July 11, 2024

TO: Shannon Weld and Grace Haggerty

FROM: Chad McKenna, GeoSystems Analysis, Inc.

RE: Albuquerque Habitat Restoration Design Project Update Memo

Under this work order, GeoSystems Analysis (GSA) developed conceptual designs and conducted supporting analysis for constructing multiple habitat restoration projects located within the Angostura Reach through Albuquerque, New Mexico. Work focused on the stretch of the Rio Grande between approximately one mile upstream of Alameda Bridge and one-half mile downstream of the Interstate 25 crossing (referred to as the "study area" in this document). The study area spanned about 20.5 river miles from RM 172.5 to RM 193. GSA's staff also worked closely with SWCA to support their contracted tasks, which focused on environmental compliance and other regulatory components.

The primary functional objectives for habitat restoration sites identified and designed in this task order include:

- Increase the areal extent of inundated floodplain habitat under moderate discharge levels (1500-3000 cfs) to benefit spawning and rearing Rio Grande silvery minnow and breeding Southwestern willow flycatchers
- Promote drainage of potentially entrapped water following higher discharge events (3000-5000 cfs)
- Theoretically, improve the conveyance capacity of the Rio Grande mainstem channel at moderate discharge levels by lowering the surface elevation of islands and midchannel bars
- Reduce the overall evapotranspiration within a 600-foot-wide channel approximately centered along the current channel centerline by removing primarily exotic vegetation that has established within these geomorphic features over the last ten to twenty years
- When applicable, improve the hydraulic function of previously constructed habitat restoration sites, primarily via removal of sediment that has accumulated in channel mouths and/or bankline berms

The following sections of this memorandum describe the approach for deriving GSA's conceptual designs. This memo is intended to supplement the Environmental Analysis report drafted by SWCA.

Field and Desktop Site Assessment

Rapid site assessment

Sites were selected using a combined desktop and field analytic approach. As an initial step, GSA biologists completed a rapid site reconnaissance with NMISC staff to evaluate construction potential at sites previously proposed by NMISC and SWCA. This visit focused on identifying potential constructability challenges, prioritizing locations for further evaluation, discussing overall project objectives and potential design components, and locating additional sites for further consideration. The sites visited with NMISC during the rapid site assessment were primarily located within previously constructed habitat restoration sites near Central Avenue in Albuquerque. After further discussion with NMISC, rapid site assessments were performed throughout the entire study area with the primary goal of locating additional sites throughout the city of Albuquerque with potential to meet the forementioned project objectives. The rapid site assessments initially focused on assessing sedimentation trends, vegetation community composition, noxious weed presence/absence, and identifying maintenance needs at previously constructed habitat restoration project sites.

Vegetation mapping

Tetra Tech recently (2021) mapped woody vegetation communities in Rio Grande floodplain portions of Albuquerque using the Hink and Ohmart (1982, "H&O") mapping convention under a contract with the City of Albuquerque Open Space Division. GSA staff used this dataset (Tetra Tech 2021) to characterize woody vegetation types within floodplain areas, however, this coverage did not include islands within the city. To fill this data gap, GSA staff mapped H&O types on islands during an inflatable watercraft-based field effort. The vegetation maps used for design purposes combine H&O vegetation types from Tetra Tech 2021 and GSA 2024.

GSA also used a combination of remote sensing techniques and field validation to map the current distribution of ravennagrass (*Tripidium ravennae*) on islands, banklines, and recently established point bars throughout the city. Ravennagrass dominated areas were initially digitized on screen by closely reviewing digital orthophotography acquired during March 2022. The ravennagrass mapping was then further refined during multiple field verification efforts.

LiDAR analysis

Multiple Light Detection and Ranging (LiDAR) derived Digital Terrain Models (DTM) were used to evaluate sedimentation and scour trends throughout the study area. Specifically, LiDAR DTM elevations were differenced between 2010, 2012, 2018, and 2022 LiDAR acquisitions to spatially quantify floodplain elevation changes to represented sediment accumulation or scour trends on a grid cell basis. This result was generally used to assess the distribution and volume of sedimentation within different geomorphic surfaces throughout the study area. GSA also used sedimentation trends within previously constructed habitat restoration sites to prioritize areas for ongoing maintenance and guide design concepts.

The 2022 LiDAR DTM was also used to build a Relative Elevation Model (REM), also sometimes referred to as a Height Above River (HAR) raster. REMs are raster datasets that normalize adjacent floodplain land surface elevations to the measured water surface elevation (WSE) within a channel, or from a hydraulic model predicted WSE, by interpolating a WSE along virtual cross sections that span the entire floodplain and subtracting it from the bare-earth DTM. REMs can be useful to visualize fluvial landforms, floodplain depressions, terraces, and historic spoil areas that may be hard to discern from an aerial image, shaded relief map, or DTM alone. The 2022 LiDAR derived REMs were developed for the entire Albuquerque Reach. Amongst other utilities, this output was used to identify and target existing depressions for placing habitat restoration features to minimize required excavation volumes.

Topographic field surveys

GSA staff collected new high resolution topographic data with Hemisphere s321 and s631 Real Time Kinematic (RTK) devices to capture topographic changes that occurred after the 2022 LiDAR were acquired. The RTK surveying focused on portions of sites where recent sediment deposition was observed during the rapid site assessments (e.g. recent levied bankline deposits), and in some cases, throughout freshly deposited sandbars that formed over the past year (typically during spring runoff 2023).

After field data collection, RTK survey points were integrated (or mosaicked) with 2022 LiDAR data to build an updated topographic dataset that would later be used to calculate excavation volumes and produce excavation depth grids as shown in later sections of this memo.

Hydrodynamic Modeling Outputs

Hydraulic model outputs from MIKESHE and its associated model packages were used to directly link predicted WSEs at a range of discharges to the post-construction design elevation. MIKESHE is an integrated groundwater/surface water model originally developed by Système Hydrologique Européen (SHE), with additional development and maintenance by Dansk Hydraulisk Institute (DHI). MIKESHE–predicted WSEs at a range of discharges were used to assign post-excavation elevation targets within each proposed habitat restoration feature as described here. The model scenario simulated spatially-varying and time-varying net gains and losses to surface water which were acquired from the Albuquerque Reach MIKESHE model. The net gains and losses represent gains from baseflow and losses from the atmosphere (i.e. evapotranspiration) and the subsurface (e.g. to the groundwater). Both scenarios modeled the inflow hydrograph from the Alameda Bridge from April 15, 2019, to May 15, 2019. DHI provided GSA with time varying grids at 1-hour timesteps in Dfsu format. The Dfsu's included the following attributes:

- Total water depth (m)
- U velocity (m/s)
- V velocity (m/s)
- Water surface elevation (m)
- Current speed (m/s)

QGIS, a free and open-source geographic information system software, was used in conjunction with DHI's "2D Visualization Driver for QGIS" to export total water depth and water surface elevation grids at specific time stamps. Once the plug in was installed in QGIS, the water depth and WSE grids were fixed to specific timesteps and exported as a GIS-ready raster format and metric units were converted to feet. These M21 water depth and elevation grids were then used to create the habitat restoration design contours and design elevation points.

The exported M21 grids only provided WSE and depth values for cells predicted to inundate at a specific discharge, so GSA calculated floodplain wide REMs for M21 outputs when flow was near the following discharges: 800 cfs, 1000 cfs, 1500 cfs, 2,000 cfs, and 3,000 cfs. The REM outputs could then be used to assign gridded post-construction design elevations that were uniformly consistent with the M21 predicted WSE for a specific discharge. For example, if the site was designed to inundate at 1,000 cfs, the post-construction design elevations matched the M21 predicted WSE at that discharge.

Habitat Restoration Conceptual Designs

GSA's conceptual designs created multiple types of habitat restoration features within 79 total project sites. Design details, including project area map sets displaying habitat restoration features and contours; inundation design and target discharge; and excavation depth and contours are provided in Appendix A. Site specific quantities tables are provided in Appendix B. In some cases, the habitat restoration site designs included multiple types of habitat restoration features. In the MRG, and especially in the ABQ Reach, the floodplain is primarily disconnected from the channel during flows less than approximately 3,000 cfs. Thus, most features were designed to entirely inundate at this discharge.

GSA designed a total of five unique habitat restoration features:

1. Bankline modification
2. Island destabilization
3. Flow through channel
4. Backwater
5. Inlet cleanout

Bankline Modification

Areas selected for bankline modification included bank-attached bars that either recently formed (primarily during spring runoff 2023) and/or when topographic data analysis detected recent formation of bankline berms immediately adjacent to the active channel. The narrow bankline berms impede low to moderate flows from reaching the floodplain while also trapping water in the floodplain following high runoff events. The bankline modification design involves a combination of overall bankline lowering and building terrace steps targeted to inundate at different discharges. Floodplain terraces are designed to increase inundation at discharges between 1,000 and 2,500 cubic feet per second (cfs). The lowered floodplain terraces would remove bankline levees and would provide additional low-velocity nursery and spawning habitat at relatively low discharges. Lowering and terracing the bank would increase areal extent of spawning and larval rearing habitats at low to moderate average runoff conditions. Bankline modification would occur at thirty-three areas.

Island Destabilization

In the mid-1990s, with the listing of the Rio Grande Silvery Minnow (RGSM) as a federally endangered species, channel maintenance activities, including island mowing, ceased. With the end of this type of maintenance, island and bank-attached bars began to form and grow as they became heavily vegetated, often with nonnative vegetation. Additionally, following completion of Cochiti Dam the magnitude of high flow events has reduced and flows are insufficient to mobilize islands that have formed within the channel. There is growing evidence that channel capacity has now reached a threshold in the MRG where higher, sustained spring runoff flows (e.g. >5,000 cfs) are causing more expansive flooding than they did 5-10 years ago, while also threatening the integrity of flood protection levees. NMISC is also concerned that this reduced channel capacity has had a negative impact on efficiency of water delivery to Elephant Butte Reservoir.

Due to decreasing regulated high-flow discharges, as well as sustained drought conditions, islands in the MRG have become permanent, large, vegetated features that create narrower and deeper channels within the river. Dense vegetation is unlikely to be removed by river flows alone once root systems, which resist erosion and stabilize islands, are firmly established (Reclamation 2007; Harvey 2022). The establishment of permanent islands results in reduced aquatic habitat, unsuitable habitat for listed riparian birds, and reduced channel capacity to transmit water and sediment downstream during spring runoff. This creates a negative feedback loop with the formation of more islands and bars and increases the flood risk to levees.

Island destabilization, particularly on islands that have the potential to become or have become permanent channel features, may assist in alleviating adverse changes to RGSM critical habitat and improve the quality and quantity of available habitat (USFWS 2003). Island destabilization can be accomplished by planned physical disturbance, such as removing vegetation and destabilizing soil and sediment, mowing vegetation, root-plowing vegetation and sediment, and raking vegetation and surface sediment (Tetra Tech 2004).

Selected treatments would be applied to thirty-two islands within the five project subreaches.
The conceptual design for vegetated island modification and evaluation Island destabilization activities would involve cutting vegetation and excavating a portion of the island or the entire island to encourage inundation to begin at approximately 1,500 cfs. The target post-construction elevation intends to achieve full inundation of the island at approximately 3,000 cfs. Vegetation removal would be accomplished by root-plowing the island in the treatment area to a depth that would remove all vegetation in that area. The ground surface of the excavated area would be such that inundation during lower river flows would provide RGSM habitat over a wider range of flows, particularly 2,000 to 3,000 cfs.

Flow-through Channels

Flow-through channels are low-velocity, ephemeral channels that are connected to the main river channel across bars and islands. These channels are normally dry but carry high discharge flows from the main channel, characteristically during spring snowmelt and summer monsoon events. These channels typically carry water at lower velocities than the main channel and may include mesohabitats suitable for RGSM, such as pools and backwaters.

Modification of an ephemeral flow-through channel would require removing vegetation, most likely along the edges of vegetated islands that are not connected to the bank, and disturbing sediment or soil. The channels would be excavated to a depth that would allow water to flow at moderate discharges (1,500–2,000 cfs). Channels may also be excavated along sediment bars that are now connected to the banks. This type of feature provides habitat for RGSM larval development and refuge for young RGSM. Modification of flow-through channels would be applied to nine areas within four of the five project subreaches.

Backwater Channels

The creation of moderate- to high-flow backwater channels would involve the removal of riverbank and inland vegetation, and the excavation of soils to prescribed depths. Backwater channels with no upstream inlet would be constructed on the bottom of large point bars (at existing low-velocity areas) and islands at a range of elevations that allow for inundation at a range of river flows beginning as low as approximately 800 cfs. Backwater channels would slope slightly, with the downstream end lower in elevation than the upstream end, thereby increasing the amount of RGSM habitat available at a range of river flows.

This technique would be used to increase the amount of low-flow and no-flow habitat areas available to RGSM. The technique is intended to retain drifting RGSM eggs and to provide RGSM rearing habitat and shallow, low-velocity habitats with abundant food supplies for developing RGSM larvae. Forty-one backwater channels would be created.

Inlet Cleanout

Inlet cleanout takes place at the mouth of previously constructed high flow channels that have become plugged with sediment, debris, and vegetation, reducing inundation at the original design discharge and limiting overall functionality. Excavating the materials that plug the mouth would reconnect tributaries to the river, increasing eddies where adult RGSMs and larvae aggregate and creating egg retention sites. Inlet cleanout would occur at seven areas.

Design Contours

Design contours were generated using a combination of hydraulic model outputs and manually sketching target inundation discharges in each feature. A hydraulic model of the reach was run in the MIKE21 software package, using a historical hydrograph referencing the USGS gage Rio Grande at Albuquerque, NM (08330000) during the summer of 2019. Water surface elevation (WSE) rasters were exported for the entire reach at all target inundation discharges – 800, 1000, 1500, 2000, 2500, and 3000cfs. These WSE rasters were then used to generate rasters that extrapolate the river's WSE across the entire floodplain laterally from the river channel.

Next, a point grid was generated for each restoration feature, with points spaced an equal 1m apart from one another. Attribute fields for design discharge and elevation were added to the attribute table of the point grid shapefile. Using the "Select by Lasso" tool within ESRI ArcGIS Pro, groups of points were selected in each feature which had the same target discharge. That target discharge was recorded in the attribute table for each group of points; this method was repeated for each design discharge and, in this way, the inundation targets were set across every feature (reference the "Inundation Design & Target Discharge maps in Appendix A).

With the design discharge point grid and the interpolated WSE rasters created, the next step was to combine the data. By using the "Extract Multi Values to Points" tool within ESRI ArcGIS Pro, the interpolated WSE was calculated for every single point in the design discharge grid at every design discharge. ArcGIS Pro's "Select by Attributes" tool was then used to select all points with the same target discharge, after which the elevation attribute was set to be equal to the extracted WSE value at each point. In other words, points with a design discharge of 1000 cfs had their elevation attributes set to be equal to the interpolated WSE at 1000 cfs as sampled at each point, and this was repeated for each different design discharge.

The ESRI Spatial Analyst "Topo to Raster" interpolation tool was then used to generate a continuous raster surface from the elevation attribute values in the point grid. The "Focal Statistics" tool was used to calculate a mean for each pixel with a circular neighborhood of 9 pixels and smooth the overall gradient. The resulting raster was clipped to the feature boundary shapefile, creating the final DTM for all restoration features. The "Contour" tool was then used to generate a shapefile depicting design contours at 0.5 ft intervals.

Excavation Volume Calculations

The final design DTM for the restoration features was further used to calculate excavation volumes for each feature. The LiDAR-derived DTM across the entire reach was updated in several small locations where field site assessments indicated some change in topography between the LiDAR acquisition in 2022 and the restoration feature design stage in 2024. This updated DTM was then differenced from the restoration feature design DTM (with the design DTM being subtracted from the LiDAR DTM). This resulted in an output raster showing the number of feet of sediment, per pixel, that needs to be removed to match the feature designs. Each pixel of the differenced DTM was in 3ft × 3ft spatial resolution, or 1 square yard, thus the raster was divided by 3 to express the sediment removal needed in vertical yards. Afterwards, the "Zonal Statistics" tool was used to calculate the sum of the differenced DTM in each restoration feature, resulting in an output of cubic yards of sediment that need removal from every feature to match the feature designs.

APPENDIX A. DESIGN PACKAGE MAPS

Esri Community Maps Contributors, New Mexico State University, City of Albuquerque, City of Rio Rancho, Bernalillo County, NM, Texas Parks & Wildlife, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, US Census Bureau, USDA, USFWS, MRCOG-NM, Bohannan Huston, Maxar

Habitat Restoration Features & Contours

0 0.125 0.25 0.5 Miles

Scale: 1:10,000

N

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HR Sites

1/2ft Contours

HR Features

Feature Type

Backwater

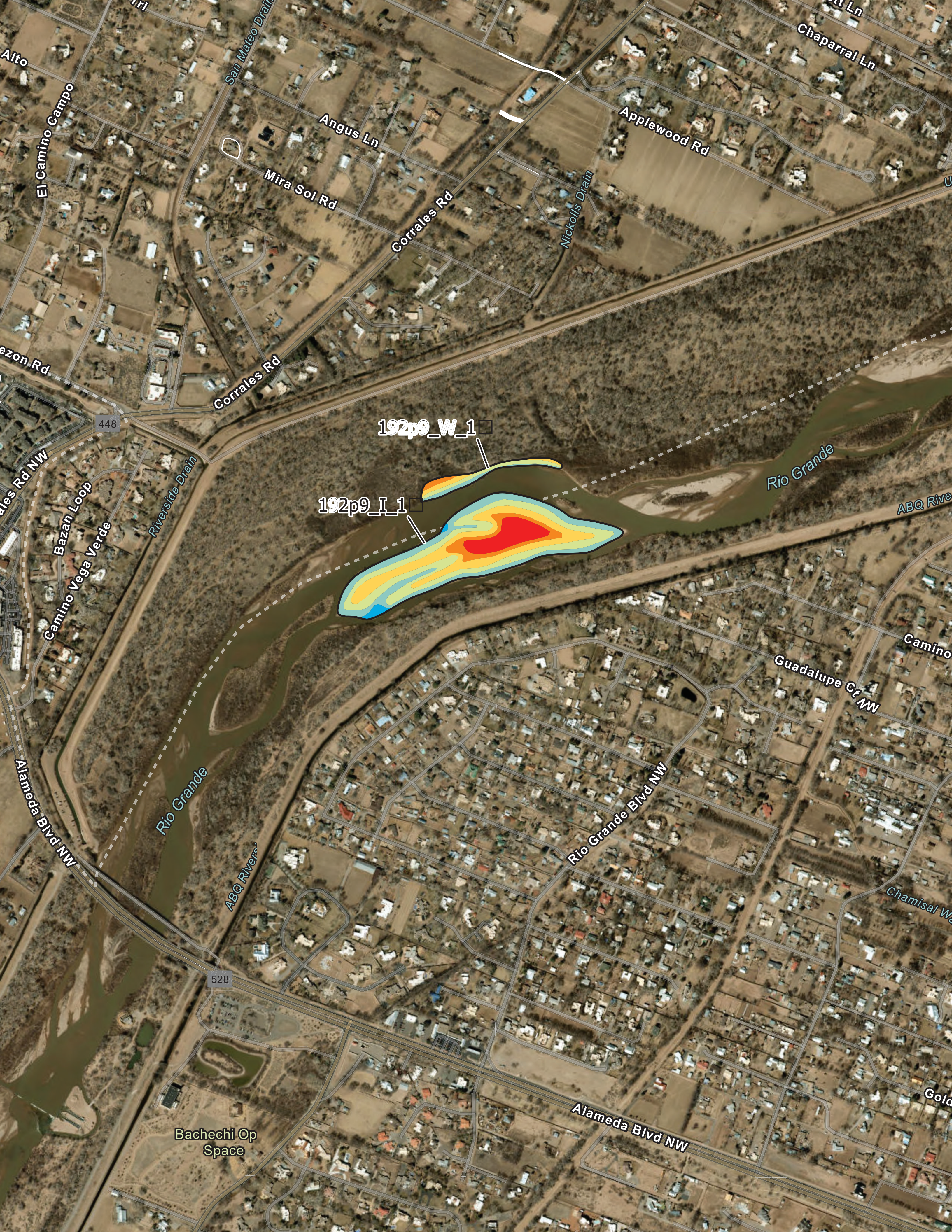
Bankline Modification

Flowthrough Channel

Island Destabilization

Confluence Maintenance

Jetty Jack Removal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Rio Grande
Rio Grande
Corrales Rd
Corrales Rd
Angus Ln
Mira Sol Rd
Applewood Rd
Chaparral Ln
El Camino Campo
San Mateo Drain
Nickolls Drain
Riverside Drain
Bazan Loop
Camino Vega Verde
448
528
Alameda Blvd NW
Alameda Blvd NW
Rio Grande Blvd NW
Guadalupe Ct NW
ABQ River
Chamisal
Bachechi Op
Space

Excavation Depth & Contours

0 0.125 0.25 0.5 Miles

Scale: 1:10,000

N

HR Sites
1/2ft Contours
Potential Access
Potential Spoil

Sediment Excavation

Excavation Depth (ft)

- No Excavation
- 0 - 0.5
- 0.5 - 1
- 5 - 3
- 1 - 5
- 3 - 8.9

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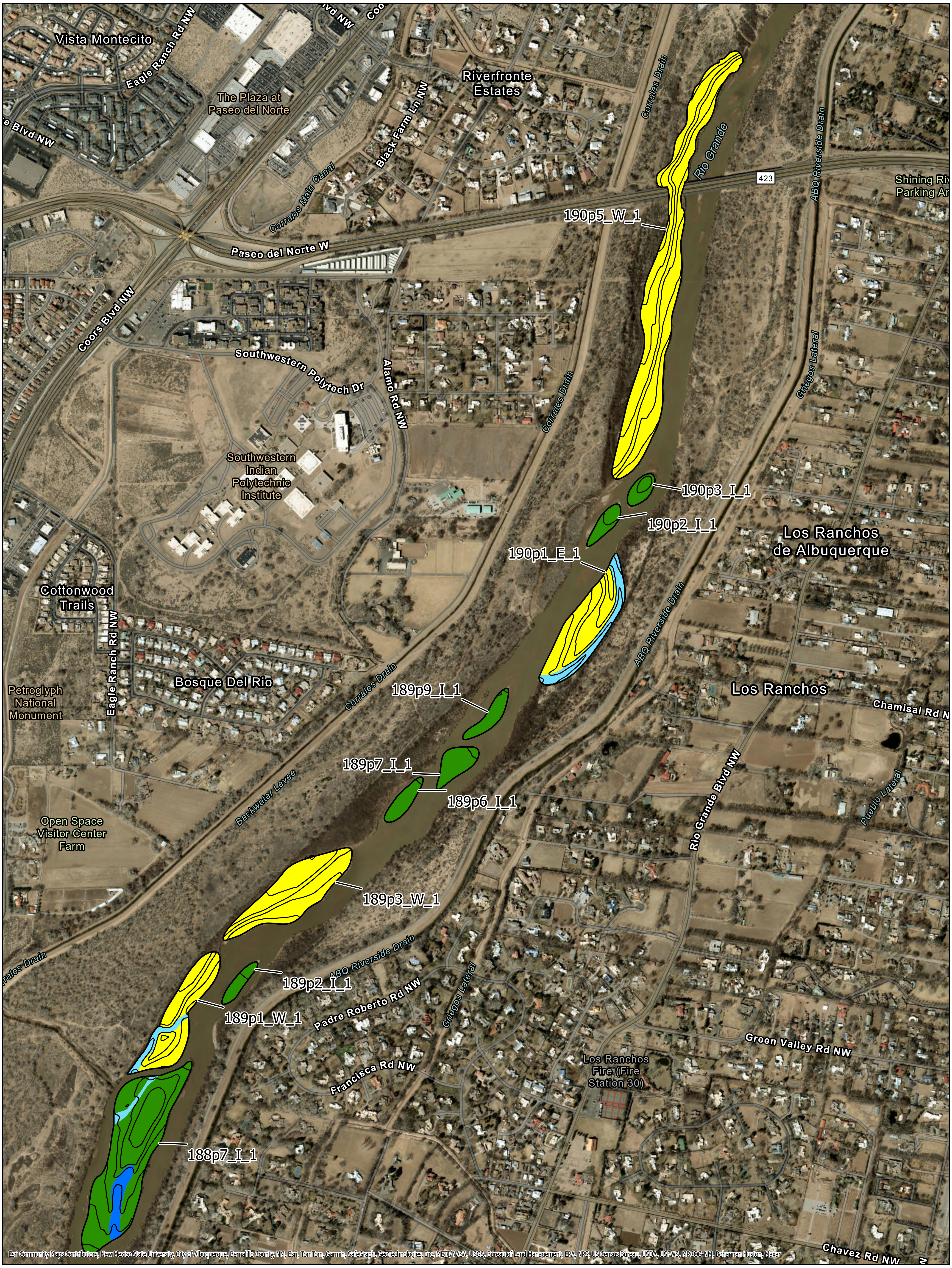

Habitat Restoration Features & Contours

0 0.125 0.25 0.5 Miles

Scale: 1:10,000

N

HR Sites

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HR Features

Feature Type

Backwater

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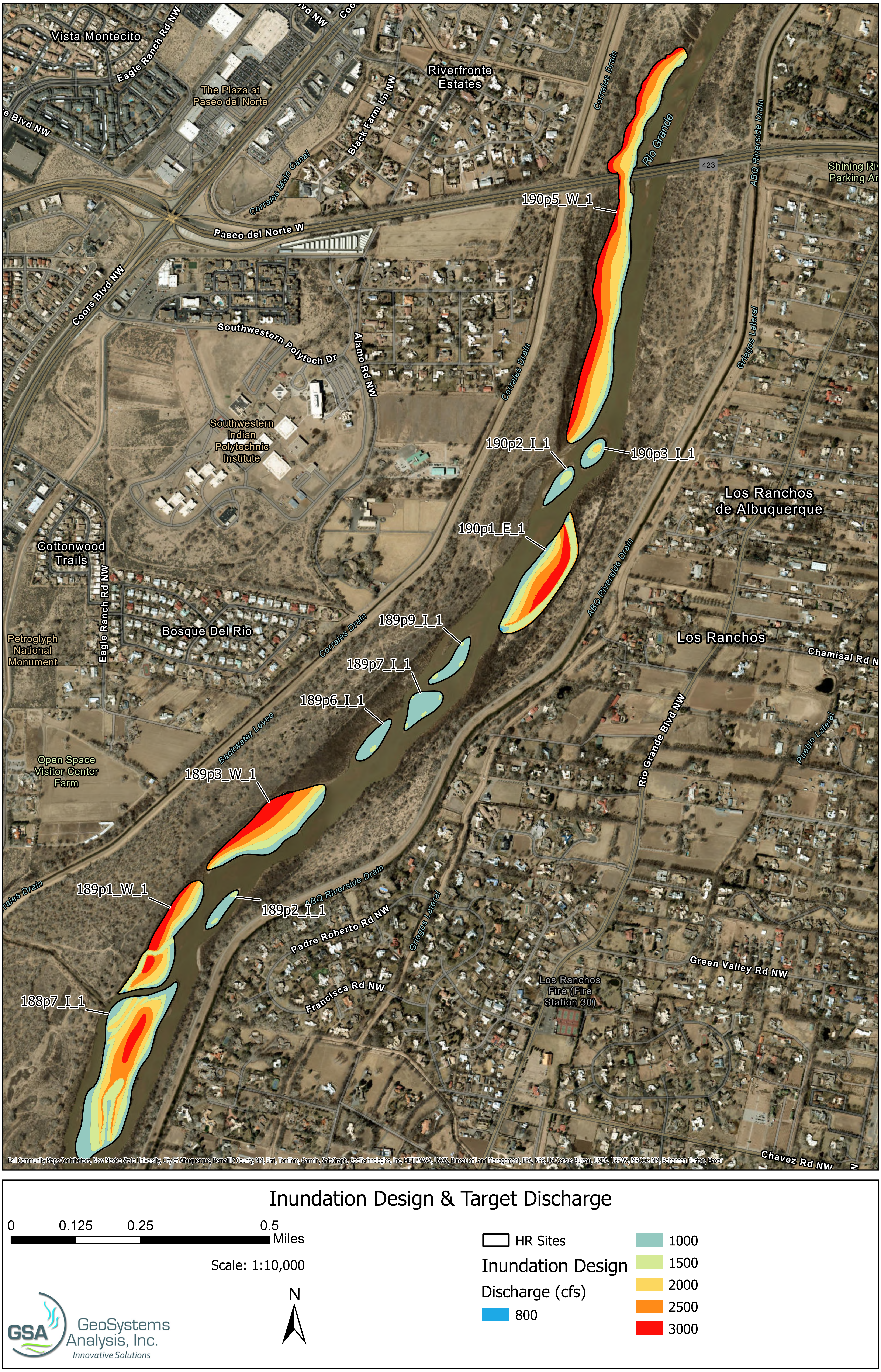
Vista Montecito
Eagle Ranch Rd NW
The Plaza at Paseo del Norte
Riverfronte Estates
Black Farm Ln NW
Corrales Main Canal
Corrales Drain
Rio Grande
ABQ Riverside Drain
423
Shining Riv Parking Ar
190p5_W_1
Paseo del Norte W
Coors Blvd NW
Southwestern Polytech Dr
Alamo Rd NW
Griegos Lateral
Southwestern Indian Polytechnic Institute
190p2_I_1
190p3_I_1
Los Ranchos de Albuquerque
190p1_E_1
Cottonwood Trails
Eagle Ranch Rd NW
Bosque Del Rio
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Los Ranchos
Chamisal Rd N
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Rio Grande Blvd NW
Pueblo Lateral
Backwater Levee
Open Space Visitor Center Farm
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189p2_I_1
Padre Roberto Rd NW
Francisca Rd NW
Los Ranchos Fire (Fire Station 30)
Green Valley Rd NW
188p7_I_1
Chavez Rd NW
Esri Community Maps Contributors, New Mexico State University, City of Albuquerque, Bernalillo County, NM, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, US Census Bureau, USDA, USFWS, MRCOG NM, Bohannan Huston, Maxar
Inundation Design & Target Discharge
0
0.125
0.25
0.5
Miles
Scale: 1:10,000
N
HR Sites
Inundation Design
Discharge (cfs)
800
1000
1500
2000
2500
3000
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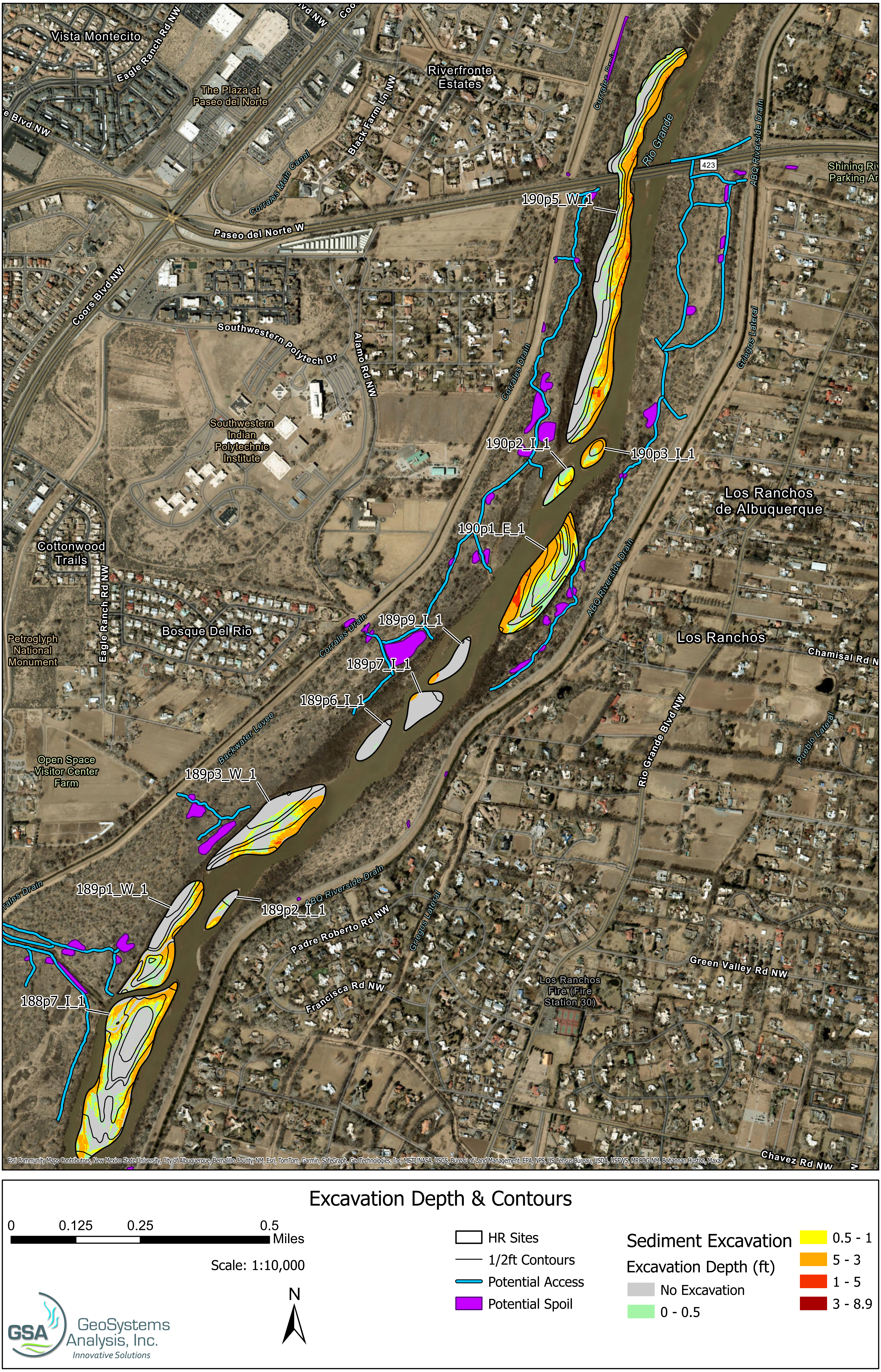

Vista Montecito
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Cottonwood Trails
Bosque Del Rio
189p9_I_1
Los Ranchos
Chamisal Rd NW
Petroglyph National Monument
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Rio Grande Blvd NW
Backwater Levee
Open Space Visitor Center Farm
Pueblo Lateral
189p3_W_1
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Chavez Rd NW
Excavation Depth & Contours
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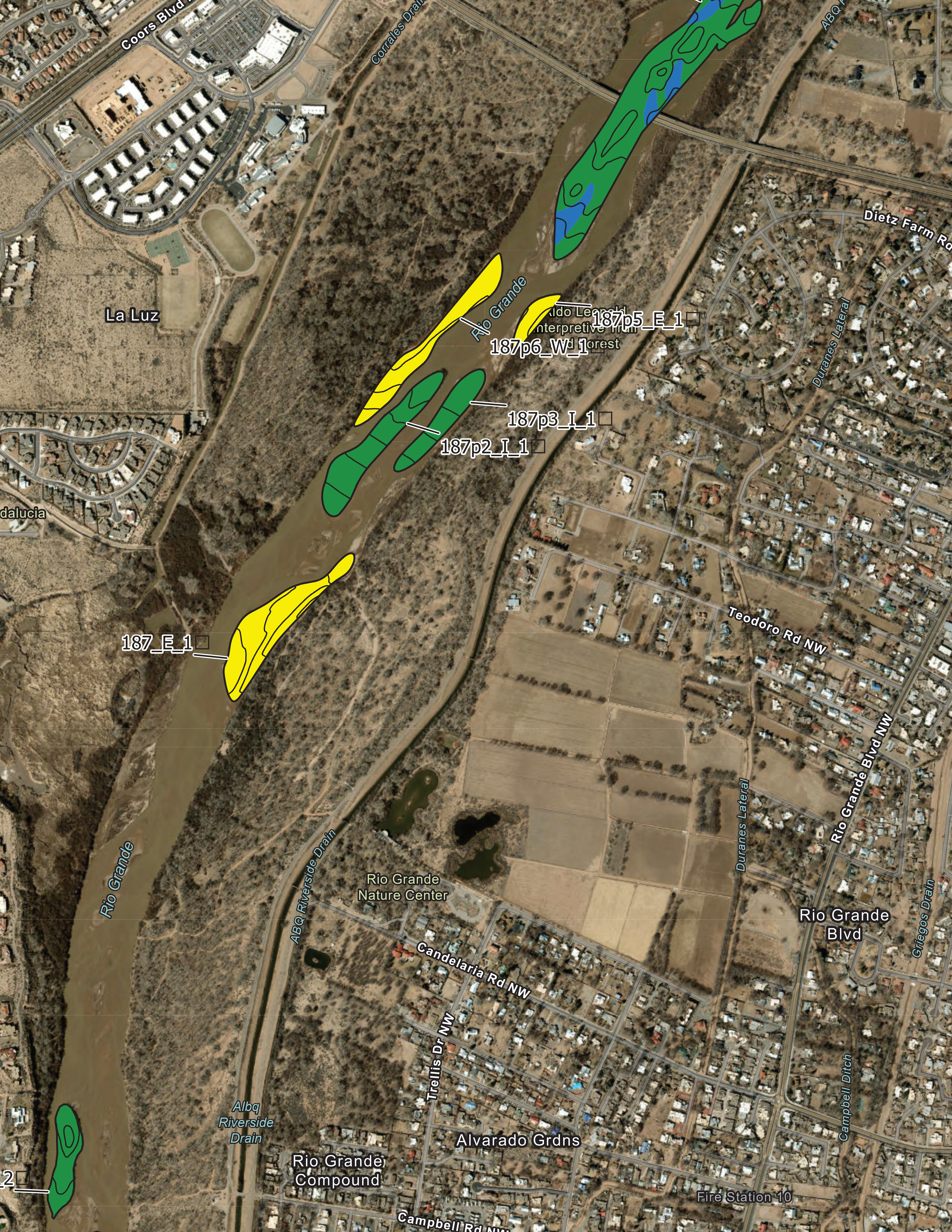
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La Luz
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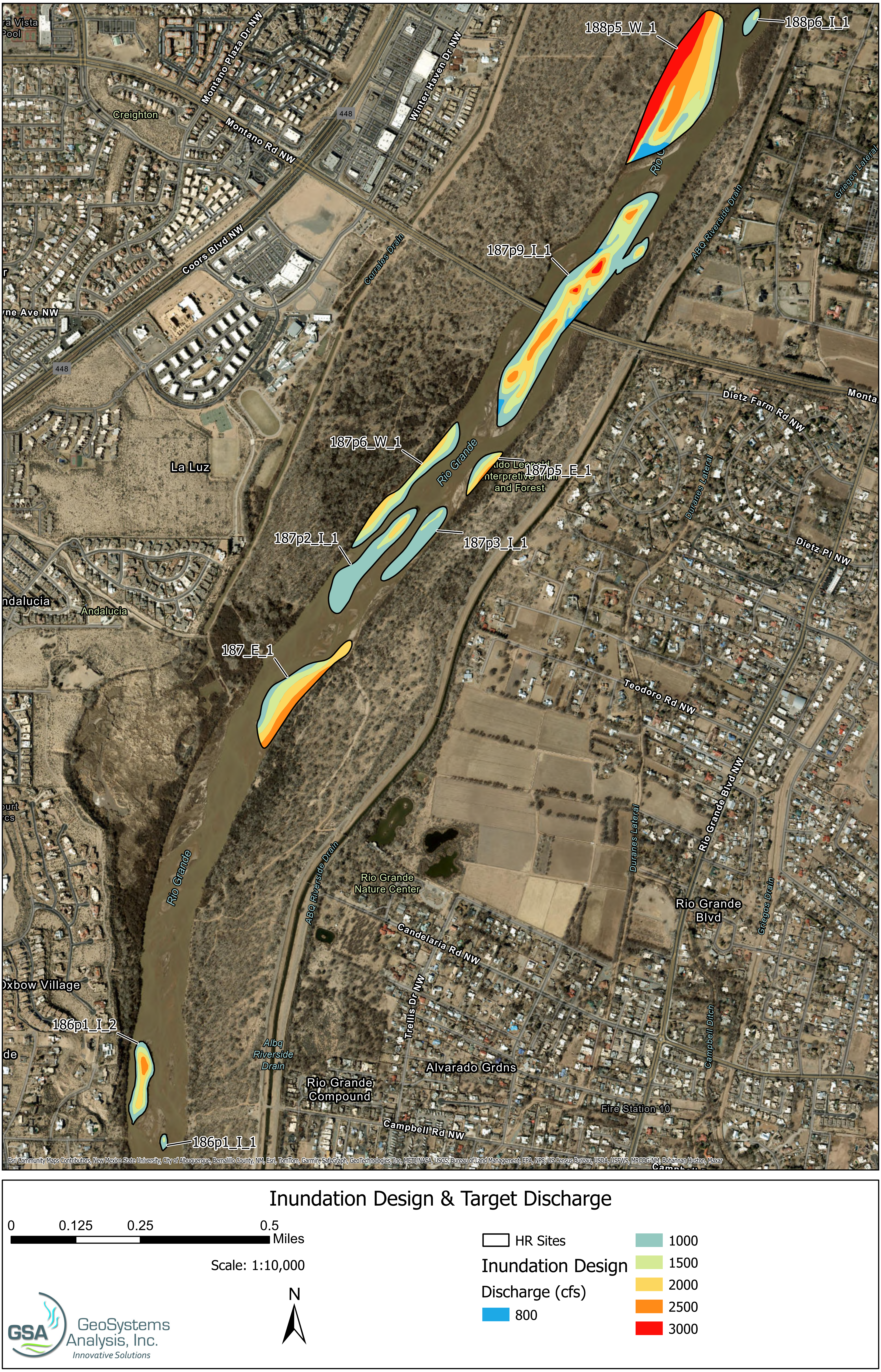
Teodoro Rd NW
Duranes Lateral
Rio Grande Blvd NW
Rio Grande Nature Center
ABQ Riverside Drain
Rio Grande Blvd
Griegos Drain
Candelaria Rd NW
Trellis Dr NW
Albq Riverside Drain
Rio Grande Compound
Alvarado Grdns
Campbell Ditch
Fire Station 10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Montano Plaza Dr NW
Montano Rd NW
Winter Haven Dr NW
Creighton
Coors Blvd NW
Corrales Drain
ABQ Riverside Drain
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Dietz Farm Rd NW
Dietz Pl NW
Duranes Lateral
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Rio Grande Compound
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0.25
0.5
Miles
Scale: 1:10,000
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Inundation Design
Discharge (cfs)
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1500
2000
2500
3000
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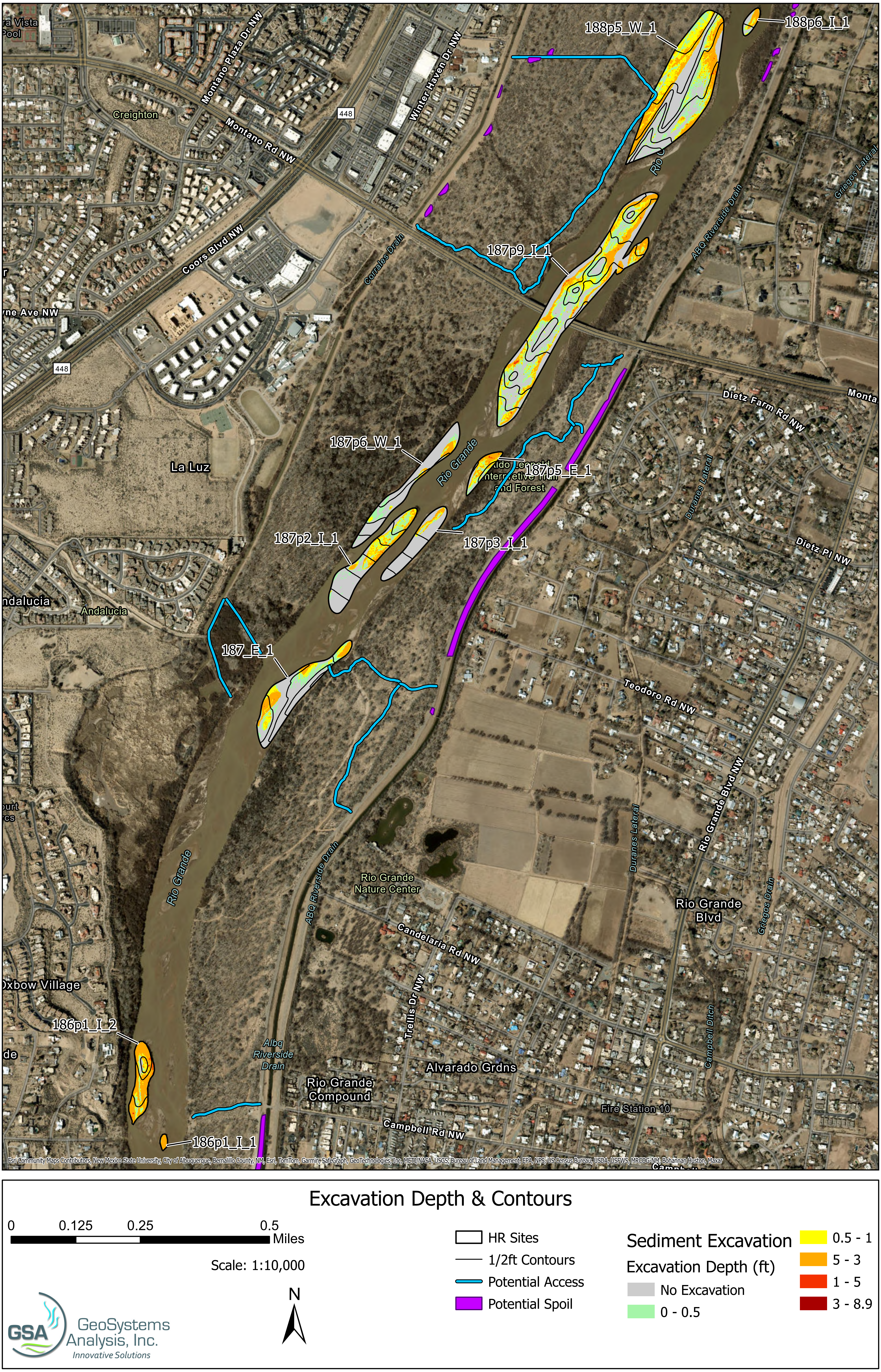
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186p1_I_2
186p1_I_1
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Rio Grande
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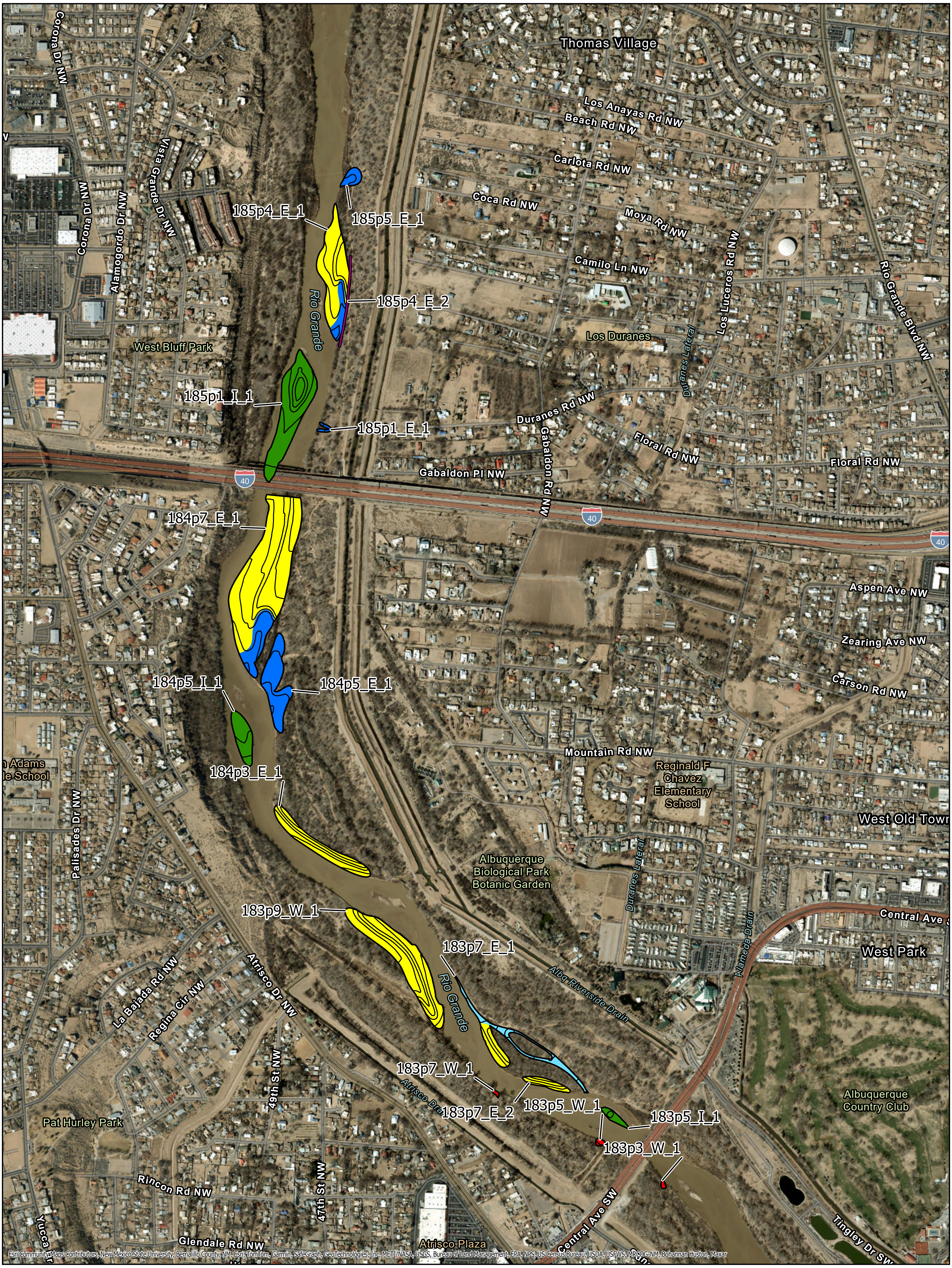

Habitat Restoration Features & Contours

0 0.125 0.25 0.5 Miles

Scale: 1:10,000

N

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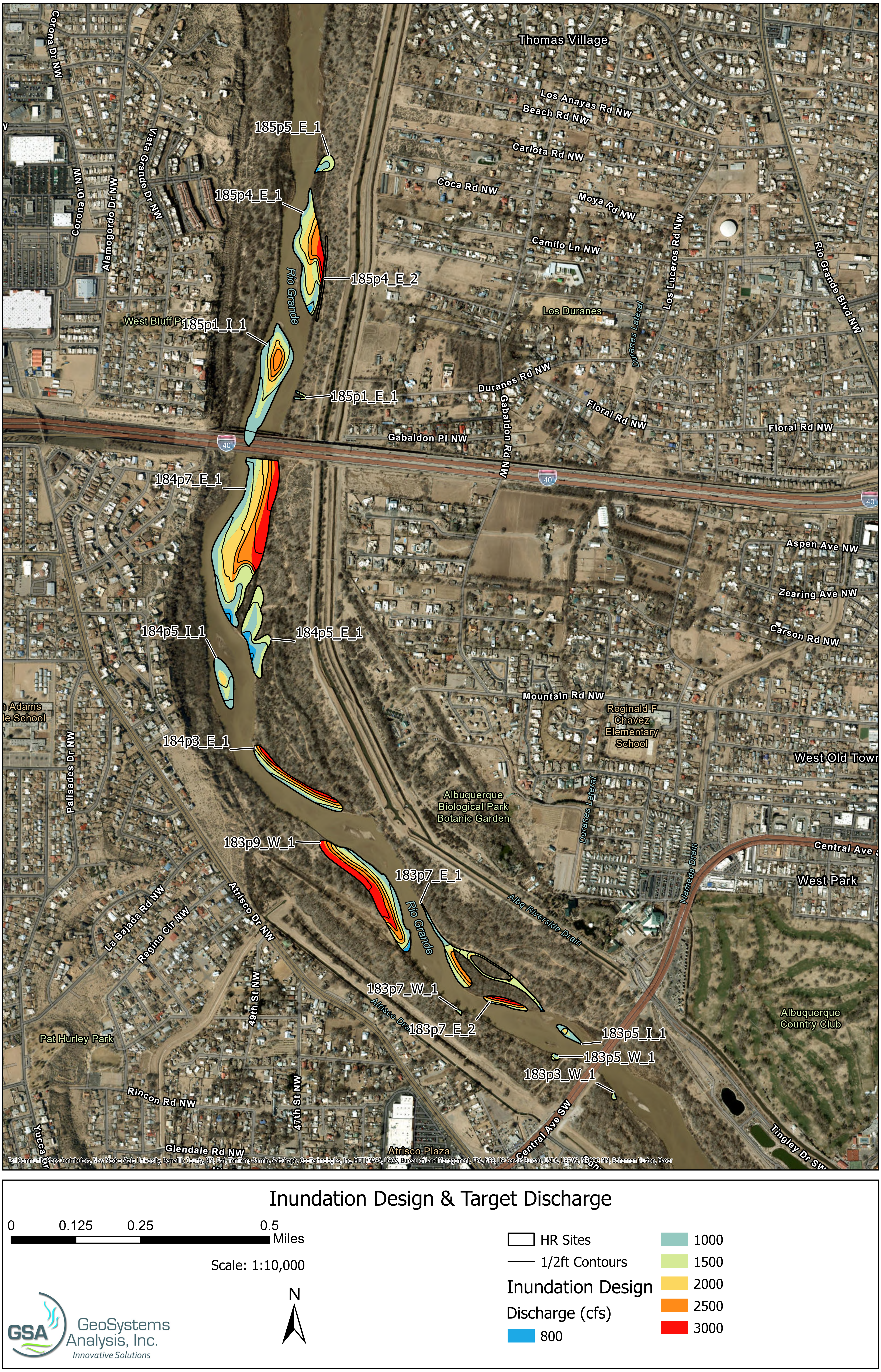
- HR Sites
- 1/2ft Contours

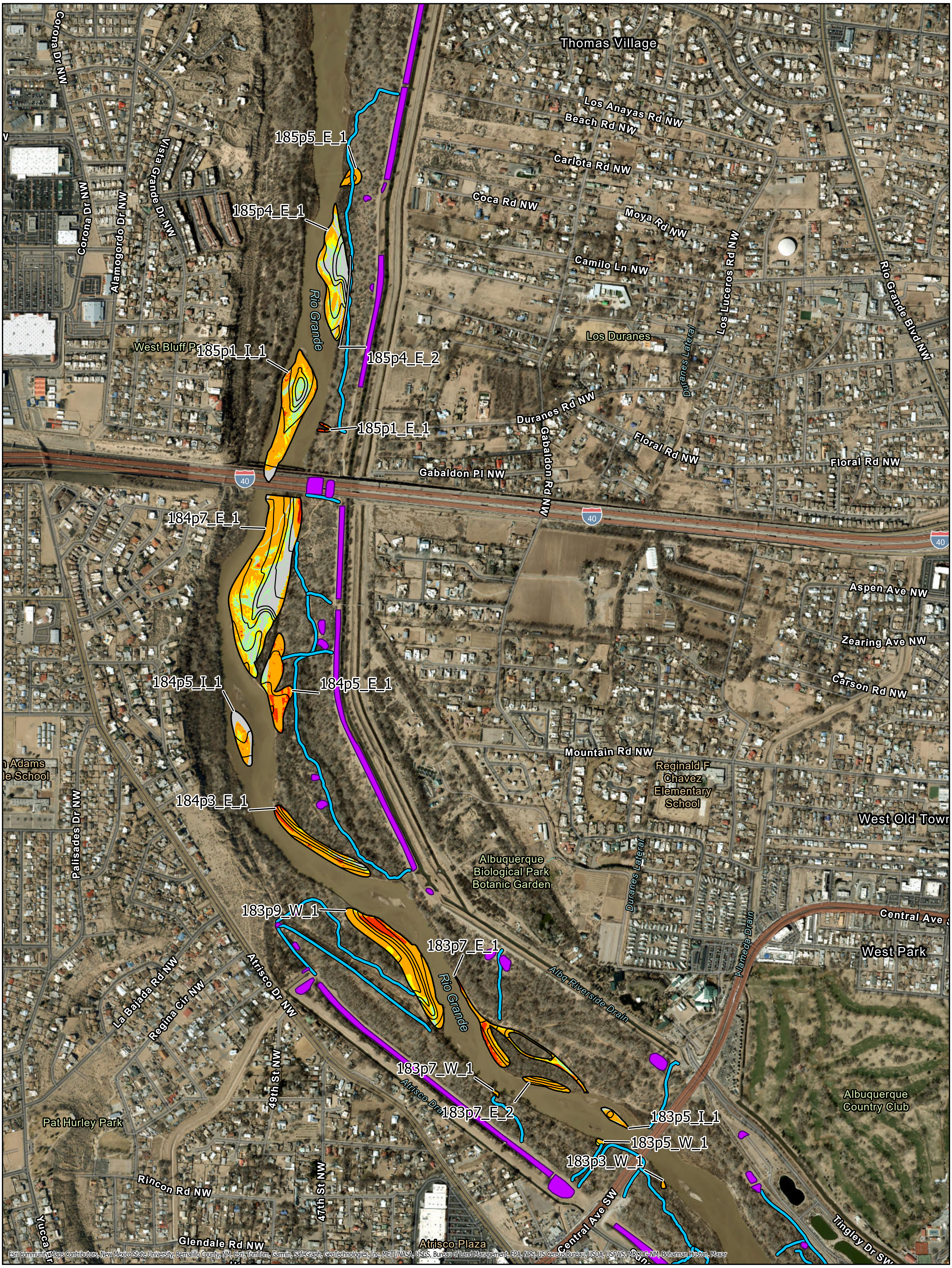
HR Features

Feature Type

- Backwater
- Bankline Modification
- Flowthrough Channel
- Island Destabilization
- Confluence Maintenance
- Jetty Jack Removal



Inundation Design & Target Discharge



Excavation Depth & Contours

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Scale: 1:10,000

N

- HR Sites
- 1/2ft Contours
- Potential Access
- Potential Spoil

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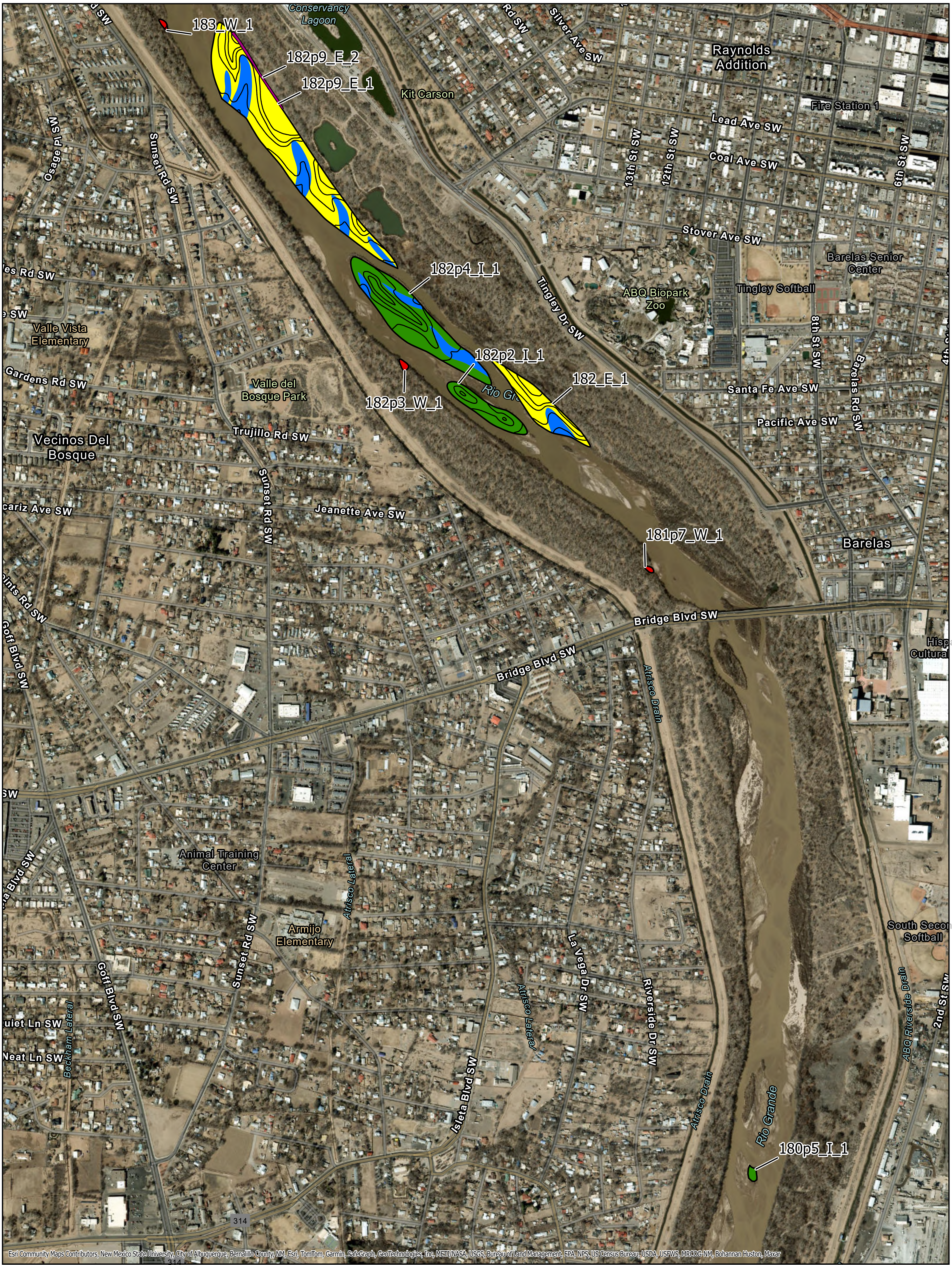

Habitat Restoration Features & Contours

0 | 0.125 | 0.25 | 0.5 Miles

Scale: 1:10,000

N

HR Sites
1/2ft Contours

HR Features

Feature Type
- Backwater
- Bankline Modification
- Flowthrough Channel
- Island Destabilization
- Confluence Maintenance
- Jetty Jack Removal

GeoSystems Analysis, Inc.
Innovative Solutions

Inundation Design & Target Discharge

0 0.125 0.25 0.5 Miles

Scale: 1:10,000

N

HR Sites

Inundation Design

Discharge (cfs)

	Discharge (cfs)
Blue	800
Teal	1000
Light green	1500
Yellow	2000
Orange	2500
Red	3000

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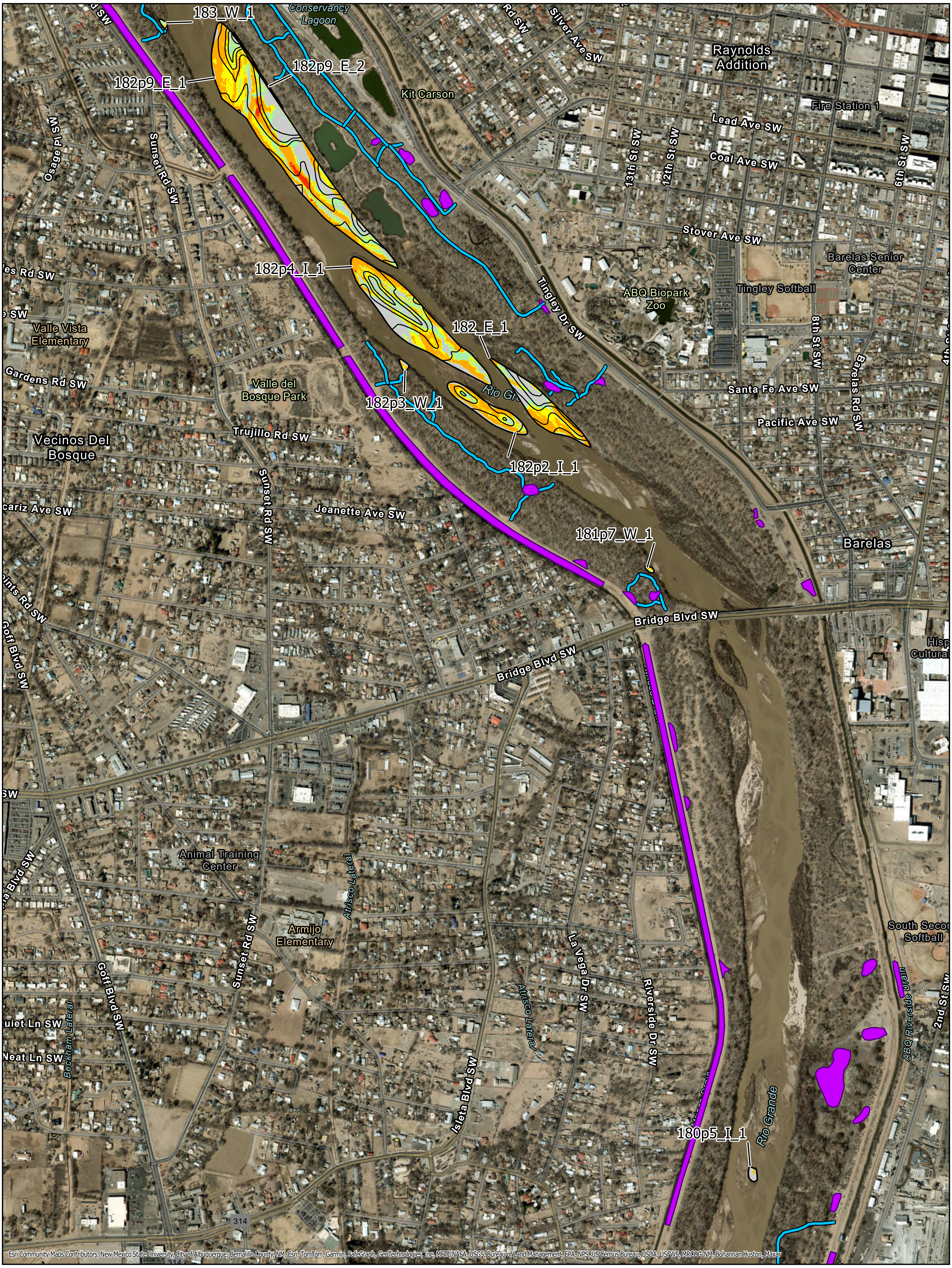

Esri Community Maps Contributors, New Mexico State University, City of Albuquerque, Bernalillo County, NM, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, US Census Bureau, USDA, USFWS, MRGCD NM, Bohannan Huston, Maxar

Excavation Depth & Contours

0 0.125 0.25 0.5 Miles

Scale: 1:10,000

N

HR Sites
1/2ft Contours
Potential Access
Potential Spoil

Sediment Excavation

Excavation Depth (ft)

- No Excavation
- 0 - 0.5
- 0.5 - 1
- 5 - 3
- 1 - 5
- 3 - 8.9

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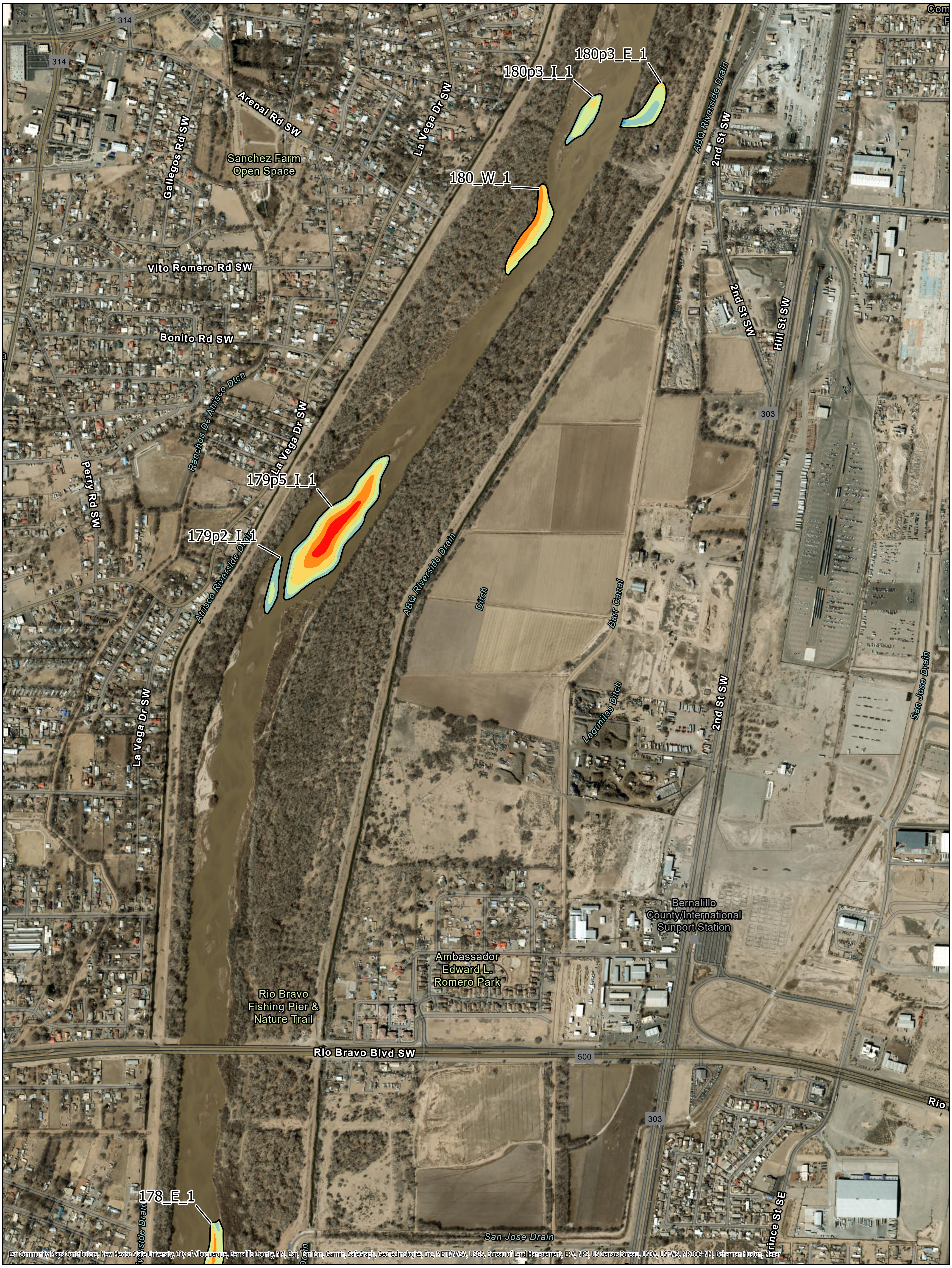
180p3_I_1
180p3_E_1
180_W_1
179p5_I_1
179p2_I_1
178_E_1
Arenal Rd SW
Sanchez Farm Open Space
La Vega Dr SW
Gallegos Rd SW
Vito Romero Rd SW
Bonito Rd SW
Ranchos De Atrisco Ditch
Perry Rd SW
Atrisco Riverside Drain
ABQ Riverside Drain
Ditch
Barr Canal
2nd St SW
Hill St SW
Lagunitas Ditch
San Jose Drain
Bernalillo County/International Sunport Station
Ambassador Edward L. Romero Park
Rio Bravo Fishing Pier & Nature Trail
Rio Bravo Blvd SW
314
303
500
San Jose Drain
Esri Community Maps Contributors, New Mexico State University, City of Albuquerque, Bernalillo County, NM, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, US Census Bureau, USDA, USFWS, MRCOG-NM, Bohannan Huston, Maxar
Habitat Restoration Features & Contours
0
0.125
0.25
0.5
Miles
Scale: 1:10,000
N
HR Sites
1/2ft Contours
HR Features
Feature Type
Backwater
Bankline Modification
Flowthrough Channel
Island Destabilization
Confluence Maintenance
Jetty Jack Removal
GSA
GeoSystems Analysis, Inc.
Innovative Solutions



Inundation Design & Target Discharge

0 0.125 0.25 0.5
Miles

Scale: 1:10,000

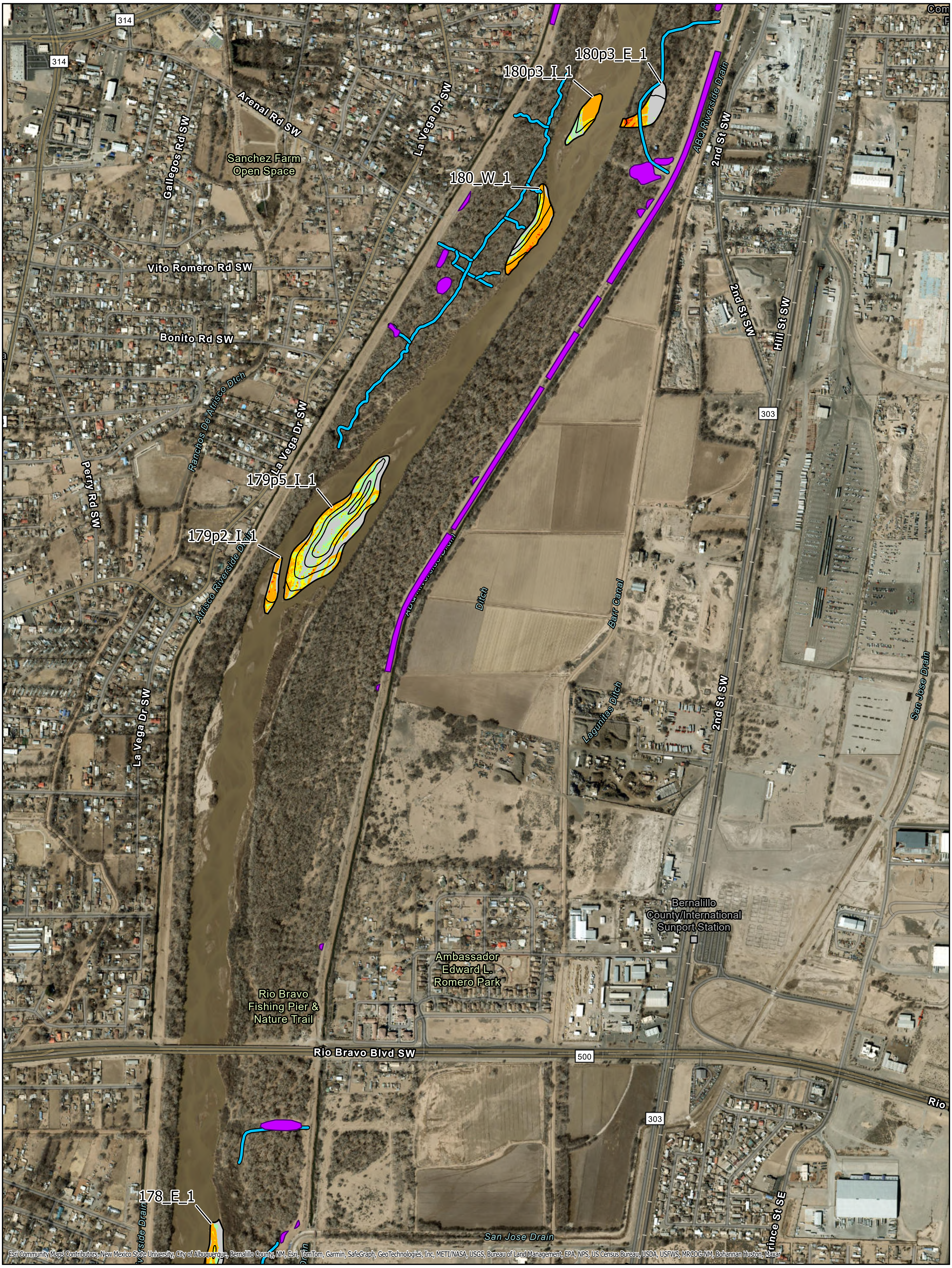
N

HR Sites

Inundation Design
Discharge (cfs)

800
1000
1500
2000
2500
3000

GSA GeoSystems Analysis, Inc.
Innovative Solutions



Excavation Depth & Contours

0 0.125 0.25 0.5 Miles

Scale: 1:10,000

N

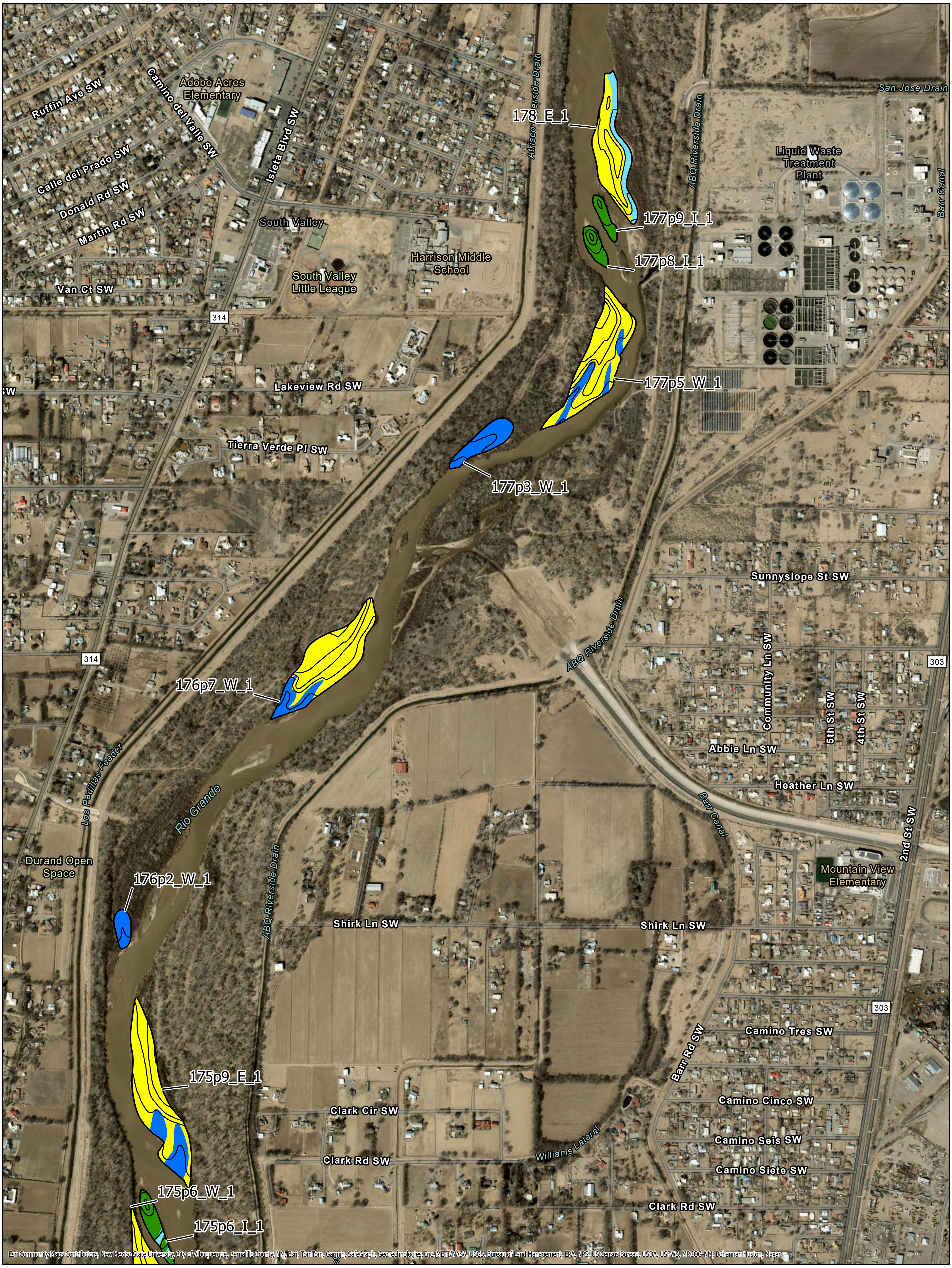
- HR Sites
- 1/2ft Contours
- Potential Access
- Potential Spoil

Sediment Excavation

Excavation Depth (ft)

- No Excavation
- 0 - 0.5
- 0.5 - 1
- 5 - 3
- 1 - 5
- 3 - 8.9

GSA GeoSystems Analysis, Inc.
Innovative Solutions



Habitat Restoration Features & Contours

0 0.125 0.25 0.5 Miles

Scale: 1:10,000

N

HR Sites

1/2ft Contours

HR Features

Feature Type

Backwater

Bankline Modification

Flowthrough Channel

Island Destabilization

Confluence Maintenance

Jetty Jack Removal

GeoSystems Analysis, Inc.
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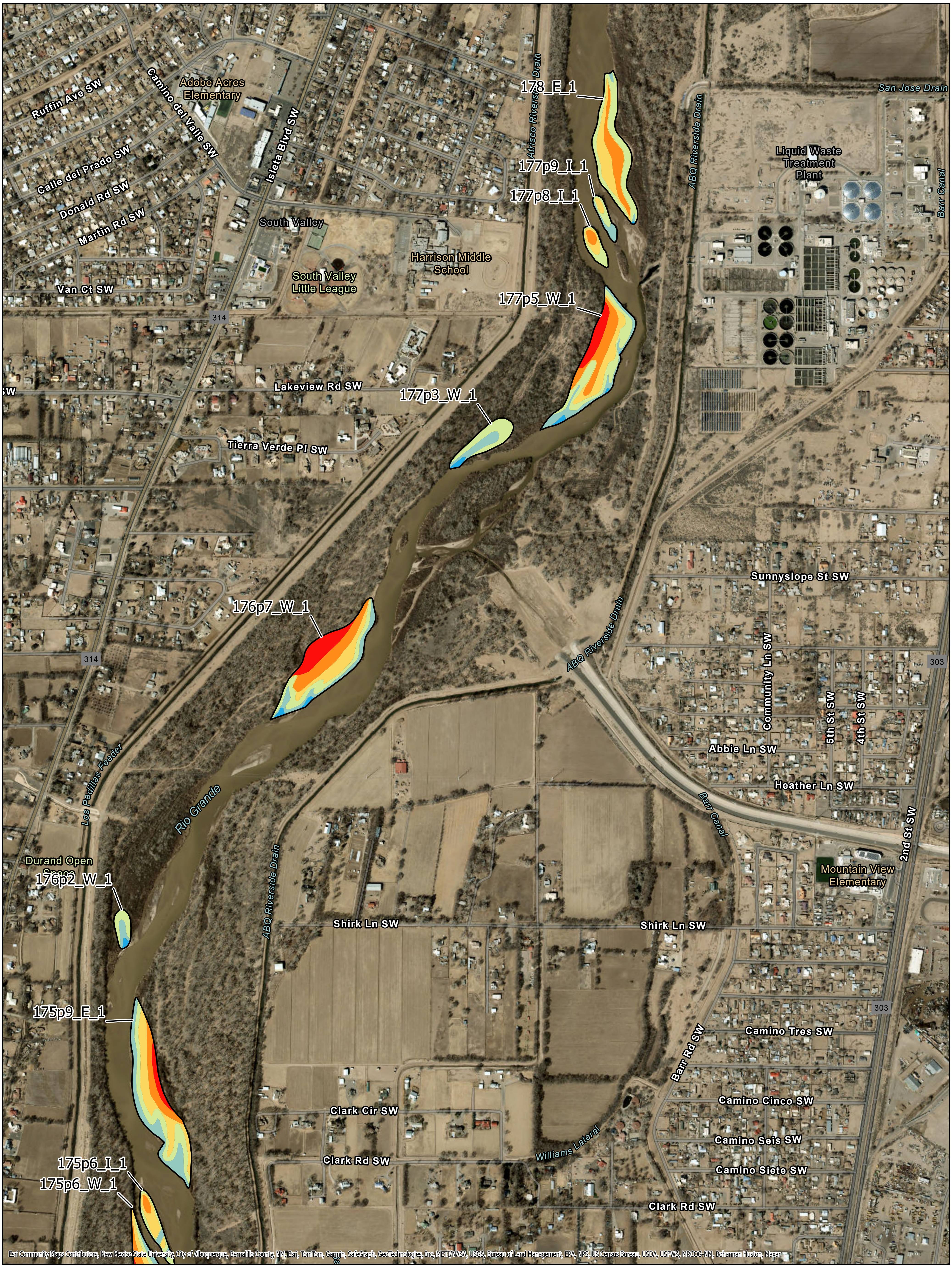


Inundation Design & Target Discharge

0 0.125 0.25 0.5 Miles

Scale: 1:10,000

N

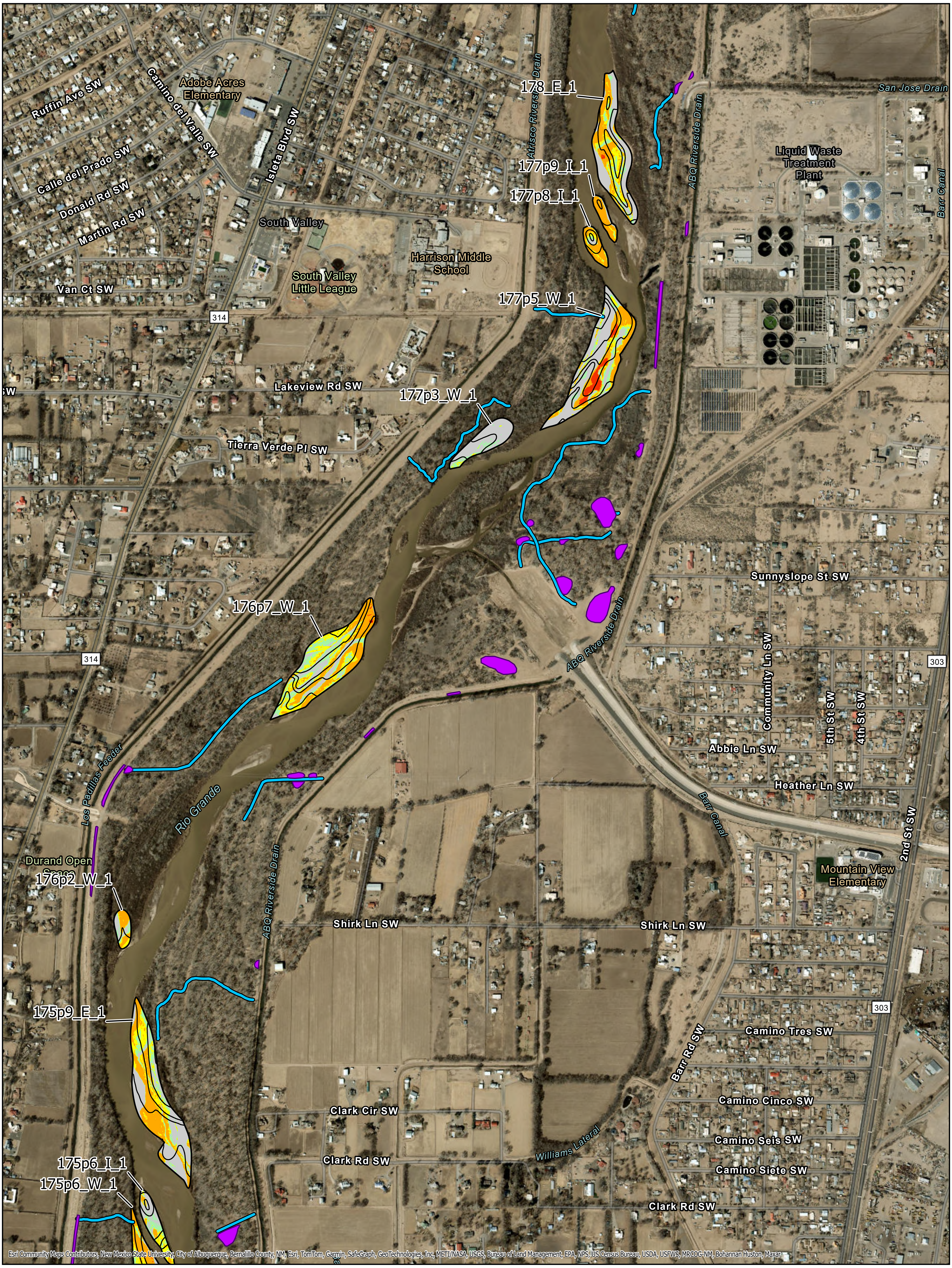
HR Sites

Inundation Design

Discharge (cfs)

- 800
- 1000
- 1500
- 2000
- 2500
- 3000

GSA GeoSystems Analysis, Inc.
Innovative Solutions



Excavation Depth & Contours

0 0.125 0.25 0.5 Miles

Scale: 1:10,000

N

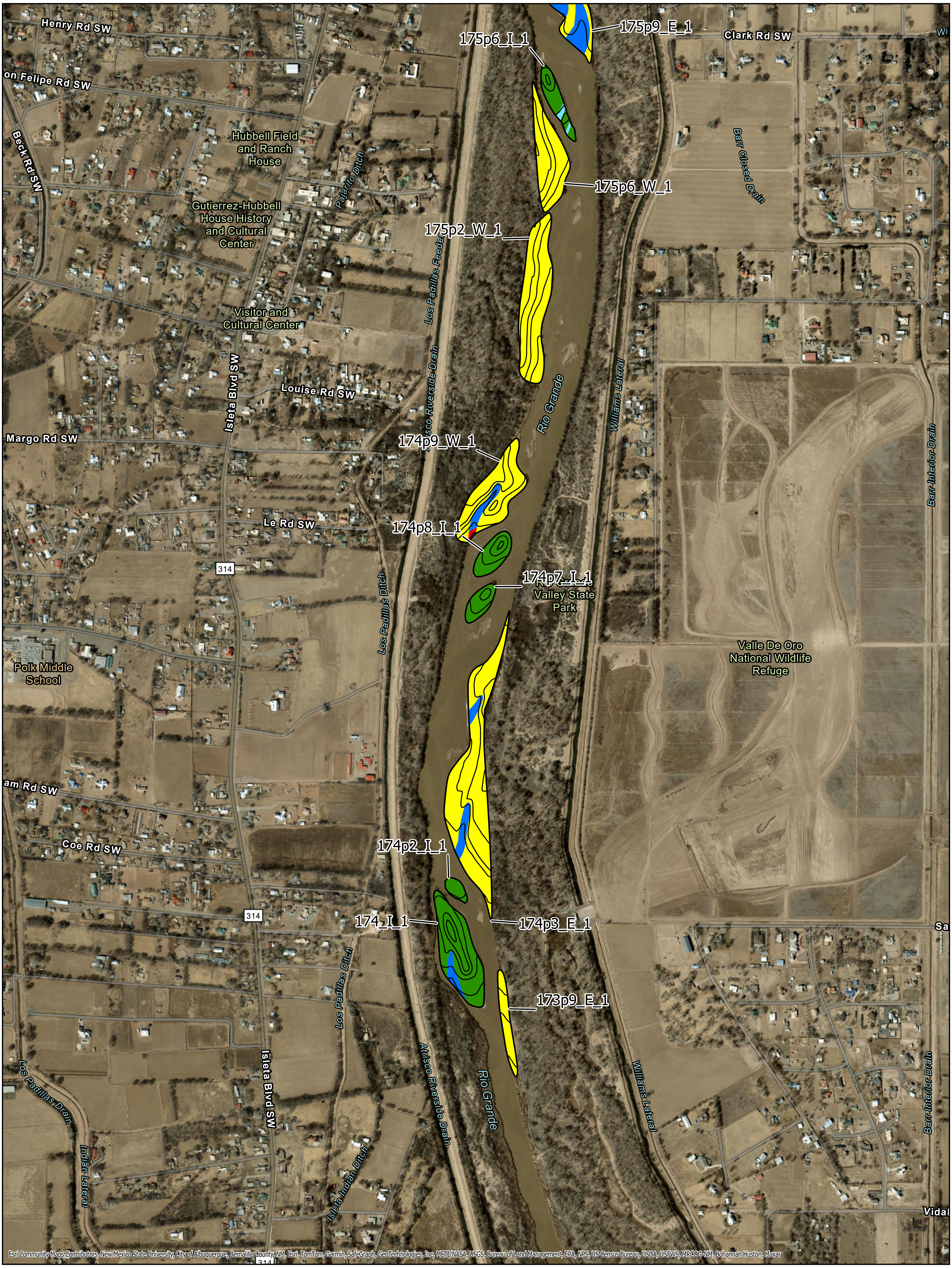
HR Sites
1/2ft Contours
Potential Access
Potential Spoil

Sediment Excavation

Excavation Depth (ft)

No Excavation
0 - 0.5
0.5 - 1
5 - 3
1 - 5
3 - 8.9

GeoSystems Analysis, Inc.
Innovative Solutions



Habitat Restoration Features & Contours

0 0.125 0.25 0.5 Miles

Scale: 1:10,000

N

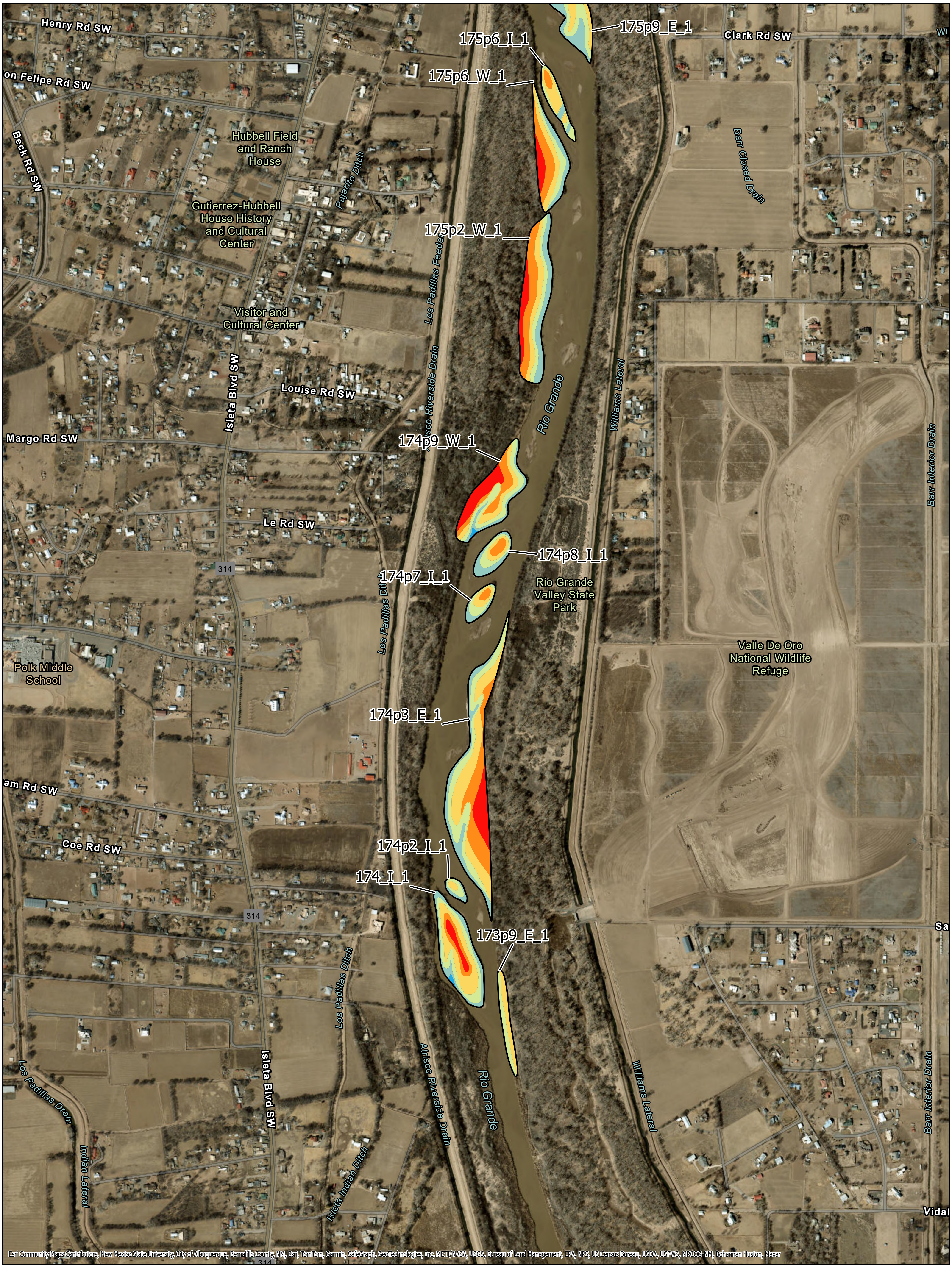
GSA GeoSystems Analysis, Inc. *Innovative Solutions*

HR Sites
1/2ft Contours

HR Features

Feature Type

- Backwater
- Bankline Modification
- Flowthrough Channel
- Island Destabilization
- Confluence Maintenance
- Jetty Jack Removal



Inundation Design & Target Discharge

0 0.125 0.25 0.5 Miles

Scale: 1:10,000

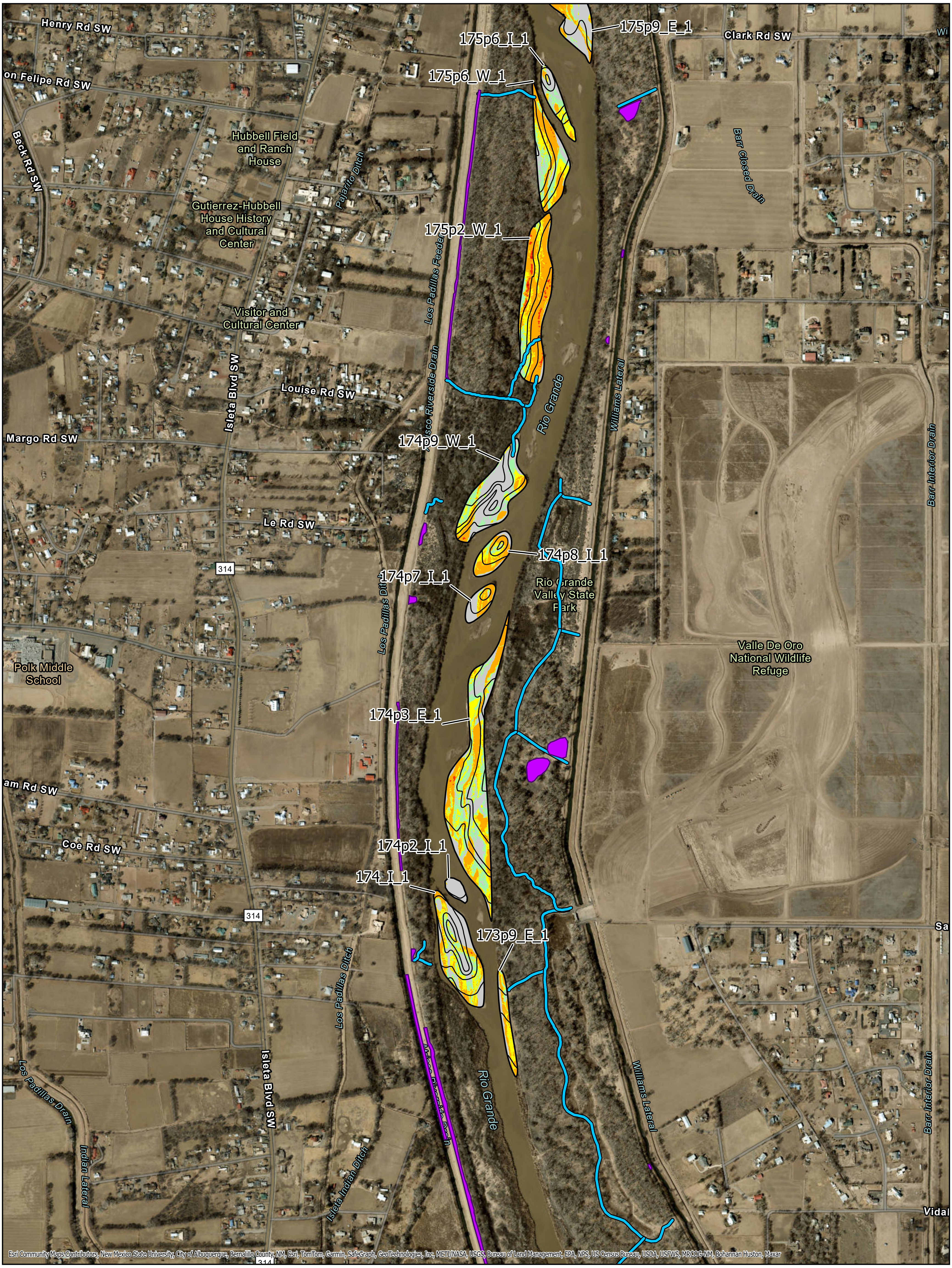
N

GSA GeoSystems Analysis, Inc. *Innovative Solutions*

HR Sites

Inundation Design Discharge (cfs)

- 800
- 1000
- 1500
- 2000
- 2500
- 3000



Excavation Depth & Contours

0 0.125 0.25 0.5 Miles

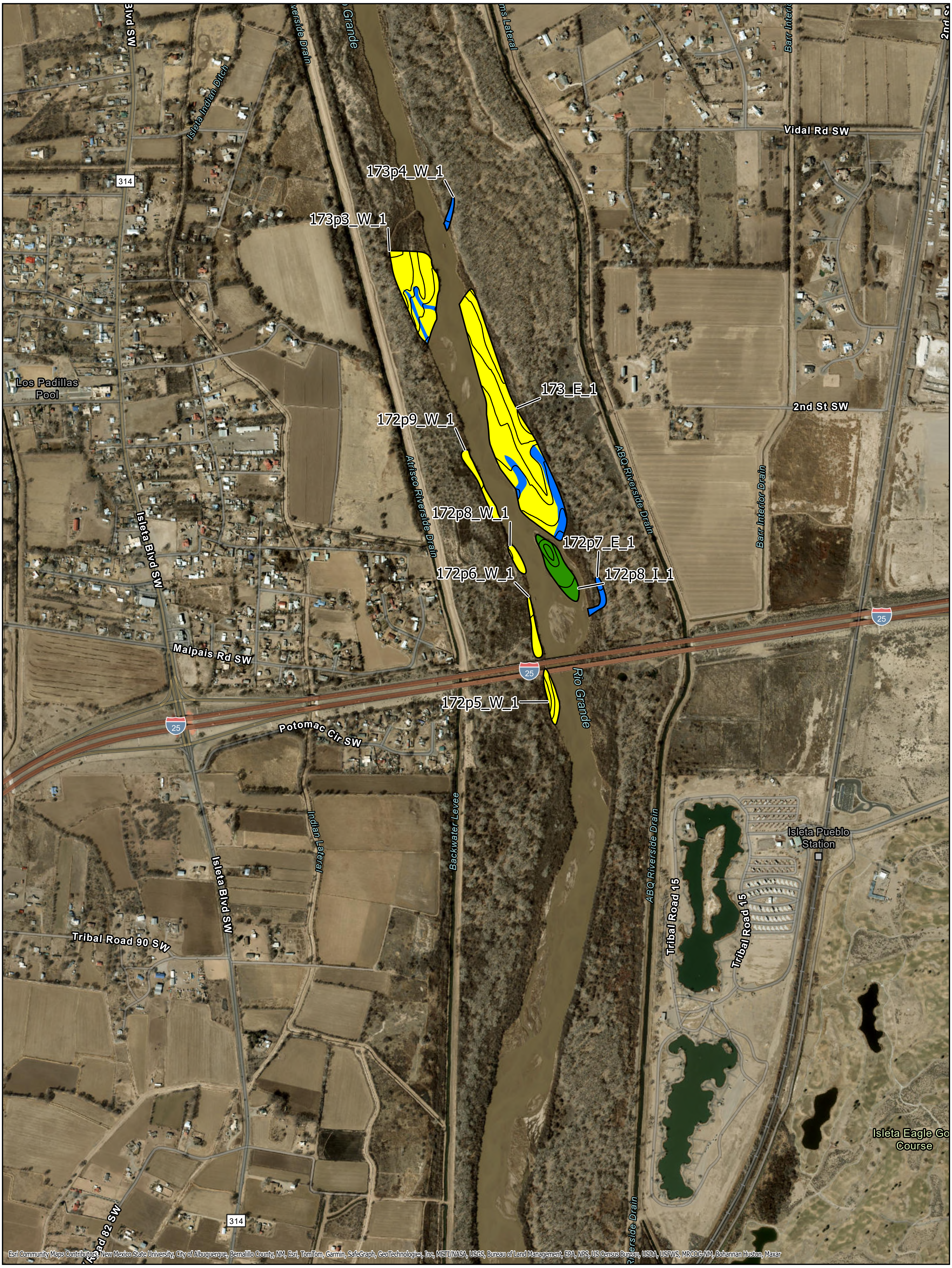
Scale: 1:10,000

N

HR Sites
1/2ft Contours
Potential Access
Potential Spoil

Sediment Excavation
Excavation Depth (ft)
No Excavation
0 - 0.5
0.5 - 1
5 - 3
1 - 5
3 - 8.9

GSA GeoSystems Analysis, Inc. Innovative Solutions



Habitat Restoration Features & Contours

0 0.125 0.25 0.5 Miles

Scale: 1:10,000

N

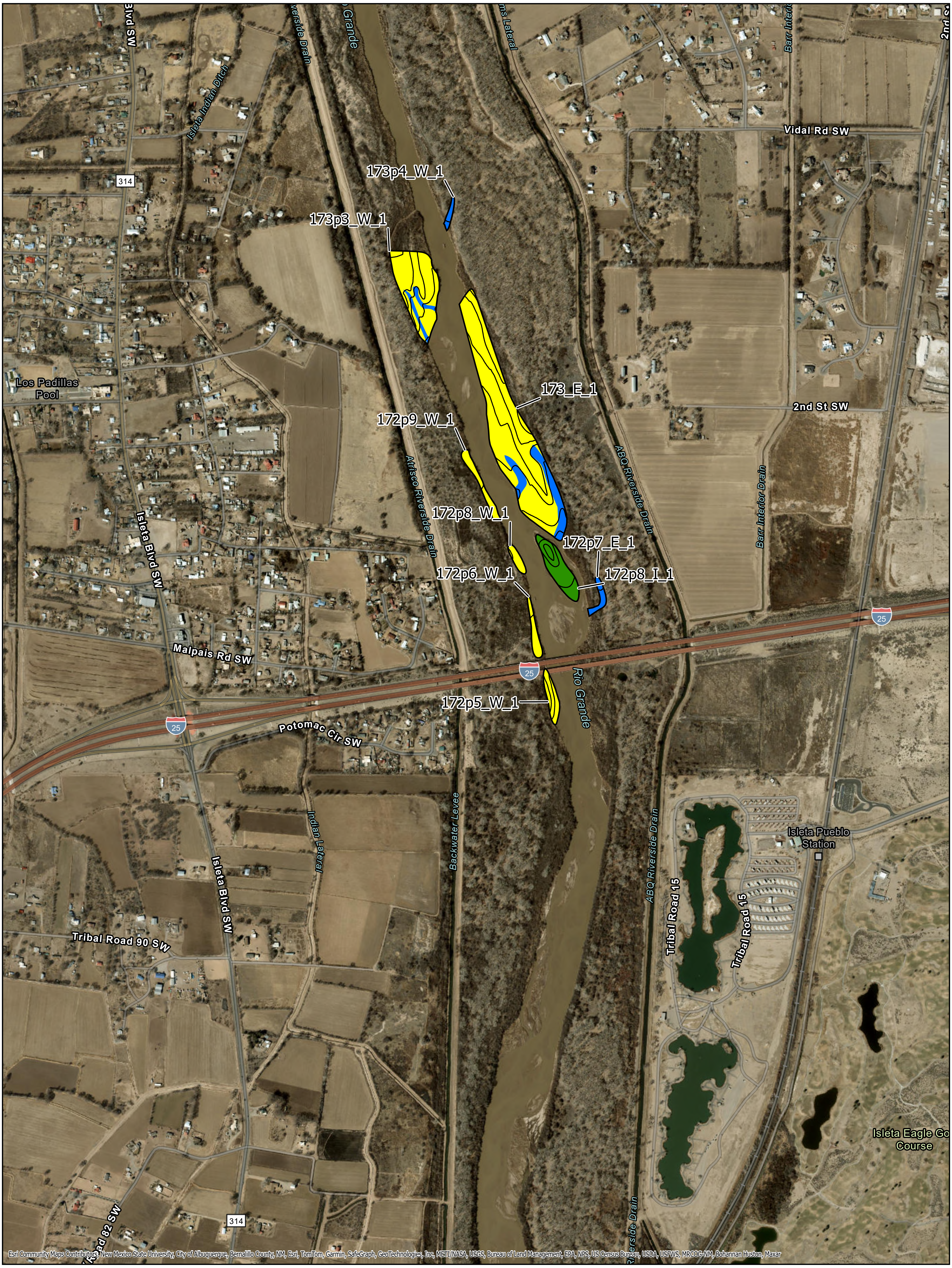
GeoSystems Analysis, Inc.
Innovative Solutions

HR Sites
1/2ft Contours

HR Features

Feature Type

- Backwater
- Bankline Modification
- Flowthrough Channel
- Island Destabilization
- Confluence Maintenance
- Jetty Jack Removal



Habitat Restoration Features & Contours

0 0.125 0.25 0.5 Miles

Scale: 1:10,000

N

HR Sites

1/2ft Contours

HR Features

Feature Type

Backwater

Bankline Modification

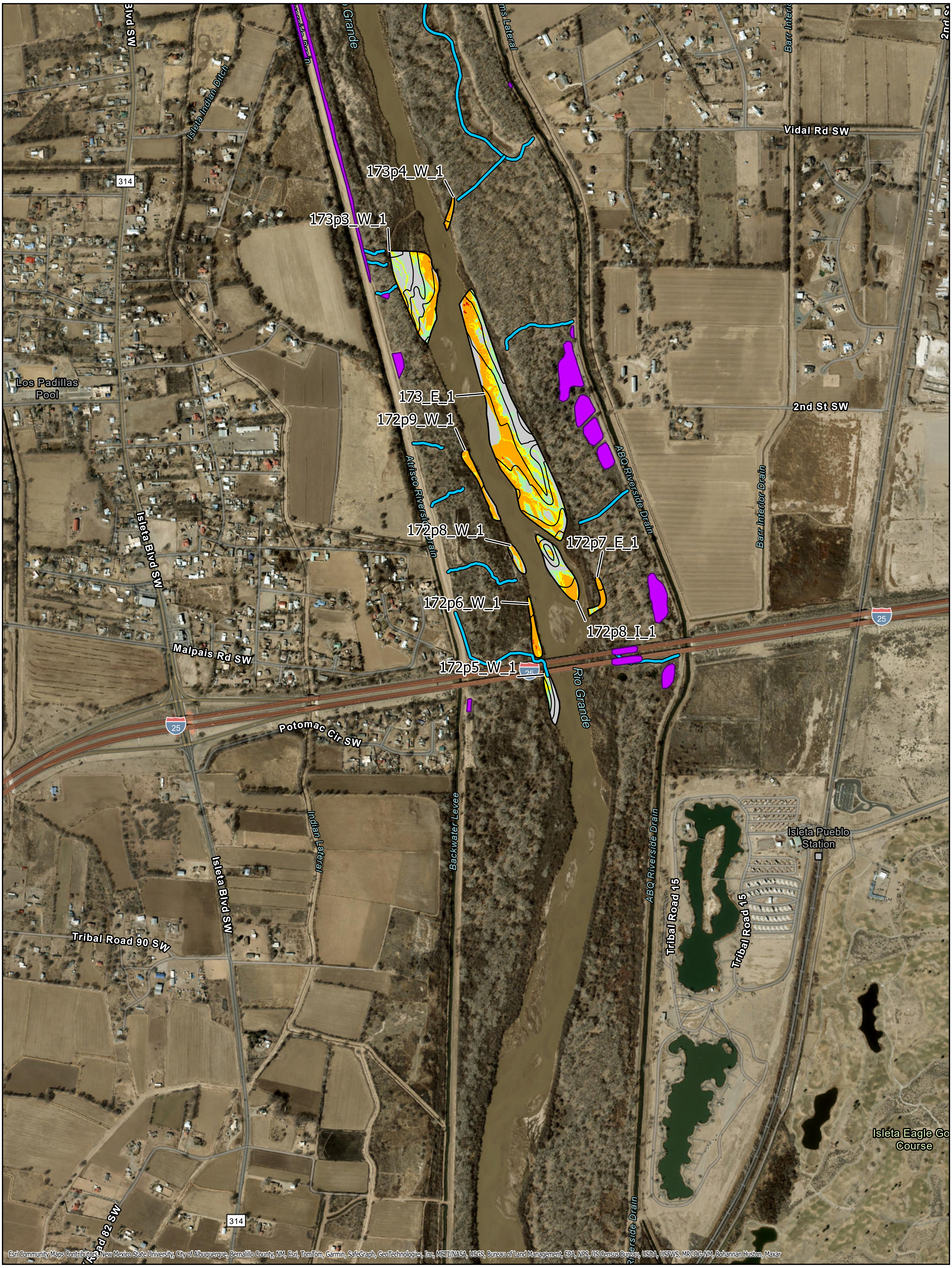
Flowthrough Channel

Island Destabilization

Confluence Maintenance

Jetty Jack Removal

GSA GeoSystems Analysis, Inc. *Innovative Solutions*



Excavation Depth & Contours

0 0.125 0.25 0.5 Miles

Scale: 1:10,000

N

- HR Sites
- 1/2ft Contours
- Potential Access
- Potential Spoil

Sediment Excavation

Excavation Depth (ft)

- No Excavation
- 0 - 0.5
- 0.5 - 1
- 5 - 3
- 1 - 5
- 3 - 8.9

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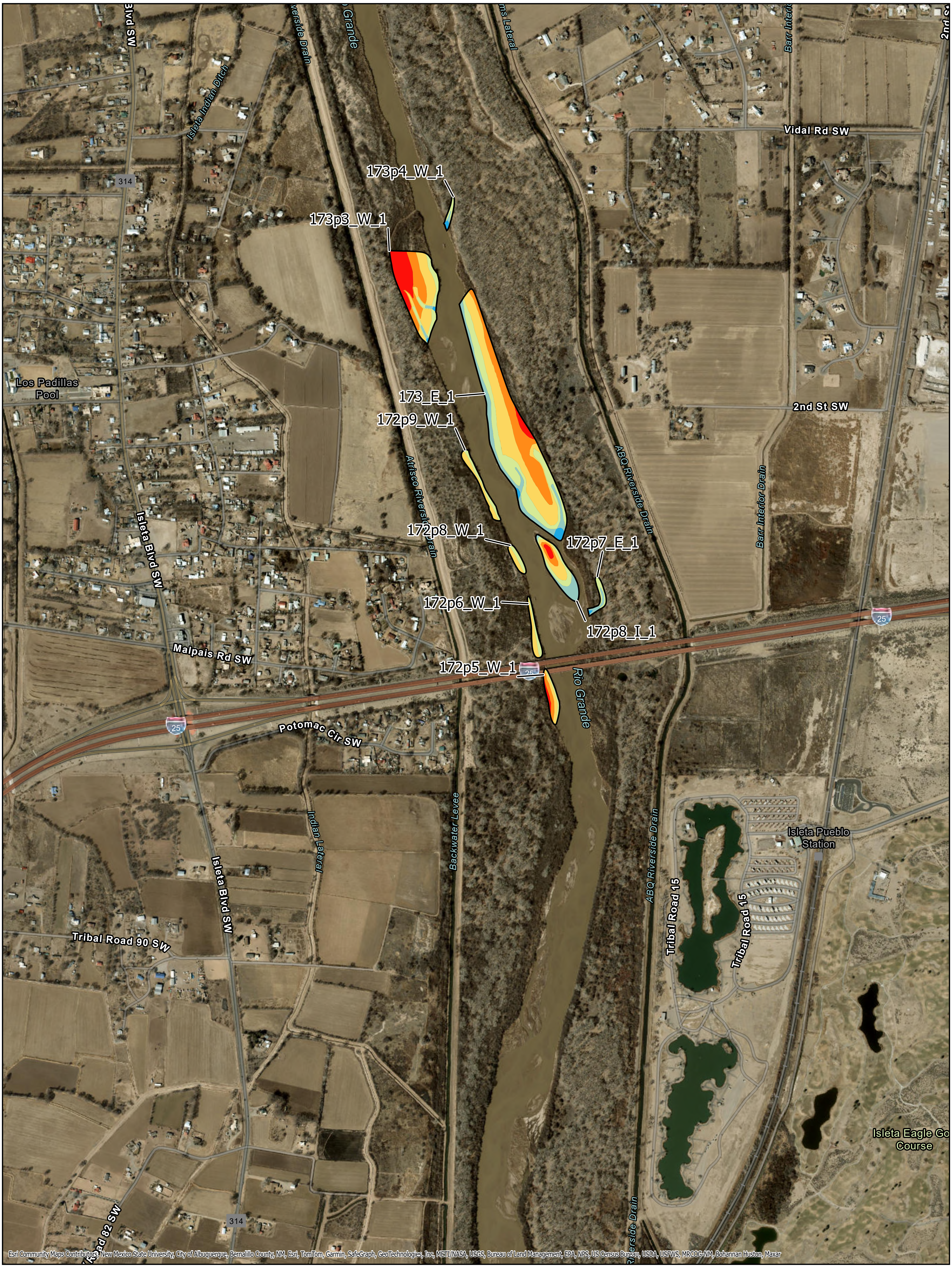


Inundation Design & Target Discharge

0 0.125 0.25 0.5 Miles

Scale: 1:10,000

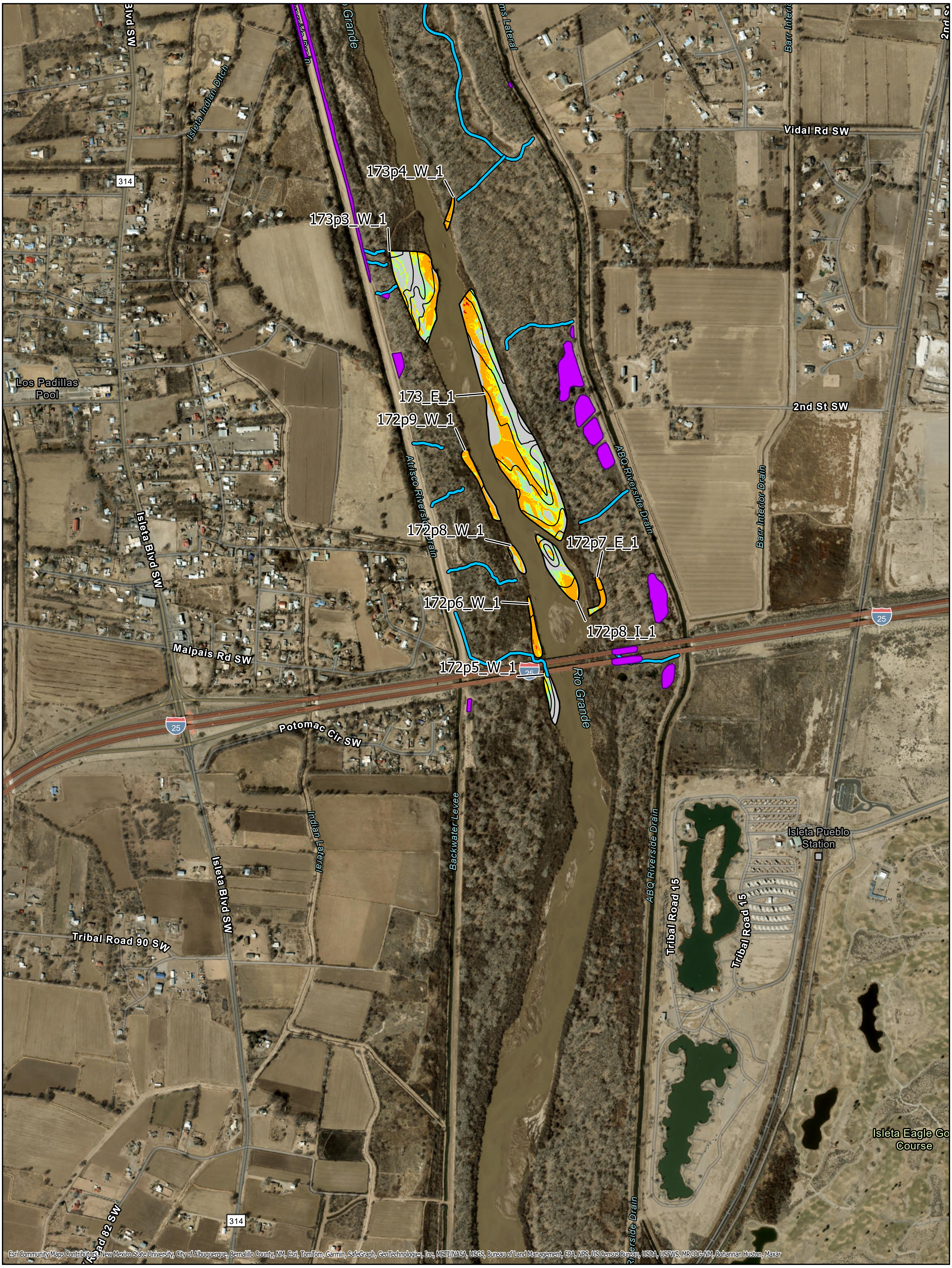
N

HR Sites

Inundation Design Discharge (cfs)

- 800
- 1000
- 1500
- 2000
- 2500
- 3000

GSA GeoSystems Analysis, Inc. *Innovative Solutions*



Excavation Depth & Contours

0 0.125 0.25 0.5 Miles

Scale: 1:10,000

N

- HR Sites
- 1/2ft Contours
- Potential Access
- Potential Spoil

Sediment Excavation

Excavation Depth (ft)

- No Excavation
- 0 - 0.5
- 0.5 - 1
- 5 - 3
- 1 - 5
- 3 - 8.9

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APPENDIX B. QUANTITES TABLE

Project Area Identification (site ID)*	Associated River Mile	Restoration Activity Type(s)	Priority Designation (1–4)†	Surface Disturbance (acres)	Maximum Sedimentation Quantity (cubic yards)
NDC Subreach – NDC to Alameda Boulevard (State Road 528) – River Miles 194 to 192					
192p9_I_1	192.9	Backwater, island destabilization	2	18.5	26,695.3
192p9_W_1	192.9	Bankline modification	2	1.8	3,198.2
Subtotal				20.3	29,893.5
PDN Subreach – Paseo Del Norte (State Road 423) to Montano Road Northwest Subreach – River Miles 192 to 186					
190p5_W_1	190.5	Bankline modification	2	22.6	29,898.7
190p3_I_1	190.3	Island destabilization	2	1.2	2,485.2
190p2_I_1	190.2	Island destabilization	3	1.3	910.8
190p1_E_1	190.1	Bankline modification, flow-through channel	2	9.3	14,489.8
189p9_I_1	189.9	Island destabilization	3	1.6	531.7
189p7_I_1	189.7	Island destabilization	3	2.1	251.2
189p6_I_1	189.6	Island destabilization	3	1.5	4.8
189p3_W_1	189.3	Bankline modification	2	9.3	7,211.4
189p2_I_1	189.2	Island destabilization	3	1.1	551.7
189p1_W_1	189.1	Flow-through channel, bankline modification	2	7.5	5,282.0
188p7_I_1	188.7	Backwater, island destabilization, flow-through channel	2	17.6	12,916.9

Project Area Identification (site ID)*	Associated River Mile	Restoration Activity Type(s)	Priority Designation (1–4)†	Surface Disturbance (acres)	Maximum Sedimentation Quantity (cubic yards)
188p6_I_1	188.6	Island destabilization	2	0.7	765.7
188p5_W_1	188.5	Backwater, bankline modification	2	16.2	13,830.6
187p9_I_1	187.9	Backwater, island destabilization	2	19.4	14,920.1
187p6_W_1	187.6	Bankline modification	2	4.6	1,058.4
187p5_E_1	187.5	Bankline modification	2	1.4	1,751.5
187p3_I_1	187.3	Island destabilization	2	3.0	586.9
187p2_I_1	187.2	Island destabilization	2	5.3	3,104.1
187_E_1	187	Bankline modification	3	6.4	3,942.7
186p1_I_1	186.1	Island destabilization	2	0.2	659.7
186p1_I_2	186.1	Island destabilization	1	2.9	6,456.2
Subtotal				135.2	121,610.1
Interstate (I-40) Subreach – I-40 and Central Avenue – River Miles 186 to 181					
185p5_E_1	185.5	Backwater	2	0.5	1,776.3
185p4_E_1	185.4	Backwater, bankline modification	2	5.3	5,840.8
185p1_E_1	185.1	Backwater	2	0.1	630.0
185p1_I_1	185.1	Island destabilization	1	5.5	10,673.1
184p7_E_1	184.7	Backwater, bankline modification	0	13.9	20,349

Project Area Identification (site ID)*	Associated River Mile	Restoration Activity Type(s)	Priority Designation (1–4)†	Surface Disturbance (acres)	Maximum Sedimentation Quantity (cubic yards)
184p5_E_1	184.5	Backwater	1	3.0	11,633.2
184p5_I_1	184.5	Island destabilization	2	1.5	2,570.9
184p3_E_1	184.3	Bankline modification	2	2.9	8,101.4
183p9_W_1	183.9	Bankline modification	2	6.2	18,745.4
183p7_W_1	183.7	Confluence maintenance (mouth cleanout)	2	0.1	174.2
183p7_E_2	183.7	Bankline modification	2	0.7	2,172.6
183p7_E_1	183.7	Flow-through channel, bankline modification	2	2.6	8,003.5
183p5_I_1	183.5	Island destabilization	2	0.4	966.7
183p5_W_1	183.5	Confluence maintenance (mouth cleanout)	1	0.1	165.8
183p3_W_1	183.3	Confluence maintenance (mouth cleanout)	2	0.1	188.5
183_W_1	183	Confluence maintenance (mouth cleanout)	1	0.1	77.2
182p9_E_2	182.9	Jetty jack removal	1	0.3	–
182p9_E_1	182.9	Backwater, bankline modification	1	18.0	25,505.4
182p4_I_1	182.4	Island destabilization, backwater	2	10.0	10,513.7
182p3_W_1	182.3	Confluence maintenance (mouth cleanout)	2	0.1	156.0
182p2_I_1	182.2	Island destabilization	2	2.8	4,048.9
182_E_1	182	Bankline modification, backwater	3	4.2	5,048.9

Project Area Identification (site ID)*	Associated River Mile	Restoration Activity Type(s)	Priority Designation (1–4)†	Surface Disturbance (acres)	Maximum Sedimentation Quantity (cubic yards)
Subtotal				78.4	137,341.5
ACC Subreach – Avenida Dolores Huerta Bridge (ACC Road) to SDC – River Miles 181 to 177					
181p7_W_1	181.7	Confluence maintenance (mouth cleanout)	1	0.1	101.4
180p5_I_1	180.5	Island destabilization	1	0.2	50.3
180p3_E_1	180.3	Backwater	2	1.8	2,146.5
180p3_I_1	180.3	Island destabilization	2	1.5	2,331.6
180_W_1	180	Bankline modification	1	2.8	6,083.5
179p5_I_1	179.5	Island destabilization	1	10.2	8,062.0
179p2_I_1	179.2	Island destabilization	2	1.0	1,700.4
178_E_1	178	Bankline modification, flow-through channel	2	6.8	6,887.6
177p9_I_1	177.9	Island destabilization	1	1.0	2,004.6
177p8_I_1	177.8	Island destabilization	1	1.2	2,194.1
177p5_W_1	177.5	Backwater, bankline modification	4	8.9	11,599.4
177p3_W_1	177.3	Backwater	2	2.6	182.4
Subtotal				38.1	43,343.8
SDC Subreach – SDC to I-25 – River Miles 177 to 172					
176p7_W_1	176.7	Backwater, bankline modification	1	9.2	12,468.4

Project Area Identification (site ID)*	Associated River Mile	Restoration Activity Type(s)	Priority Designation (1–4)†	Surface Disturbance (acres)	Maximum Sedimentation Quantity (cubic yards)
176p2_W_1	176.2	Backwater	2	1.1	1,374.1
175p9_E_1	175.9	Backwater, bankline modification	1	9.6	10,288.4
175p6_I_1	175.6	Flow-through channel, island destabilization	1	1.9	1,174.0
175p6_W_1	175.6	Bankline modification	1	5.2	7,137.7
175p2_W_1	175.2	Bankline modification	1	8.1	17,237.6
174p9_W_1	174.9	Backwater, bankline modification, confluence maintenance (mouth cleanout)	1	6.6	3,630.1
174p8_I_1	174.8	Island destabilization	2	2.1	3,376.3
174p7_I_1	174.7	Island destabilization	2	1.4	1,616.1
174p3_E_1	174.3	Backwater, bankline modification	1	14.2	14,925.1
174p2_I_1	174.2	Island destabilization	2	0.7	7.1
174_I_1	174	Island destabilization, backwater	1	6.7	4,789.6
173p9_E_1	173.9	Bankline modification	1	1.8	2,511.6
173p4_W_1	173.4	Backwater	1	0.3	805.9
173p3_W_1	173.3	Backwater, bankline modification	1	5.9	5,064.7
173_E_1	173	Backwater, bankline modification	1	16.2	20,870.1
172p9_W_1	172.9	Bankline modification	1	1.0	1,923.6

Project Area Identification (site ID)*	Associated River Mile	Restoration Activity Type(s)	Priority Designation (1–4)†	Surface Disturbance (acres)	Maximum Sedimentation Quantity (cubic yards)
172p8_I_1	172.8	Island destabilization	1	2.3	2,380.6
172p8_W_1	172.8	Bankline modification	1	0.5	699.1
172p7_E_1	172.7	Backwater	1	0.5	985.9
172p6_W_1	172.6	Bankline modification	1	0.7	1,624.2
172p5_W_1	172.5	Bankline modification	1	1.0	244.5
Subtotal				97.0	115,134.7
Total				369.0	447,323.6