Middle Rio Grande Nursery Habitat Monitoring — 2008

Prepared for

U.S. BUREAU OF RECLAMATION, ALBUQUERQUE AREA OFFICE
555 Broadway N.E., Suite 100
Albuquerque, New Mexico 87102
Telephone: (505) 462-3540

Prepared by

SWCA ENVIRONMENTAL CONSULTANTS
5647 Jefferson Street N.E.
Albuquerque, NM 87109
Telephone: (505) 254-1115; Fax: (505) 254-1116
www.swca.com

Michael D. Hatch, M.S.
and
Eric Gonzales, M.S.

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Cover Photo

Photo of 38mm SL Rio Grande silvery minnow (*Hybognathus amarus*) by Michael Hatch, SWCA.

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EXECUTIVE SUMMARY

Surveys were conducted to reveal limiting factors that may underlie Rio Grande silvery minnow (*Hybognathus amarus*; silvery minnow) populations. We present an ecological characterization of fish species assemblages that include silvery minnow and that occur in isolated habitats lateral to running water in the main channel of the Middle Rio Grande. Some of these habitats conceivably represent nursery habitats for developing stages of young-of-year fish, although under circumstances of hydrologic scarcity, these habitats may also represent refugia for fish to escape mortality linked to diminishing surface water habitats. We offer a provisional description of how the faunal assemblages are structured by underlying physical and chemical features of their environment. Dispersal, environmental and biotic factors are presented as principal determinants of silvery minnow habitat occupancy. This description provides a context within which environmental, ecological, and other factors can be weighed against one another in formulating management goals, monitoring restoration progress, and measuring recovery of rare taxa.

Advancing pathways of ecological succession in the Middle Rio Grande result in increased fish species diversity with distance downstream. The number of fish reproductive guilds also increases with distance downstream, indicating the existence of a greater diversity of available ecological niches. We speculate that the rapid downstream increase in the number of reproductive guilds supported over the relatively short geographic distance spanned by the Albuquerque and Isleta reaches is attributable, in large part, to the natural restoration of successional stages of the river continuum that is disrupted upstream by the storage of water in Cochiti Reservoir.

Diminution in lateral connectivity of river channel-floodplain habitats has contributed significantly to a contemporary fish fauna that represents a depleted native species set compared to the historical fauna (Sublette et al. 1990). The uncoupling of river channel-floodplain habitats is a notable consequence of anthropogenic modification of the natural flow regime in the Middle Rio Grande, most importantly including the elimination of extreme high flow events. Compared to the early settlement hydrograph (pre-1931), the contemporary (post-1975) hydrograph is most profoundly characterized by reduced monthly average flow for April through June, and reduced monthly variation in flow.

River channel-floodplain coupling represents a plausible and attractive strategy to accommodate silvery minnow spawning and enhance retention and survival of eggs and larvae in upstream river segments. Understanding the links between species' fitness characters and habitat features is crucial for the effective management and restoration of running water ecosystems. Planning for the adequacy of conservation measures to overcome various habitat limitations ultimately requires that a quantitative relationship between habitat and population size be established for the species, and that sufficient habitat be maintained to meet an established recovery target based on the habitat-population relationship. For silvery minnow, this relationship, although unquantified, is known to vary profoundly by life stage and with varying hydrologic circumstances (Hatch et al. 2008). As such, habitat-population relationships will be complicated by the necessary consideration of age- or stage-specific estimates of survival (i.e., the fraction of the population that successfully recruits to the next age or life history stage) and separate relationships between habitat and abundance for each life stage over a representative range of hydrologic conditions. It is anticipated that study results will serve as an important basis for a planned approach to habitat restoration designed specifically to benefit multiple, consecutive life stages of the silvery minnow.

INTRODUCTION

Understanding the links between species' fitness characteristics and habitat features is crucial for the effective management and restoration of running water ecosystems. Planning for the adequacy of conservation measures to overcome various habitat limitations ultimately requires that a quantitative relationship between habitat and population size be established for the species, and that sufficient habitat be maintained to meet an established recovery target based on the habitat-population relationship. For the Rio Grande silvery minnow (*Hybognathus amarus*; silvery minnow), this relationship, although unquantified, is known to vary profoundly by life stage and with varying hydrologic circumstances (Hatch et al. 2008). As such, habitat-population relationships will be complicated by the necessary consideration of age- or stage-specific estimates of survival (i.e., the fraction of the population that successfully recruits to the next age or life history stage) and separate relationships between habitat and abundance for each life stage over a range of hydrologic conditions.

Knowledge of how habitat quality and quantity sequentially limit the abundance of different life stages is fundamental to the identification of habitat essential to species conservation. To be successful, management actions for the conservation of small animal populations, such as the silvery minnow, must generally strive to increase the intrinsic rate of population growth while simultaneously minimizing the between-generation variance of the rate of population growth to reduce the probability of species extinction.

The problems that managers face in the Middle Rio Grande primarily involve systems of interconnected components that are problematic, the effective resolution of which demands systems-level analysis and intervention. Priority management strategies should contribute to the enhancement of silvery minnow reproduction and recruitment, and serve to maintain critical source populations with sufficient parental stock to constitute viable populations.[1] These management purposes provide a structured context for organizing relevant information and for formulating and evaluating management alternatives for the conservation of the silvery minnow. The primary population processes of birth, death, immigration, and emigration represent leverage opportunities for directed management to achieve these management purposes. Efficient and effective strategies to enhance silvery minnow reproduction and recruitment will depend on the specific temporal and spatial circumstances. Key information needs for the conservation of species at risk include the determinants of habitat quality, knowing how to improve or provide

[1] A viable population has been defined as having a low probability of extinction within a specified time frame (Morris and Doak 2002) and large enough to maintain a specified effective population size (N_e), where effective size is a measure of the number of breeding individuals in an idealized population (Wright 1931; Crow and Kimura 1970). Relating population viability to effective size acknowledges the important role of effective size in minimizing inbreeding and maintaining genetic variance. Genetic variance is widely acknowledged to be necessary for adaptability and population persistence, and experiments show a clear linkage of adaptability and fitness with population size (Reed and Bryant 2000; Reed 2005). It is often cited that the maximum acceptable rate of loss of genetic diversity to avoid inbreeding depression is 1% per generation (Frankel and Soule 1981), which will occur on average with N_e equal to 50. However, Reed and Bryant (2000) found that even short-term population persistence required an N_e >50. Others have suggested that an N_e > 500 is necessary for a population to retain its adaptive potential (Franklin 1980). Theoretical assessments suggest that avoidance of long-term detrimental effects of mutation could require an N_e greater than 5,000 (Lande 1995; Lynch 1996), although it has been acknowledged that populations with an N_e > 1,000 can be viewed as genetically secure (National Research Council 2002).

these elements, and understanding quantitative effects of habitat quality on growth, abundance, and survival.

We present an ecological characterization of fish species assemblages that occur in isolated habitats lateral to running water in the main channel of the Middle Rio Grande. Some of these habitats conceivably represent nursery habitats for developing stages of young-of-year fish, although under circumstances of hydrologic scarcity they may also represent refugia for fish to escape mortality linked to diminishing surface water habitats. Consistent with an earlier study conducted by Hatch et al. (2008), we target lentic habitats that formed at the critical juncture in which flow in the river is reduced to the extent that isolated pools form. Although flow in the Middle Rio Grande became greatly reduced following the first week of July 2008 (approximately one week after the study was initiated), flow in the river remained continuous in time and space over the duration of the study. Most of the selected study pools are located in the active river channel, although an isolated floodplain pool is included in the study. This floodplain pool has an incipient hydrologic linkage to running water habitats of the main channel at approximately 3,200 cubic feet per second (cfs) as measured at the nearby Bosque Farms U.S. Geological Survey (USGS) gage. We also include two irrigation wasteways among study sites to determine if silvery minnow differentially occupy these lateral habitats compared to running water habitat of the main channel. The original scope of work also included a study element designed to document silvery minnow movement coincidental with diminishing flows that would result in channel drying. This study element was not conducted due to the persistent continuity of running water habitat throughout the Middle Rio Grande during 2008.

GENERAL HYDROLOGIC SETTING

A notable consequence of anthropogenic modification of the natural flow regime in the Middle Rio Grande is the elimination of extreme high flow events. Compared to the early settlement hydrograph (pre-1931), the contemporary (post-1975) hydrograph is characterized by reduced monthly average flow, most profoundly for April through June, and reduced monthly variation in flow. However, broad temporal patterns in the hydrologic regime have been retained over time. The highest hydrologic discharge events in the Middle Rio Grande have remained linked most predictably over time to snowmelt, the height of which generally occurs each year during May, but also occurs with high frequency as early as April and as late as June.

The periodicity and volume of high discharge events associated with runoff from monsoon rains is stochastic in nature and is therefore inherently less predictable than snowmelt-associated discharge. Whereas temporal aspects of snowmelt discharge have remained relatively predictable over time, the magnitude of snowmelt discharge was generally higher and more variable historically compared to the contemporary flow regime. Generally, average discharge in the Middle Rio Grande has diminished with increasing distance from headwater tributaries, predictably resulting in fish mortality as flows are frequently reduced to base discharge with attendant extremes in water quality and periodic cessation of flow over extensive reaches of river, especially outside of the influence of runoff from snowmelt and monsoonal rains (Baldwin 1938).

Traditional river engineering activities within the Middle Rio Grande have served to confine the river to its channel and isolate it from the adjacent floodplain for the purposes of preventing flooding and to remove water from catchments as soon as possible to, among other reasons, reduce depletions of water and drain water-saturated lands. The unaltered, natural flow regime of the Middle Rio Grande seasonally inundated floodplain habitats of the Middle Rio Grande, and thus provided increased habitat heterogeneity and refugia for young fish relative to the active channel. Many fish species native to low-gradient rivers are known to spawn on inundated floodplains, and the heightened productivity of these areas has been demonstrated to be important as nursery habitat (Copp 1989; Junk et al. 1989; Junk and Welcomme 1990; Galat et al. 2004; Valett et al. 2005; Pease et al. 2006). Although the importance of inundated floodplains to early life stages of many fish species that are adapted to potamon[2] ecosystems is generally acknowledged, the challenge remains to develop a mechanistic understanding of how observed silvery minnow demographic effects are influenced by inundated floodplain habitats. Knowledge of how silvery minnow and other fish species use nursery habitats, including those on the floodplain, is essential to guide habitat restoration efforts.

CONTEMPORARY HYDROLOGY

Sampling for fish occurred over the general period of June 24, 2008, through October 30, 2008. During this time, flow in the main channel of the Albuquerque Reach of the Middle Rio Grande dropped precipitously from a high of 5,080 cfs on June 10, 2008, to a low of 729 cfs on July 9, 2008, as measured at the Albuquerque USGS Gage # 08330000 (Figure 1). Low flow prevailed over the duration of the study beyond July 9, 2008, averaging 607.7 cfs (SD = 192.8; Figure 1).

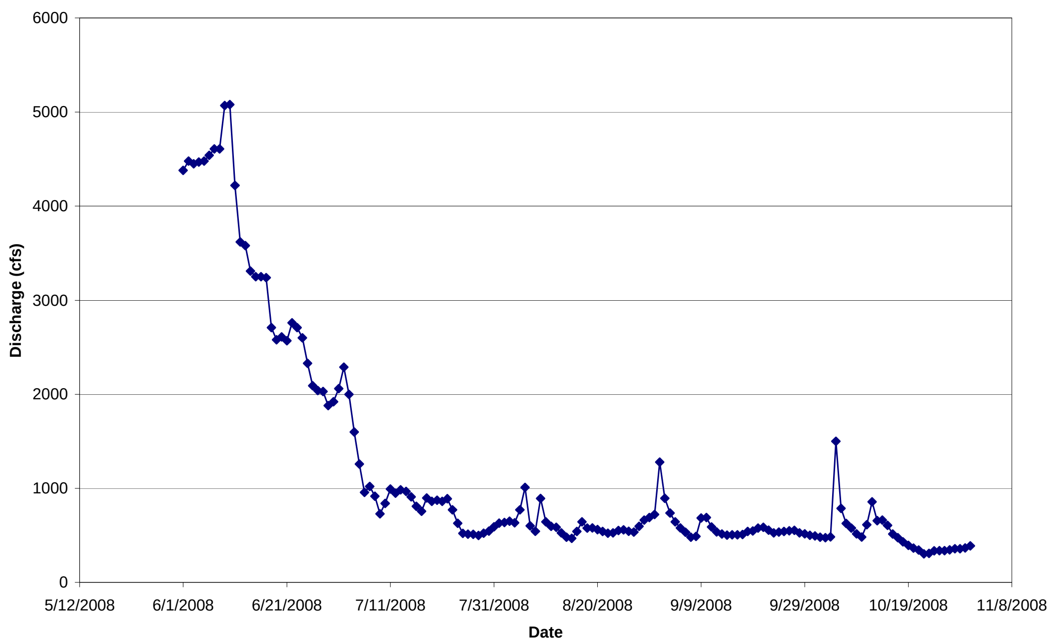

Figure 1. Discharge at Rio Grande at Albuquerque USGS Gage #08330000.

[2] *Potamon* refers to the warmer and lower gradient river of the lowlands. Unaltered, the potamon is characterized by slower currents, finer substrate materials, and variety of size, depth, and flow of the river channel, including large river channels, oxbows, sloughs, and habitats of the floodplain. Autochthonous inputs of organic materials support a preponderance of detritivores, herbivores, and planktivores.

Similar to the Albuquerque Reach, flow in the main channel of the Isleta Reach of the Middle Rio Grande dropped precipitously from a high of 5,020 cfs on June 10, 2008, to 415 cfs on July 10, 2008, as measured at the Bosque Farms USGS Gage #08331510 (Figure 2). Low flow prevailed over the duration of the study beyond July 10, 2008, averaging 286.3 cfs (SD = 207.5; Figure 2).

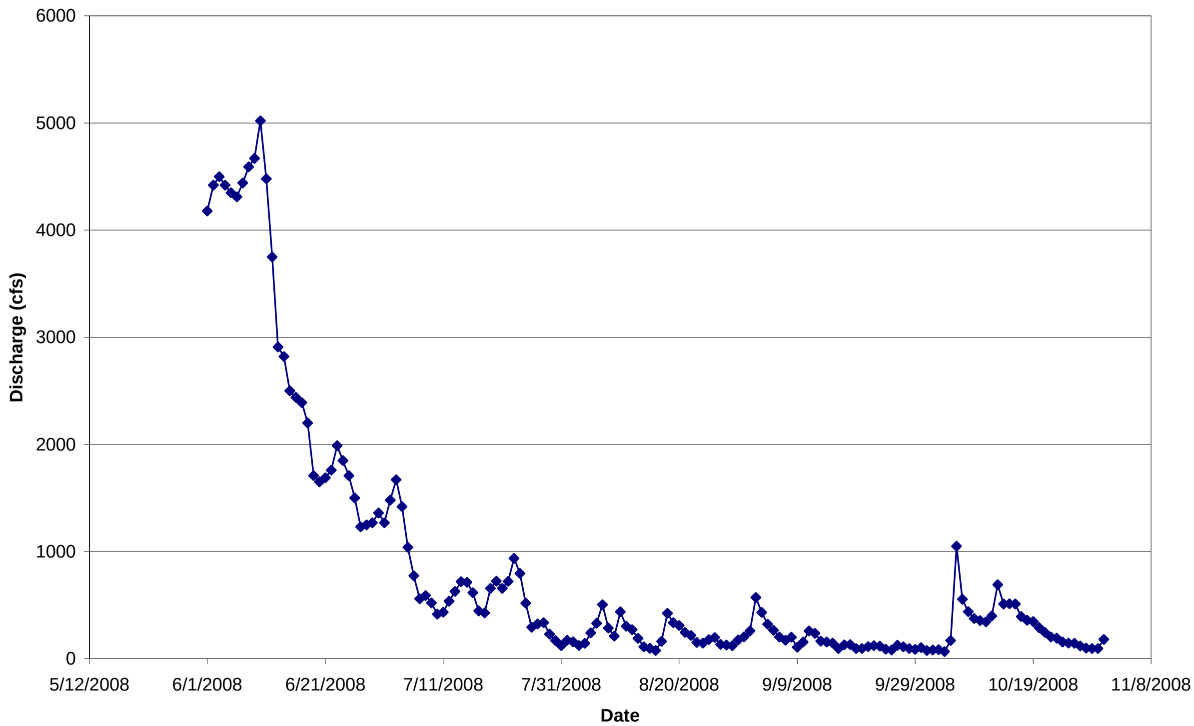

Figure 2. Discharge at Bosque Farms USGS Gage #08331510.

HISTORIC AND CONTEMPORARY FISH FAUNA

The contemporary fish fauna of the Middle Rio Grande is depauperate of native species and families. Absent from contemporary collections of fish from the Middle Rio Grande are species of the families Acipenseridae, Anguillidae, Characidae, Lepisosteidae, and Sciaenidae (Sublette et al. 1990). Large impoundment structures have precluded the upstream migration of the catadromous American eel (*Anguilla rostrata;* Anguillidae). The neotropical Mexican tetra (*Astyanax mexicanus;* Characidae), a peripheral occurrence in the Rio Grande of New Mexico (northern distributional limits), likely succumbed to events of channel drying coupled with cold temperatures in the 1950s (Sublette et al. 1990). Species of Acipenseridae, Lepisosteidae, and Sciaenidae are all large-bodied, main channel species. To the degree that deep perennial pools of the potamon were limiting, such forms would be disadvantaged in times of drought (relative to small-bodied species). Based on the chronology of fish collection records (Sublette et al. 1990), these species probably succumbed to channel drying events no later than the 1890s.

Within the contemporary range of the silvery minnow, collection records chronicle the loss of several native fish species of the families Catostomidae and Cyprinidae. Blue sucker (*Cycleptus elongatus)* and gray redhorse (*Moxostoma congestum*), two large-bodied, main channel catostomid species, were extirpated from the Rio Grande of New Mexico by the 1940s, after large-scale channel drying events and the advent of large-scale irrigation practices (Sublette et al. 1990).

Within the Rio Grande of New Mexico, three small-bodied, pelagic spawning species of Cyprinidae survived the drought of the 1950s, including bluntnose shiner (*Notropis simus*), speckled chub (*Macrhybopsis aestivalis*), and the silvery minnow. Bluntnose shiner and speckled chub persisted into the 1960s but were extirpated following water impoundment in Cochiti Reservoir (Sublette et al. 1990). There is no evidence that Rio Grande shiner (*Notropis jemezanus*) or phantom shiner (*Notropis orca*), two other native small-bodied, pelagic spawning species of Cyprinidae, survived in the Rio Grande of New Mexico beyond the late 1940s (Sublette et al. 1990).

Pooled samples from recent fish surveys, aggregated over multiple sampling methods, suggest that the contemporary fish fauna of the Albuquerque and Isleta reaches[3] of the Middle Rio Grande consists of 25 and 21, species respectively (Table 1). Table 1 represents pooled results from recent surveys composed variously of datasets provided by personnel of the Division of Fishes, Museum of Southwestern Biology, University of New Mexico; the American Southwest Ichthyological Research Foundation; and Hatch et al. (2008). Native (*n*) and nonnative (*e*) determinations follow Sublette et al. (1990). This table also presents the rank abundance of species from these pooled samples. The most abundant species was assigned a rank of 1, while subsequent species rank assignments increased with decreasing relative abundance. Dashes indicate species absence.

[3] For reference, the "Middle Rio Grande" is defined as the Rio Grande downstream from Cochiti Dam to Elephant Butte Reservoir. The Middle Rio Grande below Cochiti Dam is further separated into four reaches. The Cochiti Reach extends from Cochiti Dam to Angostura Diversion Dam. The reach from Angostura Diversion Dam to Isleta Diversion Dam is called the Albuquerque Reach. The Isleta Reach is bounded upstream by Isleta Diversion Dam and downstream by San Acacia Diversion Dam. The reach downstream of San Acacia Diversion Dam to the headwaters of Elephant Butte Reservoir is the San Acacia Reach.

Table 1. Rank Abundance of Fish Species of the Albuquerque and Isleta Reaches of the Middle Rio Grande

Family	Species	Common Name	Species Rank by Reach	
			Albuquerque	Isleta
Catostomidae	*Carpiodes carpio (n)*	river carpsucker	5	5
	Catostomus commersonii	white sucker	2	9
Centrarchidae	*Lepomis cyanellus (e)*	green sunfish	18	17
	Lepomis macrochirus (n)	bluegill	17	16
	Micropterus salmoides (n)	largemouth bass	15	15
	Pomoxis annularis (e)	white crappie	14	11
	Pomoxis nigromaculatus	black crappie	20	21
Clupeidae	*Dorosoma cepedianum (n)*	gizzard shad	19	13
Cyprinidae	*Campostoma anomalum*	central stoneroller	26	–
	Cyprinella lutrensis (n)	red shiner	1	1
	Cyprinus carpio (e)	common carp	11	6
	Gila pandora (n)	Rio Grande chub	25	–
	Hybognathus amarus (n)	Rio Grande silvery	4	3
	Pimephales promelas (n)	fathead minnow	6	4
	Platygobio gracilis (n)	flathead chub	7	8
	Rhinichthys cataractae (n)	longnose dace	8	10
Ictaluridae	*Ameiurus melas (e)*	black bullhead	16	18
	Ameiurus natalis (e)	yellow bullhead	10	12
	Ictalurus punctatus (e)	channel catfish	9	7
Percichthyidae	*Morone chrysops (e)*	white bass	12	14
Percidae	*Perca flavescens (e)*	yellow perch	13	19
	Sander vitreum (e)	walleye	21	20
Poeciliidae	*Gambusia affinis (e)*	Western mosquitofish	3	2
Salmonidae	*Oncorhynchus mykiss (e)*	rainbow trout	23	–
	Salmo trutta (e)	brown trout	22	–

METHODS

FISH AND ENVIRONMENTAL QUALITY SURVEYS

Fish were collected with a 3.7 × 1.2–m seine (0.476-cm delta mesh) and with a D-frame kick net (0.0428 m² opening fitted with 0.2-mm mesh Nytex netting) from nursery habitat sites. The D-frame kick net was used when a monitoring site was too shallow or heavily vegetated to effectively seine. The seine was used to collect fish from wasteway sites on all sampling days. Fish sampling was conducted to assess silvery minnow presence or absence and to assess fish species relative abundance at each site.

Post-larval fish species were identified in the field utilizing taxonomic keys provided in Sublette et al. (1990); phylogenetic classification followed Nelson et al. (2004). Species counts were maintained for all collections. Standard length[4] (+/-mm) was recorded for all captured silvery minnow. Detailed records of fish collections appear in Appendices A-D). Silvery minnow mortality was quantified and preserved for eventual museum accession. After processing, all live fish were released at the site of capture.

Water quality parameters were monitored concurrent with fish sampling at nursery habitat and wasteway sites. Water quality parameters were measured using a YSI 556 multiparameter handheld meter, including temperature (degrees Celsius [°C]), dissolved oxygen (parts per million [ppm]), conductivity (microsiemens per centimeter [μS/cm]), salinity (parts per thousand [ppt]), turbidity (NTU), and hydrogen ion concentration (pH). Water depth (m) and flow velocity (meters per second [m/s]) were measured using a USGS top-setting wading rod fitted with a Marsh-McBirney Flo-Mate portable flow meter. Hobo event loggers were used to obtain hourly records of water temperature at each nursery habitat location, at one adjacent main channel location, and at each wasteway. Detailed water quality and water temperature data appear in Appendices E and F respectively). A series of bivariate plots of all monitored environmental variables appears in Appendix G. USGS stage gages located at Central Bridge in the Albuquerque Reach (#08330000) and near Bosque Farms in the Isleta Reach (#08331510) were used to the assess river discharge over the sampling period (see Figure 1 and Figure 2).

Maps depicting features at sample site locations were created using ArcGIS 9.x (Appendix H). A digital camera was employed for all photo documentation (Appendix I). A relational database (Microsoft Access) and a spreadsheet database (Microsoft Excel) were developed for the storage, analysis, and retrieval of fish survey data. The database incorporated a hierarchical structure that allowed aggregations of data over multiple scales of time and space, and phylogenetic and ecologic ordering. So long as observations are recorded at the finest practical scale of a hierarchy, aggregation of data by progressively coarser scales is always possible, but the converse is never possible.

[4] Standard length is defined as the distance from the anteriormost projection of the head to the hypural notch; the hypural notch is the point between the end of the body vertebrae and the beginning of the caudal fin, generally denoted as the crease in the caudal peduncle made by bending the caudal fin to one side or the other.

REPRODUCTIVE GUILDS

We assigned fish species to one of nine reproductive guilds[5] that represent a synthesis of embryonic development and adult spawning behavior, along with additional multiple aspects of life history fundamental to species survival. The approach we employ is adopted from a strategy employed by Hatch et al. (in prep) that in turn is modified from Balon (1975, 1987). These reproductive guilds form a hierarchy of specializations in reproductive patterns, beginning with three major categories regarding the degree of parental care: (1) nonguarders, (2) guarders, and (3) livebearers. Each of these is subdivided according to aspects of spawning location, preferred or required substrate, and egg development. Nonguarders include fishes that abandon eggs that are scattered over open substratum or buried in redds. Guarders provide parental care to incubating eggs and larvae and either choose some natural substratum on which to deposit eggs or they construct some artificial substratum or redd. Reproduction in livebearers is substrate independent.

SITE SELECTION

One isolated floodplain pool, four main channel lateral pools, and two irrigation wasteways were selected as survey sites. Two isolated floodplain pools were located in the Albuquerque Reach, and all other sample sites were located in the Isleta Reach (Figure 3). Scouting surveys were conducted in each river reach to identify potential lateral nursery habitats and to judge the expected longevity that surface water would persist at individual sites. Most candidate sites visited during scouting surveys were dry or nearly dry, and were therefore not chosen for monitoring. The relative scarcity of suitable monitoring sites is a consequence of the rapid decline in discharge that occurred during June 2008 (see Figure 1 and Figure 2).

In the Albuquerque Reach, two nursery habitat sites were selected for monitoring, one on the west side of the river near the Calabacillas Arroyo (Calabacillas) at river mile (RM) 191.3, and one located on the east side of the river near Interstate 40 (I-40 Restoration Bar) at RM 184.7 (see Figure 3). The Calabacillas site was monitored weekly for five weeks beginning on June 25, 2008, and ending on July 31, 2008. The I-40 Restoration Bar dried rapidly and was sampled only once on June 25, 2008.

[5] A guild is defined as a group of species that exploit a resource in a similar fashion and that can take over each other's functional roles in an ecosystem.

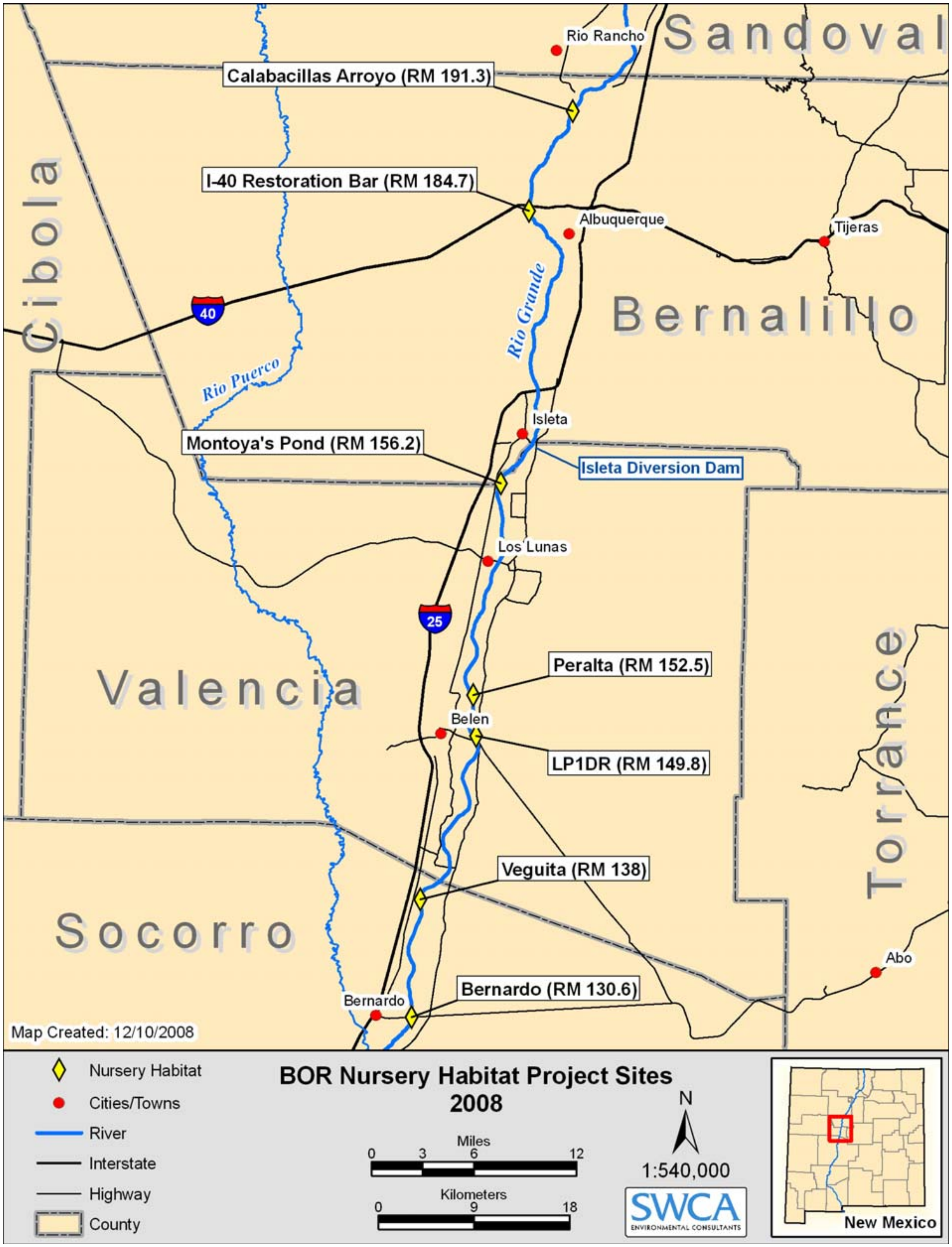

Figure 3. Overview map of nursery habitat and wasteway sites selected for monitoring.

In the Isleta Reach, three sites lateral to running water habitat of the main channel and two irrigation wasteways sites were selected for monitoring. Monitoring sites included (listed in geographic order from north to south) a site on the east side of the Middle Rio Grande near the southern boundary of the Isleta Pueblo at RM 156.2 near the levee road (Montoya's Pond), one near Veguita (Veguita) on the east side of the river at RM 138, and one near U.S. 60 Bridge (Bernardo) on the west side of the river at RM 130.6. Montoya's Pond was monitored weekly from June 24 to August 13, 2008, and bi-weekly from August 27 to October 30, 2008. Veguita was monitored weekly from June 24 to July 10, 2008, until drying occurred. The Bernardo site dried rapidly and was only monitored on July 2, 2008. Lastly, the Peralta Main Wasteway (Peralta) (RM 152.4) and the Lower Peralta Drain (LP1DR) (RM 149.8) were monitored weekly from July 10 to August 13, 2008, and bi-weekly from August 27 to October 30, 2008. Maps of all sample sites appear in Appendix G.

Incipient inundation of the floodplain pool (Montoya's Pond) occurred at about 3,200 cfs, beginning on approximately April 1, 2008, and it retained wetted surface habitat beyond the last day of sampling on October 30, 2008 (spanning a period of about seven months). Although the four main channel lateral pools had a much lower incipient level of inundation, they possessed limited capacity to maintain wetted surface habitat, varying from one to six weeks.

RESULTS

FISH COMMUNITY MONITORING

LONGITUDINAL FAUNAL PATTERNS

Table 2 presents the relative abundance and percent composition of fish species observed during sampling for each river reach. As would be predicted by ecologic theory (e.g., Vanotte et al. 1980), the Isleta Reach, the most downstream study reach, supported the most diverse ichthyofauna. A total of 16 fish species were observed in lateral pools of the Isleta Reach while only eight species were observed in the Albuquerque Reach (see Table 2 and Appendix B).

Although fish species composition varied over time and space (Appendix A), maximum species diversity in main channel lateral pools was restricted to eight and seven species at Calabacillas and Veguita, respectively (Appendix C). Five species were found at the I-40 and Bernardo sites (Appendix C). Only three species were found at the single floodplain pool in our sample (i.e., Montoya’s Pond). These relatively low proportions of the regional species pools in the Albuquerque and Isleta reaches (see Table 1) suggests a restricted influence of regional diversity on the fish fauna of lateral pools in the main channel and in pools of the floodplain. Species occupation of the floodplain appears to depend significantly on annual species-specific reproduction cycles and high flows that serve to facilitate dispersal of advanced life stage fish. Whereas high flows of the Middle Rio Grande are disruptive and serve to disperse fish, lateral habitats offer velocity refuges that can operate to moderate this effect.

Table 2. Relative Abundance of Fish Species by River Reach

Species	River Reach			
	Albuquerque		Isleta	
Ameiurus melas	–	–	15	(1.02)
Carpiodes carpio	–	–	15	(1.02)
Catostomus commersonii	210	(16.92)	20	(1.36)
Cyprinella lutrensis	178	(14.34)	264	(18.00)
Cyprinus carpio	399	(32.15)	83	(5.66)
Gambusia affinis	15	(1.21)	600	(40.90)
Hybognathus amarus	100	(8.06)	274	(18.68)
Ictalurus punctatus	–	–	21	(1.43)
Lepomis cyanellus	–	–	8	(0.55)
Lepomis macrochirus	–	–	7	(0.48)
Micropterus dolomieu	–	–	1	(0.07)
Micropterus salmoides	–	–	4	(0.27)
Pimephales promelas	330	(26.59)	140	(9.54)
Platygobio gracilis	8	(0.64)	3	(0.20)
Pomoxis annularis	–	–	12	(0.82)
Sander vitreum	1	(0.08)	–	–

Note: Percent by river reach given parenthetically. Dashes indicate species absence.

Silvery minnow was the fifth most abundant species encountered in the Albuquerque Reach, and the second most common species encountered in the Isleta Reach. Table 3 chronicles changes in the relative abundance of silvery minnow at each site and over the duration of monitoring. Dispersal constraints (behavioral or physical) are the primary determinants of silvery minnow occupancy. Obviously, pool isolation represents a physical constraint to fish dispersal. Environmental constraints are secondary determinants of silvery minnow occupancy. The duration of lateral pool occupancy by silvery minnow varies inversely with increasing levels of environmental constraints that generally pertain to environmental stability. Lastly, biotic constraints are considered tertiary determinants of silvery minnow occupancy. Sites with a longer record of silvery minnow occupancy theoretically would be less burdened by biotic constraints (i.e., predation and competition).

Among the lateral pools monitored during this study, Montoya's Pond, the single isolated pool in the floodplain, exhibited conditions most conducive to silvery minnow survival over the period of observation. However, habitat at that site became severely diminished by the end of the study, making it unlikely that fish will be able to survive at that site through the approaching winter. Although the record of water temperatures is fragmented over time and space (Appendix E),[6] we can synthesize from the available information that water temperatures in Montoya's Pond through July were vastly cooler than the temperatures at the other sample sites, especially compared to main channel temperature records (Appendix E). Low-growing willows that occupy the floodplain pool at Montoya's Pond provide an element of cover and a degree of environmental stability by effectively reducing the amount and duration of solar radiation that reaches the pool. We also speculate that the cooler temperatures are partially attributable to a cooling effect from a hyporheic source of water.

Water temperatures in Montoya's Pond increased during August 2008, exceeding the water temperatures for the same period in the irrigation wasteways, the only other lateral habitats that were still being monitored at that time. During this period, Montoya's Pond experienced precipitous reductions of water depth and water surface area. Such diminution of habitat would be expected to result in diel cycles of mortality-causing water quality. Diel fluctuations in dissolved oxygen and alkalinity, which have been noted for other floodplain pools (Hatch et al. 2008), are logically associated with the effects of photosynthesis. Our collection records chronicle a precipitous drop in silvery minnow relative abundance at Montoya's Pond during this time of limiting environmental conditions (see Table 3). Diminution of pool depth and areal coverage of surface water was accompanied by mortality-causing conditions of low dissolved oxygen and high water temperatures (Appendices D and E). We speculate that competition due to severe crowding may have operated synergistically with environmental constraints to reduce species abundance in Montoya's Pond.

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[6] The record of water temperature is inconsistent across study sites (Appendices D and E) due primarily to temporal and spatial variation in the areas targeted for monitoring, including variable water elevations, and wetted surface area that contracted over summer months, often resulting in site desiccation.

Table 3. Temporal Changes in Rio Grande Silvery Minnow Relative Abundance

Albuquerque Reach		
Site	**Date**	**Number Observed**
Calabacillas	25-Jun-08	2
	8-Jul-08	41
	15-Jul-08	30
	22-Jul-08	21
	31-Jul-08	0
I-40 Habitat Restoration Site	25-Jun-08	6
Isleta Reach		
Site	**Date**	**Number Observed**
Montoya's Pond	24-Jun-08	50
	9-Jul-08	52
	15-Jul-08	50
	22-Jul-08	69
	31-Jul-08	17
	07-Aug-08	0
	13-Aug-08	1
	27-Aug-08	6
	18-Sep-08	0
	30-Sep-08	5
	13-Oct-08	2
	30-Oct-08	2
Peralta Wasteway	10-Jul-08	0
	15-Jul-08	1
	22-Jul-08	1
	31-Jul-08	0
	13-Oct-08	2
	07-Aug-08	0
	13-Aug-08	0
	27-Aug-08	0
	18-Sep-08	0
	30-Sep-08	0
	30-Oct-08	0
Veguita	24-Jun-08	16
	02-Jul-08	0
	10-Jul-08	0

Table 4 presents an ecological perspective of survey results. The relative abundance and percent composition of fish species observed are aggregated by reproductive guilds for each river reach. As would be predicted from ecologic theory (e.g., Vanotte et al. 1980), the most downstream study reach supported the fauna with the most diverse reproductive needs. These results are consistent with the results presented by Hatch et al. (in prep).

The species encountered in the lateral pools of each reach, especially the more common species, are eurytopic—as a group they are habitat generalists. Although habitat sensitive, stenoecious fish species exist as faunal elements of the contemporary reach-specific pool of species (see Table 1), these species were not observed in the lateral pools that were surveyed. Nonetheless, nonrandom patterns of species distribution were distinguishable among the lateral pool fish fauna on the basis of reproductive guild (see Table 4). Phytophils, spelenophils, lithophils, and pelagophils dominated the species observed in the lateral pools of the Albuquerque Reach (listed in descending order of relative abundance). In contrast, livebearers, phytophils, pelagophils, and spelenophils represented the most abundant fractions of the Isleta Reach fish fauna (again, listed in descending order of relative abundance). Phyto-epipilophils, polyphils, and psammophils were conspicuously absent from lateral pools in the Albuquerque Reach; species of these guilds existed at intermediate levels of abundance in the Isleta Reach (see Table 4).

Table 4. Relative Abundance of Fish Species Aggregated by Reproductive Guild and River Reach

Reproductive Guild	River Reach	
	Albuquerque	Isleta
Litho-pelagophils (Nonguarding, brood hiding, rock and gravel spawner with pelagic larvae)	1	–
Lithophils (Nonguarding, brood hiding, rock and gravel spawner)	218	54
Livebearers (Substrate independent, obligate lecithotrophic livebearers)	15	600
Pelagophils (Nonguarding, open substrate pelagic spawner)	100	274
Phyto-epipilophils (Guarding, plant material and/or mud nesting spawner)	–	4
Phytophils (Nonguarding, open substrate plant spawner)	577	347
Polyphils (Guarding, miscellaneous substrate and material nesters)	–	12
Psammophils (Nonguarding, open substrate sand spawner)	–	15
Spelenophils (Guarding, hole nesting spawner)	330	161

Note: Reproductive guild classification adapted from Balon (1975, 1987). Dashes indicate guild absence.

Lateral Faunal Patterns

Floodplain Pools

Table 5 presents the relative abundance and percent composition of fish species observed in each lateral habitat type, including floodplain pools, main channel lateral pools, and irrigation system wasteways. Only three species, each representing its own reproductive guild (Table 6) and each representing eurytopic habitat generalists, were observed in our samples from the single floodplain pool selected for sampling, i.e., Montoya's Pond. Patterns of community composition indicate that fauna-environment interactions of the Middle Rio Grande floodplain favor colonizing species.[7]. Furthermore, collections of Western mosquitofish (*Gambusia affinis*), silvery minnow, and common carp (*Cyprinus carpio*) at these sites were generally composed of young-of-year fish, suggesting that their existence in isolated floodplain pools is the result of recent floodplain spawning.

[7] Colonist species are distinguished as fast growing opportunists. There is no parental care. Species quickly take advantage of intervals of more favorable growth and are generally tolerant of high-frequency disturbance.

Table 5. Relative Abundance and Percent Composition of Fish Species by Habitat Type

Habitat	Species	Number Observed	Percent Composition by Habitat
Floodplain Pool			
	Gambusia affinis	259	47.44
	Hybognathus amarus	254	46.52
	Cyprinus carpio	33	6.04
Irrigation Wasteway			
	Cyprinella lutrensis	254	51.42
	Gambusia affinis	124	25.10
	Cyprinus carpio	23	4.66
	Ictalurus punctatus	21	4.25
	Catostomus commersonii	15	3.04
	Carpiodes carpio	14	2.83
	Pomoxis annularis	12	2.43
	Lepomis cyanellus	8	1.62
	Lepomis macrochirus	7	1.42
	Hybognathus amarus	4	0.81
	Micropterus salmoides	4	0.81
	Pimephales promelas	3	0.61
	Platygobio gracilis	3	0.61
	Ameiurus melas	1	0.20
	Micropterus dolomieu	1	0.20
Main Channel Lateral Pool			
	Pimephales promelas	467	28.00
	Cyprinus carpio	426	25.54
	Gambusia affinis	232	13.91
	Catostomus commersonii	215	12.89
	Cyprinella lutrensis	188	11.27
	Hybognathus amarus	116	6.95
	Ameiurus melas	14	0.84
	Platygobio gracilis	8	0.48
	Sander vitreum	1	0.06
	Carpiodes carpio	1	0.06

Table 6. Relative Abundance of Fish Species Aggregated by Reproductive Guild and Habitat Type

Reproductive Guild	Habitat Type		
	Floodplain Pool	Irrigation Wasteway	Main Channel Lateral Pool
Litho-pelagophils (Nonguarding, brood hiding, rock and gravel spawner with pelagic larvae)	–	–	1
Lithophils (Nonguarding, brood hiding, rock and gravel spawner)	–	35	237
Livebearers (Substrate independent, obligate lecithotrophic livebearers)	259	124	232
Pelagophils (Nonguarding, open substrate pelagic spawner)	254	4	116
Phyto-epipilophils (Guarding, plant material and/or mud nesting spawner)	–	4	–
Phytophils (Nonguarding, open substrate plant spawner)	33	277	614
Polyphils (Guarding, miscellaneous substrate and material nesters)	–	12	–
Psammophils (Nonguarding, open substrate sand spawner)	–	14	1
Spelenophils (Guarding, hole nesting spawner)	–	24	467

Note: Reproductive guild classification adapted from Balon (1975, 1987). Dashes indicate guild absence.

Importantly, silvery minnow were relatively more abundant in the isolated floodplain pool than in any other lateral pool surveyed. Also noteworthy is their survival in Montoya's Pond nominally from May through some point beyond October 2008 (minimally, a period of six months). The results of this study, coupled with those reported by Buhl (2006), suggest that the silvery minnow is physiologically flexible—capable of surviving absolute extremes and diel fluctuations in chemical and physical conditions (Appendix D). Short of complete or near desiccation of habitat, the silvery minnow exhibits a capacity to withstand the wide variety of environmental conditions common to the monitored pools over the periods of observation. Whereas the survival of silvery minnow in a floodplain pool over a minimal period of six months is noteworthy, the reader is reminded that these events alone do not serve to increase the rate of silvery minnow population growth, nor do they serve to minimize the between-generation variance of the rate of population growth that effectively would reduce the probability of species extinction. Minimal sustained duration of river channel-floodplain coupling is essential to allow silvery minnow adults a chance to occupy the floodplain and spawn, to allow time for embryo development and hatching, and finally to allow sufficient time for young-of-year silvery minnow development to at least the juvenile stage to effectively enable fish to evacuate draining floodplain habitats. Higher levels of recruitment can be expected with longer periods of sustained floodplain inundation.

We surmise that, while adult silvery minnow may have spawned on the floodplain while it was confluent with running water habitats of the main channel, they evacuated the floodplain as flow receded, leaving developing eggs and larvae of recently spawned fish stranded in isolated pools of the floodplain. Presumably, a similar sequencing of reproductive events would account for the existence of other young-of-year oviparous fish species in the isolated floodplain pool. The sequencing of events accounting for the presence of Western mosquitofish in the floodplain pool is more equivocal because that species could have spawned in floodplain pool after it became isolated from the river.

Often overlooked or discounted in dictating patterns of species diversity is time, both in duration and in temporal sequence. Isolated lateral habitats offer a temporal reference for observed phenomena because they generally have a relatively well-defined hydrological, and hence, chronological record. The absence of some other fish species in isolated floodplain pools is likely the result of a timing mismatch of floodplain inundation and fish spawning.

Main Channel Lateral Pools

Ten fish species were represented in main channel lateral pools (see Table 5). Although fish species composition varied over time and space, maximum species diversity in main channel lateral pools was restricted to eight and seven species at Calabacillas and Veguita, respectively; five species were found at the I-40 and Bernardo sites (Appendix C). Collectively, fathead minnow (*Pimephales promelas*), common carp, Western mosquitofish, white sucker (*Catostomus commersonii*), and red shiner (*Cyprinella lutrensis*) comprised 91.61 percent of the fish species collected in main channel lateral pools. Aside from walleye (*Sander vitreum*), species encountered in the main channel lateral pools are eurytopic. The presence of the white sucker (a rock and gravel spawner) in floodplain habitats of the Rio Grande potamon is regarded as adventitious—its presence or absence is not likely to have a significant ecological consequence, especially given its low relative abundance. Significantly, the contemporary hydrologic disturbance regime of the Middle Rio Grande appears to disadvantage nest-guarding lithophils, which serves to reduce the diversity and abundance of predatory fish species.

Although habitat sensitive stenoecious fish species exist as faunal elements of the contemporary reach-specific pool of species (see Table 1), these species were not found in the main channel lateral pools that were surveyed. The fish fauna of main channel lateral pools was dominated by phytophils and spelenophils, lithophils, and livebearers (see Table 6Error! Reference source not found.). Of the seven reproductive guilds represented in our samples of main channel lateral pools, pelagophils, represented solely by the silvery minnow, is the fifth most abundant reproductive guild, suggesting that the characteristics of the main channel lateral pools were not especially attractive to the silvery minnow (see Table 6**).**

Irrigation Wasteways

Fifteen fish species were represented in irrigation wasteway samples (see Table 5). Although fish species composition varied over time and space, maximum species diversity in main channel lateral pools was restricted to 13 species in the Peralta Wasteway and 12 species in the Lower Peralta Drain (Appendix C). Differences in species composition and relative abundance could be attributed to the different relative effects of conveyance-return versus drain-return irrigation canals (Cowley et al. 2007). Collectively, red shiner, Western mosquitofish, common carp, and channel catfish (*Ictalurus punctatus*) comprised 85.43 percent of the fish species collected in irrigation wasteway samples. Silvery minnow represented a small fraction (less than one percent) of the irrigation wasteway samples. In contrast, Cowley et al. (2007) found silvery minnow to be the fifth most abundant species in the canal system from samples collected in 2004, a time when irrigation system return flow represented a greater portion of the flow in the main channel. They also point out that species composition varies greatly by season, which likely accounts for the differences in our samples.

The fish fauna of irrigation wasteway samples was dominated by phytophils and livebearers (see Table 6). Of the eight reproductive guilds represented in our samples of main channel lateral pools, pelagophils, represented solely by the silvery minnow, tied with phyto-epipilophils, represented solely by largemouth bass (*Micropterus salmoides*), as the least abundant reproductive guilds, suggesting that the characteristics of the irrigation wasteway were not especially attractive to the silvery minnow under the prevailing hydrologic conditions during our sampling (see Table 6). Interestingly, compared to the fish fauna of main channel and floodplain lateral pools, the irrigation wasteway fauna exhibited the greatest species diversity, the greatest representation of reproductive guilds, and the greatest degree of species evenness across the reproductive guilds.

DISCUSSION

We compare fish communities of lateral aquatic habitats of the Middle Rio Grande over a range of temporal, ecological, and geographic scales that differ in the extent to which life history traits contribute to community assembly and structure. Distributional and environmental data are combined with life history traits to assess how and why communities of fish species differ from random expectations to reveal ecological relatedness at the habitat-specific scale. Of particular interest are the roles of environmental filtering and competitive interactions in dictating community composition.

Dispersal and environmental constraints contribute to distinct faunal patterns that vary along longitudinal and lateral axes. Advancing pathways of ecological succession in the Middle Rio Grande result in increased fish species diversity with distance downstream. The number of fish reproductive guilds also increases with distance downstream, indicating the existence of a greater diversity of available ecological niches. We speculate that the rapid downstream increase in the number of reproductive guilds supported over the relatively short distance spanned by the Albuquerque and Isleta reaches is attributable in large part to the natural restoration of successional stages of the river continuum that is disrupted upstream by the storage of water in Cochiti Reservoir.

Diminution in lateral connectivity of river channel-floodplain habitats has contributed significantly to a contemporary fish fauna in the Middle Rio Grande that represents a depleted species set compared to the historical fauna (Sublette et al. 1990). The uncoupling of river channel-floodplain habitats is a notable consequence of anthropogenic modification of the natural flow regime in the Middle Rio Grande, most importantly stemming from the elimination of high flow events. Compared to the early settlement hydrograph (pre-1931), the contemporary (post-1975) hydrograph is characterized by reduced monthly average flow, most profoundly for April through June, and reduced monthly variation in flow.

River channel-floodplain coupling represents a plausible and attractive strategy to accommodate silvery minnow spawning and enhance retention and survival of eggs and larvae in upstream river segments. Hatch and Gonzales (2008) offer evidence in support of a working hypothesis that silvery minnow adaptively and preferentially spawn in low water exchange lateral habitats, including most importantly backwater and other hydrologic retentive floodplain habitats when possible to reduce downstream displacement of eggs and larvae. It is believed that inundated floodplain habitats factor prominently in the survival and growth of larval and older silvery minnow due in part to the existence of highly productive food chains founded on the bacterial conditioning of retained fine and course particulate organic material and newly inundated terrestrial vegetation. Heightened floodplain productivity is further enhanced by lower water exchange rates, heightened subsidy of allochthonous energy inputs at the aquatic-land interface, and heightened temperatures characteristic of such areas (Schlosser 1991; Valett et al. 2005). Hatch and Gonzales (2008) speculate that deeper and more expansive habitats are vital to silvery minnow survival in the floodplain due to enhanced temporal environmental stability intrinsic to such habitats. Additionally, it is more likely that deeper floodplain habitats offer greater protection against avian and other predators compared to shallow areas.

Flows that inundate the floodplain of the Middle Rio Grande, primarily during spring and summer months, generally contribute to increasing trajectories of silvery minnow populations. A strong correlation exists between maximum annual consecutive days of strong recruitment stage discharge flows and average estimated density of Rio Grande silvery minnow for the period of 1993 to 2007. Moderate to high levels of silvery minnow recruitment to at least the juvenile stage usually result from flows that inundate floodplain habitats for a minimum sustained period of seven to ten consecutive days. Higher levels of recruitment are expected with longer periods of sustained floodplain inundation. This prediction applies to situations in which the duration of river channel-floodplain coupling is sustained to allow adults opportunity to occupy the floodplain and spawn, to allow time for embryo development and hatching, and finally to allow sufficient time for young-of-year silvery minnow development to at least the juvenile stage to effectively enable fish to evacuate floodplain habitats as they drain (Hatch and Gonzales 2008). Although findings suggest that adult silvery minnows will actively evacuate floodplain habitats as flows recede, significant numbers of silvery minnow eggs and larvae can be stranded if the river channel-floodplain become uncoupled prematurely (i.e., before eggs hatch and fish mature to post-larval stages) or if flows are abruptly reduced (U.S. Fish and Wildlife Service 2006).

Community composition at any point in time is the result of past immigration and extinction, together with associated interactions that vary according to the sequence of assembly and the rate and extent of disturbance. To be successful, management actions for the conservation of small animal populations, such as the silvery minnow, must generally strive to increase the intrinsic rate of silvery minnow population growth while simultaneously minimizing the between-generation variance of the rate of population growth to reduce the probability of species extinction.

Priority management strategies should contribute to the enhancement of silvery minnow reproduction and recruitment, and serve to maintain critical source populations with sufficient parental stock to constitute viable populations. These management purposes provide a structured context for organizing relevant information and for formulating and evaluating management alternatives for the conservation of the silvery minnow. The primary population processes of birth, death, immigration, and emigration represent leverage opportunities for directed management to achieve these management purposes.

The period of pool isolation is an important consideration in the provision and maintenance of nursery and refugial habitats. As running water habitats recede in the Middle Rio Grande, the period of pool isolation tends to be longer for those positioned lateral and distal to the lowest line of elevation in the main channel. As such, pools in closest association with perennial flow will inevitably exhibit greater environmental stability over a longer period. They would certainly be aligned with dispersal corridors during periods of low flow.

Inundated floodplains, including isolated pools in and adjacent to the floodplain, can factor prominently in silvery minnow conservation so long as connectivity with main channel running water habitats can be restored periodically to prevent silvery minnow mortality. Galat et al. (2004) found that larval fish taxa richness increased in lateral pools of the lower Missouri River with increased degrees of coupling with running water due largely to the addition of rheophilic larval taxa, including *Hybognathus* species. Usually, inundated floodplains provide heightened heterogeneity of habitat and structural refugia for developing fish species relative to the active channel (Valett et al. 2005).

The results of this study, coupled with those reported by Buhl (2006), suggest that the silvery minnow is physiologically flexible—capable of surviving absolute extremes and diel fluctuations in chemical and physical conditions. Short of complete or near desiccation of habitat, the silvery minnow exhibits a capacity to withstand a wide variety of environmental conditions. It is believed that inundated floodplain habitats factor prominently in the survival and growth of larval and older silvery minnows, not just due to the heightened productivity of such areas, but also because reduced water velocity habitats that typify the margins of rivers, especially flood terraces, are conducive to energy conservation—a general life strategy shared by many lotic fish species (Facey and Grossman 1992). This seems logical considering that silvery minnows will focus much of their foraging on diatom-rich periphyton communities associated with finer sediments that typically characterize floodplain habitats (Cowley et al. 2006; Magana 2007).

Pool depth, spacing, and frequency of pool refreshing play key determinative roles in the utility of isolated pools to serve as nursery habitats and refugial habitats allowing fish to survive periods of drought (Hatch et al. 2008). We have found that longer and deeper pools with abruptly steep sides are inherently superior as prospective nursery habitats for fish due primarily to their enhanced temporal environmental stability compared to smaller pools. Hatch et al. (2008) found that larger pools tended to support a greater diversity of fish species, which is conducive to the maintenance of stable and persistent fish assemblages. Hatch et al. (2008) also found that pools adjacent to flowing river segments have a heightened degree of environmental stability and, due to proximity, have a heightened potential for reciprocal faunal exchanges with adjacent habitats.

It is anticipated that study results will serve as an important basis for a planned approach to habitat restoration designed specifically to benefit multiple, consecutive life stages of the silvery minnow. Surveys were conducted to reveal limiting factors that may underlie silvery minnow populations and the communities of which they are a part. Additionally, surveys establish baseline datasets that will be essential to future efforts to determine whether management actions have placed fishery resources on a trajectory towards agreed-upon desired conditions.

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APPENDIX A
FISH COLLECTIONS BY SITE AND DATE

Fish Community by Site

River Reach / Site Name / UTM	Date	Species	Number Observed	Percent Composition by Site and Date
Albuquerque Reach				
Site: Calabacillas				
Northing: 3895066				
Easting: 349790				
	25-Jun-2008			
		Cyprinus carpio	100	80.00
		Cyprinella lutrensis	14	11.20
		Catostomus commersonii	4	3.20
		Pimephales promelas	4	3.20
		Hybognathus amarus	2	1.60
		Gambusia affinis	1	0.80
	08-Jul-2008			
		Catostomus commersonii	122	29.33
		Pimephales promelas	101	24.28
		Cyprinus carpio	79	18.99
		Cyprinella lutrensis	70	16.83
		Hybognathus amarus	41	9.86
		Gambusia affinis	2	0.48
		Sander vitreum	1	0.24
	15-Jul-2008			
		Cyprinus carpio	55	24.77
		Pimephales promelas	53	23.87
		Cyprinella lutrensis	44	19.82
		Hybognathus amarus	30	13.51
		Catostomus commersonii	30	13.51
		Gambusia affinis	5	2.25
		Platygobio gracilis	5	2.25
	22-Jul-2008			
		Pimephales promelas	165	55.56
		Cyprinus carpio	62	20.88
		Hybognathus amarus	21	7.07
		Cyprinella lutrensis	21	7.07
		Catostomus commersonii	20	6.73
		Gambusia affinis	5	1.68
		Platygobio gracilis	3	1.01
	31-Jul-2008			
		Cyprinella lutrensis	14	46.67
		Cyprinus carpio	8	26.67
		Pimephales promelas	6	20.00
		Gambusia affinis	2	6.67
Albuquerque Reach				
Site: I-40 Habitat Restoration Site				
Northing: 3885695				
Easting: 345670				
	25-Jun-2008			
		Cyprinus carpio	95	62.91
		Catostomus commersonii	34	22.52
		Cyprinella lutrensis	15	9.93
		Hybognathus amarus	6	3.97
		Pimephales promelas	1	0.66

River Reach / Site Name / UTM	Date	Species	Number Observed	Percent Composition by Site and Date
Isleta Reach				
Site: Montoya's Pond				
Northing: 3860084				
Easting: 342984				
	24-Jun-2008			
		Hybognathus amarus	50	87.72
		Cyprinus carpio	7	12.28
	09-Jul-2008			
		Hybognathus amarus	52	88.14
		Cyprinus carpio	7	11.86
	15-Jul-2008			
		Hybognathus amarus	50	79.37
		Cyprinus carpio	13	20.63
	22-Jul-2008			
		Hybognathus amarus	69	93.24
		Gambusia affinis	3	4.05
		Cyprinus carpio	2	2.70
	31-Jul-2008			
		Hybognathus amarus	17	100.00
	07-Aug-2008			
		Gambusia affinis	9	90.00
		Cyprinus carpio	1	10.00
	13-Aug-2008			
		Gambusia affinis	10	90.91
		Hybognathus amarus	1	9.09
	27-Aug-2008			
		Gambusia affinis	73	92.41
		Hybognathus amarus	6	7.59
	18-Sep-2008			
		Gambusia affinis	71	100.00
	30-Sep-2008			
		Gambusia affinis	44	84.62
		Hybognathus amarus	5	9.62
		Cyprinus carpio	3	5.77
	13-Oct-2008			
		Gambusia affinis	40	95.24
		Hybognathus amarus	2	4.76
	30-Oct-2008			
		Gambusia affinis	9	81.82
		Hybognathus amarus	2	18.18

River Reach / Site Name / UTM	Date	Species	Number Observed	Percent Composition by Site and Date
Isleta Reach				
Site: Peralta Wasteway				
Northing: 3840196				
Easting: 340412				
	10-Jul-2008			
		Cyprinella lutrensis	31	96.88
		Catostomus commersonii	1	3.13
	15-Jul-2008			
		Cyprinella lutrensis	147	93.63
		Cyprinus carpio	6	3.82
		Platygobio gracilis	2	1.27
		Catostomus commersonii	1	0.64
		Hybognathus amarus	1	0.64
	22-Jul-2008			
		Cyprinella lutrensis	14	73.68
		Catostomus commersonii	2	10.53
		Gambusia affinis	1	5.26
		Hybognathus amarus	1	5.26
		Pimephales promelas	1	5.26
	31-Jul-2008			
		Gambusia affinis	15	55.56
		Cyprinella lutrensis	10	37.04
		Catostomus commersonii	1	3.70
		Cyprinus carpio	1	3.70
	07-Aug-2008			
		Gambusia affinis	28	56.00
		Cyprinella lutrensis	13	26.00
		Cyprinus carpio	3	6.00
		Cyprinella lutrensis	2	4.00
		Cyprinella lutrensis	2	4.00
		Lepomis cyanellus	1	2.00
		Cyprinus carpio	1	2.00
	13-Aug-2008			
		Cyprinella lutrensis	11	47.83
		Gambusia affinis	11	47.83
		Ictalurus punctatus	1	4.35
	27-Aug-2008			
		Gambusia affinis	3	30.00
		Ictalurus punctatus	3	30.00
		Pomoxis annularis	2	20.00
		Cyprinella lutrensis	1	10.00
		Ameiurus melas	1	10.00
	18-Sep-2008			
		Ictalurus punctatus	8	40.00
		Cyprinella lutrensis	4	20.00
		Gambusia affinis	3	15.00
		Carpiodes carpio	3	15.00
		Pomoxis annularis	1	5.00
		Cyprinus carpio	1	5.00

River Reach / Site Name / UTM	Date	Species	Number Observed	Percent Composition by Site and Date
	30-Sep-2008			
		Gambusia affinis	2	28.57
		Pomoxis annularis	2	28.57
		Carpiodes carpio	1	14.29
		Cyprinella lutrensis	1	14.29
		Cyprinus carpio	1	14.29
	13-Oct-2008			
		Gambusia affinis	24	60.00
		Carpiodes carpio	6	15.00
		Pomoxis annularis	3	7.50
		Cyprinus carpio	2	5.00
		Hybognathus amarus	2	5.00
		Cyprinella lutrensis	2	5.00
		Pimephales promelas	1	2.50
	30-Oct-2008			
		Gambusia affinis	2	40.00
		Carpiodes carpio	2	40.00
		Micropterus dolomieu	1	20.00
Isleta Reach				
Site: Lower Peralta Drain				
Northing: 3836340				
Easting: 340676				
	10-Jul-2008			
		Cyprinella lutrensis	8	72.73
		Cyprinus carpio	2	18.18
		Catostomus commersonii	1	9.09
	15-Jul-2008			
		Cyprinella lutrensis	7	77.78
		Lepomis macrochirus	1	11.11
		Cyprinus carpio	1	11.11
	22-Jul-2008			
		Ictalurus punctatus	4	50.00
		Cyprinus carpio	3	37.50
		Catostomus commersonii	1	12.50
	31-Jul-2008			
		Gambusia affinis	25	92.59
		Pimephales promelas	1	3.70
		Cyprinella lutrensis	1	3.70
	07-Aug-2008			
		Catostomus commersonii	3	42.86
		Gambusia affinis	3	42.86
		Lepomis cyanellus	1	14.29
	13-Aug-2008			
		Micropterus salmoides	2	50.00
		Platygobio gracilis	1	25.00
		Lepomis cyanellus	1	25.00

River Reach / Site Name / UTM	Date	Species	Number Observed	Percent Composition by Site and Date
	27-Aug-2008			
		Catostomus commersonii	3	33.33
		Ictalurus punctatus	2	22.22
		Lepomis macrochirus	1	11.11
		Lepomis cyanellus	1	11.11
		Pomoxis annularis	1	11.11
		Cyprinus carpio	1	11.11
	18-Sep-2008			
		Catostomus commersonii	2	25.00
		Pomoxis annularis	2	25.00
		Micropterus salmoides	1	12.50
		Gambusia affinis	1	12.50
		Carpiodes carpio	1	12.50
		Lepomis cyanellus	1	12.50
	30-Sep-2008			
		Lepomis macrochirus	2	50.00
		Micropterus salmoides	1	25.00
		Lepomis cyanellus	1	25.00
	13-Oct-2008			
		Gambusia affinis	4	50.00
		Ictalurus punctatus	3	37.50
		Lepomis macrochirus	1	12.50
	30-Oct-2008			
		Gambusia affinis	2	22.22
		Lepomis cyanellus	2	22.22
		Lepomis macrochirus	2	22.22
		Carpiodes carpio	1	11.11
		Pomoxis annularis	1	11.11
		Cyprinus carpio	1	11.11
Isleta Reach **Site: Veguita** Northing: 3821050 Easting: 335404				
	24-Jun-2008			
		Pimephales promelas	52	57.78
		Hybognathus amarus	16	17.78
		Gambusia affinis	11	12.22
		Catostomus commersonii	5	5.56
		Cyprinus carpio	5	5.56
		Cyprinella lutrensis	1	1.11
	02-Jul-2008			
		Pimephales promelas	31	44.93
		Gambusia affinis	27	39.13
		Cyprinus carpio	11	15.94
	10-Jul-2008			
		Gambusia affinis	122	74.39
		Pimephales promelas	19	11.59
		Ameiurus melas	14	8.54
		Cyprinus carpio	6	3.66
		Cyprinella lutrensis	3	1.83

River Reach / Site Name / UTM	Date	Species	Number Observed	Percent Composition by Site and Date
Isleta Reach				
Site: Bernardo				
Northing: 3809939				
Easting: 334573				
	02-Jul-2008			
		Gambusia affinis	57	54.81
		Pimephales promelas	35	33.65
		Cyprinella lutrensis	6	5.77
		Cyprinus carpio	5	4.81
		Carpiodes carpio	1	0.96

APPENDIX B
FISH SPECIES RELATIVE ABUNDANCE BY RIVER REACH

Species Relative Abundance by River Reach

Reach	Species	Number Observed	Percent by Reach
Albuquerque			
	Cyprinus carpio	399	32.15
	Pimephales promelas	330	26.59
	Catostomus commersonii	210	16.92
	Cyprinella lutrensis	178	14.34
	Hybognathus amarus	100	8.06
	Gambusia affinis	15	1.21
	Platygobio gracilis	8	0.64
	Sander vitreum	1	0.08
Isleta			
	Gambusia affinis	600	40.90
	Hybognathus amarus	274	18.68
	Cyprinella lutrensis	264	18.00
	Pimephales promelas	140	9.54
	Cyprinus carpio	83	5.66
	Ictalurus punctatus	21	1.43
	Catostomus commersonii	20	1.36
	Carpiodes carpio	15	1.02
	Ameiurus melas	15	1.02
	Pomoxis annularis	12	0.82
	Lepomis cyanellus	8	0.55
	Lepomis macrochirus	7	0.48
	Micropterus salmoides	4	0.27
	Platygobio gracilis	3	0.20
	Micropterus dolomieu	1	0.07

APPENDIX C
FISH SPECIES BY RIVER REACH AND SAMPLE SITE - 2008

Fish Species by River Reach and Sample Site - 2008

Reach	Site	Species	24-Jun	25-Jun	02-Jul	08-Jul	09-Jul	10-Jul	15-Jul	22-Jul	31-Jul	07-Aug	11-Aug	13-Aug	27-Aug	18-Sep	30-Sep	13-Oct	30-Oct
Albuquerque																			
	Calabacillas																		
		Catostomus commersonii	---	4	---	122	---	---	30	20	0	---	---	---	---	---	---	---	---
		Cyprinella lutrensis	---	14	---	70	---	---	44	21	14	---	---	---	---	---	---	---	---
		Cyprinus carpio	---	100	---	79	---	---	55	62	8	---	---	---	---	---	---	---	---
		Gambusia affinis	---	1	---	2	---	---	5	5	2	---	---	---	---	---	---	---	---
		Hybognathus amarus	---	2	---	41	---	---	30	21	0	---	---	---	---	---	---	---	---
		Pimephales promelas	---	4	---	101	---	---	53	165	6	---	---	---	---	---	---	---	---
		Platygobio gracilis	---	0	---	0	---	---	5	3	0	---	---	---	---	---	---	---	---
		Sander vitreum	---	0	---	1	---	---	0	0	0	---	---	---	---	---	---	---	
	I-40 Habitat Restoration Site																		
		Catostomus commersonii	---	34	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
		Cyprinella lutrensis	---	15	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
		Cyprinus carpio	---	95	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
		Hybognathus amarus	---	6	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
		Pimephales promelas	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Isleta																			
	Montoya's Pond																		
		Cyprinus carpio	7	---	---	---	7	---	13	2	0	1	---	0	0	0	3	0	0
		Gambusia affinis	0	---	---	---	0	---	0	3	0	9	---	10	73	71	44	40	9
		Hybognathus amarus	50	---	---	---	52	---	50	69	17	0	---	1	6	0	5	2	2
	Peralta Wasteway																		
		Ameiurus melas	---	---	---	---	---	0	0	0	0	0	---	0	1	0	0	0	0
		Carpiodes carpio	---	---	---	---	---	0	0	0	0	0	---	0	0	3	1	6	2
		Catostomus commersonii	---	---	---	---	---	1	1	2	1	0	---	0	0	0	0	0	0
		Cyprinella lutrensis	---	---	---	---	---	31	147	14	10	17	---	11	1	4	1	2	0
		Cyprinus carpio	---	---	---	---	---	0	6	0	1	4	---	0	0	1	1	2	0
		Gambusia affinis	---	---	---	---	---	0	0	1	15	28	---	11	3	3	2	24	2
		Hybognathus amarus	---	---	---	---	---	0	1	1	0	0	---	0	0	0	0	2	0
		Ictalurus punctatus	---	---	---	---	---	0	0	0	0	0	---	1	3	8	0	0	0
		Lepomis cyanellus	---	---	---	---	---	0	0	0	0	1	---	0	0	0	0	0	0
		Micropterus dolomieu	---	---	---	---	---	0	0	0	0	0	---	0	0	0	0	0	1
		Pimephales promelas	---	---	---	---	---	0	0	1	0	0	---	0	0	0	0	1	0
		Platygobio gracilis	---	---	---	---	---	0	2	0	0	0	---	0	0	0	0	0	0
		Pomoxis annularis	---	---	---	---	---	0	0	0	0	0	---	0	2	1	2	3	0
	Lower Peralta Drain																		
		Carpiodes carpio	---	---	---	---	---	0	0	0	0	0	---	0	0	1	0	0	1
		Catostomus commersonii	---	---	---	---	---	1	0	1	0	3	---	0	3	2	0	0	0
		Cyprinella lutrensis	---	---	---	---	---	8	7	0	1	0	---	0	0	0	0	0	0
		Cyprinus carpio	---	---	---	---	---	2	1	3	0	0	---	0	1	0	0	0	1
		Gambusia affinis	---	---	---	---	---	0	0	0	25	3	---	0	0	1	0	4	2
		Ictalurus punctatus	---	---	---	---	---	0	0	4	0	0	---	0	2	0	0	3	0
		Lepomis cyanellus	---	---	---	---	---	0	0	0	0	1	---	1	1	1	1	0	2
		Lepomis macrochirus	---	---	---	---	---	0	1	0	0	0	---	0	1	0	2	1	2
		Micropterus salmoides salmoides	---	---	---	---	---	0	0	0	0	0	---	2	0	1	1	0	0
		Pimephales promelas	---	---	---	---	---	0	0	0	1	0	---	0	0	0	0	0	0
		Platygobio gracilis	---	---	---	---	---	0	0	0	0	0	---	1	0	0	0	0	0
		Pomoxis annularis	---	---	---	---	---	0	0	0	0	0	---	0	1	2	0	0	1

Reach	Site	Species	24-Jun	25-Jun	02-Jul	08-Jul	09-Jul	10-Jul	15-Jul	22-Jul	31-Jul	07-Aug	11-Aug	13-Aug	27-Aug	18-Sep	30-Sep	13-Oct	30-Oct
	Veguita																		
		Ameiurus melas	0	---	0	---	---	14	---	---	---	---	---	---	---	---	---	---	---
		Catostomus commersonii	5	---	0	---	---	0	---	---	---	---	---	---	---	---	---	---	---
		Cyprinella lutrensis	1	---	0	---	---	3	---	---	---	---	---	---	---	---	---	---	---
		Cyprinus carpio	5	---	11	---	---	6	---	---	---	---	---	---	---	---	---	---	---
		Gambusia affinis	11	---	27	---	---	122	---	---	---	---	---	---	---	---	---	---	---
		Hybognathus amarus	16	---	0	---	---	0	---	---	---	---	---	---	---	---	---	---	---
		Pimephales promelas	52	---	31	---	---	19	---	---	---	---	---	---	---	---	---	---	---
	Bernardo																		
		Carpiodes carpio	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---
		Cyprinella lutrensis	---	---	6	---	---	---	---	---	---	---	---	---	---	---	---	---	---
		Cyprinus carpio	---	---	5	---	---	---	---	---	---	---	---	---	---	---	---	---	---
		Gambusia affinis	---	---	57	---	---	---	---	---	---	---	---	---	---	---	---	---	---
		Pimephales promelas	---	---	35	---	---	---	---	---	---	---	---	---	---	---	---	---	---

APPENDIX D
FISH SPECIES BY SAMPLE SITE AND DATE - 2008

Species Observed by Site and Date

Reach	Site	Date	Ameiurus melas	Carpiodes carpio	Catostomus commersonii	Cyprinella lutrensis	Cyprinus carpio	Gambusia affinis	Hybognathus amarus	Ictalurus punctatus	Lepomis cyanellus	Lepomis macrochirus	Micropterus dolomieu	Micropterus salmoides	Pimephales promelas	Platygobio gracilis	Pomoxis annularis	Sander vitreum
Albuquerque																		
	Calabacillas																	
		25-Jun-2008	0	0	4	14	100	1	2	0	0	0	0	0	4	0	0	0
		08-Jul-2008	0	0	122	70	79	2	41	0	0	0	0	0	101	0	0	1
		15-Jul-2008	0	0	30	44	55	5	30	0	0	0	0	0	53	5	0	0
		22-Jul-2008	0	0	20	21	62	5	21	0	0	0	0	0	165	3	0	0
		31-Jul-2008	0	0	0	14	8	2	0	0	0	0	0	0	6	0	0	0
	I-40 Habitat Restoration Site																	
		25-Jun-2008	0	0	34	15	95	0	6	0	0	0	0	0	1	0	0	0
Isleta																		
	Montoya's Pond																	
		24-Jun-2008	0	0	0	0	7	0	50	0	0	0	0	0	0	0	0	0
		09-Jul-2008	0	0	0	0	7	0	52	0	0	0	0	0	0	0	0	0
		15-Jul-2008	0	0	0	0	13	0	50	0	0	0	0	0	0	0	0	0
		22-Jul-2008	0	0	0	0	2	3	69	0	0	0	0	0	0	0	0	0
		31-Jul-2008	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0
		07-Aug-2008	0	0	0	0	1	9	0	0	0	0	0	0	0	0	0	0
		13-Aug-2008	0	0	0	0	0	10	1	0	0	0	0	0	0	0	0	0
		27-Aug-2008	0	0	0	0	0	73	6	0	0	0	0	0	0	0	0	0
		18-Sep-2008	0	0	0	0	0	71	0	0	0	0	0	0	0	0	0	0
		30-Sep-2008	0	0	0	0	3	44	5	0	0	0	0	0	0	0	0	0
		13-Oct-2008	0	0	0	0	0	40	2	0	0	0	0	0	0	0	0	0
		30-Oct-2008	0	0	0	0	0	9	2	0	0	0	0	0	0	0	0	0
	Peralta Wasteway																	
		10-Jul-2008	0	0	1	31	0	0	0	0	0	0	0	0	0	0	0	0
		15-Jul-2008	0	0	1	147	6	0	1	0	0	0	0	0	0	2	0	0
		22-Jul-2008	0	0	2	14	0	1	1	0	0	0	0	0	1	0	0	0
		31-Jul-2008	0	0	1	10	1	15	0	0	0	0	0	0	0	0	0	0
		07-Aug-2008	0	0	0	17	4	28	0	0	1	0	0	0	0	0	0	0
		13-Aug-2008	0	0	0	11	0	11	0	1	0	0	0	0	0	0	0	0
		27-Aug-2008	1	0	0	1	0	3	0	3	0	0	0	0	0	0	2	0
		18-Sep-2008	0	3	0	4	1	3	0	8	0	0	0	0	0	0	1	0
		30-Sep-2008	0	1	0	1	1	2	0	0	0	0	0	0	0	0	2	0
		13-Oct-2008	0	6	0	2	2	24	2	0	0	0	0	0	1	0	3	0
		30-Oct-2008	0	2	0	0	0	2	0	0	0	0	1	0	0	0	0	0

Reach	Site	Date	*Ameiurus melas*	*Carpiodes carpio*	*Catostomus commersonii*	*Cyprinella lutrensis*	*Cyprinus carpio*	*Gambusia affinis*	*Hybognathus amarus*	*Ictalurus punctatus*	*Lepomis cyanellus*	*Lepomis macrochirus*	*Micropterus dolomieu*	*Microptersu salmoides*	*Pimephales promelas*	*Platygobio gracilis*	*Pomoxis annularis*	*Sander vitreum*
	Lower Peralta Drain																	
		10-Jul-2008	0	0	1	8	2	0	0	0	0	0	0	0	0	0	0	0
		15-Jul-2008	0	0	0	7	1	0	0	0	0	1	0	0	0	0	0	0
		22-Jul-2008	0	0	1	0	3	0	0	4	0	0	0	0	0	0	0	0
		31-Jul-2008	0	0	0	1	0	25	0	0	0	0	0	0	1	0	0	0
		07-Aug-2008	0	0	3	0	0	3	0	0	1	0	0	0	0	0	0	0
		13-Aug-2008	0	0	0	0	0	0	0	0	1	0	0	2	0	1	0	0
		27-Aug-2008	0	0	3	0	1	0	0	2	1	1	0	0	0	0	1	0
		18-Sep-2008	0	1	2	0	0	1	0	0	1	0	0	1	0	0	2	0
		30-Sep-2008	0	0	0	0	0	0	0	0	1	2	0	1	0	0	0	0
		13-Oct-2008	0	0	0	0	0	4	0	3	0	1	0	0	0	0	0	0
		30-Oct-2008	0	1	0	0	1	2	0	0	2	2	0	0	0	0	1	0
	Veguita																	
		24-Jun-2008	0	0	5	1	5	11	16	0	0	0	0	0	52	0	0	0
		02-Jul-2008	0	0	0	0	11	27	0	0	0	0	0	0	31	0	0	0
		10-Jul-2008	14	0	0	3	6	122	0	0	0	0	0	0	19	0	0	0
	Bernardo																	
		02-Jul-2008	0	1	0	6	5	57	0	0	0	0	0	0	35	0	0	0

APPENDIX E
WATER QUALITY DATA

Water Quality Results

Reach	Site	Date	Time	Depth	Current	Water Temp	DO (PPM)	DO % Sat	pH	Salinity	Specific Cond	Turbidity
Albuquerque												
	Calabacillas											
		25-Jun-2008	8:15 AM	2.30	0.00	20.08	5.09	56.40	8.33	0.12	247.00	29.75
		08-Jul-2008	9:58 AM	0.70	0.00	20.56	1.92	21.40	7.88	0.19	391.00	57.00
		15-Jul-2008	8:26 AM	0.15	0.00	18.04	0.75	8.10	6.74	0.15	313.00	567.00
		22-Jul-2008	9:06 AM	0.10	0.00	19.16	3.30	35.50	7.52	0.20	411.00	158.00
		31-Jul-2008	8:17 AM	0.03	0.00	16.55	2.62	27.40	7.11	0.20	412.00	194.00
	Summary Statistics for the Calabacillas sampling site:											
			Avg.	0.66	0.00	18.88	2.74	29.76	7.52	0.17	354.80	201.15
			St. Dev.	0.96	0.00	1.62	1.62	17.94	0.62	0.04	72.64	215.59
	I-40 Habitat Restoration Site											
		25-Jun-2008	11:49 AM	0.75	0.00	27.15	7.98	101.30	8.84	0.11	231.00	37.46
	Summary Statistics for the I-40 Habitat Restoration Site sampling site:											
			Avg.	0.75	0.00	27.15	7.98	101.30	8.84	0.11	231.00	37.46
			St. Dev.	--	--	--	--		--	--	--	--

Reach	Site	Date	Time	Depth	Current	Water Temp	DO (PPM)	DO % Sat	pH	Salinity	Specific Cond	Turbidity
Isleta												
	Montoya's Pond											
		24-Jun-2008	8:50 AM	2.90	0.00	17.45	0.81	9.00	7.71	0.24	486.00	4.39
		09-Jul-2008	9:24 AM	0.90	0.00	20.25	7.04	90.80	7.82	0.22	451.00	7.10
		15-Jul-2008	1:44 PM	0.60	0.00	24.86	13.90	167.90	7.07	0.22	457.00	23.59
		22-Jul-2008	11:17 AM	0.50	0.00	24.33	2.70	33.40	7.11	0.28	573.00	22.40
		31-Jul-2008	10:54 AM	0.70	0.00	21.83	5.73	65.50	7.67	0.30	617.00	9.39
		07-Aug-2008	11:28 AM	0.50	0.00	23.49	8.93	105.00	8.17	0.41	838.00	13.18
		13-Aug-2008	9:58 AM	0.45	0.00	20.06	2.58	28.70	7.37	0.41	841.00	14.34
		27-Aug-2008	11:18 AM	0.10	0.00	21.66	4.09	46.80	7.30	0.41	836.00	17.93
		18-Sep-2008	11:41 AM	0.33	0.00	18.78	6.52	71.00	7.04	0.59	1182.00	13.48
		30-Sep-2008	10:54 AM	0.04	0.00	16.25	8.22	84.20	7.79	0.53	1055.00	14.55
		13-Oct-2008	10:40 AM	1.10	0.00	9.52	2.00	17.60	7.65	0.71	984.00	6.24
		30-Oct-2008	11:30 AM	1.20	0.00	8.03	0.44	3.60	7.55	0.58	763.00	8.14
	Summary Statistics for the Montoya's Pond sampling site:											
			Avg.	0.78	0.00	18.88	5.25	60.29	7.52	0.41	756.92	12.89
			St. Dev.	0.76	0.00	5.40	3.94	47.48	0.35	0.16	243.35	6.18
	Peralta Wasteway											
		10-Jul-2008	11:12 AM	2.10	0.74	22.58	9.26	107.30	6.65	0.16	334.00	165.00
		15-Jul-2008	12:06 PM	2.40	0.36	24.23	8.08	96.40	7.70	0.16	331.00	125.00
		22-Jul-2008	12:35 PM	2.10	0.18	25.32	8.77	107.00	5.33	0.17	365.00	1000.00
		31-Jul-2008	1:19 PM	1.10	0.00	27.21	8.80	110.80	7.83	0.18	397.00	194.00
		07-Aug-2008	1:15 PM	1.80	0.00	25.79	7.27	89.60	8.08	0.16	334.00	470.00
		13-Aug-2008	11:50 AM	1.25	0.09	26.04	4.71	57.50	8.11	0.18	372.00	267.00
		27-Aug-2008	1:05 PM	2.00	0.53	23.59	5.16	60.90	6.37	0.19	401.00	596.00
		18-Sep-2008	1:01 PM	1.50	0.01	21.38	5.85	66.30	6.64	0.19	396.00	121.00
		30-Sep-2008	12:52 PM	1.60	0.06	19.39	10.09	109.00	8.32	0.19	394.00	116.00
		13-Oct-2008	1:07 PM	2.60	0.00	12.60	9.75	91.90	8.17	0.18	375.00	119.00
		30-Oct-2008	12:00 PM	1.30	0.00	12.56	10.01	94.50	8.43	0.22	445.00	87.00
	Summary Statistics for the Peralta Wasteway sampling site:											
			Avg.	1.80	0.18	21.88	7.98	90.11	7.42	0.18	376.73	296.36
			St. Dev.	0.49	0.25	5.11	1.96	19.78	1.01	0.02	34.98	284.88

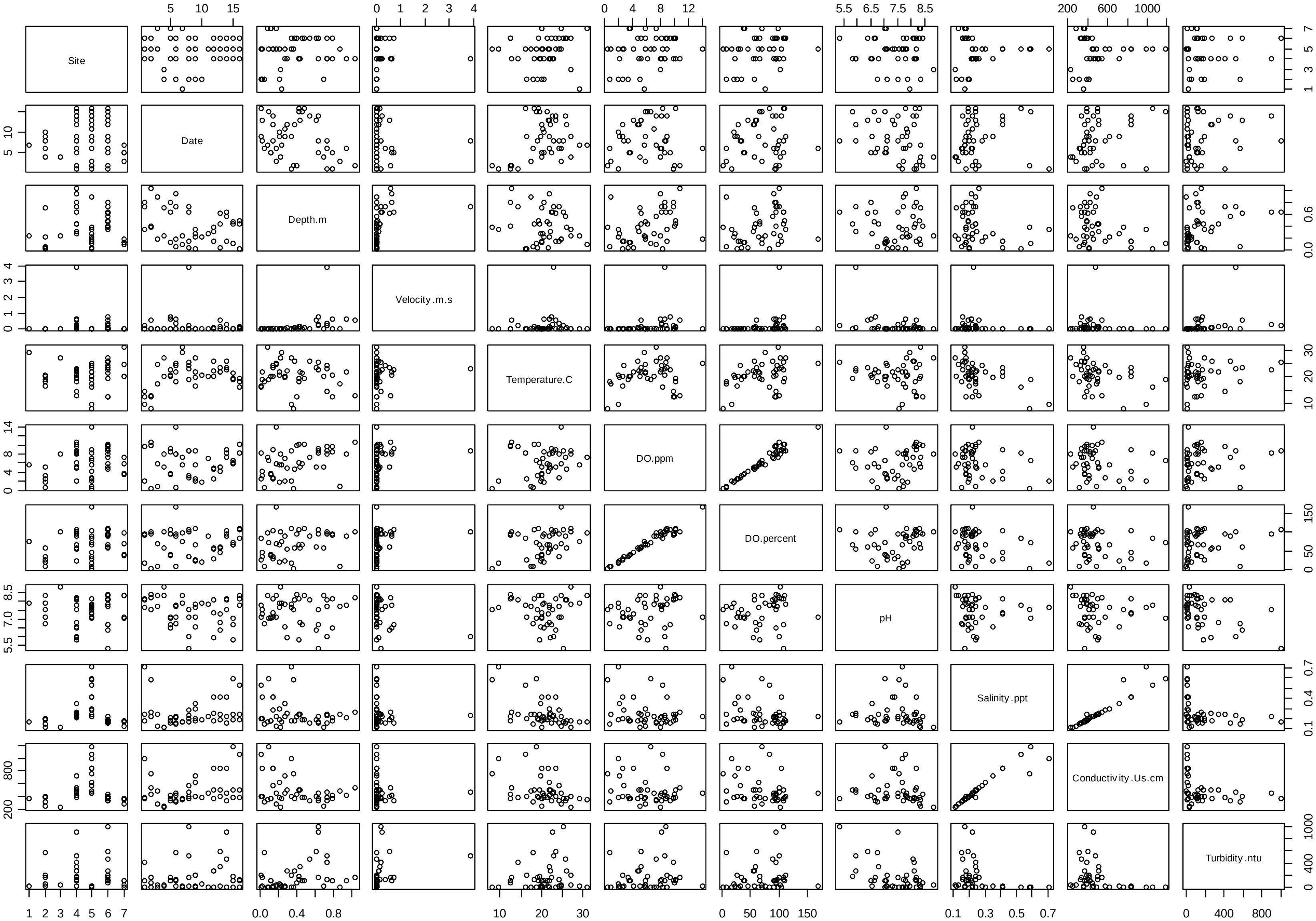
Reach	Site	Date	Time	Depth	Current	Water Temp	DO (PPM)	DO % Sat	pH	Salinity	Specific Cond	Turbidity
	Lower Peralta Drain											
		10-Jul-2008	12:21 PM	2.60	0.65	20.69	8.53	95.20	6.51	0.21	429.00	122.00
		15-Jul-2008	11:21 AM	3.10	0.62	21.84	7.89	90.30	7.78	0.21	428.00	107.00
		22-Jul-2008	1:19 PM	2.40	0.39	23.02	8.60	100.40	5.96	0.23	476.00	524.00
		31-Jul-2008	12:40 PM	0.90	0.00	19.92	2.15	23.50	6.56	0.35	723.00	17.77
		07-Aug-2008	10:19 AM	2.10	0.25	22.67	8.14	94.50	7.52	0.22	454.00	903.00
		13-Aug-2008	2:44 PM	1.00	0.08	22.27	4.87	56.20	5.95	0.25	511.00	266.00
		27-Aug-2008	2:02 PM	1.45	0.14	22.00	5.16	59.10	6.77	0.24	507.00	337.00
		18-Sep-2008	2:16 PM	1.40	0.03	19.53	6.08	66.00	5.83	0.24	500.00	178.00
		30-Sep-2008	1:50 PM	1.40	0.15	18.27	10.14	107.80	8.15	0.24	497.00	128.00
		13-Oct-2008	2:18 PM	2.40	0.21	14.33	9.74	95.60	8.11	0.24	394.00	404.00
		30-Oct-2008	1:00 PM	3.40	0.58	12.80	10.70	100.70	8.19	0.26	539.00	159.00
Summary Statistics for the Lower Peralta Drain sampling site:												
			Avg.	2.01	0.28	19.76	7.45	80.85	7.03	0.24	496.18	285.98
			St. Dev.	0.84	0.24	3.40	2.61	26.06	0.94	0.04	86.85	252.57
	Veguita											
		24-Jun-2008	12:11 PM	0.60	0.00	24.81	5.84	70.10	8.31	0.13	285.00	51.00
		02-Jul-2008	1:40 PM	0.30	0.00	31.02	7.26	98.80	8.36	0.17	357.00	9.04
		10-Jul-2008	8:37 AM	0.40	0.00	20.20	3.67	41.10	7.04	0.18	370.00	112.00
		10-Jul-2008	8:37 AM	0.40	0.00	20.23	3.47	37.90	7.07	0.18	372.00	112.00
Summary Statistics for the Veguita sampling site:												
			Avg.	0.43	0.00	24.07	5.06	61.98	7.70	0.17	346.00	71.01
			St. Dev.	0.13	0.00	5.12	1.82	28.50	0.74	0.02	41.21	50.34
	Bernardo											
		02-Jul-2008	12:23 PM	0.80	0.02	29.24	5.65	75.20	7.93	0.17	364.00	26.94
Summary Statistics for the Bernardo sampling site:												
			Avg.	0.80	0.02	29.24	5.65	75.20	7.93	0.17	364.00	26.94
			St. Dev.	--	--	--	--	--	--	--	--	--

APPENDIX F
WATER TEMPERATURE DATA

Week		Floodplain Site	Irrigation Wasteway Sites		Main Channel Lateral Pools				Main Channel Lotic Sites			
		Montoya's Pond	Peralta Main	Lower Peralta	Calabacillas	I-40	US Hwy. 60	Veguita	I-40 Main Channel	Adj. Montoya's Pond	Veguita (Main Channel	US Hwy 60
26 (June 23–June 28)	**Avg.**	17.57	---	---	22.48	23.92	---	22.66	21.09	22.30	23.48	---
	St. Dev.	0.62	---	---	2.00	4.34	---	2.74	1.41	1.56	1.28	---
	Min.	16.33	---	---	19.47	19.00	---	18.33	19.19	19.47	20.71	---
	Max.	18.71	---	---	27.37	33.54	---	31.68	24.74	25.51	25.61	---
27 (June 29–July 05)	**Avg.**	19.08	---	---	24.51	---	27.16	23.35	---	23.90	24.94	26.10
	St. Dev.	1.39	---	---	3.12	---	5.35	3.75	---	2.08	1.74	1.40
	Min.	16.62	---	---	19.85	---	19.19	17.09	---	19.66	21.00	23.97
	Max.	23.20	---	---	30.26	---	40.30	33.33	---	29.65	28.66	29.15
28 (July 06–July 12)	**Avg.**	21.88	23.53	21.59	23.45	---	---	23.45	---	21.93	24.21	---
	St. Dev.	1.41	1.03	1.11	3.05	---	---	4.75	---	3.71	3.49	---
	Min.	19.38	21.86	19.76	18.62	---	---	17.76	---	16.14	17.38	---
	Max.	25.32	25.71	24.06	30.46	---	---	45.20	---	36.40	31.06	---
29 (July 13–July 19)	**Avg.**	23.38	25.52	23.45	23.16	---	---	---	---	---	---	---
	St. Dev.	2.34	1.70	1.67	4.41	---	---	---	---	---	---	---
	Min.	19.57	22.62	20.62	17.57	---	---	---	---	---	---	---
	Max.	28.75	31.47	26.78	35.54	---	---	---	---	---	---	---
30 (July 20–July 26)	**Avg.**	23.48	25.99	23.05	22.58	---	---	---	---	---	---	---
	St. Dev.	1.93	1.24	1.53	3.76	---	---	---	---	---	---	---
	Min.	20.52	24.06	18.62	17.86	---	---	---	---	---	---	---
	Max.	27.76	31.47	26.49	35.12	---	---	---	---	---	---	---
31 (July 27–August 02)	**Avg.**	23.15	25.80	22.28	21.83	---	---	---	---	---	---	---
	St. Dev.	3.58	1.63	2.07	4.16	---	---	---	---	---	---	---
	Min.	17.19	22.24	17.67	16.33	---	---	---	---	---	---	---
	Max.	30.86	29.75	26.20	30.96	---	---	---	---	---	---	---
32 (August 03 – August09)	**Avg.**	23.20	26.02	23.25	---	---	---	---	---	---	---	---
	St. Dev.	2.83	1.29	1.70	---	---	---	---	---	---	---	---
	Min.	18.52	22.43	19.00	---	---	---	---	---	---	---	---
	Max.	30.66	28.85	27.37	---	---	---	---	---	---	---	---
33 (August 10 – August 16)	**Avg**	22.34	25.51	22.17	---	---	---	---	---	---	---	---
	St. Dev	3.31	1.53	2.55	---	---	---	---	---	---	---	---
	Min.	16.90	21.76	17.86	---	---	---	---	---	---	---	---
	Max.	29.15	29.55	28.56	---	---	---	---	---	---	---	---
34 (August 17 – August 23)	**Avg.**	21.15	24.42	22.35	---	---	---	---	---	---	---	---
	St. Dev	4.31	1.85	1.96	---	---	---	---	---	---	---	---
	Min.	15.38	20.71	17.76	---	---	---	---	---	---	---	---
	Max.	32.60	28.66	25.81	---	---	---	---	---	---	---	---
35 (August 24 – August 30)	**Avg.**	20.63	24.25	22.11	---	---	---	---	---	---	---	---
	St. Dev.	4.41	1.30	1.40	---	---	---	---	---	---	---	---
	Min.	13.94	21.57	19.38	---	---	---	---	---	---	---	---
	Max.	32.60	27.57	25.32	---	---	---	---	---	---	---	---

Week		Floodplain Site	Irrigation Wasteway Sites		Lateral Channel Sites				Main Channel Sites			
		Montoya's Pond	Peralta Main	Lower Peralta	Calabacillas	I-40	US Hwy. 60	Veguita	I-40 Main Channel	Adj. Montoya's Pond	Veguita (Main Channel	US Hwy. 60
36 (August 31 – September	**Avg.**	19.03	22.56	20.72	---	---	---	---	---	---	---	---
	St. Dev.	4.64	1.48	1.46	---	---	---	---	---	---	---	---
	Min.	10.75	18.90	17.95	---	---	---	---	---	---	---	---
	Max.	31.06	25.22	23.87	---	---	---	---	---	---	---	---
37 (September 07 –	**Avg.**	18.05	21.94	19.93	---	---	---	---	---	---	---	---
	St. Dev.	4.35	1.68	2.27	---	---	---	---	---	---	---	---
	Min.	11.82	19.28	14.71	---	---	---	---	---	---	---	---
	Max.	30.05	26.49	28.26	---	---	---	---	---	---	---	---
38 (September 14 –	**Avg.**	16.87	21.12	18.90	---	---	---	---	---	---	---	---
	St. Dev.	4.60	1.77	2.97	---	---	---	---	---	---	---	---
	Min.	9.28	18.33	9.87	---	---	---	---	---	---	---	---
	Max.	27.57	25.71	28.06	---	---	---	---	---	---	---	---
39 (September 21 –	**Avg.**	18.42	21.64	19.27	---	---	---	---	---	---	---	---
	St. Dev.	3.09	1.68	2.71	---	---	---	---	---	---	---	---
	Min.	13.27	18.62	10.46	---	---	---	---	---	---	---	---
	Max.	25.13	25.22	31.06	---	---	---	---	---	---	---	---
40 (September 28 –	**Avg.**	16.06	19.39	16.19	---	---	---	---	---	---	---	---
	St. Dev.	2.58	1.56	4.53	---	---	---	---	---	---	---	---
	Min.	11.92	16.05	6.57	---	---	---	---	---	---	---	---
	Max.	21.28	22.33	29.45	---	---	---	---	---	---	---	---
41 (October 05 – October	**Avg.**	13.84	17.57	16.94	---	---	---	---	---	---	---	---
	St. Dev.	1.01	1.28	1.21	---	---	---	---	---	---	---	---
	Min.	11.33	15.09	14.52	---	---	---	---	---	---	---	---
	Max.	16.05	20.71	19.09	---	---	---	---	---	---	---	---
42 (October 12 – October	**Avg.**	11.72	14.41	14.68	---	---	---	---	---	---	---	---
	St. Dev.	1.57	1.85	1.45	---	---	---	---	---	---	---	---
	Min.	9.57	10.65	11.72	---	---	---	---	---	---	---	---
	Max.	15.47	18.43	18.24	---	---	---	---	---	---	---	---
43 (October 19 – October	**Avg.**	10.01	13.75	14.08	---	---	---	---	---	---	---	---
	St. Dev.	1.70	2.34	2.07	---	---	---	---	---	---	---	---
	Min.	6.88	8.98	9.97	---	---	---	---	---	---	---	---
	Max.	12.40	19.00	17.95	---	---	---	---	---	---	---	---
44 (October 26 – October	**Avg.**	9.64	13.07	13.37	---	---	---	---	---	---	---	---
	St. Dev.	2.52	2.12	2.30	---	---	---	---	---	---	---	---
	Min.	7.98	10.06	9.37	---	---	---	---	---	---	---	---
	Max.	22.62	22.62	23.29	---	---	---	---	---	---	---	---
All Weeks	**Avg.**	18.57	21.65	19.72	23.13	27.16	25.45	23.19	22.54	22.83	24.33	25.15
	St. Dev.	5.24	4.55	3.95	3.66	5.35	5.96	3.84	2.96	2.78	2.37	3.89
	Min.	6.88	8.98	6.57	16.33	19.19	17.48	17.09	17.57	16.14	17.38	17.57
	Max.	32.60	31.47	31.06	35.54	40.30	43.60	45.20	47.37	36.40	31.06	40.19

APPENDIX G
BIVARIATE ENVIRONMENTAL PLOTS


Site
Date
Depth.m
Velocity.m.s
Temperature.C
DO.ppm
DO.percent
pH
Salinity.ppt
Conductivity.Us.cm
Turbidity.ntu
5 10 15
0 1 2 3 4
0 4 8 12
5.5 6.5 7.5 8.5
200 600 1000
1 2 3 4 5 6 7
0.0 0.4 0.8
10 20 30
0 50 100 150
0.1 0.3 0.5 0.7
0 400 800

APPENDIX H
MAPS

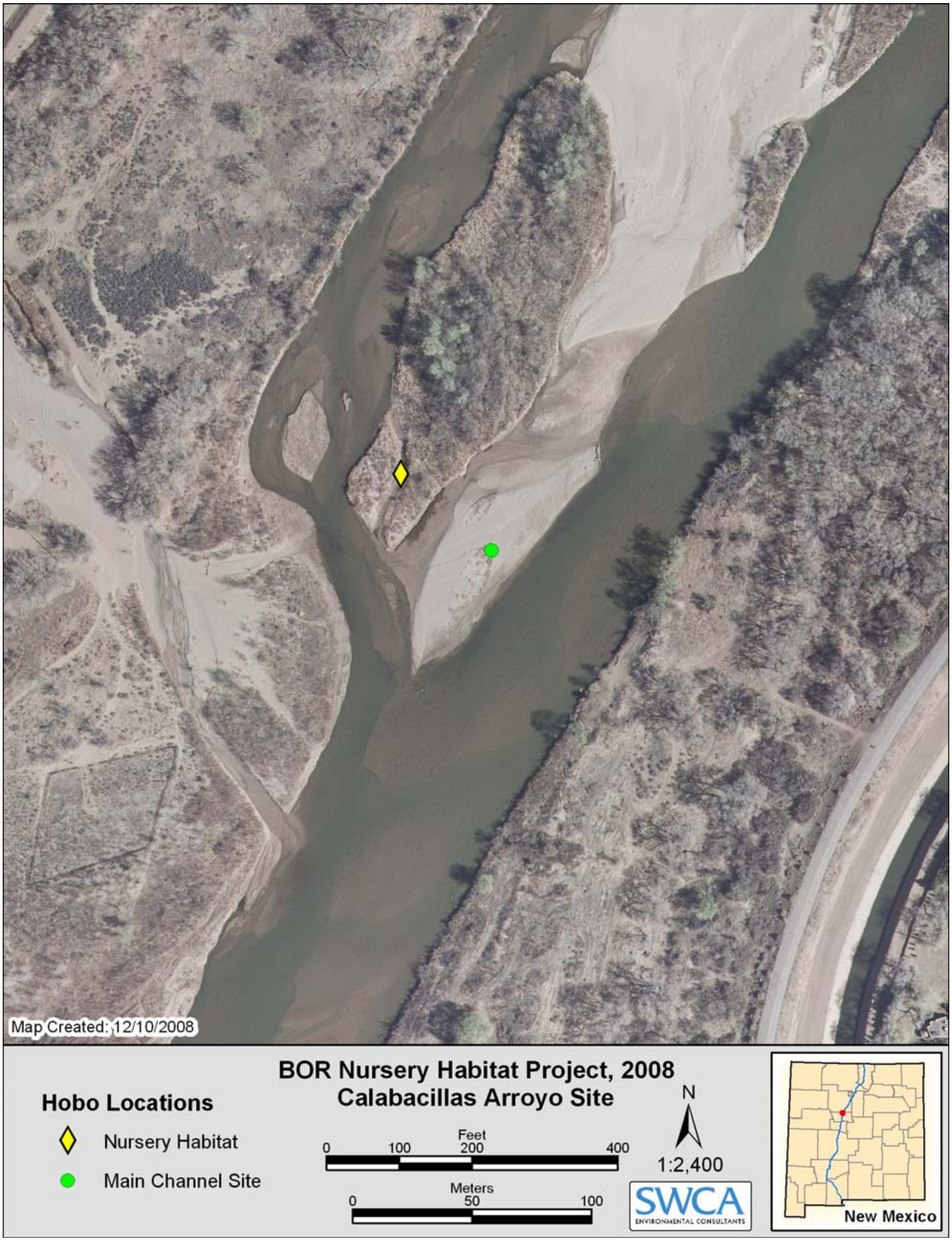


Figure H.1. Nursery habitat and main channel hobo locations at Calabacillas Nursery habitat site.

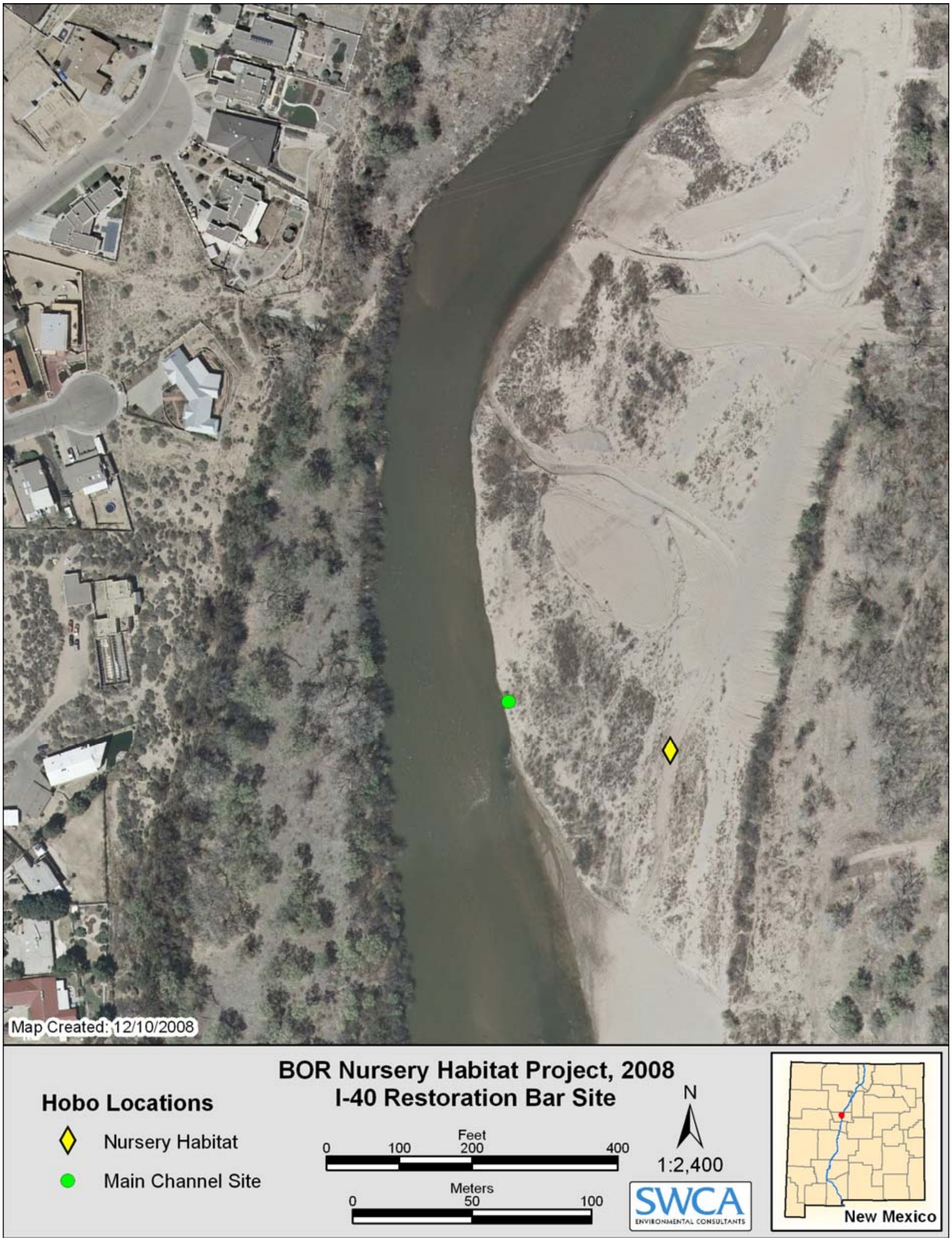


Figure H.2. Nursery habitat and main channel hobo locations at I-40 Restoration Bar nursery habitat site.

Figure H.3. Nursery habitat and main channel hobo locations at Montoya's Pond nursery habitat site.

Figure H.4. Hobo location at the Peralta Wasteway site.

Figure H.5. Hobo location at Lower Peralta Drain site.

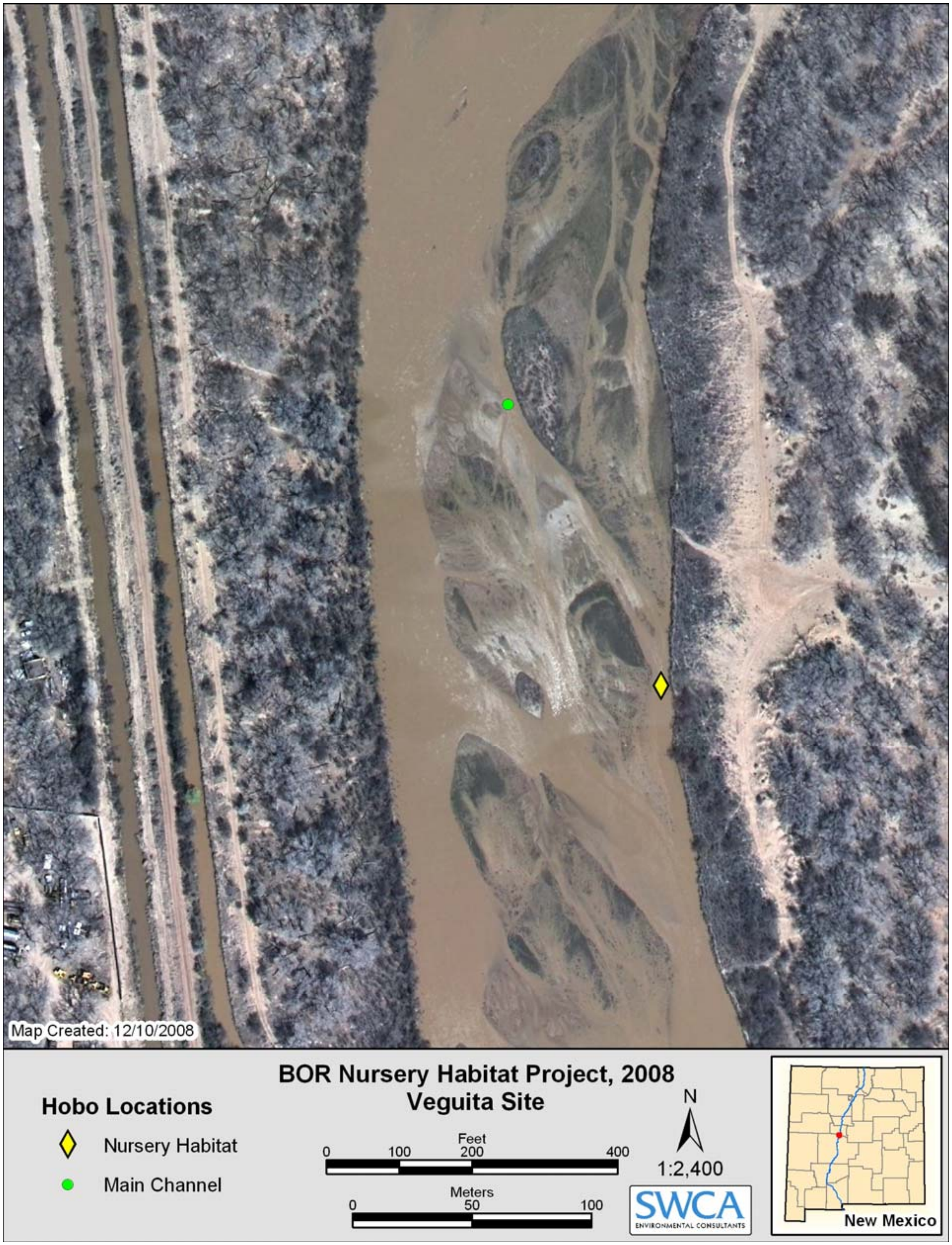


Figure H.6. Nursery habitat and main channel hobo locations at Veguita nursery habitat site.

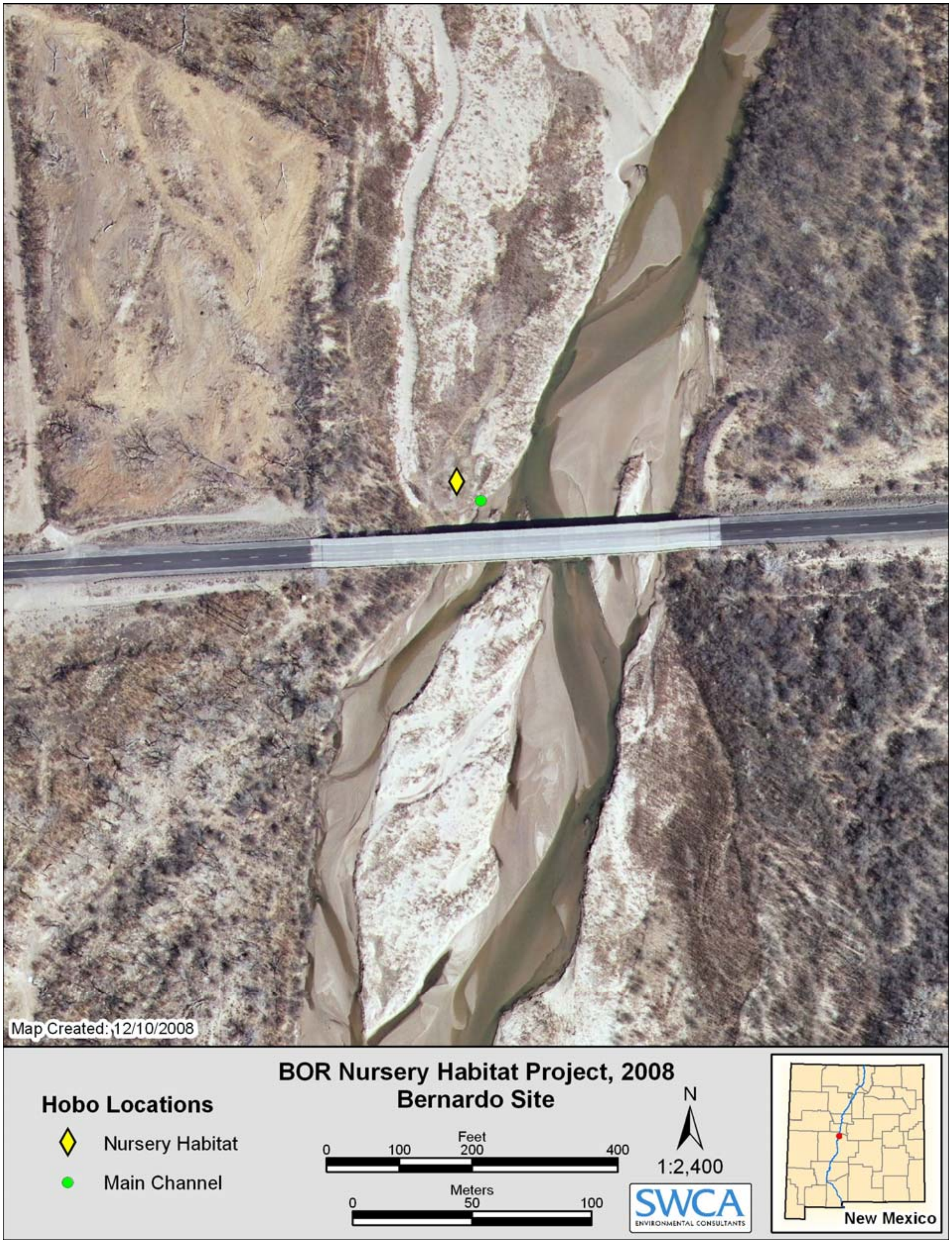


Figure H.7. Nursery habitat and main channel hobo locations at Bernardo nursery habitat site.

APPENDIX I
PHOTOGRAPHS

Figure I.1. Calabacillas nursery habitat site on June 25, 2008.

Figure I.2. Calabacillas nursery habitat site on July 31, 2008, which was the last day the site was monitored.

Figure I.3. I-40 Restoration Bar nursery habitat site on June 25, 2008.

Figure I.4. I-40 Restoration Bar nursery habitat site on July 8, 2008

Figure I.5. Crew using a D-frame kick net to sample for fish from Montoya's pond nursery habitat site on August 13, 2008

Figure I.6. Montoya's pond nursery habitat site on September 30, 2008.

Figure I.7. Peralta Main Wasteway on October 30, 2008.

Figure I.8. Lower Peralta Drain on October 13, 2008.

Figure I.9. Veguita nursery habitat site on July 2, 2008.

Figure I.10. Bernardo nursery habitat site on July 2, 2008.