ANNUAL MONITORING REPORT FOR THE CITY OF ALBUQUERQUE'S RIO BRAVO NORTH AND SOUTH HABITAT RESTORATION PROJECTS: 2009

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INTRODUCTION

The City of Albuquerque (City) Bosque Habitat Restoration Project (Project) evaluated several habitat restoration techniques within the Rio Bravo Subreach of the Middle Rio Grande (MRG) to create and improve habitat for the Rio Grande silvery minnow (*Hybognathus amarus*; silvery minnow) and the southwestern willow flycatcher (*Empidonax traillii extimus*; flycatcher). The long-term goal of the Project is to promote egg retention, larval rearing, young-of-year, and over-wintering habitat for the silvery minnow and thin non-native vegetation and create habitat for the benefit of the flycatcher. The objective of the restoration process is to increase measurable habitat complexity that supports various life stages of silvery minnow by facilitating lateral migration of the river across islands, bars, and river banks during various mid-level and high flows. This waterbody is a river; the watershed name is Rio Grande – Albuquerque, U.S. Geological Survey (USGS) Cataloging Unit No. 1302023.

The Project involved the implementation of various habitat restoration/rehabilitation techniques to restore riverine and riparian habitat for the benefit of the silvery minnow and the flycatcher within the MRG. Specific rehabilitation and restoration activities occurred within the river floodway at three locations within the Rio Bravo Subreach: the Rio Bravo North (RBN) site, Rio Bravo South (RBS) point bar, and South Diversion Channel (SDC) Island (Figure 1). Site-specific Project restoration techniques were implemented for the benefit of both species and the riverine ecosystem as a whole. The Rio Bravo Subreach was accessed via the levee road on the southwest portion of Rio Bravo Boulevard on the west side of the Rio Grande, on the northeast side of Rio Bravo Boulevard to access the RBN site on the east side of the Rio Grande, and off of Shirk Road on the east side to access SDC Island. The RBS point bar and SDC Island portion of the Project started on April 9, 2007, and was completed on April 26, 2007. Construction of the RBN features started the week of April 2, 2008, and was completed on May 1, 2008. Control photo points were taken at two of the three habitat restoration location for monitoring and comparison purposes. Approximately 33 acres (13 ha) at the RBN site, 20.3 acres (8.2 ha) at the RBS point bar, and 6.5 acres (2.6 ha) at SDC Island were modified. As the Project's goal was mitigation, the spoil was placed within the affected areas where construction took place. At the sites, spoil was spread out adjacent to the modified areas or used as fill material. During the course of the Project, one proposed channel at the RBN site and two proposed channels at the RBS point bar were eliminated because they were already functioning as potential habitat for the silvery minnow.

The RBN site covers 33 acres (12.7 ha) on the east side of the channel, approximately 0.5 mile north of the Rio Bravo Bridge (Figure 2). The site was characterized by mixed native and non-native riparian vegetation; however, the majority of the area was cleared of non-native vegetation and is now an open Rio Grande cottonwood (*Populus deltoides*) bosque with scattered New Mexico olive (*Forestiera pubescens*) and black willow (*Salix nigra*). The bankline vegetation within the project area was left undisturbed and remains characterized by a cottonwood canopy with an understory dominated by Russian olive (*Elaeagnus angustifolia*) and saltcedar (*Tamarix ramosissima*). Within the bosque, four depressions—two approximately 0.75 acre (0.3 ha) each and two approximately 0.30 acre (0.12 ha) each—were excavated to function as surface water catchments that will encourage the recruitment of native vegetation for the benefit of flycatcher. In addition, 120 jetty jacks were removed from this location to improve access in the event of wildfire. A proposed channel was eliminated at the RBN site due to complications with depletions.

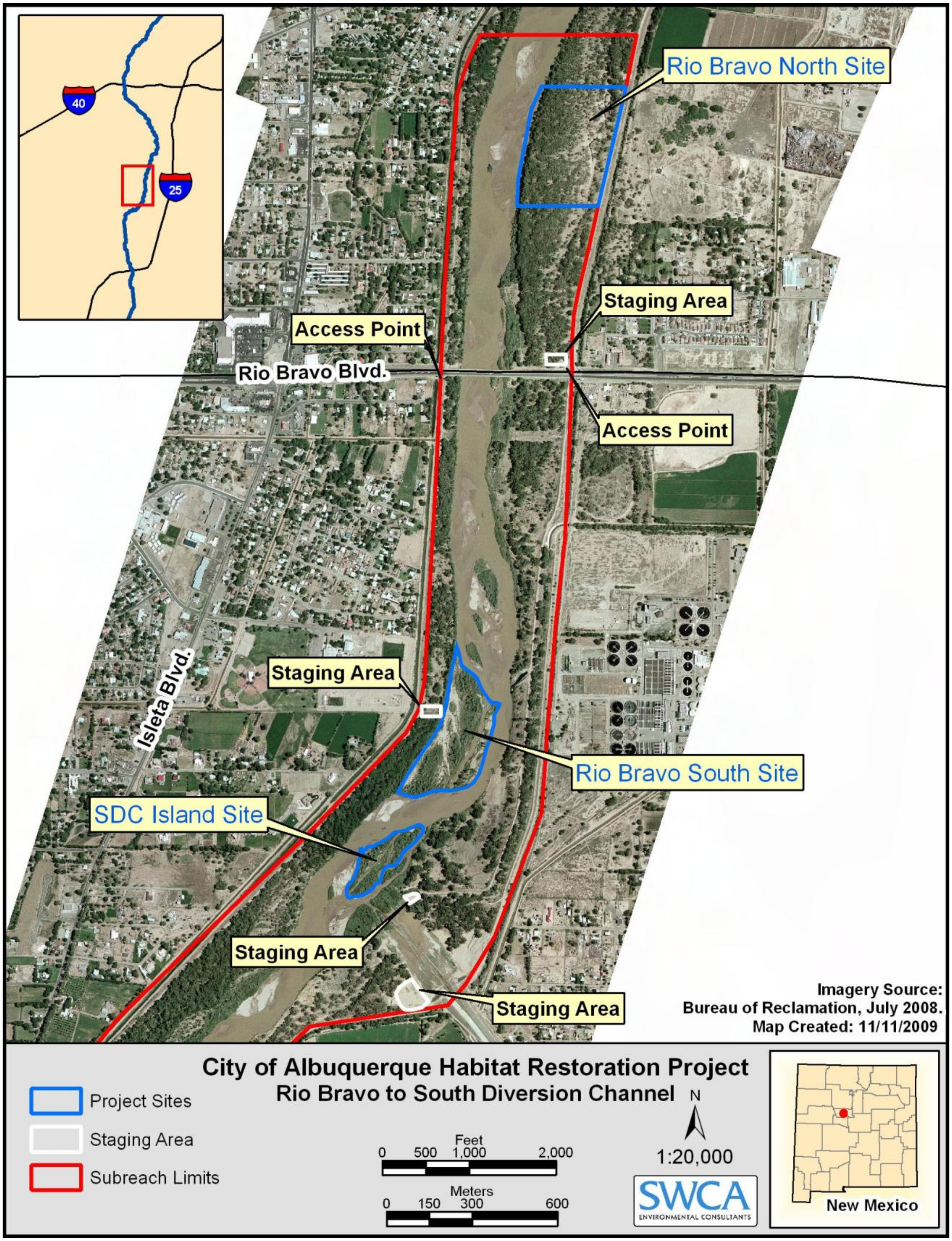

Figure 1. Rio Bravo to South Diversion Channel Project sites.

Figure 2. RBN site restoration features.

The RBS site, on the west side of the Rio Grande approximately 0.6 mile south of the Rio Bravo Boulevard Bridge, consists of a 20.3-acre (8.2-ha) point bar with intermittent stands of native willow (*Salix* sp.) and non-native vegetation (Figure 3). The bar was modified to create low-, mid-, and high-flow habitat to support multiple life stages of the silvery minnow. Techniques included constructing ephemeral channels and bankline scours (scallops). Four 0.25-acre (0.10 ha) scallops were excavated on the east side of the bar to create low-velocity habitat for the silvery minnow. Although three channels were proposed, one channel was excavated the length of the bar and was designed to function at 500 cubic feet per second (cfs) in the mainstem. The combined area of the four scallops was approximately 1 acre (0.4 ha), and the length of the side channel was approximately 340.5 linear m (1,117 linear feet).

At the time of construction, the water level in the river was approximately 1,000 cfs, and as such the design features were changed to function at 1,000 cfs. The variety of inundation levels will provide habitat for the silvery minnow at multiple discharge levels in the mainstem of the MRG. The development of ephemeral and low-flow channels and scallops at this location will also create seasonal open water habitat that will benefit breeding and migrating flycatchers.

Non-native vegetation was removed from the bar, and all native vegetation outside the Project footprint was left intact. Large woody debris was used to armor select constructed features to minimize erosion and encourage the development of additional mesohabitat for the benefit of the silvery minnow.

The final locality is a 6.5-acre (2.6-ha) island immediately adjacent to the outfall of the South Diversion Channel (Figure 4). Techniques applied at SDC Island included constructing low- and high-flow ephemeral channels and bankline scallops for the benefit of the silvery minnow. Non-native vegetation was removed from the modification areas on the island. Two 0.25-acre (0.10-ha) scallops were excavated to act as low-velocity habitat for the species. Two channels—one 152 linear m (500 linear feet) long designed for inundation at 500 cfs and the other 229 linear m (752 linear feet) long to be inundated at 2,500 cfs—were excavated through the island to increase low-velocity habitat for the silvery minnow and increase native vegetation recruitment for the benefit of the flycatcher.

Project photographs of all three sites are located in Appendix A.

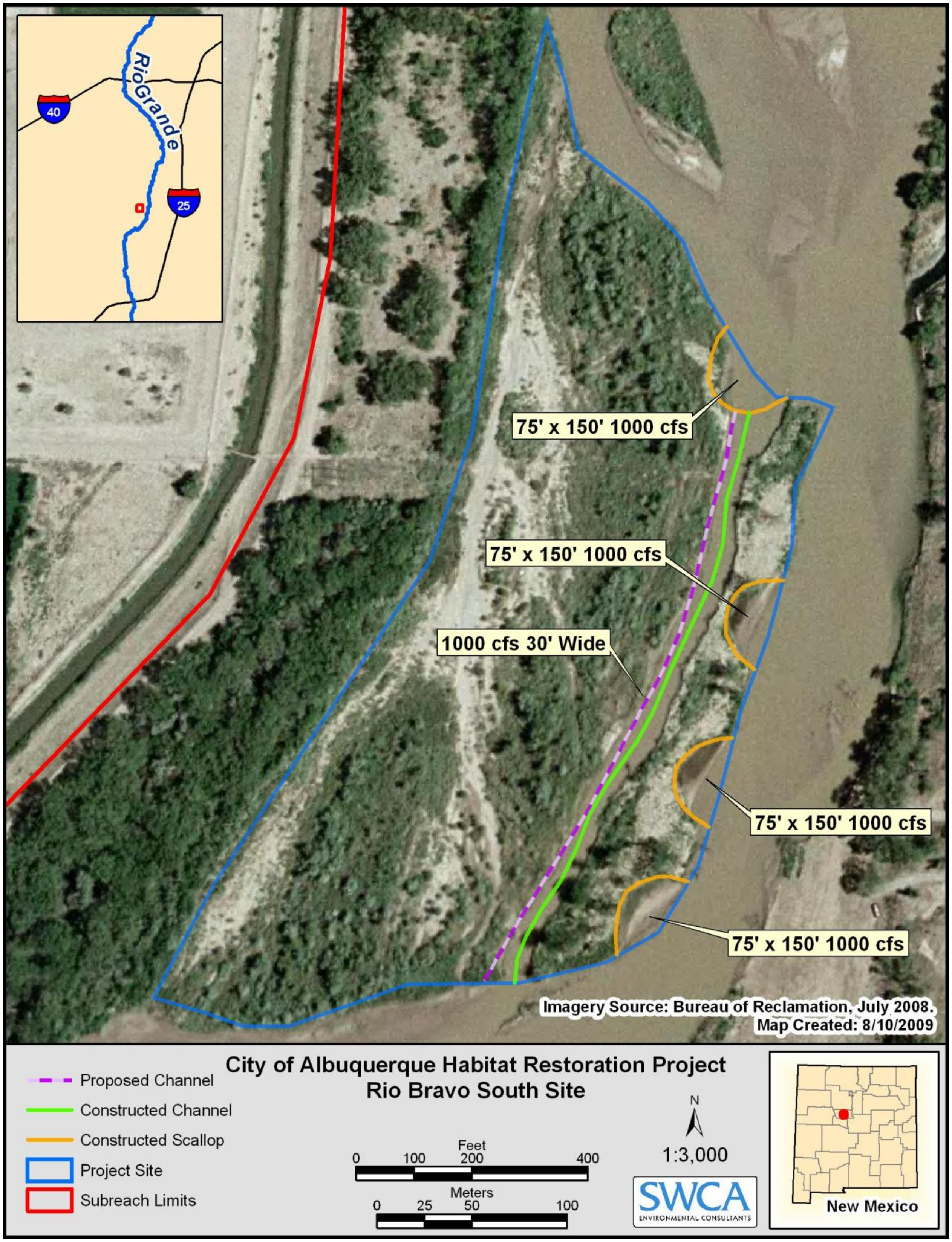

Figure 3. RBS point bar restoration features.

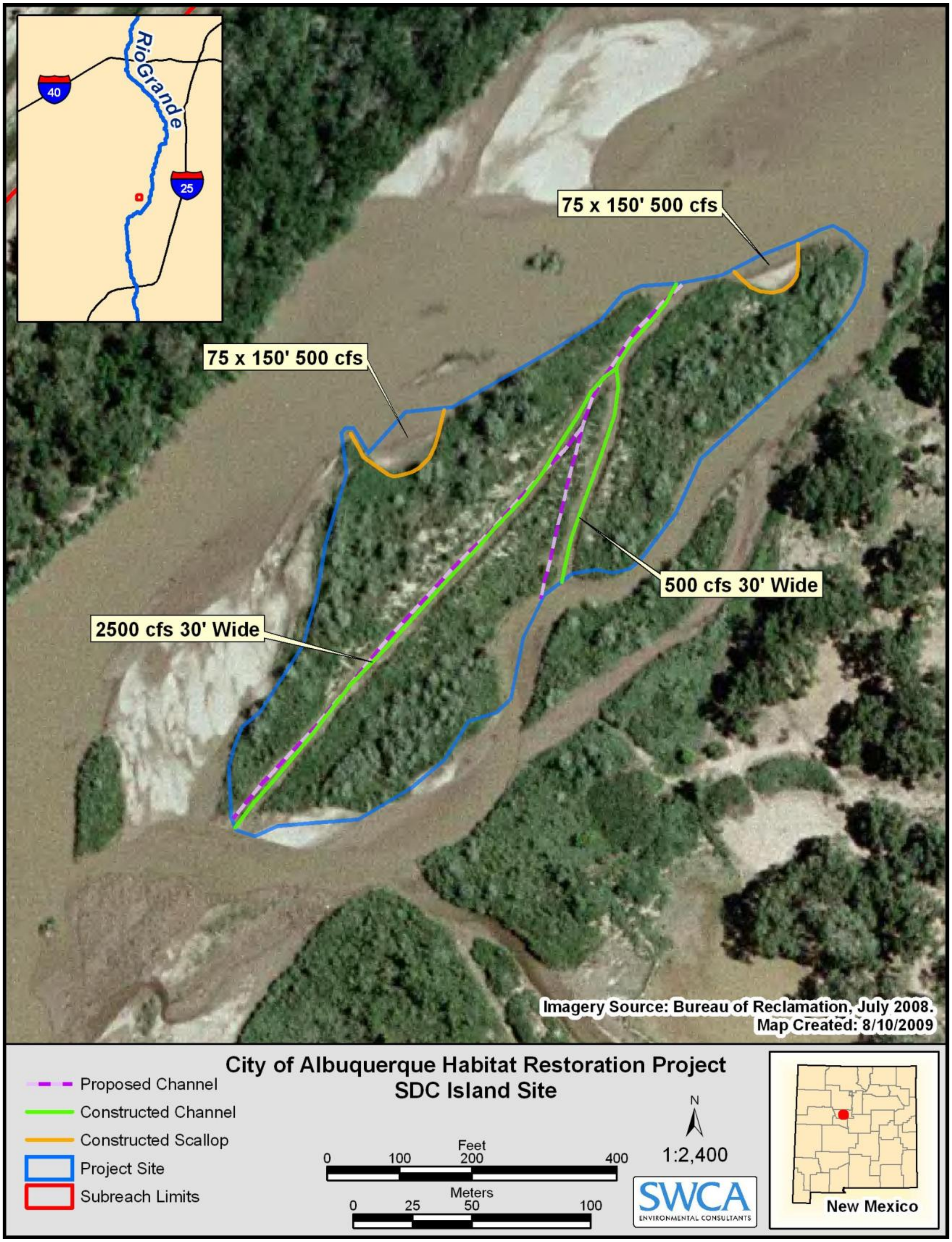

Figure 4. SDC Island restoration features.

ENVIRONMENTAL OBJECTIVES

The primary objective of the monitoring is to evaluate the effectiveness of habitat restoration conducted within the Rio Bravo Subreach of the MRG in benefiting or improving conditions for the silvery minnow and the flycatcher. This objective includes verifying whether construction has improved the prior conditions for the restoration sites and determining what level of maintenance will be required, if any, to maintain an acceptable level of benefit from the Project.

Secondarily, the monitoring serves to characterize the community structure of fish at habitat restoration sites and expand on the site-specific fisheries surveys that have been conducted throughout the MRG (Porter et al. 2004; Fluder and Hayes 2005; Porter and Massong 2005; Beck and Fluder 2006; Fluder et al. 2007). The excavated sections of the habitat restoration area are inundated to some extent during spring runoff, coinciding with silvery minnow spawning and potential egg retention. Also, describing the use of channels and inlets by fish during these periods provides valuable information regarding predation on silvery minnow eggs and larvae.

The final objective involves monitoring and recording the recolonization of vegetative communities and any geomorphic changes that will occur at habitat restoration sites for the benefit of the silvery minnow and the flycatcher. Vegetative communities have been disturbed during construction, and it is important to understand species composition and community types following disturbance. The reshaping of the habitat restoration sites to create mesohabitat features has been monitored and recorded as well. Monitoring objectives are summarized in Table 1.

Table 1. Monitoring Objectives

Objective	Monitoring Level	Monitoring Activity	Type of Survey
Regenerating native riparian species	Effectiveness	Vegetation	Vegetation class, composition, and structure surveys
Preventing and monitoring the diffusion of invasive deciduous species	Implementation and effectiveness	Vegetation	Removal of invasive species during construction; vegetation surveys and monitoring
Creating silvery minnow nursery habitat	Implementation and effectiveness	Fisheries	Nursery habitat surveys
Increasing silvery minnow habitat	Implementation and effectiveness	Fisheries and Geomorphic	Topographical survey; mesohabitat survey; fisheries survey
Creating low-velocity habitats	Implementation and effectiveness	Geomorphic	Topographical survey; mesohabitat survey; depth and substrate

PLANNING, COMPLIANCE, AND PERMITTING

Construction activities for City's habitat restoration work have been in full compliance with all applicable environmental regulations. Compliance documentation started in early 2006 and continued until February 2007. Table 2 lists the compliance documents for this project. The monitoring work has adhered to the environmental commitments contained in those documents, where applicable.

Table 2. Compliance Documents for the Project

Compliance Requirement	Agency*	Compliance Documents
National Environmental Policy Act	Reclamation	Final Environmental Assessment (EA) and Finding of No Significant Impact: February 2007
Clean Water Act (CWA) Section 404	USACE	Individual Section 404 Permit: January 2007
CWA Section 401 (NM Certification)	NMED SWB	Section 401 Certification: January 2007
Endangered Species Act Section 7	USFWS	USFWS Biological Opinion (BO) and Incidental Take Permit: February 2007
Migratory Bird Treaty Act	USFWS	Best management practices covered in the EA and BO

* Reclamation = U.S. Bureau of Reclamation; USACE = U.S. Army Corps of Engineers; New Mexico Environment Department Surface Water Bureau; USFWS = U.S. Fish and Wildlife Service.

A Biological Assessment (BA), completed in accordance with provisions of the Endangered Species Act (ESA), evaluated and analyzed potential impacts of the Project on listed threatened, endangered, or other special-status species that may occur within the Project area.

Other applicable permits obtained by the City prior to implementation included landowner access permissions and a Temporary Construction Noise Permit from the City of Albuquerque Environmental Health Department.

General commitments for all locations and treatment areas as outlined in the environmental compliance documents included:

1) Impacts to terrestrial habitats would be minimized by using existing roads and cleared staging areas. In general, equipment operation would take place in the most open area available and would minimize damage to vegetation.
2) Designated critical habitat for the silvery minnow encompasses the entire project area (Federal Register 2003) in the river channel. Best management practices would be enforced to minimize potential impacts to the silvery minnow from direct construction and erosional inputs into the river during periods of work.
3) To avoid direct impacts to migratory birds protected by the Migratory Bird Treaty Act (16 United States Code 703, et seq.), construction and clearing of vegetated islands would be scheduled between August 15 and April 15, outside the normal breeding season for most avian species. Should vegetation removal be required during the breeding season, pre-construction breeding bird surveys would be conducted to assure that no breeding birds would be affected. Any positive pre-construction survey results or observation of affected species during construction would be discussed with the U.S. Fish and Wildlife Service (USFWS) to coordinate nesting area avoidance.
4) If a bald eagle (*Haliaeetus leucocephalus*) is observed within 0.25 mile of the proposed Project area in the morning when activity starts, or arrives during breaks in activity, the contractor would be required to suspend all construction activity until the bird leaves on its own volition, or until the project biologist, in consultation with the USFWS, determines that the potential for harassment is minimal. If a bald eagle arrives during construction activities, or is observed more than 0.25 mile from the construction site, activity would not be interrupted.

5) To mitigate potential short-term construction impacts to the flycatcher, clearing of dense woody vegetation would be avoided and conducted only between August 15 and April 15. Should vegetation removal be required during the breeding season, pre-construction breeding bird surveys would be conducted to assure that no breeding birds would be affected. Any positive pre-construction survey results or observation of affected species during construction would be discussed with the USFWS to coordinate nesting area avoidance. Construction would cease in the location if a flycatcher is observed between April 15 and August 15, and the USFWS would be notified.
6) The shortest path would be used to cross the wetted channel to access the SDC Island site, and silt fencing would be installed downstream of the crossing. If amphibious equipment is not available for the crossing, a temporary portable bridge would be employed to allow for equipment crossing. Water quality would be monitored before silt fencing is installed, and the fencing would not be removed until it has returned to within 10% of the original measures.
7) Clean Water Act (CWA) compliance is required for all aspects of the Project, and since most of the proposed work would be completed within the active floodplain, a 404 permit is required. A state water quality certification permit under Section 401 of the CWA may also be required. The 404 and 401 permitting processes would be completed before beginning Project activities.
8) Stormwater discharges associated with the Project would be limited to ground-disturbing activities outside the ordinary high water mark. All such activities would be evaluated for compliance with the National Pollutant Discharge Elimination System.
9) All necessary permits for access points, staging areas, and study sites would be acquired before Project construction activities. Access coordination began with the U.S. Bureau of Reclamation, the Middle Rio Grande Conservancy District, and the Albuquerque Metropolitan Arroyo Flood Control Authority.
10) Additional evaluation of the net depletion effects of each proposed technique would be included in the monitoring of project elements. Restoration techniques that are determined to add significant levels of depletion to the surface waters of the Rio Grande would be curtailed.

METHODOLOGY

FISHERIES

Fisheries monitoring was conducted on May 21, 26, and 29, and June 2, 2009. Four fyke nets were deployed to capture and release silvery minnow. Two fyke nets were place at the RBS point bar and two were placed at the SDC Island site. Within each of the habitat restoration sites, one fyke net was placed within a scallop and one was placed within a channel treatment type. Additional collections for eggs, larval fish, and water quality information were conducted on each sampling date. Locations of fyke nets, water quality collection locations, and egg transects for the monitored habitat restoration site are in Appendix B.

Data from the U.S. Geological Survey (USGS) stage gage located at the Central Avenue Bridge (#08330000) was used as a record of river discharge over the sampling period (Figure 5). A relational database (Microsoft Access) and a spreadsheet database (Microsoft Excel) were developed for the storage, analysis, and retrieval of fish survey data.

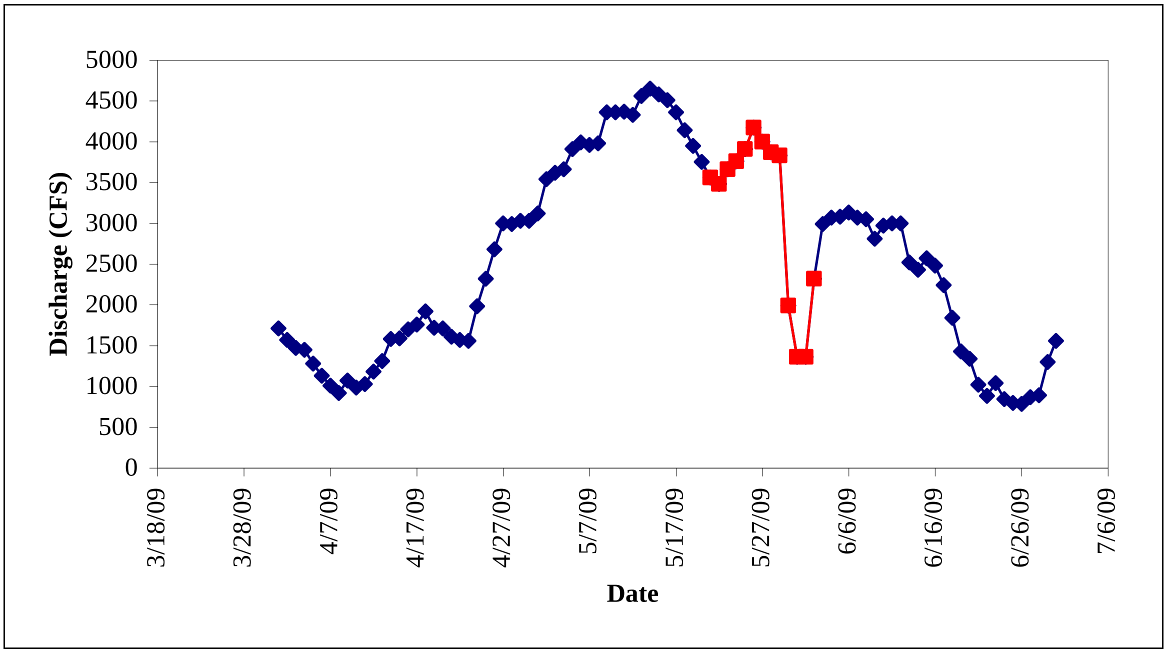

Figure 5. Average daily discharge from the U.S. Geological Survey (USGS) stage gage located at the Central Avenue Bridge (#08330000). The study period is highlighted in red.

FISH COLLECTIONS

Fish were collected at habitat restoration sites with D-frame or rectangular fyke nets (0.5 × 0.5 m [1.6 × 1.6 feet]; 6.4-mm mesh size) that were attached to metal posts (1.8-m [6-foot] t-posts). Fish were sampled under SWCA's USFWS permit number TE-045236 and New Mexico Department of Game and Fish (NMDGF) permit number 3143. On each sampling date fyke nets were set for three to five hours when conditions were conducive to sampling (i.e., sufficient inundation present at each site). Depth (m), velocity (m/s), and time (hours) that each fyke net was fished were recorded on each sampling date. A Trimble GeoXT handheld global positioning system (GPS) unit with sub-meter accuracy was used to record spatial characteristics of fyke net sampling locations.

During monitoring, standard length was measured to the nearest millimeter (mm) and wet weight to the nearest 0.1 g was recorded from captured silvery minnow when this could be accomplished without stressing the fish. Standard length was measured with a handheld ruler, and fish were weighed with an Ohaus model CL series digital balance.

On each sampling date, silvery minnow were observed for signs of reproductive status and classified as gravid female, male issuing milt, spent female, and unknown. Reproductive status (for each classification group) is expressed as a percentage of the total number of silvery minnow inspected during sampling.

All post-larval fish collected were identified to species in the field using taxonomic keys from Sublette et al. (1990); phylogenetic classification followed Nelson et al. (2004). Species counts were maintained for all collections, and all live fish were released back to the site of capture.

SILVERY MINNOW CATCH RATES AND SILVERY MINNOW SIZE

Silvery minnow catch per unit effort (CPUE) was calculated for fyke net samples by dividing the total number of fish captured by the total number of hours each fyke net was fished on each day (Quinn and Deriso 1999; Hubert and Fabrizio 2007). Standardization of fyke net captures (assumes no periodic effect on captures) is expressed as fish per hour and is the index used to assess variation in species abundance among sites throughout the monitoring period.

Non-parametric statistical tests were conducted to assess if CPUE varied among sites, among sampling dates, and between treatment types (i.e., scallop and channel treatments). A Kruskal-Wallis single-factor analysis of variance by rank was used to test for CPUE differences among fyke nets and among sampling dates (Zar 1999). A non-parametric Wilcoxon rank-sum test was used to assess mean differences in CPUE between habitat restoration treatment types (Zar 1999; Dalgaard 2002). Non-parametric statistical analysis assumes random assignment of net locations and was chosen because the presence of zero values for individual net sites prevented normalization of the CPUE data through transformation.

The mathematical relationship between weight and length was investigated for silvery minnow through least squares regression using the formula:

$$W = a+b*L$$

where W is weight, L is length, a is the y-intercept, and b is the slope of the line (Pope and Kruse 2007).

EGG AND LARVAL FISH COLLECTIONS

On each sampling day, silvery minnow eggs and post-larval fish were sampled with D-frame kick nets (0.0428-m^2 opening fitted with 0.2-mm mesh nytex) with multiple grab samples over established 10-m-long (33-foot-long) transects and along fyke net wings. All collected eggs and larval fish were identified (when possible), enumerated, and released back to the site of collection. Eggs and larval fish collected from fyke net wings and transects established at each site were not standardized and are simply expressed as the total number collected summed over all sites by sampling date.

WATER QUALITY

Water quality parameters were monitored concurrent with fish sampling events from the main channel and at floodplain sites. Water quality parameters were measured using a YSI 556 multi-parameter handheld meter, including temperature, dissolved oxygen, conductivity, salinity, pH, and turbidity (Appendix C). Water depth and flow velocity were measured using a USGS top-setting wading rod fitted with a Marsh-McBirney Flo-Mate portable flowmeter. Hobo event loggers were used to obtain hourly records of water temperature at each floodplain fish sample location and at one main channel location (Appendix D).

VEGETATION

HINK AND OHMART

Methods developed by Hink and Ohmart (1984) were employed to complete the vegetation classification for treatment areas within the Project site. The Hink and Ohmart classification system was formulated to enable efficient, yet reliable characterization and sectioning of woody species dominance in the canopy, midstory, and understory layers of the MRG. This methodology allows for the inclusion of up to four species per polygon, implying a minimum of 25% per species in the total composition of a specific study area. It is important to note that the alphanumeric hierarchical codes (i.e., the first species in the code is more abundant but can be a 50% member in the case of a two-species mix), developed by Hink and Ohmart, were conceived to characterize dominant woody species and were not intended to account for all species present (Appendix E). For example, C-RO/CW-SC1 denotes a cottonwood–Russian olive canopy that is over 12 m (40 feet) tall, with a coyote willow [*Salix exigua*] and saltcedar understory. Table 3 summarizes the vegetative conditions recognized by Hink and Ohmart related to their six structural classes.

Table 3. Hink and Ohmart Structural Classes for MRG Riparian Vegetation

Hink and Ohmart Structural Type (ST)	Woody Vegetation Composition
ST 1	Mature and mid-aged trees with shrubby vegetation at all heights
ST 2	Mature and mid-aged trees with little or no shrubby vegetation
ST 3	Intermediate-aged trees with dense shrubby vegetation
ST 4	Intermediate-aged trees with little or no shrubby vegetation
ST 5	Young stands with dense shrubby vegetation
ST 6	Very young, low, and/or sparse vegetation

The SWCA Environmental Consultants (SWCA) habitat assessment team used a combination of June 2008 (high-flow imagery) and July 2008 (low- to moderate-flow imagery) high-resolution orthophotography to assist in the on-the-ground field mapping survey. Hink and Ohmart field data forms that incorporate vegetation density at different heights, vegetation composition, and other factors, such as evidence of previous disturbance, fire, recent flood, or erosion, were completed inside each definitive structural type. A Trimble GeoXT unit with sub-meter accuracy was used to collect the data point position and Hink and Ohmart classification in each representative polygon. In addition, digital photographs were taken within the polygons to illustrate the vegetation type. Field data, digital photographs, and GPS points were processed in SWCA's geographic information system (GIS) laboratory the same day that the field data are collected. SWCA's GIS team, with the assistance of field staff, created a master set of Hink and Ohmart classification shapefiles.

CONTINUOUS LINE TRANSECTS

Vegetation monitoring transects and plots designed by University of New Mexico Bosque Ecosystem Monitoring Program (BEMP) were used to document and monitor entire plant species composition and canopy cover at two of the three restoration sites. BEMP currently has a monitoring site located at the RBS point bar that has been in place since 2003, to which SWCA data for the Project may be compared. SWCA added six additional transects and associated plots that were measured using the same methodology as the BEMP procedures at SDC Island (see Appendix E). BEMP and SWCA vegetation transects are 30 m (98 feet) long and are situated in the center of a 5 × 30–m (16 × 98–foot) rectangular plot. Plant species composition and canopy cover were measured using continuous line-intercept vegetation measurement methods (Elzinga et al. 2001), measured at 1-cm (0.4-inch) resolution along each 30-m (98-foot) transect line. Bare soil and leaf litter also was measured along the lines as encountered where plant canopy cover is lacking. The 30-m (98-foot) line-intercept transects provide data on canopy cover for all species and account for overlapping vertical canopy layers. SWCA vegetation transects and plots were randomly located within each of the different Hink and Ohmart vegetation structural types that is greater than 2.5 acres (1 ha) in size, at each of the two restoration sites (not to overlap with existing BEMP transects at RBS). Transects are oriented north-south parallel to the river channel in order to accommodate environmental gradients parallel to the river channel.

Woody shrub and tree species were additionally measured and monitored from each of the 5 × 30–m (16 × 98–foot) vegetation plots to provide data on density, height, and age-class distribution. All stems were counted in each vegetation plot, using different methods to determine age class for single-stemmed species (e.g., cottonwood) versus multiple-stemmed (rhizomonous) species (e.g., coyote willow and saltcedar). Each individual of single-stemmed species was recorded by species and the height class, and then assigned to age classes, also following the methods of Burton et al. (2008): 1) seedling = < 1 m (3 feet) tall, 2) young = 1 to 2 m (3–6.6 feet) tall, or 3) mature = >2 m (6.6 feet) tall, 4) dead = all canopy dead. The root-crown diameter for each was recorded. For multi-stemmed species, the number of clumps of stems and stems per clump was recorded for multi-stemmed, and using the live stem count values, an age class was assigned to each clump following the methods of Burton et al. (2008): 1) seedling = 1 stem, 2) young = 2 to 10 stems, 3) mature = >10 stems, 4) dead = all stems dead. Data for woody species composition, age classes, and number of dead snags was obtained from this method.

WETLANDS

Wetland areas are those that are "inundated or saturated by surface or groundwater at a frequency and saturation sufficient to support…a prevalence of vegetation typically adopted for life in saturated soil" (Environmental Laboratory 1987:9). However, if a wetland area is not saturated, but dry at the time of a survey, multiple indicators that are characteristic of wetland areas can be used to determine wetland status. These characteristics include hydric soil types, evidence of surface hydrology in the area, and hydrophytic vegetation types (Environmental Laboratory 1987). In addition, for a wetland to be considered jurisdictional, it must provide water flow to an interstate river, stream, or tributary thereof. Jurisdictional wetlands are considered to be Waters of the U.S. and are subject to regulation by the U.S. Army Corps of Engineers (USACE) pursuant to Section 404 of the CWA.

Wetlands were identified in the field using routine on-site delineation methods outlined in the *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory 1987) and the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Arid West Region* (Environmental Laboratory 2008). Determination of wetland habitat (type) is based on the classification system developed by Cowardin et al. (1979). Data at each site verifying the wetland were recorded on a USACE sample site form. The wetland boundary was delineated where all three fundamental characteristics of hydrophytic vegetation, hydric soils, and hydrology were present. All observational data for each wetland site were recorded by hand onto USACE datasheets. Data recorded included the following variables:

- Dominant vegetation species and indicator status;
- Presence of obligate or facultative vegetation species (hydrophytic); and
- Wetland hydrology indicators, such as water marks and drift lines

The entire project area was surveyed for wetlands, as well as a 50-m (150-foot) buffer area around each modification area. As a wetland was identified, its spatial extent was recorded and the areas were digitized. Spatial/location data and location of wetland pits were recorded using a Trimble GPS device. Numerous coordinates were recorded automatically along the perimeter of each wetland.

Photographic documentation was performed using a digital camera at each potential wetland area surveyed at each treatment site.

GEOMORPHOLOGY

Channel geomorphology (cross-sectional and longitudinal) was monitored to determine physical changes in response to flow (discharge). Monitoring surveys were conducted by Wolf and SWCA in September 2009, following expected peak Rio Grande flows. The baseline for assessing geomorphic change at each of the sites was the pre-construction surveys that were conducted by MEI in December 2005. Monitoring surveys were conducted with a Trimble TSC2 RTK-GPS unit in the NAVD88 and New Mexico State Plane Central NAD83 coordinate systems. City of Albuquerque and Reclamation monuments as well as Vectors, Inc. stationary base provided controls within the subreach. Temporary benchmarks consisting of 0.5-inch rebar with silver caps were previously set to facilitate future resurveys.

PHOTO POINT DOCUMENTATION

Permanent photo control point sites were established for all restoration sites to photo document temporal changes. Photographs were taken at these points prior to construction, facing the river, and the bearing taken and entered on a photo log sheet. Coordinates were collected and rebar was used to ensure that each site was adequately georeferenced. Photo point locations are shown in Appendix H.

EFFECTIVENESS MONITORING RESULTS

Pre-construction surveys for vegetation, wetlands, and geomorphology were conducted in 2005 and 2006. In 2007 SWCA conducted fisheries effectiveness monitoring after the completion of habitat restoration construction. In summer/fall 2009, SWCA conducted fisheries, vegetation, wetlands, and geomorphology effectiveness monitoring for the completion of Year One riverine and riparian monitoring activities. The City, SWCA, and the BEMP are working together and coordinating Project data and information. The City will use BEMP groundwater data and vegetation transects methodology for Project monitoring in coordination with vegetation transect data collected by SWCA.

FISH MONITORING

A total of 65 fish representing eight species were collected during fisheries monitoring (Table 4). Silvery minnow were most abundant comprising 50% and 40% of the total catch, respectively, at the SDC Island and RBS sites. Overall, silvery minnow, fathead minnow (*Pimephales promelas*), flathead chub (*Platygobio gracilis*), and red shiner (*Cyprinella lutrensis*) comprised 94% of the combined catch, while the remainder of collected species comprised only 6%.

Table 4. Total Number Captured, and Percent Composition (parenthesis) for Fish Community Collections at Habitat Restoration Sites

Common Name	Scientific Name	RBS*		SDC Island*		Overall*	
Rio Grande silvery minnow	*Hybognathus amarus*	12	(40)	20	(57)	32	(49)
fathead minnow	*Pimephales promelas*	9	(30)	11	(31)	20	(31)
flathead chub	*Platygobio gracilis*	3	(10)	2	(6)	5	(8)
red shiner	*Cyprinella lutrensis*	3	(10)	1	(3)	4	(6)
channel catfish	*Ictalurus punctatus*	1	(3)	0	(0)	1	(2)
common carp	*Cyprinus carpio*	0	(0)	1	(3)	1	(2)
green sunfish	*Lepomis cyanellus*	1	(3)	0	(0)	1	(2)
western mosquitofish	*Gambusia affinis*	1	(3)	0	(0)	1	(2)
Total		**30**	**100**	**35**	**100**	**65**	**100**

*Percent composition is rounded to the nearest whole number for display purposes. Project totals take into account more decimal figures and may not equal the sum displayed for specific species.

Silvery minnow CPUE did not differ among habitat restoration sites (Kruskal-Wallis single-factor analysis of variance P = 0.48), among sampling dates (Kruskal-Wallis single-factor analysis of variance P = 0.28), or between treatment types (Wilcoxon rank-sum test P = 0.39). The highest CPUE value was observed at the SDC Island (3.41 fish/hour) on May 21, 2009, and was qualitatively greatest at channel treatment types (Figure 6). Among dates CPUE was qualitatively highest on May 21 and lowest on May 29, 2009 (Figure 7). The channels constructed at SDCI are low velocity and shallow relative to main channel flow and have undergone a substantial amount of sediment deposition since construction which may have resulted in a greater amount of suitable habitat for silvery minnow than anticipated.

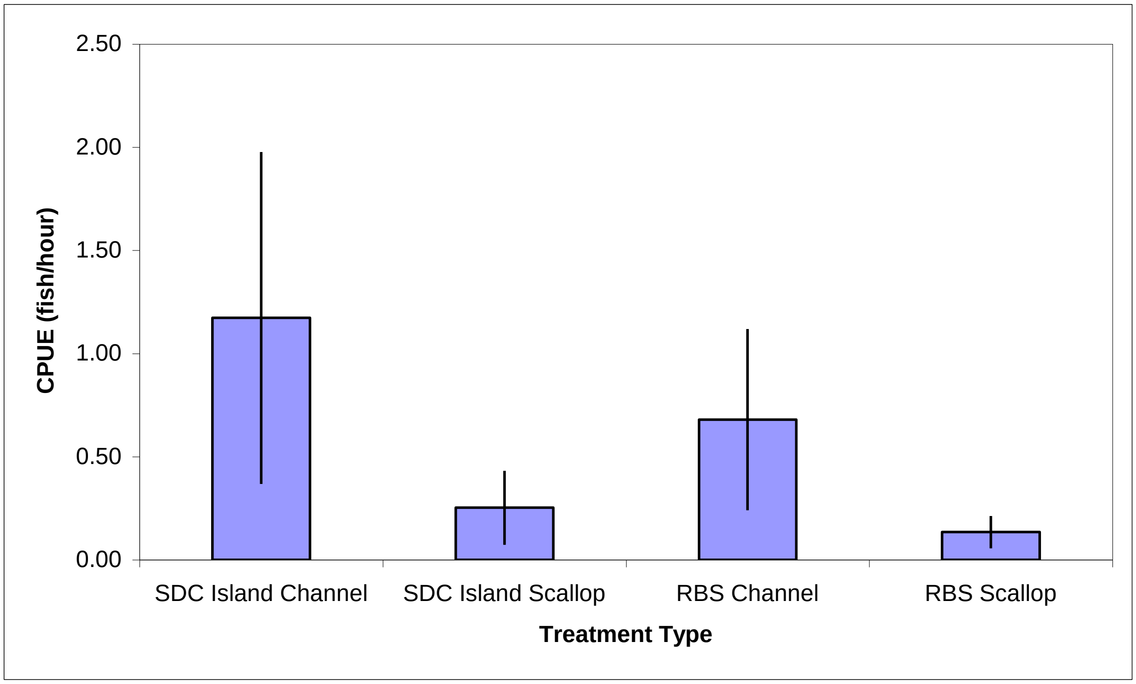

Figure 6. Mean CPUE values at each fyke net site. Error bars represent plus or minus one standard error from the mean.

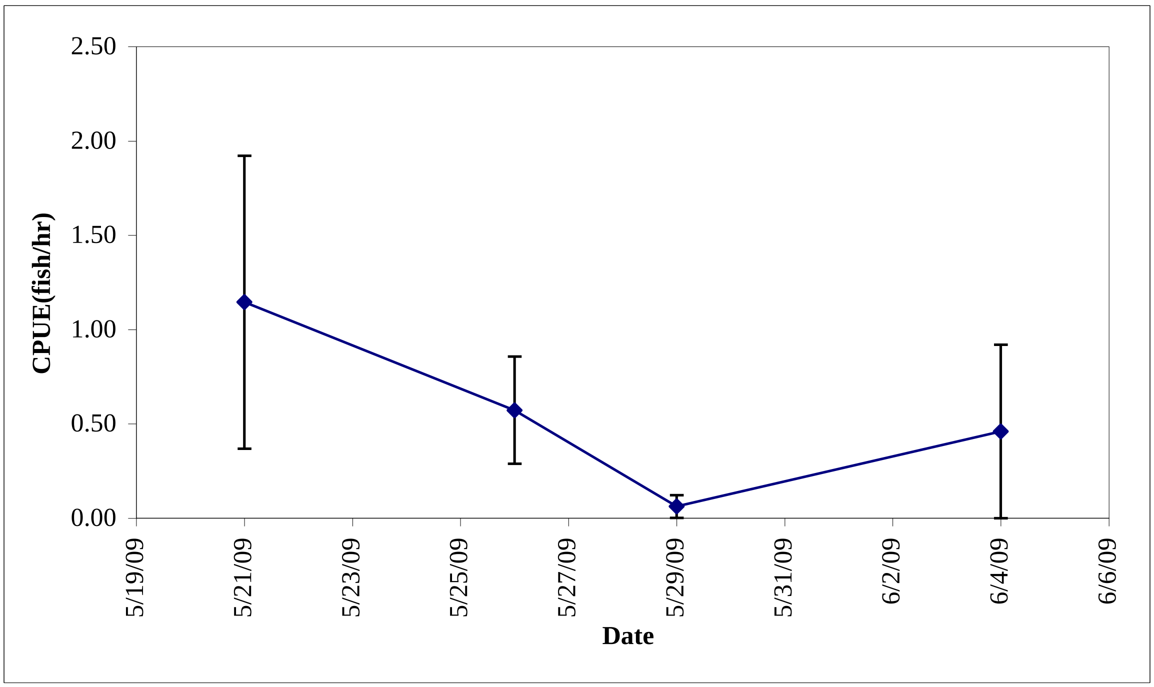

Figure 7. Arithmetic mean CPUE (fish/hour) values for silvery minnow collected from the habitat restoration sites during monitoring. Error bars denote one standard error.

Silvery minnow length and weight ranged from 46 to 66 mm and 1.8 to 4.7g, respectively. The relationship between length and weight for silvery minnow collected from the habitat restoration sites is illustrated in Figure 8. Typically the relationship between length and weight for fish is best described using a power function or by linear regression of log transformed length and weight data; however, the linear relationship of the raw data provides a reasonably good approximation for this dataset because the independent variables do not span a wide range of values (Pope and Kruse 2007), and data transformation did not result in a higher coefficient of determination (R^2).

A total of 30 silvery minnow were observed for signs of reproductive maturity. Gravid females (40%) and males issuing milt (27%) comprised the largest fractions of collected silvery minnow. Two silvery minnow, including the largest fish collected (66 mm) were observed issuing eggs during processing. Seven silvery minnow were classified as unknown and three were classified as spent females (Figure 9).

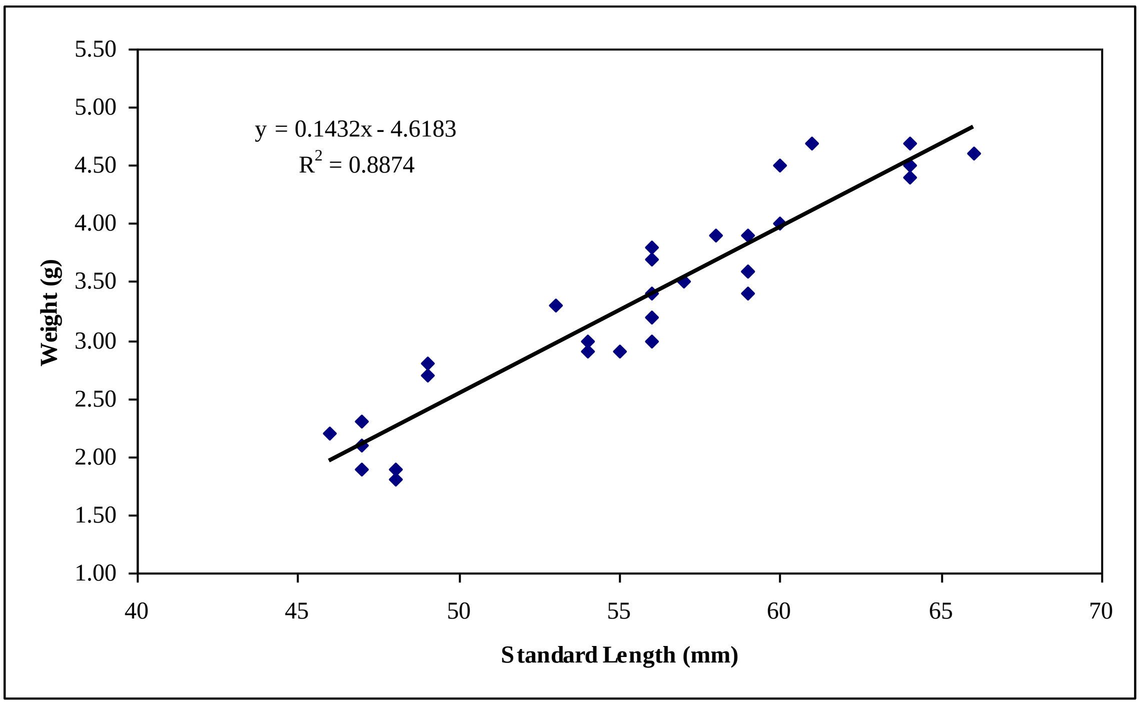

Figure 8. Raw length-weight relationship for silvery minnow collected from habitat restoration sites.

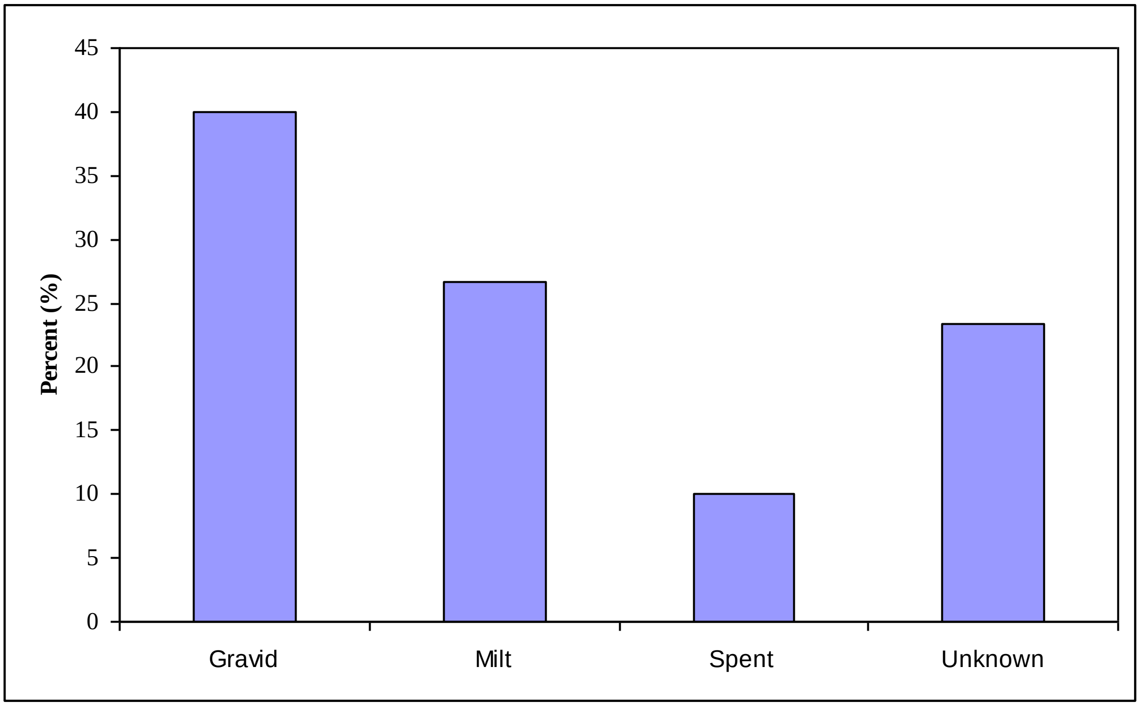

Figure 9. Percent of silvery minnow by reproductive classification observed during monitoring.

EGG AND LARVAL FISH COLLECTIONS

Although silvery minnow were observed issuing eggs during fish processing, no silvery minnow eggs were collected from transects and fyke net wings during monitoring. A total of 326 larval fish were collected from transects and fyke net wings on floodplain habitats during monitoring. Larval fish were collected during all monitoring dates and were most abundant on May 26 (112) and May 29, 2009 (111) (Figure 10). Only seven larval fish were collected on June 4, 2009.

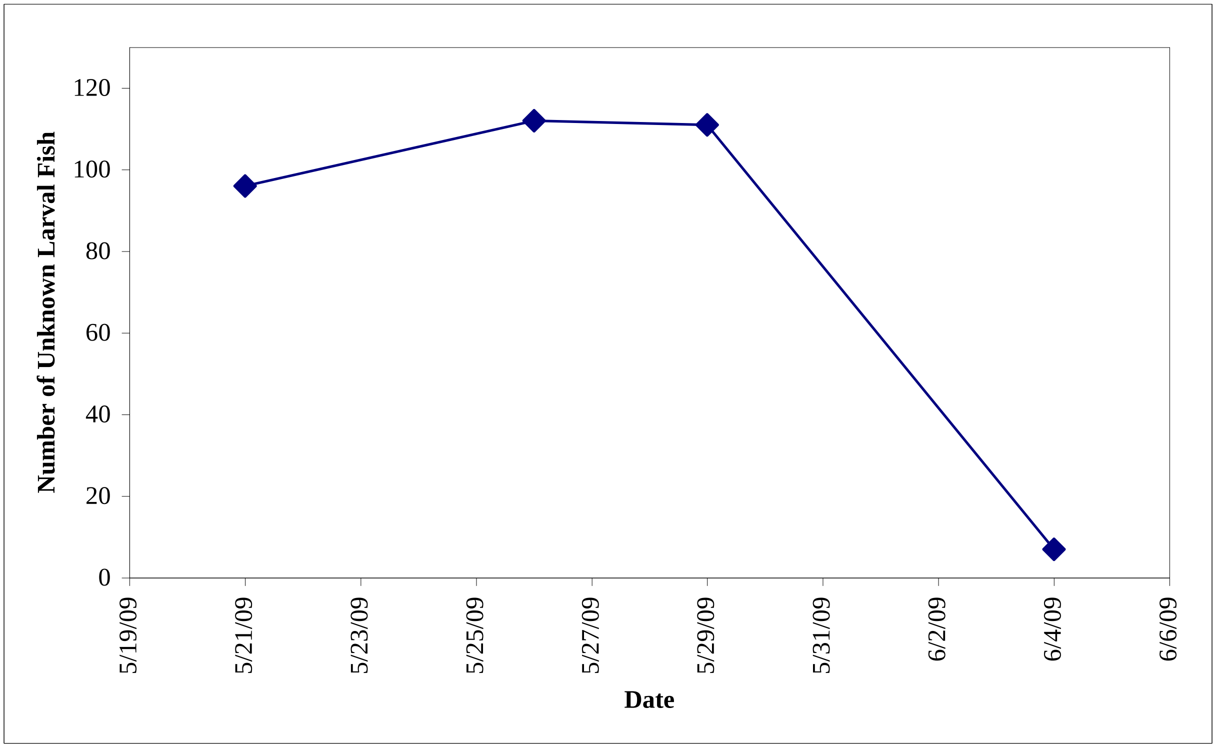

Figure 10. Number of unknown larval fish collected on during each monitoring date from habitat restoration sites.

WATER QUALITY

Water quality data for main channel and floodplain monitoring sites are illustrated in Appendix C. Values for all water quality parameters were within the provisional LC_{50} (concentration that results in 50% mortality of the test animals) provided for silvery minnow by Buhl (2006). In general, temperature was higher at floodplain sites than main channel sites, and recorded values increased at all sites throughout monitoring (Appendix D).

FISHERIES DISCUSSION

More silvery minnow were collected at the habitat restoration sites during spring 2009 than during spring 2007. Comparisons between data collected in 2007 and 2009 are confounded because two different gear types were used (seine nets in 2007 and fyke nets in 2009). Gear selectivity between the two datasets is evident from species composition standpoint. In 2007 red shiner was the most abundant species while in 2009 silvery minnow was the most abundant species. It is unclear from these data if absolute numbers collected by the different gear types represent actual proportions of the fish community.

The presence of substantial numbers of unknown larval fish during both years indicates that the habitat restoration sites are actively used as nursery habitat by the fish community during spring runoff. Although the species composition of the larval fish is unknown, it is likely that a significant fraction of those collected are silvery minnow. Despite the collections of larval fish, no silvery minnow eggs were collected during monitoring. Silvery minnow were observed issuing eggs and milt indicating that individuals may have been actively spawning on or around the habitat restoration sites.

Population monitoring for the silvery minnow over the past decade has documented order of magnitude increases and decreases in abundance, which appear to be related to changing environmental conditions (Dudley and Platania 2008; Dudley et al. 2008). Evidence suggests that recruitment success for the species appears highly dependent on the magnitude and duration of spring runoff (USFWS 2007; Dudley and Platania 2008; Dudley et al. 2008) and less dependent on river drying during irrigation season (Dudley et al. 2008). Despite this evidence, a mechanistic explanation describing the use and function of the river channel and its remaining floodplain by silvery minnow during spawning is lacking.

Spawning on floodplain habitats will benefit silvery minnow recruitment through the increased availability of low-velocity floodplain and backwater habitats that reduce downstream displacement of eggs and larvae (Fluder et al. 2007; Hatch and Gonzales 2008; Gonzales and Hatch 2009), reduced hatching and rearing time for eggs and larvae retained in warmer floodplain and backwater habitats (Jobling 1995; Pease et al. 2006; Hatch and Gonzales 2008), increased production of newly inundated habitats (Junk et al. 1989; Valett et al. 2005), and increased nursery habitat area (Pease et al. 2006). Conversely, spawning on floodplain habitats could result in loss of reproductive effort if the descending limb of the hydrograph is not moderated such that individuals are stranded on floodplain habitats or forced into less suitable main channel habitats before sufficient size has been attained by the newly hatched fish.

VEGETATION

A summary of the baseline Hink and Ohmart vegetation structural classification data collected for the modification areas is displayed in Table 5. The total vegetation areas differ between pre- and post-construction because pre-construction monitoring included a larger project area at the RBN site and more features at the RBS point bar. This provided a larger estimate of the acreage of vegetation that could be impacted by the Project prior to construction.

Comparing the Hink and Ohmart classifications at the three monitoring sites demonstrates a decreasing trend in non-native species stands and an increase in native species growth compared to pre-construction monitoring results. The RBN and RBS sites had the understory cleared prior to construction activities in 2007; however, SDC Island was not accessible for clearing. All three sites supported non-native species, mainly Russian olive, Siberian elm (*Ulmus pumila*), and saltcedar, prior to construction and continue to have non-native species present in 2009; however, the overall trend is a decrease in the size of non-native species and new growth of native species, such as coyote willow, within the sites. With the removal and control of the non-natives during the construction activities, the native plants had the opportunity to repopulate the sites, and the future potential for dense stands of native trees to develop in these areas has appeared to improve.

Table 5. Hink and Ohmart Vegetation Data

Modification Area	2005 Pre-construction		2009 Monitoring	
	Hink & Ohmart Structural Types	Acres	Hink & Ohmart Structural Types	Acres
Rio Bravo North	C/RO-SC1	38.13	C/RO-SC1	2.73
	C/SC3s	16.54	C/SC1	8.51
	C2	4.79	C2	7.23
	C-CW5	0.86	C4s	14.46
	CW6	0.57		
	RO3	3.00		
	SE-RO3	1.23		
RBN Total		65.13		32.93
Rio Bravo South	CW5	0.78	C/CW3s	0.79
	RO/CW-C3	4.90	C-RO/CW3	3.94
	RO-CW5	4.91	CW5	7.44
	SE-RO/SC-CW5	2.81	CW5s	0.58
	SE-TW-C/SC-RO3	0.08	OP	1.78
			RO-C/CW3	3.6
			SE/SE-RO-CW3s	0.83
			SE5s	0.28
			SE6s	0.26
			SE-CW-RO5s	0.78
RBS Total		13.48		20.28
SDC Island	RO/CW-SC3	5.46	C-RO/CW3	1.30
			CW5	3.00
			OP	0.27
			RO-C/CW3	0.74
			RO-C/CW3s	1.20
SDC Island Total		5.46		6.51
Monitored Sites Total		**84.06**		**59.72**

*Areas are rounded to the nearest 0.01-acre for display purposes. Project totals take into account more decimal figures and may not equal the sum of areas displayed for specific site.

CONTINUOUS LINE TRANSECTS

Aggregation of continuous line-intercept data by form type (i.e., bare ground, forbs, grass, leaf litter, and woody debris) reveals differences among types specific to individual sites (Figure 11 and Figure 12). Cover was significantly different among form types at both the RBS and SDCI sites (Kruskal-Wallis single-factor analysis of variance, both sites $P < 0.0001$). Leaf litter was similar between the two sites however there was more overall cover, predominately forbs and grasses, at the SDCI site than at the RBS site.

For both sites combined native vegetation was more abundant than exotic vegetation (Wilcoxon rank sum test $P < 0.0001$) (Figure 13 and Figure 14). Between sites cover of exotic vegetation did not differ (Wilcoxon rank sum test $P = 0.2$), however cover of native vegetation did (Wilcoxon rank sum test $P = 0.04$). Cover of native vegetation was greatest at the SDCI site averaging three times that of native cover at the RBS site. Native species were found within all of the four Hink and Ohmart classifications, while exotic vegetation was found within three of the four Hink and Ohmart classifications (Figure 15 and Figure 16).

A total of 26 species of vegetation (including two unknown species) were collected during line-intercept surveys. Cover varied among species at both the RBS and SDC sites (Kruskal-Wallis single-factor analysis of variance, both sites $P < 0.0001$). Average cover (m) and the number of species were greater at the SDCI site than the RBS site (Figure 17 and Figure 18). At the RBS site, annual ragweed (*Ambrosia artemisiifolia*) (AMAR; mean = 2.4 m) and Canadian horseweed (*Conyza canadensis*) (COCA; mean = 1.5 m) were most abundant species whereas at SDCI Canadian horseweed (COCA; mean = 7.8), water sedge (*Carex aquatilis*) (CAAQ; mean = 3.7 m), Indianhemp (*Apocynum cannabinum*) (APCA; mean = 3.6 m), and common reed (*Phragmites australis*) (PHAU; mean = 3.4 m) were most abundant. The remaining species at RBS all had mean abundances below 1.0 meters; however at SDCI the remaining species all had mean abundances below 2.0 meters. From these data herbaceous vegetation is more diverse at the SDCI site than the RBS site. Plant species names and acronyms are listed in Appendix E.

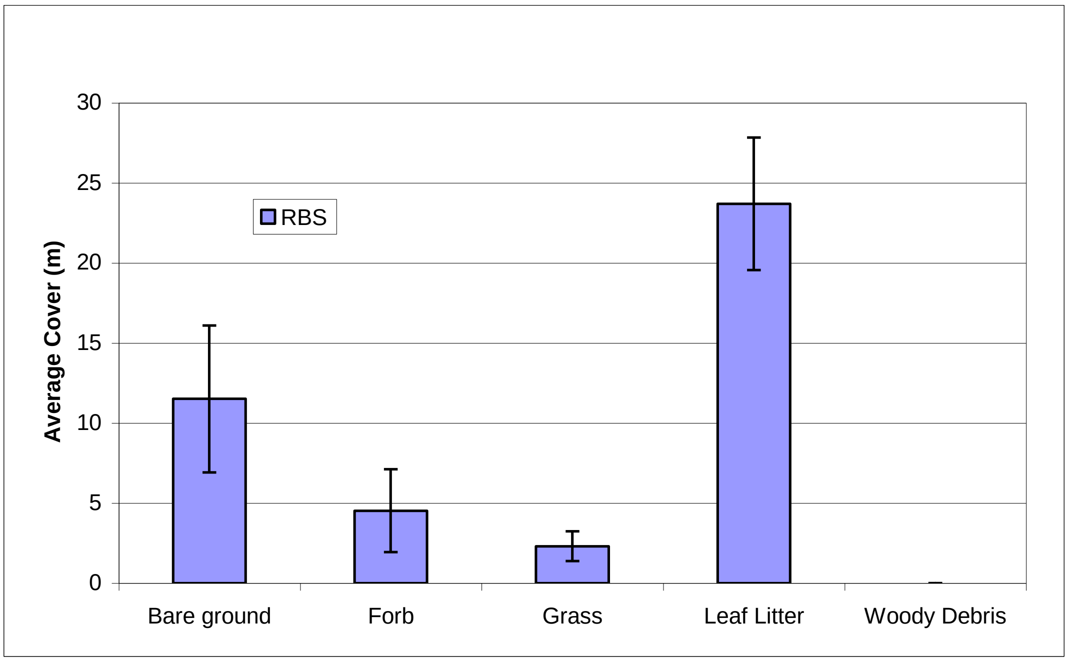

Figure 11. Average cover (m) of form types (i.e., bare ground, forbs, grass, leaf litter, and woody debris) estimated from line-intercept data collected at the RBS site.

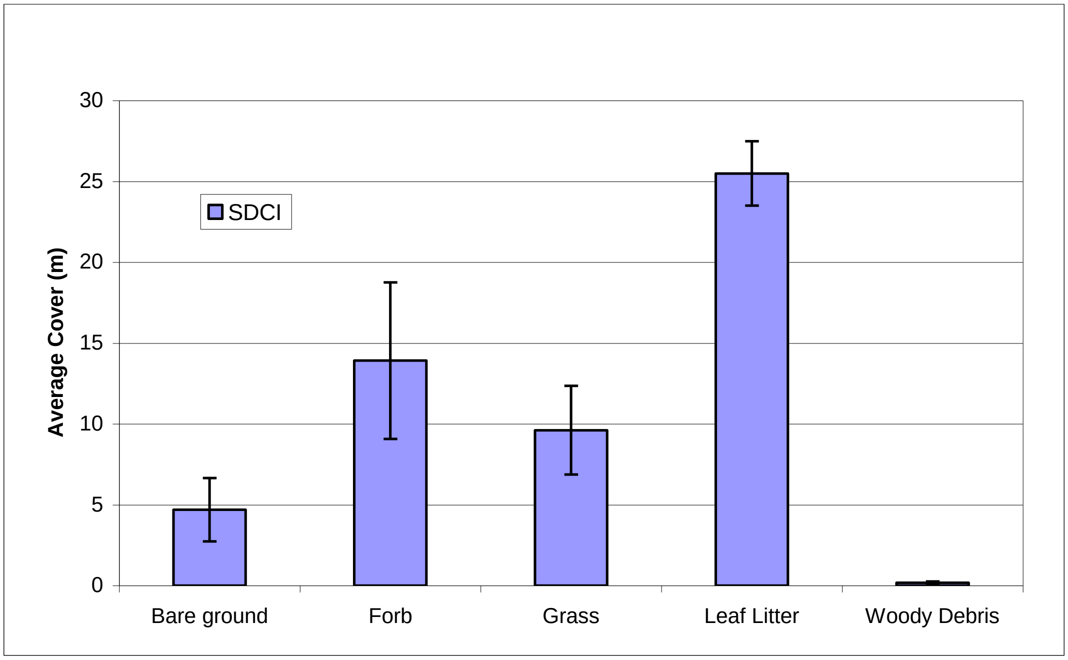

Figure 12. Average cover (m) of form types (i.e., bare ground, forbs, grass, leaf litter, and woody debris) estimated from line-intercept data collected at the SDCI site.

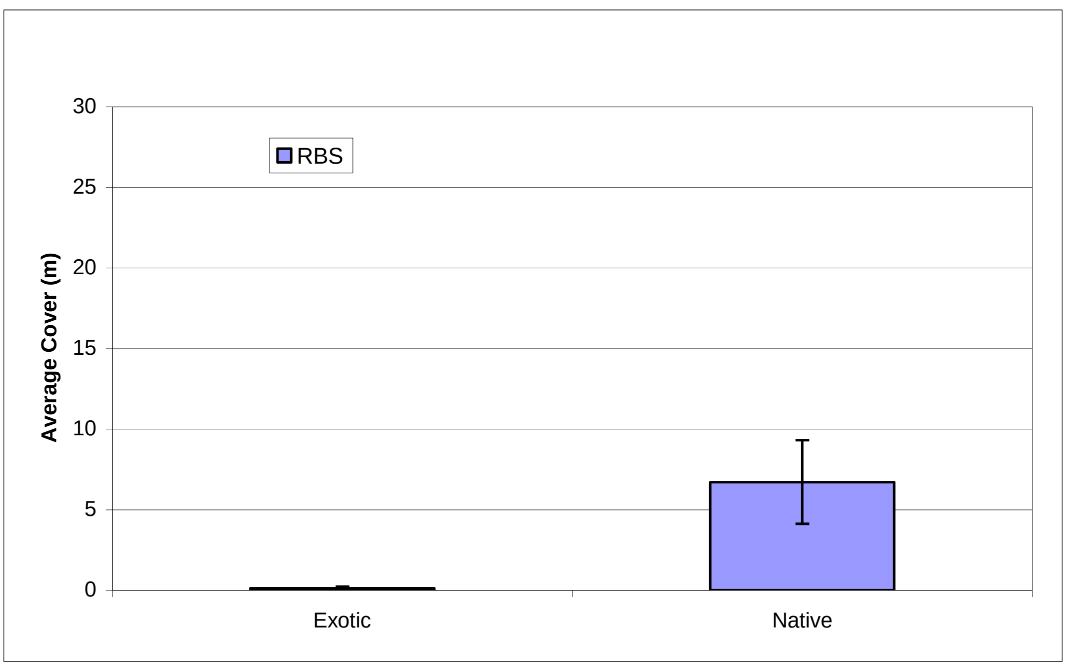

Figure 13. Average cover (m) of native and exotic vegetation estimated from line-intercept data collected at the RBS site.

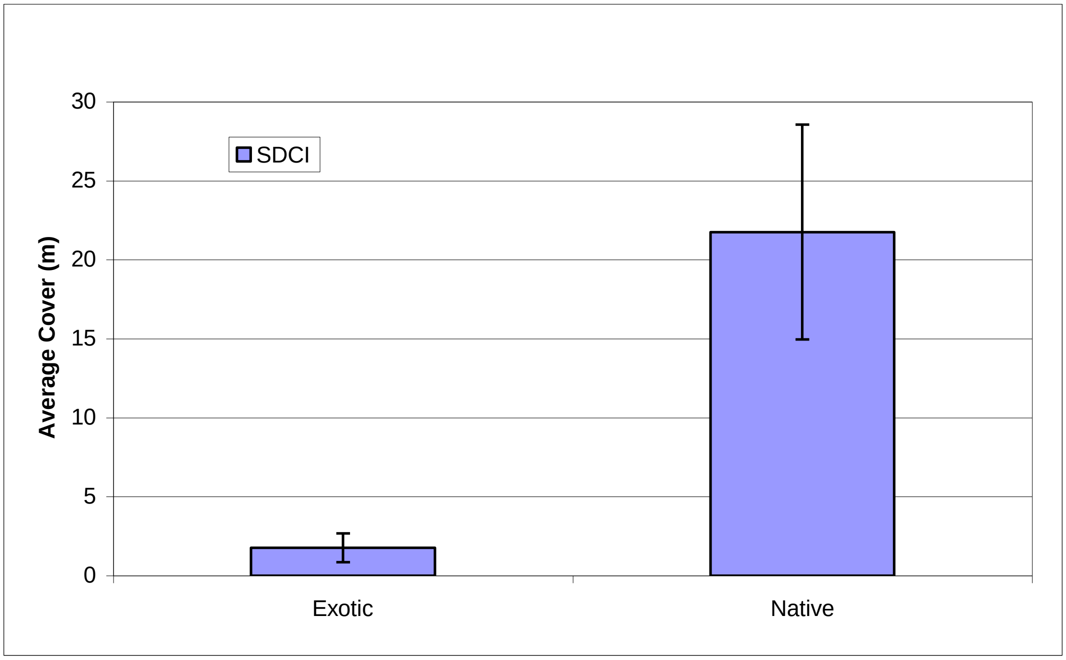

Figure 14. Average cover (m) of native and exotic vegetation estimated from line-intercept data collected at the SDCI site.

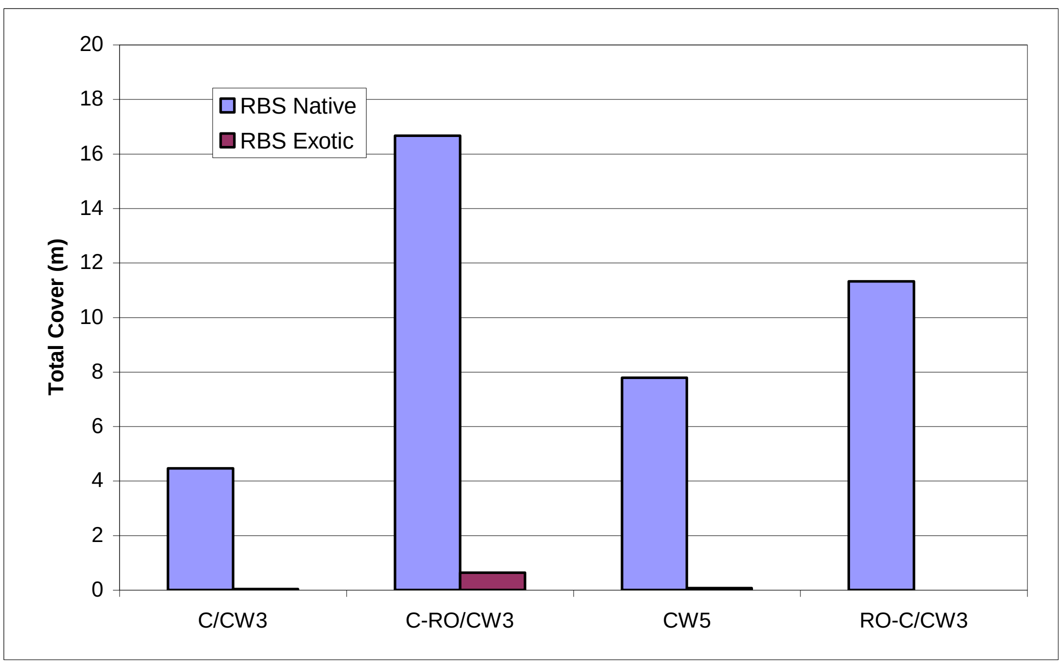

Figure 15. Total cover (m) of native and exotic vegetation within Hink and Ohmart classification types from line-intercept data collected at the RBS site.

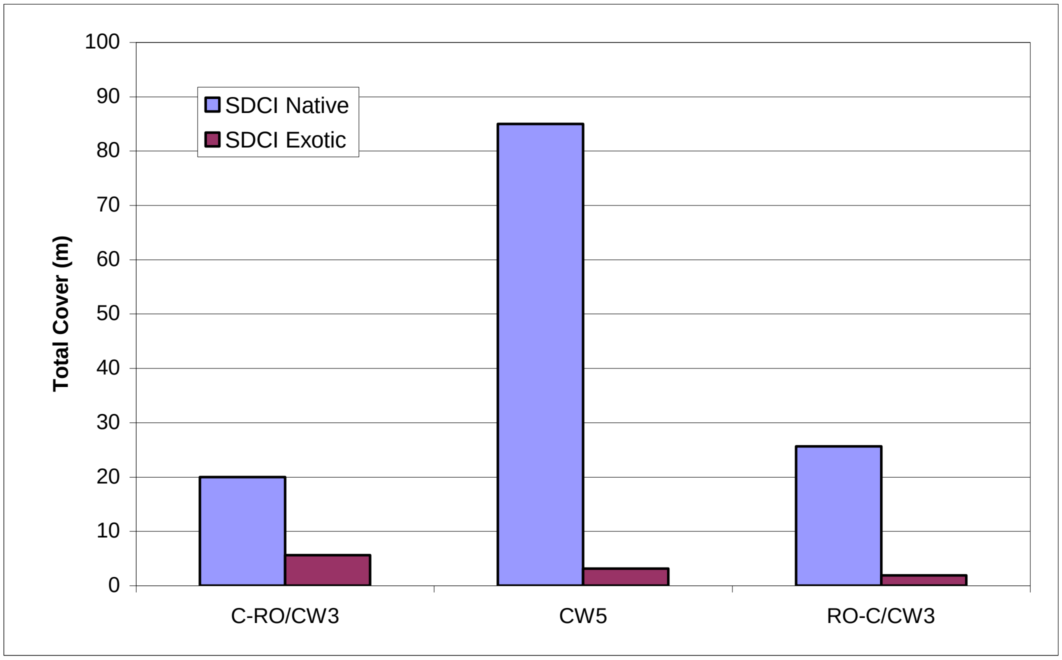

Figure 16. Total cover (m) of native and exotic vegetation within Hink and Ohmart classification types from line-intercept data collected at the SDCI site.

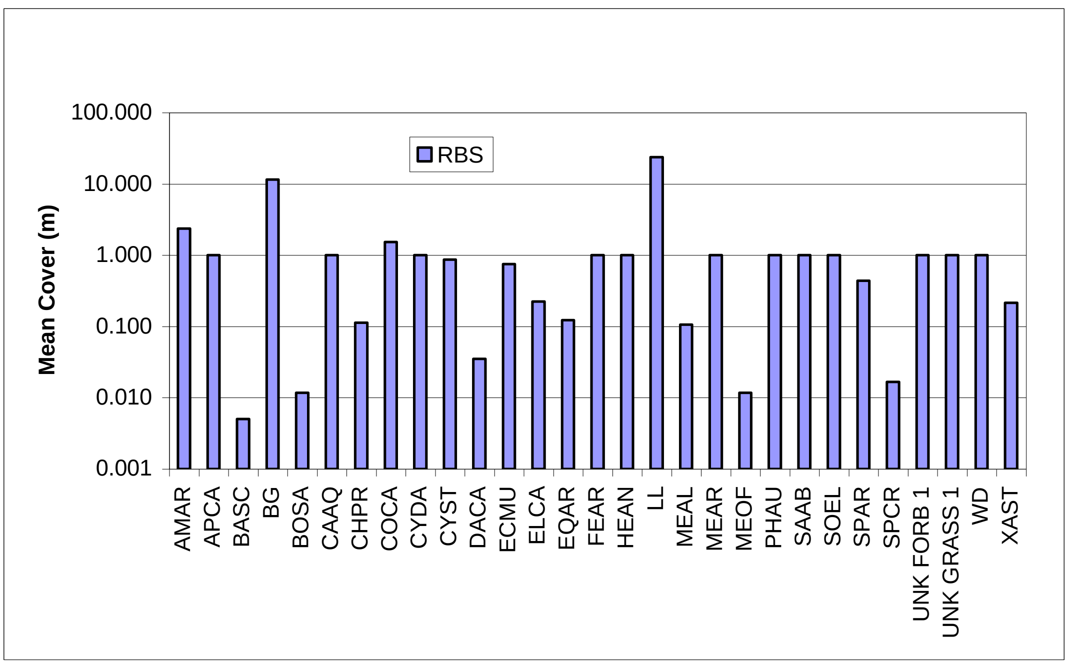

Figure 17. Average cover (m) by species estimated from line-intercept data collected at the RBS site.

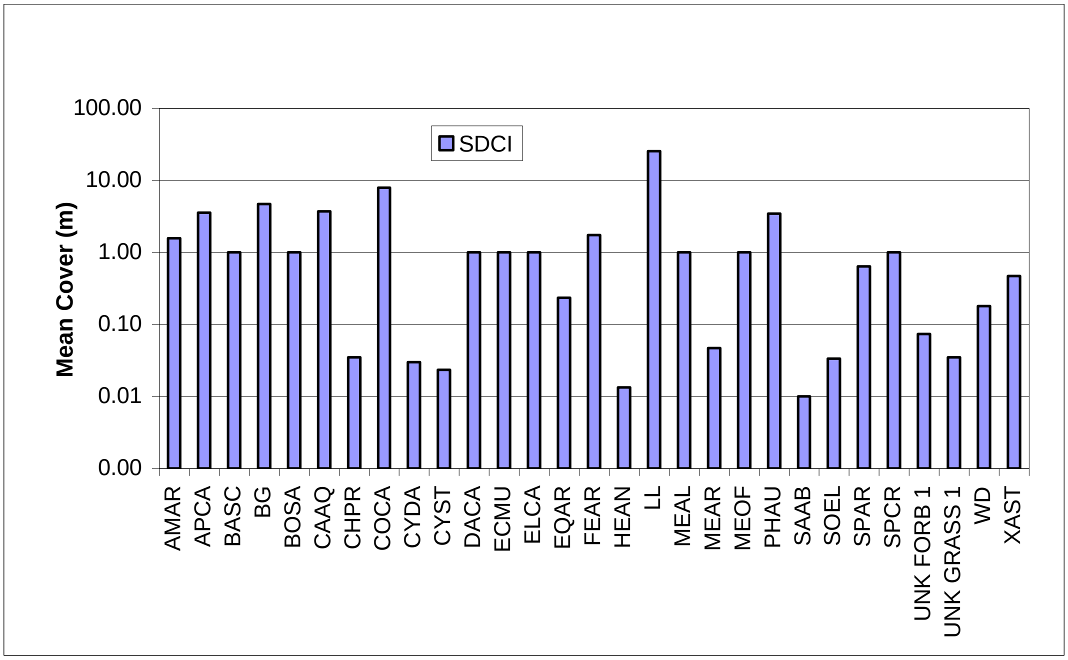

Figure 18. Average cover (m) by species estimated from line-intercept data collected at the SDCI site.

WETLANDS

The MRG is considered to be a Water of the U.S, and therefore wetlands located adjacent to it fall under the regulatory jurisdiction of the CWA and the USACE. Within the monitored modification areas, SWCA verified the presence of three wetland areas (Appendix F), two of which were human-made wetlands within the RBN site. The remaining wetland was present at the south end of the RBS point bar. No wetlands were delineated on SDC Island. Wetland acreage data are summarized in Table 6.

Table 6. Wetland Acreages Located within or near Modification Areas Associated with the Project

Modification Area	Wetland and Data Point Identifier	2005 Pre-construction Wetland Size (acres)	2009 Monitoring Wetland Size (acres)
RBN	RBN-1	N/A	0.35
RBN	RBN-2	N/A	0.43
RBS	RBS-1	0.06	0.06
Total		**0.06**	**0.84**

The wetland acreage monitored in 2009 has increased compared to previous monitoring efforts. The City constructed two willow swales and two soil depressions at the RBN site. At the time of the wetland delineation survey (July 2009), the soil depressions did not have any wetland vegetation and, as a result, do not meet the requirements of being classified as a wetland. The willow swales were constructed in spring 2008, whereas the soil depressions were not constructed until spring 2009.

GEOMORPHOLOGY

Three flow-through channels were constructed at RBS and SDCI. The two channels at SDCI experienced some level of deposition, while the channel at RBS eroded greatly vertically and laterally. This is likely a function of hydrology. The channels at SDCI have a tremendous amount of vegetation, mostly coyote willow. The constructed channel at the RBS site has become the main thalweg of the Rio Grande. The channel had a design width of 30 feet and at the time of the survey has extended to approximately 50-60 feet. The existing channel on the east side of the river has accumulated sediment deposition in which inundation only occurs with flows greater than 2,500 cfs. Six scallops were constructed at RBS and SDCI. The scallops experienced varying levels of erosion and deposition. Scallop #1 has eroded away with the widening of the channel at RBS. The remaining scallops have experienced some deposition along their eastern edge allowing for a backwater environment to exist and creating suitable habitat for silvery minnow. The back edge of Scallop #2 at RBS however, has been eroded and is connected to the constructed channel at high flows (Figure 19). Similarly at the SDCI site, the scallops have had some deposition and backwater environment also exist. The RBN site was also surveyed, but post-construction surveys were not completed. The channel planned for RBN was eliminated from the project. Geomorphology maps are located in Appendix G.

Figure 19. The effect of erosion at Scallop #2 at the RBS site. This scallop is now connected to the constructed channel at high flows (south orientation).

CONCLUSION

The Project did not result in long-term negative changes to water quality, and short-term, and localized adverse effects to water quality did not exceed applicable standards. No federally listed threatened or endangered species or nests were observed during construction activities. Revegetation of access sites, staging areas, and Project locations was not necessary. Photographs of 2009 effectiveness monitoring are in Appendix A.

In summer/fall 2009, the City and SWCA conducted fisheries, vegetation, wetlands, and geomorphology effectiveness monitoring for the completion of Year One riverine and riparian monitoring activities. Effectiveness monitoring will continue on an annual basis for two years, with vegetation monitoring occurring once a year and geomorphic monitoring occurring in summer 2009 and after runoff in 2010. Wetland delineations will be conducted on a yearly basis. Egg, fish, and nursery habitat monitoring occurred in spring 2009 and will continue in 2010. The City, SWCA, and BEMP are currently working together and coordinating Project data and information. The City will use BEMP groundwater data and vegetation transects methodology for additional Project monitoring and analysis.

Although more silvery minnow were collected at the habitat restoration sites during spring 2009 than during spring 2007, comparisons between data collected in 2007 and 2009 are confounded because two different gear types were used (seine nets in 2007 and fyke nets in 2009). The presence of substantial numbers of unknown larval fish during both years indicates that the habitat restoration sites are actively used as nursery habitat by the fish community during spring runoff. Although the species composition of the larval fish is unknown it is likely that a significant fraction of those collected are silvery minnow. Despite the collections of larval fish, no silvery minnow eggs were collected during monitoring. Silvery minnow were observed issuing eggs and milt indicating that individuals may have been actively spawning on or around the habitat restoration sites.

The vegetation at the three monitoring sites demonstrates a decreasing trend in non-native species stands and an increase in native species growth compared to pre-construction monitoring results. The removal and control of the non-natives will allow native plants to repopulate the sites and increase the future potential for dense stands of native trees to develop in these areas. With time and an increase in the stands of native vegetation, future monitoring of these sites may demonstrate a propensity for potential flycatcher habitat as well as habitat for other migratory birds. A total of 26 species of vegetation (including two unknown species) were identified during line-intercept surveys. Average cover (m) and the number of species were greater at the SDCI site than the RBS site. Cover was significantly different among form types at both the RBS and SDCI sites. Native vegetation was more abundant than exotic vegetation at both sites and the SDCI site averaged three times that of native cover at the RBS site. Native species were found within all of the four Hink and Ohmart classifications, while exotic vegetation was found within three of the four Hink and Ohmart classifications.

The wetland acreage in 2009 has increased compared to previous monitoring efforts due to the two willow swales constructed at the RBN site by the City. Although the two soil depressions constructed at the RBN site do not meet the requirements of being classified as wetlands, with time wetland plants should flourish at the RBN site.

Erosion and deposition varied among the two primary treatment types: channels and scallops. Channels constructed at SDCI were perpendicular to river flow. These channels experienced deposition through the channel and at the mouth of the channel forming a lip. The channel at RBS experienced extensive erosion. This channel is parallel to flow and immediately downstream and diagonal from the Albuquerque wastewater treatment plant outflow. Much of this flow is now being funneled through the constructed channel at RBS instead of the existing channel. The scallop at the mouth of the RBS channel has been completely eroded away. The scallops along the eastern edge of RBS have experienced both deposition and erosion. They have eroded laterally while experiencing variable deposition and erosion.

The construction at RBS and SDCI impacted local geomorphology to the extent that the existing channel on the east side of the river, adjacent to RBS, experienced significant deposition. Further downstream, the bank on the east side of the river experienced cutting and erosion. It is unknown what other factors contributed to these changes other than the adjacent restoration. Topographic surveys were not conducted in 2007 or 2008. It is unknown if deposition started occurring in the existing channel prior to 2009.

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APPENDIX A
PROJECT PHOTOS

Figure A1. Bosque area of RBN site before construction. Taken from within the site at 12:16 hours on November 16, 2005; southwest orientation.

Figure A2. Bosque area of RBN site before construction. Taken from within the site at 13:11 hours on November 16, 2005; south orientation.

Figure A3. Near south end of Willow Swale #1 at RBN site after construction. Taken from within Willow Swale #1 at 09:39 hours on July 24, 2009; northeast orientation.

Figure A4. The mid-section of Willow Swale #2 at RBN site after construction. Taken from within Willow Swale #2 at 10:14 hours on July 24, 2009; southeast orientation.

FigureA5. Soil Depression #1 in bosque area of RBN site after construction. Taken at 08:57 hours on July 24, 2009; northeast orientation.

FigureA6. Soil Depression #2 in bosque area of RBN site after construction. Taken at 09:19 hours on July 24, 2009; south orientation.

Figure A7. Southeast bank of RBS before construction. Taken from east bank at 12:29 hours on March 28, 2007; north orientation.

Figure A8. Southeast bank of RBS after construction. Taken from east bank at 13:03 hours on March 28, 2007; southwest orientation.

Figure A9. East bank of RBS before construction. Taken from the east bank at 12:38 hours on March 28, 2007; southwest orientation.

Figure A10. East bank of RBS after construction. Taken from the east bank at 16:50 hours on September 9, 2009; southwest orientation.

Figure A11. **Southern tip of SDC Island before construction. Taken from the east bank at 12:26 hours on March 28, 2007; north orientation.**

Figure A12. West bank of SDC Island before construction. Taken from the west bank at 14:22 hours on March 28, 2007; south orientation.

Figure A13. West bank of SDC Island before construction. Taken from the west bank at 14:22 hours on March 28, 2007.

Figure A14. Channel #1 and #2 on SDC Island during construction. Taken from north end of Channel #1 at 11:00 hours on April 23, 2007; southwest orientation.

Figure A15. Channel #1 and #2 of SDC Island after construction. Taken from the north end of Channel #1 at 15:04 hours on May 14, 2007; southwest orientation.

Figure A16. Channel #1 and #2 of SDC Island during fish monitoring. Taken from the north end of Channel #1 at 10:31 hours on May 21, 2009; southwest orientation.

APPENDIX B
SPRING 2009 FISHERIES MONITORING SITES

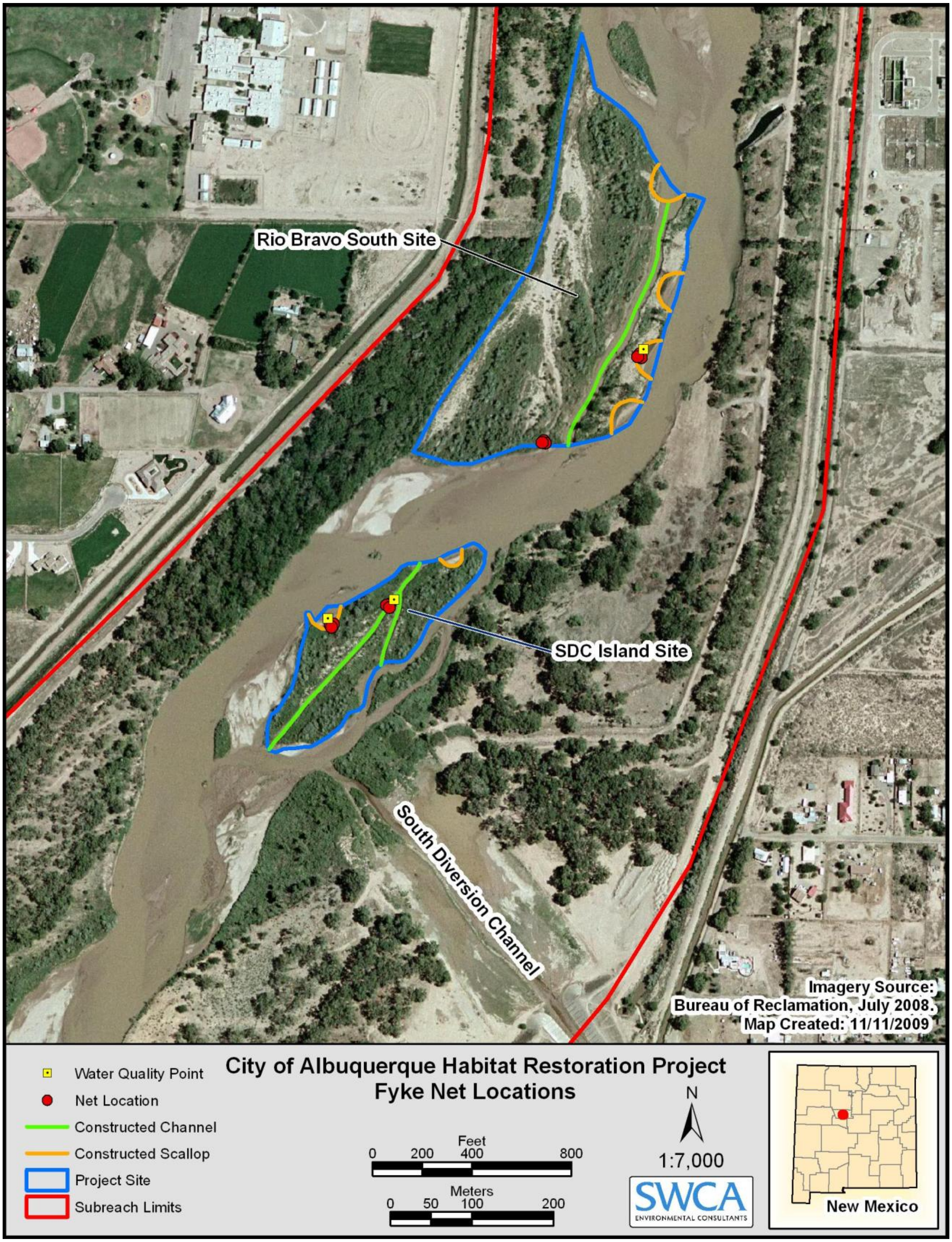

Figure B1. Habitat restoration sites with fyke net locations.

APPENDIX C
WATER QUALITY DATA

Table C.1. Water Quality Data Collected from Habitat Restoration Sites during Monitoring

	Date	Time	Depth	Current	Water Temp	DO (PPM)	DO % Sat	pH	Salinity	Specific Cond	Turbidity
South Diversion Channel Island Main Channel											
	21-May-2009	2:49 PM	1.60	0.30	18.25	7.42	78.70	6.45	0.12	245.00	59.00
	26-May-2009	1:42 PM	2.10	0.51	17.87	9.67	102.30	3.98	0.12	209.00	0.00
	29-May-2009	9:08 AM	1.90	0.39	17.50	10.11	105.10	7.96	0.10	234.00	0.00
	04-Jun-2009	9:48 AM	1.30	0.04	18.44	8.78	94.00	7.96	0.14	289.00	0.00
	Avg.		**1.72**	**0.31**	**18.02**	**8.99**	**95.02**	**6.59**	**0.12**	**244.25**	**14.75**
	St. Dev.		**0.35**	**0.20**	**0.42**	**1.19**	**11.86**	**1.88**	**0.02**	**33.42**	**29.50**
	Max.		**2.10**	**0.51**	**18.44**	**10.11**	**105.10**	**7.96**	**0.14**	**289.00**	**59.00**
	Min.		**1.30**	**0.04**	**17.50**	**7.42**	**78.70**	**3.98**	**0.10**	**209.00**	**0.00**
Rio Bravo South Scallop #2											
	21-May-2009	1:48 PM	1.40	0.07	18.48	6.26	67.00	6.78	0.12	242.00	60.00
	26-May-2009	12:21 PM	1.90	0.13	17.31	9.09	94.60	3.88	0.12	2.70	0.00
	29-May-2009	7:38 AM	1.30	0.11	17.30	7.60	78.90	7.89	0.10	268.00	0.00
	04-Jun-2009	9:04 AM	0.80	0.00	18.72	3.67	39.40	7.55	0.22	457.00	0.00
	Avg.		**1.35**	**0.08**	**17.95**	**6.66**	**69.98**	**6.53**	**0.14**	**242.43**	**15.00**
	St. Dev.		**0.45**	**0.06**	**0.75**	**2.30**	**23.31**	**1.82**	**0.05**	**186.34**	**30.00**
	Max.		**1.90**	**0.13**	**18.72**	**9.09**	**94.60**	**7.89**	**0.22**	**457.00**	**60.00**
	Min.		**0.80**	**0.00**	**17.30**	**3.67**	**39.40**	**3.88**	**0.10**	**2.70**	**0.00**
South Diversion Channel Island Channel #1											
	21-May-2009	3:11 PM	3.60	0.66	18.18	7.64	810.00		0.12	244.00	65.00
	26-May-2009	2:02 PM	4.10	0.94	17.94	11.96	126.10	4.42	0.12	210.00	0.00
	29-May-2009	9:42 AM	3.70	0.82	17.60	9.71	99.80	7.91	0.10	265.00	0.00
	04-Jun-2009	10:06 AM	3.00	0.68	18.37	8.98	95.80	7.99	0.14	289.00	0.00
	Avg.		**3.60**	**0.78**	**18.02**	**9.57**	**282.93**	**6.77**	**0.12**	**252.00**	**16.25**
	St. Dev.		**0.45**	**0.13**	**0.33**	**1.81**	**351.64**	**2.04**	**0.02**	**33.50**	**32.50**
	Max.		**4.10**	**0.94**	**18.37**	**11.96**	**810.00**	**7.99**	**0.14**	**289.00**	**65.00**
	Min.		**3.00**	**0.66**	**17.60**	**7.64**	**95.80**	**4.42**	**0.10**	**210.00**	**0.00**

APPENDIX D
TEMPERATURE DATA PLOTS

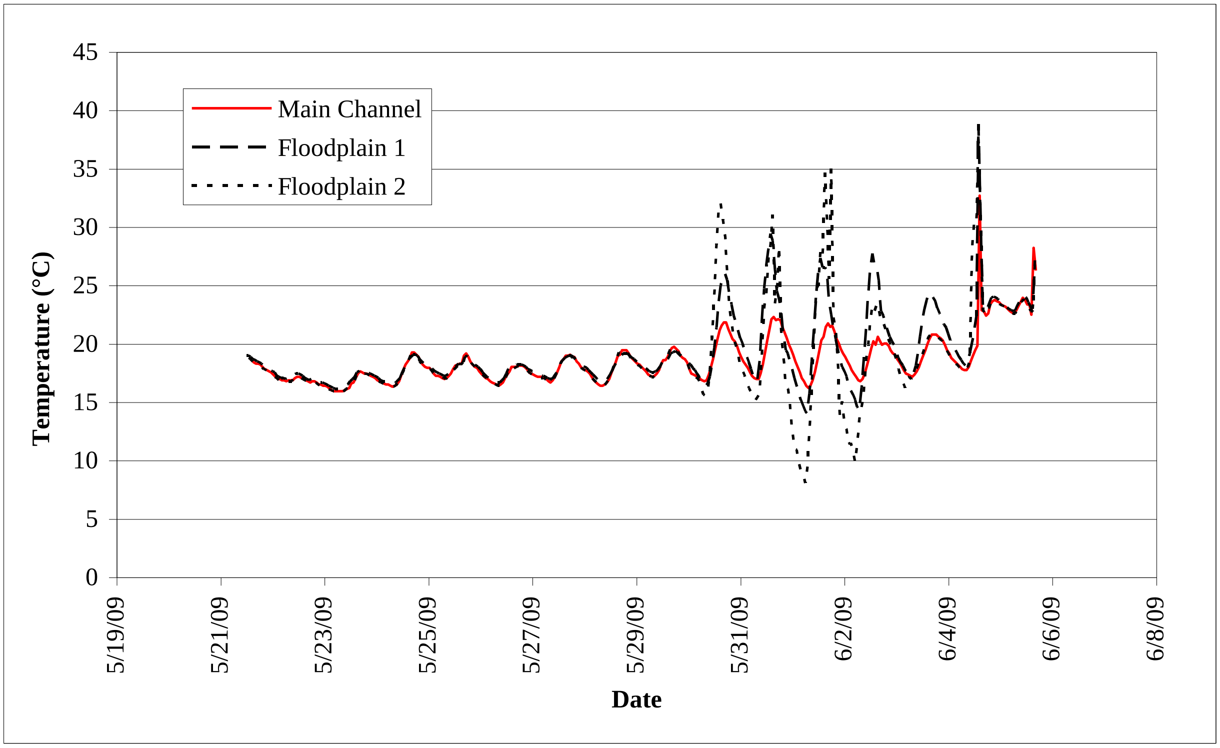

Figure D.1. Temperature plots (°C) collected from habitat restoration sites and the adjacent main channel during monitoring.

APPENDIX E
VEGETATION TRANSECTS AND HINK AND OHMART VEGETATION MAPS

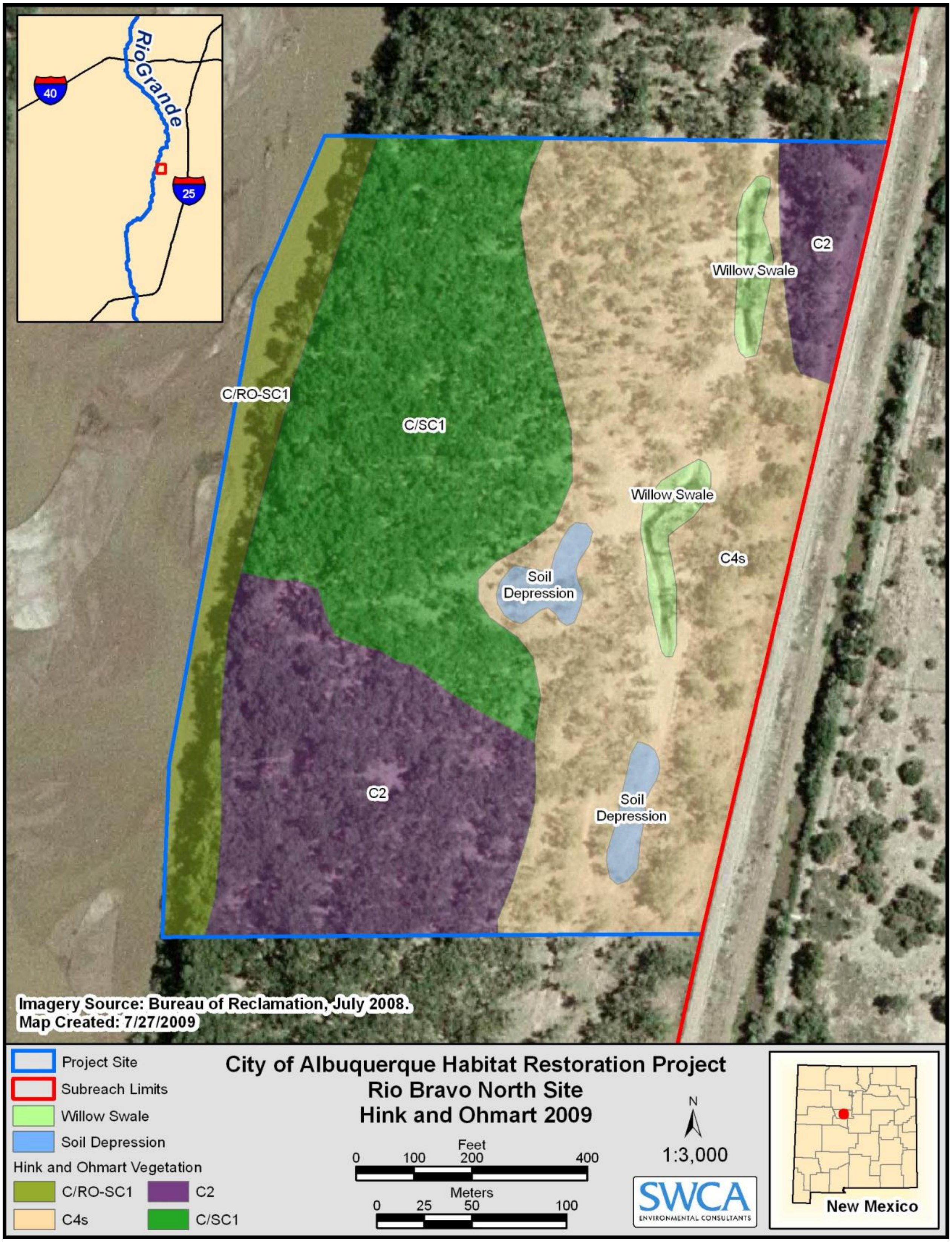

Figure E.1. Hink and Ohmart vegetation types on the RBN site.

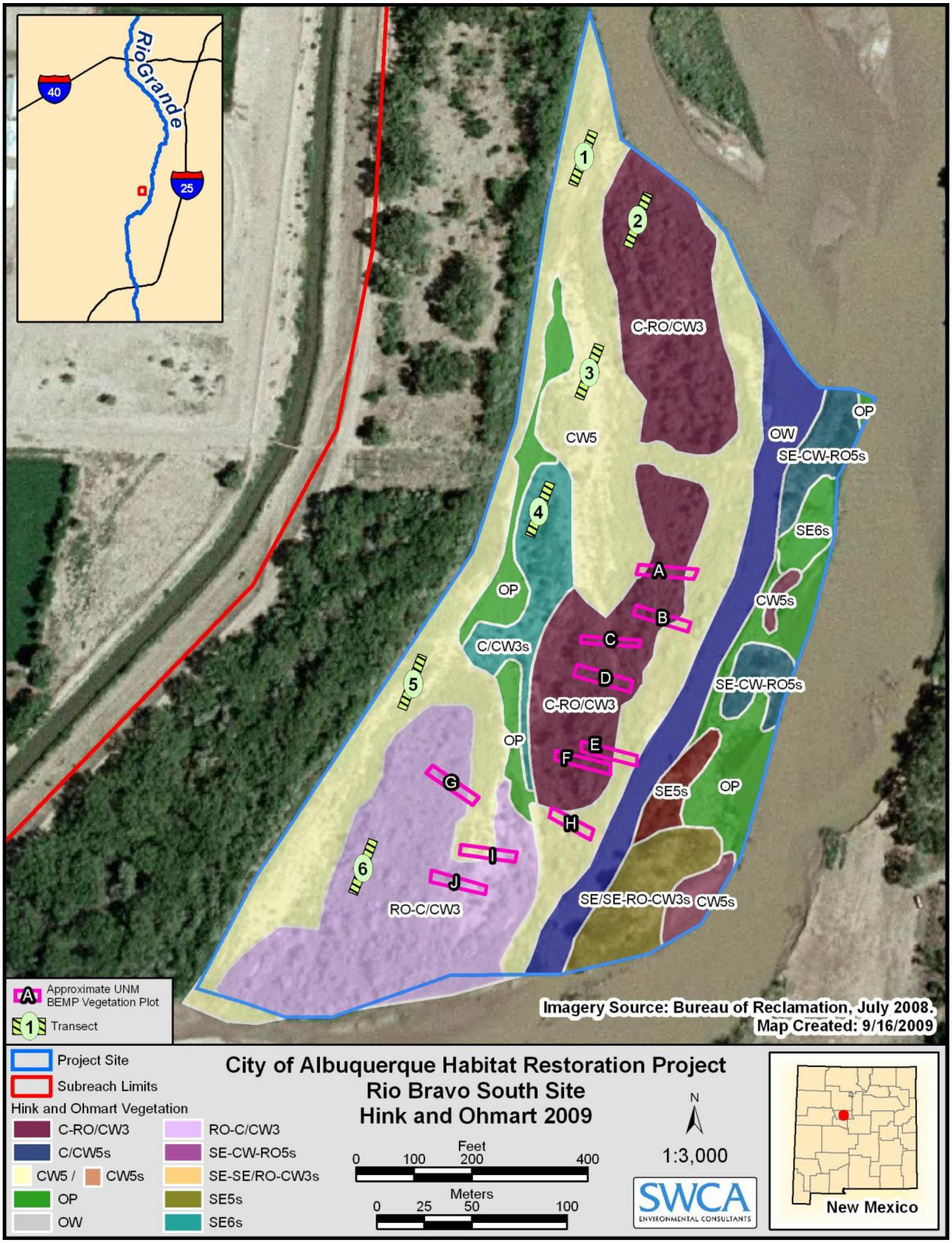

Figure E.2. **Location of SWCA and BEMP vegetation transects within Hink and Ohmart vegetation types on the RBS site.**

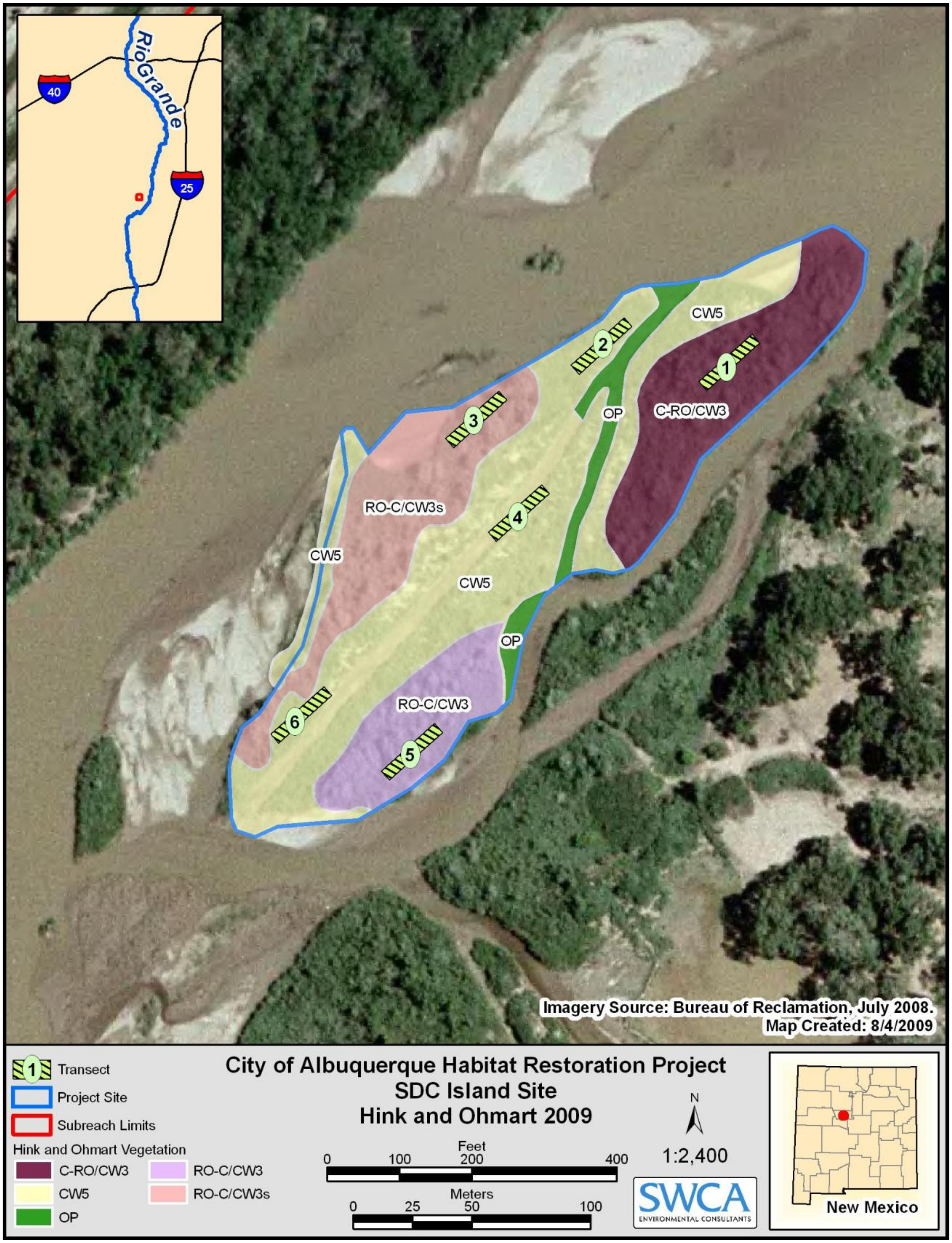

Figure E.3. Location of SWCA vegetation transects within Hink and Ohmart vegetation types on the SDC Island site.

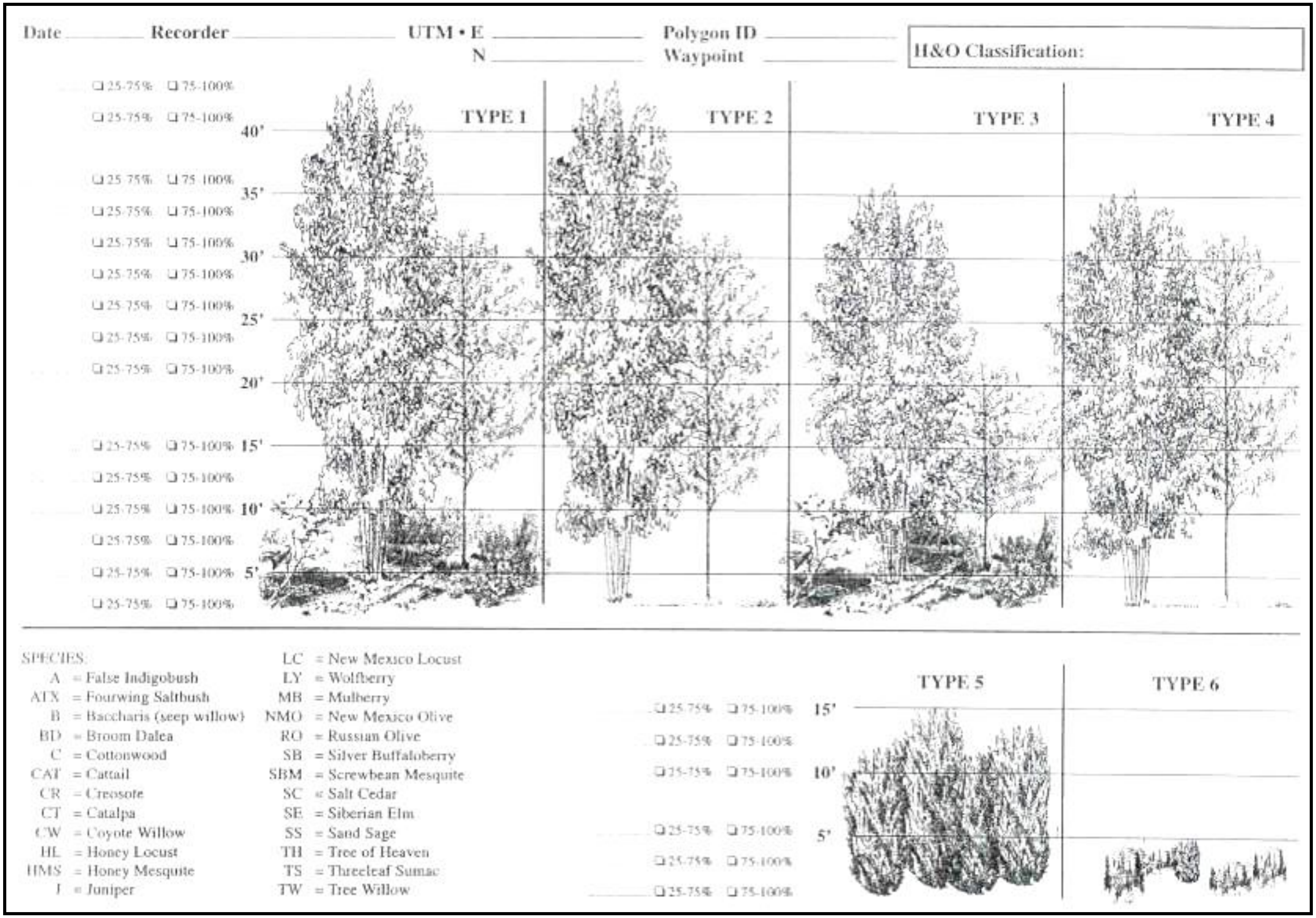

Figure E.4. Hink and Ohmart (1984) vegetation structure classification

Table E.1. Common, Scientific, and Acronym names for plant species identified during continuous line-transect measurements. Acronyms follow the PLANTS Database (USDA, NRCS. 2010).

Common Name	Scientific Name	Acronym
annual ragweed	*Ambrosia artemisiifolia*	AMAR
Indianhemp	*Apocynum cannabinum*	APCA
burningbush	*Bassia scoparia*	BASC
silver bluestem	*Bothriochloa saccharoides*	BOSA
water sedge	*Carex aquatilis*	CAAQ
prostrate sandmat	*Chamaesyce prostrata*	CHPR
Canadian horseweed	*Conyza canadensis*	COCA
Bermudagrass	*Cynodon dactylon*	CYDA
strawcolored flatsedge	*Cyperus strigosus*	CYST
white prairie clover	*Dalea candida*	DACA
rough barnyardgrass	*Echinochloa muricata*	ECMU
Canada wildrye	*Elymus canadensis*	ELCA
field horsetail	*Equisetum arvense*	EQAR
tall fescue	*Festuca arundinacea* (=*Schedonorus phoenix*)	FEAR
common sunflower	*Helianthus annuus*	HEAN
yellow sweetclover	*Melilotus officinalis* (=*Melilotus alba*)	MEOF
wild mint	*Mentha arvensis*	MEAR
common reed	*Phragmites australis*	PHAU
Abert's creeping zinnia	*Sanvitalia abertii*	SAAB
silverleaf nightshade	*Solanum elaeagnifolium*	SOEL
alkali sacaton	*Sporobolus airoides*	SPAR
sand dropseed	*Sporobolus cryptandrus*	SPCR
rough cocklebur	Xanthium strumarium	XAST

APPENDIX F
WETLAND DELINEATION MAPS

Figure F.1. Location of wetlands at the RBN site.

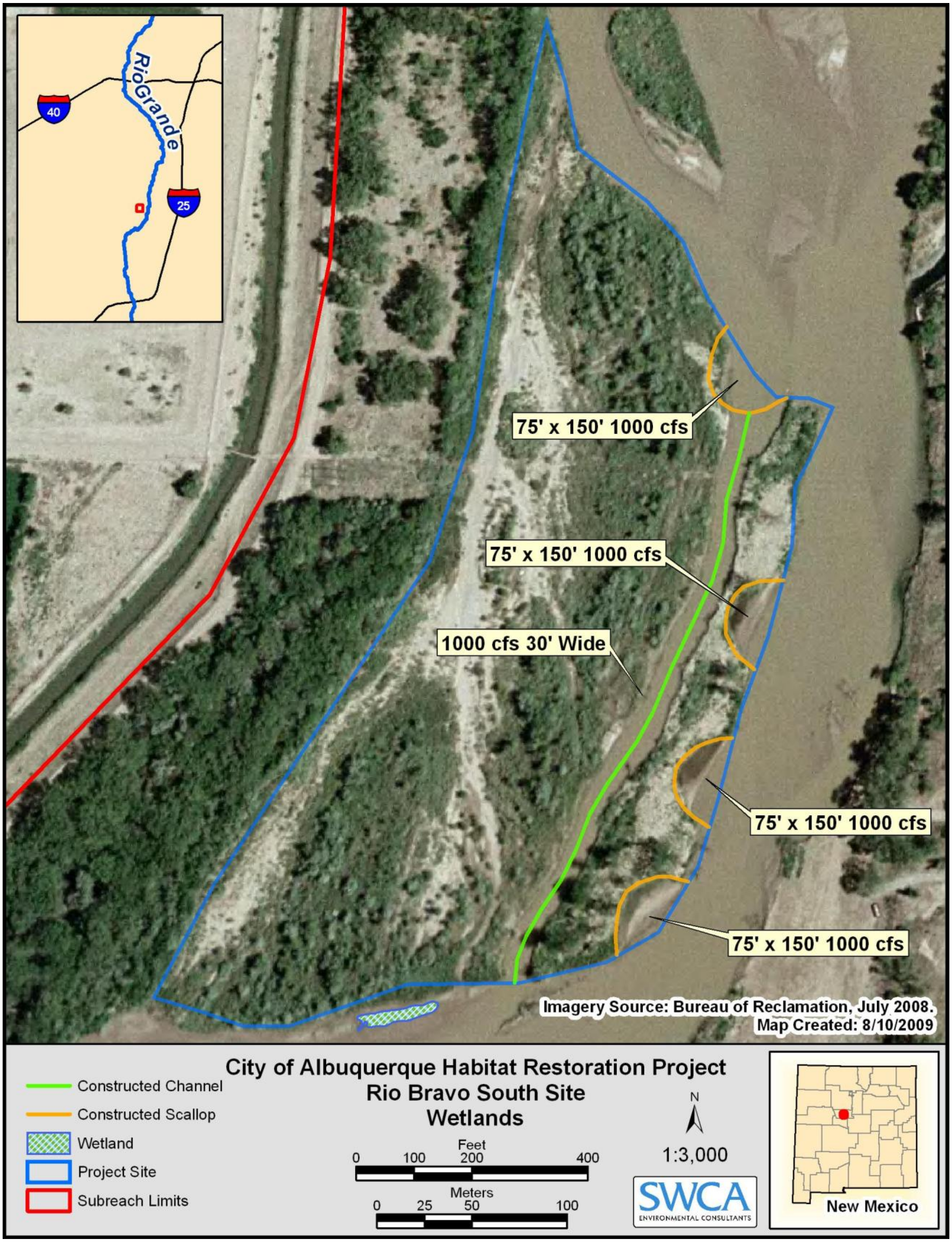

Figure F.2. Location of wetland at the RBS site.

APPENDIX G
GEOMORPHOLOGY MAPS

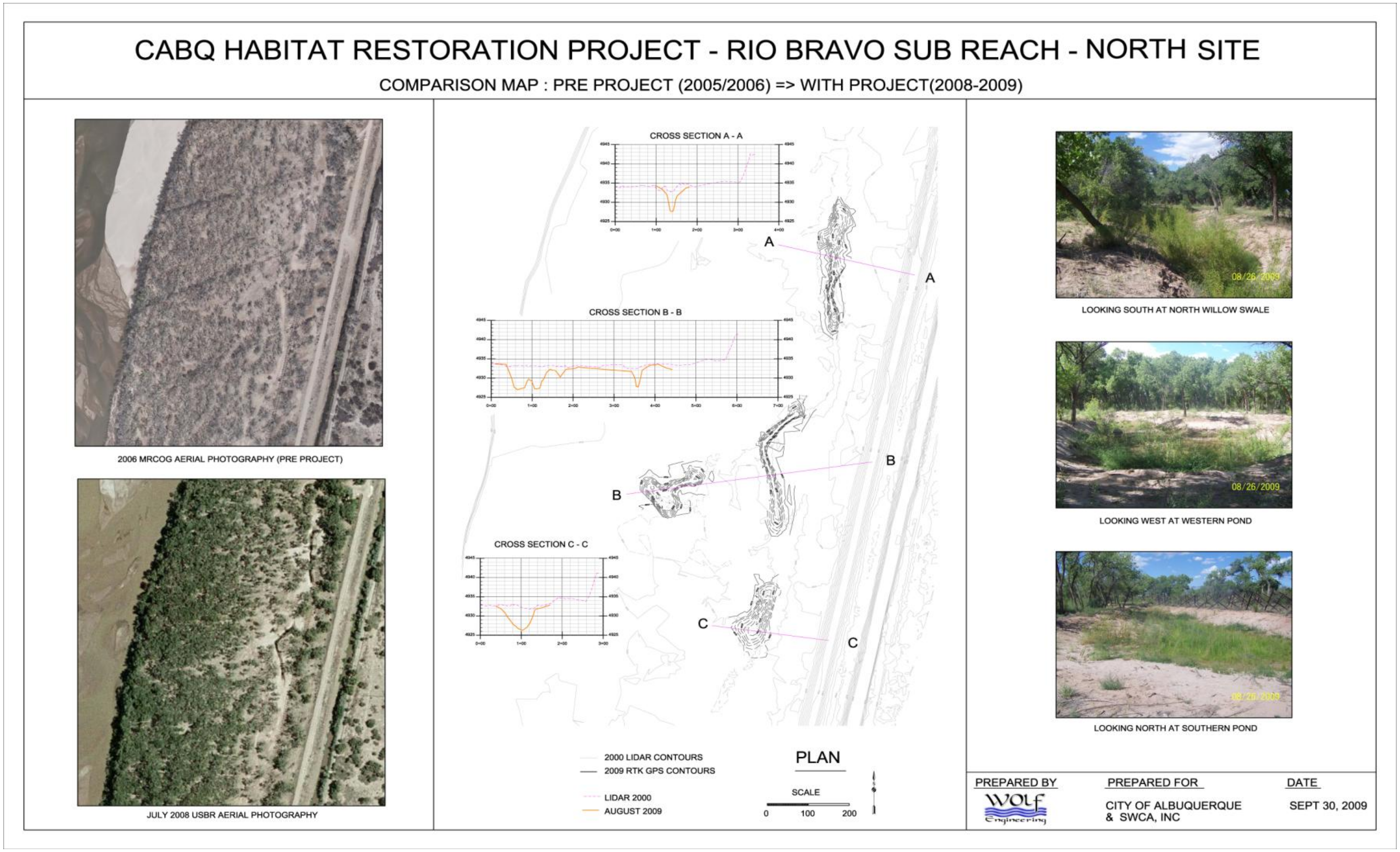

Figure G.1. Geomorphology at the RBN site.

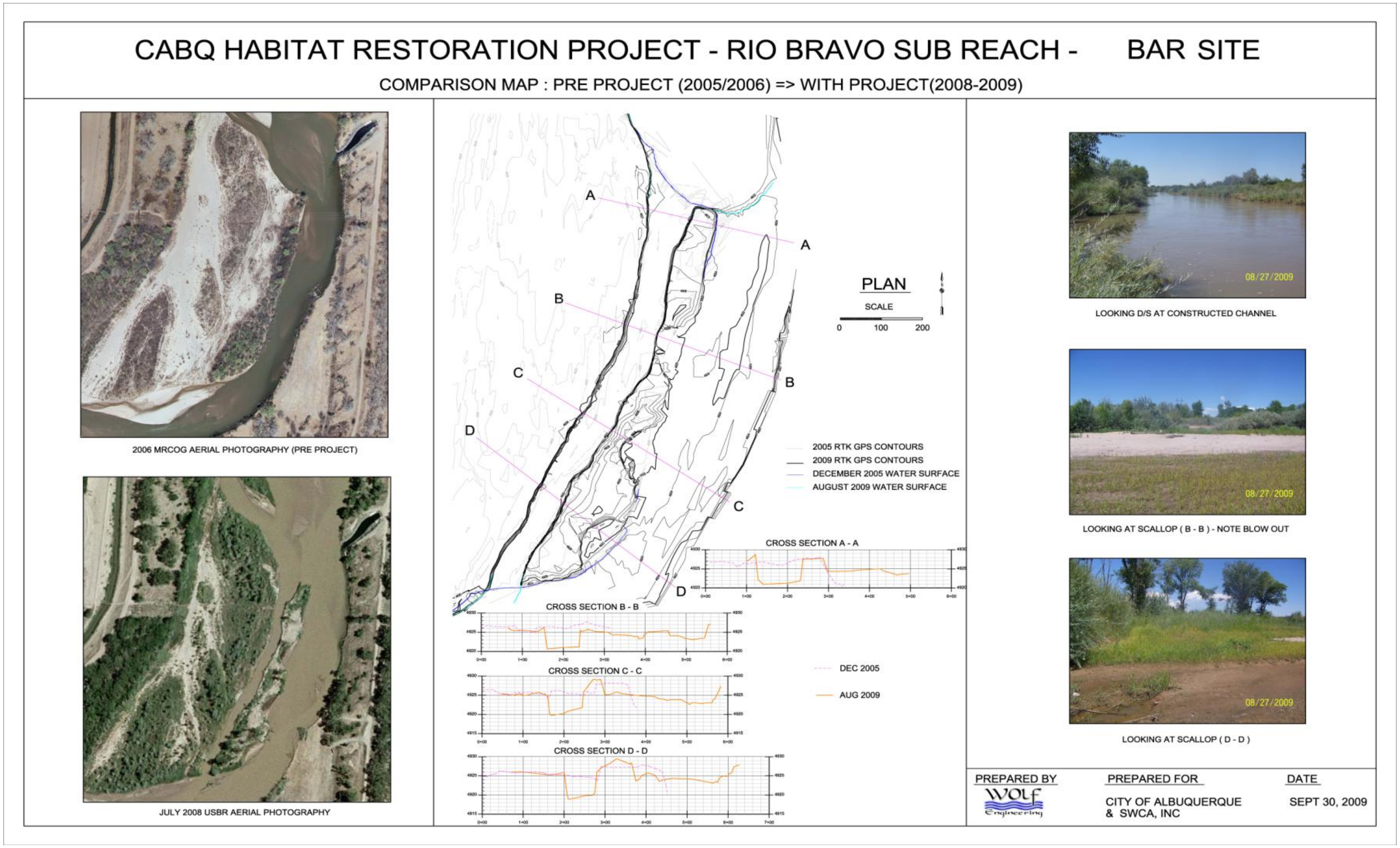

Figure G.2. Geomorphology at the RBS site.

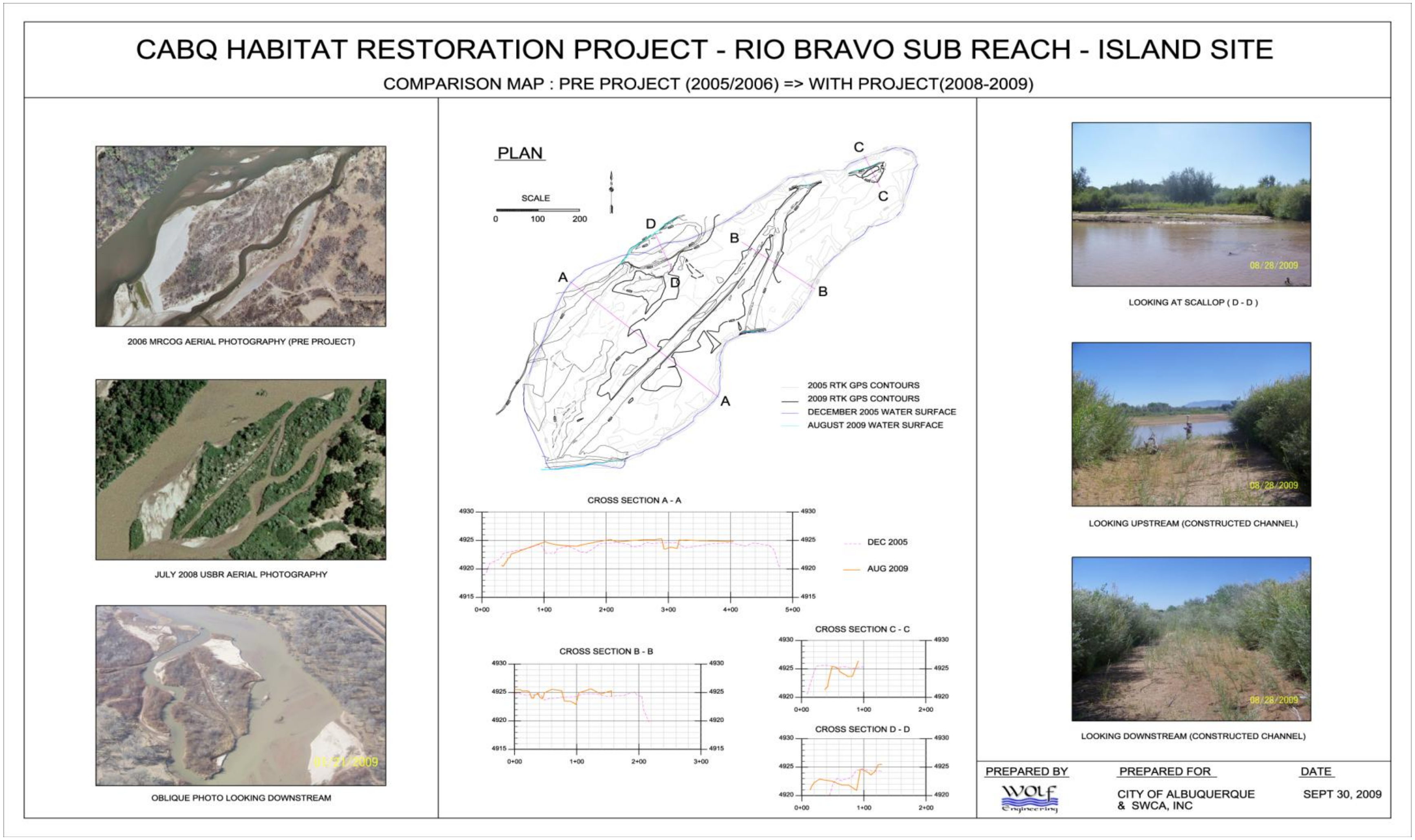

Figure G.3. Geomorphology at the SDC Island site.

APPENDIX H
PHOTO POINT LOCATION MAPS

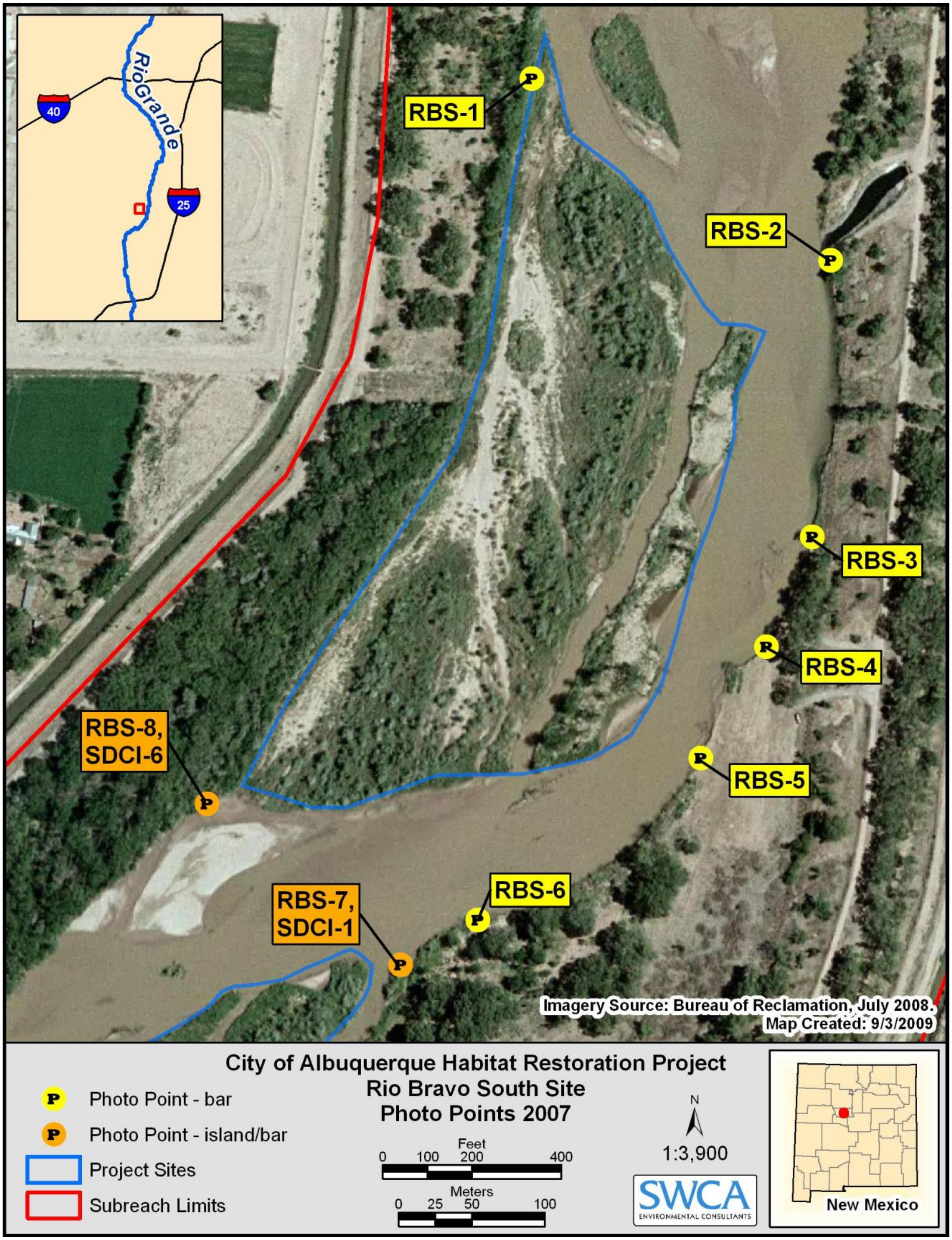

Figure H.1. Photo control points at the RBS site

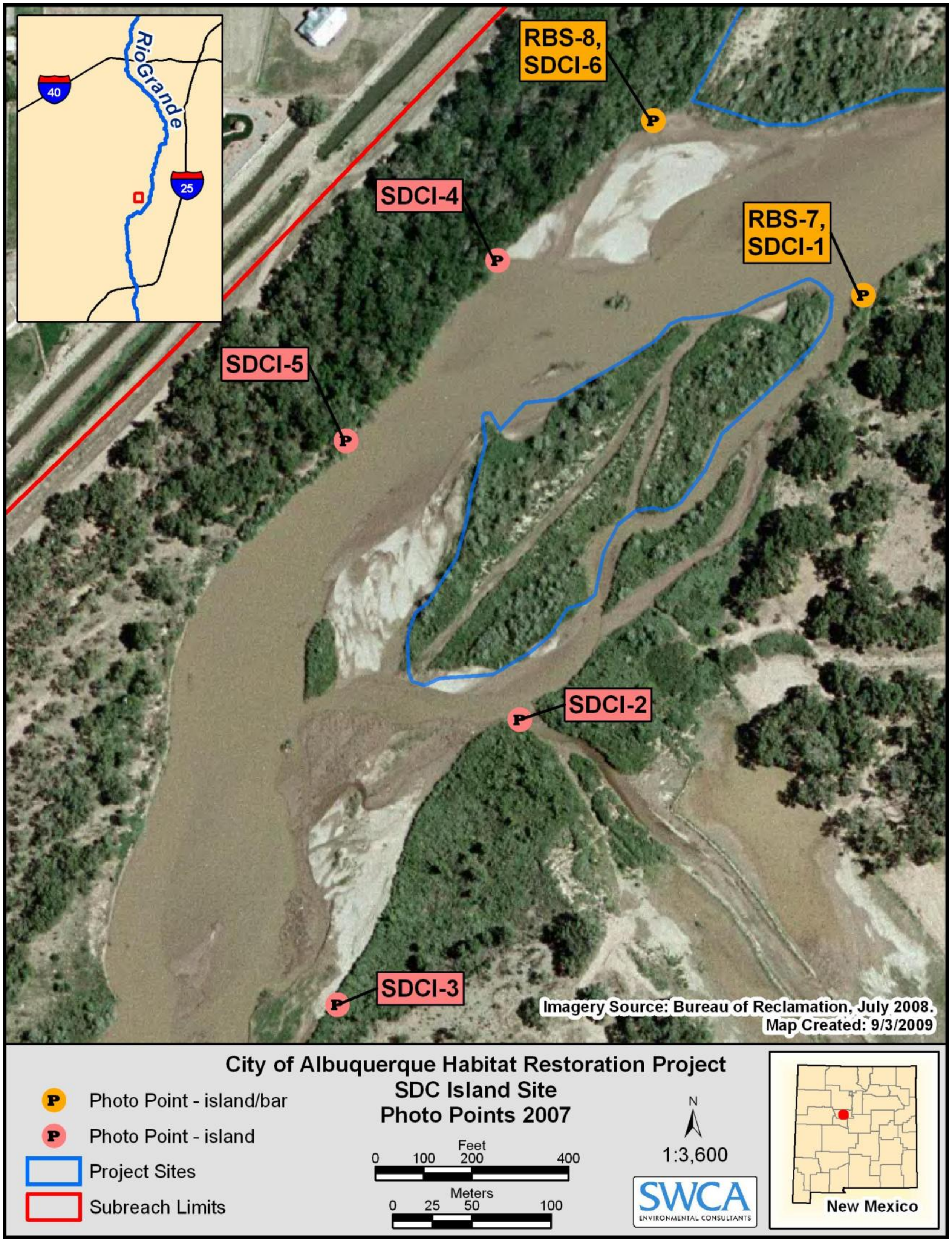

Figure H.2. Photo control points at the SDC Island site