NEW MEXICO INTERSTATE STREAM COMMISSION
MIDDLE RIO GRANDE
RIVERINE RESTORATION PROJECT PHASE I
ANNUAL REPORT

Prepared for

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SWCA Project No. 11966-276

June 2007

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1.0 BACKGROUND

The New Mexico Interstate Stream Commission (NMISC) has begun implementing portions of the Reasonable and Prudent Alternative (RPA) of the March 2003 *U.S. Fish and Wildlife Service Biological and Conference Opinions on the Effects of Actions Associated with the Programmatic Biological Assessment of Bureau of Reclamation's Water and River Maintenance Operations, the U.S. Army Corps of Engineers' Flood Control Operations, and Related Non-Federal Actions on the Middle Rio Grande, New Mexico* (hereafter referred to as the 2003 Biological Opinion [BiOp]) (U.S. Fish and Wildlife Service [USFWS] 2003), which involves addressing priority habitat restoration (HR) goals of the Middle Rio Grande (MRG) Endangered Species Act (ESA) Collaborative Program (Collaborative Program). The HR being conducted is aimed at satisfying the federal requirements under 2003 BiOp RPA Element S, specifying that agencies in coordination with the U.S. Fish and Wildlife Service (USFWS), shall "…conduct habitat/ecosystem restoration projects in the Middle Rio Grande to increase backwaters and oxbows, widen the river channel, and/or lower river banks to produce shallow water habitats, over-bank flooding, and regeneration of stands of willows and cottonwood to benefit the Rio Grande silvery minnow (*Hybognathus amarus*; silvery minnow), the Southwestern willow flycatcher (*Empidonax traillii extimus*; flycatcher), or their habitats." (USFWS 2003:95-96).

The NMISC has applied several HR techniques in three subreach locations in the Albuquerque Reach of the Rio Grande (Project Area) to create or improve habitat for the silvery minnow. These reaches, as shown in Figure 1, include the North Diversion Channel (NDC) Subreach, the I-40/Central (I-40) Subreach, and the Southern Diversion Channel (SDC) Subreach. HR project activities included constructing over-wintering, egg retention, and larval-rearing habitat for the silvery minnow within these three subreaches. The project was designed to facilitate the evaluation of the selected techniques at the locations noted in this document and is primarily funded by the State of New Mexico, with partial funding by the Collaborative Program. This report includes activities conducted between November 2005 and December 2006, and does not include monitoring activities conducted by the NMISC in 2007.

Phase I construction began in 2006 and Phase IV will continue through 2009 (Reclamation 2005). A phased approach has been applied to future restoration activities, with monitoring and evaluation of the outcomes utilized in subsequent phases.

2.0 INVOLVED PARTIES

Numerous agencies and entities contributed to the success of this project, as led by the NMISC. Agencies that contributed to the successful compliance, coordination, and implementation of the project include U.S. Bureau of Reclamation (Reclamation); Collaborative Program; New Mexico Environment Department (NMED); City of Albuquerque, Open Space Division; Middle Rio Grande Conservancy District (MRGCD); New Mexico Office of the State Engineer (OSE); New Mexico Department of Game and Fish (NMDGF); U.S. Army Corps of Engineers (USACE); Pueblo of Sandia; and the USFWS.

3.0 INTRODUCTION

3.1. The Project

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 in support of the RPA, Element S of the 2003 BiOp. The objective of the restoration process is to increase measurable habitat(s) complexity that supports various life stages of the silvery minnow by facilitating lateral migration of the river across islands, bars, and river banks during various mid-level and high flows. The project is directed at documenting and evaluating the effectiveness of specific HR techniques in establishing diverse mesohabitats at a range of river flows between 500 cubic feet per second (cfs) and 3,500 cfs that support silvery minnow.

The project consists of HR techniques designed to create aquatic habitat applied in three subreaches of the Albuquerque Reach of the MRG, which includes the stretch of river east of the Village of Corrales and through the City of Albuquerque (Figure 1). The project comprises several alternative techniques for improving aquatic habitats at an intermediate scale (mesohabitats), as discussed and adapted from the *Habitat Restoration Plan for the MRG* (Tetra Tech 2004). Specific techniques were implemented, monitored, and evaluated, and the HR plans of subsequent phases will be adjusted to increase treatments that are most effective in meeting the habitat needs of silvery minnow. Four primary restoration/rehabilitation techniques (Table 1) were selected in Phase I for their theoretical ability to improve available over-wintering, silvery minnow egg retention, and larval-rearing habitat for the silvery minnow at flows ranging from 500 cfs to 3,500 cfs.

During Phase I of the project, a number of techniques described in the *Habitat Restoration Plan for the MRG* (Tetra Tech 2004) have been implemented for their utility in addressing channel narrowing and bar formation by islands, and in creating essential silvery minnow habitat (Table 1). Restoration techniques included island, bar, and bank line modification. Bank lowering and scouring techniques were used to facilitate over-bank flooding and allow the river to create ephemeral nursery habitat for retention of silvery minnow larvae and eggs. Island modification should increase habitat connectivity to alleviate adverse changes to silvery minnow critical habitat and improve habitat quality and quantity (USFWS 2003). Photo points and survey transects were established for the project for monitoring purposes (Appendix A and Appendix B).

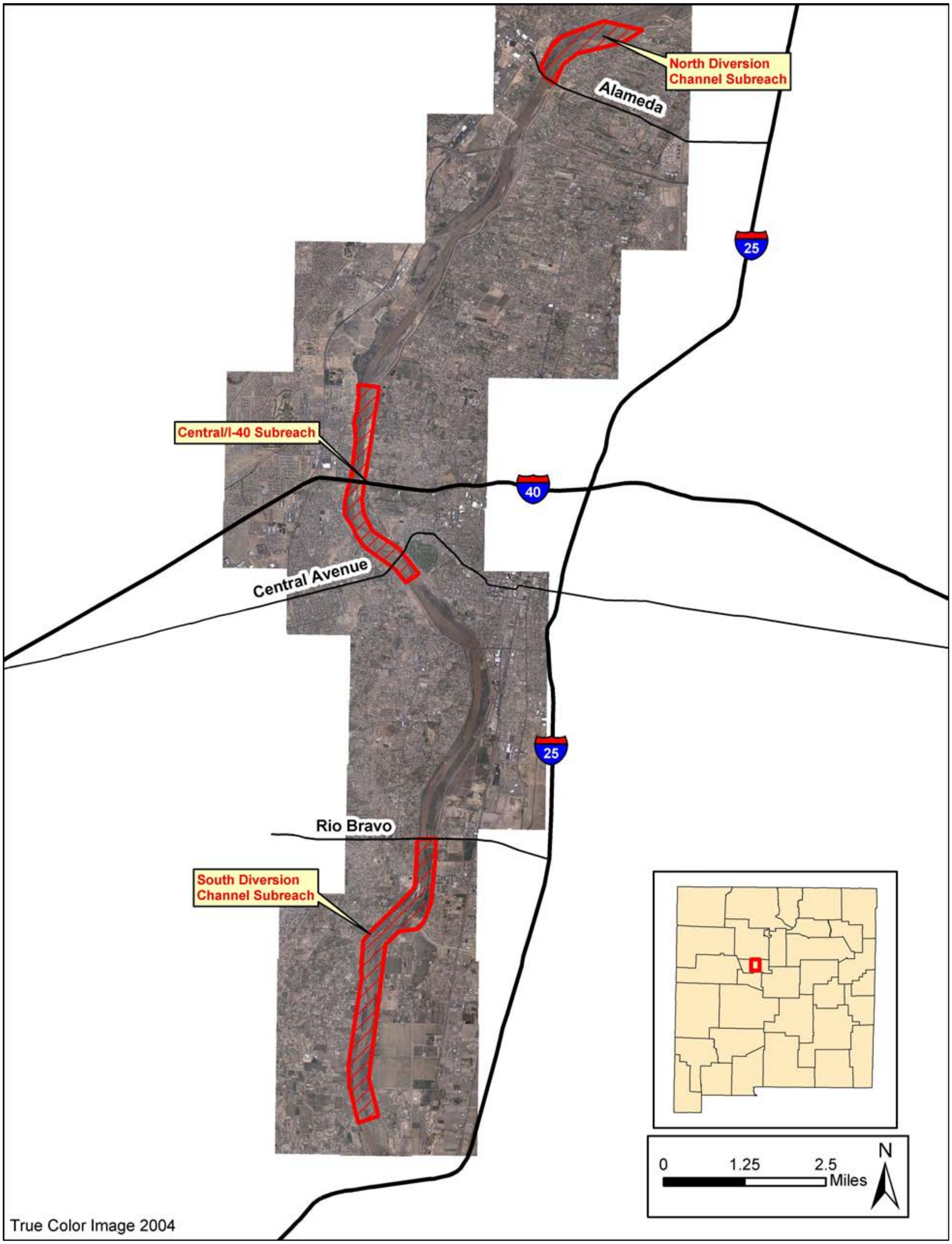

Figure 1. Middle Rio Grande riverine HR subreaches.

Table 1. Potential Restoration Benefits of Implemented Techniques

Technique	Description	Benefits of Technique
Evaluation and modification of islands and bars	Physical disturbance (disking, mowing, root-plowing, raking) of islands or bars to remove vegetation and mobilize features during high flows	Creates more complex habitat for silvery minnow by reducing average channel depth, widening the channel, and increasing backwaters, pools, eddies, and runs of various depths and velocities. Increased inundation will benefit native vegetation and potentially increase habitat for the flycatcher.
High-flow ephemeral channels	Construction of ephemeral channels on islands to carry flow from the main river channel during high-flow events	Creates shallow, ephemeral (normally dry), low-velocity aquatic habitats important for silvery minnow egg and larval development during high flow time periods. Increased inundation will benefit native vegetation, potentially increasing habitat for flycatcher.
High-flow bank-line embayments	Areas cut into banks where water enters, primarily during high-flow events, including spring runoff and floods	Intended to retain drifting silvery minnow eggs and to provide rearing habitat and enhance food supplies for developing silvery minnow larvae. Increased inundation will benefit native vegetation, potentially increasing habitat for flycatcher.
Terrace and bank lowering	Removing vegetation and excavating soils adjacent to the main channel to create potential for over-bank flooding	Could provide for increased retention of silvery minnow eggs and larvae. Increased inundation will benefit native vegetation, potentially increasing habitat for flycatcher.

SOURCE: Tetra Tech 2004

3.2. Environmental Commitments

All applicable permits were obtained by the NMISC prior to implementation of the Project, including but not limited to:

- Landowner access permissions
- Clean Water Act (CWA), Section 404
- State Water Quality Certification under CWA, Section 401
- Pueblo of Sandia Water Quality Certificate under CWA
- Temporary Construction Noise Permit, City of Albuquerque Environmental Health Department
- National Pollutant Discharge Elimination System (NPDES) Permit
- Storm Water Pollution Prevention Plans

In addition to obtaining these permits, the following environmental commitments were undertaken by the NMISC:

1. Impacts to terrestrial habitats were minimized by using existing roads and cleared staging areas. In general, equipment operation took place in the most open area available to minimize damage to native vegetation.

2. Silvery minnow critical habitat encompasses the entire Project Area (Federal Register [FR] 2003) in the river channel. Best Management Practices (BMPs) were enforced to minimize potential impacts to silvery minnow from direct construction impacts and erosion inputs into the river during periods of work.
3. To avoid direct impacts to migratory birds protected by the Migratory Bird Treaty Act (16 U.S. Code [USC] 703, et seq.), construction and clearing of vegetated islands was scheduled between August 15 and April 15, outside of the normal breeding season for most avian species. If vegetation removal was required during the breeding season, pre-construction breeding bird surveys would have been conducted to ensure that no breeding birds would be affected – but no vegetation removal was needed during the breeding season. Any positive preconstruction survey results or observation of affected species during construction would have been coordinated with USFWS to discuss nesting area avoidance.
4. To mitigate potential short-term construction impacts to flycatcher, clearing dense woody vegetation was avoided and conducted only between August 15 and April 15.
5. If flycatchers were observed, construction ceased in the project location, and the USFWS was notified.
6. The shortest crossing path was used to cross the NDC and SDC, and silt fencing was installed downstream of the crossing. Water quality was monitored before silt fencing was installed, and the fencing was not removed until it returned to within 10 percent of the original measures.
7. If a bald eagle was observed within one-quarter mile of the proposed Project Area in the morning before activity started, or if a bald eagle arrived during breaks in activity, the contractor was required to suspend all construction activity until the bird left on its own volition, or until the project biologist, in consultation with the USFWS, determined that the potential for harassment was minimal. However, if a bald eagle arrived during construction activities, or was observed more than one-quarter mile from the construction site, activity was not interrupted.
8. Clean Water Act (CWA) compliance was required for all aspects of the project, and because most work associated with the HR project was completed within aquatic areas regulated by this law, a 404 permit was required. A state water quality certification permit under Section 401 of the CWA was also required, including consultation with the Pueblo of Sandia and the Pueblo of Isleta. The 404 and 401 permitting processes were completed prior to commencement of the HR project.
9. Storm water discharges under the HR project were limited to ground-disturbing activities outside the mean high water mark. All such activities were evaluated for compliance with National Pollutant Discharge Elimination System (NPDES) guidance, an NPDES permit, or a Storm Water Pollution Prevention Plan.
10. Additional evaluation of the net depletion effects of each proposed technique were included in the monitoring of project elements. Restoration techniques that were determined to add significant levels of depletion to the surface waters of the Rio Grande were curtailed.

11. All necessary permits for access points, staging areas, and study sites were acquired prior to construction activity. Access coordination has begun with the City of Albuquerque Open Space Division, the MRGCD, the Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA), and the Pueblo of Sandia.

3.3. Biological Assessment

A phased approach to HR activities was implemented. Phase I included applying a set of techniques applied to selected areas. Phase II followed by monitoring and evaluating the outcomes. The results were incorporated into subsequent planned activities. A Biological Assessment (BA), which was 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 have occurred within the project area during Phase I of the project. The time frame for Phase I was from November 2005 through December 2006.

3.4. Project Locations and Phase I Treatments

As shown in Figure 1, three general locations in the Albuquerque Reach were chosen for application of restoration/rehabilitation techniques: (1) from the NDC to the Alameda Bridge, (2) from I-40 to Central Avenue, and (3) from the Rio Bravo Bridge to the SDC.

Specific sites on vegetated islands, bars, and riverbanks were chosen for testing the efficacy of these techniques. Phase I of the project began in November 2005 and continued through December 2006. Treated acres included approximately 24 acres that were root–plowed and re-contoured, plus nearly 50 acres of new low-flow habitat that was created adjacent to the treated sites using soil sediments. The treated area and adjacent surrounding area is termed *effective area*, which is the combined construction area and impacted area for an HR site. For example, an 8-acre island may have only the upstream half (4 acres) modified, but the entire island will be monitored. The total effective area for Phase I was 74.41 acres (Table 2).

Table 2. Phase I Restoration Technique Treatment Areas

Subreach	Phase I Acres Treated		
	Construction	Effected Area	Total
NDC	10.54	13.47	24.01
I-40/Central	2.73	18.76	21.49
SDC	4.97	23.94	28.91
Total	**18.24**	**56.17**	**74.41**

3.4.1. North Diversion Channel Subreach

Four treatment islands were selected for evaluation in the subreach between the NDC and the Alameda Bridge, as shown in Figure 2. In this subreach, three types of island treatments were implemented, and one undisturbed (control) island was mapped for comparison with treatment islands (Figure 3). Of the four treatment islands, one site was selected for bank scouring and scalloping and three ephemeral channels were constructed.

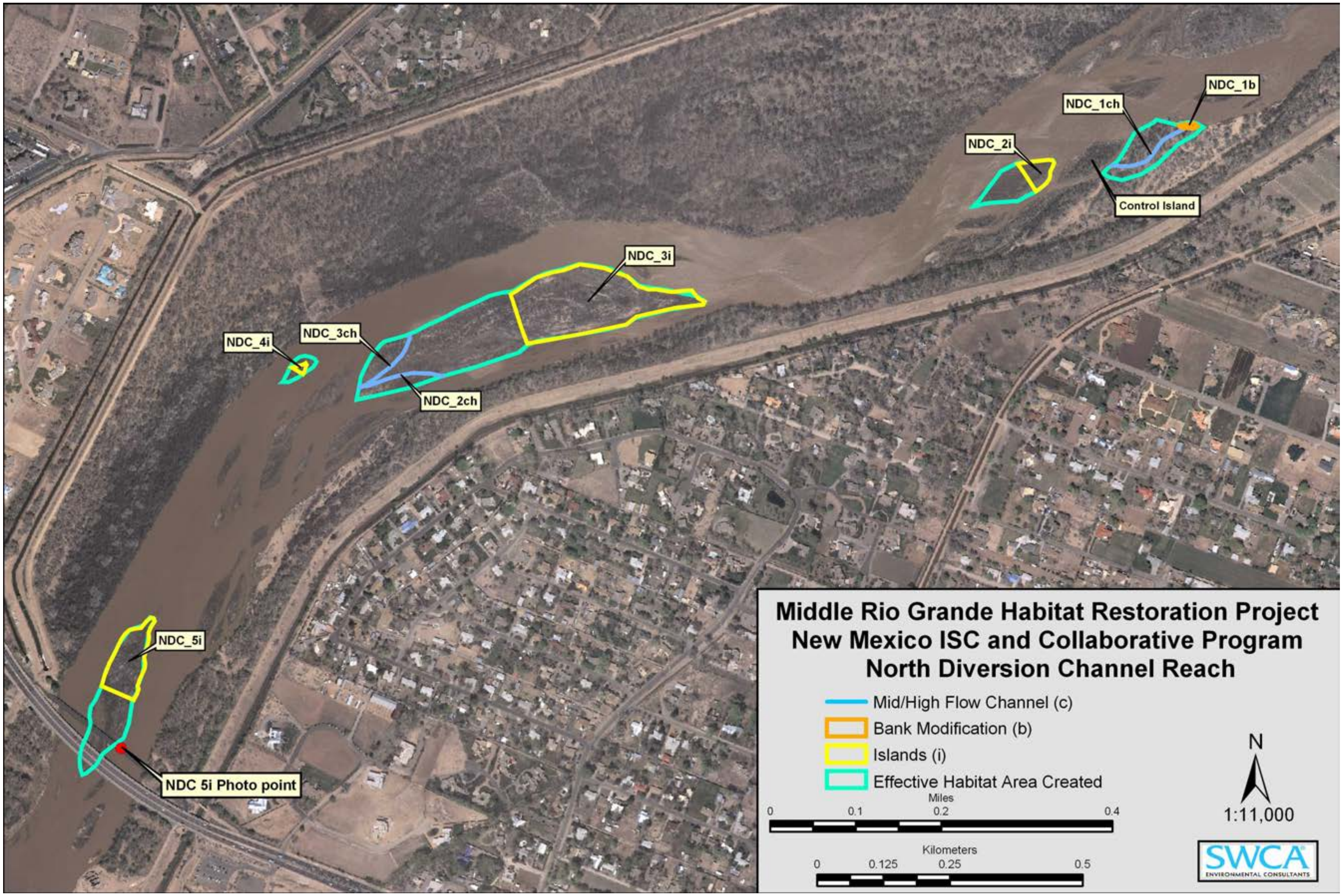

Figure 2. Treatment locations for the NDC Subreach.

Figure 3. NDC Subreach control island with topographic detail.

3.4.2. I-40 to Central Subreach

Four vegetated island evaluation and modification sites, three bank scoured and scalloped sites, and one ephemeral channel site were created within the I-40 to Central Subreach, as shown in Figure 4. Some sites were modified or eliminated from the original design due to time constraints.

3.4.3. South Diversion Channel Subreach

The area between the Rio Bravo Bridge and the SDC consists of three treated islands, as shown in Figure 5. Four ephemeral channels and five bank scours and scallops were implemented in the SDC Subreach. One island in this subreach was left undisturbed as a control island and monitored for comparison with treated islands (Figure 6).

While many of the techniques were designed primarily to enhance silvery minnow habitat, they also promote riparian functionality and interconnectedness. For example, bank lowering has increased the frequency of inundation during periods of above-base flow discharge (not annual events). The overbank areas have not remained flooded for significant periods of time since construction occurred.

3.5. Topographical Designs and Survey

Topographical contours of the selected sites and the surrounding river channel were mapped using survey data collected at selected cross sections in conjunction with orthorectified aerial photography and digital elevation models (DEMs) with 1-foot contours. These data were collected over at least two flows to develop a stage-to-discharge relationship to help quantify the available low-velocity habitat at different river flows. This relationship also provided the basis for determining the elevations at which modifications should be excavated for each island.

Conceptual engineering designs were developed for each site restoration method, showing a topographical representation of the site before restoration and cross sections of the river channel. These engineering designs took into account potential increased sediment retention in the modified sections of the river as well as potential flow-through velocities and depths.

General commitments for all locations and treatment areas included:

- As-built plan and profile maps were developed after treatment but before high flows;
- All applicable permits, certifications, and authorizations were in place prior to construction, including CWA Section 404 Permits and Section 401 certifications;
- Storm Water Pollution Prevention Plans were implemented, including appropriate silt-fencing and other erosion protection; and
- Wetlands and dense native vegetation were avoided whenever possible during construction.

3.6. Egg and Larval Monitoring

The primary objectives of egg and larval monitoring were to determine if constructed HR sites attract spawning silvery minnow, particularly gravid females and/or larvae, as well as to determine if these areas retain eggs. A secondary objective was to determine if silvery minnow actively seek areas of emergent or inundated terrestrial vegetation. Because of low spring flows in 2006, few HR sites existed within the study area. Only shallow, low-velocity areas within constructed embayments were available for the study during the spring and summer of 2006.

3.7. Geomorphology/Hydrology Monitoring

The HR process was initiated to increase measurable habitat complexity in support of various life stages of the silvery minnow by facilitating lateral migration of the river across islands, bars, and riverbanks at a variety of river flows. Monitoring the effects of hydrology on HR sites within the MRG was initiated in the winter of 2006. The goal of monitoring was to determine if spring and summer flows led to significant changes of the modified features and destabilization of the islands. Localized bank erosion and deposition at the NDC and SDC subreaches were also monitored. The Rio Grande was once a meandering, braided river whose morphological diversity facilitated the survival of a diverse array of species within the MRG. It is hypothesized that island and bank destabilization will encourage the river to meander again and create a collection of mesohabitats suitable for the silvery minnow and the wealth of species that make up its critical habitat.

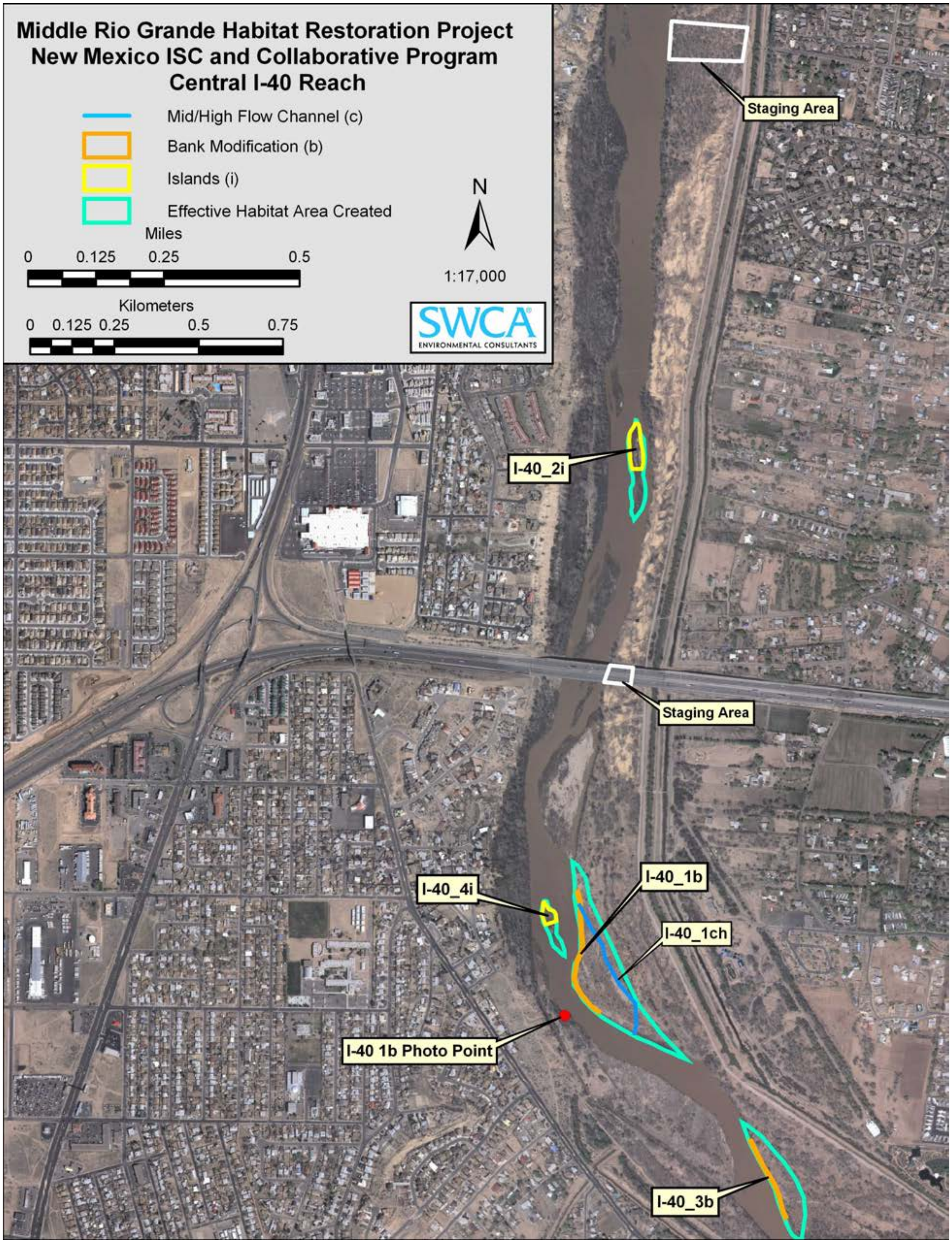

Figure 4. Treatment locations for I-40 /Central Subreach.

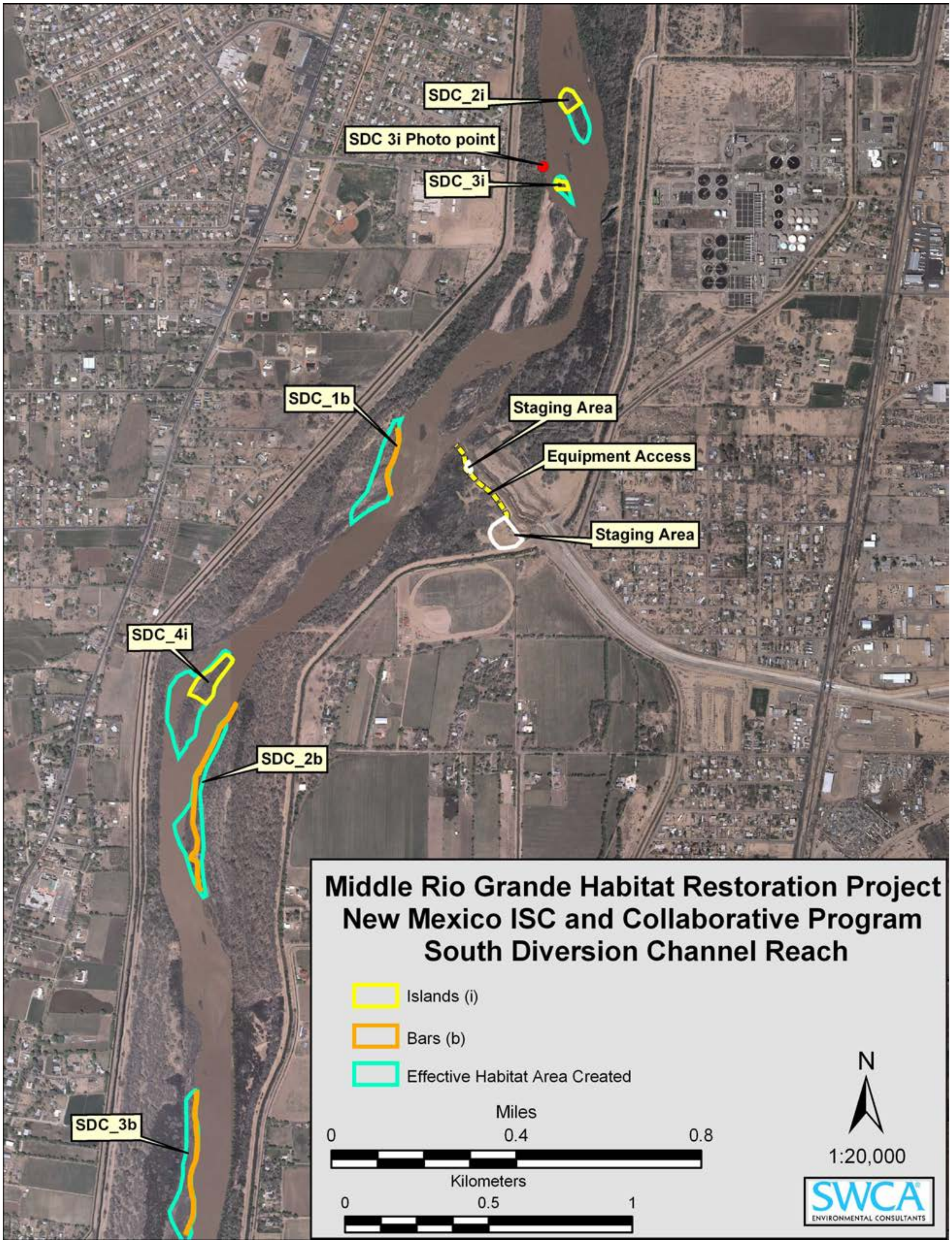

Figure 5. Treatment locations for SDC Subreach.

Figure 6. SDC Subreach control island detail.

4.0 SPECIES INFORMATION

4.1. Rio Grande Silvery Minnow (*Hybognathus amarus*)

The silvery minnow was federally listed as endangered under the ESA on July 20, 1994 (FR 1994) and is listed as endangered by the State of New Mexico as well. The final recovery plan for the silvery minnow was released in July 1999 (USFWS 1999). The primary objectives are to increase numbers of the silvery minnow, enhance its habitat in the MRG valley, and expand its current range by re-establishing the species in at least three other areas in its historic range (USFWS 2003).

The silvery minnow is a moderate-sized, stout minnow that reaches 3.5 inches in total length and spawns in the late spring and early summer, coinciding with high spring snowmelt flows (Sublette et al. 1990). The silvery minnow is herbivorous, feeding primarily on diatoms (Shirey 2004). The silvery minnow travels in schools and tolerates a wide range of habitats (Sublette et al. 1990), but generally prefers low-velocity (<0.33 foot per second, 10 cm/second [cm/sec]) areas over silt or sand substrate that are associated with shallow (<15.8 inches [40 cm]), braided runs, backwaters, or pools (Dudley and Platania 1997). Adults are most commonly found in backwaters, pools, and habitats associated with debris piles; whereas, young-of-year occupy shallow, low-velocity backwaters with silt substrates (Dudley and Platania 1997). Habitat includes stream margins, side channels, and off-channel pools where water velocities are low or reduced from main-channel velocities. Stream reaches dominated by straight, narrow, incised channels with rapid flows are not typically occupied by silvery minnow (Bestgen and Platania 1991).

The species is a pelagic spawner that produces 3,000 to 6,000 semi-buoyant, non-adhesive eggs during a spawning event (Platania 1995; Platania and Altenbach 1998). Adults may spawn multiple times during spring runoff and increased summer monsoon flows (USFWS 2003). Eggs and larvae may drift for 3 days to 5 days and be transported from 134 miles to 223 miles (216 km to 359 km) downstream. Recent data from augmentation and relocation projects suggests that dispersal of eggs, larvae, and older age classes is less than 10 miles (Dudley et al 2005; Porter et al. 2004; Remshardt and Davenport 2003). Silvery minnow larvae can be found in low-velocity habitats where food (mainly phytoplankton and zooplankton) is abundant and predators are scarce.

Platania (1995) suggested that historically, the downstream transport of eggs and larvae of the silvery minnow over long distances was likely beneficial to the survival of its populations. The spawning strategy of releasing floating eggs allows recolonization of reaches impacted during periods of natural drought (Platania 1995). Swimming studies demonstrate that silvery minnow can traverse distances equivalent to 50 km in 72 hours (Bestgen et al. 2003). Bestgen et al. (2003) also determined silvery minnow speed bursts up to 118 cm/sec (70.8 m/min) for short periods of time.

The 2003 BiOp (USFWS 2003) lists the following primary constituent elements of silvery minnow critical habitat:

- A hydrologic regime that provides sufficient flowing water with low to moderate currents capable of forming and maintaining a diversity of aquatic habitats (such as, but not limited to, backwaters, shallow side channels, pools, eddies, and runs of varying depth and velocity) is necessary for silvery minnow life-history stages in given seasons (e.g., habitat with sufficient flows from early spring [March] to early summer [June] to trigger spawning, flows in the summer [June] and fall [October] that do not increase prolonged periods of low or no flow, relatively constant winter flow [November through February]).

- The presence of eddies created by debris piles, pools, or backwaters, or other refuge habitat within unimpounded stretches of flowing water of sufficient length (i.e., river miles) is needed to provide a variety of habitats with a wide range of depth and velocities.
- Substrates predominantly of sand or silt are necessary.
- Water of sufficient quality is necessary to maintain natural, daily, and seasonally variable water temperatures in the approximate range of more than 1ºC (35ºF) and less than 30ºC (85ºF) and mitigate degraded conditions (e.g., decreased dissolved oxygen [DO], increased pH).

4.2. Southwestern Willow Flycatcher (*Empidonax traillii extimus*)

The flycatcher was listed as endangered without critical habitat designation on February 27, 1995 (FR 1995), and critical habitat was designated on July 22, 1997 (FR 1997) but was later withdrawn. In October 2004, the USFWS proposed a new designation of critical habitat (FR 2004). The flycatcher historic range includes riparian areas throughout Arizona, California, Colorado, New Mexico, Texas, Utah, and Mexico (FR 1993). The flycatcher is an insectivore, foraging in dense shrub and tree vegetation along rivers, streams, and other wetlands (USFWS 2003), and prefers dense riparian thickets, typically willows with a scattered cottonwood overstory. Dense riparian woodlands are particularly important as breeding habitat.

The proposed extent of critical habitat within the Project Area begins just south of the Alameda Bridge and extends southward to Elephant Butte Reservoir. The I-40/Central and SDC subreaches fall within the proposed critical habitat area; the entire NDC subreach lies outside of the designated portion of the Rio Grande floodplain. As described in the 2003 BiOp, declining flycatcher numbers have been attributed to loss, modification, and fragmentation of riparian breeding habitat, loss of wintering habitat, and brood parasitism by the brown-headed cowbird (*Molothrus ater*). Habitat loss and degradation are caused by a variety of factors, including urban, recreational, and agricultural development; water diversion and groundwater pumping; and channelization, dams, and livestock grazing.

4.3. Bald Eagle (*Haliaeetus leucocephalus*)

The bald eagle is listed as threatened by both the USFWS and the State of New Mexico. Bald eagles are associated with habitats near open water. In New Mexico, bald eagles commonly winter adjacent to rivers and lakes or where carrion is available. The major food items for bald eagles in New Mexico are waterfowl, fish, and carrion (New Mexico Department of Game and Fish [NMDGF] 2004). Bald eagles are uncommon during the summer and have limited breeding sites in New Mexico, with documented nests in the extreme northern and western portions of the state. The number of birds wintering in the state has been steadily increasing. The bald eagle commonly winters along the Rio Grande, and over-wintering bald eagles have been recorded within the Project Area, where a few individuals may roost in tall cottonwood (*Populus deltoides*) trees near the river.

5.0 ANALYSIS OF THE EFFECTS ON SPECIES

5.1. Rio Grande Silvery Minnow (*Hybognathus amarus*)

Silvery minnow critical habitat encompasses the entire Project Area (FR 2003). The species has declined as a result of impacts from dewatering, channelization and flow regulation for irrigation, diminished water quality, and competition/predation by non-native species (FR 1994). The project will provide long-term direct and indirect beneficial effects on silvery minnow and their critical habitat in the Albuquerque Reach. Beneficial effects of the project include improved egg and larval retention in the Albuquerque Reach, increased recruitment rates, and increased survival of both young-of-year and adults. The described techniques will be implemented in phases and monitored for achievement of HR goals.

5.1.1. Direct Effects

While accessing the islands, the amphibious personnel carriers and the excavator were in partial contact with the submerged sediment. In water more than 3 feet deep, the Caterpillar 325 was in full flotation, and fish movement was not impeded. In water shallower than 3 feet, the equipment moved along the riverbed surface. The average speed of the Caterpillar 325 is approximately 1 mile per hour, or 26 m per minute. In comparison, silvery minnow are capable of swimming up to 70.8 m per minute (118 cm/sec) (Bestgen et al. 2003) and could readily avoid the equipment as it moves through the river channel. The slow speed and sound of the amphibious equipment, the sensitivity of silvery minnow to sound, their high swimming speed, and access to the water column around the equipment made it possible, but unlikely that any silvery minnow would be physically harmed by the equipment. Once at the construction site, equipment operated on the riverbanks, bars, and islands, wherever it was possible to avoid contact with aquatic habitats of the silvery minnow.

Creating new, low-flow habitats on islands was accomplished by placing sediments and debris from root plowing in a pre-defined area adjacent to the disturbed area on the island. A silt curtain was used to contain the sediments while they were being put in place and compacted, and work proceeded by filling and compacting the upstream portion of the contained area first and allowing displaced water and fish to move out of a downstream opening. Large woody debris were placed directly in the channel adjacent to the island, where the flow and depth of the channel were adequate to disperse the material into locations during high flows, allowing habitats to form around the wood, benefiting silvery minnow.

5.1.2. Indirect Effects

Indirect harm or mortality from reduced water quality in the critical habitat of silvery minnow from accidental introduction of hydrocarbon contaminants from fuel and fluids used with the proposed equipment was low. Hydraulic lines were protected to prevent punctures during operation. All fueling activities took place outside of the active floodplain, and all equipment underwent thorough cleaning and inspection prior to operation. Excavator personnel were trained and equipped for emergency spill prevention and clean-up, with detailed specifications to prevent any accidental introduction of hazardous materials into the river channel. Equipment was parked on predetermined locations on high ground overnight. Upstream gages were monitored in the days prior to and during operation in the channel, and equipment was removed from the channel when high storm surges were detected at the upstream gages. No effects on silvery minnow resulted from contamination related to equipment fueling and leakage or accidental spills.

It was considered that disturbance of contaminated sediments could occur when equipment was crossing wetted portions of the NDC and SDC subreaches during access. As a result, the shortest possible path was taken when crossing the wetted portion of the channels, crossing was avoided during high flows, and silt fences were installed to prevent the downstream dispersal of disturbed sediments and allow sediments to resettle before they were removed. This was done to avoid any unintended water quality effects. In addition, water quality parameters, including DO were monitored before the silt fences were installed and equipment crossed the diversion channel. The silt fencing was removed only after the water quality returned to within 10 percent of original levels. Because direct access into the channel was off of dry banks near, but not within the diversion channels, transfer of any contaminated sediments on the equipment tracks was minimized.

Some disturbance of the subsurface sediments in the river channel occurred as the equipment traveled to the islands. The temporary suspension of sediments by amphibious caterpillars at operational flows (less 1,000 cfs) was less than normal suspended sediment levels at higher flows (3,000+ cfs). When moving in shallow water, there was some disturbance of the water-sediment interface with low impact to the interface. When traveling in deep water, the equipment floated and used a boom with an attached bucket to propel itself forward. Some sediment was moved when the edge of the bucket secured itself, and the boom used this leverage to pull the machine forward. The bucket of the amphibious excavator is about 4 feet wide, and some disturbances increased local turbidity within the water column in deep water. The suspended sediments settled quickly at projected flows. Water quality was monitored before, during, and after equipment operation in the channel. The dispersed effects of and limited increase in turbidity were negligible and did not affect silvery minnow because they can move to avoid short-term water quality effects.

Prior to any modification, turbidity and other water quality parameters were measured in areas adjacent to the treatment area where new habitats were being created with sediments. Effects to turbidity were monitored at both locations. No effects to silvery minnow were anticipated.

The risk of harm or harassment to silvery minnow in the immediate area during construction due to heavy equipment moving and working near silvery minnow was present. Silvery minnow were identified in the project area in fairly high numbers. Although silvery minnow present near the work area were able to move freely in the water column to avoid direct contact, there was uncertainty regarding silvery minnow behavior in the presence of heavy equipment operating in the channel.

5.2. Southwestern Willow Flycatcher (*Empidonax traillii extimus*)

5.2.1. Direct Effects

Short-term potential effects on flycatcher during construction were related to temporary noise issues and timing in relation to the nesting season. Project construction took place outside of the breeding season for flycatcher and had no direct effect on the species' nesting activities. Portions of the project were within proposed critical habitat for flycatcher. To minimize impacts to this and other riparian species, clearing and grubbing of woody vegetation only took place between August 15 and April 15.

5.2.2. Indirect Effects

Indirect effects to flycatcher occurred from removing potentially suitable migratory habitat outside of flycatcher critical habitat. In the MRG, flycatcher are known to form territories and nest in very dense riparian vegetation ranging in height from about 12 feet to 29 feet, according to Moore and Ahlers (2004). These habitats are most frequently dominated by willow, but may also contain cottonwood, Russian olive (*Elaeagnus angustifolia*), or salt cedar (*Tamarix* spp.). The primary habitat requirement is for very dense twig structure at the 12 foot to 29 foot height, plus proximity to water. Critical habitat for the flycatcher has been proposed (FR 2004) that includes the I-40 to Central and SDC subreaches. Removing suitable habitat with the preferred height, density, and species composition in these subreaches would decrease opportunities for breeding.

To determine if vegetation proposed for disturbance constituted suitable habitat for flycatcher, a vegetation survey was conducted in July 2005. Vegetation was surveyed at each individual restoration site and quantified and described using a modified Hink and Ohmart classification system that has been used in earlier vegetation studies of the MRG (Hink and Ohmart 1984). Summary data of the baseline vegetation that was disturbed by the HR project appear in Table 3.

A careful review of the vegetation on each of the HR sites indicates that some vegetation occurs with Hink and Ohmart structural Type 3, which may have had the height and structure used by the flycatcher. However, the survey found these habitats to have lower density, which might be characteristic of flycatcher habitats. Removal of these habitats is temporary. Revegetation with native willow has been implemented for some island areas to supplement the natural regeneration process. Vegetation has and will be monitored as it re-establishes in the disturbed island and bar restoration areas. Dynamic succession characterizes riparian bar and island habitats, and because the HR will bring the island and bar ground levels closer to groundwater, the future potential for these areas will be improved for dense stands of native trees to develop, providing better support for flycatcher in the future. However, short-term loss of suitable flycatcher habitat has resulted from the project.

Table 3. Preconstruction Existing Vegetation Structure and Composition in Project Area, by Subreach and Restoration Site prior to modification (summer 2005)1

Subreach and Site	Hink & Ohmart Structural Type	Vegetation Composition	USFWS Resource Category	Acres
NDC Island 4	Marsh	Monotypic cattail	1	<.05
NDC Island 5	Marsh	Monotypic cattail	1	<.05
NDC Bank 1	4	Intermediate cottonwood	2	0.05
NDC Ephemeral Channel 1	4	Intermediate cottonwood	2	0.15
NDC Ephemeral Channel 2	5	5–15 ft Coyote willow	2	0.20
NDC Island 2	5	5–15 ft Coyote willow	2	0.60
NDC Ephemeral Channel 3	5	5–15 ft Coyote willow	2	0.10
NDC Island 3	5	5–15 ft Coyote willow	2	4.20
NDC Island 4	5	5–15 ft Coyote willow and young Russian olive	2	0.10
NDC Island 5	3	Intermediate Russian olive overstory with coyote willow and young cottonwood understory	2	1.90
NDC Ephemeral Channel 3	5	5–15 ft Young Russian olive, coyote willow, and salt cedar	3	0.05
NDC Island 3	5	5–15 ft Young Russian olive, coyote willow, and salt cedar	3	3.20
TOTAL NDC VEGETATION DISTURBANCE				**10.65 Acres**
I-40 Island 3	Marsh	Monotypic cattail	1	<0.05
I-40 Bank 1	5	5–15 ft Coyote willow	2	0.40
I-40 Ephemeral channel 1	5	5–15 ft Coyote willow	2	0.10
I-40 Island 1	5	5–15 ft Coyote willow	2	0.45
I-40 Ephemeral channel 2	5	5–15 ft Coyote willow	2	0.05
I-40 Ephemeral channel 2	3	Intermediate Cottonwood overstory with coyote willow understory	2	0.10
I-40 Island 1	5	5–15 ft Coyote willow and salt cedar	3	1.10
I-40 Island 3	5	5–15 ft Coyote willow and Russian olive	3	2.20
I-40 Island 4	5	5–15 ft Young Russian olive and coyote willow	3	0.45
I-40 Ephemeral channel 1	6	Herbaceous	4	0.40

[1] Suitable flycatcher habitat is indicated by structural type 3 -1

Table 3. Preconstruction Existing Vegetation Structure and Composition in Project Area, by Subreach and Restoration Site prior to modification (summer 2005), continued

Subreach and Site	Hink & Ohmart Structural Type	Vegetation Composition	USFWS Resource Category	Acres
I-40 Ephemeral channel 2	6	Herbaceous	4	0.05
I-40 Bank 2	6	Herbaceous	4	0.25
I-40 Bank 3	6	Herbaceous	4	0.25
TOTAL I-40-CENTRAL VEGETATION DISTURBANCE				**5.85 Acres**
SDC Ephemeral Channel 1	3	Intermediate cottonwood overstory with Russian olive understory	2	0.25
SDC Ephemeral Channel 2	5	5–15 ft Coyote willow	2	0.10
SDC Ephemeral Channel 2	3	Intermediate Russian olive overstory with coyote willow, salt cedar, and young cottonwood understory	2	0.05
SDC Bank 4	5	5–15 ft Coyote willow	2	1.20
SDC Ephemeral Channel 1	3	Intermediate Russian olive and salt cedar overstory with coyote willow understory	3	0.05
SDC Bank 2	3	Intermediate Russian olive and salt cedar overstory with coyote willow understory	3	0.15
SDC Island 2	5	5–15 ft Young Russian olive	3	0.90
SDC Bank 3	3	Intermediate Russian olive overstory with Russian olive, mulberry, and salt cedar understory	3	0.35
SDC Island 3	5	5–15 ft Young Russian olive	3	0.30
SDC Island 4	3	Intermediate Russian olive overstory with coyote willow understory	3	1.7
SDC Island 4	5	5–15 ft Coyote willow and Russian olive	3	.73
SDC Ephemeral Channel 1	6	Herbaceous	4	0.05
SDC Ephemeral Channel 1	6	Coyote willow	4	0.05
SDC Bank 2	6	Herbaceous	4	0.15
Total SDC Vegetation Disturbance				**6.03 Acres**
Total Vegetation Disturbance, All Subreaches				**22.53 Acres**

5.3. Bald Eagle (*Haliaeetus leucocephalus*)

The HR project had only short-term and indirect effects on the bald eagle during construction, related to temporary noise issues and other disruptions. The project did not include removing any large trees or snags that could provide suitable bald eagle habitat. No long-term effects on bald eagle populations or habitat resulted from the project.

6.0 2006 CONSTRUCTION MONITORING

Detailed construction monitoring reports for each of the three subreaches are located in Appendix C1-C3. These reports include information and descriptions regarding the time period of work, details of work completed at each location, access and staging areas, and photos of each site. Monitoring for water quality constituents, discharge, and biology are summarized in the document. Water quality constituents measured during construction activities were water temperature, turbidity, pH, salinity, DO, DO by percent saturation, and specific conductivity. Discharge was recorded from upstream U.S. Geological Survey (USGS) gages. Biological commitments included monitoring for bald eagles, silvery minnow, and flycatcher.

7.0 2006 POST-CONSTRUCTION MONITORING

7.1. Fisheries Monitoring

The egg and larval fish monitoring project conducted during the spring of 2006 following construction activities was a joint project between the NMISC and Reclamation. All sites were constructed embayments created during HR projects. Sites were selected at four locations within the Albuquerque Reach (Alameda, Montaño, I-40, and SDC) and at one location in the Isleta Reach (Los Lunas). The NMISC sites discussed in this report are Alameda and the SDC; both contain embayments constructed by the NMISC.

Methods used were those set forth by Mickey Porter of Reclamation (personal communication 2006). Ideal sites had low-current or no-current velocity and depths between 0.2 m and 0.3 m. Two rectangular hoop nets (0.5 m by 0.5 m, 6.4-mm mesh size) were placed side by side, and a nylon mesh bag of timothy hay was placed in the cod end of one of the two hoop nets (experimental), while the other net did not contain hay (control). Both were securely attached to the substrate. Two square quadrats (0.5 m by 0.5 m) fitted with 1-mm mesh were placed under the rear section of each hoop net. At each of the sites were two pairs of hoop nets, a total of four experimental and four controls.

Sites were visited daily between May 9, 2006 and May 27, 2006. Water quality data (DO, temperature, conductivity, specific conductance, and salinity) were recorded before water at the site was disturbed. Hoop nets were carefully untied and moved aside so that the quadrats underneath could be inspected for silvery minnow eggs. Hoop nets were then inspected for the presence of fish. If fish were present, they were identified, counted, and released with the presence of gravid silvery minnow females noted. Hoop nets were reset, and quadrats were replaced underneath. Water depth and current velocity were recorded for each hoop net. Unknown fish, major changes in water level, and anything else of note was logged and photographed if appropriate.

Over the 18-day sample period, 77 silvery minnow were collected from the constructed embayments at Alameda and the SDC; only 1 silvery minnow was a gravid female, and no silvery minnow eggs were collected at either site. In all, 259 total larvae (species undetermined) were collected at both sites. A summary table (Table 4) is provided below. Appendix D contains the complete report with results of both Reclamation and NMISC sites.

Additional fisheries monitoring (egg, larval, or adult) was not conducted due to the low flows in 2006 during runoff. More detailed fisheries monitoring will be conducted starting in 2007.

Table 4. Summary of Fish and Egg Findings in Hoop Nets and Quadrats during 2006 Nursery Habitat Study

Site	Type	Silvery Minnow Adults	Gravid Silvery Minnow	Other Fish	Silvery Minnow Eggs	Larvae
NDC Alameda	Experimental	49	1	177	0	59
	Control	17	0	130	0	118
SDC	Experimental	10	0	144	0	21
	Control	1	0	96	0	61

Table 5. Average Water Quality and Flow Conditions for Both Main Channel and Hoop Net Sites during 2006 Nursery Habitat Study

Site	Type	Temp (°C)	Dissolved O_2 (mg/L)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	Salinity (ppt)	Water Depth (m)	Water Velocity (m/s)
NDC Alameda	Experimental	21.6	7.85	308.4	329.2	0.2	0.36	0.01
	Control	21.6	7.77	308.5	329.4	0.2	0.33	0.01
	Main Channel	21.1	7.55	296.9	319.5	0.2	0.66	0.86
SDC	Experimental	20.9	7.21	303.0	333.9	0.2	0.32	0.05
	Control	20.9	7.20	302.9	333.9	0.2	0.29	0.04
	Main Channel	20.5	7.67	308.5	337.2	0.2	0.65	0.69

7.2. Hydrologic and Geomorphic Monitoring

The construction of Phase I restoration concluded in spring 2006, ahead of the anticipated spring runoff. Typically, runoff commences in the beginning of April when the mountain snow begins to melt and lasts through July (Figure 7). The winter of 2005/2006 was especially dry in the Rio Grande basin. In March, the snow pack was less than 50 percent of the average, so runoff was below recorded average. The late summer and fall monsoon season was quite active as evidenced by the 2006 daily flow hydrograph (Figure 8). Examining the 15-minute data shows that flows at the Albuquerque gage reached 2,000 cfs 8 times between mid-June and mid-October with a peak of 4,027 cfs (Figure 9). These events were very short in duration, lasting less than 10 hours on only 3 occasions. These are still short in duration compared to an average year where flow is greater than 2,500 cfs for approximately 55 days. The ability of these moderately large, short duration flows to alter channel geometry is significantly less than that of a sustained runoff event leading to minimal to moderate changes to the restored features.

Topographic surveys were conducted twice prior to post-construction monitoring. Initial surveys were conducted prior to 2006 construction and at the end of construction (As-builts). A post-construction survey was conducted during the fall of 2006, following the late summer and fall monsoon season. The synopsis below briefly describes changes between these survey periods. Detailed maps showing erosive and depositional results for each site surveyed is available in Appendix E. Additional surveys will be conducted at least once a year following runoff.

7.2.1. Survey Results at the NDC Subreach

NDC 1b & 1ch

A channel was cut down the middle of the bar with a scallop at the upstream end. The spoil was deposited primarily between the river and the cut channel with an additional pile to the south of the scallop feature. Since construction, this feature has experienced widespread deposition of less than 0.5 foot. Some erosion of the spoil piles occurred along with some erosion of the main channel bank.

NDC 2i

The upstream third of this island was lowered approximately 0.5 foot to the 2,000 cfs inundation level. Since construction, a very small amount of deposition has occurred over much of the modified areas. The island has not yet been destabilized as intended.

NDC 4i

The upstream half of this island was to be lowered to the 2,000 cfs inundation level. Comparison of the original and very sparse, as-built data showed no appreciable modification to the elevation to the island was made, but during the monitoring survey it was clear that the area was grubbed during construction. A very small amount of deposition has occurred over much of the modification area.

NDC CI

This island has experienced pockets of erosion and deposition but has had no net change between the 2005 and 2006 surveys.

7.2.2. Survey Results at the I-40 Subreach

I-40

Islands within the I-40 reach were not monitored during this phase due to lack of funding. Based on the data collected in the NDC and SDC subreaches, it is likely that HR features in the I-40 subreach underwent similar morphological changes following late summer and early fall precipitation events. Select treatments in the I-40 subreach will be monitored for changes in morphology if future funding is secured.

7.2.3. Survey Results at the South Diversion Channel Subreach

SDC 1b

The outside 15 feet of the bar was lowered to the 2,000 cfs inundation level, and the spoil was simply piled adjacent to the lowered area. The summer flows resulted in minor deposition over the upstream portion of the feature and bank erosion along the downstream half.

SDC 2i

The upstream third of this island was lowered by between 1 foot and 2 feet to achieve inundation at 2,000 cfs, and the spoil was placed immediately downstream of the cut area. Since construction, the modified area has experienced widespread deposition of less than 0.5 foot. There was also deposition on the east side of the spoil pile and bank erosion along the west side of the island. The treatment has not yet caused destabilization of this island as intended.

SDC 3i

The middle third of this island was cut by approximately 1 foot to achieve inundation at 2,000 cfs, and the spoil was placed immediately downstream. The summer flows have not caused any appreciable erosion or deposition. The treatment has not yet caused destabilization of this island as intended.

SDC 4i

The upstream half of this island was modified with approximately 2 feet of cut at the upstream end tapering to very little cut toward the middle, creating terraces corresponding to levels of inundation corresponding to flows of 1,500 cfs; 2,500 cfs; and 3,500 cfs. Since construction, there has been deposition up to 1 foot.

SDC CI

The island has not had much appreciable change since the original 2005 survey. However, the lower elevation areas adjacent to the island that are void of vegetation showed some major changes. There was more than 2 feet of scour over a large area north of the control island; it appears the low-flow channel has shifted and eroded some barren bar features. Also, moderate deposition occurred between the control island and SDC 2i.

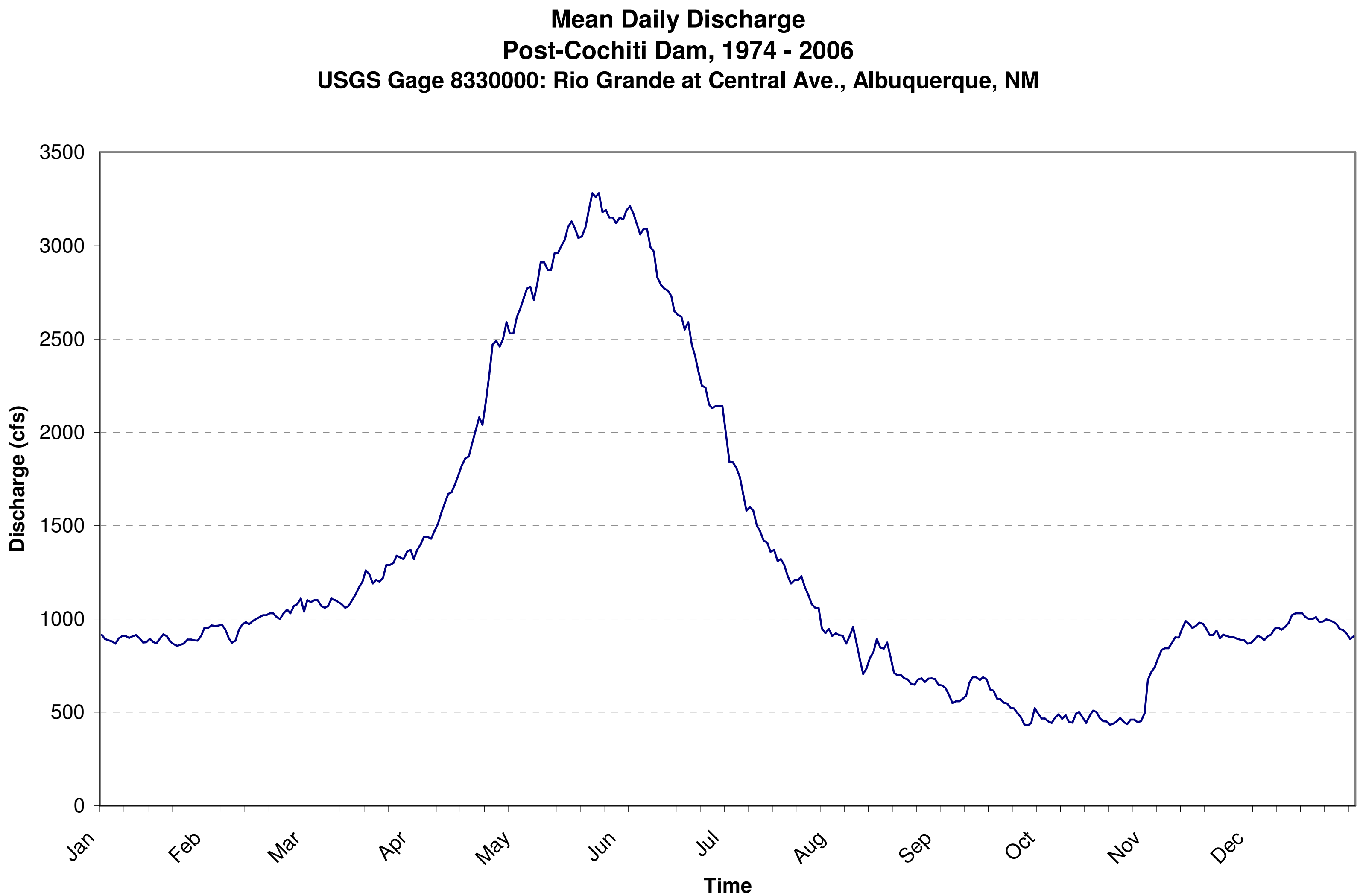

Figure 7. Mean Daily Discharge at Albuquerque Gage, 1974-2006.

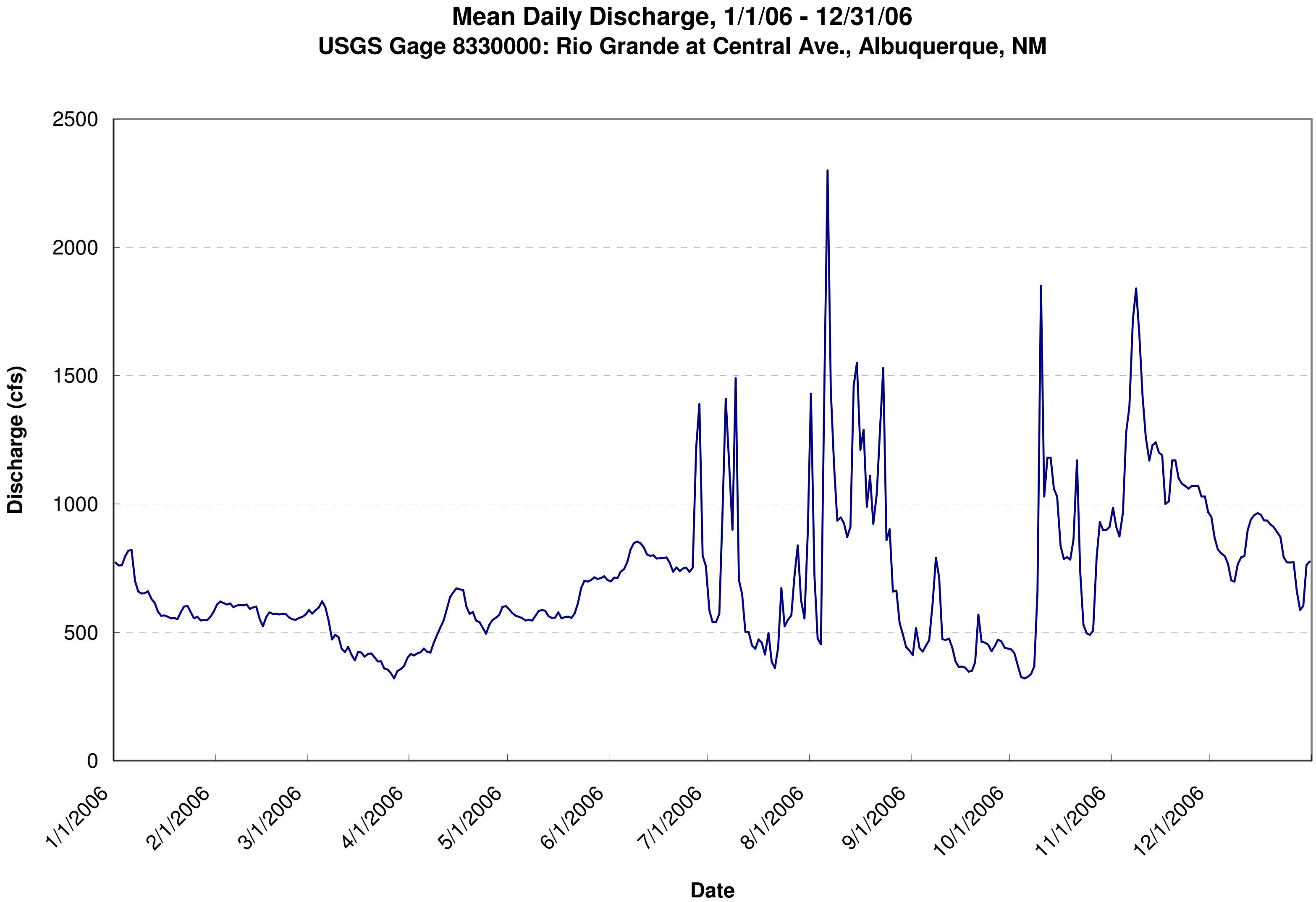

Figure 8. 2006 Hydrograph at Albuquerque Gage.

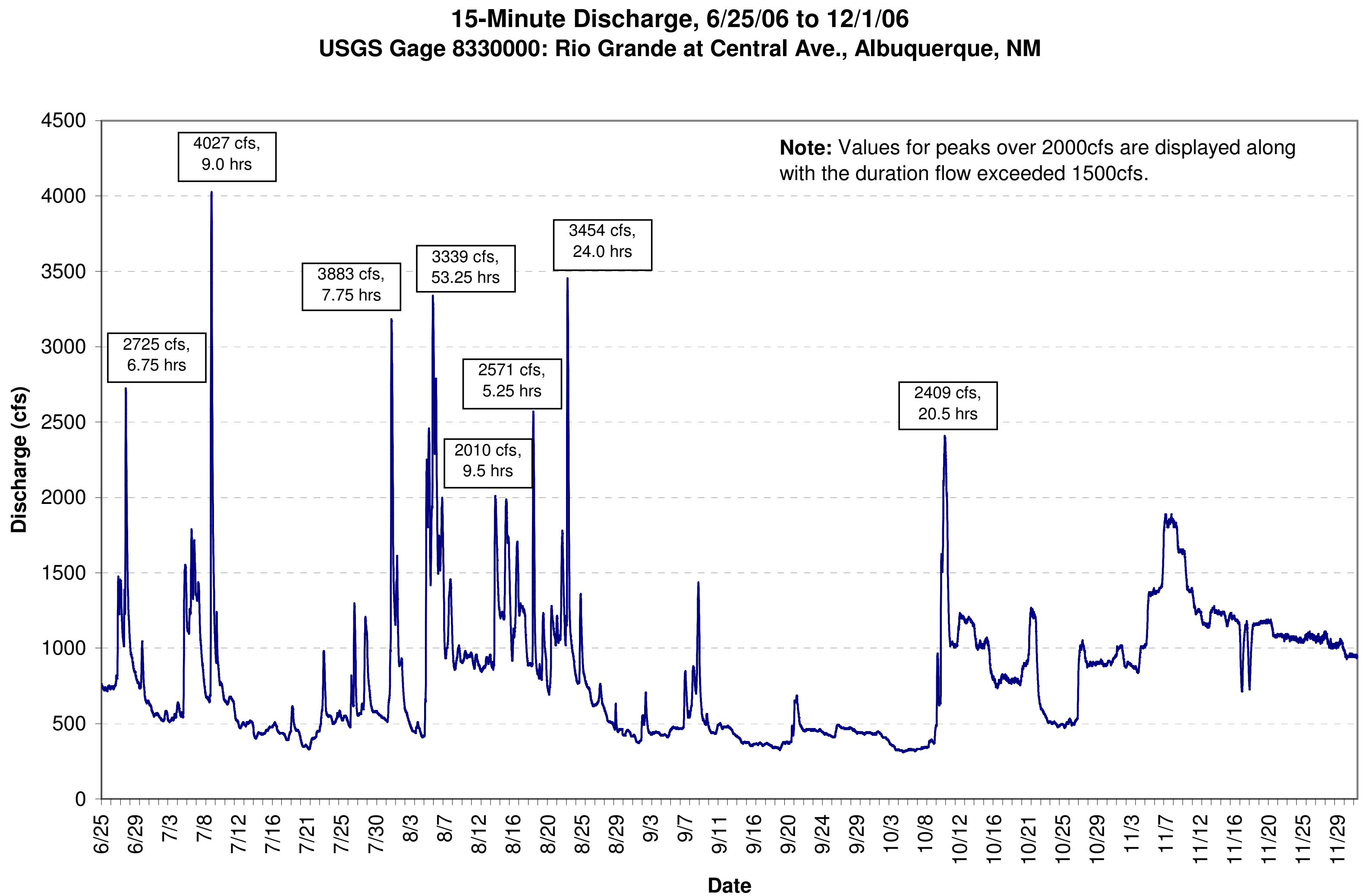

Figure 9. 15-minute Discharge at Albuquerque Gage, 06/25/2006-12/01/2006.

7.3. Vegetation Monitoring

Vegetation monitoring was conducted prior to 2006 construction activities. This information was provided in the 2005 BA, and subsequential BiOp, that was prepared in support of the environmental assessment for this project (USFWS 2005). The survey was conducted in the summer of 2005. The survey area included not only the treatment sites but the entire subreach where work was to occur. Post-construction vegetation monitoring occurred during the late summer/early fall of 2006. Future monitoring will be conducted at least once a year, depending on available funding.

7.3.1. Methods

The Hink and Ohmart (1984) classification system was used to determine riparian vegetation structure along the MRG. This method includes walking random transect through the site using a line intercept method. At regular intervals, the following variables were recorded:

- Percentage of herbaceous species;
- Percentage of species in height class 1, 2, 3, 4, 5 and 6;
- Percentage of canopy cover in each height class;
- Percentage of each species in each height class; and
- Most dominate species in each height class.

Table 6 shows vegetation structure in 2005 and can be compared to Table 7, which shows vegetation structure in 2006. By comparing this information, short-term restoration effects can begin to be determined.

7.3.2. Results

Vegetation monitoring shows a steep decline in structural classes containing non-native species, such as Russian olive and salt cedar (Figure 10 and Figure 11). The 2005 vegetation structural classification (Table 6) data clearly shows a dominate Russian olive, salt cedar overstory 5 feet to 15 feet in over 80 percent of the Project Area and several structural class 3 habitats dominated by Russian olive and salt cedar. In contrast, the 2006 data (Table 7) shows no Russian olive or salt cedar overstory for structural type 3 in any of the project areas and a significant reduction in salt cedar and Russian olive in structural class 5. Where salt cedar covered 52 percent of the Project Area in 2005, in 2006 it was reduced to 6 percent of the Project Area. In 2006, Russian olive exists within 70 percent of the Project Area; whereas, in 2005 it could be found in 87 percent of the Project Area. Figure 12 is an example of the field data sheet.

Table 6. Hink & Ohmart Vegetation Structure Monitoring 2005

Site Name	Hink & Ohmart Structural Types	Vegetation Composition Hink & Ohmart 2005	Acres
I -40			
I-40_1b	5	Coyote Willow	0.41
I-40_1ch	6/5	Herbaceous under 5 feet , Coyote Willow 5-15 ft	0.47
I-40_2i	5	Coyote Willow-Salt Cedar 5-15 ft	1.08
I-40_3b	6	Herbaceous	0.26
I-40_4i	5	Russian Olive-Coyote Willow 5-15 ft	0.43
TOTAL I-40-CENTRAL VEGETATION DISTURBANCE			**2.65**
Northern Diversion Channel			
NDC_1b	4	Intermediate Cottonwood	0.06
NDC_1ch	6/ 4	0-5 ft Coyote Willow/ intermediate Cottonwood	0.21
NDC_2ch	5	5-15 ft Coyote Willow	0.18
NDC_2i	5	5-15 ft Coyote Willow	0.58
NDC_3ch	5	5-15 ft Salt Cedar/Russian Olive/Coyote Willow	0.16
NDC_3i	5	5-15 ft Salt Cedar/Russian Olive/Coyote Willow	7.40
NDC_4i	5	5-15 ft Coyote Willow-Russian Olive	0.07
NDC_5i	3	Intermediate Cottonwood & Russian Olive overstory with coyote willow understory	1.90
TOTAL NDC VEGETATION DISTURBANCE			**10.56**
SDC			
SDC_1b	6/3	Intermediate Cottonwood & Russian Olive overstory coyote willow understory Intermediate Russian Olive-Salt Cedar overstory with Coyote Willow 0-5 ft Herbaceous growth	0.35
SDC_2i	5	5-15 ft Russian Olive	0.89
SDC_2b	6	Herbaceous	0.13
SDC_3i	5	5-15 ft Russian Olive	0.27
SDC_3b	3	Intermediate Russian Olive-Mulberry-Salt Cedar	0.34
SDC_4i	3	Intermediate Russian Olive/Coyote Willow	2.77
TOTAL SDC VEGETATION DISTURBANCE			**4.75**
TOTAL VEGETATION DISTURBANCE, ALL SUBREACHES			**17.96**

Table 7. Hink & Ohmart Vegetation Structure Monitoring 2006

Site Name	Hink & Ohmart Structural Types	Vegetation Composition Hink & Ohmart 2006	Acres
I -40			
I-40_1b	6	Herbaceous	0.41
I-40_1ch	6	Herbaceous	0.47
I-40_2i	5	5-15 ft Coyote Willow-Salt Cedar	1.08
I-40_3b	6	Herbaceous	0.26
I-40_4i	5	5-15 ft Coyote Willow	0.43
TOTAL I-40-CENTRAL VEGETATION DISTURBANCE			**2.65**
Northern Diversion Channel			
NDC_1b	6	0-5 Cottonwood/Coyote Willow	0.06
NDC_1ch	6	0-5 Cottonwood/Coyote Willow	0.21
NDC_2ch	5	5-15 ft Russian Olive/Coyote Willow	0.18
NDC_2i	5	5-15 ft Coyote Willow	0.58
NDC_3ch	5	5-15 ft Russian Olive/CW	0.16
NDC_3i	5	5-15 ft Coyote Willow-Cottonwood-Russian Olive	7.40
NDC_4i	5	5-15 ft Coyote Willow	0.07
NDC_5i	5	5-15 ft Coyote Willow	1.90
TOTAL NDC VEGETATION DISTURBANCE			**10.56**
SDC			
SDC_1b	6	Herbaceous	0.35
SDC_2i	5	5-15 ft Coyote Willow-Russian Olive	0.89
SDC_2b	5	5-15 ft Coyote Willow	0.13
SDC_3i	5	5-15 ft Coyote Willow	0.27
SDC_3b	5	5-15 ft Coyote Willow	0.34
SDC_4i	5	5-15 ft Coyote Willow-Russian Olive	2.77
TOTAL SDC VEGETATION DISTURBANCE			**4.75**
TOTAL VEGETATION DISTURBANCE, ALL SUBREACHES			**17.96**

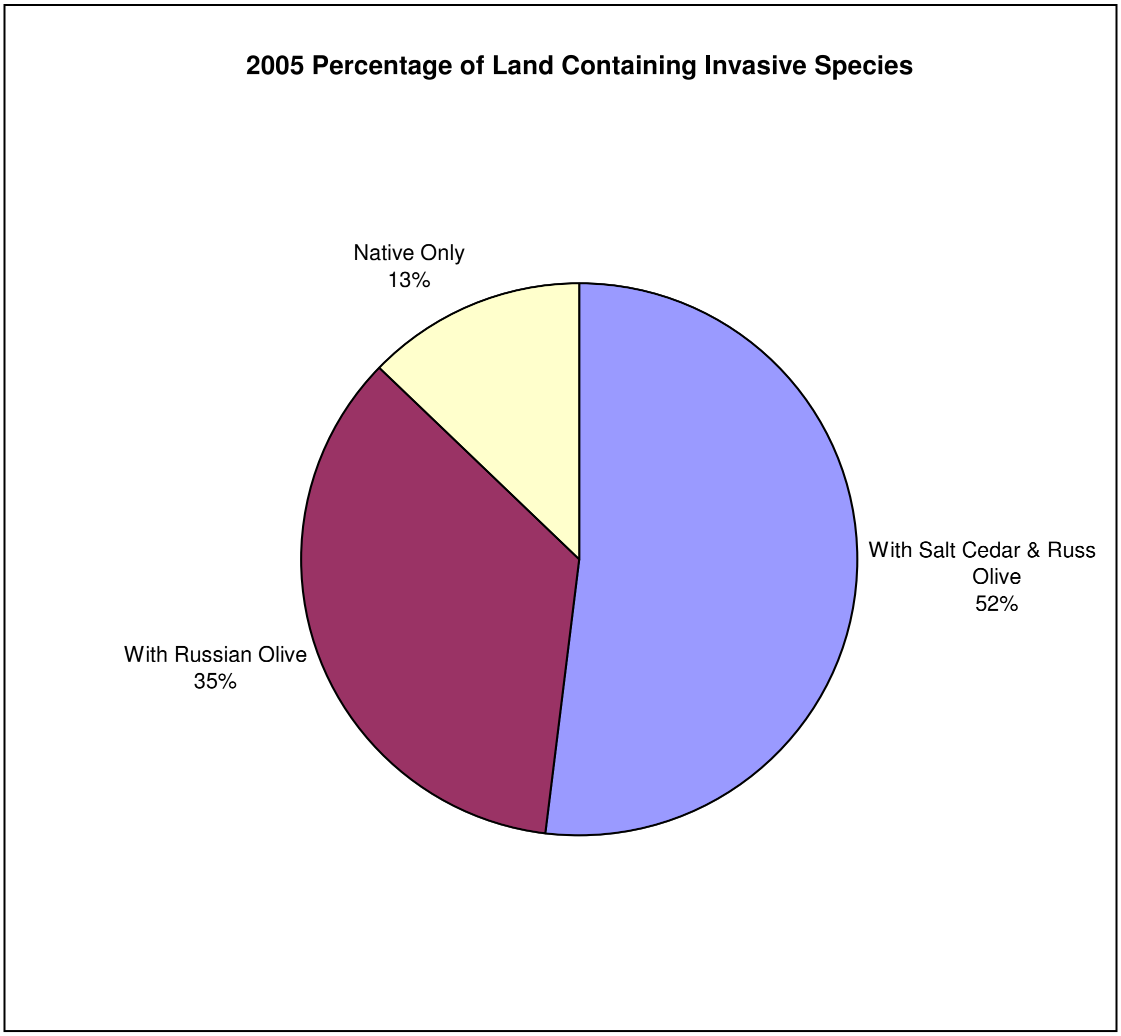

Figure 10 Percentage of native species vs. the percentage of non-native species within preconstruction restoration sites, 2005.

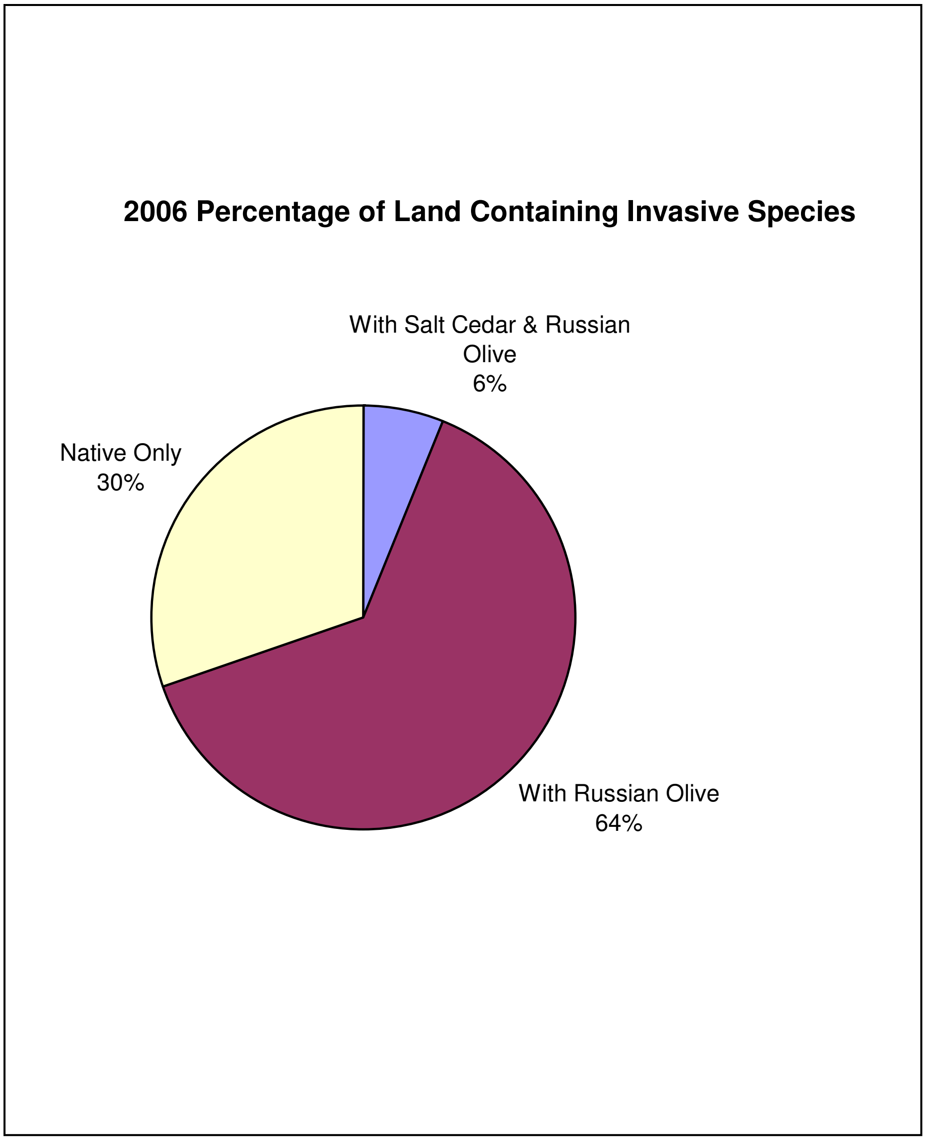

Figure 11. Percentage of native species vs. non-native species in post construction restoration sites, 2006.

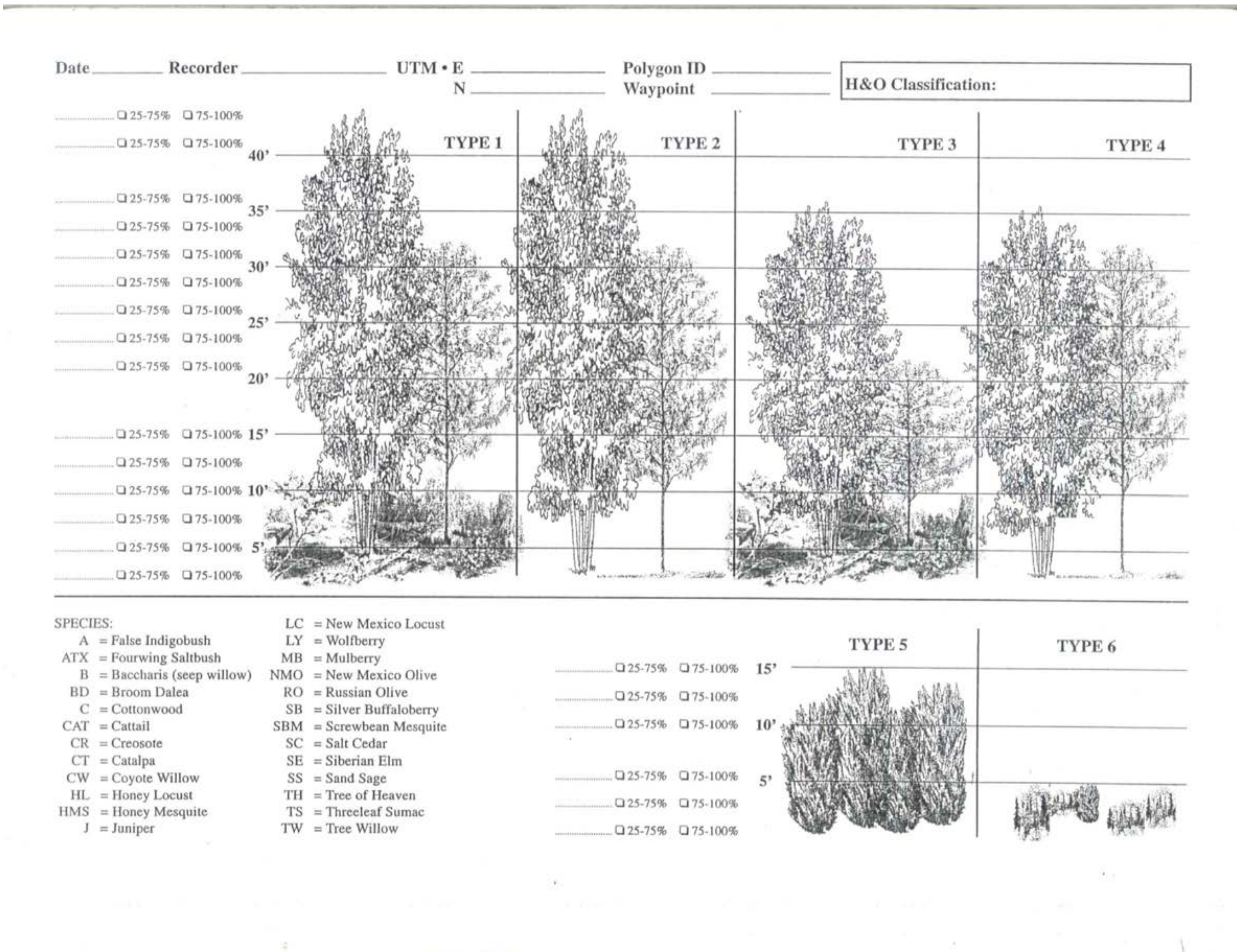

Figure 12. Hink and Ohmart vegetation structure classification.

8.0 CONCLUSION

8.1. Construction Activities

There were no direct effects to silvery minnow, flycatcher, or bald eagle during modification of the three subreaches. There were, however, indirect effects to the silvery minnow and flycatcher. Bald eagle were observed in the vicinity of construction activities, but none were present in the morning before construction began. They were, therefore, not displaced or harassed as a result of construction activities. Likewise, silvery minnow were not directly affected by construction activities, but three silvery minnow were found dead in semi-frozen water near the embayment of NDC-5i, and four other silvery minnow were found stressed but did not die. No flycatcher were observed during construction. Structural type 3 willow, salt cedar, and Russian olive stands were removed from the Project Area, and the flycatcher could have been indirectly affected due to loss of migratory sites.

8.2. Egg and Larval

Future monitoring of constructed embayments would build upon the work completed in this study and would include more rigorous investigations and testing hypotheses. To explore these hypotheses in the future, a greater number and more densely placed array of hoop nets or another method of capture should be placed within HR sites. As HR sites mature and support native riparian emergent vegetation, the conditions that support the life histories of silvery minnow could be present, and increased use of the HR sites may occur by the fishery.

Previous studies (Porter and Massong 2004; Porter and Massong 2005; Widmer et al. 2007) have used gellan beads to simulate silvery minnow eggs to determine egg movement and settling in various mesohabitats. Using these artificial eggs would be an ideal way to determine if HR sites retain silvery minnow eggs.

8.3. Hydrology and Geomorphic Monitoring

The lack of sustained high flows during 2006 led to minimal changes of the modified features and has not significantly destabilized the islands. Localized bank erosion occurred at NDC 1ch, SDC 1b, and SDC 2i. Most of the other features experienced small amounts, generally less than 0.5 foot on average, of widespread deposition. Monitoring for destabilization, deposition, and localized bank erosion will continue in future years.

8.4. Vegetation Monitoring

Table 6 and Table 7 show that structural types 1 and 2 were not present in the modified areas and that structural types 3 and 4 have diminished. While a healthy riparian area and bosque would consist of all height classes, the tables show that the amount of non-native species has diminished in the modified areas. In order for native vegetation to be represented in multiple height classes, competition with non-native species must be mitigated. Removing salt cedar and Russian olive will allow native species to compete more successfully and grow to maturity. Modifying the in-channel islands and island bars will encourage cottonwoods and willows to access groundwater and provide them with a chance to out-compete non-native species, allowing them to dominate structural types 1, 2, and 3.

8.5. Future Monitoring

Post-construction monitoring will continue for at least two years (existing Collaborative Program funding). The NMISC has initiated fisheries-related monitoring for the spring and summer of 2007. The monitoring includes an egg drift study, presence and absence of silvery minnow eggs and gravid females, presence/absence of larval fish, and mesohabitat use by adult silvery minnow. Monitoring will occur within each subreach and attempt to capture results from different HR treatments sites. Vegetation monitoring will occur twice a year, with geomorphic monitoring on an annual basis, at minimum.

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10.0 CONTRIBUTORS

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Mike Harvey, Ph.D., P.G. – Geomorphologist

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APPENDIX A
PHOTOPOINT AND SURVEY TRANSECT MAPS

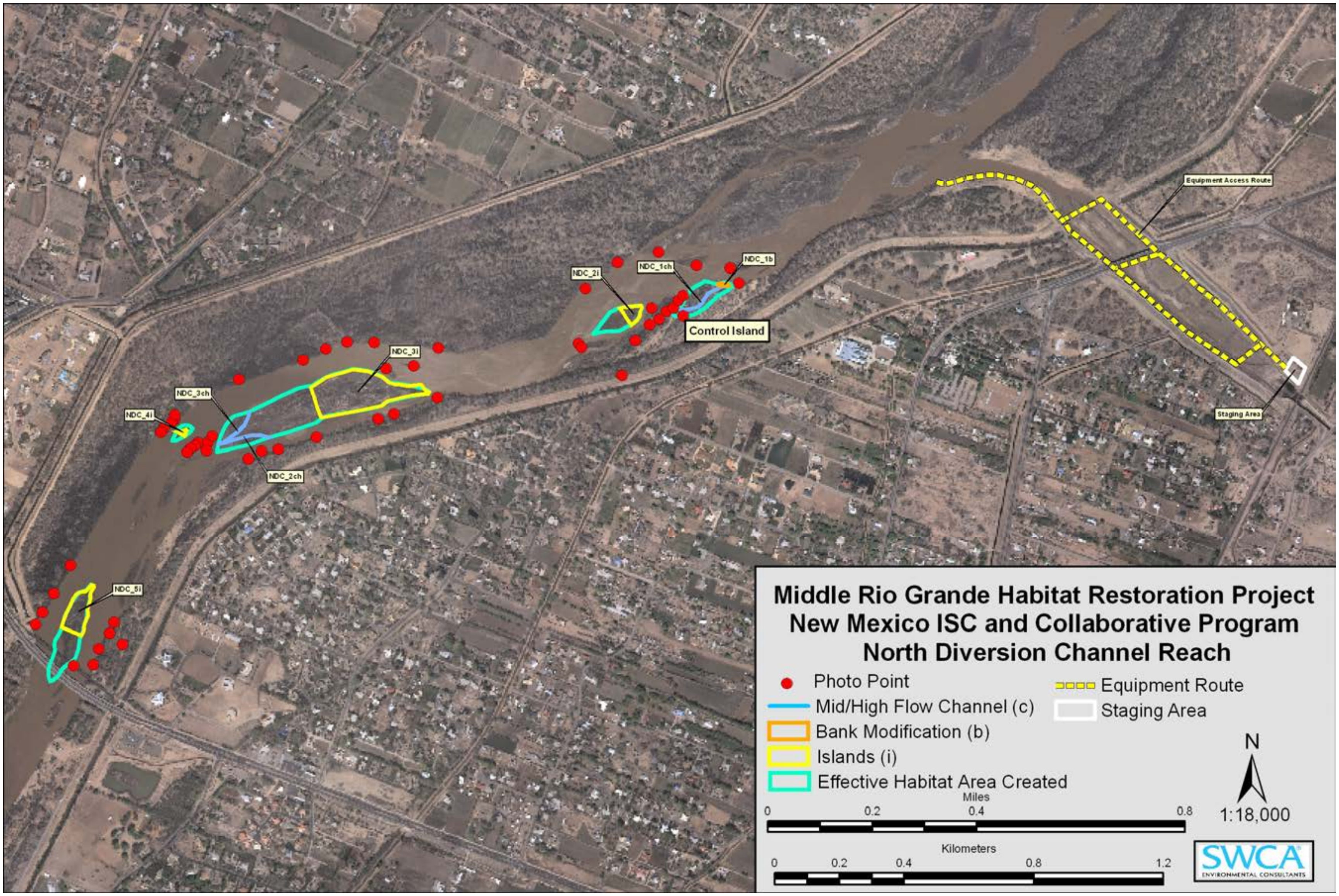

Figure 1. North Diversion Channel Subreach photo points and access locations.

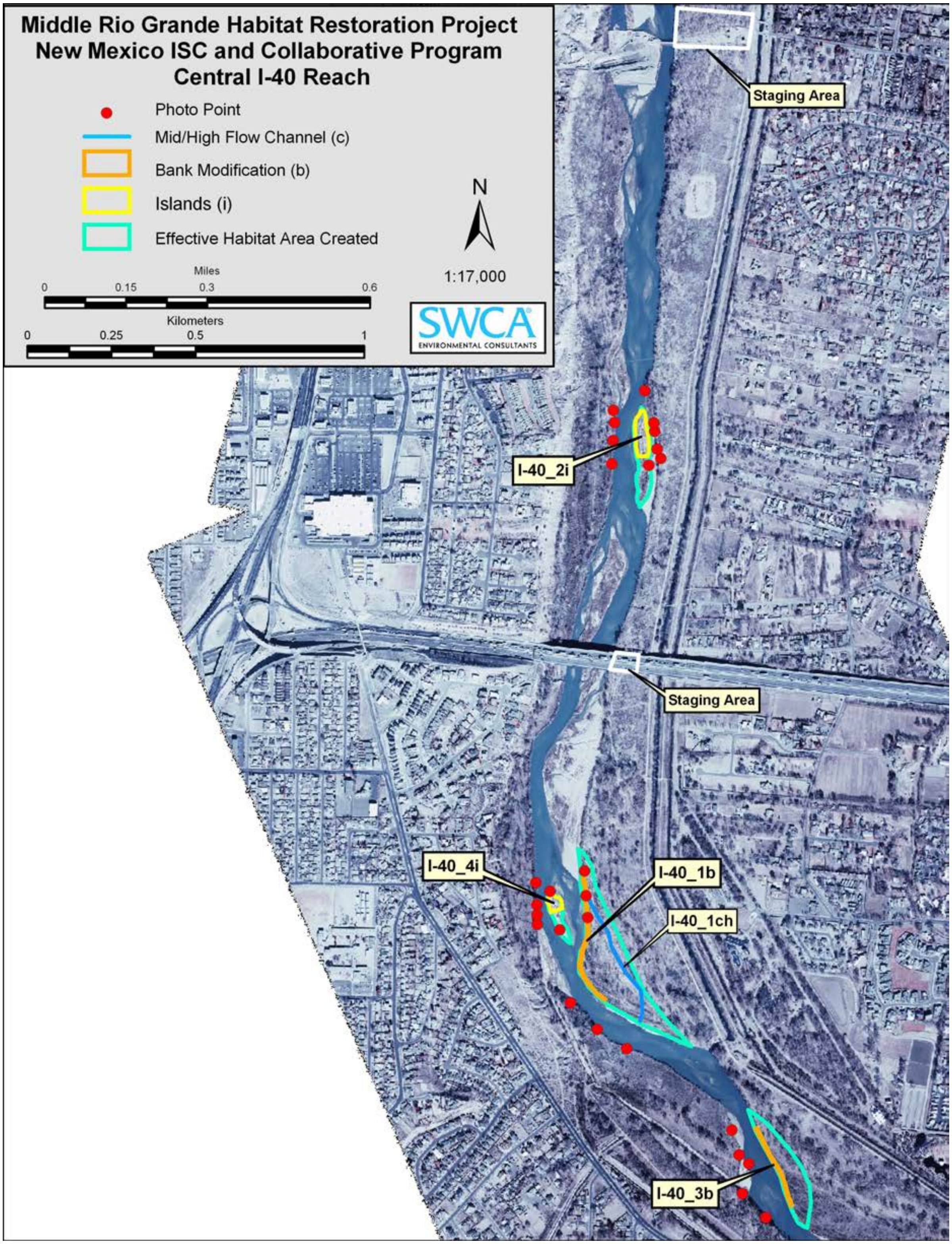

Figure 2. I-40 Subreach photo points.

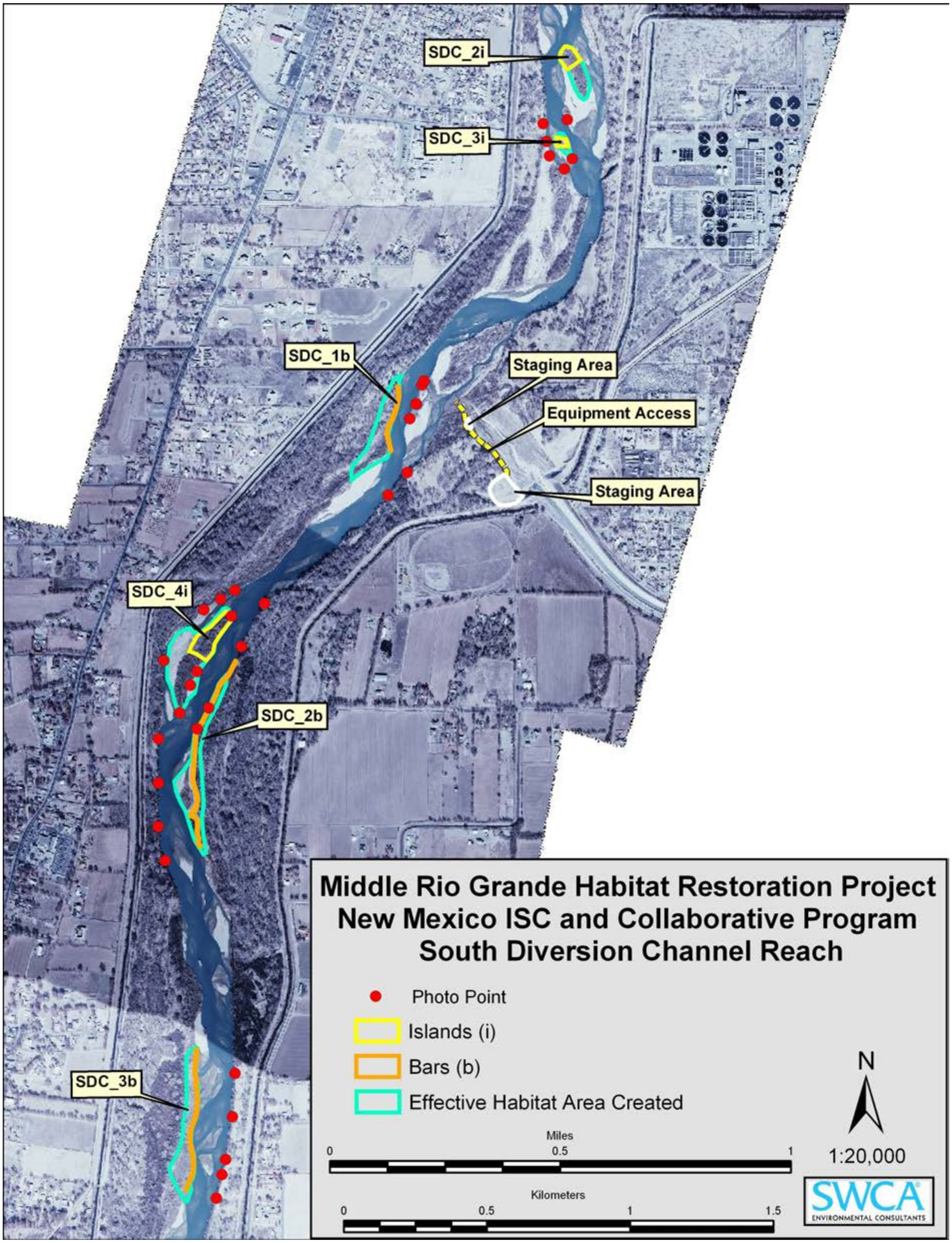

Figure 3. South Diversion Channel Subreach photo points and access locations.

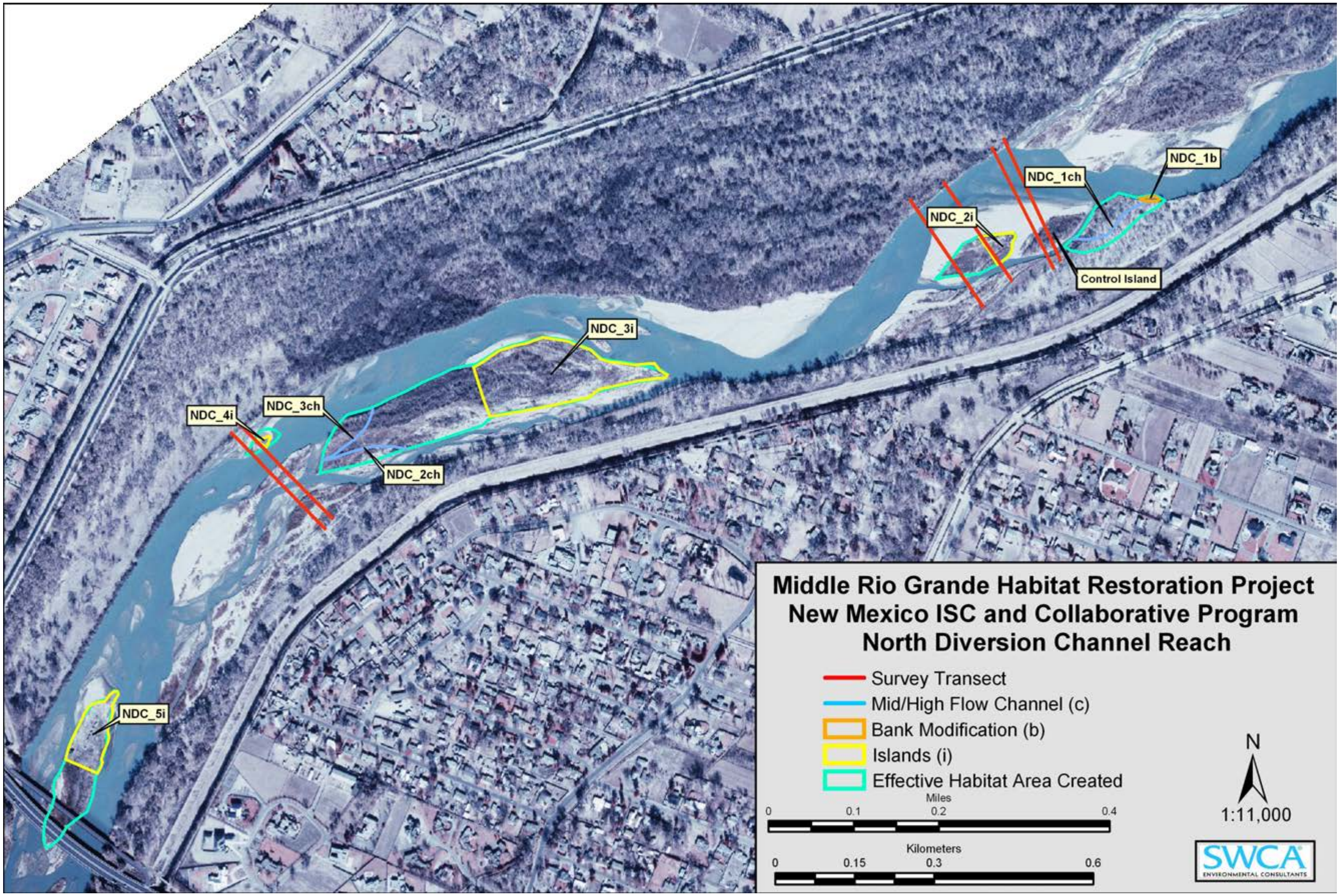

Figure 4. North Diversion Channel Subreach survey transects.

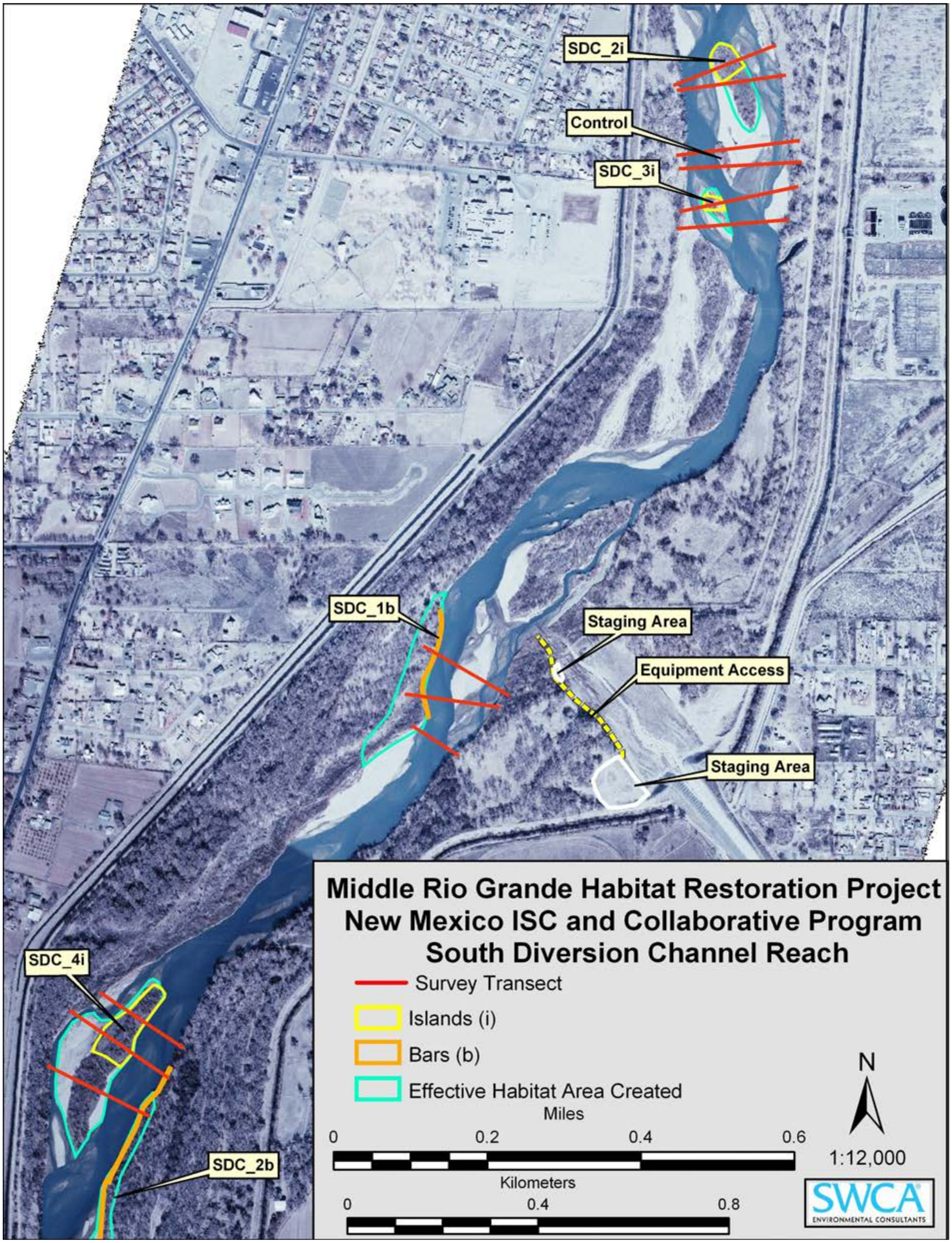

Figure 5. South Diversion Channel Subreach survey transects.

APPENDIX B
EXAMPLE PHOTOS FROM PROJECT AREA

PHOTO COMPARISONS OF SELECTED SITES

NDC-1b: Construction

The bank scallop was constructed on the east bank of the Rio Grande, northeast of NDC-2i and north of NDC-1ch. The scallop was constructed as an embayment to function at 1,000 cfs, with an outflow channel (NDC-1ch) that will be inundated and flowing at approximately 1,500 cfs (Figure 1). The channel returns to the Rio Grande downstream within a side channel near NDC-2i. Work started with the excavator moving sediment and spreading the spoil on the bank to the south and east of NDC-1ch. Downed pieces of large woody debris were tagged and placed in the river by the excavator.

Figure 1. NDC-1b prior to construction

NDC-1b: Post-Construction

The scallop (and channel inflow) had quite a bit of sediment deposition and developed a shelf along the eastern side (Figure 2). The water level has reached the top level of the scallop and the current water level (829 cfs) was approximately 6 inches below the surface level. Some herbaceous vegetation has grown within the scallop and along the waters edge (Hink and Ohmart C4). Russian thistle, *Salsola tragus*, has also grown quite extensively along the bank of the scallop.

Figure 2. NDC-1b after construction

NDC-1ch: Construction

The channel was constructed on the east bank of the Rio Grande, northeast of NDC-2i. It was constructed as an ephemeral channel, about 25 feet wide, with inundation to occur at approximately 1,500 cfs (Figure 3). After the channel was surveyed, construction work started with the excavator digging from the downstream end to the upstream end. Fill material was deposited adjacent to the created channel on the bank.

Figure 3. Outflow area of NDC-1ch prior to construction

NDC-1ch: Post-Construction

The channel has had sediment deposition mainly from the inflow of the scallop (1b) and from the eastern slope of the channel. The water level reached the top level of the channel on both sides and over-banked on parts of the eastern side. Two cottonwoods have fallen (from beaver activity) into the middle section of the channel and have caused sediment deposition to develop just downstream. Small pools have also developed in the same area. Some cottonwood and coyote willow saplings as well as herbaceous vegetation has grown within the channel and along the banks where the spoil was spread out (Hink and Ohmart C-CW6). Russian thistle has also grown quite extensively along the banks of the channel. The outflow area also has some sediment deposition and herbaceous vegetation growth just at the water's edge (Figure 4).

Figure 4. Outflow area of NDC-1ch after construction

NDC-2ch and NDC-3ch: Construction

These channels are on the downstream end of the large island, NDC-3i. They were constructed as ephemeral channels, about 25 feet wide, with inundation to occur at approximately 1,000 cfs.

Work started with the excavator constructing NDC-2ch from the upstream end to the downstream end and then constructing NDC-3ch from the downstream end (Figure 5) to the upstream end. The spoil was spread on both sides of the created secondary channels.

Figure 5. Outfall of NDC-2ch and NDC-3ch prior to construction

NDC-2ch and NDC-3ch: Post-Construction

Channel 2ch had sediment deposited at the inflow area, which caused the bank level to be higher. Although, the woody vegetation surrounding the channels remains similar to pre-construction (Hink and Ohmart RO/CW5), the vegetation within the channels is mainly coyote willow and some cottonwood saplings along the banks. A remarkable amount of 5 – 10 foot vegetation (mainly *Salix exigua* and herbaceous) is also present at the inflow of 2ch and extends downstream to approximately the convergence with 3ch. South of the convergence herbaceous vegetation has grown within the channel as well as on the banks where the spoil was spread out. Channel 2ch was inundated with at least 2 – 3 inches throughout most of the channel. The inflow for channel 3ch had also received sediment deposition increasing the bank height. However, the vegetation throughout the channel is approximately 3 ft. tall and is mainly herbaceous. Channel 3ch is also inundated throughout most of the channel, but is deeper than 2ch having up to 1 foot of water. The outflow area (Figure 7) has been blocked by sediment buildup and growing vegetation, and although mainly herbaceous, may anchor and prevent the channel from functioning properly.

Figure 6. Outfall of NDC-2ch and NDC-3ch

NDC-2i: Construction

NDC-2i is part of the island destabilization project funded by the Collaborative Program. The upper third of the island was modified (1) to create an elevation at which inundation at approximately 2,000 cfs could support various life stages of the silvery minnow and (2) to test the efficacy of destabilizing an island (Figure 7). The spoil was spread out on the southern end of the island

Figure 7. Northeast section of 2i.

NDC-2i: Post-Construction

Island 2i has a large amount of sediment deposition on the northern tip of the island where it is connected to a bar (at low flows) that borders the northeastern and western sides of the island (Figure 8). The entire project area had been inundated during high flows and only on the south central section was there water remaining in a few spots. Most of the modified area had *Salix exigua* (5 – 10 ft.) growing back along with some patches of young *Populus deltoides*, *Elaeagnus angustifolia*, and *Tamarix ramosissima*, which was primarily restricted to the northern tip of the island (Hink and Ohmart CW5).

Figure 8. Northeast section of 2i.

NDC-3i: Construction

The upstream half of the island was modified to create three terraces at different elevations at which inundation could help support various life stages of the silvery minnow (Figure 9). The terraces will be inundated at approximately 1,500, 2,500, and 3,500 cfs. The original design included construction of an embayment downstream of the silt curtain. Because there was not enough fill material to create an embayment, the material was spread across the different terraces to fill several small depressions. The extra spoil material and vegetation were used as fill for several depressions in the center of the island.

Figure 9. Northern tip of 3i prior to construction

NDC-3i: Post-Construction

Sediment deposition was extensive on the northern tip of the island as flows pushed in about 20 feet (Figure 10). High flows had sustained inundation on both outer terraces whereas the inner terrace was inundated, but had already begun to dry out in spots. There was some ponding throughout the project area with the majority in the southeast corner, which still had 2 – 3 inches of standing water. The vegetation is mostly *S. exigua* with sparse patches of young *P. deltoides*, *Elaeagnus angustifolia,* *Ulmus pumila*, and *Tamarix ramosissima* (Hink and Ohmart CW-C-RO5). Most of the vegetation is approximately 5 – 15 ft tall.

Figure 10. Northern tip of 3i after construction

NDC-4i: Construction

NDC-4i is part of the island destabilization project funded by the Middle Rio Grande Endangered Species Act Collaborative Program (Collaborative Program). The middle third of NDC-4i was modified to create an elevation at which inundation at approximately 2,000 cfs can take place to help support various life stages of the silvery minnow and to test the efficacy of destabilizing an island. The spoil material was then spread out on the island (Figure 11).

Figure 11. Eastern bank of NDC-4i prior to construction

NDC-4i: Post-Construction

This small island was inundated throughout the project area during high flows and sediment deposition was extensive on the entire island especially along the eastern and western sides of the island (bar connected to the west bank during low flows). The vegetation on this island consists primarily of 5 – 7 foot coyote willow (Hink and Ohmart CW5) with a few Russian olives, but less than 25%. On the northern section of the island, herbaceous plants such as cattails (*Typha angustifolia*) were very abundant (Figure 12).

Figure 12. Eastern bank of NDC-4i after construction

NDC-5i: Construction

The upstream half of the island was modified to create terraces at different elevations that can be inundated to help support various life stages of the Rio Grande silvery minnow (silvery minnow). The three created terraces will be inundated at approximately 1,500, 2,500, and 3,500 cubic feet per second (cfs) discharge. The embayment created downstream of the silt curtain will be inundated at low flows, to less than 500 cfs (Figure 13). Spoil material from the island was placed on the inside of the silt curtain to secure it, partitioning the river flow to the east of the silt curtain and creating an embayment.

Figure 13. NDC-5i creation of silt curtain and embayment.

NDC-5i: Post-Construction

Sediment deposition was significant on the north and eastern sides of the project area. The embayment area is almost entirely filled in and there is only a small amount of water at the southern end. Although the innermost terrace showed little signs of recent inundation (mostly dry), high flows inundated all three terraces and the outer two had sustained inundation with the lowest terrace still very saturated. The vegetation within the modified area consists primarily of 5 – 15 foot coyote willow (Hink and Ohmart CW5) with some cottonwood and Russian olive saplings, but less than 25%. The outer terrace as well as the embayment (Figure 14) area had a considerable amount of herbaceous and wetland vegetation.

Figure 14: NDC-5i embayment after construction.

APPENDIX C
SUMMARY REPORTS FOR CONSTRUCTION ACTIVITIES

Middle Rio Grande Riverine Habitat Restoration: Phase I
New Mexico Interstate Stream Commission Project RG-22

SUMMARY OF CONSTRUCTION ACTIVITIES AT THE NORTH DIVERSION CHANNEL TO ALAMEDA SUBREACH

Time period: January 11th – February 23rd. A total of thirty-five days constituted the construction work north of the Alameda Bridge to south of the North Diversion Channel (NDC).

SWCA Costs Incurred: $45,719 (46.1% of total budget)

Who worked (and in what capacity): Joseph Fluder, Burt McAlpine, Matthew McMillan, Jeannie Welch, Quinton Daigre, and Heather Timmons. Joseph Fluder is the project manager and is responsible for project oversight, document production, and data collection. Burt McAlpine is responsible for GIS maps, survey data, and downloading GPS data. Matthew McMillan is the environmental compliance monitor responsible for biological monitoring of Rio Grande silvery minnow (silvery minnow), Southwestern willow flycatcher, and bald eagles and environmental monitoring of water quality constituents. Mr. McMillan also assists the construction crew in building silt fence/silt curtains and assuring the construction crew follows techniques and guidelines outlined in numerous environmental compliance documents. Jeannie Welch is responsible for assisting the Wilco surveyor with pre-construction surveys and as-builts, and with constructing silt fence/silt curtains. Quinton Daigre is the alternate environmental compliance monitor and has the same duties as Mr. McMillan when he is not present. Heather Timmons has been a substitute for M. McMillan or for J. Welch when necessary.

NDC Subreach Habitat Restoration Sites

Staging Area: The staging area was located on the southwest side of Alameda Boulevard. The staging area was accessed via the levee road on the west side of the Rio Grande through City of Albuquerque Open Space land. The City of Albuquerque cleared a large area of the bosque for their drinking water project. The New Mexico Interstate Stream Commission used the disturbed area to minimize additional impact to the bosque. The staging area contained construction work vehicles, a container full of supplies, a fuel vehicle, and an airboat.

NDC-5i:
The upstream half of the island was modified to create terraces at different elevations to be inundated in support of various life stages of the Rio Grande silvery minnow. The three created terraces will be inundated at approximately 1500, 2500, and 3500 cubic feet per second (cfs) discharge. The embayment created downstream of the silt curtain will be inundated at low flows, including less than 500 cfs (Figure 1).

Work started on 12 January for NDC-5i in which the survey crew staked out the back-line and then constructed the silt curtain on the east side of the island. The flow of the river was focused to the east of the island, causing the silt curtain to collapse. To secure the silt curtain, spoil material from the island was placed on the inside of the silt curtain. The silt curtain process partitioned the river flow to the east of the silt current and also created an embayment.

Figure 1: NDC 5i silt curtain and embayment.

Some survey stakes could not be placed due to dense vegetation. The excavator started grubbing the vegetation and at the same time, survey stakes were being placed after clearing (Figure 2). When the grubbing concluded, the excavator started to create the terraces outlined in the survey and detailed schematics. Excess vegetation gathered during grubbing was used to support the fill area around the embayment. Much of this vegetation was invasive Russian olive or immature tamarisk. Scattered coyote willows or immature cottonwoods were left throughout the modified area.

Figure 2: NDC 5i during implementation.

During the course of work on NDC-5i, several silvery minnow were positively identified in the embayment created by the construction crew. The embayment created a slow-velocity habitat different than the relatively deep and constricted mesohabitats predominantly present on the east and west sides of the island. During a cold period in January, three silvery minnow were found dead in semi-frozen water near the embayment. Four other silvery minnows were found stressed but did not die. Two sample seine hauls were accomplished on 25 January 2006 by SWCA and the NMISC in which 56 total fish were caught and identified. Of the 56 capture fish, 52 were identified as silvery minnows and four were fathead minnows. Work concluded on 26 January.

NDC-4i:
The middle third of the island was modified to create an elevation to be inundated in support of various life stages of the silvery minnow and to test the efficacy of destabilizing an island. The modified area will be inundated at approximately 2000 cfs. NDC-4i is part of the Collaborative Program funded island destabilization project.

Work started on 27 January with the excavator grubbing the vegetation and grading the contours. The spoil material was spread out on the island (Figure 3). Surveying of the island was completed in advance of the excavator's arrival. Work concluded on 27 January.

Figure 3: NDC 4i during implementation.

NDC-3i:
The upstream half of the island was modified to create terraces at different elevations to be inundated in support of various life stages of silvery minnow. The three created terraces will be inundated at approximately 1500, 2500, and 3500 cfs. The original design included the creation of an embayment constructed downstream of the silt curtain. There was not enough fill material to create an embayment. Instead, the material was spread across the different terraces to fill several small depressions.

Work started on 30 January with the grubbing of the vegetation (Figure 4). Although the survey crew had previously staked the back-line, it was necessary to remove the excess vegetation before the rest of the island could be staked out. The excavator started grubbing the vegetation and at the same time, survey stakes were placed. When the grubbing concluded, the excavator started to construct the terraces (Figure 5). The extra spoil material and vegetation was used as fill for several depressions in the center of the island. Work concluded on 10 February.

Figure 4: NDC 3i looking northeast.

Figure 5: NDC 3i after the vegetation has been grubbed.

NDC-2ch and NDC-3ch:
Both of these channels are located on the downstream end of the large island, 3i. The channels have been constructed as ephemeral channels, with inundation to occur at approximately 1000 cfs. Fill material was deposited adjacent to the created channels on the island. The channels are about twenty-five feet wide.

Work started on 10 February with the excavator constructing NDC-2ch (Figure 6) from the upstream end to downstream end and then constructing NDC-3ch (Figure 7) from the downstream end to upstream end. The spoil was spread on both sides of the created secondary channels. Surveying of the island was completed in advance of the excavator's arrival. Work concluded on 14 February.

Figure 6: NDC 2ch looking east, northeast.

Figure 7: NDC 3ch after construction.

NDC-2i:
The upper third of the island was modified to create an elevation to be inundated in support of various life stages of the silvery minnow and to test the efficacy of destabilizing an island. The modified area will be inundated at approximately 2000 cfs. NDC-2i is part of the Collaborative Program funded island destabilization project.

Work started on 14 February with the grubbing of the vegetation. The spoil was spread out on the southern end of the island (Figure 8). Surveying of the island was completed in advance of the excavator's arrival. Work concluded on 16 February.

Figure 8: NDC 2i looking north, northwest.

NDC-1ch:
The channel was constructed on the east bank of the Rio Grande, northeast of island 2i. The channel has been constructed as an ephemeral channel, with inundation to occur at approximately 1500 cfs. Fill material was deposited adjacent to the created channel on the bank and then spread evenly (Figure 9). The channel is about twenty-five feet wide.

Work started on 16 February with the excavator digging from the downstream end to upstream end. Surveying of the channel was completed in advance of the excavator's arrival. Work concluded on 21 February.

Figure 9: NDC 1ch, looking south.

NDC-1b:
The bank scallop was constructed on the east bank of the Rio Grande, northeast of island 2i and north of 1ch. The scallop has been constructed as an embayment to function at 1000 cfs with an outflow channel (1ch) being inundated and flowing at approximately 1500 cfs. The channel returns to the Rio Grande downstream of the scallop.

Work started on 21 February with the excavator moving sediment and spreading the spoil on the bank to the south and to the east of NDC-1ch (Figure 10). Downed, large woody debris was tagged and placed in the river by the excavator as part of the NMISC's Large Woody Debris project. A GPS point, physical measurements, and identification information were recorded. Surveying of the channel was completed in advance of the excavator's arrival. Work concluded on 22 February.

Figure 10: NDC 1b during construction.

Water Quality

Water quality constituents, air temperature (Celsius), turbidity (FTU), pH, salinity (ppt), water temperature (Celsius), dissolved oxygen by percentage, dissolved oxygen (mg/L), and specific conductivity (uS), were measured daily. The water quality data for the North Diversion Channel subreach are as follows (Table 1).

Table 1. Minimum, Maximum, and Average Daily Water Quality Measurements by Constituent

	Daily Temp (ºC)	Turbidity (FTU)	pH	Salinity (ppt)	Water Temp (ºC)	DiO_2 (%)	DO (mg/L)	Specific Conductivity (uS)
MIN	-7.00	8.67	6.80	0.10	0.60	1.70	0.88	162.20
MAX	11.00	228.00	9.40	0.20	14.90	158.00	106.50	510.00
AVG	-0.23	48.02	8.23	0.17	6.09	52.57	7.85	335.16

Biological Commitments

Bald eagles: A total of 29 bald eagles were seen within 0.25 miles of the construction area and one was seen perched in a cottonwood tree at the staging area. A total of 0.86 eagles per day were present. None of the bald eagles landed or were perched within the construction areas, nor did they appear to be harassed by the construction work.

Rio Grande Silvery Minnows: A total of 63 Rio Grande silvery minnow (*Hybognathus* amarus) were recorded in the North Diversion Channel subreach. Each of the silvery minnows was recorded within the backwater area of the silt curtain that was created at NDC-5i. Three were dead and four stressed on a cold morning (21 January) when the embayment area was partially frozen. The stressed minnows were encouraged to travel to a slightly deeper, unfrozen portion of the embayment. Dead silvery minnows were not collected. Two sample seine hauls were accomplished on 25 January 2006 in which 56 fish were collected. Of the 56 fish, 52 silvery minnow and four fathead minnows (*Pimephales promelas*) were caught and identified in the seine hauls. All fish were released back into the embayment.

Southwestern Willow flycatchers: No willow flycatchers or willow flycatcher nests were seen within North Diversion Channel subreach.

Weather: Inclement weather was not an issue during construction activities within the subreach. See table above for air temperature.

Discharge: The USGS gage near Alameda Boulevard was out of commission for most of the project period. The Central and North Floodway gages were used to track discharge instead. The maximum average daily flow at the Central Gage was 721 cfs on January 11th. The minimum average daily flow occurred on February 15th with 514 cfs being recorded (Figure 11). The maximum average daily flow at the North Floodway Gage was

3.1 cfs on January 25th. The minimum average daily flow was 0.0 cfs, which occurred on numerous occasions (Figure 12). Please note median daily streamflow (discharge) on the hydrographs below.

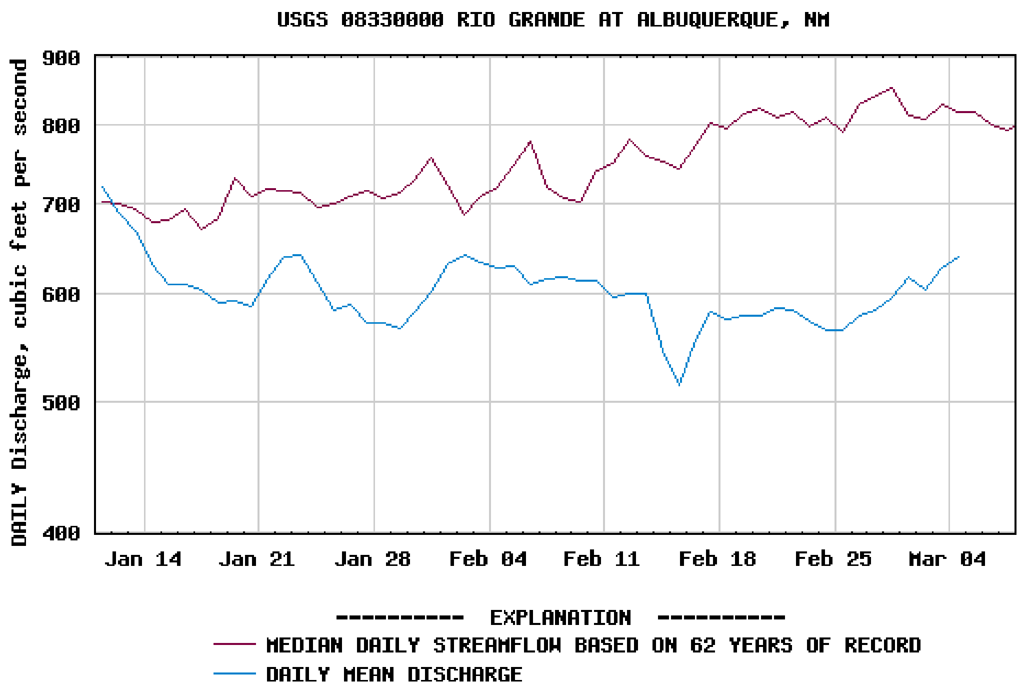

Figure 11. Central Gage discharge during project implementation.

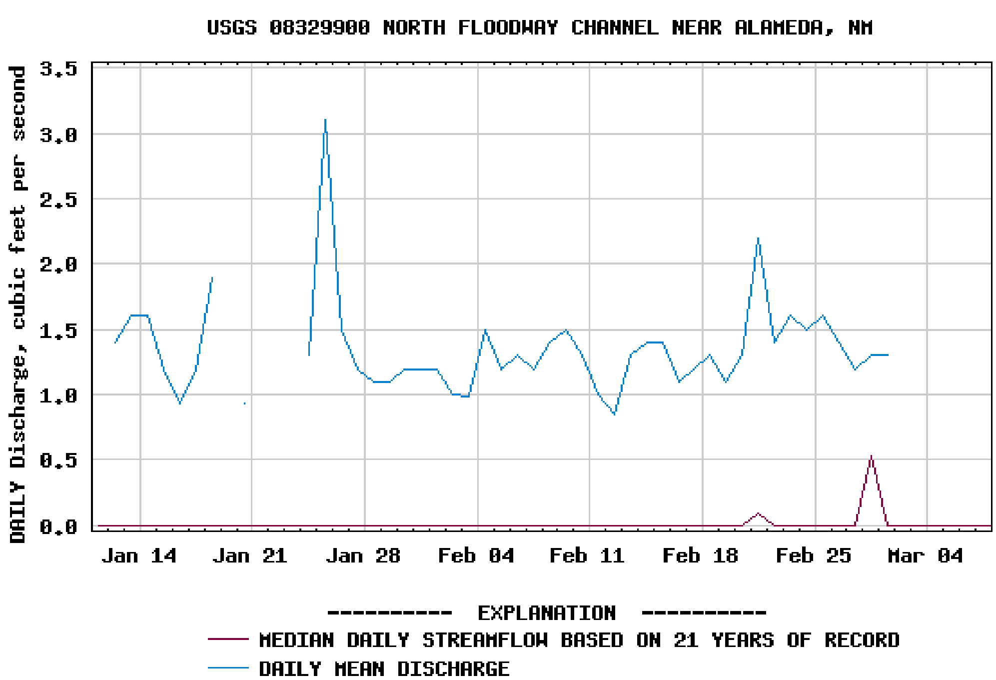

Figure 12. North Floodway Gage discharge during project implementation.

Photo points: Control photo points have been taken at each habitat restoration location for monitoring and comparison purposes.

Demobilization/mobilization: On January 11th, SWCA and Wilco crews met at the North Diversion Channel on Sandia lands to prepare for the arrival of the excavator and mobilize into the Rio Grande via the North AMAFCA Floodway and Pueblo of Sandia lands (Figures 13 and 14). On February 23rd, the excavator tracked upstream to the launch site for demobilization to travel to the South Diversion Channel subreach. Silt fences were used during both the mobilization and demobilization process and water quality samples were taken accordingly.

Figure 13. Silt fencing used while crossing the North Floodway Channel.

Figure 14. Construction of a ramp to access the Rio Grande from Sandia lands.

Middle Rio Grande Riverine Habitat Restoration: Phase I
New Mexico Interstate Stream Commission Project RG-22

SUMMARY OF CONSTRUCTION ACTIVITIES AT THE I-40/CENTRAL SUBREACH

Time Period: 27 March – 15 April. A total of seventeen days constituted the construction work at the I-40/Central subreach.

SWCA Costs Incurred: $25,485 (25.9% of total budget)

Who Worked (and in What Capacity): Joseph Fluder, Burt McAlpine, Matthew McMillan, Jeannie Welch, and Quinton Daigre. Joseph Fluder was the project manager responsible for project oversight, document production, and data collection. Burt McAlpine was responsible for preparing GIS maps and survey data and downloaded GPS data. Matthew McMillan was the environmental compliance monitor responsible for monitoring Rio Grande silvery minnow (*Hybognathus amarus*), Southwestern willow flycatcher (*Empidonax trailii extimus*), bald eagles (*Haliaeetus leucocephalus*), and water quality constituents. Mr. McMillan also assisted the construction crew with building silt fences/silt curtains and assuring that the construction crew followed techniques and guidelines outlined in numerous environmental compliance documents. Jeannie Welch assisted the Wilco surveyor with pre-construction surveys, as-builts, and silt fences/silt curtains construction. Quinton Daigre was the alternate environmental compliance monitor and had the same duties as Mr. McMillan when he was not present.

I-40/Central Subreach Habitat Restoration Sites

Staging Area: The staging area was located on the east bank of the Rio Grande, underneath the I-40 Bridge (Figure 1). The staging area was accessed from Central Avenue on the north side of the bridge leading directly onto the levee road. From I-40, Floral Road to Gabaldon Place or Campbell Road was used to access the levee road. City of Albuquerque Open Space Division keys open each of the levee road gates. The staging area, located in a previously disturbed area that was not altered in any way to circumvent any mitigation, contained construction work vehicles, a container full of supplies, a fuel vehicle, and one airboat.

I-40-2i:

The upstream half of the island was modified to create terraces at different elevations at which inundation could occur to help support various life stages of the Rio Grande silvery minnow. The three created terraces will be inundated at approximately 1500, 2500, and 3500 cubic feet per second (cfs) discharge. The embayment created downstream of the silt curtain will be inundated at low flows, including less than 500 cfs (Figure 2).

Work started on 29 March, after the island was surveyed, with the excavator grubbing the vegetation and then creating the terraces (Figure 3). To secure the silt curtain, spoil material from the island was placed on the inside of the silt curtain. The silt curtain process partitioned the river flow to the west of the silt curtain. Work concluded on 5 April.

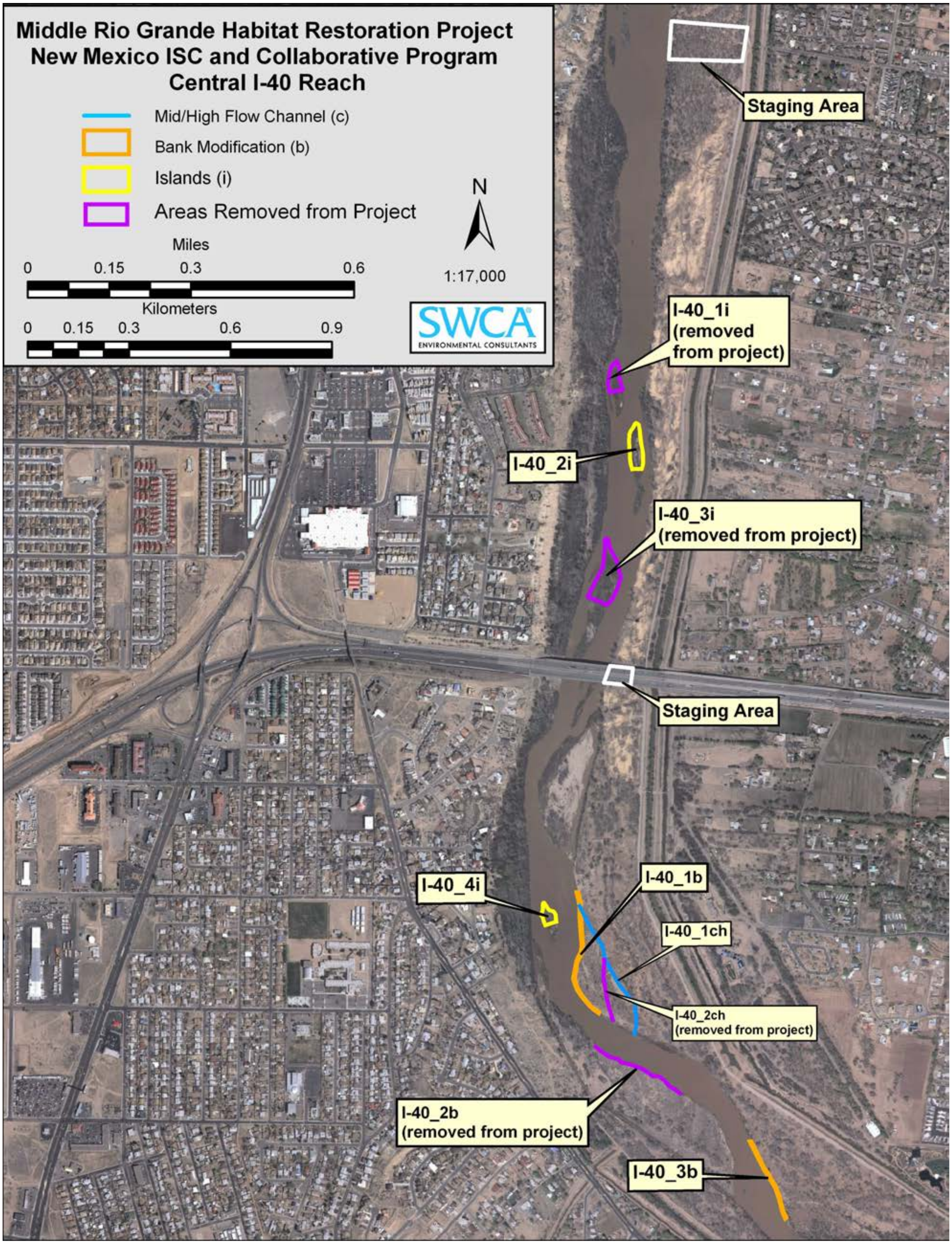

Figure 1. I-40/Central subreach with restoration sites and staging area.

Figure 2. Excavator moving spoil into embayment at I-40-2i.

Figure 3. Excavator creating terraces at I-40-2i.

I-40-4i:
The upstream half of the island was modified to create terraces at different elevations at which inundation could occur to help support various life stages of silvery minnow. The three created terraces will be inundated at approximately 1500, 2500, and 3500 cfs (Figure 4). The original design included constructing an embayment downstream of the silt curtain. However, there was

not enough fill material to create an embayment; instead, the material was spread on the back half of the island.

Work started on 5 April, after the island was surveyed, with the grubbing of the vegetation and creating the terraces. Work concluded on 6 April.

Figure 4. Moving spoil and creating terraces at I-40-4i.

I-40-1b:
This bank modification was constructed on the east bank of the Rio Grande east-southeast of island 4i. The bank modification was cut with the elevation dropping 0.0009 feet per linear foot from the upstream to downstream end. Inundation of this modification should occur at approximately 2000 cfs.

Work started on 6 April, after the bank modification was surveyed, with the excavator cutting the bank and moving the spoil material to the east of the bank modification Work concluded on 10 April (Figure 5).

Figure 5. Moving spoil material from the bank modification at I-40-1b.

I-40-3b:
This bank modification was constructed on the east bank of the Rio Grande downstream of I-40-1ch. The bank modification was cut with the elevation dropping 0.0009 feet per linear foot from the upstream to downstream end. Inundation of this modification should occur at approximately 2000 cfs.

Work started on 13 April, after the bank modification was surveyed, with the excavator cutting the bank and moving the spoil material east of the bank modification (Figure 6). The spoil material was spread evenly in the bosque. Work concluded on 14 April.

Figure 6. I-40-3b looking south.

I-40-1ch:
This channel is located just east of bank modification 1b and also starts at the northern end of bank modification 1b (just east of island 4i). The channel has been constructed as an ephemeral channel 25 feet wide, with inundation to occur at approximately 2000 cfs. Fill material was deposited on both sides of the created channel.

Work started on 10 April, after the channel was surveyed, with the excavator working (Figure 7) from the downstream end to upstream end. Work concluded on 13 April.

Figure 7. I-40-1ch looking north.

Water Quality

Water quality constituents, air temperature (Celsius), turbidity (FTU), pH, salinity (ppt), water temperature (Celsius), dissolved oxygen by percentage, dissolved oxygen (mg/L), and specific conductivity (μS) were measured daily for the I-40/Central subreach (Table 1).

Table 1. Minimum, Maximum, and Average Daily Water Quality Measurements by Constituent

	Air Temp (ºC)	Turbidity (FTU)	pH	Salinity (ppt)	Water Temp (ºC)	DiO_2 (%)	DO (mg/L)	Specific Conductivity (μS)
MIN	4.00	0.00	8.20	0.10	7.50	14.90	1.41	181.80
MAX	13.00	73.00	8.60	0.30	21.60	32.10	3.51	342.60
AVG	8.94	30.42	8.39	0.16	13.54	19.27	2.03	301.10

Biological Commitments

Bald Eagles: A total of 0 bald eagles were seen within 0.25 miles of the construction area. A total of 0.0 eagles per day were present.

Rio Grande Silvery Minnows: No silvery minnows were observed within the I-40/Central subreach.

Southwestern Willow flycatchers: No willow flycatchers or willow flycatcher nests were seen within the I-40/Central subreach.

Weather: Inclement weather was not an issue during construction activities at this subreach. See table above for air temperature.

Discharge: The Central gage was used to track discharge during construction at the I-40/Central subreach. The maximum average daily flow at the Central Gage was 666 cfs on 15 April. The minimum average daily flow occurred was 190 cfs on 30 March (Figure 8). Please note median daily streamflow (discharge) on the hydrograph below.

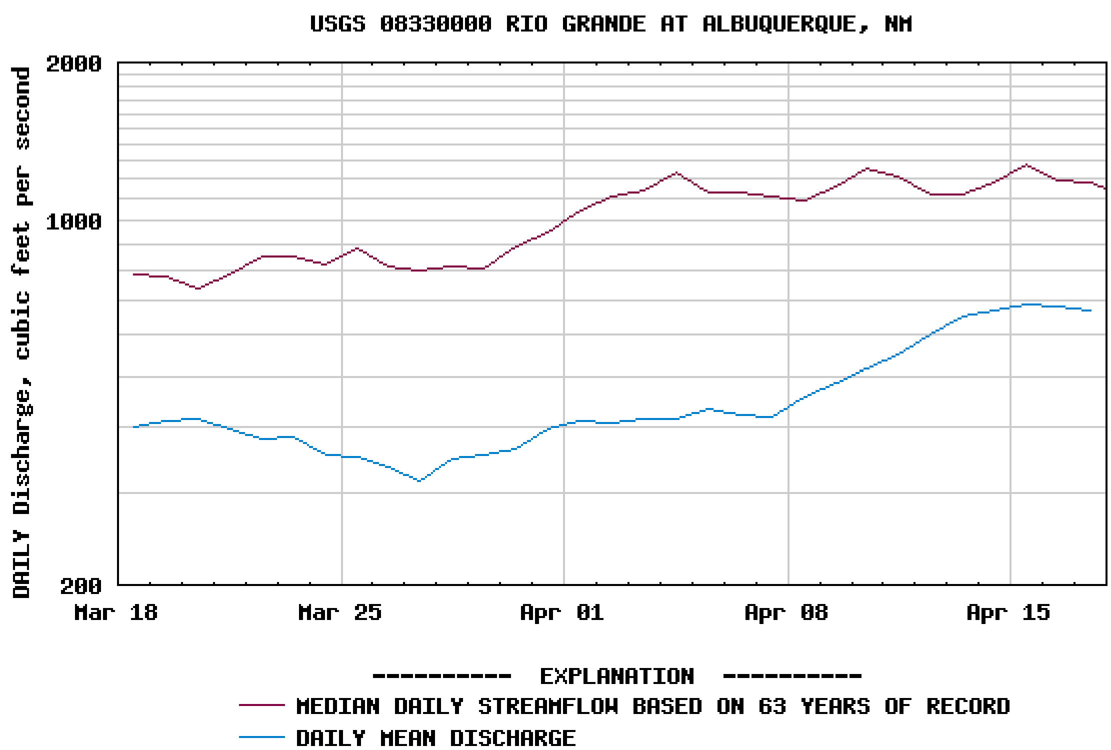

Figure 8. Central Gage discharge during project implementation.

Photo Points: Control photo points were taken at each habitat restoration location for monitoring and comparison purposes.

Demobilization/Mobilization: On 15 April, SWCA and Wilco crews finished work at the I-40/Central subreach and prepared to demobilize and mobilize to the South Diversion Channel. For mobilization, the excavator tracked downriver to access the staging area and levee road off of Shirk Road. Silt fences were not necessary for the mobilization/demobilization process, and water quality samples were taken accordingly. The machine was washed after exiting the river channel.

Middle Rio Grande Riverine Habitat Restoration: Phase I
New Mexico Interstate Stream Commission Project RG-22

SUMMARY OF CONSTRUCTION ACTIVITIES AT THE SOUTH DIVERSION CHANNEL SUBREACH

Time Period: Construction work occurred for 27 days (24 February to 27 March) south of the Rio Bravo Bridge.

SWCA Costs Incurred: $28,000 (28.2% of total budget)

Who Worked (and in What Capacity): Joseph Fluder, Burt McAlpine, Matthew McMillan, Jeannie Welch, and Quinton Daigre. Joseph Fluder was the project manager responsible for project oversight, document production, and data collection. Burt McAlpine was responsible for preparing GIS maps and survey data and downloading GPS data. Matthew McMillan was the environmental compliance monitor responsible for monitoring Rio Grande silvery minnow (*Hybognathus amarus*), Southwestern willow flycatcher (*Empidonax trailii extimus*), bald eagles (*Haliaeetus leucocephalus*), and water quality constituents. Mr. McMillan also assisted the construction crew with building silt fences/silt curtains and assuring that the construction crew followed the techniques and guidelines outlined in numerous environmental compliance documents. Jeannie Welch assisted the Wilco surveyor with pre-construction surveys, as-builts, and silt fences/silt curtains construction. Quinton Daigre was the alternate environmental compliance monitor and had the same duties as Mr. McMillan when he was not present.

SDC Subreach Habitat Restoration Sites

Staging Area: The staging area was located east of the Rio Grande off of Shirk Road (Figure 1). The first 200 meters of levee road off of Shirk Road is owned by MRGCD, AMAFCA owns the land adjacent to the levee, and the City Open Space Division controls all other roads within the park. The staging area was accessed via the levee road off of on the east side of the Rio Grande through City of Albuquerque Open Space land. The staging area, located in a previously disturbed area that was not further altered in any way to circumvent any mitigation, contained construction work vehicles, a container full of supplies, a fuel vehicle, and two airboats. The New Mexico Interstate Stream Commission used the disturbed area to minimize additional impact to the bosque.

SDC-2i:
The upper third of the island was modified to create an elevation at which inundation could occur at approximately 2000 cubic feet per second (cfs); this will help support various life stages of the silvery minnow and test the efficacy of destabilizing an island. SDC-2i is part of the island destabilization project funded by the Collaborative Program.

Work started on 24 February, after the island was surveyed, with the excavator grubbing the vegetation and grading the contours. The spoil material was spread out on the island (Figure 2). Work concluded on 2 March.

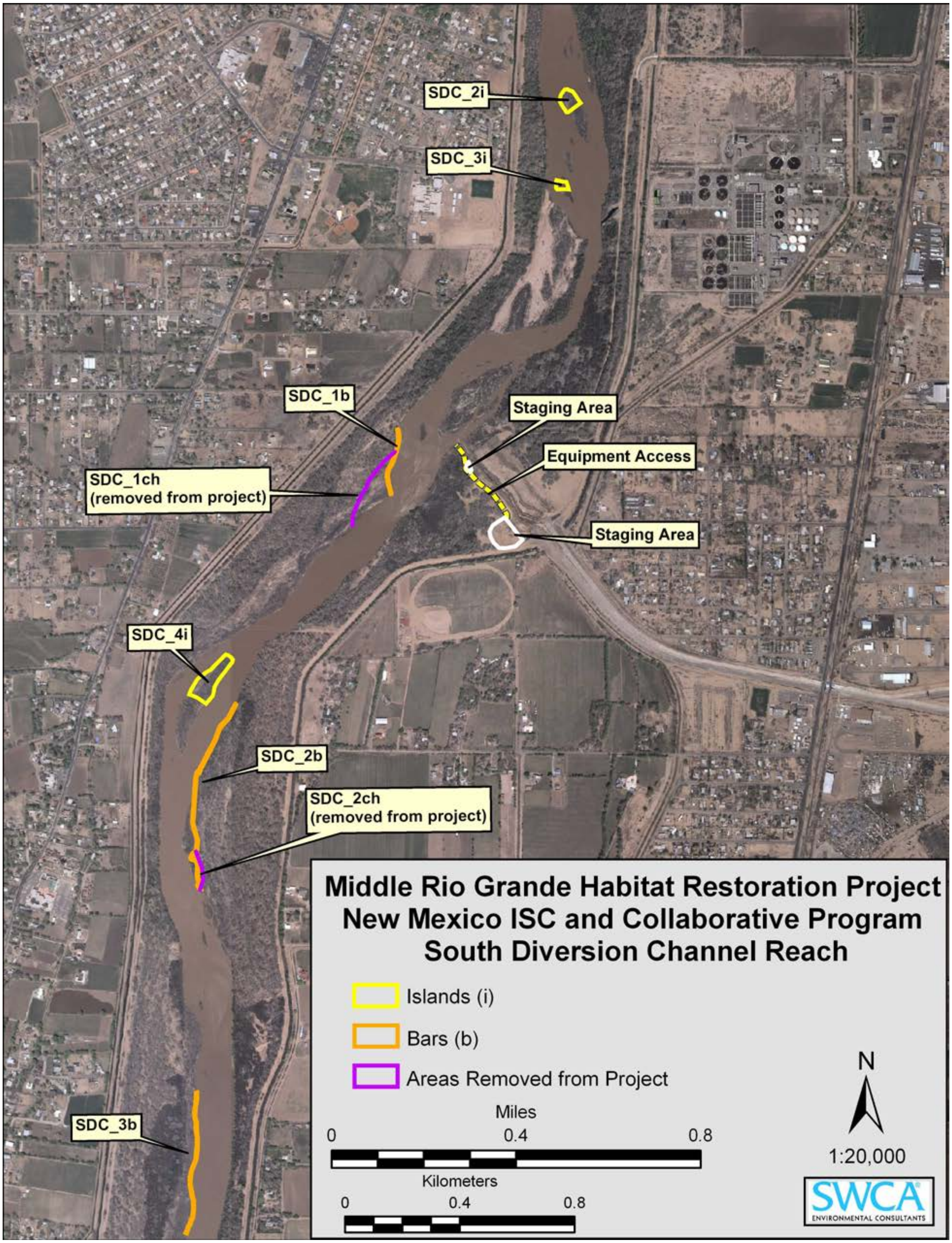

Figure 1. SDC subreach with restoration sites and staging area.

Figure 2. Excavator moving spoil and creating contours at SDC-2i.

SDC-3i:
The middle third of the island was modified to create an elevation at which inundation could occur at approximately 2000 cfs; this will help support various life stages of the silvery minnow and test the efficacy of destabilizing an island. SDC-3i is part of the island destabilization project funded by the Collaborative Program.

Work started on 2 March, after the island was surveyed, with the excavator grubbing the vegetation and grading the contours (Figure 3). The spoil material was spread out on the downstream end of the island. Work concluded on 3 March.

Figure 3. Moving spoil and grading contours at SDC-3i.

SDC-4i:

The upstream half of the island was modified to create terraces at different elevations at which inundation could occur to help support various life stages of silvery minnow. The three created terraces will be inundated at approximately 1500, 2500, and 3500 cfs. The embayment (Figure 4) created downstream of the silt curtain will be inundated at low flows, including less than 500 cfs. To secure the silt curtain, spoil material from the island was placed on the inside of the silt curtain. The silt curtain process partitioned the river flow to the east of the silt current.

Figure 4. SDC-4i embayment.

Although the survey crew had previously staked the back-line, it was necessary to remove the excess vegetation before the rest of the island could be staked out. Beginning on 3 March, survey stakes were placed directly after the excavator grubbed the vegetation. Excess vegetation gathered during grubbing was used to support the fill area around the embayment (Figure 5). Much of this vegetation was invasive Russian olive (*Elaeagnus angustifolia*) or immature salt cedar (*Tamarix spp.*). Scattered coyote willows (*Salix exigua)* or immature cottonwoods (*Populus deltoides*) were left throughout the modified area. When the grubbing concluded, the excavator started to construct the terraces (Figure 6). Work concluded on 18 March.

Figure 5. Excavator moving spoil and excess vegetation to build silt curtain at SDC-4i.

Figure 6. Excavator moving spoil to create terraces at SDC-4i.

SDC-1b:
This bank modification was constructed on west bank of the Rio Grande north-northeast of island 4i and spanned 369 meters. The bank modification was cut with the elevation dropping 0.0009 feet per linear foot from northern to southern end. Inundation of this modification should occur at approximately 2000 cfs. Work started on 25 March, after the bank modification was surveyed, with the excavator cutting the bank and moving the spoil material to the west of the bank modification (Figure 7). Work concluded on 27 March.

Figure 7. SDC-1b looking north.

SDC-2b:
This bank modification was constructed on east bank of the Rio Grande just east-southeast of island 4i and spanned 635 meters. The bank modification was cut with the elevation dropping 0.0009 feet per linear foot from northern to southern end. Inundation of this modification should occur at approximately 2000 cfs.

Work started on 18 March, after the bank modification was surveyed, with the excavator cutting the bank and moving the spoil material to the east of the bank modification (Figure 8). Work concluded on 20 March.

Figure 8. SDC-2b looking south.

SDC-3b:
This bank modification was constructed on the west bank of the Rio Grande, south of bank modification 2b, and spanned 504 meters. The bank modification was cut with the elevation dropping 0.0009 feet per linear foot from northern to southern end. Inundation of this modification should occur at approximately 2000 cfs.

Work started on 20 March, after the bank modification was surveyed, with the excavator cutting the bank and moving the spoil material to the west of the bank modification (Figure 9). Work concluded on 24 March.

Figure 9. SDC-3b looking north.

Water Quality

The water quality constituents air temperature (Celsius), turbidity (FTU), pH, salinity (ppt), water temperature (Celsius), dissolved oxygen by percentage, dissolved oxygen (mg/L), and specific conductivity (µS) at the South Diversion Channel subreach were measured daily (Table 1).

Table 1. Minimum, Maximum, and Average Daily Water Quality Measurements by Constituent

	Daily Temp (ºC)	**Turbidity (FTU)**	**pH**	**Salinity (ppt)**	**Water Temp (ºC)**	**DiO_2 (%)**	**DO (mg/L)**	**Specific Conductivity (µS)**
MIN	-3.00	0.00	7.60	0.10	4.10	3.60	0.40	161.80
MAX	12.00	73.00	8.60	0.30	18.60	85.60	10.90	576.00
AVG	4.15	40.68	8.20	0.20	10.80	44.40	5.10	365.10

Biological Commitments

Bald Eagles: A total of 5 bald eagles were seen within 0.25 miles of the construction area. A total of 0.19 eagles per day were present. None of the bald eagles landed or were perched within the construction areas, nor did they appear to be harassed by the construction work.

Rio Grande Silvery Minnows: No silvery minnows were observed within the South Diversion Channel subreach.

Southwestern Willow Flycatchers: No willow flycatchers or willow flycatcher nests were seen within the South Diversion Channel subreach.

Weather: Inclement weather was an issue during construction activities only once within the subreach. On 22 March 2006, a snowstorm hit the Rio Grande Valley and interrupted work for that day. See table above for air temperature.

Discharge: The Central and Tijeras gages were used to track discharge at the SDC subreach. At the Central Gage, the maximum average daily flow was 679 cfs on 6 March, and the minimum average daily flow was 366 cfs on 27 March (Figure 10). The Tijeras Gage had no reportable daily flows (0.0 cfs) during the duration of the project at the South Diversion Channel subreach. Please note median daily streamflow (discharge) on the hydrograph below.

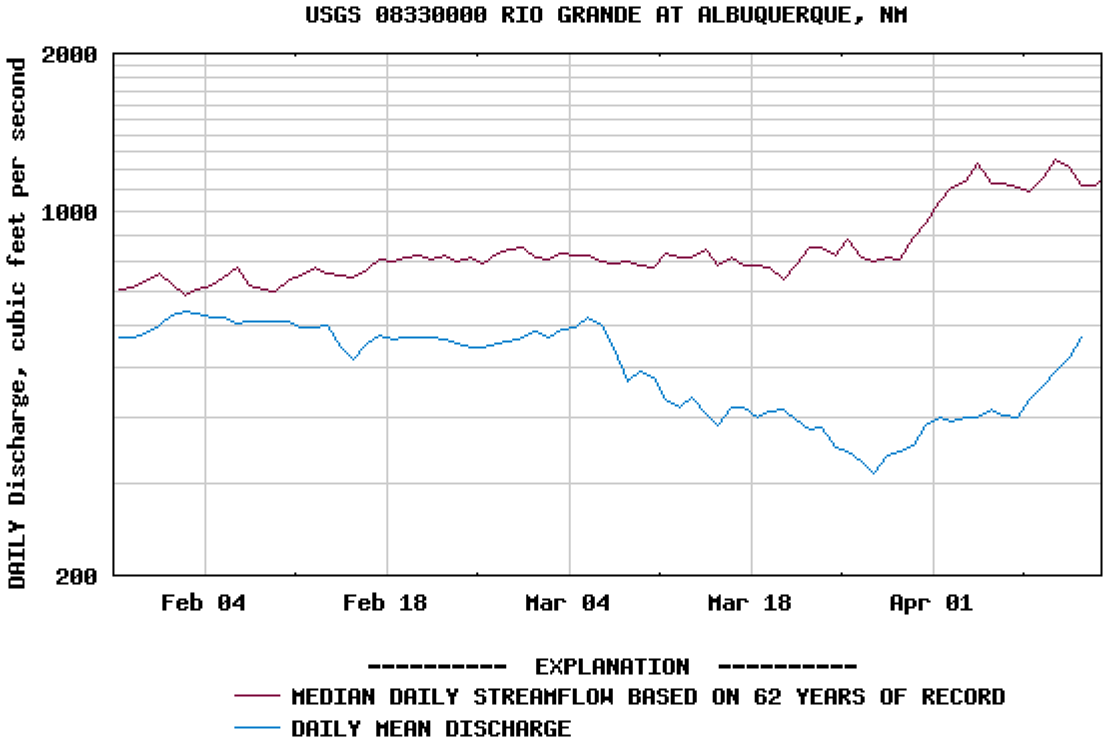

Figure 10. Central Gage discharge during project implementation.

Photo Points: Control photo points have been taken at each habitat restoration location for monitoring and comparison purposes.

Demobilization/Mobilization: On 27 March, SWCA and Wilco crews finished work at the South Diversion Channel subreach then prepared to mobilize to the I-40/Central subreach. To access the I-40/Central subreach, the excavator tracked upriver on 27 March. Silt fences were not necessary for the mobilization process, and water quality samples were taken accordingly.

APPENDIX D
FISHERIES MONITORING AT CONSTRUCTED EMBAYMENTS

SILVERY MINNOW EGG AND LARVAL FISH MONITORING IN CONSTRUCTED EMBAYMENTS: SUMMARY OF FINDINGS REPORT

FINAL REPORT

Prepared for

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SWCA Project No. 11354-196

August 2, 2006

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INTRODUCTION

As part of the effort to monitor use of constructed embayments by the Rio Grande silvery minnow (Hybognathus amarus; silvery minnow), New Mexico Interstate Stream Commission (NMISC) contracted with SWCA Environmental Consultants to conduct this NMISC Middle Rio Grande Riverine Habitat Restoration Project (Project) nursery habitat monitoring program. The primary objectives of this study were to determine if embayments constructed as part of the Project attract spawning Rio Grande silvery minnows (*Hybognathus amarus*; silvery minnow), particularly gravid females and/or larvae, as well as determine if these areas retain eggs. A secondary objective was to determine if silvery minnows actively seek areas of emergent or inundated terrestrial vegetation. Because of low spring flows in 2006, such areas did not exist within the study area, so this type of habitat was simulated using dried terrestrial vegetation (hay) in shallow, low-velocity areas within constructed embayments.

The NMISC Project applied several habitat restoration techniques in the Albuquerque Reach of the Middle Rio Grande (MRG) to create or improve habitat for the silvery minnow. The Project constructed egg-retention, larval-rearing, and over-wintering habitat for silvery minnow within three subreaches of the Albuquerque Reach. The Project was designed to facilitate evaluation of selected restoration techniques and was primarily funded by the State of New Mexico, with partial funding by the Middle Rio Grande Endangered Species Act Collaborative Program. The State of New Mexico funded the embayment monitoring effort.

The long-term goal of the Project is to promote egg retention, larval rearing, young-of-year, and over-wintering habitat for silvery minnow in support of Element S of the of the U.S. Fish and Wildlife's (USFWS's) Reasonable and Prudent Action in the March 2003 Biological Opinion (BO) (U.S. Fish and Wildlife Service [USFWS 2003]). The objective of the restoration process is to increase measurable habitat complexity in support of various life stages of silvery minnow by facilitating lateral migration of the river across islands, bars, and riverbanks at a variety of river flows.

The BO was released by the USFWS in 2003, covering the Bureau of Reclamation's (Reclamation's) water and river maintenance operations, the U.S. Army Corps of Engineer's flood control operations, and related non-federal actions on the MRG (USFWS 2003). The BO requires habitat restoration projects on the MRG that would improve survival of all life stages of the endangered silvery minnow and other endangered species. The 2003 MRG BO identified the need for increased availability of low-velocity habitat and silt and sand substrates to provide food, shelter, and sites for reproduction for silvery minnow and thereby alleviate jeopardy to the continued existence of the species in the MRG.

Crews worked to enhance an island near Alameda Bridge (river mile [RM] 192.2) to create areas of low-velocity habitat. The upstream half of the island was modified to create terraces of different elevations that could be inundated to help support various life stages of the silvery minnow. The three created terraces can be inundated at approximately 1,500, 2,500, and 3,500 cubic feet per second (cfs) discharge. Spoil from the terraces was used to create an embayment on the east side of the island that is inundated at low flows of less than 500 cfs.

A similar modification was performed on an island downstream of the South Diversion Channel (RM 176.5). Three terraces were also created on the upstream half of the island so that inundation can occur to help support various life stages of silvery minnow. The created terraces will be inundated at approximately 1,500, 2,500, and 3,500 cfs. The embayment created can be inundated at low flows, including less than 500 cfs. Excess vegetation gathered during grubbing was used to support the fill area around the embayment. Much of this vegetation was invasive Russian olive (*Elaeagnus angustifolia*) or immature salt cedar (*Tamarix* spp.). Scattered coyote willows (*Salix exigua)* or immature cottonwoods (*Populus deltoides*) were left throughout the modified area.

BACKGROUND

The silvery minnow is a moderate-sized, stout minnow, reaching 3.5 inches in total length, that spawns in the late spring and early summer, coinciding with high spring snowmelt flows (Sublette et al. 1990). Spawning also may be triggered by other high-flow events such as spring and summer thunderstorms. The species is a pelagic spawner, producing neutrally buoyant eggs that drift downstream with the current (Platania 1995). The eggs hatch in 2 to 3 days, and the larvae may continue to drift or become retained in backwaters or embayments. The species normally lives about 2 to 3 years in the wild. Natural flow regimes, movement within the limited remaining range, and habitat diversity are important to completion of the life cycle.

In 1994, the silvery minnow was classified as endangered by the USFWS (Federal Register [FR] 1994) and has been considered endangered at the state level since 1979. Historically, the silvery minnow was one of the most widespread and abundant fishes in New Mexico. The species has declined as a result of impacts from dewatering, channelization and flow regulation for irrigation, diminished water quality, and competition/predation by non-native species. The species is endemic to New Mexico, where it historically occupied large rivers with shifting sand substrates. The silvery minnow currently occupies less than 10 percent of its historic range and is found only in the Rio Grande from Cochiti Reservoir downstream to Elephant Butte Reservoir (Propst 1999) (Figure 1).

Silvery minnows prefer low-velocity (less than 0.1 m/s) and shallow water (<0.4 m) in areas over sand and silt substrates (Dudley and Platania 1997). Nursery habitat for larval fish would ideally consist of slow-velocity slackwaters found in inlets, floodplain depressions, and inundated arroyos (Porter and Massong 2004a). Early life stages (egg and larvae) are especially dependent on these low-velocity habitats (Porter and Massong 2004a, b). Previous studies using gellan beads to simulate silvery minnow eggs have shown that low-velocity inlets and shelves have retained higher numbers of beads than bankline or other high-velocity areas (Fluder et al. 2006). The presence of emergent vegetation in these shallow-water, low-velocity habitats also serves to retain beads, eggs, and larval fish (Fluder et al. 2006). In addition to this, emergent vegetation often slows flows and provides food for larvae and adults and cover from predators (Massong et al. 2004).

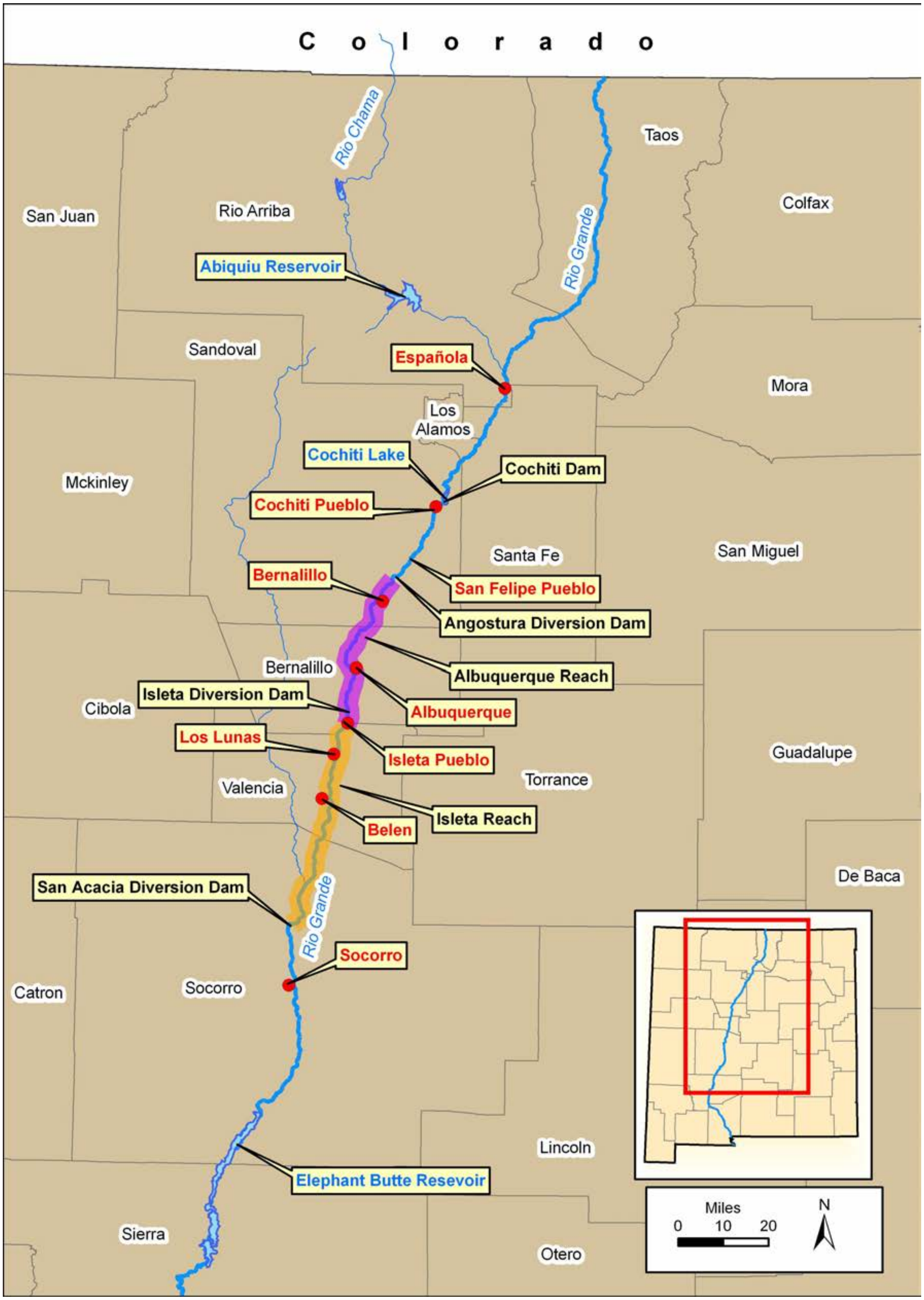

Figure 1. Overview of Middle Rio Grande. The Albuquerque Reach is highlighted in purple, the Isleta Reach in yellow.

Previous restoration efforts in the Middle Rio Grande sought to restore and create such habitats. Constructed inlets and embayments retain silvery minnow eggs and larvae as well as attract free-swimming fish (Massong et al. 2004). A drift zone (inundated area with neglible flow occurring in the back of the inlet) is especially important for egg retention (Massong et al. 2004). It can be assumed that the silvery minnow is using inundated, slow-velocity island and bar habitat similar to the way in which it would use historic floodplain habitat: as a means for the retention of eggs and during early life stages (Fluder et al. 2006). Silvery minnows do not typically occupy stream reaches dominated by straight, narrow, or incised channels with rapid flows (Sublette et al. 1990; Bestgen and Platania 1991). Critical habitat for the silvery minnow was designated by the USFWS and includes the Albuquerque Reach of the Rio Grande. This designation became effective February 19, 2003 (FR 2003).

Emergent or inundated terrestrial vegetation is one possible component of ideal habitat for silvery minnows. First, it is necessary to determine the mechanism by which minnows could seek out emergent vegetation. Although well studied, there are many components of the olfactory system in fish that are not completely understood. It is known that *Brycon cephalus* (a South American ray-finned fish) exhibit alarm reactions when exposed to a conspecific skin extract (Ide et al. 2003). Fathead minnows (Cyprinidae: *Pimephales promelas*) respond to skin extracts of both breeding and nonbreeding females, but only to skin extracts of nonbreeding males (Pollock et al. 2005). Other studies have demonstrated changes in the relative size and morphology of olfactory organs in zebra fish (Cyprinidae: *Danio rerio*) as they mature from larvae to adults (Poling and Brunjes 2000), suggesting that scent cues may play a more important role during periods of rapid development than in adult life. However, there is little research suggesting that Cyprinidae or related fishes respond to scent cues in seeking spawning habitat. Field observations of gravid and ready-to-spawn females in an area of inundated terrestrial vegetation suggest that silvery minnows may actively seek these areas of decreased flow and increased forage to spawn (M. Porter, personal communication 2006). It is possible that emergent or inundated vegetation could provide ideal habitat by way of lower flow, cover, and increased nutrients.

The University of New Mexico and the USFWS have monitored silvery minnow populations within this reach on an ongoing basis. Generally, the data collected indicate that silvery minnow are rare throughout the reach, with many of the individuals collected being adults (Dudley et al. 2003). This data set indicates that the population may benefit by retaining eggs, larvae, and juveniles in upstream areas like the Albuquerque Reach, where they can contribute to population growth and aid in the recovery of the species.

METHODS

Sites were selected at four locations within the Albuquerque Reach (Alameda, Montaño, I-40, and South Diversion Channel) and at one location in the Isleta Reach (Los Lunas) (Figure 2). The sites discussed in this report are Alameda and the South Diversion Channel; both contain embayments constructed by the NMISC (Figure 3, Figure 4, Figure 5). Methods used were those set forth by Mickey Porter of Reclamation (personal communication 2006). Ideal sites had low- or no-current velocity and depths between 0.2 and 0.3 m. Two rectangular hoop nets (0.5 m by 0.5 m, 6.4-mm mesh size) were placed side by side, and a nylon mesh bag of timothy hay was placed in the cod end of one of the two hoop nets ("experimental"), while the other net did not contain hay ("control"). Both were securely attached to the substrate. Two square quadrats (0.5 m by 0.5 m) fitted with 1-mm mesh were placed under the rear section of each hoop net. At each of the sites were two pairs of hoop nets, a total of four experimental and four control.

Sites were visited daily between 9 May 2006 and 27 May 2006. First, water quality data (dissolved oxygen, temperature, conductivity, specific conductance, and salinity) were recorded before water at the site was disturbed. Next, hoop nets were carefully untied and moved aside so that the quadrats underneath could be inspected for Rio Grande silvery minnow eggs. After that, hoop nets were inspected for the presence of fish. If fish were present, they were identified, counted, and released, with the presence of gravid silvery minnow females noted. Hoop nets were reset, and quadrats were replaced underneath. Finally, water depth and current velocity were recorded for each hoop net. Unknown fish, major changes in water level, and anything else of note was logged and photographed if appropriate. Appendix A contains photographs of each site.

RESULTS

Over the 18-day sample period, 77 silvery minnows were collected from the constructed embayments at Alameda and the South Diversion Channel; only one silvery minnow was a gravid female, and no silvery minnow eggs were collected at either site. In all, 259 total larvae (species undetermined) were collected at both sites. A summary table (Table 1) is provided below, and the full data set is available in an attached Excel spreadsheet.

Water quality data are summarized in Table 2. It should be noted that the sites were not visited at the same time each day, and some water quality parameters had large diel fluctuations. For example, during this study, the main channel at Alameda had an all-time low temperature of 14.6°C at 7:30 A.M. on the morning of May 12 and an all-time high of 25.5°C at 4:18 P.M. the afternoon of May 21. The USGS gage at Central Avenue indicated that flows ranged from about 550 cfs to about 750 cfs for the duration of the study (Figure 6). Within the main channel at Alameda, water quality ranges were as follows: temperature, 14.6–25.5°C; dissolved oxygen, 6.38–8.47 mg/L; conductivity, 240.2–333.9 µS/cm; specific conductance, 293.6–331.7 µS/cm; salinity, 0.1–0.2 ppt, water depth, 0.30–0.94 m; and current velocity, 0.57–1.14 m/sec. At the hoop nets, the temperature

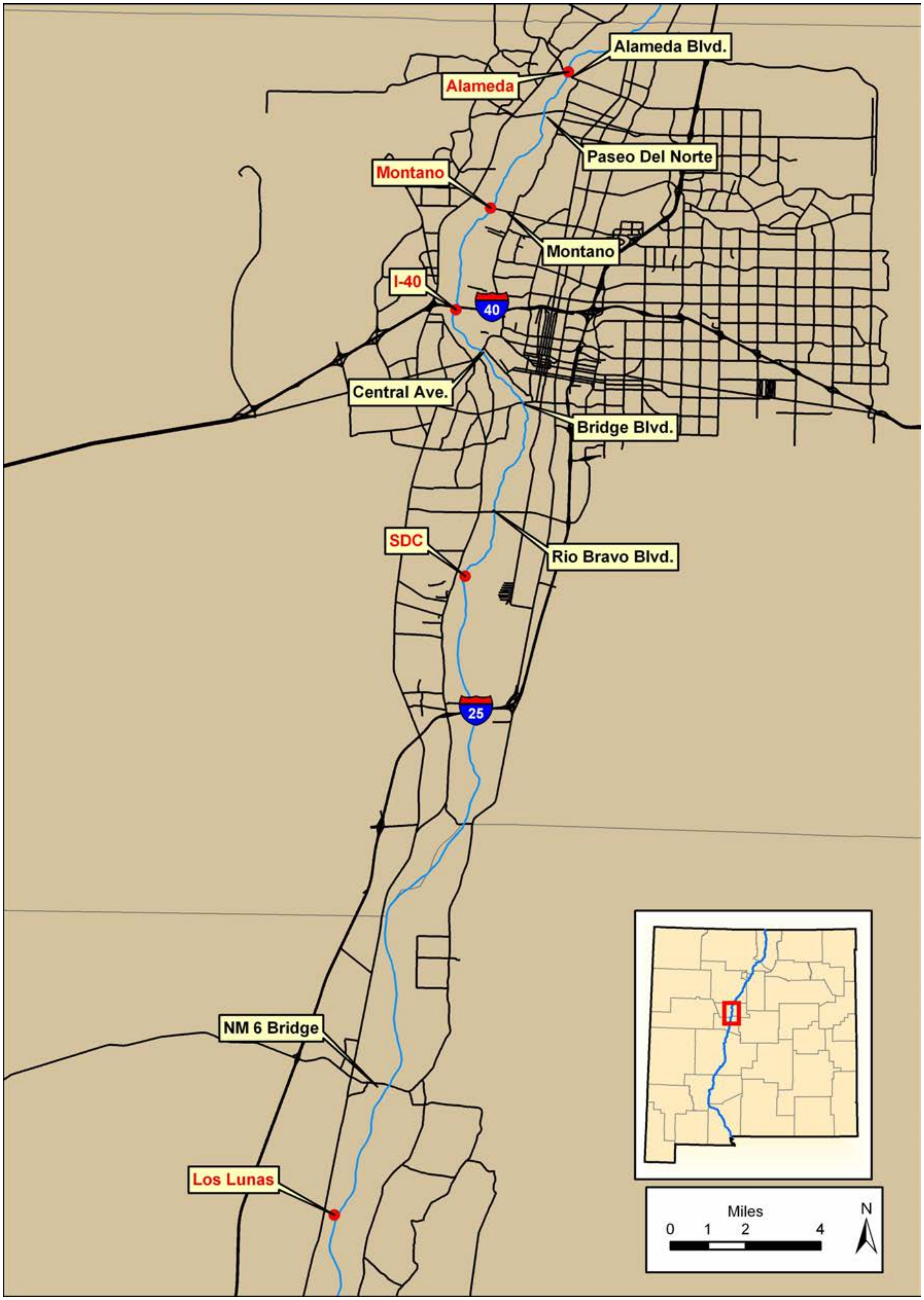

Figure 2. 2006 Middle Rio Grande. Nursery habitat monitoring sites are indicated by red font. NMISC-funded sites are Alameda and SDC.

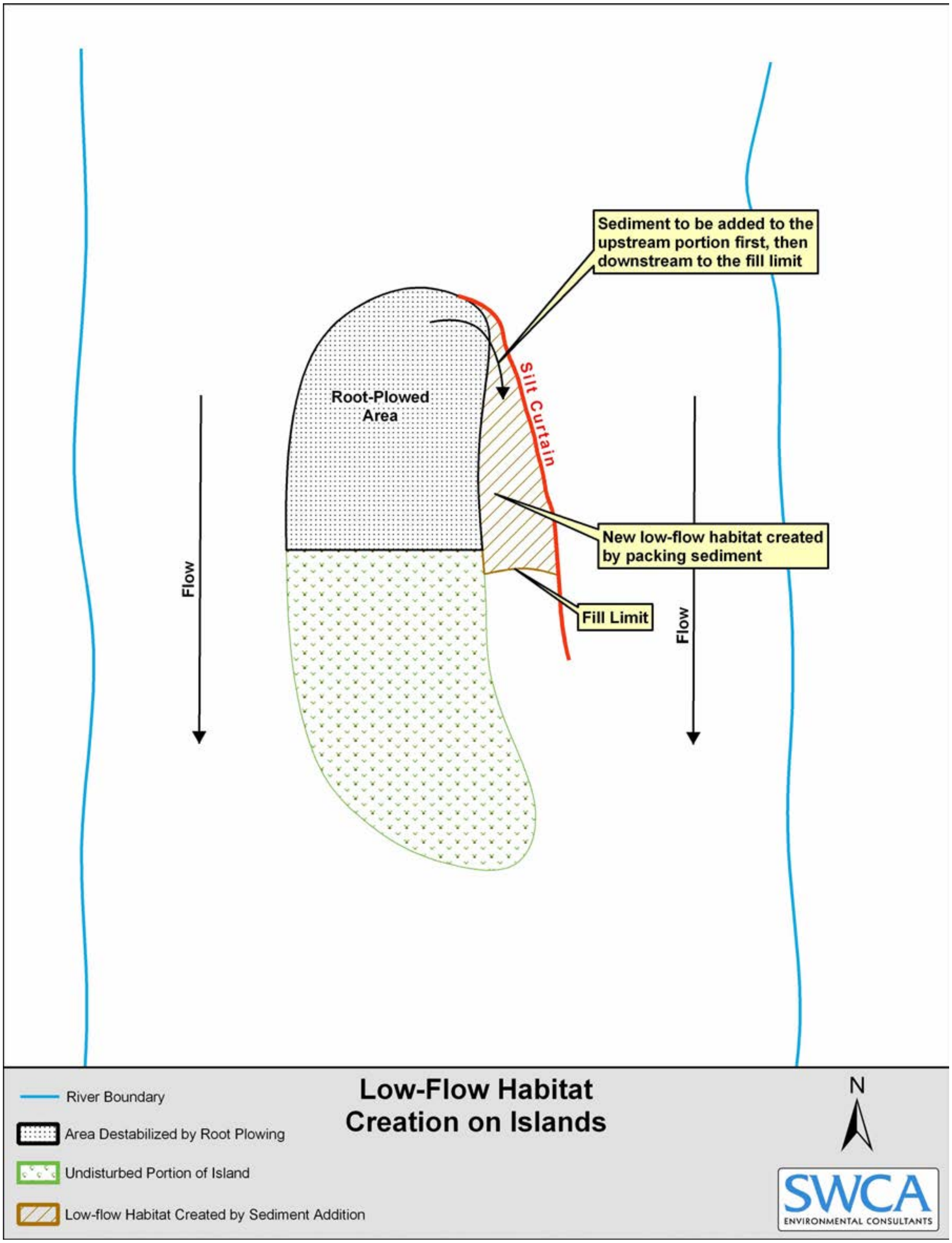

Figure 3. Hypothetical design for island modification and creating embayments within the Rio Grande.

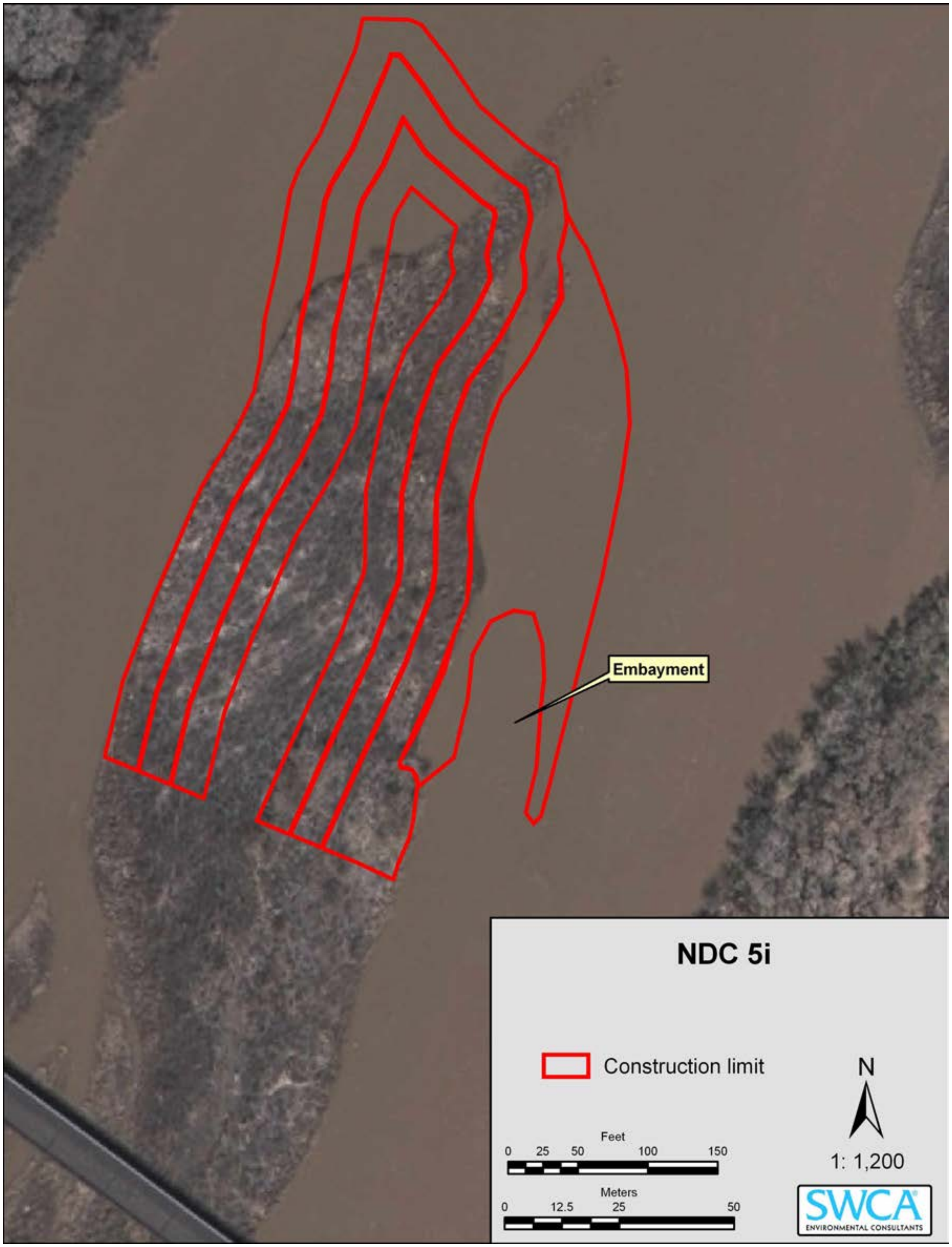

Figure 4. Constructed embayment at Alameda site.

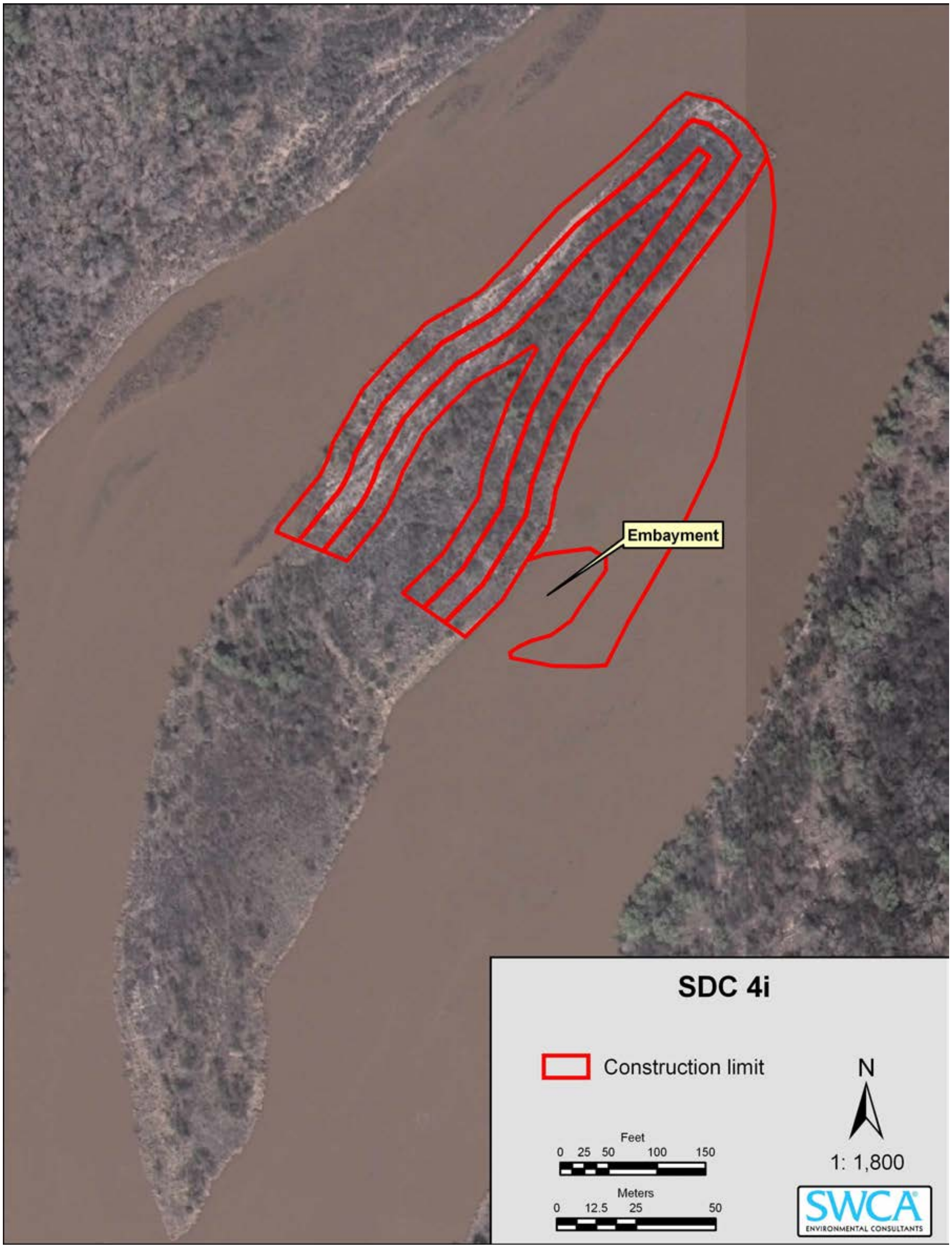

Figure 5. Constructed embayment at South Diversion Channel site.

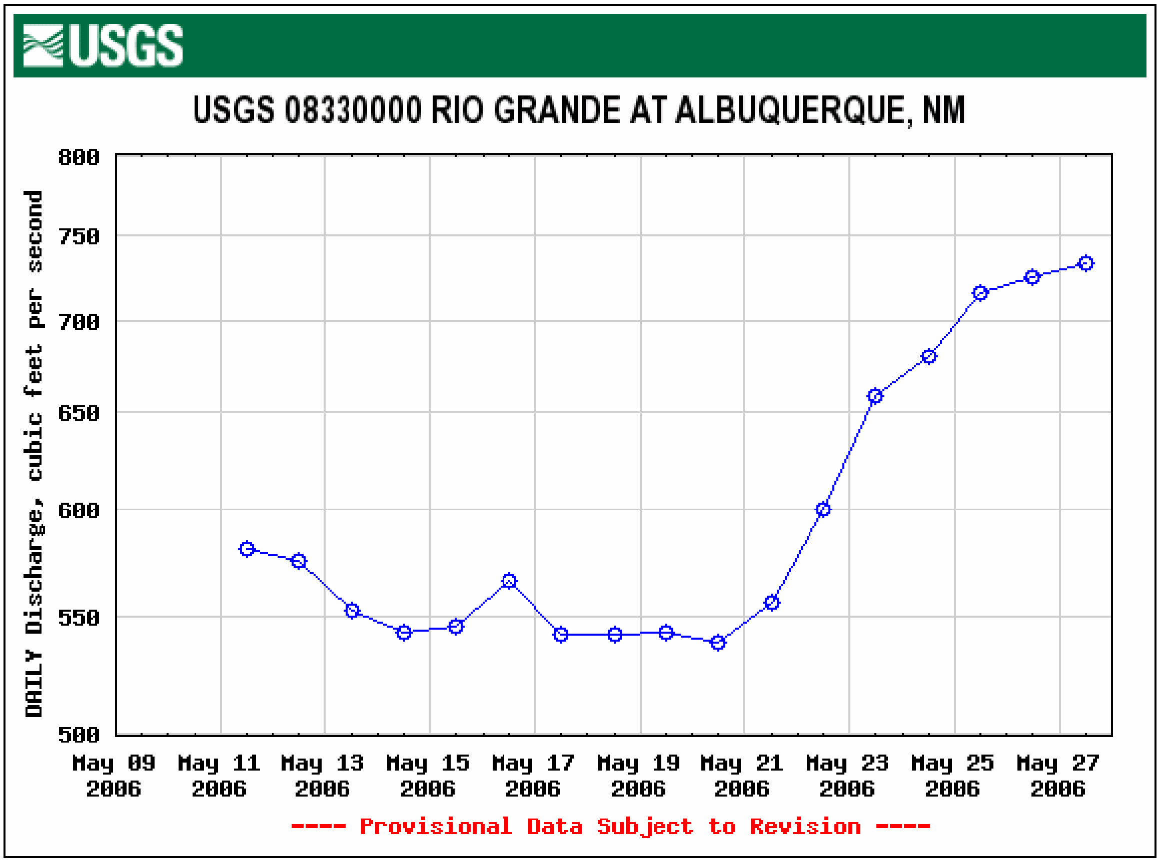

Figure 6. USGS hydrograph for the gage at Central Avenue for the study period.

Table 1. Summary of Fish and Egg Findings in Hoop Nets and Quadrats during 2006 Nursery Habitat Study

Site	Type	Silvery Minnow Adults	Gravid Silvery Minnow	Other Fish	Silvery Minnow Eggs	Larvae
Alameda	Experimental	49	1	177	0	59
	Control	17	0	130	0	118
South Diversion Channel	Experimental	10	0	144	0	21
	Control	1	0	96	0	61

Table 2. Average Water Quality and Flow Conditions for Both Main Channel and Hoop Net Sites during 2006 Nursery Habitat Study

Site	Type	Temp (°C)	Dissolved O_2 (mg/L)	Conduc-tivity (µS/cm)	Specific Conduc-tance (µS/cm)	Salinity (ppt)	Water Depth (m)	Water Velocity (m/s)
Alameda	Experimental	21.6	7.85	308.4	329.2	0.2	0.36	0.01
	Control	21.6	7.77	308.5	329.4	0.2	0.33	0.01
	Main Channel	21.1	7.55	296.9	319.5	0.2	0.66	0.86
South Diversion Channel	Experimental	20.9	7.21	303.0	333.9	0.2	0.32	0.05
	Control	20.9	7.20	302.9	333.9	0.2	0.29	0.04
	Main Channel	20.5	7.67	308.5	337.2	0.2	0.65	0.69

Range was 14.2–26.9°C; dissolved oxygen, 5.52–9.81 mg/L; conductivity, 257.6–347.7 µS/cm; specific conductance, 317.5–340.4 µS/cm; water depth, 0.21–0.45 m; and current velocity, 0–0.1 m/sec.

At the South Diversion Channel, water quality ranges in the main channel were: temperature, 17.1–23.8°C; dissolved oxygen, 6.00–8.80 mg/L; conductivity, 285.6–359.4 S/cm; 315.7–391.1 µS/cm; water depth, 0.39–0.94 m; and current velocity, 0.28–1.13 m/sec. Salinity was constant at 0.2 ppt throughout the duration of the study. At the hoop nets, temperature ranged from 17.3–24.7°C; dissolved oxygen, 4.95–8.87 mg/L; conductivity, 151.8–341.2 µS/cm; specific conductance, 241.9–348.9 µS/cm; salinity, 0.1–0.2 ppt; water depth, 0.03-0.61 m; and current velocity, 0–0.33 m/sec.

CONCLUSIONS

Future monitoring of constructed embayments should build upon the work completed in this study and would include more rigorous investigations and testing hypotheses. Little is known about how Cyprinidae respond to non-alarm scent cues, and even less is known about such cues and the silvery minnow. In order to explore this issue in the future, a greater number and more densely placed array of hoop nets or another method of capture should be placed within the embayments. A more methodical experimental design would allow investigators to ascertain whether or not silvery minnow are responding to dried terrestrial vegetation. If the dried vegetation aspect is not of concern, then a greater number of hoop nets placed within the embayment should determine whether or not silvery minnows are using these areas. Additionally, as restoration sites mature and support native riparian vegetation the conditions that support the life histories of silvery minnow could be present, and increased utilization of the restoration sites may occur by the fishery.

Previous studies (Porter and Massong 2004a; Porter and Massong 2005) have used gellan beads to simulate Rio Grande silvery minnow eggs in order to determine egg movement and settling in various mesohabitats. Using these artificial eggs would be an ideal way to determine if constructed embayments at the Alameda and South Diversion Channel sites retain silvery minnow eggs. Artificial eggs could be released upstream from the mouth of the embayment, and quadrats could be placed within the embayment with Moore egg collectors in the main channel. Comparisons could then be made as to the proportion of eggs released that successfully drift into the constructed low-velocity habitat.

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ACKNOWLEDGEMENTS

This work was conducted with funding from the New Mexico Interstate Stream Commission. Page Pegram was the project manager and Peter Wilkinson a technical reviewer for the New Mexico Interstate Stream Commission. Dr. Michael D. Porter of the U.S. Bureau of Reclamation assisted in the creation of field and data collection protocols. For SWCA, Joseph Fluder was the project manager. Sarah Beck led the fish identification and field data collection process, assisted by Burt McAlpine, Jeanne Welch, Matt McMillan, Heather Timmons, Andy Hawk, Josh Sammons, Patrick McKnight, Carly Welch, Eric Barker, Steve Shoup, and Matthew Martin. Burt McAlpine prepared the maps, and Deborah Risberg was the technical editor.

APPENDIX A
SITE PHOTOS

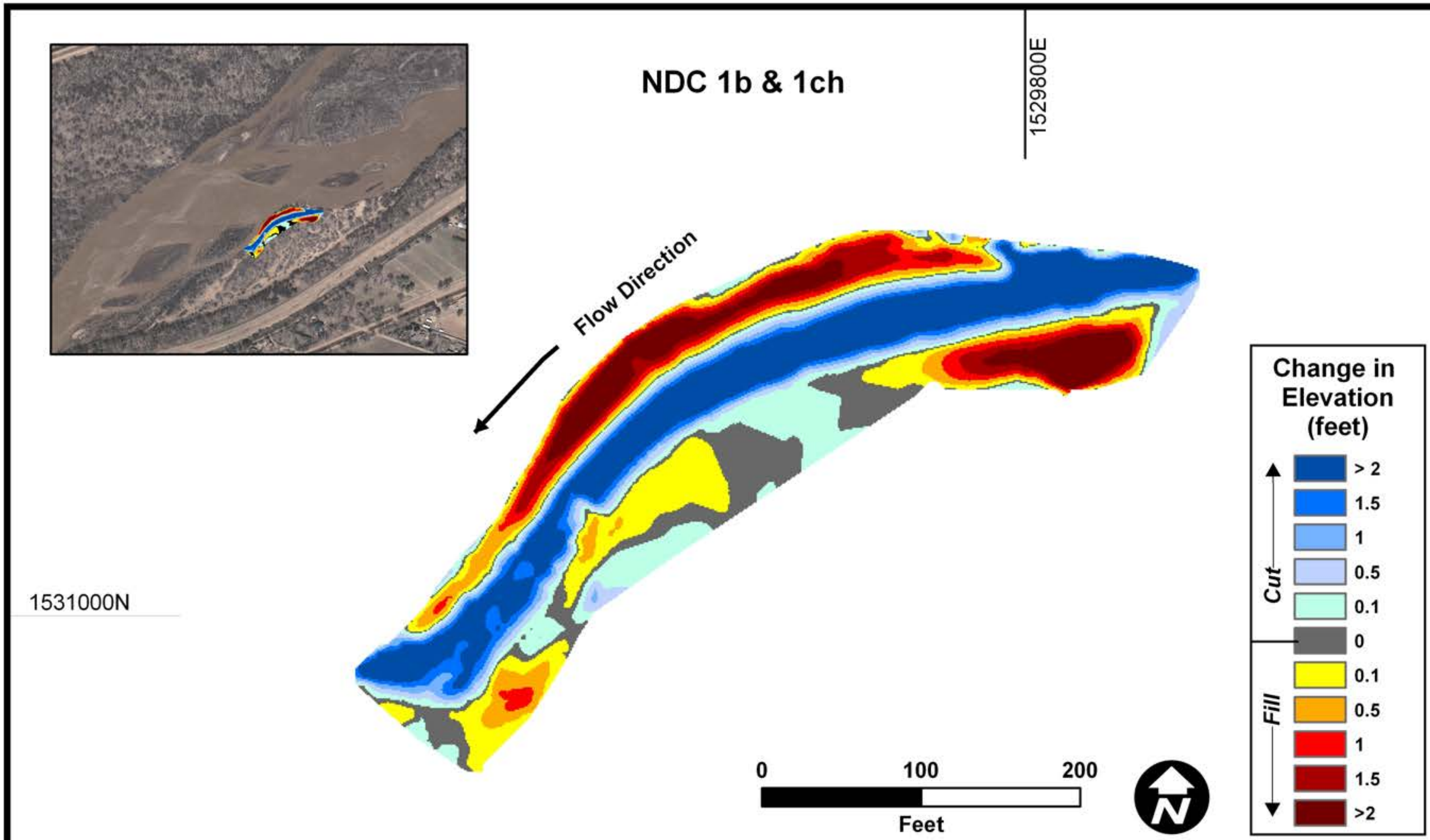
Figure A.1. Hoop net set up within the constructed embayment at Alameda. The hoop net on the left contains a nylon bag of hay, while the hoop net on the right does not. The main channel of the Rio Grande is on the right side, and the photograph was taken looking upstream.

Figure A.2. Both set-ups within the constructed embayment at Alameda.

Figure A.3. Both hoop net set-ups within constructed embayment at South Diversion Channel. The main channel of the Rio Grande is in the back half of the photograph, and the river is flowing from left to right.

Figure A.4. Westernmost set-up at South Diversion Channel. A medial sandbar has been deposited across the mouth of the embayment, and the water becomes substantially deeper behind the hoop nets.

APPENDIX E
DETAILED MAPS FROM GEOMORPHIC SURVEYS



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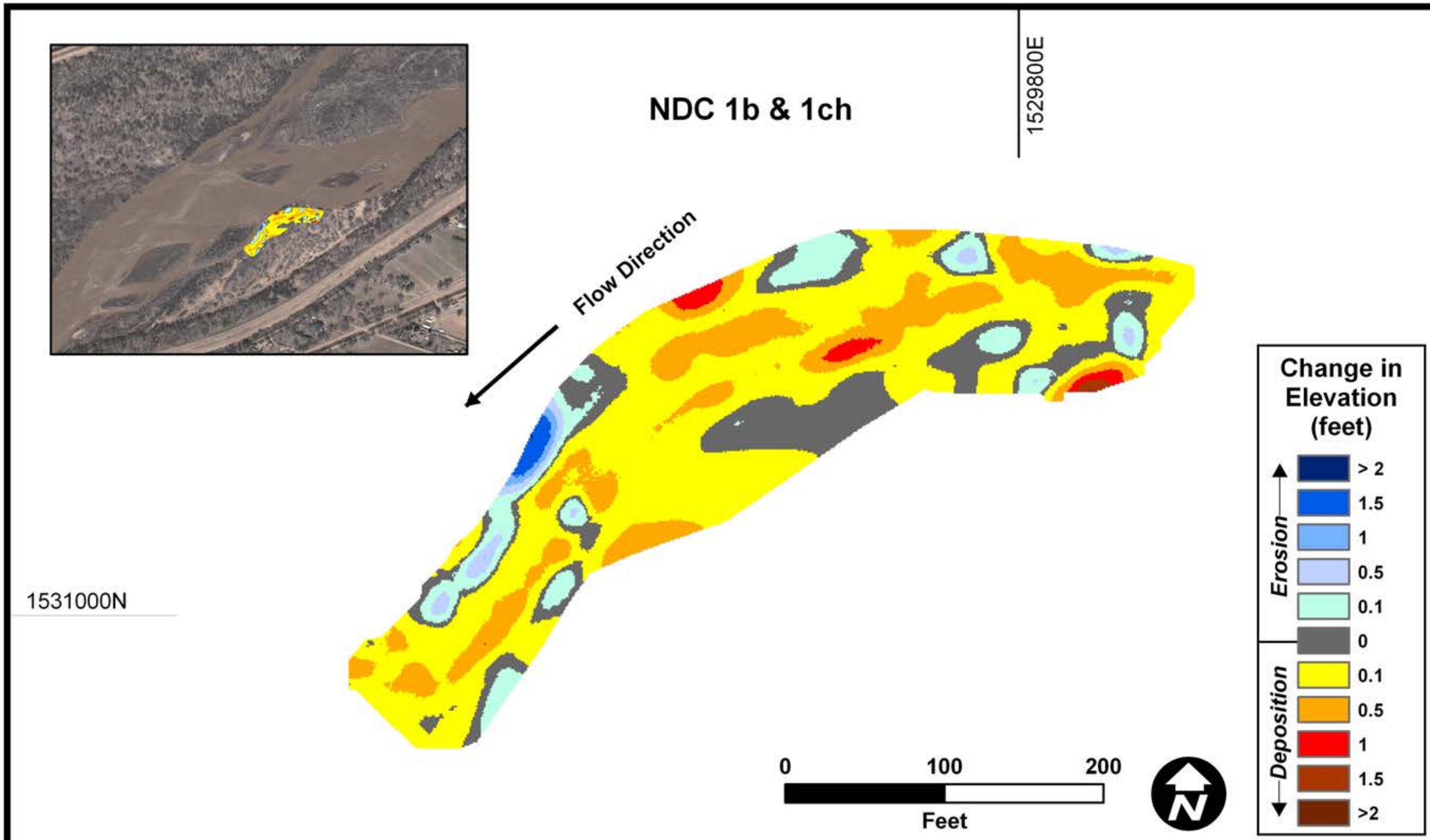

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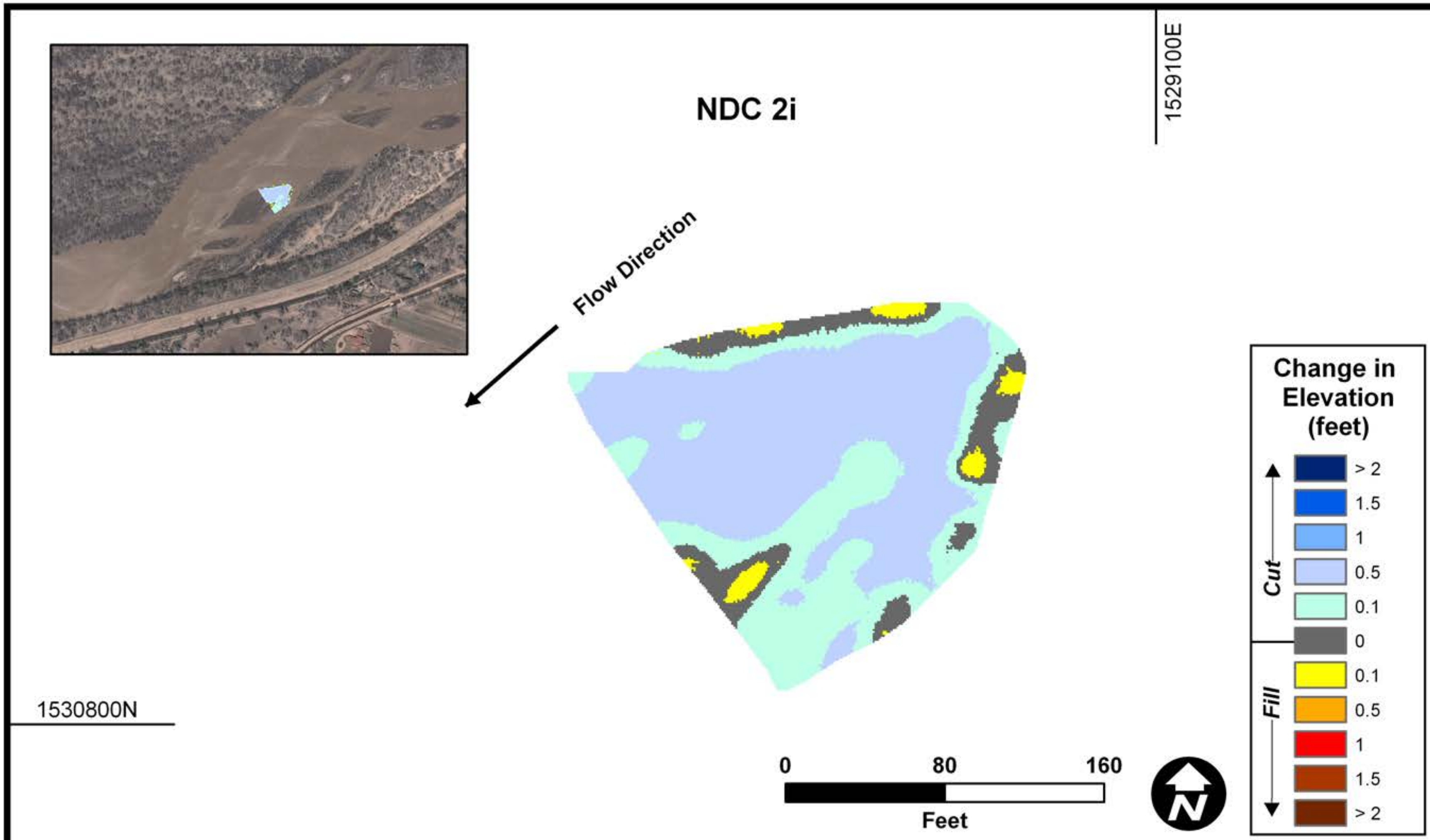

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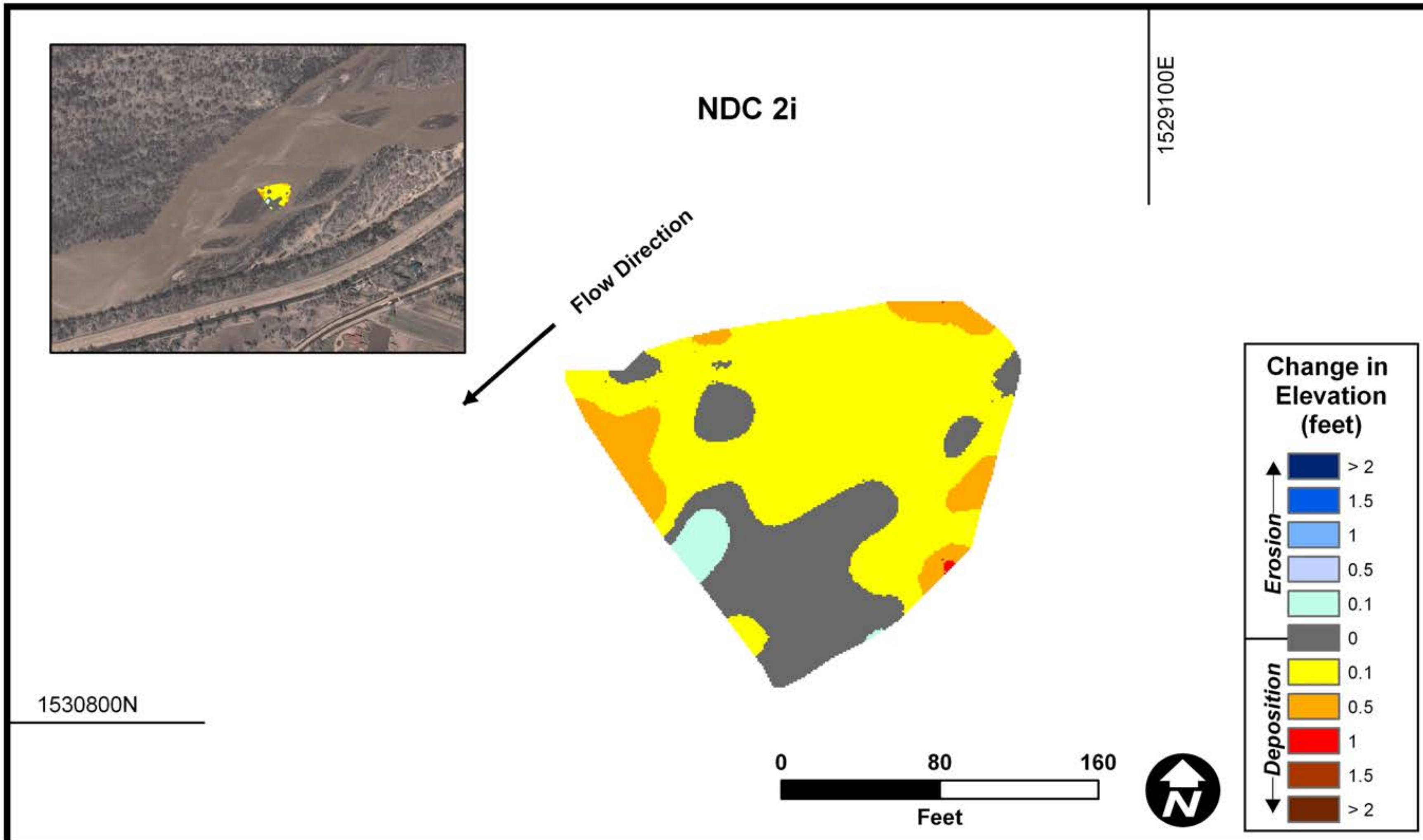

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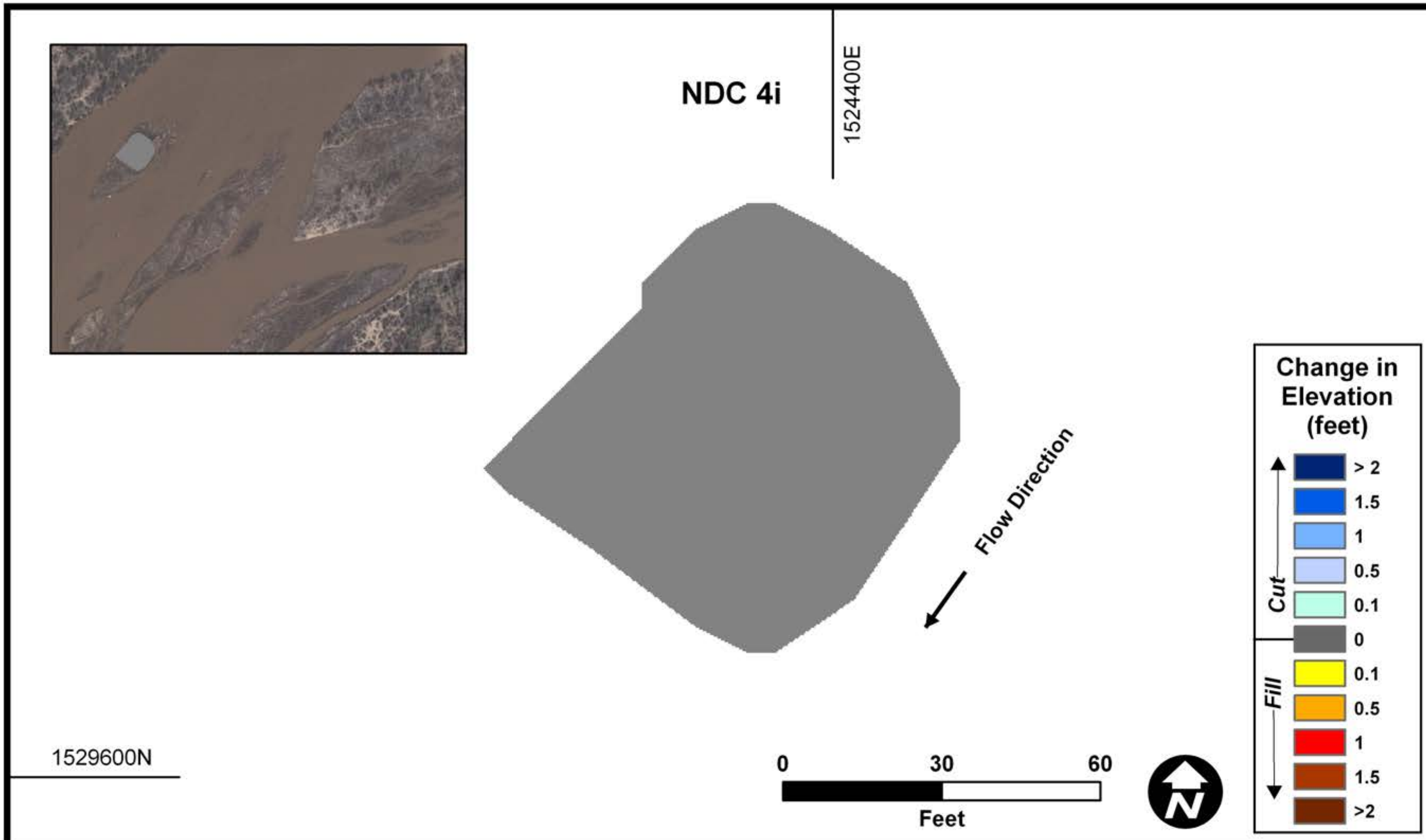

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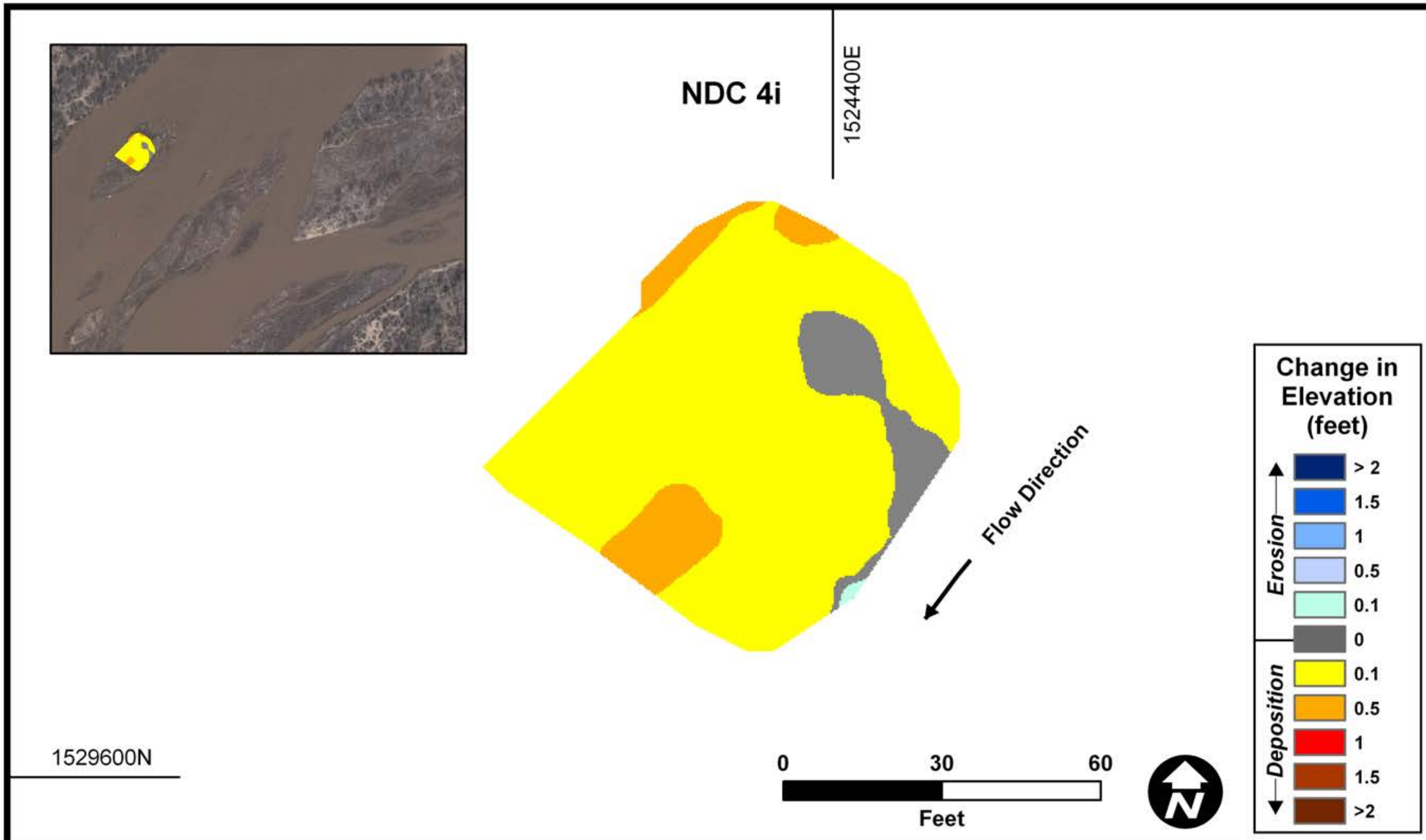

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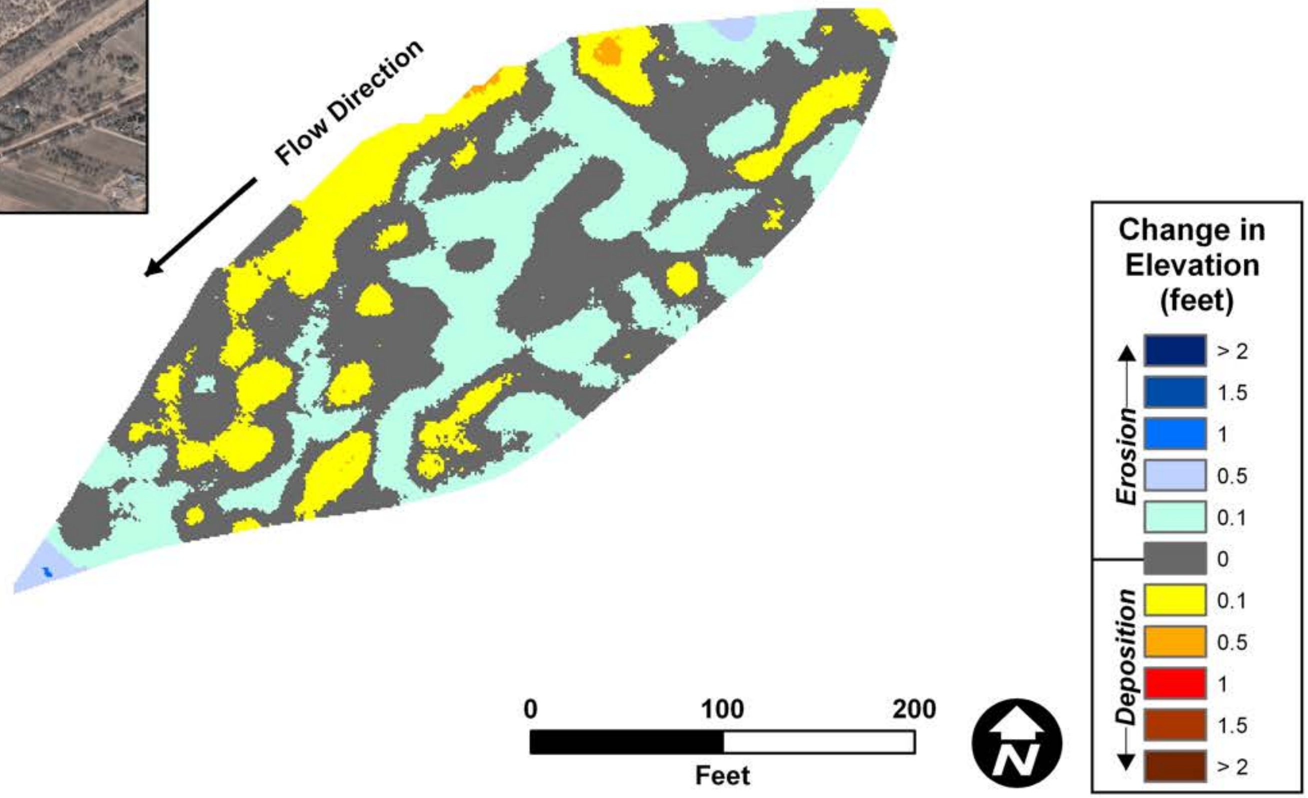
NDC Control Island



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Natural Changes - Comparison of September 2005 and December 2006

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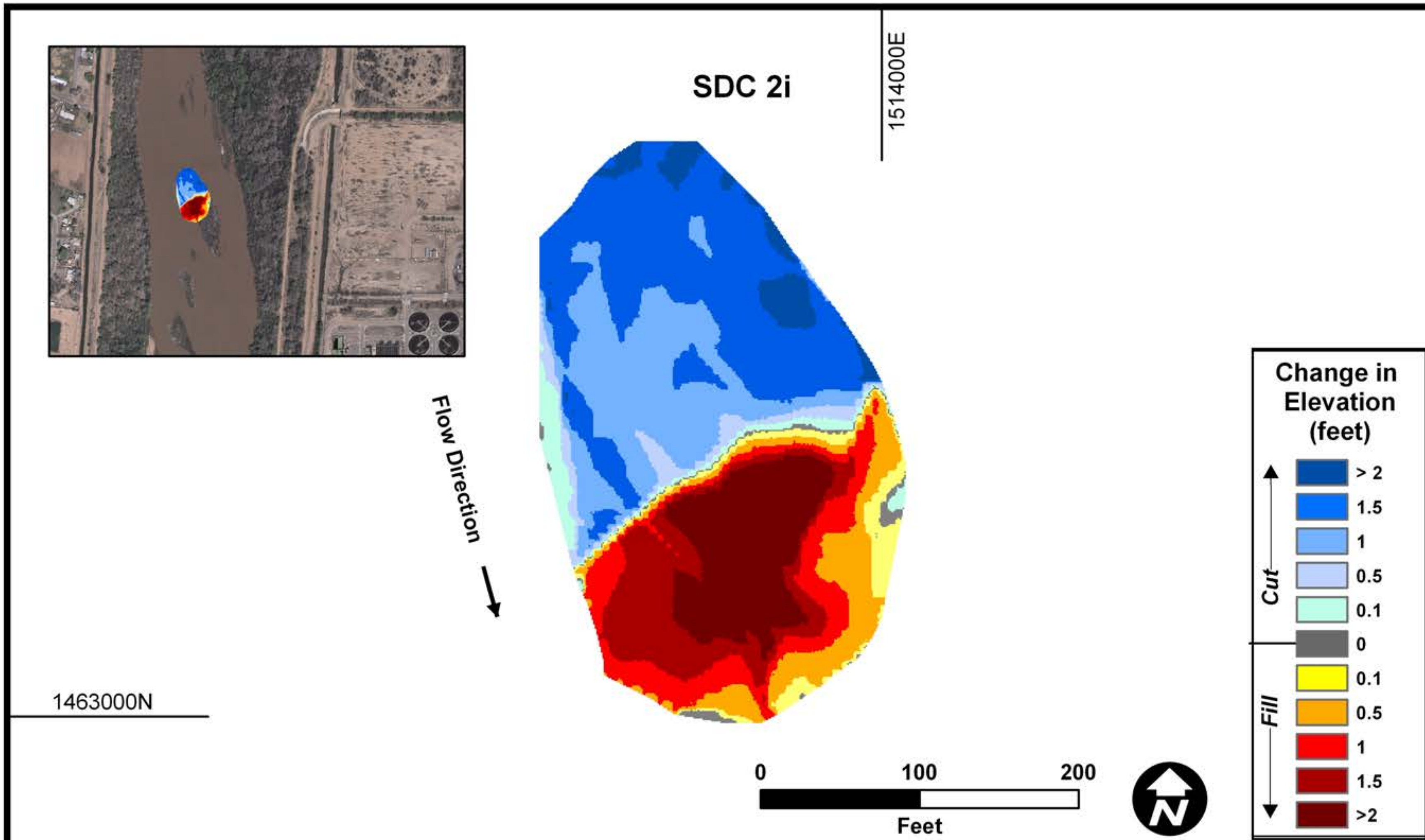

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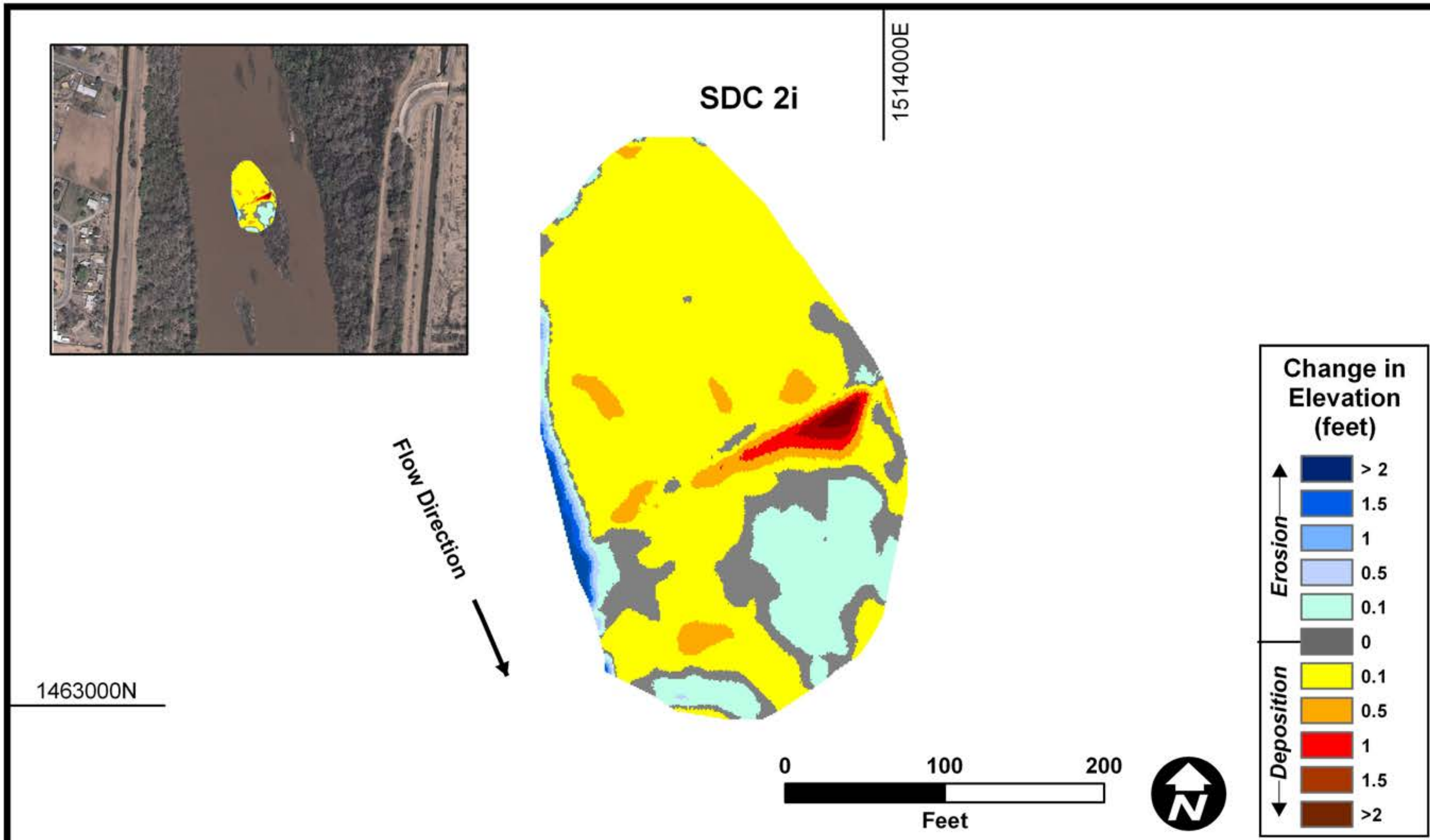

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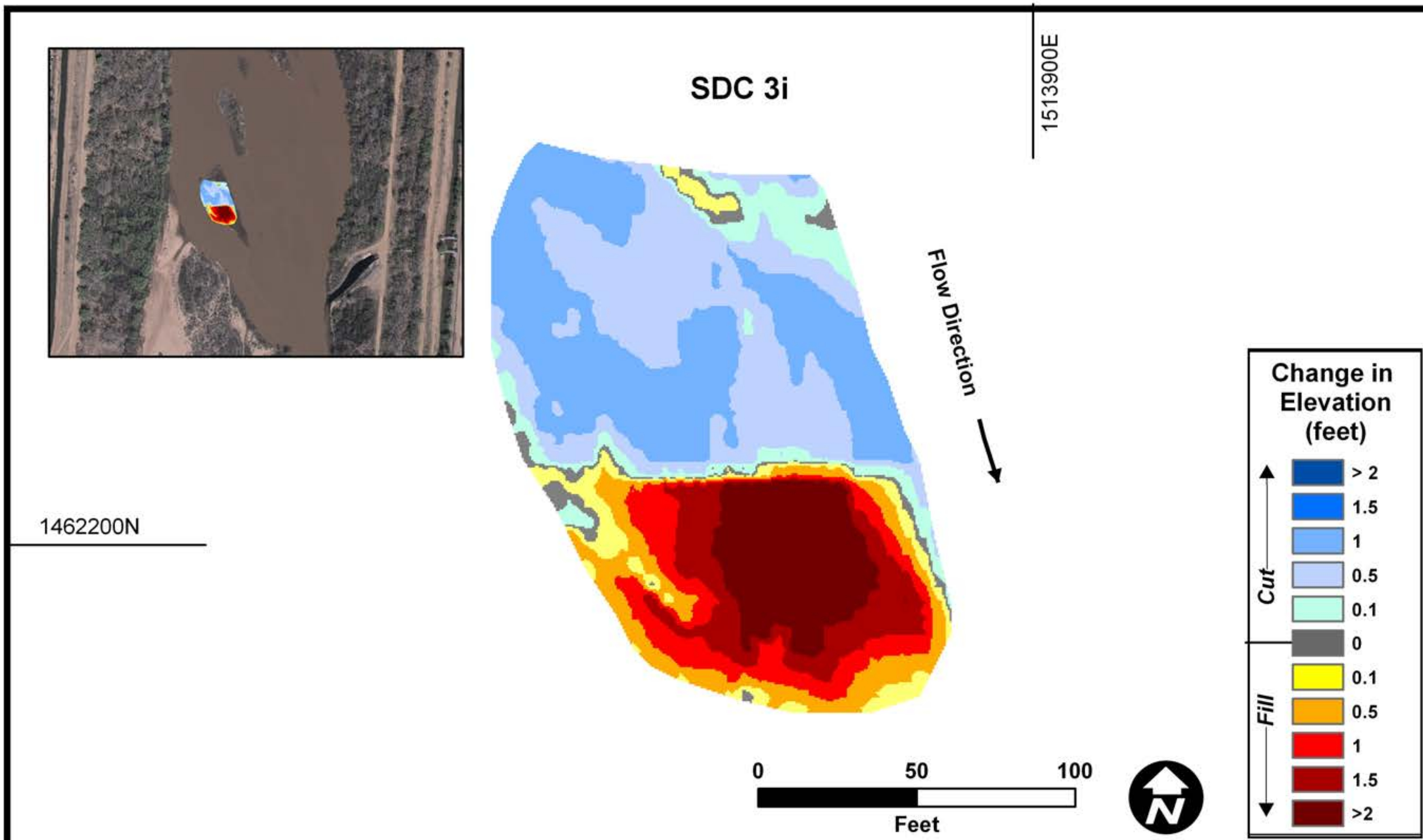

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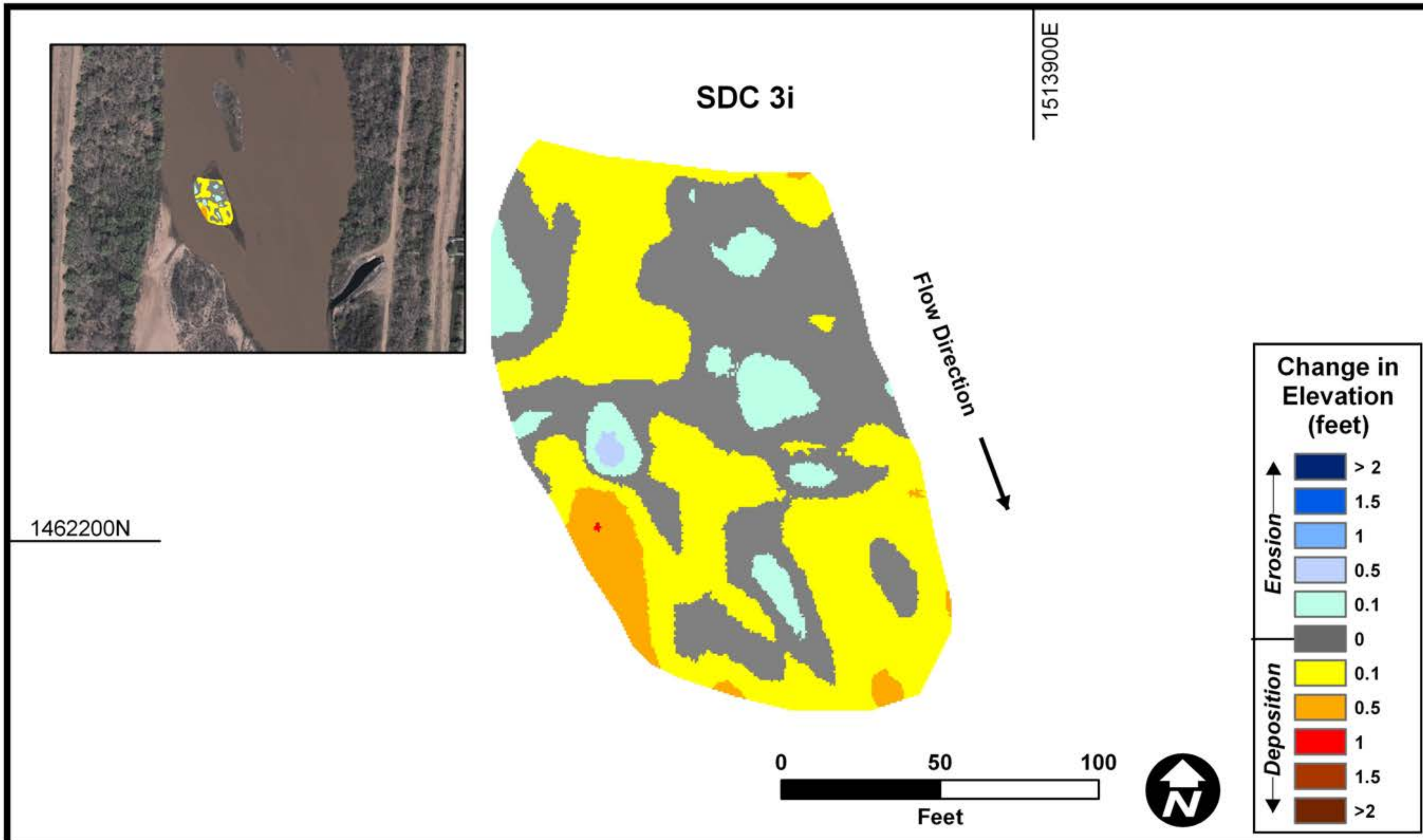

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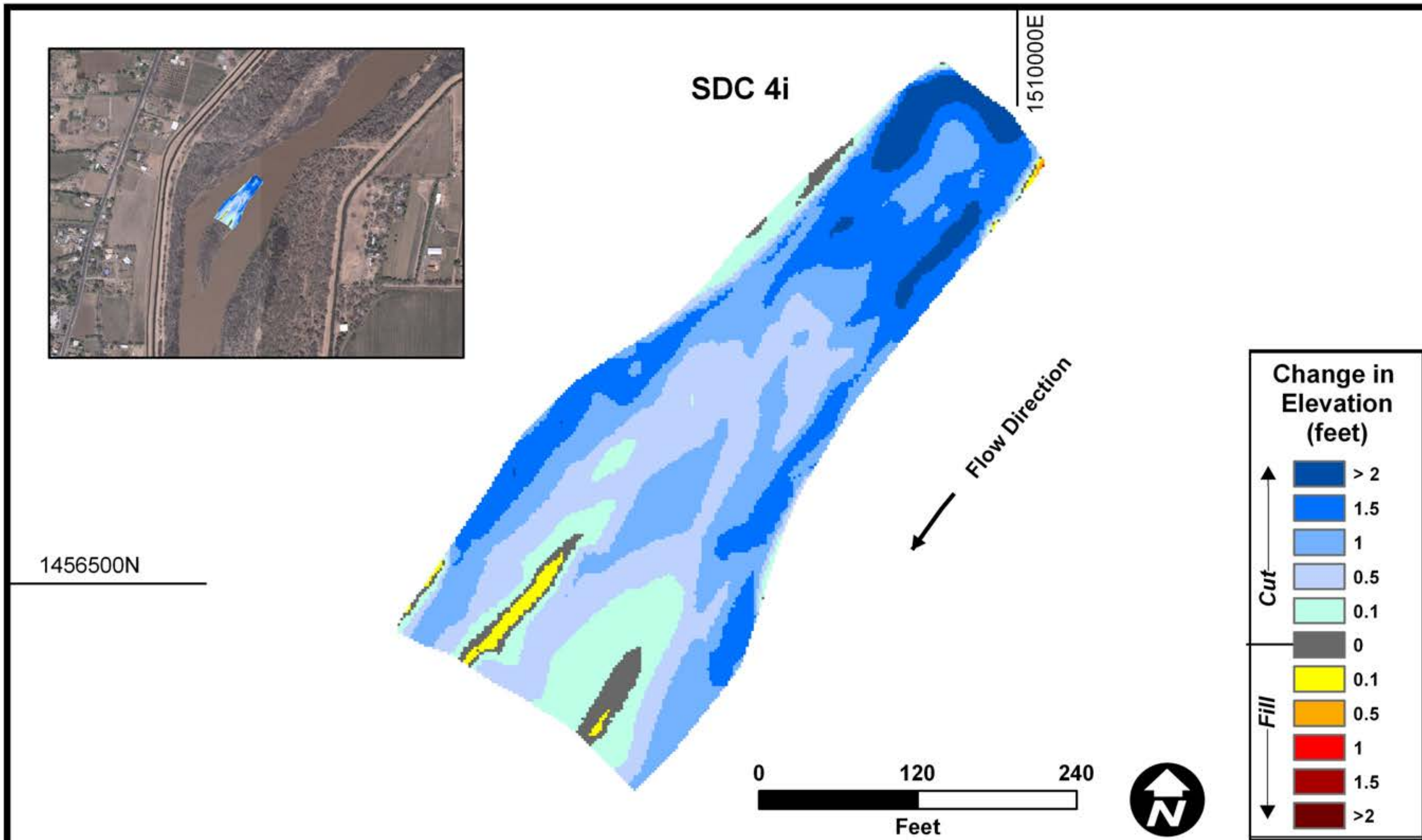

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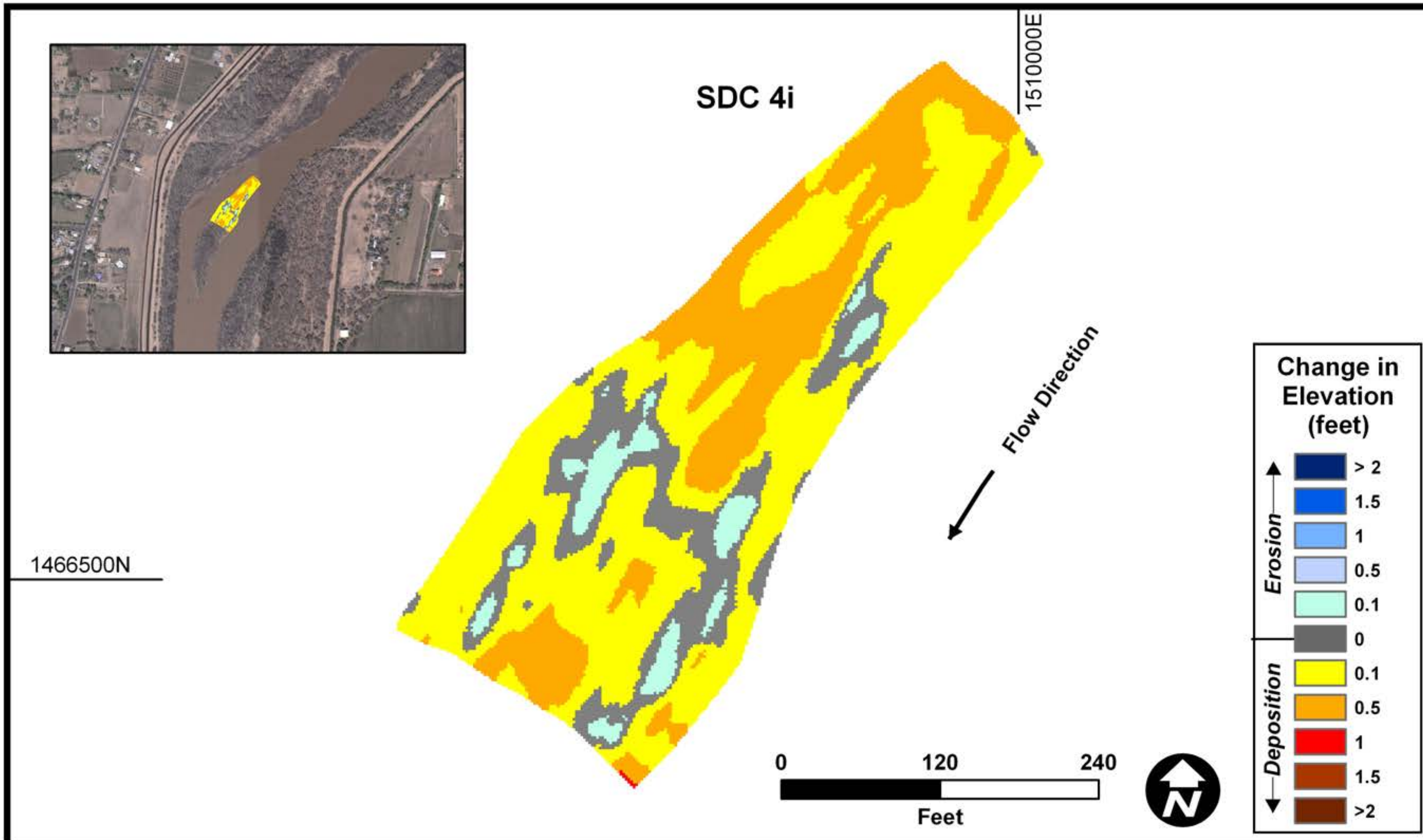

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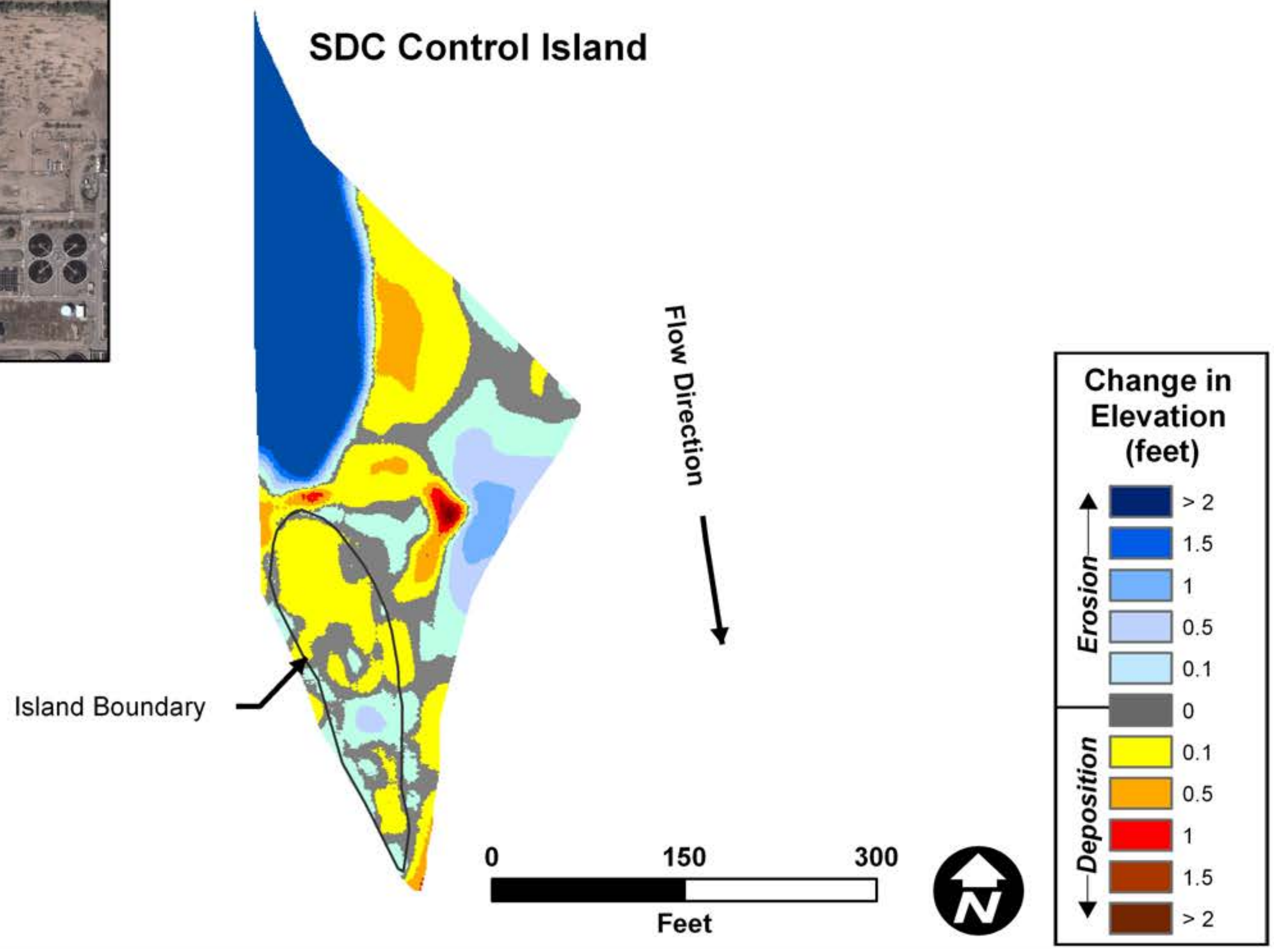

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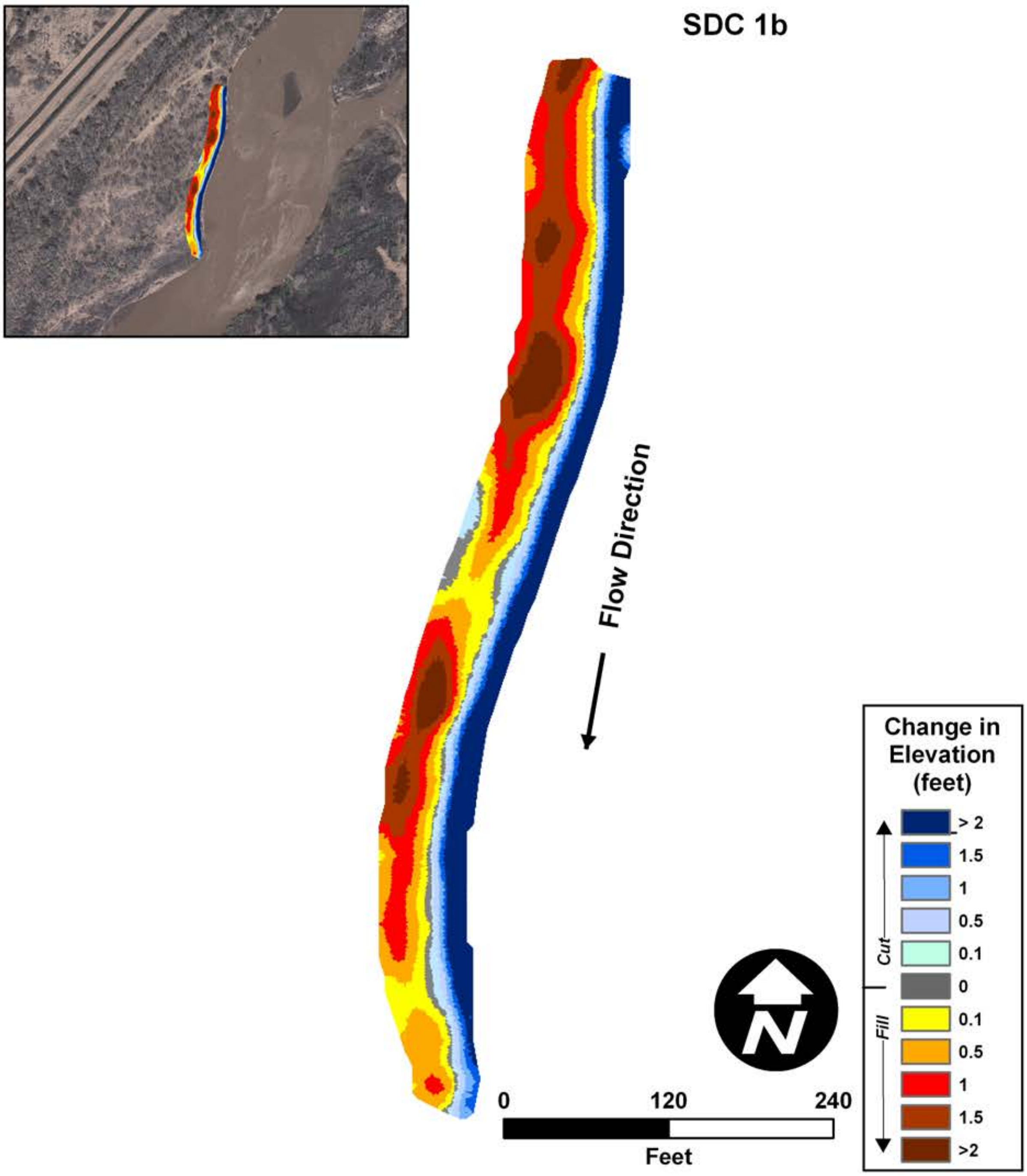

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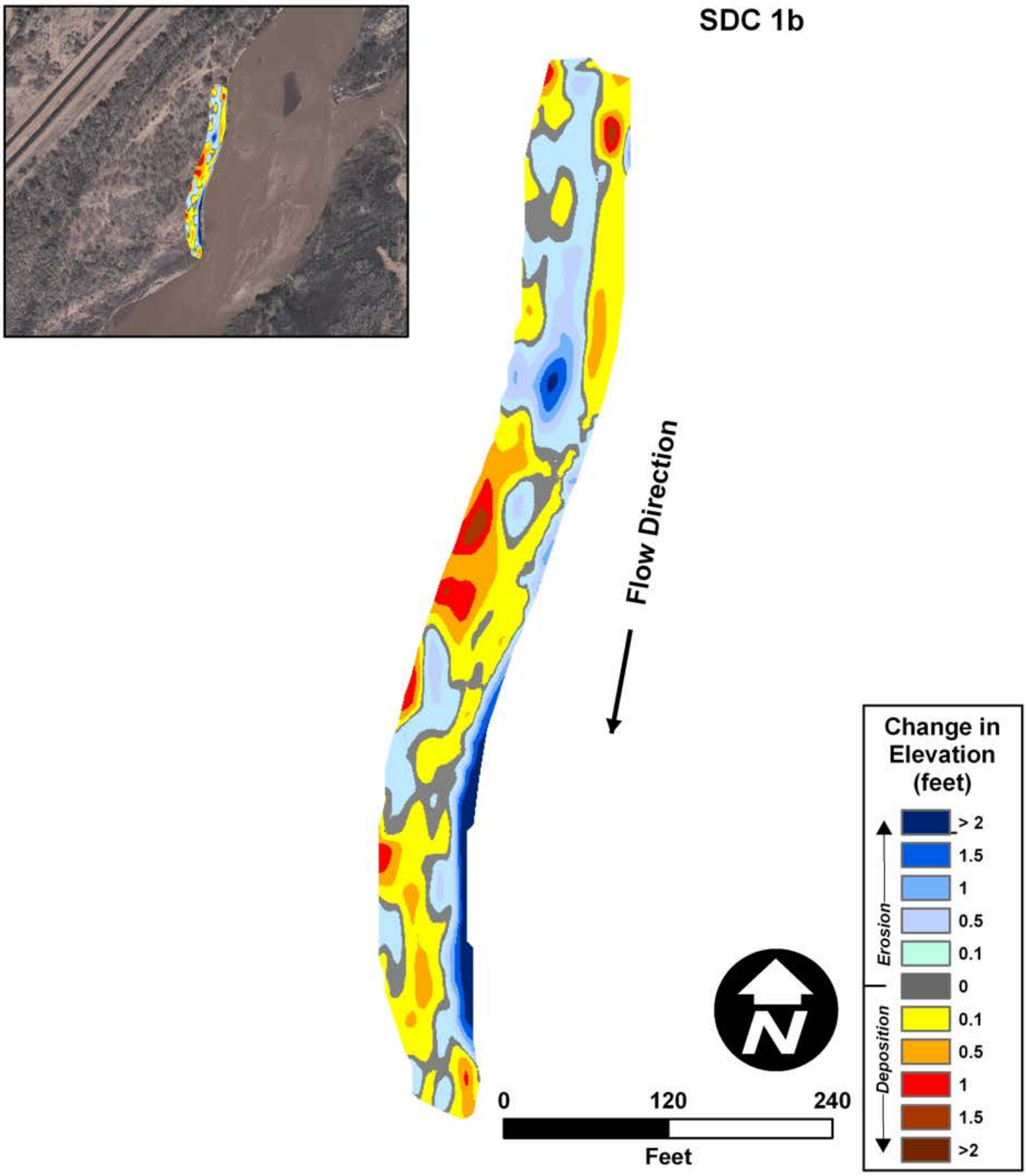

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