did not change significantly between the two survey dates but the channel cross sections at the Pinabete Arroyo stations changed due to floods redistributing sediment deposits within the channel. The change in channel cross sections at the No Name Arroyo stations were much less than at the Pinabete station locations.

Pinabete Arroyo Inventory

The main Pinabete Arroyo channel profile shown in [Exhibit 18.A-1](#) exhibits a slightly concave channel profile with channel slopes of 0.55 % or higher at the upstream segment near the eastern permit boundary and decrease to about 0.43 % downstream at the western permit boundary. No knickpoints, or convex segments, are present in the channel profile in the vicinity of the Navajo Mine Extension permit area. Road crossings and monitoring station locations within or near Pinabete Arroyo are also shown on [Exhibit 18.A-1](#). No surface water impoundments are located within the main channel of Pinabete Arroyo within the permit area.

The inventory of channel conditions was conducted at six cross section locations along the main stem of Pinabete Arroyo within or near the permit area. The inventory is presented below. The location descriptions begin with the upstream location and proceed downstream at distances measured along the channel. The cross section locations are shown on [Exhibit 18.A-2](#).

Location P1

This location is at the upstream monitoring station of Pinabete Arroyo. The channel at this location is incised with a trapezoidal shape featuring a bottom width of 24.5 feet, a top width of 42.5 feet, and a depth of 3 feet. Channel bottom materials are sands (SP) with pebbles and stones. Channel banks consist of medium sand (SP) with semi-consolidated sands and gravels that form steep near vertical banks. Bedrock outcrops occur in the channel banks upstream of location P1. Sandstone slabs and fragments have sloughed into the channel from the erosion of the embankments on meander bends as shown in Figure 18.A-1. No vegetation is found on the channel bottom and sparse shrubs grass and tamarisk occur on the channel banks and sand bars as shown in Figure 18.A-2. The channel appears to be in a state of dynamic equilibrium along this reach. The erosion of the channel banks on meander bends is compensated by sand deposition

on the inside of the meanders. The channel slope at this location is about 0.56% and the valley slope about 0.8%.

The value of Manning's roughness coefficient, n , was estimated to be 0.032 using the procedure for small channels described in Gray (1970). The estimated contribution to roughness from component conditions includes:

Channel materials,	0.022
Channel vegetation, negligible	0.000
Surface irregularities,	0.005
Variations in channel section,	0.005
Obstructions, and meandering,	0.000



Figure 18.A-1 Pinabete Arroyo upstream of location P1, looking upstream



Figure 18.A-2 Pinabete Arroyo location P1, looking downstream

Location P2

This location is approximately 7,700 feet down the channel from location P1. The channel at this location is trapezoidal but wider and shallower than P1 with a bottom width of 40 feet, a top width of 58 feet, and a depth of about 2.1 feet. The channel bottom is comprised of fine sand (SP) with sparse coal and rock fragments. The channel banks consist of sand with negligible fines (SW). Salt deposits occur on bed and bank materials due to evaporation of ground water seepage as shown in Figure 18.A-3. The rate of seepage is insufficient to cause surface flow. The No. 8 coal seam outcrop occurs near this cross section location as shown in Figure 18.A-4 and may be the source of seepage. No vegetation occurs on the channel bottom. Dense shrubs and forbs occur on the channel banks and overbanks. The channel slope at this location is about 0.51% and the valley slope about 0.6%.



Figure 18.A-3 Pinabete Arroyo location P2, looking upstream



Figure 18.A-4 Coal outcrop on channel bank at Pinabete Arroyo location P2

Location P3

This location is approximately 5,530 feet down channel from location P2. This location is on a meander bend immediately upstream of the Burnham Road crossing as shown in Figure 18.A-5. The channel at this location is approximately trapezoidal with a 48-foot wide sand bar and the inside of the meander bend. The

bottom width is 24 feet and top width, excluding the sand bar, is 40 feet. The channel is about 2.8 feet deep. The channel bottom and sand bar are comprised of sand with gravel (SW), with a greater gravel fraction on the sand bar. The channel banks are comprised of sand with a higher fine fraction (SP) and are cohesive enough to form steep banks in places. The channel banks are sparsely vegetated and the sand bar and channel bottom are devoid of vegetation as shown in Figure 18.A-5. Shrubs occur on the overbanks. The channel slope at this location is about 0.51% and the valley slope about 0.7%



Figure 18.A-5 Pinabete Arroyo location P3, looking upstream

Location P4

This location is at the road crossing to the dug alluvial well and monitoring well PA-1 and is approximately 5,750 feet down the channel from location P3. The channel at this location exhibits considerable meandering with bedrock outcrops common on the outside of meander bends. The channel at this location is approximately trapezoidal with a bottom width of 54 feet and top width of 65 feet. The channel is about 2.0 feet deep. The channel bed and banks are comprised of medium to coarse sand (SW), with a higher gravel fraction on the sand bars located on the inside of meander bends. The channel banks and overbanks are vegetated with grasses and shrubs while channel bottom is devoid of vegetation as shown in Figure 18.A-6. The channel slope at this location is about 0.51% and the valley slope about 0.9%



Figure 18.A-6 Pinabete Arroyo location P4, looking upstream

Location P5

This location is approximately 6,600 feet down the channel from location P4. The channel at this location exhibits considerable meandering with steep cutbanks on the outside of meander bends. The channel at this location is slightly narrower than at location P4 with a bottom width of 33 feet. The channel is about 3.0 feet deep. The channel bends and banks on the inside of meander beds are comprised of medium sand (SW) with pebbles. The channel banks on the outside of meander bends are comprised of cohesive sand with fines (SP). The channel banks and overbanks are vegetated with grasses and shrubs while channel bottom is devoid of vegetation as shown in Figure 18.A-7. The channel slope at this location is about 0.51% and the valley slope about 1.2%.



Figure 18.A-7 Pinabete Arroyo location P5, looking downstream

Location P6

Location P6 is approximately 16,600 feet downstream of location P5. This location is downstream of the western permit boundary and includes stage crest gages and single stage samplers for the Lower Pinabete Arroyo surface water monitoring station. The channel is approximately trapezoidal in shape with a top width of approximately 115 feet, a bottom width of about 70 to 80 feet, and a channel depth of 4 feet. Channel cross sections associated with the crest stage gages are included on [Exhibit 18.A-1](#). Bottom sediments consist of sand with sparse gravel and rock fragments (SW). Channel banks are sand (SW). A sandstone outcrop occurs on the south bank of the location as shown in Figure 18.A-8. There is no vegetation on the channel bottom and the channel banks are steep with sparse shrub cover. The overbanks have a variable cover of grasses and shrubs. The channel slope at this location is about 0.33 % and the valley slope is about 0.6%.

Manning roughness coefficient for the channel is estimated to be 0.032 using the procedure for small channels described in Gray (1970). The estimated contribution to roughness from component conditions includes:

Channel materials,	0.022
Channel vegetation, negligible	0.000
Surface irregularities,	0.005
Variations in channel section,	0.005
Obstructions, and meandering,	0.000



Figure 18-A.8 Pinabete Arroyo location P6, looking upstream

No Name Arroyo Inventory

An inventory of channel conditions was conducted at nine locations along the main stem of No Name Arroyo within the permit area. The inventory location descriptions begin with the No Name Arroyo downstream monitoring station location (NN-1) and proceed up the channel to the No Name Arroyo upstream monitoring station location (NN-7) ([Exhibit 18.A-3](#)). The No Name surface water impoundment is located on the channel just upstream of location NN-4 at the Burnham road crossing as shown on [Exhibit 18.A-3](#). The water quality monitoring station locations within No Name Arroyo are also shown on [Exhibit 18.A-3](#). The main No Name Arroyo channel profile is shown in [Exhibit 18.A-3](#). Knickpoints are present in the channel profile near inventory locations NN-2 and NN-4 as shown on [Exhibit 18.A-3](#). A small knickpoint also occurs at the bedrock outcrop below location NN-1, although this does not show up on the longitudinal profile.

Location NN-1

This location is at the No Name Arroyo downstream monitoring station which is downstream of the western permit boundary. The channel is incised and is approximately trapezoidal in shape with a bottom width of 12 to 15 feet, a top width of 35 to 50 feet and a depth of about 8 feet. Bottom materials are medium to coarse sand with rock fragments (SW). Bank materials are comprised of cohesive silt (MH). No vegetation is found on the channel bottom although the channel is at times partially filled with tumbleweeds as shown in Figure 18-A.9. Shrubs, grass and forbs occur on the channel overbank while the

channel banks are steep and support sparse vegetation. Sandstone bedrock outcrops in the channel just below the monitoring station as shown in Figure 18.A-9. The channel slope at this location is about 1.4% and the valley slope about 1.4%. Manning roughness coefficient for the channel is estimated to be about 0.037 using the procedure for small channels described in Gray (1970). The estimated contribution to roughness from component conditions includes:

Channel materials,	0.022
Channel vegetation, low	0.000
Surface irregularities,	0.010
Variations in channel section,	0.005
Obstructions, and meandering,	0.000



Figure 18.A-9 No Name Arroyo location NN-1, looking upstream

Location NN-2

This location is immediately above a 15-foot head cut on No Name Arroyo approximately 3,000 feet upstream of the location NN-1. The channel upstream of the head cut is approximately parabolic in shape

with a bottom width of about 5 feet, a top width 15 feet, and a depth of about 1 to 1.5 feet. Channel bed and bank materials are comprised cohesive silts (MH) with dense shrubs and grass as shown in Figure 18-A.10. A relatively broad, well-vegetated floodplain occurs on either side of the channel. Downstream of the head cut, the channel is deeply incised with near vertical banks that slough readily as seen in Figure 18-A.11. Bank materials are cohesive silts (MH). The channel bottom and banks are devoid of vegetation and the channel is partially filled with tumbleweeds as shown in Figure 18.A-11. The channel slope at this location is about 0.71% and the valley slope about 1.3%.



Figure 18.A-10 No Name Arroyo location NN-2, looking upstream



Figure 18.A-11 Headcut below No Name Arroyo Location NN-2, looking downstream

Location NN-3

This location is approximately 3,100 feet upstream of the No Name Arroyo location NN-2. The channel is approximately trapezoidal in shape with a bottom width of 5 feet, a top width of approximately 20 feet, and a depth of about 5 feet. The channel bed is composed of medium sand with fine gravel and rock fragments (SP). The channel banks are composed of cohesive silty sand (SM). No vegetation is found on channel bottom but shrubs and grasses are abundant on the channel banks and overbanks as shown in Figure 18-A.12. The channel was partially filled with tumbleweeds as shown in Figure 18.A-12. The channel slope and valley slope at this location are both approximately 0.72%.



Figure 18.A-12 No Name Arroyo location NN-3, looking upstream

Location NN-4

This location is immediately below the No Name impoundment approximately 3,350 feet upstream of the No Name Arroyo location NN-3. A channel section was not measured at this location because of the significant variation in channel conditions. The spillway overflow from the impoundment crosses the Burnham road on the south side and flows down a bedrock lined channel to the valley floor below the impoundment as shown in Figure 18-A.13. A very dense growth of shrubs and tamarisk is present in the valley below the impoundment with channel headcuts occurring at a number of places within the valley floor as shown in Figure 18.A-14. The valley floor soils consist of silt and very fine sand (MH). The valley slope just below the No Name impoundment is about 1.0%.



Figure 18.A-13 Spillway channel below No Name Impoundment, location NN-4, looking upstream



Figure 18.A-14 No Name Arroyo location NN-4, looking upstream

Location NN-5

This location is upstream of the No Name Impoundment and approximately 3,300 feet upstream of location NN-4. The channel is incised 2 to 3 feet and is irregular in shape with several channels terminating in headcuts upstream of NN-5. Channel top widths vary from several feet to approximately 20 feet on the main channel below location NN-5. No distinct channel occurs in the valley bottom for a distance of about 1,000 feet upstream of the headcuts. Channel bed and bank materials consist of cohesive silt and fine sand

(MH). No vegetation is found on the near vertical banks where they occur but dense shrubs and grasses are abundant on the overbank but less dense on the channel bottom. The dimensions of the channel section were not measured at this location because of the widely varying sections. Tumbleweeds were found at numerous places within the channel as shown in Figure 18.A-15. The valley and channel slope at this location are about 0.78%.



Figure 18.A-15 No Name Arroyo location NN-5, looking downstream

Location NN-6

This location is approximately 5,060 feet upstream of the location NN-5. The channel is incised about 2 feet and is irregular in shape as shown in Figure 18-A.16. Small channel headcuts and soil pipes were common around location NN-6. The channel above and below this location occurs intermittently within the valley bottom and is typically associated with channel incision with headcuts and soil pipes. Channel bed and bank materials consist of cohesive silts (MH). Vegetation in these areas is sparse due to the presence of limiting soil conditions. The density of vegetation is greatest in minor depressions where water and windblown soils accumulate but channel erosion or scouring does not occur. A channel section was not measured at this location because of the widely varying sections. Tumbleweeds were found at

numerous places within the channel as shown in Figure 18.A-16. The channel and valley slope at this location is about 0.82%.



Figure 18.A-16 No Name location NN-6, looking upstream

Location NN-7

This location is at the upstream monitoring station on No Name Arroyo located just west of the eastern lease boundary approximately 400 feet upstream of location NN-6. The surface water monitoring station includes one stage crest gage and one single stage sampler. The channel is approximately parabolic in shape with a top width of less than 6 feet and a depth of less than 1 foot but varies along the channel. The channel does not extend upstream of this location and occurs intermittently downstream. Channel rills are found within the broad flat valley of No Name Arroyo both upstream and downstream of the eastern lease boundary. Channel cross-sections associated with the stage crest gage and sediment sampler are included on [Exhibit 18.A-3](#). Channel bed sediments at this location are fine sands (SM). Channel banks are comprised of cohesive silty sand (ML). Vegetation occurs on the channel bank and overbank but is very sparse on the channel bed as shown in Figure 18.A-17. The channel and valley slope at this location are about 0.82%. The Manning roughness coefficient for the channel is estimated to be about 0.055 using the procedure for small channels described in Gray (1970). The estimated contribution to roughness from component conditions includes:

Channel materials,	0.020
Channel vegetation, moderate	0.010

Surface irregularities,	0.010
Variations in channel section,	0.015
Obstructions, and meandering,	0.000



Figure 18.A-17 No Name Arroyo location NN-7, looking downstream

References

Gray, D.M. 1970. Handbook on the Principles of Hydrology. Water Information Center, Inc.

**CHANNEL INVENTORY AND EVALUATION FOR
NO NAME ARROYO AND PINABETE ARROYO
2007, EDITED 2013**

Introduction

From August 27 to August 29, 2007, two URS teams independently conducted a baseline channel inventory survey and a drainage density survey on the Pinabete and No Name Arroyos within Area IV South and Area V. The Pinabete Arroyo is the main drainage path for Area IV South, bisecting the lease by flowing from the southeast corner to the northwest corner. The No Name Arroyo is the main drainage path for Area V, and flows from east to west along its northern boundary, just south of Area IV South. The Pinabete Arroyo is proposed to be diverted into the No Name Arroyo during the mining operation of Area IV South. [Exhibit 18.A-6](#) is a map of the study area.

The baseline channel inventory was performed by the team of Bud Brock and Samrat Mohanty as part of the effort to obtain hydrologic information necessary for evaluation of Probable Hydrologic Consequences (PHC) of the previously proposed mining operations in Area IV South. The drainage density survey was completed by the team of Briana Gunn and Bill Sabatka to estimate input parameters for the development of the Approximate Original Contours (AOC) for Area IV South.

Baseline Channel Inventory

The specific objectives of the Baseline Channel Inventory effort are:

- Perform reconnaissance of Pinabete Arroyo and No Name Arroyo, including their major tributaries and associated floodplains to describe pre-mining conditions.
- Evaluate channel stability for both the major arroyos.
- Estimate channel characteristics, such as sinuosity and Manning's n values, for use in later modeling efforts.
- Perform limited conceptual classification of bed and bank soils.

Field Reconnaissance Methodology

The URS team performed reconnaissance of the Pinabete Arroyo between the Upper Pinabete Monitoring Station, P-1, and Lower Pinabete Monitoring Station, P-6, and of the No Name Arroyo between Upper No Name Monitoring Station, NN-7, and Lower No Name Monitoring Station, NN-1, as well as their major tributaries and floodplains.

Key channel features identified included road crossings, culverts, dams, tributary junctions, bedrock outcrops, head cuts, bend points, and locations of convex segments within the channel flow path. The conditions of the channels along each course were described, including vegetative conditions in the channel

and on the overbanks, the occurrence of steep bank slopes, evidence of bank failure, extent of scouring and deposition along the stream, and the classification of stream bed sediments. Photographs of the channel conditions were taken as part of the channel baseline survey for future reference during the Surface Water PHC project. A representative sample of the photos is presented in the text.

Limited soil classifications were performed on the channel bed and bank soils. Physical characteristics such as gradation, texture, moisture, plasticity, and density were noted for soils at selected locations. Locations were chosen based on their proximity to the monitoring stations, survey cross-sections, and any location with a perceived change in soil type.

Observations on No Name Arroyo

The No Name Arroyo is a fairly “young” arroyo, currently undergoing significant evolution. Overall, the No Name Arroyo is fairly straight for the reach located within the BNCC mining lease and flows in a general northwesterly direction. There are numerous small bends and turns in the channel, but they are minor and have little effect on the overall direction of the stream. The exception is the last major bend in the channel, approximately 900 feet upstream of NN-2. At this location, the channel takes a bend of approximately 30-degrees to the north. From here the channel continues on a north-by-northwesterly direction until the confluence point with Chaco River.

The stream characteristics for No Name Arroyo can be divided into two distinct sections, upstream (east) of Burnham Road and downstream (west) of Burnham Road. For the majority of the stream reach upstream of the Burnham Road, there is a narrow, shallow, and discontinuous low flow channel with the capacity to convey runoff from the frequent storm events (1 to 5 year storm events). The low flow channel varies from 1 to 4 feet in dept and 2 to 10 feet in width. Bends in the channel are up to, and in a few locations exceed, 90-degrees. Flows resultant from the larger storm events overtop the low flow channel and are conveyed in a wide “U” shaped shallow concentrated flow area. The shallow concentrated flow area ranges from approximately 50 to 100 feet wide, with some locations approaching 200 feet. The soil has minimal alluvial deposits consisting primarily of a clayey loam. Vegetation in the shallow concentrated flow area consists of low to medium grass with scattered low to medium brush for an effective ground cover of 60% to 80%. The Manning’s n value for the channel is estimated to be 0.04. The two areas where the channel does not conform to these general statements are described below.



Figure 18.A-18 No Name Arroyo low flow channel upstream of Burnham Road

The area from NN-7 to approximately 500 feet downstream, the channel is incised at a depth of 2 to 4 feet and a width of 10 to 20 feet and has significant braiding. With the exception of the rare major storm events, flow is confined to the channel. The vegetation in the channel is consistent with the downstream section; however, the effective ground cover is approximately 50% in the channel resulting in an estimated Manning's n value of 0.035.



Figure 18.A-19 No Name Arroyo shallow concentrated flow area upstream of Burnham Road

Immediately upstream of Burnham Road is the other location where the No Name Arroyo characteristics deviate from the typical channel section described above. Burnham Road acts as a retention structure creating a ponding area on the upstream side of the road. No crossing culverts were found. The gradient of the road slopes downward from north to south with a small dip in the road just south of the effective ponding area before the gradient of the road starts in an upward slope. This dip in the road acts as an overflow location for the ponding area and corresponds to a sandstone outcrop that limits the erosion of the roadway. The ponding area has an effective ponding depth of approximately 4 to 6 feet before flow will inundate the overflow location. It is assumed this ponding area was intentionally created to serve as a cattle watering pond. The bottom of the ponding area is covered with clayey soil. There is little to no vegetation in the bottom of the ponding area; however, heavy brush is present on the upstream half of the pond overbanks. This heavy brush extends into and up the channel feeding the pond for approximately 500 feet creating an effective ground cover of almost 100% resulting in an estimated Manning's n value for this part of the channel of 0.15.



Figure 18.A-20 No Name Arroyo upstream of NN-7



Figure 18.A-21 No Name Arroyo ponding area upstream of Burnham Road looking upstream

Vegetation in the overbank area is fairly consistent along the stream reach and is composed primarily of low grass with interspersed low brush covering approximately 5% to 30% of the ground. The soil in the overbank area is fairly consistent with that in the channel, with the exception of the presence of more gravel. There are few medium to large size rocks in the channel or overbank area. The Manning's n value is estimated to be approximately 0.035 for the overbank area.

The overbank areas consist of a gently sloping floodplain area leading to widely spaced rolling hills. The hills range up to approximately 100 feet high and are composed primarily of fractured sandstone gravel intermixed with loose soils. Tributaries in the area are typically shallow concentrated or sheet flow with only a few of the tributaries having incising at the main channel with a head cut depth of 1 to 3 feet. Upstream of the tributary head cut, the flow regime consists of shallow concentrated and sheet flow.

For the majority of the stream reach downstream of Burnham Road, the channel is well defined with incised depths up to 15 feet, steep to vertical side slopes, and bends ranging from 10 to 45-degrees. The soils in the channel banks are collapsible clayey silt. There is a significant amount of fractured sandstone in the bottom of the channel that has washed into the arroyo from the outcroppings to the north or from discrete outcroppings in the channel banks. There are a few scattered locations where fractured sandstone outcroppings are present in the channel banks, almost always on the north side. Sandstone outcroppings were noted in the channel bottom at two locations, approximately 200 feet upstream of NN-2 and approximately 1,500 feet downstream of NN-4. Vegetation in the overbank area is fairly consistent along the stream reach and is composed primarily of low grass with interspersed low brush covering

approximately 5% to 30% of the ground surface. The soil in the overbank area is fairly consistent with that in the channel, with the exception of the presence of more gravel. There are few medium to large size rocks in the channel and overbank areas. The Manning's n value is estimated to be approximately 0.035 for this overbank area. Vegetation and Manning's n values in the channel varies from upstream to downstream and are discussed per section below.



Figure 18.A-22 No Name Arroyo sandstone outcropping upstream of NN-2

Immediately downstream of Burnham Road, the channel is difficult to discern due to the thick vegetation consisting of dense salt cedar, brush, and grass constituting an effective ground cover of approximately 100%. Approximately 500 feet downstream of Burnham Road, the channel flairs out and becomes visible. The channel cross section in this area displays a benched condition. From the channel bank, it drops approximately 8 to 15 feet where it hits a small bench, roughly 5 feet wide. It then drops another 2 to 5 feet to the low flow portion of the channel, which is generally 2 to 5 feet wide. Overall, the channel width varies from approximately 15 to 40 feet wide. This general channel configuration continues downstream for approximately 500 feet to near the location of NN-4. The channel is fairly straight in the area with bends not exceeding 10 to 20 degrees. Due to the thick vegetation, the Manning's n for this portion of the channel is estimated to be 0.15.

From NN-4 to downstream approximately 1,000 feet, the channel is 10 to 12 feet deep and 10 to 20 feet wide. Vegetation in the channel is very thick constituting a ground cover of approximately 80%. Bends are more pronounced and frequent but do not exceed approximately 45 degrees. Due to the thick vegetation, the Manning's n value for this portion of the channel is estimated to be 0.10.



Figure 18.A-23 No Name Arroyo at approximately NN-4

From approximately 1,000 feet downstream of NN-4 to approximately 500 feet downstream of NN-3, the channel is 8 to 10 feet deep and 10 to 20 feet wide. Vegetation in the channel still consists of salt cedar, brush, and low to medium grasses, but the density has decreased to an effective ground cover of approximately 50%. Bends are still fairly frequent but do not exceed approximately 45 degrees. The Manning's n value for this portion of the channel is estimated to be 0.05.

At approximately 500 feet downstream of NN-3, the channel dissipates over the course of approximately 200 feet as it exits a tight meander. The flow regime reverts to shallow concentrated and overland flow for a stretch of approximately 2,000 feet. Where a defined channel exists for this stretch of the arroyo, it is heavily braided, no more than 3 feet deep, and in excess of 30 feet wide. There are stretches where a definitive channel is not present and runoff reverts to sheet flow conditions. Vegetation in the channel and overland flow area is thicker than the downstream channel reaches, consisting of low to medium grasses and weeds, brush, and some salt cedar constituting a ground cover of approximately 50%. The Manning's n value for this portion of the channel is estimated to be 0.04. The overland flow terminates at a major head cut in the channel located approximately 1,000 feet upstream of NN-2. The head cut is approximately 30 feet wide and 12 feet deep. Downstream of the head cut, there is a definable channel as described in the following paragraph.

From the head cut to NN-2, braiding is frequent and the side slopes are vertical. The channel is approximately 8 to 12 feet deep and approximately 10 to 30 feet wide. The top edge of the channel banks tend to be sharp, indicating the channel is relatively new. Bends are fairly minor and range from less than

10 degrees to a maximum of 45 degrees. Vegetation in the channel consists primarily of low grass with some salt cedar and low brush constituting a ground cover of approximately 30%. The Manning's n value for this portion of the channel is estimated to be 0.03.



Figure 18.A-24 No Name Arroyo headcut approximately 1,000 feet upstream of NN-2



Figure 18.A-25 No Name Arroyo from NN-2 to NN-1

From NN-2 to NN-1, the channel banks are vertical or nearly vertical in most locations. In the locations where the channel banks are not vertical, they range to a side slope of approximately 3h:1v. The top edge

of the channel banks have been rounded over by erosion, indicating the incision has been in place for a few years. There is little to no braiding in the channel. Channel depths, widths, vegetative cover, Manning's n value, and bends are consistent with the preceding section.

The overbank areas consist of a gently sloping floodplain area with a varied width from 50 to 200 feet leading to a fairly dense clustering of steep hills. The hills are generally up to approximately 100 feet high and are composed primarily of fractured sandstone overlain by loose soils. The majority of the hills have at least one side consisting of a vertical face of fractured sandstone. Tributaries in the area are typically incised at the main channel and upstream for up to 200 feet with a head cut depth of 2 to 5 feet. Upstream of the tributary head cut, the flow regime consists of shallow concentrated and sheet flow.

Observations on Pinabete Arroyo

The Pinabete Arroyo is a well defined and established channel. The overall trend of the channel is fairly straight through the BNCC mining lease area flowing in a general north by northwesterly direction. Right before the channel exits the mining lease area, there are a series of bends that result in an almost 90 degree change in the overall direction of the channel leaving it flowing in a west-by-northwesterly direction until its confluence with the Chaco River.

The stream characteristics for the Pinabete Arroyo are fairly consistent through the study area. The slope of the channel upstream of the BNCC mining lease boundary is 0.65% and downstream of the lease boundary is 0.31%. Typically, the channel is 4 to 10 feet deep and 20 to 80 feet wide with side slopes in the range of 4h:1v to 10h:1v. At the bend points, the side slopes on the outside of the bend transition to vertical. Vegetation in the channel is almost solely confined to the channel banks and consists of low grass, some small brush, and the occasional salt cedar clump. The soil in the channel is primarily silty sand with very little to no clay content. There are a couple of locations where bedrock is exposed in the channel. These are at Burnham Road and approximately half way between P-1 and P-2. Otherwise, the channel is basically devoid of rock of any size, with the exception of the sandstone outcroppings at the bend points. The estimated Manning's n value for the channel is 0.022.

Although the general trend of the arroyo is fairly straight, the sinuosity of the channel is relatively high. There are numerous bend points with angles greater than 90 degrees, with a large percent of the bends approaching 180 degrees. Typically, between the major bend points the channel is fairly straight or has a gentle meander. There are a few locations on the stream reach where the sinuosity is very high, as one bend ties directly into the next and the bends approach or are in excess of 90 degrees. These areas are from P-1 downstream for 1,500 feet, upstream and downstream of P-3 for approximately 1,500 feet, and a 2,500 stretch of the channel centered approximately half way between P-5 and P-6.



Figure 18.A-26 Pinabete Arroyo typical channel



Figure 18.A-27 Pinabete Arroyo exposed bedrock between P-1 and P-2



Figure 18.A-28 Pinabete Arroyo typical bend point upstream of Burnham Road

Tributaries to the Pinabete Arroyo are typically incised near the confluence point to the main channel. The incising extends up the tributary for no more than approximately 300 feet where it terminates in a small head cut of 2 to 5 feet deep. The overbank area can be divided into two sections, upstream (east) and downstream (west) of Burnham Road. As with the No Name Arroyo, the overbank area upstream of Burnham Road consists primarily of gently rolling hills up to approximately 100 feet high composed primarily of fractured sandstone gravel intermixed with loose soils. The soil in the overbank area is fairly consistent with that in the channel, with the exception of the presence of more gravel. Vegetation is composed primarily of low grass with interspersed low brush covering approximately 5% to 30% of the ground. There are few medium to large size rocks in the overbank area. The Manning's n value is estimated to be approximately 0.035 for the overbank area.



Figure 18.A-29 Pinabete Arroyo typical bend point upstream of Burnham Road

Downstream of Burnham Road, the overbank area is also similar to that of the No Name Arroyo. Typically, a gently sloping floodplain area up to 200 feet wide leads to steep hills up to approximately 100 feet high. The hills generally have at least one vertical face of exposed sandstone with the other sides composed of fractured sandstone and soil. The soil in the overbank area is fairly consistent with that in the channel, with the exception of the presence of more gravel. Vegetation is composed primarily of low grass with interspersed low brush covering approximately 5% to 50% of the ground. There are numerous medium to large size rocks in the overbank area consisting of sandstone that has eroded off the nearby hills. The Manning's n value is estimated to be approximately 0.05 for this overbank area.

Drainage Density Survey

This 3-day effort included field reconnaissance of the Pinabete and No Name Arroyos and their major tributaries, developing drainage density data by measuring tributary lengths and areas, measurement of A-channel lengths, and head to ridge lengths.

Several drainage areas for the Pinabete and No Name Arroyos were identified prior to field survey where drainage parameters could be estimated. These locations were selected based on identified hydrologic features and soil types, as well as recommendations from environmental staff of BNCC. Pinabete Drainage Basins 18 and 21, and No Name Basin 1 were selected for reconnaissance. Drainage basin designations are based on a SedCAD model developed by BNCC, and are shown on [Exhibit 18.A-6](#).



Figure 18.A-30 Pinabete Arroyo near confluence of main tributary channel from Drainage Basin 18

Day - 1

The URS team performed an overall reconnaissance of the area by driving through the project area from north to south over the watersheds of both the arroyos. The first basin explored was Drainage Basin 18. This drainage basin is located immediately downstream of Burnham Road and drains to the Pinabete Arroyo directly downstream of cross section P-3. A GPS receiver was used to mark the drainage features of the tributary channels within Drainage Basin 18.

The tributary channels within Drainage Basin 18 are fairly flat and narrow, rectangular in shape, have a bottom width varying from less than 1 foot to over 10 feet, and side slopes from 1h:1v to 3h:1v. The main tributary channel within Drainage Basin 18 extends approximately 5,000 feet to the southwest from the confluence with the Pinabete Arroyo. The total length of all the tributary channels within the Drainage Basin 18 is 18,400 feet. The contributing drainage area is estimated to be 322 acres. The estimated drainage density is 60 feet per acre (ft/acre).



Figure 18.A-31 Main tributary channel from Drainage Basin 18 near confluence with Pinabete Arroyo



Figure 18.A-32 Top segment of Drainage Basin 18 main tributary channel



Figure 18.A-33 Top ridge within Drainage Basin 18 - note increased gravel content

During the field investigation, the team observed that there were very few channels that could be classified as type A or B, with the majority of the channels consistent with type C. For this reason, only a few A-channel lengths were measured within Drainage Basin 18. However, due to the flatness of the area and the small changes in grade between channels, none of the measured head to crest lengths were considered representative of the project area.

The soil within the tributaries is alluvial deposits with very few bedrock outcrops. The channel contains small to large fractured sandstone fragments along the channel bottom, extending into the channel side slopes. The channel bank is unstable, resulting in sustained erosion except for the areas with high rock concentrations.

Day - 2

During the second day, Drainage Basin 22 and the north end of Drainage Basin 21 were identified to have distinct ridges and valleys containing concave to convex channels where A-channel lengths could be evaluated, and the overall terrain contained a greater amount of elevation change.

In these areas, the tributary channel lengths were measured and coordinates were recorded along the tributary alignments to estimate elevation change and A-channel lengths. Within these areas a soil type that was slightly different than that within Drainage Basin 18 was identified. The soil type has less alluvial

sands and a greater volume of gravel. These areas have a more stable channel configuration, which is narrower with a reduced amount of riling. The estimated average A-channel length and head to ridge length are approximately 30 feet and 150 feet, respectively; with one outlying head to ridge length of approximately 650 feet.



Figure 18.A-34 Center of tributary channel 18R1 in Drainage Basin 18



Figure 18.A-35 Channel 18 on south bank of Pinabete Arroyo



Figure 18.A-36 Bedrock outcrop within main tributary channel of Drainage Basin 18 after rainfall event

Towards the end of the second day, the southern portion of Pinabete Drainage Basin 21 and No Name Drainage Basin 1 were examined. Both these areas have fairly flat topography with no measurable ridges and valleys, and were therefore not further evaluated.

An attempt was made to identify additional contributing drainage areas in the Pinabete watershed that would be representative of the surface generated by the Natural Regrade model. During this process, Drainage Basin 28 was identified. This basin is approximately 1 mile downstream of Drainage Basin 18.

Day - 3

On the third day, measurements of the lengths of the tributaries within Drainage Basin 28 were conducted. The tributaries within this basin have slopes varying from 2 to 20 percent, which is steeper than tributaries measured in the preceding basins. The tributaries are narrower in comparison to those within Drainage Basin 18. The tributary channels generally have a trapezoidal shape, a bottom width varying from 0.5 to 4 feet, and 1h:1v to 2h:1v side slopes. The main tributary channel extends approximately 1,080 feet to the confluence with the Pinabete Arroyo. The total length of all tributaries within Drainage Basin 28 is 2,350 feet. The contributing drainage area is approximately 16.8 acres. The estimated drainage density is 140 ft/acre.



Figure 18.A-37 Typical upstream channel segment in Drainage Basin 28



Figure 18.A-38 Typical A-channel in Drainage Basin 28



Figure 18.A-39 Typical A-channel in Drainage Basin 18

The majority of the tributaries were found to contain an A-channel reach with a measurable head to ridge length. Measurements were taken along the tributary channels. The estimated average A-channel length and head to ridge length are approximately 20 and 100 feet, respectively.

The soil type within Drainage Basin 28 is similar to Drainage Basin 22 with a lower amount of alluvial deposits and a large amount of gravel. For the majority of the tributaries, gravel is present at the transition between the concave to convex areas. Overall, this basin appears to be more stable than Drainage Basin 18.

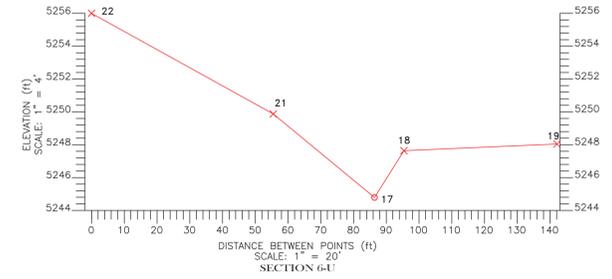
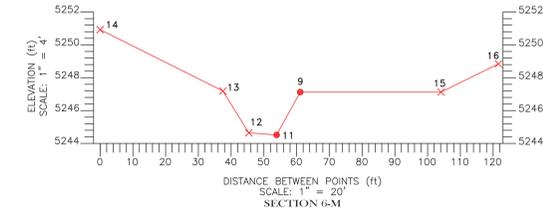
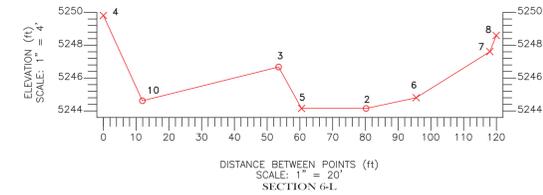
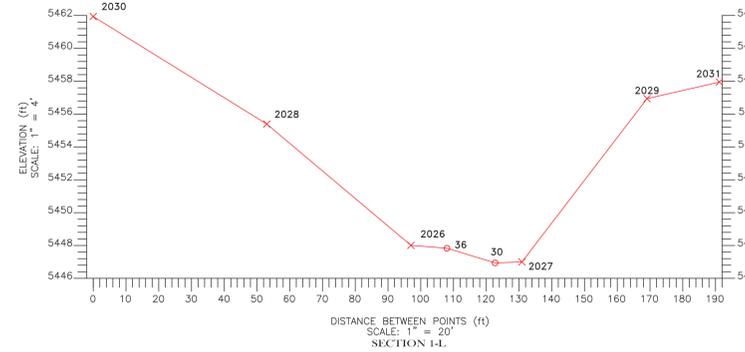
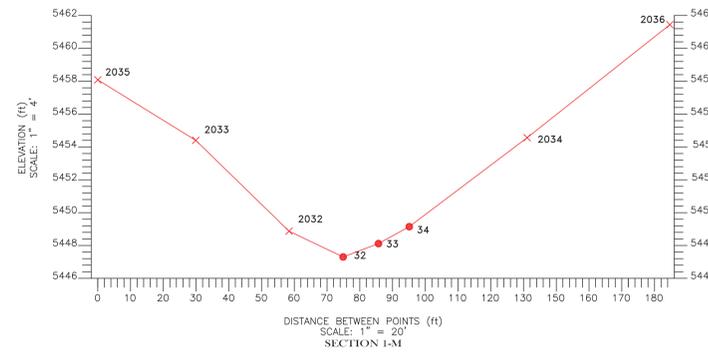
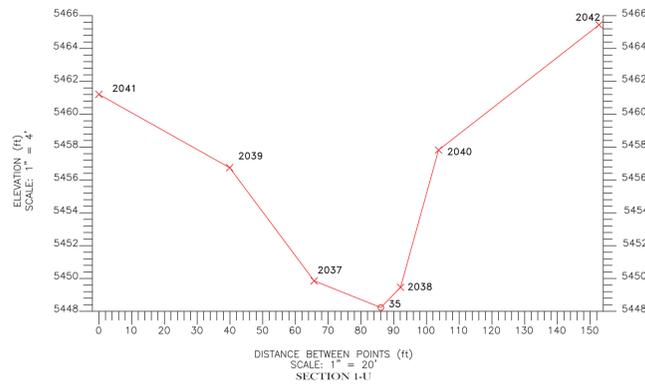
GPS data were recorded at the estimated upstream and downstream elevation of the Pinabete Arroyo in the NMEP to be used as input in the Natural Regrade model. The upstream and downstream elevations are estimated to be 5,440 feet and 5,310 feet (Mean Sea Level), respectively.



Figure 18.A-40 Typical geomorphologic formations within Drainage Basin 28



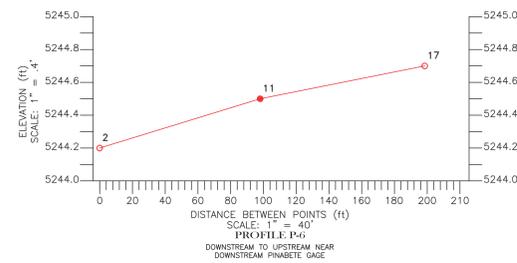
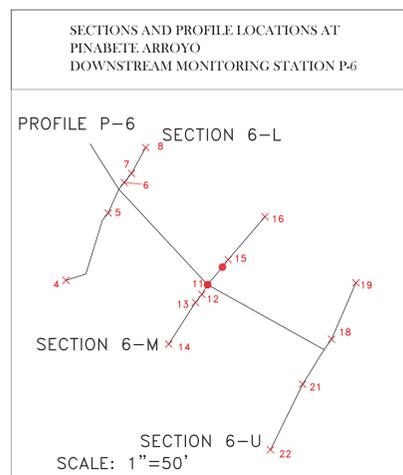
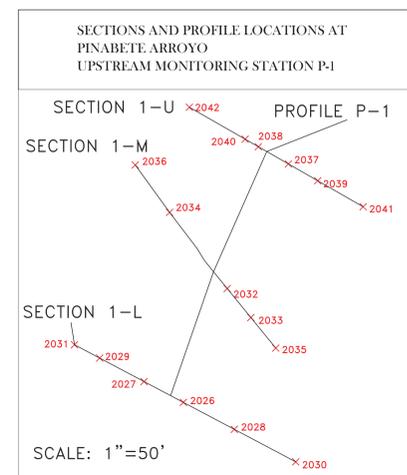
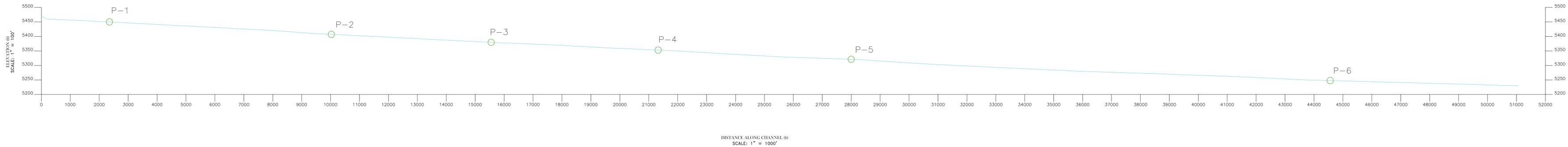
Figure 18.A-41 Southern boundary of the permit area looking north



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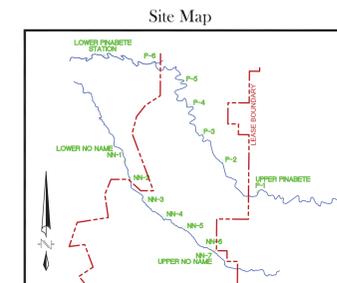
DOWNSTREAM

Longitudinal Profile for Pinabete Arroyo

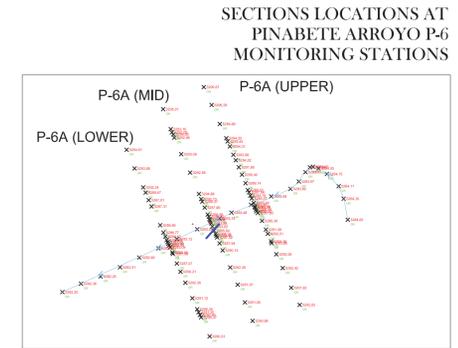
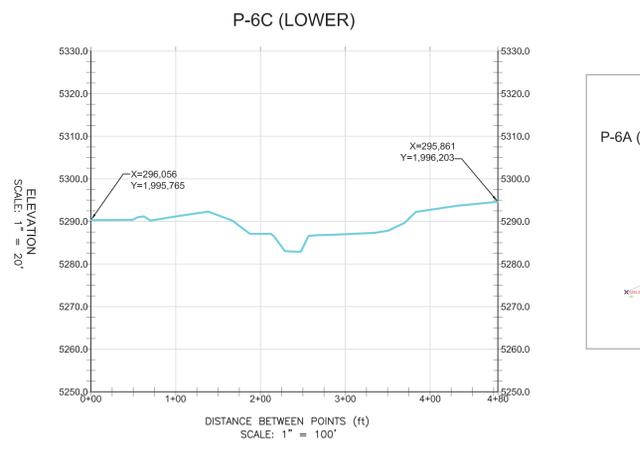
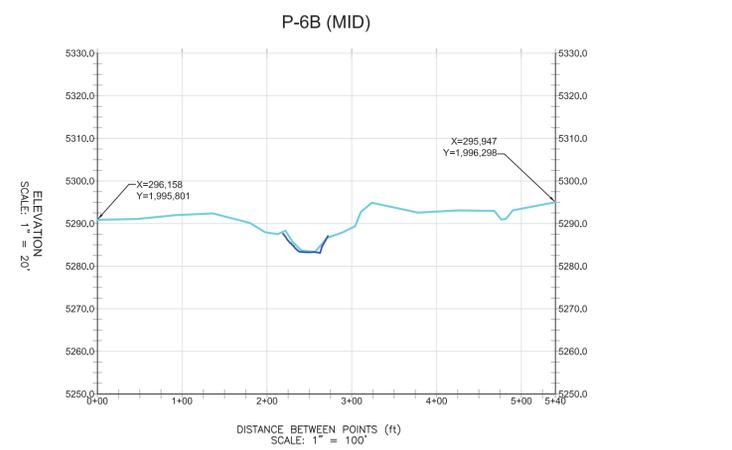
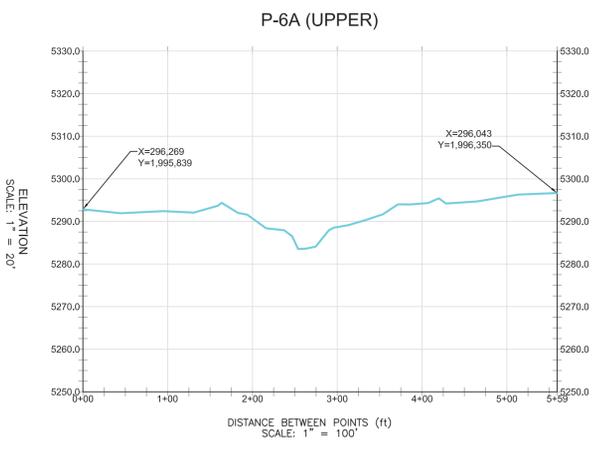
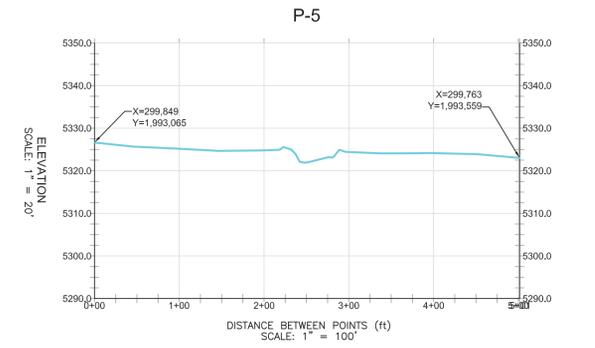
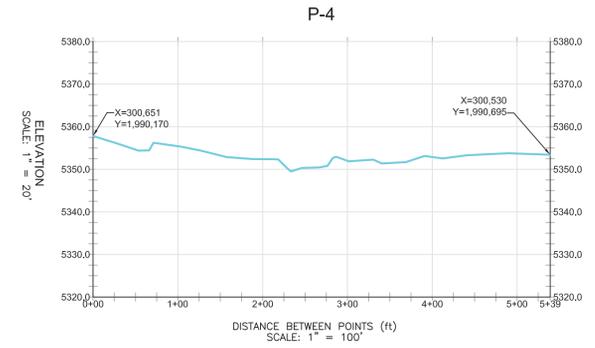
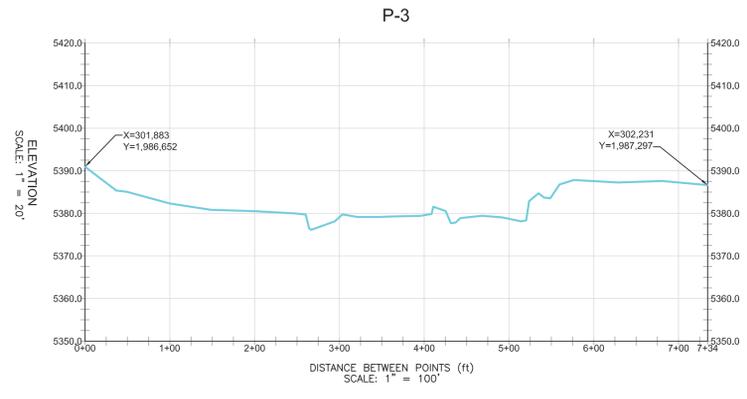
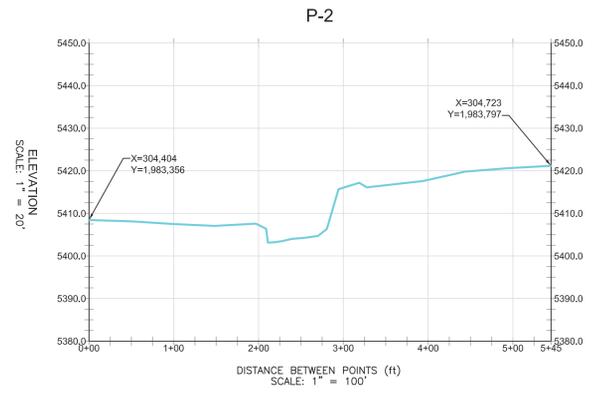
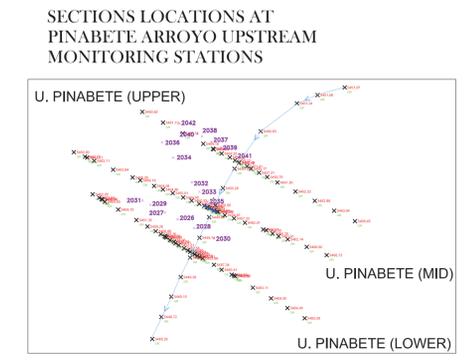
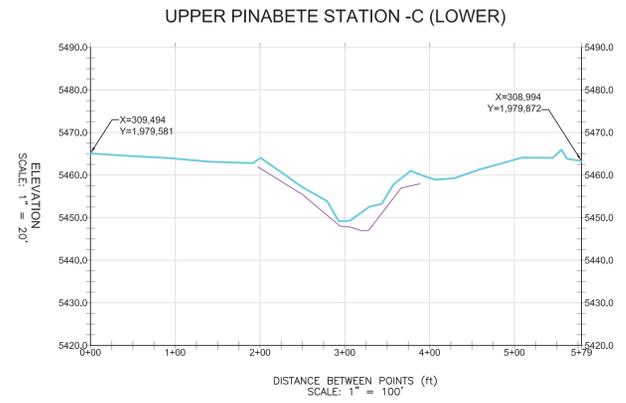
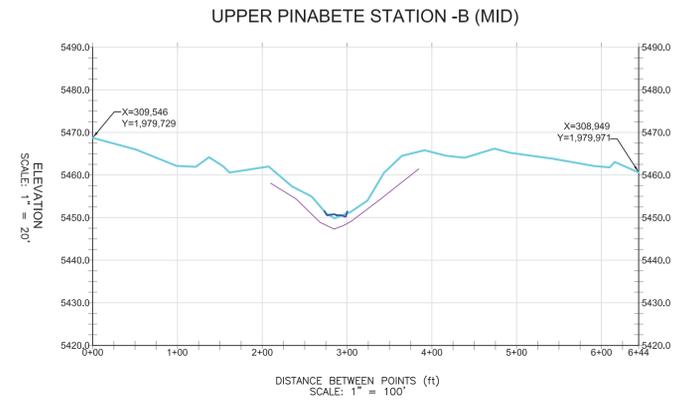
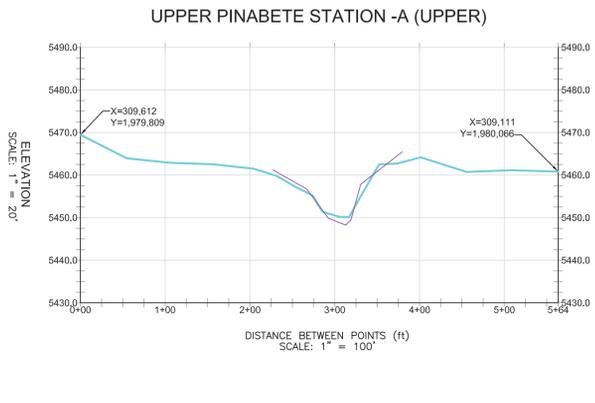


LEGEND

- P-7 CHANNEL INVENTORY LOCATION
- x SURVEY POINT
- CREST STAGE GAGE
- SINGLE STAGE SAMPLER



NO. 18-A	3/16/12	MPO	Submitted to OSM for Approval	DKA	APPROVED
REV. NO.	DATE	BY	REVISION DESCRIPTION	NO. 18-A	DATE
EXHIBIT 18.A-1					
BHP NAVAJO COAL COMPANY					
P.O. BOX 1117 FRUITLAND, NEW MEXICO 87416 PHONE: 505/698-4200 FAX: 505/698-4229					
PINABETE PERMIT					
PINABETE ARROYO MONITORING STATION					
INFORMATION AND CHANNEL					
CHARACTERIZATION 1998					
PREPARED BY	APO	DRAWN BY	JLS	SCALE:	AS SHOWN
APPROVED BY		DATE	Mar 16, 2012		

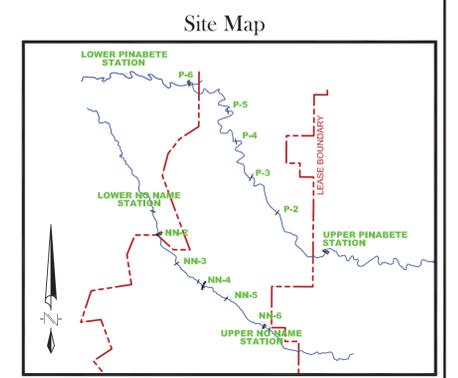


LEGEND

- 2008 SURVEYED SECTION
- 2007 SURVEYED SECTION
- 1998 SURVEYED SECTION

NOTES

- COORDINATE DATUM IS NEW MEXICO STATE PLANE NAD 27
- FEET WEST ZONE
- CROSS SECTIONS LOOKING DOWNSTREAM



REV. No.	DATE	DRAWN BY	REVISION DESCRIPTION	PREP. BY	E.D.	P.E.	APPROVED APPROVALS
12-A	3/16/12	MPO	Submitted to OSM for Approval		CKA		

NORWEST
ACCIDENT INVESTIGATION

EXHIBIT 18.A-2
BHP NAVAJO COAL COMPANY

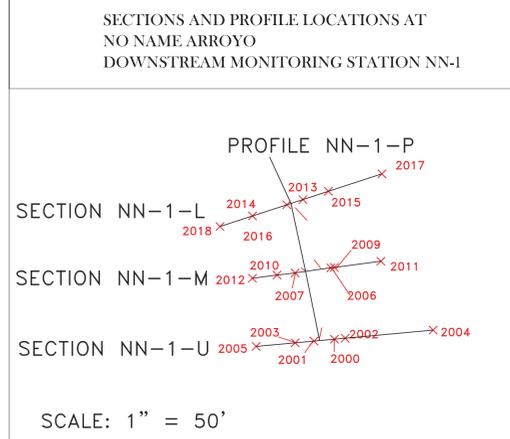
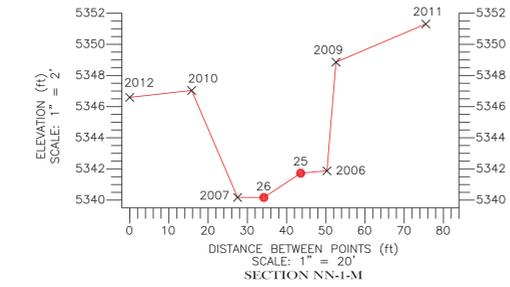
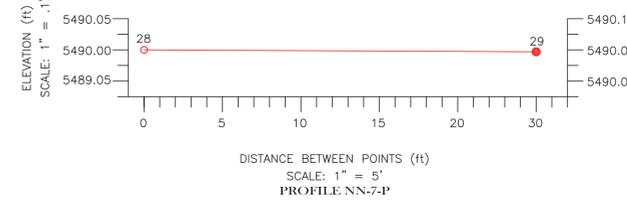
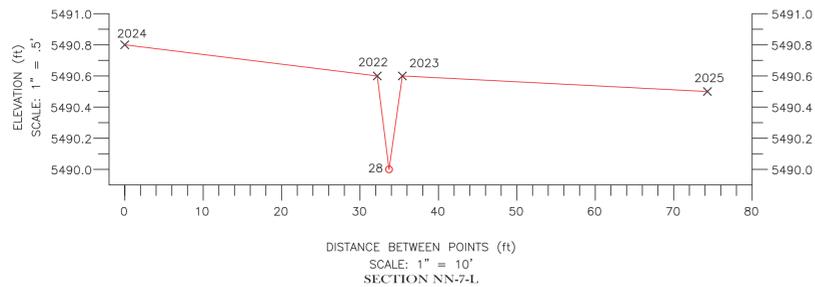
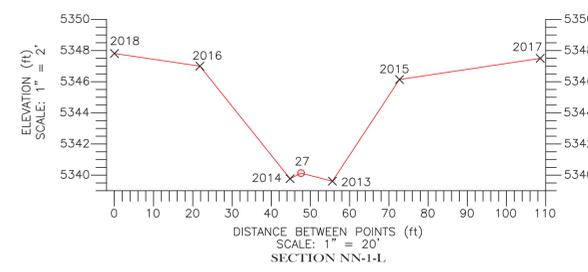
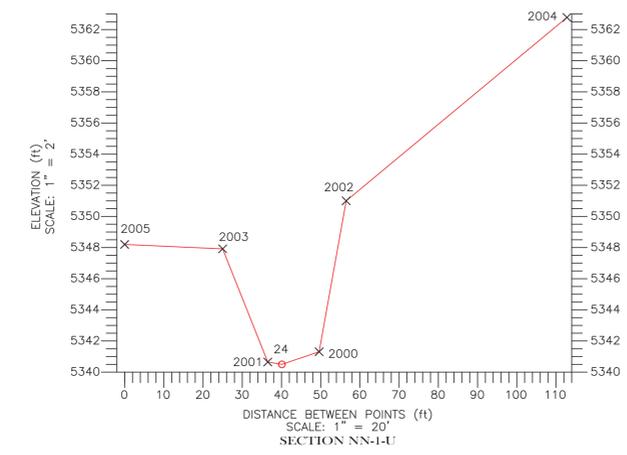
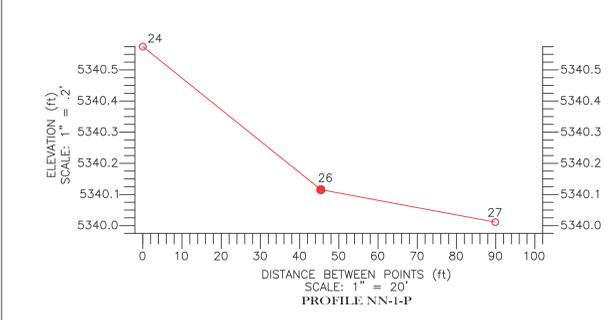
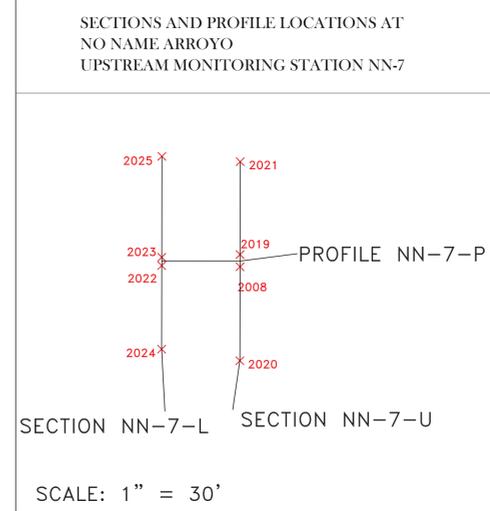
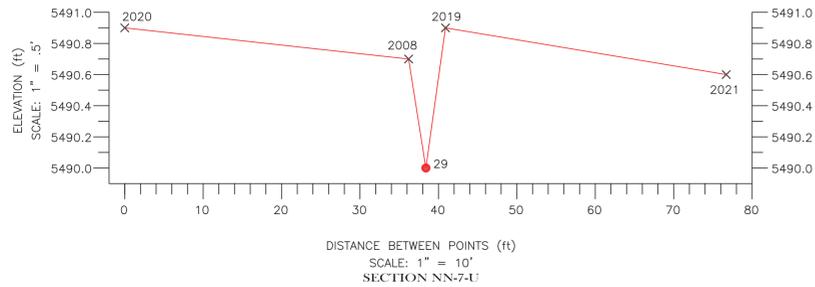
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FRUITLAND, NEW MEXICO 87416

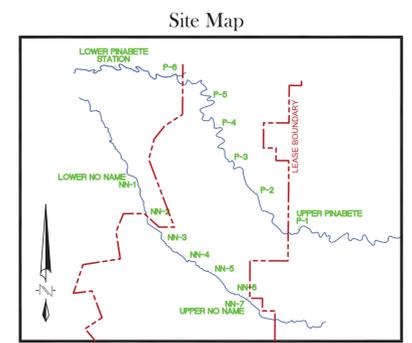
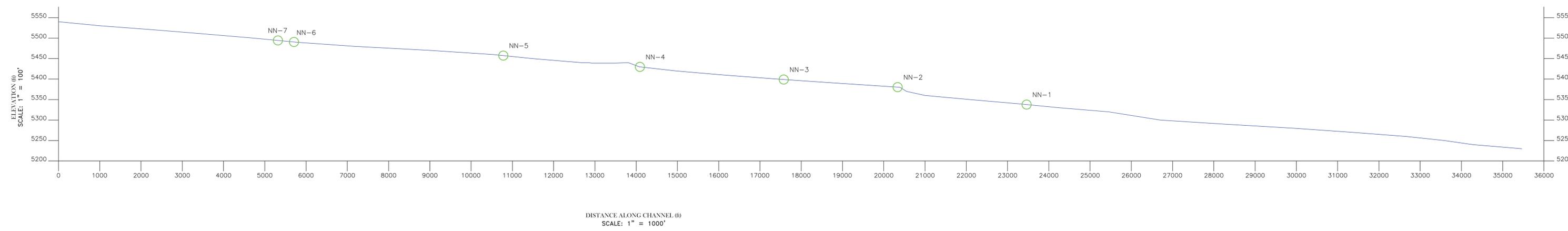
PHONE: (505) 698-4200
FAX: (505) 698-4229

PINABETE PERMIT
PINABETE ARROYO
CROSS SECTIONS

PREPARED BY	APO	DRAWN BY	JLS	SCALE:	AS SHOWN
APPROVED BY		DATE	Mar 16, 2012		



Longitudinal Profile for No Name Arroyo



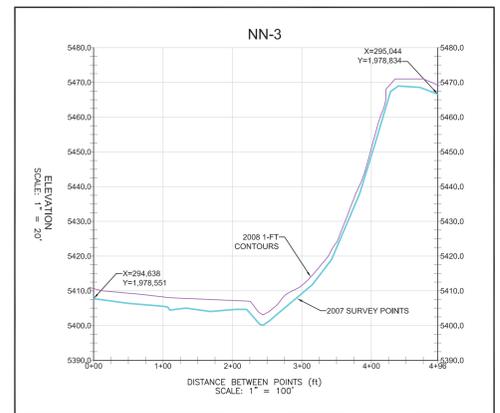
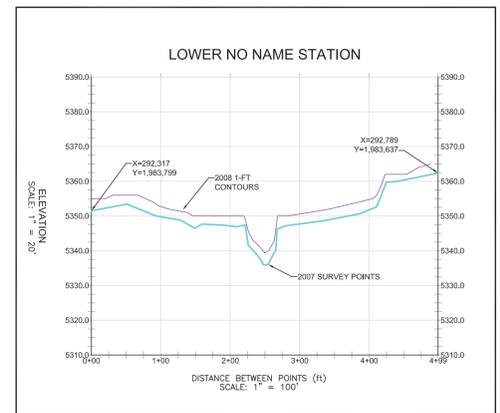
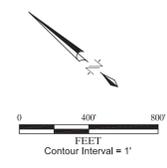
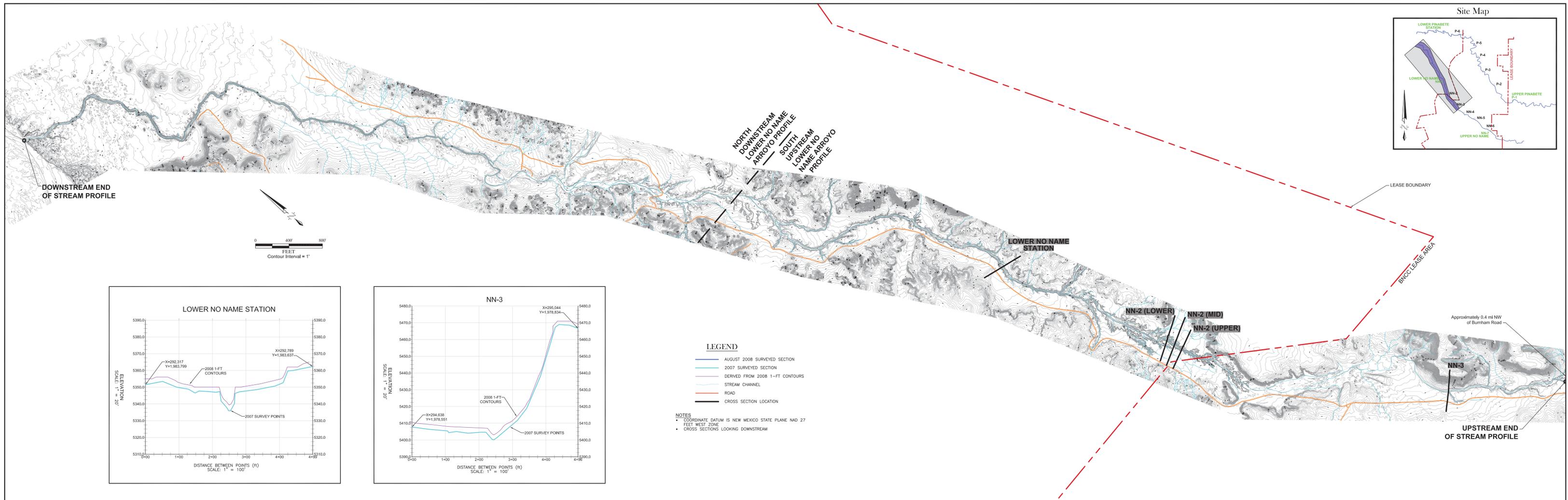
- LEGEND**
- NN-7 CHANNEL INVENTORY LOCATION
 - × SURVEY POINT
 - CREST STAGE GAGE
 - SINGLE STAGE SAMPLER

12-A	3/16/12	MPO	Submitted to OSM for Approval	CKA	
REV. NO.	DATE	DRWN. BY	REVISION DESCRIPTION	PREP. BY	APPROVED BY

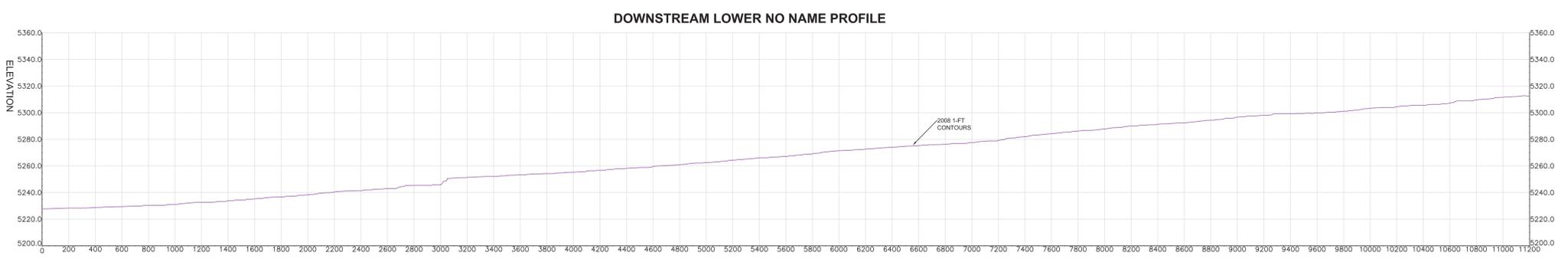
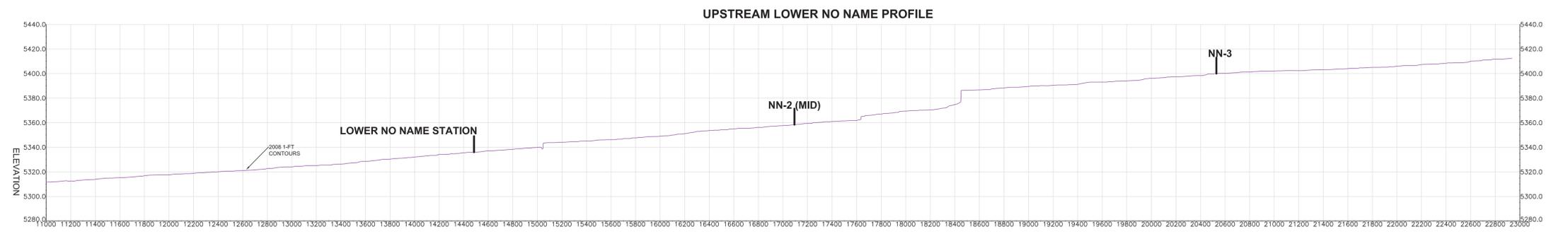
EXHIBIT 18.A-3
BHP NAVAJO COAL COMPANY
 P.O. BOX 1717 FRUITLAND, NEW MEXICO 87416 PHONE: (505) 698-4200 FAX: (505) 698-4229

PINABETE PERMIT
NO NAME ARROYO MONITORING STATION INFORMATION AND CHANNEL CHARACTERIZATION 1998

PREPARED BY: APO DRAWN BY: JLS SCALE: AS SHOWN
 APPROVED BY: DATE: Mar 16, 2012



- LEGEND**
- AUGUST 2008 SURVEYED SECTION
 - 2007 SURVEYED SECTION
 - DERIVED FROM 2008 1-FT CONTOURS
 - STREAM CHANNEL
 - ROAD
 - CROSS SECTION LOCATION
- NOTES**
- COORDINATE DATUM IS NEW MEXICO STATE PLANE NAD 27
 - FEET WEST ZONE
 - CROSS SECTIONS LOOKING DOWNSTREAM



NO.	DATE	BY	DESCRIPTION	CHK.	APPROVED BY
12-A	3/16/12	MPO	Submitted to OSM for Approval	OKA	
REVISION DESCRIPTION				PREP.	APPROVED
				BY	BY

NORWEST

EXHIBIT 18.A-4

BHP NAVAJO COAL COMPANY

bhpbilliton

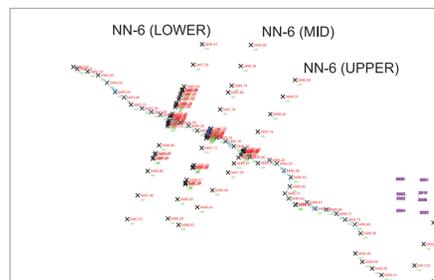
P.O. BOX 1717
FRUITLAND, NEW MEXICO 87416

PHONE: (505) 698-4300
FAX: (505) 698-4229

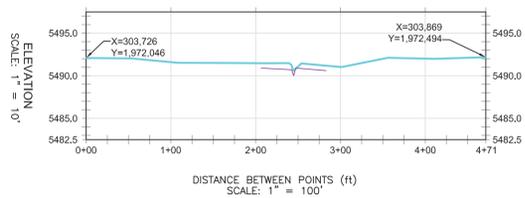
**PINABETE PERMIT
LOWER NO NAME ARROYO**

PREPARED BY	APO	DRAWN BY	JLS	SCALE:	1" = 2000'
APPROVED BY		DATE	Mar 16, 2012		

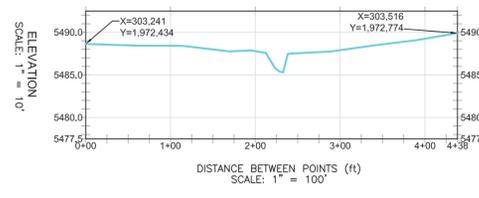
SECTIONS LOCATIONS AT
NO NAME ARROYO NN-6
MONITORING STATIONS



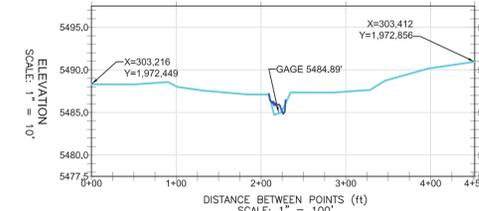
UPPER NO NAME STATION



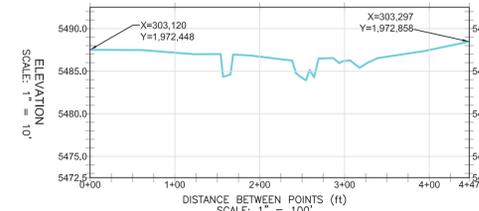
NN-6A (UPPER)



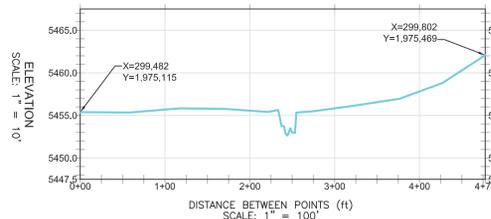
NN-6B (MID)



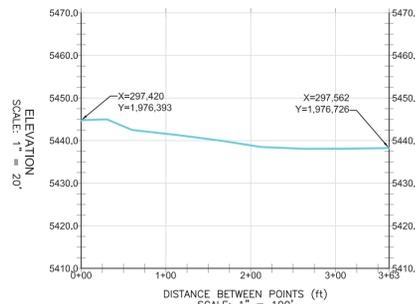
NN-6C (LOWER)



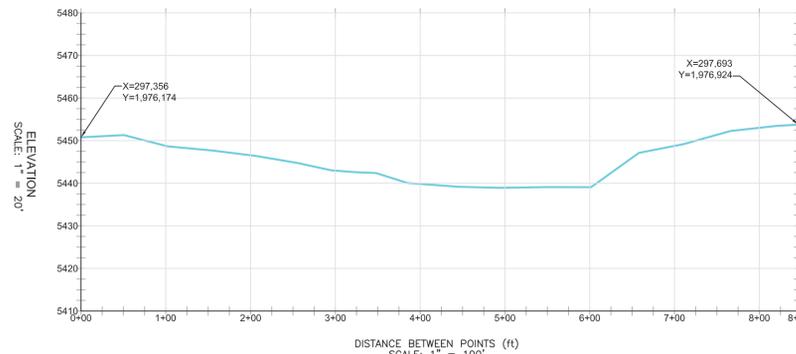
NN-5



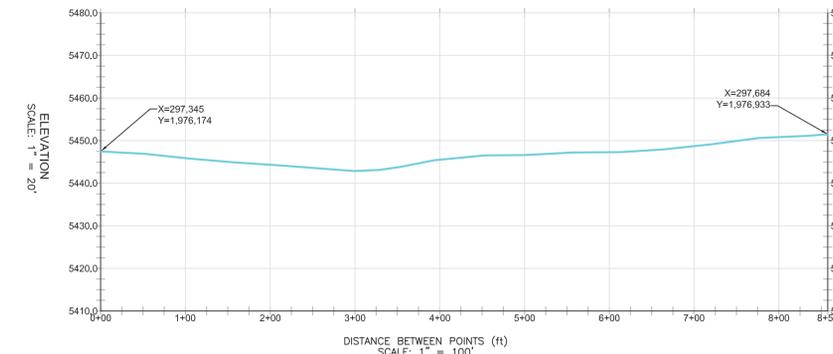
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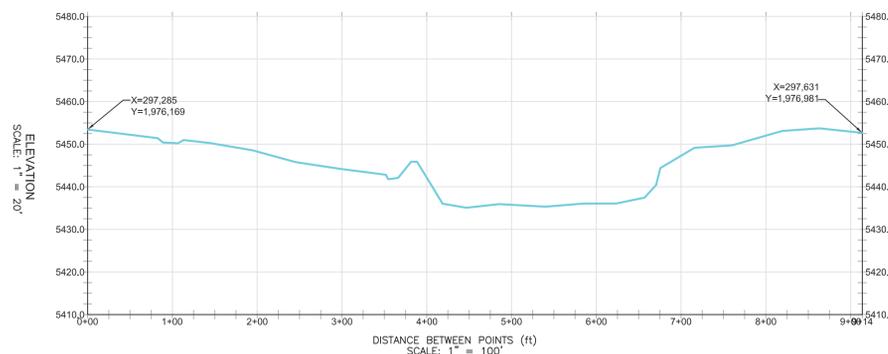
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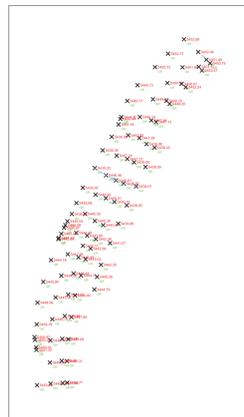
NN-4C (LOWER)



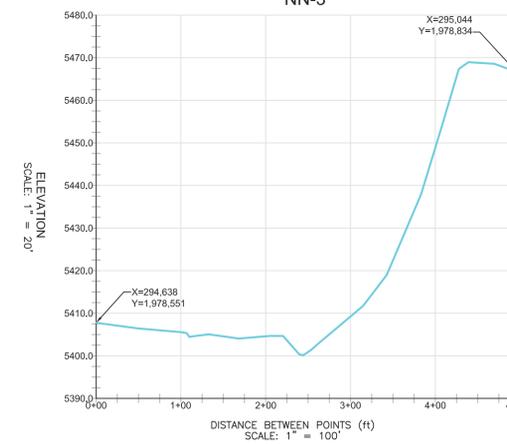
NN-4D (LOWEST)



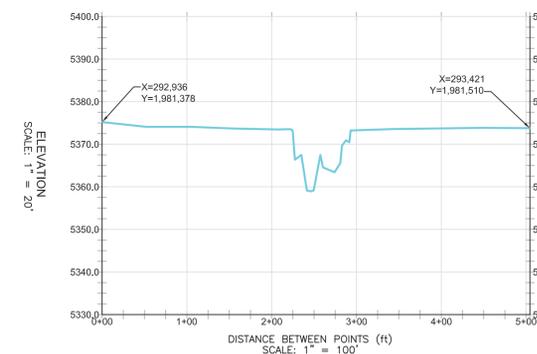
SECTIONS LOCATIONS AT
NO NAME ARROYO NN-4
MONITORING STATIONS



NN-3



NN-2A (UPPER)

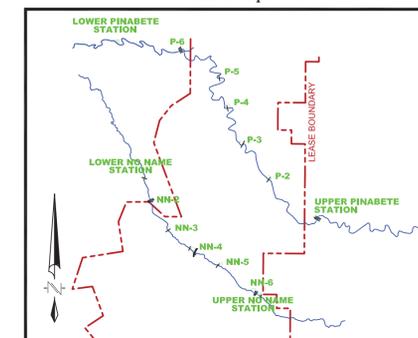


LEGEND

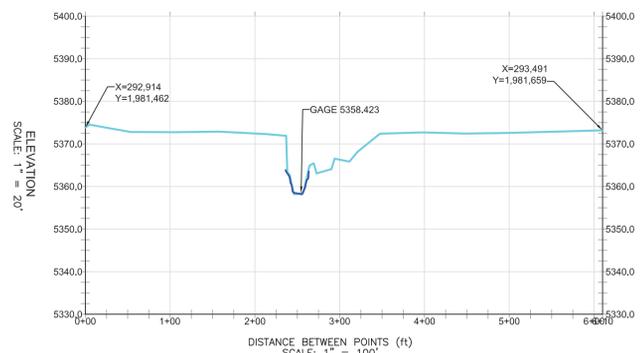
- 2008 SURVEYED SECTION
- 2007 SURVEYED SECTION
- 1998 SURVEYED SECTION

- NOTES
- COORDINATE DATUM IS NEW MEXICO STATE PLANE NAD 27
 - FEET WEST ZONE
 - CROSS SECTIONS LOOKING DOWNSTREAM

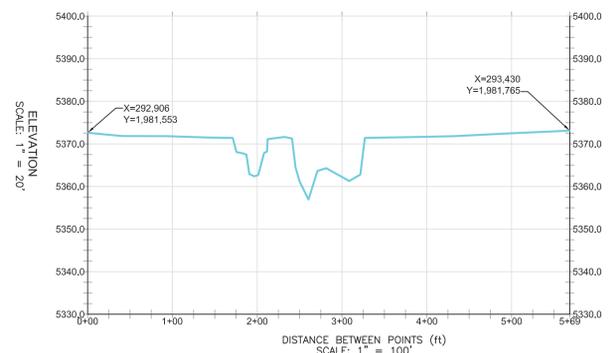
Site Map



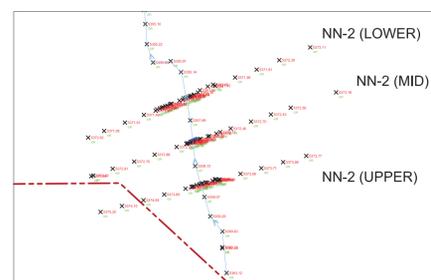
NN-2B (MID)



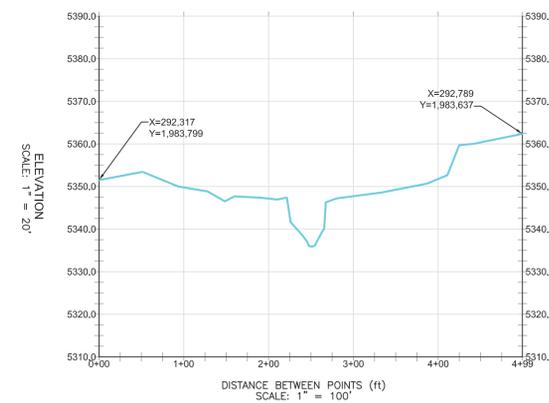
NN-2C (LOWER)



SECTIONS LOCATIONS AT
NO NAME ARROYO NN-2
MONITORING STATIONS



LOWER NO NAME STATION



REV. No.	DATE	DRAWN BY	REVISION DESCRIPTION	PREP. BY	CHECKED BY	APPROVED BY
12-A	3/16/12	MPD	Submitted to OSM for Approval			

EXHIBIT 18.A-5
BHP NAVAJO COAL COMPANY

P.O. BOX 1717
FRUITLAND, NEW MEXICO 87416
PHONE: (505) 698-4200
FAX: (505) 698-4229

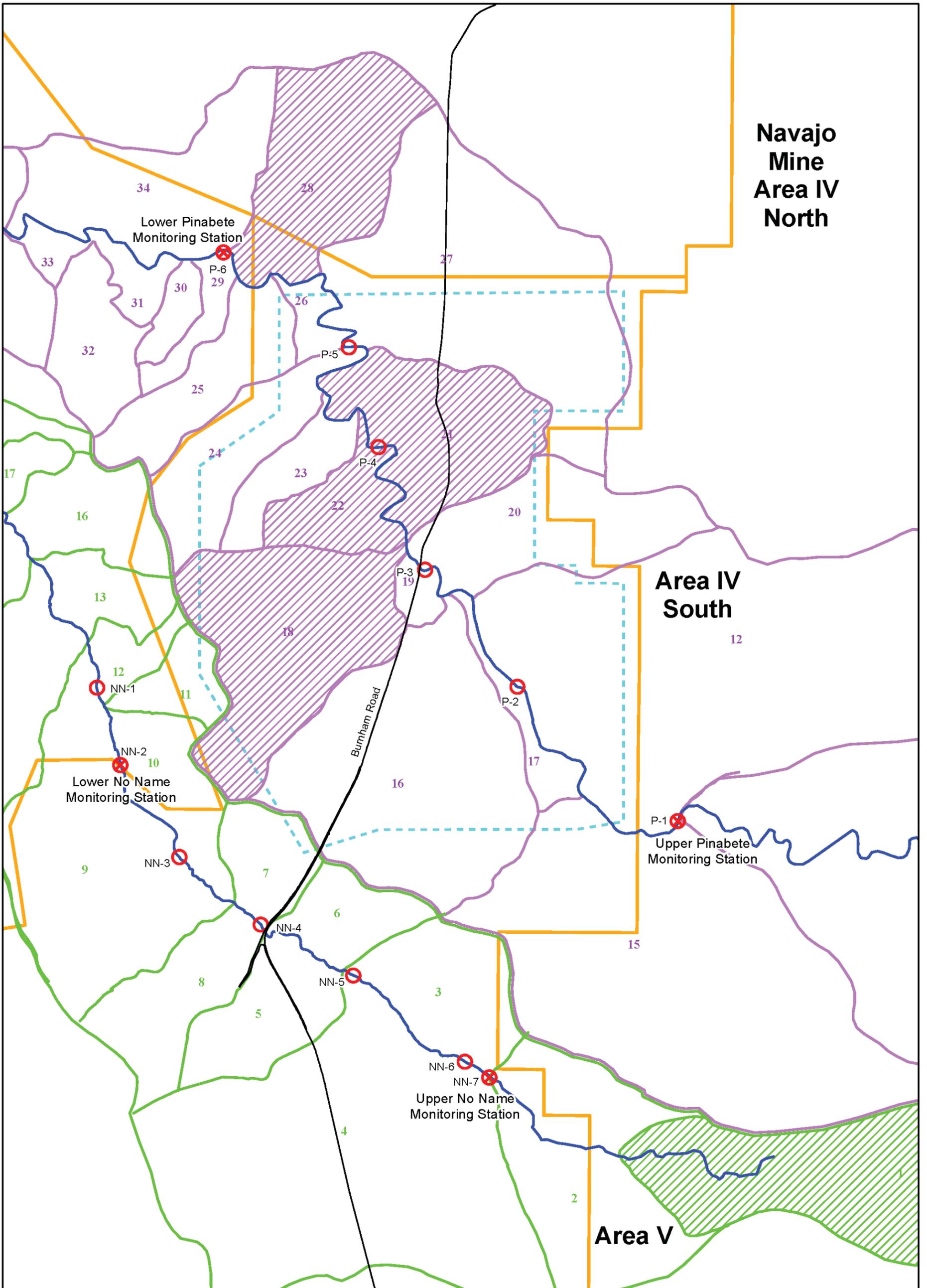
PINABETE PERMIT
NO NAME ARROYO CROSS SECTIONS

PREPARED BY	APO	DRAWN BY	JLS	SCALE:	AS SHOWN
APPROVED BY		DATE	Mar 16, 2012		

Navajo Mine Area IV North

Area IV South

Area V



Legend

No Name Basins	Burnham Road
Pinabete Basins	AOC Surveyed Basins
Stream Lines	NavExt_LeaseBoundary
Survey Cross Sections	NavExt_MineBlock

Exhibit 18.A-6
Field Reconnaissance Map

N
0 1,500 3,000 Feet