HIGH PLAINS EFFLUENT RECHARGE PROJECT:

BIOLOGICAL MONITORING, 2004

FOR:
Pima County Department of
Transportation and Flood Control District

DATE:
October 2004

PREPARED BY:

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HIGH PLAINS EFFLUENT RECHARGE PROJECT
BIOLOGICAL STUDIES
MONITORING REPORT - 2004

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1 INTRODUCTION

The Pima County Flood Control District (PCFCD) constructed an aquifer recharge demonstration project on an approximately 18-acre (7.28 ha) site on the Santa Cruz River near Marana, Pima County, Arizona (see Figure 1). Construction of the facility was completed in 2002, and the facility was operational beginning in February of 2003. The demonstration project provides floodplain aquifer recharge using treated effluent from the Santa Cruz River. Recharge is via infiltration from five shallow basins.

Prior to construction, a baseline description of the site was prepared by Entranco (1998) under contract to the PCFCD. That report included a brief history of the site with regard to human-caused changes in the surface flow, groundwater hydrology and land use of the region. The report also included baseline data collection and a description of the biological characteristics of the site.

In 2002 Environmental Planning Group (EPG) conducted initial monitoring of the biological characteristics of the site, and provided a report of the recently constructed, but then non-operational recharge project. This initial report was the first of a planned long-term series of monitoring reports on the aquifer recharge site. The present report follows the methodology established during the 2002 study season.

2 METHODS

2.1 VEGETATION

Vegetation at the High Plains Effluent Recharge Site was quantified using methods modified in 2002 by EPG after those in Entranco (1998). Plant communities were identified on a large-scale aerial photograph of the site, and each community was treated as a separate stratum in the data collection. Plant communities were classified using the Brown, Lowe, Pase (1979) digital community classification system. To randomize sample point location within each community, a grid of points spaced at 6 m was placed on the aerial photograph. Within a community, random points were selected using random number generation software (Urbaniak and Plous 2003). The location of each point was found in the field by reference to identifiable features such as trees, large shrubs, open areas, and drainage features.

Eight points were selected in each of the three habitats dominated by relatively undisturbed, natural vegetation. Each point selected in this random process was used as the center point of a 4 m by 4 m plot, with an area of 16 sq. m. These squares were oriented with the boundaries in north-south and east-west directions.

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Environmental Planning Group 330 E. 13th St. Tucson, Arizona 85701	Scale: 1:100,000 1 inch : 0.48 Mi Project No. 1432 October 2004	Figure 1. Site Location Map High Plains Effluent Recharge Site Pima County Floodwater District

For each live perennial plant on a study plot, the following data were recorded:

- maximum height within the plot;
- canopy length and width at one meter intervals above ground level; and
- location of stem inside or outside plot.

For plants under 1 meter in height, the maximum canopy was measured. For most plants the maximum height was below 7 m, and canopy extent was measured at one-meter intervals up to that point with a graduated telescoping pole. However, in two plots in the Tamarisk-Willow habitat single athel trees (*Tamarisk aphylla*) that dominated the plots were in excess of the maximum height of the pole (7.62 meters). For these two plots, above the 7-meter height, visual estimates of the canopy were made, and only the ultimate height of the portion of the tree within the plot was measured. This height was determined by use of a clinometer and tape. Annual plants were not measured, but the percent cover of annual plants was estimated on each plot. Annual plant cover is not a useful measurement for long-term monitoring because of the extreme variability in annual or seasonal rainfall patterns.

For plants that were entirely within the plot, the canopy area was calculated by assuming that the area could be approximated by the area of an ellipse, defined as area = πab, where a is half of the larger measurement and b is half of the smaller measurement. Where these measurements are equal, this equation reduces to the area of a circle. When the two measurements differ greatly, the ellipse is a much more accurate representation of the canopy area. For plants with stems outside the plot, but with branches overhanging the plot, the canopy area was approximated by the area of a triangle with a base measured along the plot boundary and a height measured in from the boundary.

Within each plot, the total canopy area was calculated for each species at each height interval by adding the areas for individual plants. The total density of plants was calculated by dividing the total number of stems within the plot by 16 sq. m and multiplying by 10,000 sq. m/ha.

Within each community type, the following values were calculated:

- Species frequency (fraction of total plots with at least one individual of a species);
- Mean height and standard deviation for each species (based on all individuals measured within the community);
- Mean canopy cover area and standard deviation for each species at each height interval;
- Mean percent canopy cover and standard deviation for each species at each height interval;
- Mean density and standard deviation for each plant community.

For the comparison of two means, the *t*-test is an appropriate statistical test. Differences can be considered significant when the probability that the means are equal is less than 0.05.

Four documentary photographs were taken at each of the vegetation plots. Two photos were taken from the center of the south boundary looking to the north, and two were taken from the center of the north boundary looking south. Each of these pairs of photos included one photo taken with a 35-mm lens and one photo taken with a 55-mm lens. Examples of these photos are given in Appendix E.

Panoramic sets of photographs were taken from the same two points used by Entranco (1998) and EPG (2002). Stakes indicating these locations were still present on the site. At each point, the camera was mounted on a tripod and series of overlapping photos were taken with 35-mm and 55-mm lenses. These panoramic photos are shown in Appendix E.

A list of vascular plants present on the site was compiled from general observations made during vegetation plot data collection and from incidental observations made during site visits performed in 2002 and 2004. Thirteen additional plant species were added to the list during 2004. Eleven plant species recorded as present in 2002 were not observed during the five site visits performed in 2004. The list is not intended to be comprehensive. The plant list is provided in Appendix D.

2.2 AQUATIC ALGAE

Aquatic Consulting and Testing, Inc performed sampling for aquatic algae at the High Plains site on June 16, 2004. Two locations within the Santa Cruz River diversion channel, designated the upstream and downstream samples, were sampled for phytoplankton, periphyton, and aquatic macroinvertebrates.

At the time of sampling the diversion channel had steeply sloping banks, creating a V-channel. Water in the channel was visibly turbid. There were limited riffle areas; the channel had little cobble, leaf litter, or submerged substrates. The bottom was composed of approximately 85 percent silt and clay, 10 percent sand, and 5 percent rock (<1/2-inch).

Field temperature and oxygen measurement of the water were made using YSI Model 85 and YSI Model 58 temperature-oxygen meters. Water pH was measured with a Hanna Model HI-9025 pH meter. Stream bed conditions were described and field measurements were made in accordance with Arizona Department of Environmental Quality guidelines described in "Biological Sampling Protocols: Reference Site Selection and Sampling Methods" (Meyerhoff and Spindler 1993).

Periphyton samples were collected upstream and downstream using variable-depth Durasampler artificial substrate samplers. Each unit was fitted with five 25x75 mm glass slides as the colonization substrate. The units were exposed to the flowing water for one week. Collected material was prepared for microscopic examination using burn mount

techniques. Periphyton species densities were computed using ocular micrometer surface area measurements.

Phytoplankton grab samples were collected at the upstream and downstream sites for suspended algae analysis. Representative aliquots were transferred to Utermohl settling chambers to concentrate cells. Observations were made using a Nikon phase-contrast inverted microscope. Species identifications were made using various taxonomic keys, which are listed in the references section. Species densities were computed using ocular micrometer surface area measurements, taking into account settling chamber concentration factors. Hestor-Dendy samplers were also installed at upstream and downstream sites to serve as artificial substrate for both macroinvertebrates and periphyton. The samplers were exposed to the flowing water for a one-week period. Because of a high suspended sediment load and severe coating and clogging of the sampler plates with silt, use of the Hestor-Dendy plates for identification and enumeration of aquatic organisms was eliminated. Aquatic Consulting & Testing, Inc performed analysis of the algae samples.

2.3 AQUATIC MACROINVERTEBRATES

Aquatic Consulting and Testing, Inc. performed sampling for aquatic invertebrates on June 16, 2004. Stream macroinvertebrates were surveyed using bottom kick net (900-um mesh) collections (2x30-second duration) at each location. Samples were preserved with alcohol-formalin solution. Initial identifications were made using McCafferty (1998), Thorp and Covisch (1991), and Arnett (1993). Organism identifications were also made by SWCA Environmental Consultants, Inc. for quality assurance purposes.

2.4 BUTTERFLIES

Butterflies were observed and sampled primarily during two concentrated efforts on May 5th and May 27th, 2004. Efforts were concentrated rather than time constrained in an attempt to document all species present. Knowledge of all species using each habitat is important for the determination of the butterfly riparian quality (BRQ) for each habitat. Each of the three defined habitats was surveyed. Additional information was obtained as incidental data during four other site visits and was included in the determination of the BRQs for each habitat.

Observations and sampling of butterflies were performed in general conformance with the procedure developed by Nelson and Andersen (1994). This method utilizes butterfly species composition and relative species disturbance susceptibility to assign a measure of riparian habitat condition, or index of butterfly riparian quality for a given riparian site. Each butterfly species found is given a weighted value in each of four ecologic categories. The sum of the four values is the disturbance susceptibility score (DSS) for each species. A higher DSS is indicative of greater species sensitivity to ecological disturbance. A mean DSS is then determined from the total of the individual disturbance susceptibility scores for all the species documented. The BRQ is calculated as the product of species richness and the proportion of species having a DSS greater than the

mean DSS. Any BRQ value is relative, and it is a significant measure only when compared with other riparian habitats. BRQs were calculated for each of the three plant associations that were identified on the project site. The values obtained may be compared with each other and, to provide a regional perspective, with the values obtained by Nelson and Anderson (1994) for the Bill Williams Delta (BWD) site on the lower Colorado River near Parker, AZ. Because of its relatively low level of disturbance and non-channelized condition, the BWD site was used as the reference riparian site in their original study. Also for comparison, the BRQ values from 2002 and 2004 are shown in Appendix B, Tables B3-a, B3-b, and B3-c.

The four ecologic categories ranked for each species were: species mobility, larval host-plant form, larval food-plant specificity and riparian dependency. The original values assigned by Nelson and Andersen (1994) were based on a maximum weight of 5 representing the "idealized" riparian condition, 3 for values deviating somewhat from the ideal, and 0 for those deviating strongly from the idealized condition. Modifications to this methodology were made by EPG during the 2002 monitoring season, but only for the values previously assigned for the larval host-plant form category. The original values assigned by Nelson and Anderson for this category were: trees = 5, grass = 3, herbs (forbs) = 2, and shrubs = 1. It was felt that a more appropriate assignment of values for this category would be: trees = 5, shrubs = 3, forbs = 2 and grass = 1. These adjustments to the larval host-plant form values do not greatly affect the calculated disturbance susceptibility scores. These reassigned values were applied to the species listed by Nelson and Andersen (1994), Entranco (1998), and additional species found at the High Plains Effluent Recharge Project site during the 2002 and 2004 studies. Additionally, the remaining ecological category values assigned each species by Nelson and Andersen (1994) and Entranco (1998) were reviewed and minor adjustments were made to some of the values based on species ecological information obtained from Stewart et al. (2001) and the USGS website on butterflies (2004). The parameter modifications implemented by EPG in 2002 have been maintained for the 2004 season. The only changes in 2004 have been the addition of DSS values for 13 species of butterflies not previously encountered at the High Plains site. DSS values for three of these species were taken from Nelson and Anderson (1994), and DSS values for the remaining 10 species were established using their protocols (Nelson and Anderson 1994).

The value of the methodology developed by Nelson and Andersen (1994) is dependent on an accurate assessment of all species of butterflies present in a habitat. For this reason, a concerted effort was made to determine all species that were present in each of the three habitats present on the project site. Susceptibility to disturbance varies in butterflies from species to species, and highly sensitive species, or those marginal for a habitat may be present in small numbers. Time constrained or cursory observations may not establish the presence of such species and could adversely affect the accuracy of the BRQ obtained. To minimize the chance of non-detection of species present in small numbers, efforts spent observing and sampling butterflies in each of the habitats were not time constrained. Possibly due to this additional effort, four species of butterflies were added to the project list in 2002, and another 13 species in 2004. A composite list of butterfly species for the site was compiled from the censuses performed by EPG in May and September of 2002, and in April and May of 2004, and includes the earlier information

from Entranco (1998) (Appendix B, Table B-2).

2.5 REPTILES AND AMPHIBIANS

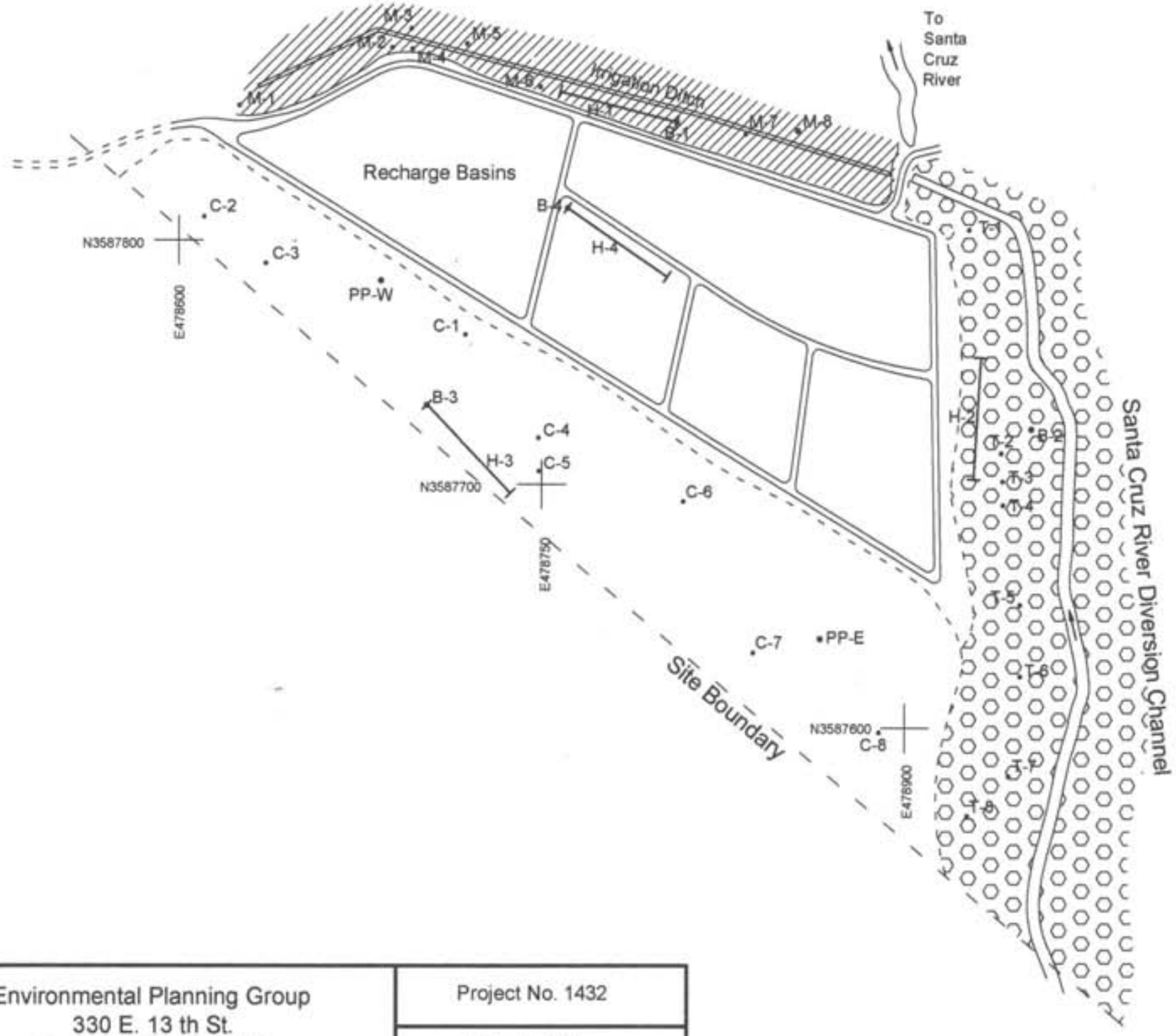
During the 2002 season, transects for reptiles and amphibians (herptiles) were located in each of the four habitats present on the site at that time. Because the activation of the recharge basins in 2003 altered the habitat of the basins, herptile transect (H-4), which was located in one of the recharge basins (near bird point B-4), has been moved to the shoulder of that recharge basin. Global Positioning System (GPS) data were obtained for each transect during the 2002 monitoring, and these sites were re-occupied in 2004, with the slight adjustment for transect H-4. Each transect is 50 meters long by 4 meters wide. Transects in the creosote bush association and the mesquite/palo verde community had one end common with the bird census point for that habitat. In the tamarisk/willow community, the herptile transect was offset from the bird census point because of the proximity of the diversion channel and the density of vegetation. Each transect was surveyed for at least five minutes on two different days. During these surveys, woody debris and rocks were moved to search for herptiles that could be hiding. These materials were replaced in their original location and orientation to minimize habitat disturbance.

Additional reptile and amphibian observations were recorded during the course of other data collection activities on the site. Lists of all species observed on the site were kept for each site visit and compiled for an overall species list for the site (Table 7).

2.6 BIRDS

Point counts for birds were conducted using the variable circular-plot method described by Reynolds et al. (1980). Counts were made at four locations on the property, with one point in each of the habitat types (see Figure 2). During each census, all birds observed (seen or heard) were recorded, with an estimated distance from the central point. For each individual, the habitat use was recorded as in the habitat of the central point, in an adjacent habitat, or flying over the site. Each point was censused twice during May, to include the early breeding season and the end of the spring migration. From the combined results, it is possible to estimate the density of species observed within the habitat of the central point.

Other bird observations were recorded during the course of other data collection activities on the site. Lists of all species observed on the site were kept for each site visit and compiled for an overall species list for the site (Appendix C, Table C-1). Observations included the immediate vicinity of the project site, including the Santa Cruz River Diversion Channel and adjacent pastures and irrigated fields. Any unusual species, behaviors, and evidence of breeding were noted on the incidental observation data sheets.



N

50 0 100

Approximate Scale, m

Legend

Plant Communities

Creosote Bush Association

Mesquite-Palo Verde Association

Tamarisk-Willow Association

Sample Points

Creosote Bush Association Plots = C
Mesquite-Palo Verde Association Plots = M
Tamarisk-Willow Association Plots = T

Bird Point Counts = B
Herptile Transects = H
Panorama Photo Points = PP

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Project No. 1432

October 2004

Figure 2. Site Plan Sketch
High Plains Effluent Recharge Site
Pima County Floodwater District

2.7 MAMMALS

No specific mammal surveys were conducted on the site. However, any observations of mammals using the area were recorded on incidental observation data sheets. Observations included direct sightings, tracks, scat, and burrows.

3 RESULTS AND DISCUSSION

3.1 VEGETATION

The plant communities present on the site in 2004 are unchanged from what was present in 2002, with the exception that the recharge basins having been periodically filled with effluent water. Because the recharge basins have only been receiving waters since February of 2003, there has been no colonization by emergent vegetation, and a vegetation classification for the basins cannot be stated at this time. The following plant associations are currently found on the site.

1. Creosote Bush Association. This association is present on the higher ground on the southwest side of the project site. The land surface is relatively flat, but it is dissected by shallow, eroded gullies. Creosote bush (*Larrea tridentata*) is the dominant species, with a few chollas (*Opuntia* sp.) present. This association is in the category 1,154.111 – *Larrea tridentata* (*divaricata*) association (Brown et al. 1979). It is a subcategory of the creosote bush-bursage series of the Lower Colorado River Subdivision of Sonoran Desertscrub.

2. Mesquite-Palo Verde Association. This association is found along the irrigation canal on the north edge of the site. Dominant species include velvet mesquite (*Prosopis velutina*), Mexican palo verde (*Parkinsonia aculeata*), and Mexican elderberry (*Sambucus nigra*). Desert broom (*Baccharis sarothroides*) is a minor component of this association. Because this habitat is adjacent to the river channel and subject to infrequent but periodic submersion, it would fit the definition of a strandland (Brown et al. 1979). This association would fit into the category 1,254.71 – Sonoran Interior Strand, mixed shrub series, but no association has been defined with this set of species (Brown et al. 1979).

3. Tamarisk-Willow Association. This association is present adjacent to the Santa Cruz River Diversion Channel. Dominant species include athel (*Tamarix aphylla*), tamarisk (*Tamarix* sp.), Goodding willow (*Salix gooddingii*), and seep-willow (*Baccharis salicifolia*). Desert broom is a minor component of this association. Because this habitat is a river channel community subject to infrequent but periodic submersion, it would fit the definition of a strandland (Brown et al. 1979). This association would fit into the category 1,254.71 – Sonoran Interior Strand, mixed shrub series, but no association has been defined with this set of species (Brown et al. 1979).

4. Recharge Basins. The central portion of the site has been highly modified since the Entranco study in 1998. During construction of the recharge facility this area was cleared and graded, and berms were built to separate it into five individual basins, with pipes and gates to control water flow. This area was mapped as a desert broom association by Entranco (1998), but in May of 2002 it supported no natural vegetation. Native tree and shrub species have been planted around the perimeter of the basins, with a drip irrigation system to get them established. Currently the basins intermittently receive water and support many disturbed ground-colonizing plant species, including some plants such as saltbush (*Atriplex* sp.) that reach approximately 1.2 meters in height. This portion of the site is in transition, and we do not currently assign any plant association as defined in the Brown et al. (1979) classification system. Once emergent vegetation becomes established, the basins may be reclassified.

CREOSOTE BUSH ASSOCIATION

The creosote bush association, which is present on the southwest portion of the project site, southwest of the recharge basins, is dominated by creosote bush with only a handful of cane cholla (*Opuntia spinosior*) scattered within the habitat. Results of vegetation sampling in this habitat are summarized in Appendix A. The habitat is elevated several feet above the remainder of the project site, and may represent an old embankment of the Santa Cruz River. This elevated section is currently being dissected from the northeast at its boundary with the site perimeter roadway. In contrast to the 2002 season, when no annual ground cover was present, the 2004 visually estimated annual ground cover averaged approximately 6 percent, and was composed almost entirely of Arab grass (*Schismus arabicus*). The two permanent panoramic photo points are located in this habitat (see Figure 2). Panoramic photos from these points are given in Appendix E, Figures E-1a & b, and E-2 a & b.

Creosote bush was present in all but one of the eight study plots in this habitat. No other woody plant species was present in any of the eight study plots. Average measured plant height for creosote bush was 1.46 m, which compares reasonably well with the 1.38 m height recorded for the 2002 season. A *t*-test of these values indicates no significant difference ($t = 0.292$, $df = 14$, $p > 0.3$). The mean canopy cover for the study plots is 20.4 percent at a height of one meter, which is less than the 35.4 percent that was recorded in 2002. A *t*-test of these values indicates no significant difference ($t = 1.963$, $df = 14$, $p > 0.05$). At a height of 2 m, the mean canopy cover for the study plots is 2.57 percent, which is considerably less than the 7.16 percent observed in 2002, but more closely approximates the canopy cover of 2.7 percent listed by Entranco (1998). A *t*-test comparing the year 2002 and 2004 data indicates no significant difference ($t = 0.770$, $df = 14$, $p > 0.4$).

The overall plant density in this habitat, 1,250 plants per hectare, was less than the density of 1,523 plants/ha reported by EPG in 2002. However, a *t*-test of these values indicates no significant difference ($t = 0.071$, $df = 14$, $p > 0.9$).

This essentially monotypic plant community provides a thin canopy where approximately 75 percent of the plants are less than 2 m in height. Some desert broom and desert-willow are present at the lower edge of this habitat, close to the recharge basins. Representative photos from this habitat are given in Appendix E, Figures E-3(a-d) and E-4(a-d).

MESQUITE-PALO VERDE ASSOCIATION

The mesquite-palo verde association is present along the northeast boundary of the project site along the existing irrigation ditch. This habitat continues northeast beyond the irrigation ditch and off the project site towards the Santa Cruz River. The density of the habitat north of the project site increases to the southeast where it intergrades with the tamarisk-willow habitat along the Santa Cruz River Diversion Channel.

Much of this habitat is quite open, with the dominant canopy elements being mesquite and Mexican palo verde. Other woody plants found in the eight plots were four-wing saltbush (*Atriplex canescens*), tree tobacco (*Nicotiana glauca*), desert broom (*Baccharis sarothroides*), and burroweed (*Isocoma tenuisecta*). Mexican elderberry occurs in the habitat, but was not present in any of the random study plots in 2004.

The total canopy cover measured for the mesquite-palo verde plant association in 2004 and corresponding results from the 2002 (EPG) and 1998 Entranco reports are reported in Table 1. Although the recent values are lower or much lower at each canopy height except for the 5-meter height, the differences in values between 2002 and 2004 are not statistically significant. In the 2002 report it was suggested that the lower canopy values obtained in 2002 may have been a result of the removal of trees during construction of the recharge basins and roads prior to the 2002 observations.

Table 1. Comparison of canopy cover measurements, mesquite-palo verde association.

Height above ground, m	Canopy Cover % - Entranco (1998)	Canopy Cover % - EPG (2002)	Canopy Cover % - EPG (2004))	t-value Comparison - EPG 2002/2004	Probability EPG 2002/2004
1	23.5	21.24	10.60	1.462	> 0.1
2	53.4	12.12	5.72	0.970	> 0.3
3	33.4	9.28	2.61	1.367	> 0.1
4	9.4	1.47	0.88	0.349	> 0.7
5	9.4	0.77	1.01	0.189	> 0.8
6	0.00*	0.00*	1.72	*	*

*No data at 6 meters from 1998 or 2002.

The average estimated percent annual ground cover of forbs and grasses for the eight plots is approximately 42 percent, up from 35 percent in 2002, and probably reflects the more normal winter rains received during the 2003/2004 winter rainfall season. The

annual plants are predominantly Bermuda grass (*Cynodon dactylon*). A few buffalo bur (*Solanum rostratum*) are present along the edges of the irrigation ditch, at a density visually estimated to be unchanged since 2002. During the site visits in April of 2004 it was noticed that milk thistle (*Silybum marianum*), an invasive species, has a higher density along the irrigation canal than the couple of plants that were present in 2002. During the site visit in early May of 2004 it was observed that most of the plants had apparently been sprayed as a method of control. However, several new plants of this species, to about one foot in height, were already present at that time.

Average woody plant density for the mesquite-palo verde association is 898 plants/ha, which is only slightly lower than the creosote bush association density of 1,250 plants/ha. While this plant density is little more than half of the year 2002 reported density (1,602 plants/ha, it is not considered significantly different ($t = 1.132$, $df = 14$, $p > 0.2$).

In addition to the plant species that were recorded in this plant association in 2002, Mexican elderberry and cheeseweed burrobrush (*Hymenoclea monogyra*) appeared in the study plots for the 2004 sampling. Mexican elderberry was reported previously by Entranco (1998), but was not present in any of the 2002 study plots. The cheeseweed burrobrush may be the "Emory baccharis" that was reported by Entranco (1998). Representative photos from this habitat are given in Appendix E, Figures E-5(a-d) and E-6(a-d).

TAMARISK-WILLOW ASSOCIATION

The tamarisk-willow association is present on the project as a relatively narrow band of vegetation bordering the Santa Cruz River Diversion Channel. The boundary with the adjacent, more xeric, creosote bush habitat is generally well defined, and abrupt. The tamarisk-willow association indistinctly intergrades with the mesquite-palo verde habitat at the northeast corner of the site. The plant community is dominated by *Tamarix* spp. and Goodding willow. Other important woody plants present are desert broom, velvet mesquite, seep-willow, and Mexican elderberry. Mature plants of Goodding willow, Tamarisk, and athel form the overstory in this habitat. The mid-story is comprised primarily of tamarisk and velvet mesquite however; Mexican elderberry and tree tobacco are not uncommon, while other woody species, generally less than 3 m in height (Appendix A, Table A-3a), form the understory. A typical multi-tiered riparian habitat is thus present. Total measured canopy cover for this plant association is 31 percent (42 percent in 2002) at 1 meter. The 2002 values showed a gradually decreasing cover up to the 5 m level, and rapidly diminishing between 5 and 6 meters. However, due to three of the 2004 random plots occurring beneath large individual athel trees, the rapid diminution of the canopy did not occur until a height of 11 to 12 meters was obtained. Two of these athel trees were over 14 meters in height.

The total canopy cover measured in this study and corresponding results from EPG (2002) and Entranco (1998) are reported in Table 2. The corresponding values are generally comparable at each canopy height, and the differences between the 2002 and 2004 values are not statistically significant.

Table 2. Comparison of canopy cover measurements, tamarisk-willow association.

Height above ground, m	Canopy Cover % - Entranco 1998	Canopy Cover % – EPG (2002)	Canopy Cover % – EPG (2004)	t-value Comparison - EPG 2002/2004	Probability EPG 2002/2004
1	53.0	42.19	32.44	0.677	> 0.5
2	44.2	32.02	39.90	0.503	> 0.6
3	22.4	20.62	36.64	1.237	> 0.2
4	11.9	15.20	28.71	1.079	> 0.2
5	6.8	11.75	24.62	1.026	> 0.3
6	4.7	3.05	20.55	1.846	> 0.05
7	2.9	2.03	17.26	1.411	> 0.1
8	*	1.02	16.77	1.444	>0.1
9	*	1.12	16.16	1.380	> 0.1
10	*	0.76	16.07	1.406	> 0.1
11	*	*	16.07	*	*
12	*	*	15.82	*	*
13	*	*	15.10	*	*
14	*	*	11.16	*	*
15	*	*	6.25	*	*
16	*	*	6.25	*	*
17	*	*	6.25	*	*

*No previous data at these canopy heights.

The average estimated percent annual ground cover of forbs and grasses for the eight plots is less than 2 percent. This is considerably less than the approximately 20 percent found in 2002, but reflects the random selection of the plots and that three of the plots (T2, T3, and T4) in this habitat were dominated by very large athel trees that have shaded out all annual plant species. Another of the plots (T7) had a dense mid-story of Mexican elderberry and tree tobacco that also precluded the presence of annual forbs or grasses. In places Tamarisk and desert broom exist either as monotypic stands or together at densities that are almost impenetrable.

Average density of plants in the tamarisk-willow association is 1875 plants/ha, which is greater than either the creosote bush or mesquite-palo verde associations during the 2004 monitoring season. However, these differences are not statistically significant ($t = 0.565$, $df = 14$, $p > 0.5$ for creosote bush association and $t = 0.855$, $df = 14$, $p > 0.4$ for the mesquite palo verde association). Likewise, this plant density is not significantly different from the density of 4,180 plants/ha reported by EPG in 2002 for this habitat ($t = 1.304$, $df = 14$, $p > 0.2$). Representative photos from this habitat are given in Appendix

E, Figures E-7(a-d) and E-8(a-d).

3.2 AQUATIC ALGAE

Basic physical properties of temperature, dissolved oxygen content, and pH of the diversion channel water were measured at the time algae samples were obtained. The results of these physical and chemical tests of the diversion channel water are summarized in Table 3. The season of sampling was almost identical in 2002 and 2004, samples having been taken on June 19th in 2002, and on June 16th in 2004. The water temperature of the sample in 2004 was 6 degrees centigrade less than in 2002. The dissolved oxygen content was down from the value of 3.6 mg/L measured in 2002. Hydrogen ion concentration (pH) was up slightly from the value of 7.5 recorded in 2002.

Table 3. Physical and chemical water parameters of the Santa Cruz River diversion channel.

Parameter	Upstream	Downstream
Temperature, C	24.3	24.5
Dissolved oxygen, mg/L	2.4	2.3
pH, SU	7.9	7.8

Six species of periphyton were found upstream, and eight species were found downstream. Cell density was very high and similar at both locations, but less than that reported in 2002. Combined overall density of periphyton for 2004 is only 29 percent of the density recorded in 2002. The unicellular diatoms, *Cymbella, Gomphonema, Navicula*, and *Planothidium* (*Achnanthes*) dominated the collections in 2004. Calculated cell density and percent of total composition for each species are summarized in Tables 4a and 4b below.

There are some differences in the suite of species represented in 2002 and 2004. In 2002 *Nitzschia* ssp. made up 34.7 and 50.1 percent of the upstream and downstream samples respectively. In 2004 *Nitzschia* was not represented in the upstream sample, and was present in the downstream sample as *N. accedans*, representing only 0.6 percent of the sample. Two species that were present in 2002, *Pinnularia substomatophora* and *Synedra affinis*, were not present in the 2004 samplings, but were only small components of the total species recorded in 2002. Two new species recorded in 2004 are *Planothidium* (*Achnanthes*) *lanceolatum* and *Synedra ulna*. *P. lanceolatum* represented the fourth highest overall density of the species recorded this year, but *S. ulna* was a minor component representing only 0.6 percent of the total density for each of the two samples. Because the 1998 algae sampling was performed during a different season, and the level of taxonomic discrimination reported was less precise, we attempt no comparisons here between those data and the data obtained in 2002 and 2004. However, it is apparent from the 1998 results that a rather different suite of algal species was present at that time, which could be attributable to changes in water quality, season of sampling, or other undetermined factors.

Table 4a. Periphyton densities at the diversion channel upstream sampling site. Species not previously recorded on the site are highlighted in blue.

Species	Density (cells/sq m)		Composition, %	
	2002	2004	2002	2004
Planothidium (Achnanthes) lanceolatum	0	1,750	0	32.5
Navicula tripunctata	580	1,560	3.5	29.0
Cymbella amphicephala	580	1,180	3.5	21.9
Gomphonema parvulum	7,600	827	45.1	15.4
Surirella ovalis	1,050	30	6.2	0.6
Synedra ulna	0	30	0	0.6
Synedra affinis	580	0	3.5	0
Nitzschia accedans	3,740	0	22.2	0
Nitzschia sp.	2,100	0	12.5	0
Pinnularia substomatophora	580	0	3.5	0
Total	**16,810**	**5,377**	**100.0**	**100.0**

Table 4b. Periphyton densities at the diversion channel downstream sampling site. Species not previously recorded on the site are highlighted in blue.

Species	Density (cells/sq m)		Composition, %	
	2002	2004	2002	2004
Gomphonema parvulum	6,430	1,780	33.1	34.8
Cymbella amphicephala	0	1620	0	31.7
Navicula tripunctata	1,640	1020	8.4	20.0
Planothidium (Achnanthes) lanceolatum	0	570	0	11.1
Nitzschia accedans	9,120	30	47.1	0.6
Synedra ulna	0	30	0	0.6
Surirella ovalis	0	30	0	0.6
Navicula sp.	0	30	0	0.6
Pinnularia substomatophora	1,050	0	5.4	0
Nitzschia sp.	585	0	3.0	0
Navicula cryptocephala	585	0	3.0	0
Total	**19,410**	**5,110**	**100.0**	**100.0**

A total of fifteen genera of phytoplankton were identified. Changes of phytoplankton diversity in 2004 over 2002 were more pronounced than that for the periphyton. New phytoplankton site records include eight new species in seven new genera, an increase of 50 percent in diversity over 2002. Seven species present in 2002, representing 64 percent of the density for that sample, were absent in 2004. *Synedra* was previously represented

by *S. affinis*, which was not found in 2004, and is currently present only as *S. ulna*. Three species previously recorded as periphyton, but new for the phytoplankton records are, *Cymbella amphicephala*, *Navicula tripunctata*, and *Surirella ovalis*. In 2004 all phytoplankton species present in the downstream sample also occurred in the upstream sample. There were three different species in the upstream sample; *Cymbella amphicephala*, *Chlorella* sp., and *Scenedesmus quadricauda*. Total phytoplankton cell densities were approximately 1.9 x 10^3 cells/mL (upstream), and 2.4 x 10^3 cells/mL (downstream). Combined overall density of phytoplankton for 2004 is only 18 percent of the density recorded in 2002. Algae species, division, form, density, and relative abundance are presented in Tables 5a and 5b.

Table 5a. Phytoplankton densities at the diversion channel upstream sampling site. Species not previously recorded on the site are highlighted in blue, and species that are new phytoplankton records, but were previously recorded as periphyton are highlighted in yellow.

Species	Division & Form	Density (cells/mL)		Composition, %	
		2002*	2004	2002*	2004
Gomphonema parvulum	Bacillariophyta Unicell	2,095	376	17.64	20.1
Planothidium (Achnanthes) lanceolatum	Bacillariophyta Unicell	0	235	0	12.6
Oscillatoria sp.	Cyanophyta Filament	2,166	189	18.25	10.1
Cymbella amphicephala	Bacillariophyta Unicell	0	188	0	10.1
Navicula tripunctata	Bacillariophyta Unicell	0	188	0	10.1
Synedra ulna	Bacillariophyta Unicell	0	141	0	7.6
Cryptomonas sp.	Cryptophyta Flagellated unicell	0	102	0	5.5
Rhoicospenia curvata	Bacillariophyta Unicell	0	94	0	5.0
Chlorella sp.	Chlorophyta Unicell	0	94	0	5.0
Synechococcus aeruginosus	Cyanophyta Colony	0	94	0	5.0
Surirella ovalis	Bacillariophyta Unicell	0	47	0	2.5
Nitzschia sp.	Bacillariiophyta Unicell	0	47	0	2.5
Gleothece sp.	Cyanophyta Colony	0	47	0	2.5

Species	Division & Form	Density (cells/mL)		Composition, %	
		2002*	2004	2002*	2004
Scenedesmus quadricauda	Chlorophyta Colony	0	15	0	0.8
Euglena sp.	Euglenophyta Flagellated unicell	7	11	0.06	0.6
Achnanthes affinis	Bacillariophyta Unicell	658	0	5.54	0
Achnanthes sp.	Bacillariophyta Unicell	60	0	0.51	0
Cymbella microcephala	Bacillariophyta Unicell	1,317	0	11.09	0
Navicula accomoda	Bacillariophyta Unicell	60	0	0.51	0
Navicula cryptocephala	Bacillariophyta Unicell	120	0	1.01	0
Nitzschia kutzingiana	Bacillariophyta Unicell	5,327	0	44.88	0
Pinnularia divergentissima	Bacillariophyta Unicell	60	0	0.51	0
Total		**11,870**	**1,868**	**100.0**	**100.0**

* The 2002 upstream and downstream phytoplankton grab samples were composited due to the rapid flow rate at the time of sampling.

Table 5b. Phytoplankton densities at the diversion channel downstream sampling site. Species not previously recorded on the site are highlighted in blue, and species that are new phytoplankton records, but were previously recorded as periphyton are highlighted in yellow.

Species	Division & Form	Density (cells/mL)		Composition, %	
		2002*	2004	2002*	2004
Gleothece sp.	Cyanophyta Colony	0	564	0	22.8
Synechococcus aeruginosus	Cyanophyta Colony	0	470	0	19.0
Gomphonema parvulum	Bacillariophyta Unicell	2,095	376	17.64	15.2
Planothidium (Achnanthes) lanceolatum	Bacillariophyta Unicell	0	282	0	11.4
Navicula tripunctata	Bacillariophyta Unicell	0	235	0	9.5
Oscillatoria sp.	Cyanophyta Filament	2,166	208	18.25	8.4
Cryptomonas sp.	Cryptophyta	0	95	0	3.9

Species	Division & Form	Density (cells/mL)		Composition, %	
		2002*	2004	2002*	2004
	Flagellated unicell				
Rhoicospenia curvata	Bacillariophyta Unicell	0	94	0	3.8
Synedra ulna	Bacillariophyta Unicell	0	94	0	3.8
Surirella ovalis	Bacillariophyta Unicell	0	47	0	1.9
Euglena sp.	Euglenophyta Flagellated unicell	7	6	0.06	0.3
Achnanthes affinis	Bacillariophyta Unicell	658	0	5.54	0
Achnanthes sp.	Bacillariophyta Unicell	60	0	0.51	0
Cymbella microcephala	Bacillariophyta Unicell	1,317	0	11.09	0
Navicula accomoda	Bacillariophyta Unicell	60	0	0.51	0
Navicula cryptocephala	Bacillariophyta Unicell	120	0	1.01	0
Nitzschia kutzingiana	Bacillariophyta Unicell	5,327	0	44.88	0
Pinnularia divergentissima	Bacillariophyta Unicell	60	0	0.51	0
Total		**11,870**	**2,471**	**100.0**	**100.0**

* The 2002 upstream and downstream phytoplankton grab samples were composited due to the rapid flow rate at the time of sampling.

3.3 AQUATIC INVERTEBRATES

Few macroinvertebrate taxa were observed in the samples. This is at least partially due to the limited number of samples obtained. Aquatic earthworms (*Amphichaeta* sp.) and chironomid larvae dominated the collections. A total of 1768 organisms were collected upstream and 272 organisms were collected downstream. Table 6 provides a list of the major taxa and the number found.

The increase in the presence of midge larvae (Diptera: chironomidae), often referred to as bloodworms, in 2004 over the 2002 sampling may be reflected in the current physical properties of the diversion channel water. The Environmental Protection Agency (EPA) has a recommended minimum dissolved-oxygen content of 5 mg/L to adequately support aquatic life (Bain and Stevenson 1999). The somewhat lower average dissolved oxygen value in 2004 (2.4 mg/L) when compared with the 2002 value of 3.6 mg/L may explain the general increase in density of bloodworms and aquatic earthworms, both of which are tolerant of lower available water oxygen contents.

The Arizona Department of Environmental Quality (ADEQ) has developed a table of tolerance values for aquatic macroinvertebrates that rates animals on their pollution tolerance (Spindler 2001). The scale ranges from 0 (intolerant) to 10 (highly tolerant). The bloodworms recorded in 2004, (*Bryophaenocladius* and *Glyptotendipes*) have pollution tolerance values of 6 and 10 respectively. These two genera of bloodworms were present in approximately a 2:1 ratio respectively (R. Amalfi, Personal Communication with R. Pape, Oct. 2004). The presence of mayflies (ephemeroptera) and water boatmen (hemiptera: corixidae) in the 2004 sampling, which were not observed in 2002, does not imply improved water quality since these animals are relatively tolerant of poor water quality. Water boatmen have a pollution tolerance value of 8. Mayflies vary in their tolerance (from 0 to 9) depending on species. The mayfly nymphs sampled were not identified beyond order, and their tolerance value cannot accurately be categorized. Due to the low dissolved oxygen content recorded, it is likely that the mayfly present is one of the more tolerant species. The amphipod (*Hyalella azteca*) recorded in 2002 has a tolerance value of 8 (ADEQ 2001), and the slight decline in water quality should not have removed this species from the habitat. It is likely that this species is still present, and the small number of samples taken could explain its apparent absence.

Table 6. Aquatic macroinvertebrates found at the High Plains Effluent Recharge Site. Species not previously recorded on the site are highlighted in blue.

Taxon/Family	Species	Upstream		Downstream	
		2002	2004	2002	2004
Haplotaxida (Aquatic earthworms) Naididae	*Amphichaeta* sp.	168	1,200	40	4
Diptera (Flies) Chironomidae	*Bryophaenocladius* sp. *Glyptotendipes* sp.	2 1	524	0 0	268
Ephemeroptera (Mayflies)	Undetermined	0	38	0	0
Hemiptera (True bugs) Corixidae	Undetermined	0	6	0	0
Odonata (Dragonflies, damselflies) Coenagrionidae	Undetermined sp.	0	0	1	0
Hemiptera (True bugs) Naucoridae	*Ambrysus* sp.	0	0	1	0
Cladocera (Water fleas) Daphnidae	*Daphnia pulex*	0	0	1	0
Amphipoda (Scuds, sideswimmers) Talitridae	*Hyalella azteca*	83	0	138	0
Total		**254**	**1,768**	**181**	**272**

3.4 BUTTERFLIES

Butterfly observation and capture data, and calculated disturbance susceptibility scores for each species are shown in Appendix B, Tables B-1a through B-1d.

The report provided by Entranco (1998) listed eight species of butterflies for the High Plains Effluent Recharge site (Table B-2). Four of the species recorded in 1998 were positively confirmed to still be present at the site in 2002, and also in 2004. These were the black swallowtail (*Papilio polyxenes*), the marine blue (*Leptotes marina*), the fatal metalmark (*Calephelis nemesis*), and the queen (*Danaus gilippus*). The remaining four species have not been positively confirmed as present in either 2002 or 2004. These are the cabbage butterfly (*Pieris rapae*), the sennae sulphur (*Phoebis sennae*), the fiery skipper (*Hylephila phyleus*), and the viceroy (*Limenitis archippus*). Based on larval food plant requirements and species range it is reasonable that all four of these species could be present, and the apparent lack of their presence in 2002 and 2004 may be coincidental. All but two species [gray hairstreak (*Strymon melinus*) and the western pygmy blue (*Brephidium exile*)] recorded in 2002 were also found to be present in 2004. The gray hairstreak was recorded from a single specimen in 2002 and was absent in 2004. The apparent rarity of this common species at the project site is not understood. The Western pygmy blue is a common and easily recognized species that should be more common at the site, particularly now that Russian thistle (*Salsola kali*) and various species of saltbush (*Atriplex* spp.), some of its preferred larval food plants, have become well established in the disturbed ground where the recharge basins were constructed. Thirteen (13) new species were added to the list of butterfly species recorded at the High Plains Recharge site in 2004. These species are highlighted in blue in table B-2.

Butterfly riparian quality values were calculated for each of the three habitat types identified at the project site utilizing the disturbance susceptibility values assigned to each species (Tables B-3a – B3c). Butterfly species diversity and density in the creosote bush habitat was found to be low in both 2002 and 2004. The BRQ values for the creosote bush habitat were 0.0 and 0.3 in 2002 and 2004 respectively. A comparison of these data with the original results of Nelson and Anderson (1994) shows the creosote bush association at the High Plains site to be depauperate of butterfly species, not unlike a portion of the No Name Lake (NNL) site of Nelson and Anderson, which was dominated by saltcedar (BRQ 0.3). Plant associations exhibiting low species diversity and lacking variability in plant form tend to have a correspondingly low BRQ.

Four species of butterflies were found in the mesquite-paloverde association in 2002, and this was increased to 11 species in 2004. The BRQ for the mesquite-paloverde association was 2.0 in 2002 and 7.3 in 2004. The higher BRQ in 2004 is a function of the addition of three species of butterflies with high DSS values: the fatal metalmark, the American snout (*Libytheana carinenta*), and the common buckeye (*Junonia coenia*). The fatal metalmark was present as a single specimen taken on salt heliotrope (*Heliotropium curassavicum*) that was in blossom at the west end of the irrigation canal. The larval food plant for the fatal metalmark, seep willow (*Baccharis salicifolia*) in not present along the irrigation canal, but is common along the diversion channel, where this butterfly is commonly observed. The fatal metalmark evidently does not wander far from

its larval food plant, and its presence in the mesquite-palo verde habitat would be associated only with utilization of nectar sources present there. The American snout was observed as a single butterfly perched on Mexican elder (*Sambucus nigra*) along the irrigation canal. None of its larval food plants (*Celtis* spp.) are recorded from the High Plains site, but may occur along the adjacent Santa Cruz River drainage nearby. This species is apparently uncommon at the High Plains site, probably due to the lack of the larval food plants. The common buckeye is probably a regular resident at the High Plains site in low numbers. One of its larval food plants, speedwell (*Veronica* sp.) is present along the diversion channel, and other larval food plant species such as owl's clover (*Orthocarpus purpurascens*) and plantains (*Plantago* spp.) are likely to be present. That the common buckeye has not been recorded previously may reflect the short life of the adult, which is usually about 10 days (Stewart et al. 2001), and the limited sampling performed at the site. The value of non-time-constrained sampling in determining species richness utilized in the calculation of BRQ values becomes evident with the documentation of species with low populations such as the buckeye.

Eight species of butterflies were found in the tamarisk-willow association in 2002, and 11 species in 2004. BRQs were 8.0 and 5.5 respectively. The decrease in the BRQ for the tamarisk-willow association in 2004 reflects the addition of three more species with low DSS values. Larval food plants for these three species are either known or likely to be present on the High Plains site, or are likely available in adjacent agricultural lands. Therefore, these species are not considered accidental, but regular residents whose populations may be regularly at a low level, or may fluctuate from year to year depending on abundance of larval food plants. Based on three years of observations it is apparent that none of these species is common here on a regular basis. The BRQ of 5.5 is probably more representative of this habitat, the higher value reported in 2002 having resulting from limited sampling data available at the time.

Comparisons of BRQ values between the 1998 (Entranco) study and the two subsequent seasons in 2002 and 2004 are limited since the 1998 samplings were time-constrained and may not accurately reflect the butterfly species diversity that is actually present at the High Plains site. Additionally, the 1998 observations were made in August and September, compared with observation times in May and September in 2002, and April and May in 2004. In Arizona the bulk of butterfly species are active sometime between May and September (Stewart et al. 2001). Because time available for sampling is limited, the selection of a season for making observations of butterflies is important. However, many species have short activity periods that may be missed by using a narrow sampling window. Restricting butterfly observations to the late summer and fall months eliminates the possibility of recording species that are present at other times, and may affect the accuracy of the BRQ value determined for any given habitat.

None of the three plant associations present at the High Plains site currently has a high BRQ. Nelson and Anderson reported a BRQ of 14.2 for the Bill Williams Delta site in their 1994 paper. This site was not a pristine riparian site, but one in relatively robust condition with a relatively natural and non-channelized hydrologic regime and a greater species diversity of grasses and herbaceous plants.

The BRQ values for the creosote bush association at the High Plains site have so far remained consistent, and it is unlikely that this will change. Because of poor species diversity in this habitat, there is little potential for these areas to become more supportive of greater butterfly species diversity. The mesquite-palo verde association may represent the best overall habitat for butterfly species at the High Plains site at the current time. The tamarisk-willow association may have greater potential value as butterfly habitat due to a greater volume of water available to support larger tree species such as cottonwood (*Populus* sp.), willow, and walnut (*Juglans major*) that would provide a valuable component of a multi-tiered habitat. Currently, only a few Goodding willows are present on the site, but the possibility of other large native tree species becoming established over time is reasonably good. The two species of tamarisk at the High Plains site provide little value to butterflies except a moderate quantity of nectar, and have the deleterious effects of crowding and shading out native understory plants. This results in loss of plant species diversity and use of a large portion of the available water resource. The overall health of this habitat, and its value for butterflies and other species could be enhanced by the removal and regular abatement of the tamarisks present.

3.5 REPTILES AND AMPHIBIANS

Transects for reptiles and amphibians were surveyed in each of the four habitats on both May 4 and May 27, 2004. These surveys were conducted between 0832 and 0858. A single western whiptail was observed on May 4, 2004 on the mesquite-palo verde transect (H-1). Two side-blotched lizards were observed on May 4, 2004 on the tamarisk-willow transect (H-2). No other herptiles were observed on any of the other transects. Each transect was surveyed for 5 minutes on each day, for a total of 40 minutes of searching for herptiles. No herptiles were found during any of the transect surveys in 2002 even though the search time was double (10 minutes) per transect and extended until 1000 when temperatures were somewhat higher. During the course of other studies on the site, a few herptiles were seen or heard, and are listed in Table 7. The most common lizards observed on the site in 2004 were the western whiptail (*Cnemidophorus tigris*) and side-blotched lizard (*Uta stansburiana*). This was also true during the 2002 surveys. A single diamondback rattlesnake (*Crotalus atrox*) was observed in mesquite-palo verde habitat adjacent to a packrat midden beneath a velvet mesquite tree north of the irrigation ditch. This has been the only snake observed on the project to date. The only amphibians identified during these monitoring studies were bullfrogs (*Rana catesbeiana*) heard calling at the diversion channel both in 2002 and on May 27, 2004.

The scarcity and the low species diversity of herptiles on this site are surprising. This is particularly unusual for reptile species. It is possible that surveys at night might have located some snake species that tend to be more nocturnal. The results of EPG herptile observations in 2004 are consistent with 2002 observations, and those of Entranco (1998).

Table 7. Reptile and amphibian species observed at the High Plains Effluent Recharge Facility. Animals shown in blue are new records in 2004.

Scientific Name	2002 Habitat Type				2004 Habitat Type			
	CBA	MPV	TW	RB	CBA	MPV	TW	RB
Rana catesbeiana		✓	✓				✓	
Cnemidophorus tigris	✓	✓	✓		✓	✓	✓	
Dipsosaurus dorsalis	✓							
Urosaurus ornatus					✓			
Uta stansburiana	✓	✓					✓	
Crotalus atrox						✓		

Habitat Types:
CBA – Creosote Bush Association
MPV – Mesquite/Palo Verde Association
TW – Tamarisk/Willow Association
RB – Recharge Basin

3.6 BIRDS

Birds were counted at four points, one in each habitat, on May 4 and May 27, 2004. Point locations are shown on Figure 2. Results of these observations are given in Tables 8-a through 8-d. Because of the small sample sizes for all species, densities for these species were not calculated. In order to obtain meaningful density estimates, multiple points in each habitat should be counted on several days. For common species, a reasonable estimate could be obtained with four to six replicate points in each habitat, and each point should be counted at least six times. For uncommon species, these efforts would need to be increased to get adequate sample sizes.

Table 8a. Bird Point Count Results, Creosote Bush Association. Combined results for two observation periods: May 4, 2004, 0719-0724 and May 27, 2004, 0700-0705.

Species Observed	Number of Observations		
	Within Habitat	Adjacent Habitat	Fly-over
Mallard		8	
Gambel's Quail	9	4	1
White-winged Dove	1	1	2
Common Raven			1
Cliff Swallow			1
Curve-billed Thrasher	1		
Red-winged Blackbird		28	

Table 8b. Bird Point Count Results, Mesquite - PaloVerde Association. Combined results for two observation periods: May 4, 2004, 0657-0703 and May 27, 2004, 0640-0645.

Species Observed	Number of Observations		
	Within Habitat	Adjacent Habitat	Fly-over
Mallard		1	
Gambel's Quail	9		
Killdeer		2	
Rock Dove			2
Mourning Dove			1
Cactus Wren	1		
Wilson's Warbler	1		
Brown-headed Cowbird			1
Red-winged Blackbird		32	
Brown-headed cowbird			1
Lesser goldfinch		1	

Table 8c. Bird Point Count Results, Tamarisk-Willow Association. Combined results for two observation periods: May 4, 2004, 0707-0712 and May 27, 2004, 0649-0654.

Species Observed	Number of Observations		
	Within Habitat	Adjacent Habitat	Fly-over
White-faced Ibis			5
Gambel's Quail	3	9	
Killdeer		2	
Black-necked Stilt		1	
Spotted Sandpiper		1	
Mourning Dove	1		5
White-winged Dove	1		2
Bell's Vireo	2		
Cliff Swallow			1
Abert's Towhee	3		
Northern Cardinal	1		
Red-winged Blackbird		1	
House Finch	2		
Lesser Goldfinch	1		

Table 8d. Bird Point Count Results, Recharge Basin. Combined results for two observation periods: May 4, 2004, 0647-0652 and May 27, 2004, 0707-0712.

Species Observed	Number of Observations		
	Within Habitat	Adjacent Habitat	Fly-over
Mallard	3		
Gambel's Quail		9	
Mourning Dove		3	2
Cactus Wren		1	
Northern Mockingbird		1	
Phainopepla		1	
Common Yellowthroat	2		
Red-winged Blackbird	30		
Red-winged Blackbird	17		
Lesser Goldfinch		1	

In addition to the point counts, lists of bird species observed on the site were kept during each site visit. The combined species list for the five site visits in 2004, along with the data from the 2002 season for comparison, is given in Appendix C, Table C-1. Table C-1 includes data on the habitats used by each of the species.

During the 2002 season EPG identified 56 species of birds on or near the High Plains Effluent Recharge Facility. During the 2004 site visits 47 species of birds were observed, including 14 that are new for the site. The presence of half (7) of these new species is probably directly attributable to the presence of water in the recharge basins. This brings the site total observed by EPG to 70 species of birds. The additional 14 species recorded in 1998 by Entranco (Table C-2) would bring the site bird list to 84 species. However, the presence of the Chihuahuan raven recorded at the High Plains site by Entranco is highly unlikely, and EPG biologists consider the current site total to be 83 species.

Forty-three of these 83 species are permanent residents in this vicinity, and the other 40 species are Neotropical migrants. During the 2004 site visits no bird species was observed in all habitats; however, in 2002, two species (mourning dove and white-winged dove) were seen in all available habitats. During the 2004 monitoring seven species of birds (snowy egret, white-faced ibis, rock dove, common raven, cliff swallow, European starling, and brown-headed cowbird) were only observed flying over the site. Turkey vultures are likely to use the site for foraging, if any carrion is present. The four species of swallows recorded on the site forage on aerial insects that are either attracted to the riparian vegetation or are residents in the aquatic resources that include the recharge basins, the diversion, the irrigation canal, and the adjacent Santa Cruz River.

Only six species of birds were observed in the recharge basins during the 2002 season. The low avian diversity in this habitat at that time was due to the lack of woody vegetation and the extensive areas of bare soil. At that time the recharge basins were

recently constructed, and had not received water. With the recharge basins currently at least partially filled during most of the year, birds that depend on or are attracted to standing water habitats, have begun to appear. During the 2004 season twelve bird species were recorded at the recharge basins, twice as many as in 2002. This species diversity is not great, but is likely to increase as emergent vegetation becomes established in the recharge basins.

The creosote bush association, with 13 species recorded for 2004, also had low species diversity, a number consistent with the 2002 figure (16). Ten of these species are permanent residents, and three are Neotropical migrants. This habitat has very low vegetative species diversity, and the shrubs provide limited structural diversity.

As was the case in 2002, the mesquite/palo verde and the tamarisk/willow habitats had similar bird species diversity, but with less than half the number of species recorded in 2002 (39 and 37 species respectively in 2002, compared with 16 and 15 species in 2004). In 2002, there was a high degree of overlap in species between these two habitats, with 32 species (84%) observed in both habitats. However, in 2004, the species overlap was not as evident (45%). In 2002, approximately 62% of the birds in each of these two habitats were represented by permanent resident species. In 2004, these values were 75% for the mesquite-palo verde habitat, and 67% for the tamarisk-willow habitat. Four Neotropical migrants were observed in the mesquite/palo verde habitat, and there were five Neotropical migrants (all summer residents) in the tamarisk willow habitat. The similarity in avian diversity in these two habitats is not surprising. These habitats are similar in their vegetative species diversity and vegetative structural diversity, and they have similar proximity to water.

3.7 MAMMALS

No specific surveys were conducted for mammal species on the High Plains Effluent Recharge Facility site. However, notes were kept on incidental observations of any evidence of mammals using the site. During the 2002 season only two mammal species, black-tailed jackrabbit (*Lepus californicus*) and round-tailed ground squirrel (*Spermophilus tereticaudus*) were actually seen on the site. The presence of other species on the site was confirmed by the presence of bones, tracks, or scat, as listed in Table 9. In 2002 the diversion channel was a good location for observing tracks as it was drying out, leaving a fine-grained mud that preserved tracks of several species. This condition of the diversion channel was not available during any of the site visits in 2004. During the 2004 season visits an additional three species of mammals [desert cottontail (*Sylvilagus audubonii*), Harris' antelope squirrel (*Ammospermophilus harisii*), and rock squirrel (*Spermophilus variegatus*)] were observed. All three of these additions were observed in creosote bush habitat. It is likely that other mammal species are using this site, and more observation time, particularly at night, would probably confirm several other species. To identify small mammals on the site, live-trapping in different habitats would be necessary.

Table 9. Mammal species observed (including indirect evidence) at the High Plains Effluent Recharge Facility. New animal records for the site in 2004 are highlighted in blue.

Scientific Name	Common Name	Notes	2002	2004
Sylvilagus audubonii	Desert Cottontail	Observed in creosote bush habitat.		✓
Lepus californicus	Black-tailed Jack Rabbit	Observed in recharge basin cells.	✓	
Ammospermophilus harrisii	Harris' Antelope Squirrel	Observed in creosote bush habitat.		✓
Spermophilus variegatus	Rock Squirrel	Observed in creosote bush habitat.		✓
Spermophilus tereticaudus	Round-tailed Ground Squirrel	Observed in adjacent habitat, just west of site.	✓	✓
Dipodomys sp.	Kangaroo Rat	Tracks in fine sand in recharge basin.	✓	
Canis latrans	Coyote	Scat and tracks in numerous locations.	✓	
Procyon lotor	Raccoon	Tracks in diversion channel.	✓	
Felis rufus	Bobcat	Tracks in diversion channel.	✓	
Pecari tajacu	Collared Peccary	Jaw bone in tamarisk/willow habitat.	✓	

3.8 DISCUSSION OF CHANGES AND TRENDS

The greatest change at the High Plains Recharge Facility since 2002 has been the introduction of water into the recharge basins. This has resulted in an overall increase in vegetation in the basins, which is currently dominated by saltbush, with a few annual grass and forb species present. Some individual saltbush plants are over five feet in height, and there is a somewhat clumped distribution of the plants. The areas where the taller plants are grouped together are attracting a variety of bird species. There is some difference in the level of development of the vegetation in the ponds, which may reflect the water input and holding schedule of each pond. The vegetation in the two ponds to the east is not as well established, and may reflect the presence of ponded water on a more regular basis. These two ponds have a greater area of open water and generally had more waterfowl present during site visits in 2004. There is no evidence of the establishment of any emergent plant species in the recharge ponds at this time; however, the increased activity of aquatic bird species at the site is likely to provide a method of introduction of emergent vegetation seed. The trees planted on the pond berms appear to be established, and most are thriving.

Along with the increase in vegetation and the presence of seasonally dependable lentic waters in the recharge basins there has been an increase in bird species utilizing this habitat. For comparison, during the survey conducted on the site in 2002 six bird species were recorded in the constructed, but dry recharge basins. In 2004 the number of birds associated with the active recharge basin habitat was 12 species, seven of which are aquatic-associates, including mallard (*Anas platyrhynchos*), cinnamon teal (*Anas*

cyanoptera), American coot (*Fulica americana*), black-necked stilt (*Himantopus mexicanus*), spotted sandpiper (*Actitis macularia*), and red-winged (*Agelaius phoeniceus*) and yellow-headed blackbirds (*X. xanthocephalus*). The increase in vegetation along with the associated lentic waters also attracts a variety of insect species to the site. This in turn provides a food resource for birds, bats, and other vertebrate species. Butterfly species recorded at the High Plains Recharge Facility increased from 11 species in 2002 to 23 species in 2004. Increases in bird and butterfly species are at least partially attributable to the presence of the lentic aquatic habitat and associated vegetation.

Because the water sampling performed has been very limited, it is difficult to make any evaluation of changes that may have occurred as a result of changes in the effluent water quality reaching the recharge facility. The differences in the values obtained in 2002 and 2004 may be within the normal parameters of the effluent waters supplied to the site. The lower oxygen content of the water may be reflected in the increase of midge larvae and aquatic earthworms recorded, but could also be due to other factors. The decrease in the overall algae content of the water in the diversion canal between the 2002 and 2004 sampling events cannot easily be attributed to any of the water properties measured.

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APPENDIX A. VEGETATION SAMPLE PLOT RESULTS AND LOCATIONS.

Table A-1a. Frequency (%) and average height by species in the Creosote bush Association. (Based on eight sample plots).

Species	Frequency	Plant Height (S.D.), m	Number of Individuals
Larrea tridentata	87.5	1.52 (0.66)	24

Table A-1b. Average percent canopy cover in the Creosote Bush Association (Based on eight sample plots).

Species	Mean % Canopy Cover (S.D.) at Height Interval	
	1m	2m
Larrea tridentata	20.4 (13.6)	2.57 (5.9)
Total Plant Canopy, %	**20.4**	**2.57**

Average density of all plants: **1,250 plants/ha (S.D. = 945)**

Table A-2a. Frequency and average height by species in the Mesquite-Paloverde Association (Based on eight sample plots).

Species	Frequency	Plant Height (S.D.), m	Number of Individuals
Baccharis sarothroides	12.5	1.56 (*)	1
Hymenoclea monogyra	12.5	1.65 (*)	1
Isocoma tenuisecta	25	0.51 (0.29)	7
Parkinsonia aculeata	12.5	3.63 (3.16)	3
Prosopis velutina	37.5	2.03 (1.06)	8
Sambucus nigra	25	2.38 (0.93)	4

*Only one individual observed.

Table A-2b. Average percent canopy cover in the Mesquite-Palo Verde Association (Based on eight sample plots).

Species	Mean % Canopy Cover (S.D.) at Height Interval					
	1m	2m	3m	4m	5m	6m
Baccharis sarothroides	0.04 (0.11)					
Hymenoclea monogyra	0.04 (0.11)					
Isocoma tenuisecta	1.38 (3.26)					
Parkinsonia aculeata	0.02 (0.07)	0.10 (0.29)	0.94 (2.67)	0.88 (2.47)	1.01 (2.85)	1.72 (4.86)
Prosopis velutina	5.27 (8.27)	3.50 (6.59)	0.97 (2.74)			
Sambucus nigra	1.67 (4.13)	0.56 (1.57)	0.70 (1.96)			
Total Plant Canopy, %	**10.60 (12.33)**	**5.72 (7.76)**	**2.61 (5.07)**	**0.88 (2.47)**	**1.01 (2.85)**	**1.72 (4.86)**

Average density of all plants: **898 plants/ha (S.D. = 1244)**

Table A-3a. Frequency and average height by species in the Tamarisk-Willow Association. (Based on eight sample plots)

Species	Frequency	Plant Height (S.D.), m	Number of Individuals
Atriplex canescens	12.5	0.74 (0.30)	11
Atriplex lentiformis	12.5	1.38 (0.76	3
Baccharis sarothroides	50	1.40 (0.94)	6
Isocoma tenuisecta	12.5	0.28 (*)	1
Larrea tridentata	25	2.81 (1.18)	5
Nicotiana glauca	12.5	5.10 (1.02)	3
Prosopis velutina	25	1.57 (0.90)	3
Sambucus nigra	12.5	4.85 (2.34)	3
Tamarix aphylla	50	11.46 (5.85)	4
Tamarix sp.	12.5	5.63 (*)	1

*Only one individual observed.

Table A-3b. Average percent canopy cover in the Tamarisk-Willow Association (Based on eight sample plots).

Species	Mean % Canopy Cover (S.D.) at Height Interval																
	1m	2m	3m	4m	5m	6m	7m	8m	9m	10m	11m	12m	13m	14m	15m	16m	17m
Tamarix sp.	3.06 (8.66)	3.31 (9.37)	2.66 (7.53)	2.18 (6.16)	1.15 (3.25)												
Baccharis sarothroides	0.92 (1.52)	0.60 (1.70)															
Prosopis velutina	0.86 (2.36)	0.38 (1.06)															
Sambucus nigra	5.75 (16.3)	5.82 (16.5)	5.75 (16.3)	3.75 (10.6)	2.78 (7.35)	0.88 (2.47)											
Tamarix aphylla	10.08 (17.4)	21.83 (30.5)	20.41 (30.3)	19.27 (30.2)	19.20 (30.1)	17.46 (30.1)	17.26 (30.2)	16.84 (30.3)	16.16 (30.7)	16.07 (30.7)	16.07 (30.7)	6.25 (17.7)	6.25 (17.7)	6.25 (17.7)	6.25 (17.7)	6.25 (17.7)	6.25 (17.7)
Larrea tridentata	3.49 (9.50)	7.48 (21.2)	7.48 (21.2)														
Isocoma tenuisecta	0.03 (0.09)																
Nicotiana glauca	0.20 (0.57)	0.48 (1.37)	0.34 (0.95)	3.06 (8.66)	1.84 (5.21)	2.21 (6.25)											
Atriplex canescens	5.30 (14.98)																
Atriplex lentiformis	2.02 (5.72)																
Total Plant Canopy, %	**32.44 (27.2)**	**39.90 (26.5)**	**36.64 (27.8)**	**28.71 (29.7)**	**24.62 (28.5)**	**20.54 (29.3)**	**17.26 (30.2)**	**16.77 (30.4)**	**16.16 (30.7)**	**16.07 (30.7)**	**16.07 (30.7)**	**6.25 (17.7)**	**6.25 (17.7)**	**6.25 (17.7)**	**6.25 (17.7)**	**6.25 (17.7)**	**6.25 (17.7)**

Average density of all plants: **1875 plants/ha (S.D. = 2983).**

Table A-4. Sample Plot Locations. GPS - UTM coordinates, referenced to NAD27, Zone 12S (estimated error ±5 m)

Plot Number	Easting	Northing
C-1	478712	3587758
C-2	478615	3587807
C-3	478647	3587782
C-4	478748	3587728
C-5	478748	3587706
C-6	478817	3587692
C-7	478838	3587625
C-8	478878	3587598
M-1	478629	3587860
M-2	478684	3587879
M-3	478689	3587887
M-4	478689	3587881
M-5	478713	3587881
M-6	478745	3587863
M-7	478830	3587845
M-8	478858	3587844
T-1	478912	3587805
T-2	478941	3587717
T-3	478941	3587699
T-4	478941	3587693
T-5	478946	3587647
T-6	478946	3587618
T-7	478943	6587578
T-8	478925	3587566
West Photo Point	478679	3587783
East Photo Point	478864	3587638

Table A-5. Other Sample Locations. Centers of bird point counts and endpoints of herptile transects. GPS - UTM coordinates, referenced to NAD27, Zone 12S (estimated error ±5 m).

Sample Point	Easting	Northing
B-1. Bird Count – Mesquite-Palo Verde	478808	3587853
B-2. Bird Count – Tamarisk-Willow	478950	3587728
B-3. Bird Count – Creosote Bush	478702	3587734
B-4. Bird Count – Recharge Basin	478762	3587814
H-1. Herptile Transect – Mesquite-Palo Verde – West End	478763	3587860
H-1. Herptile Transect – Mesquite-Palo Verde – East End	478808	3587853
H-2. Herptile Transect – Tamarisk-Willow – North End	478932	3587757
H-2. Herptile Transect – Tamarisk-Willow – South End	478930	3587706
H-3. Herptile Transect – Creosote Bush – West End	478702	3587734
H-3. Herptile Transect – Creosote Bush – East End	478736	3587697
H-4. Herptile Transect – Recharge Basin – West End	478762	3587814
H-4. Herptile Transect – Recharge Basin – East End	478802	3587779

APPENDIX B. BUTTERFLY SURVEY RESULTS.

Table B-1a. Butterflies observed and/or sampled on 05-04-04, 0648 to 0913. A question mark attached to a species reference indicates an unconfirmed (by capture) identification.

Species	No. Observed/ Captured	Habitat	DSS*
Calephelis nemesis (Fatal metalmark)	1/0	Tamarisk-Willow	18
Chlosyne lacinia ? (Bordered patch)	1/0	Mesquite-Paloverde	6
Chlosyne lacinia ? (Bordered patch)	1/0	Tamarisk-Willow	6
Danaus gilippus (Queen)	1/0	Creosote Bush	12
Danaus gilippus (Queen)	1/0	Tamarisk-Willow	12
Junonia coenia (Buckeye)	1/0	Mesquite-Paloverde	9
Leptotes marina (Marine blue)	2/0	Tamarisk-Willow	8
Papilio polyxenes (Black swallowtail)	2/0	Tamarisk-Willow	8
Pontia protodice (Checkered white)	3/0	Creosote Bush	8
Pontia protodice (Checkered white)	15/1	Tamarisk-Willow	8
Pontia protodice (Checkered white)	23/0	Mesquite-Paloverde	8
Vanessa cardui (Painted lady)	2/0	Mesquite-Paloverde	4
Total Number	**53/1**		

*Disturbance susceptibility score.

Table B-1b. Butterflies observed and/or sampled on 05-27-04, 0630 to 0901. A question mark attached to a species reference indicates an unconfirmed (by capture) identification.

Species	No. Observed/ Captured	Habitat	DSS*
Calephelis nemesis (Fatal metalmark)	5/0	Tamarisk-Willow	18
Colias cesonia ? (Southern dogface)	1/0	Mesquite-Paloverde	7
Colias eurytheme (Orange sulphur)	1/1	Tamarisk-Willow	6
Copaeodes aurantiacus (Orange skipperling)	1/1	Tamarisk-Willow	9
Danaus gilippus (Queen)	20/0	Mesquite-Paloverde	12
Danaus gilippus (Queen)	5/0	Tamarisk-Willow	12
Hemiargus ceraunus (Ceraunus blue)	1/1	Tamarisk-Willow	7
Leptotes marina (Marine blue)	5/2	Mesquite-Paloverde	8
Leptotes marina (Marine blue)	8/0	Tamarisk-Willow	8
Lerodea eufala (Euphala skipper)	2/1	Mesquite-Paloverde	5
Lerodea eufala (Euphala skipper)	1/1	Tamarisk-Willow	5
Libytheana carinenta (American snout)	1/0	Mesquite-Paloverde	14
Ministrymon leda (Leda ministreak)	1/1	Mesquite-Paloverde	13
Nathalis iole (Dainty sulphur)	1/1	Tamarisk-Willow	6

Species	No. Observed/ Captured	Habitat	DSS*
Papilio polyxenes (Black swallowtail)	3/0	Mesquite-Paloverde	8
Papilio polyxenes (Black swallowtail)	2/0	Tamarisk-Willow	8
Polydryas arachne ? (Arachne checkerspot)	1/0	Recharge Basin	6
Pontia protodice (Checkered white)	12/0	Mesquite-Paloverde	8
Pontia protodice (Checkered white)	6/0	Tamarisk-Willow	8
Pontia protodice (Checkered white)	6/0	Recharge Basin	8
Pyrgus albescens (White checkered-skipper)	1/0	Tamarisk-Willow	8
Total Number	**84/9**		

*Disturbance susceptibility score.

Table B-1c. Butterflies observed and/or sampled on April 7, 2004 (Incidental records).

Species	No. Observed/ Captured	Habitat	DSS*
Thorybes pylades (Northern cloudywing)	1/1	Mesquite-Paloverde	10
Calephelis nemesis (Fatal metalmark)	1/1	Mesquite-Paloverde	18
Total Number	**2/2**		

*Disturbance susceptibility score.

Table B-1d. Butterflies observed and/or sampled on April 8, 2004 (Incidental records).

Species	No. Observed/ Captured	Habitat	DSS*
Danaus gilippus (Queen)	1/0	Creosote Bush	8
Pontia protodice (Checkered white)	2/0	Creosote Bush	8
Total Number	**3/0**		

*Disturbance susceptibility score.

Table B-2. Butterfly species recorded at High Plains Effluent Recharge Project site, Marana, AZ. Species records added in 2004 are highlighted in blue. A question mark attached to a species reference indicates an unconfirmed (by capture) identification.

Species	Common Name	1998 (Entranco)	2002 (EPG)	2004 (EPG)
Papilio polyxenes	Black swallowtail	✓	✓	✓
Pieris rapae	Cabbage butterfly	✓*		
Pontia protodice	Checkered white		✓	✓
Colias erytheme	Orange sulphur			✓
Colias cesonia ?	Southern dogface			✓
Phoebis sennae	Sennae sulphur	✓		

Species	Common Name	1998 (Entranco)	2002 (EPG)	2004 (EPG)
Nathalis iole	Dainty sulphur			✓
Strymon melinus	Gray hairstreak		✓	
Ministrymon leda	Leda ministreak			✓
Brephidium exile	Western pygmy blue		✓	
Leptotes marina	Marine blue	✓	✓	✓
Hemiargus ceraunus	Ceraunus blue			✓
Calephelis nemesis	Fatal metalmark	✓	✓	✓
Libytheana carinenta	American snout			✓
Polydryas arachne ?	Arachne checkerspot			✓
Chlosyne lacinia ?	Bordered patch			✓
Vanessa cardui	Painted lady			✓
Junonia coenia	Buckeye			✓
Danaus gilippus	Queen	✓	✓	✓
Thorybes pylades	Northern cloudywing			✓
Hylephila phyleus ?	Fiery skipper	✓	✓ ?	
Limenitis archippus	Viceroy	✓		
Pyrgus albescens	White checkered-skipper		✓	✓
Copaeodes aurantiacus	Orange skipperling			✓
Lerodea eufala	Eufala skipper			✓
Totals by Year		**8**	**9**	**19**
Cumulative Project Total		**8**	**11**	**24**

* Species identification uncertain.

Table B-3a. Riparian Environmental Quality Assessment for Creosote Bush Association.

Species	DSS*	2002	2004
		Relative Abundance	**Relative Abundance**
Danaus gilippus	12	No Record	Uncommon
Papilio polyxenes	8	Rare	No Record
Pontia protodice	8	No Record	Uncommon
Total number of species		1	2
Butterfly Riparian Quality **(BRQ)**		**0.0**	**0.3**

*DSS – Disturbance susceptibility score.

Table B-3b. Riparian Environmental Quality Assessment for Mesquite-Paloverde Association.

Species	DSS*	2002	2004
		Relative Abundance	**Relative Abundance**
Brephidium exile	9	Uncommon	No Record
Calephelis nemesis	18	No Record	Uncommon
Chlosyne lacinia	6	No Record	Uncommon
Colias cesonia	7	No Record	Uncommon
Danaus gilippus	12	Uncommon	Common
Junonia coenia	9	No Record	Uncommon
Leptotes marina	8	Abundant	Common
Lerodea eufala	5	No Record	Uncommon
Libytheana carinenta	14	No Record	Uncommon
Papilio polyxenes	8	No Record	Common
Pontia protodice	8	Abundant	Abundant
Vanessa cardui	4	No Record	Uncommon
Total number of species		4	11
Butterfly Riparian Quality (**BRQ**)		**2.0**	**7.3**

*DSS – Disturbance susceptibility score.

Table B-3c. Riparian Environmental Quality Assessment for Tamarisk-Willow Association. A question mark attached to a species reference indicates an unconfirmed (by capture) identification.

Species	DSS*	2002	2004
		Relative Abundance	**Relative Abundance**
Calephelis nemesis	18	Common	Common
Chlosyne lacinia	6	No Record	Uncommon
Colias eurytheme	6	No Record	Uncommon
Danaus gilippus	12	Uncommon	Common
Halephila phyleus ?	9	Rare	Uncommon
Leptotes marina	8	Abundant	Common
Lerodea eufala	5	No Record	Uncommon
Nathalis iole	6	No Record	Rare
Papilio polyxenes	8	Uncommon	Uncommon
Pontia protodice	8	Abundant	Common
Pyrgus albescens	8	Uncommon	Uncommon
Strymon melinus	4	Uncommon	No Record
Total number of species		8	11
Butterfly Riparian Quality (**BRQ**)		**8.0**	**5.5**

*DSS – Disturbance susceptibility score.

APPENDIX C. BIRD SPECIES LISTS.

Table C-1. Bird species observed in various habitats at High Plains Recharge Site. New site records added in 2004 are highlighted in blue.

Scientific Name	Common Name	Status	2002 Habitat Type						2004 Habitat Type					
			CBA	MPV	TW	RB	FO	AA	CBA	MPV	TW	RB	FO	AA
Egretta thula	Snowy egret	T (S)											✓	
Plegadis chihi	White-faced Ibis	T											✓	
Cathartes aura	Turkey Vulture	S					✓	✓						✓
Dendrocygna autumnalis	Black-bellied Whistling-duck	S					✓							
Anas platyrhynchos	Mallard	P			✓		✓					✓		
Anas cyanoptera	Cinnamon Teal	T										✓		
Buteo jamaicensis	Red-tailed Hawk	P	✓				✓	✓						
Falco sparverius	American Kestrel	P		✓	✓				✓				✓	
Falco mexicanus	Prairie Falcon	P		✓										
Callipepla gambelii	Gambel's Quail	P	✓	✓	✓	✓		✓	✓	✓	✓			
Fulica americana	American Coot	P										✓		
Charadrius vociferus	Killdeer	P		✓	✓	✓		✓	✓	✓		✓		✓
Himantopus mexicanus	Black-necked Stilt	P										✓		
Actitis macularia	Spotted Sandpiper	T										✓		
Columba livia	Rock Dove	P					✓	✓					✓	
Zenaida asiatica	White-winged Dove	S	✓	✓	✓	✓	✓	✓	✓				✓	
Zenaida macroura	Mourning Dove	P	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	
Columbina passerina	Common Ground-Dove	P	✓											
Geococcyx californianus	Greater Roadrunner	P							✓	✓				✓
Bubo virginianus	Great Horned Owl	P		✓										
Archilochus alexandri	Black-chinned Hummingbird	S	✓	✓	✓					✓	✓			
Calypte costae	Costa's Hummingbird	P		✓							✓			
Melanerpes uropygialis	Gila Woodpecker	P		✓	✓					✓				

Scientific Name	Common Name	Status	2002						2004					
			Habitat Type						Habitat Type					
			CBA	MPV	TW	RB	FO	AA	CBA	MPV	TW	RB	FO	AA
Picoides scalaris	Ladder-backed Woodpecker	P	✓	✓	✓									
Colaptes chrysoides	Gilded Flicker	P			✓									
Empidonax sp.	Empidonax Flycatcher	T			✓									
Sayornis nigricans	Black Phoebe	P		✓	✓									
Myiarchus cinerascens	Ash-throated Flycatcher	S	✓	✓	✓						✓			
Tyrannus verticalis	Western Kingbird	S	✓	✓	✓	✓			✓	✓	✓			
Lanius ludovicianus	Loggerhead Shrike	P	✓					✓						
Vireo bellii	Bell's Vireo	S		✓	✓						✓			
Vireo gilvus	Warbling Vireo	T		✓	✓									
Corvus corax	Common Raven	P					✓						✓	
Eremophila alpestris	Horned Lark	P						✓						✓
Progne subis	Purple Martin	S					✓							
Stelgidopteryx serripennis	Northern Rough-winged Swallow	S					✓					✓	✓	
Petrochelidon pyrrhonota	Cliff Swallow	T (S)											✓	
Hirundo rustica	Barn Swallow	S					✓							
Auriparus flaviceps	Verdin	P	✓	✓	✓				✓	✓	✓			
Campylorhynchus brunneicapillus	Cactus Wren	P	✓	✓	✓				✓	✓				
Thryomanes bewickii	Bewick's Wren	P		✓	✓					✓				
Polioptila melanura	Black-tailed Gnatcatcher	P		✓	✓									
Mimus ploglottos	Northern Mockingbird	P								✓	✓			
Toxostoma curvirostre	Curve-billed Thrasher	P	✓	✓	✓			✓	✓					
Toxostoma crissale	Crissal Thrasher	P									✓			
Sturnus vulgaris	European starling	P											✓	
Phainopepla nitens	Phainopepla	P	✓	✓	✓			✓		✓			✓	
Vermivora luciae	Lucy's Warbler	S		✓	✓									
Dendroica petechia	Yellow Warbler	T		✓	✓									
Dendroica townsendi	Townsend's Warbler	T			✓									
Geothlypis trichas	Common Yellowthroat	S		✓	✓							✓		
Wilsonia pusilla	Wilson's Warbler	T		✓						✓				

Scientific Name	Common Name	Status	2002 Habitat Type						2004 Habitat Type					
			CBA	MPV	TW	RB	FO	AA	CBA	MPV	TW	RB	FO	AA
Icteria virens	Yellow-breasted Chat	S		✓	✓						✓			
Pipilo fuscus	Canyon Towhee	P							✓					
Pipilo aberti	Abert's Towhee	P		✓	✓					✓	✓			
Chondestes grammacus	Lark Sparrow	P	✓	✓	✓			✓						
Melospiza melodia	Song Sparrow	P		✓	✓									
Zonotrichia leucophrys	White-crowned Sparrow	T (W)		✓	✓			✓	✓					
Cardinalis cardinalis	Northern Cardinal	P		✓	✓						✓			
Guiraca caerulea	Blue Grosbeak	S		✓										
Agelaius phoeniceus	Red-winged Blackbird	P					✓	✓		✓		✓	✓	
Sturnella neglecta	Western Meadowlark	P										✓		
Xanthocephalus xanthocephalus	Yellow-headed Blackbird	T (W)										✓		
Quiscalus mexicanus	Great-tailed Grackle	P		✓	✓	✓	✓	✓				✓	✓	
Molothrus aeneus	Bronzed Cowbird	S			✓		✓	✓						
Molothrus ater	Brown-headed Cowbird	P		✓	✓		✓	✓					✓	
Icterus cucullatus	Hooded Oriole	S		✓										
Icterus bullockii	Bullock's Oriole	T		✓						✓				
Carpodacus mexicanus	House Finch	P	✓	✓	✓		✓				✓			
Carduelis psaltria	Lesser Goldfinch	P		✓	✓				✓		✓			
Total Number of Species			16	39	37	6	16	17	13	16	15	12	14	4
Permanent Residents			12	24	23	4	9	13	10	12	10	7	8	3
Summer Residents			4	10	9	2	7	3	2	2	5	2	2	1
Winter Residents			0	0	0	0	0	0	0	0	0	0	0	0
Transients			0	5	5	0	0	1	1	2	0	3	3	0

Habitat Types:

CBA – Creosote Bush Association
MPV – Mesquite/Palo Verde Association
TW – Tamarisk/Willow Association
RB – Recharge Basin (no natural vegetation remaining)
FO – Fly-over
AA – Adjacent Agricultural Areas

Status:

P – Permanent Resident
S – Summer Resident
W – Winter Resident
T – Transient; T (S) = Transient in summer; T (W) = Transient in winter

Table C-2. Additional Bird Species Reported by Entranco (1998).

Scientific Name	Common Name	Status
Nycticorax nycticorax	Black-crowned Night-Heron	T (W)
Parabuteo unicinctus	Harris's Hawk	P
Aeronautes saxatalis	White-throated Swift	T (S)
Sayornis sayi	Say's Phoebe	P
Contopus sordidulus	Western Wood-Pewee	T
Pyrocephalus rubinus	Vermilion Flycatcher	S
Myiarchus tyrannulus	Brown-crested Flycatcher	S
Vireo plumbeus	Plumbeous (Solitary) Vireo	T
Corvus cryptoleucus	Chihuahuan Raven	*
Tachycineta thalassina	Violet-green Swallow	T
Regulus calendula	Ruby-crowned Kinglet	T (W)
Piranga rubra	Summer Tanager	S
Piranga ludoviciana	Western Tanager	T
Icterus parisorum	Scott's Oriole	S

Status:
P – Permanent Resident
S – Summer Resident
W – Winter Resident
T–Transient; T (S) = Transient in summer; T (W) = Transient in winter

* Unlikely record.

APPENDIX D. PLANT SPECIES.

Table D-1. High Plains Effluent Recharge Project – Plant Species Observed on Project Site. Species highlighted in blue are new records during the 2004 season.

Family	Species	Common Name	2002	2004
Amaranthaceae	*Amaranthus (palmeri?)*	Pigweed	✓	
	Tidestromia lanuginosa	Wooly tidestromia		✓
Asteraceae	*Baccharis salicifolia*	Seep willow	✓	✓
	Baccharis sarothroides	Desert broom	✓	✓
	Cirsium sp.	Thistle	✓	✓
	Heterotheca subaxillaris	Camphorweed	✓	
	Hymenoclea monogyra	Cheeseweed burrobrush	✓	✓
	Isocoma tenuisecta	Burroweed	✓	✓
	Pectis sp.	Fetid-marigold	✓	
	Silybum marianum	Milk thistle	✓	✓
	Sonchus (oleraceus?)	Common sowthistle	✓	✓
	Xanthium strumarium	Cocklebur	✓	✓
Bignoniaceae	*Chilopsis linearis*	Desertwillow	✓	✓
Boraginaceae	*Amsinckia* sp.	Fiddleneck	✓	
	Cryptantha sp.	Popcorn flower	✓	
	Heliotropium curassavicum	Salt heliotrope	✓	✓
Brassicaceae	*Descurainia* sp.	Mustard	✓	
	Sisymbrium irio	London rocket		✓
Caprifoliaceae	*Sambucus nigra*	Mexican elder	✓	✓
Chenopodiaceae	*Atriplex canescens*	Fourwing saltbush	✓	✓
	Atriplex lentiformis	Quailbush		✓
	Atriplex polycarpa	Desert saltbush		✓
	Salsola tragus	Russian thistle	✓	✓
Cyperaceae	*Scirpus* sp.	Bulrush	✓	✓
Ephedraceae	*Ephedra trifurca*	Longleaf ephedra	✓	✓
Fabaceae	*Medicago* sp.	Clover	✓	
	**Olneya tesota*	Ironwood	✓	✓
	**Parkinsonia florida*	Blue paloverde	✓	✓
	Parkinsonia aculeata	Mexican paloverde	✓	✓

Family	Species	Common Name	2002	2004
	Prosopis velutina	Velvet mesquite	✓	✓
Geraniaceae	*Erodium cicutarium*	Filaree	✓	
Hydrophyllaceae	*Nama hispidum*	Bristly nama		✓
Lamiaceae	*Marrubium vulgare*	Horehound	✓	✓
Loasaceae	*Mentzelia (pumila?)*	Dwarf blazing star	✓	✓
Malvaceae	*Sphaeralcea (ambigua?)*			✓
Martyniaceae	*Proboscidea (parviflora?)*	Devil's claw		✓
Oleaceae	**Fraxinus* sp.	Ash	✓	✓
Poaceae	*Bromus catharticus*	Rescue grass		✓
	Bromus rubens	Red brome		✓
	Cynodon dactylon	Bermuda grass	✓	✓
	Hordeum jubadum	Foxtail barley		✓
	Hordeum murinum	Lepor barley		✓
	Polypogon monspeliensis	Annual rabbit's foot grass		✓
	Schismus arabicus	Arabian grass		✓
	Sorghum halepense	Johnson grass	✓	
Polygonaceae	*Polygonum* sp.	Polygonum	✓	
	Rumex (hymenosepalus?)	Canaigre	✓	✓
Portulacaceae	*Portulaca (oleracea?)*	Common purslane	✓	
Ranunculaceae	*Ranunculus sceleratus*	Cursed buttercup		✓
Salicaceae	*Salix gooddingii*	Goodding willow	✓	✓
Solanaceae	*Datura* sp.	Datura	✓	✓
	Nicotiana glauca	Tree tobacco	✓	✓
	Nicotiana obtusifolia	Desert tobacco		✓
	Solanum elaeagnifolium	Silverleaf nightshade	✓	✓
	Solanum rostratum	Buffalobur	✓	✓
Tamaricaceae	*Tamarix aphylla*	Athel	✓	✓
	Tamarix sp.	Salt cedar	✓	✓
Scrophulariaceae	**Leucophyllum frutescens*	Texas ranger	✓	✓

Family	Species	Common Name	2002	2004
	Veronica sp.	Speedwell	✓	✓
Zygophyllaceae	*Larrea tridentata*	Creosote bush	✓	✓
Total Species Observed by Year			**45**	**49**
Total Species Recorded at High Plains Recharge Facility			**60**	

*Planted species.

APPENDIX E. DOCUMENTARY PHOTOGRAPHS

APPENDIX E. DOCUMENTARY PHOTOGRAPHS

Edge Match A ▶

◀Edge Match A

Figure E-1a. Panoramic photograph, 35 mm lens, April 9, 2004, from west photo point (see Figure 2)

Edge Match B►

◄Edge Match B

Figure E-1b. Panoramic photograph, 55 mm lens, April 9, 2004, from west photo point (see Figure 2)

Edge Match C ►

◄Edge Match C

Figure E-2a. Panoramic photograph, 35 mm lens, April 9, 2004, from east photo point (see Figure 2)

Edge Match D►

◄Edge Match D

Figure E-2b. Panoramic photograph, 55 mm lens, April 9, 2004, from east photo point (see Figure2)

Figure E-3a. Vegetation Plot C-3, Creosote Bush Association, view north, April 8, 2004, 35-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-3b. Vegetation Plot C-3, Creosote Bush Association, view north, April 8, 2004, 55-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-3c. Vegetation Plot C-3, Creosote Bush Association, view south, April 8, 2004, 35-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

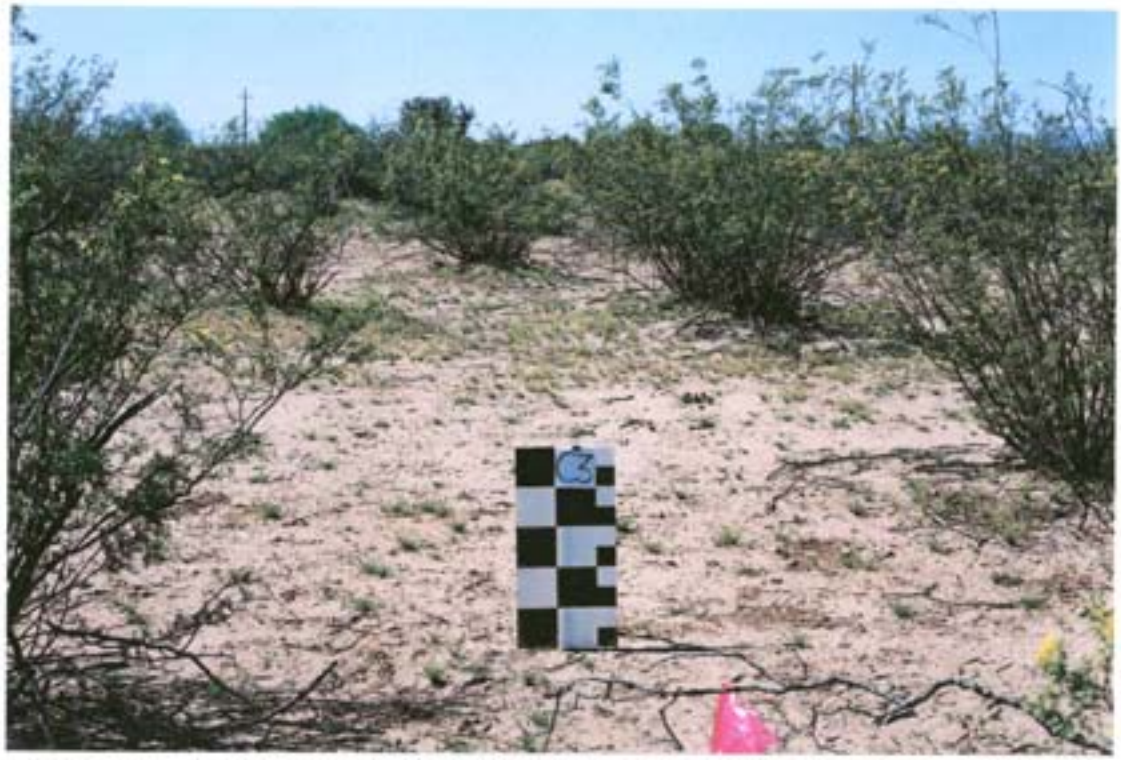

Figure E-3d. Vegetation Plot C-3, Creosote Bush Association, view south, April 8, 2004, 55-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-4a. Vegetation Plot C-7, Creosote Bush Association, view north, April 8, 2004, 35-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

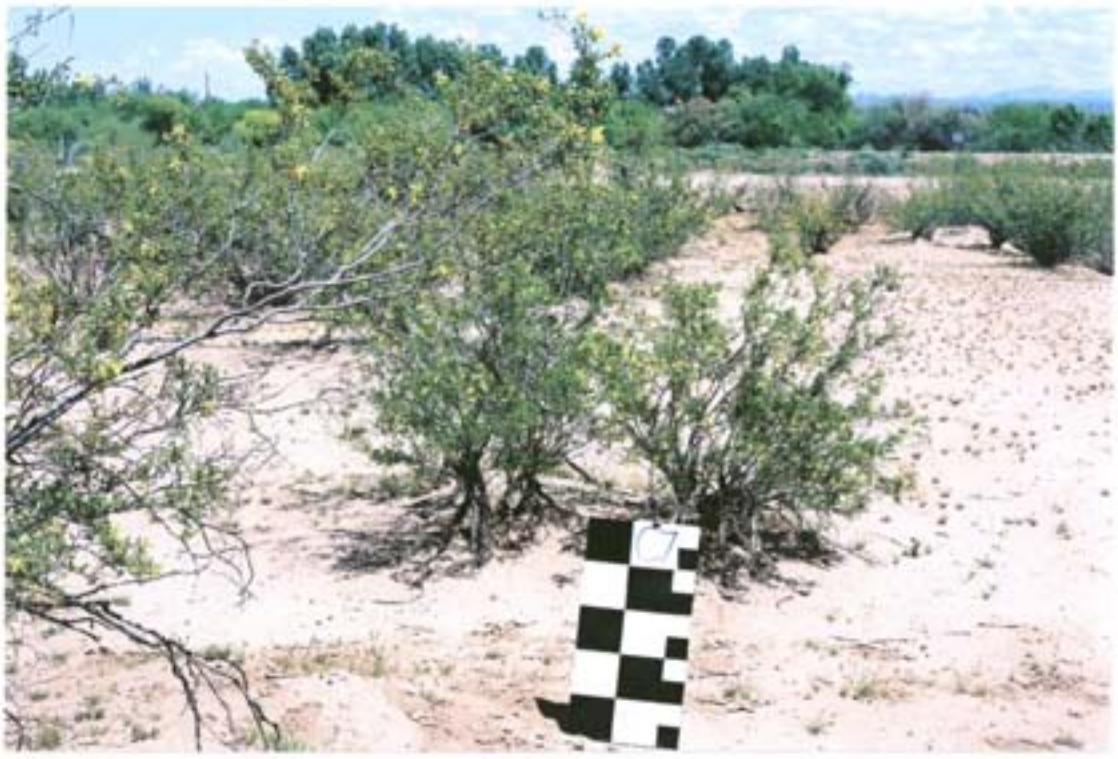

Figure E-4b. Vegetation Plot C-7, Creosote Bush Association, view north, April 8, 2004, 55-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-4c. Vegetation Plot C-7, Creosote Bush Association, view south, April 8, 2004, 35-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-4d. Vegetation Plot C-7, Creosote Bush Association, view south, April 8, 2004, 55-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-5a. Vegetation Plot M-5, Mesquite-Palo Verde Association, view north, April 7, 2004, 35-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-5b. Vegetation Plot M-5, Mesquite-Palo Verde Association, view north, April 7, 2004, 55-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-5c. Vegetation Plot M-5, Mesquite-Palo Verde Association, view south, April 7, 2004, 35-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-5d. Vegetation Plot M-5, Mesquite-Palo Verde Association, view south, April 7, 2004, 55-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-6a. Vegetation Plot M-6, Mesquite-Palo Verde Association, view north, April 7, 2004, 35-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-6b. Vegetation Plot M-6, Mesquite-Palo Verde Association, view north, April 7, 2004, 55-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-6c. Vegetation Plot M-6, Mesquite-Palo Verde Association, view south, April 7, 2004, 35-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-6d. Vegetation Plot M-6, Mesquite-Palo Verde Association, view south, April 7, 2004, 55-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-7a. Vegetation Plot T-2, Tamarisk-Willow Association, view north, April 7, 2004, 35-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-7b. Vegetation Plot T-2, Tamarisk-Willow Association, view north, April 7, 2004, 55-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-7c. Vegetation Plot T-2, Tamarisk-Willow Association, view south, April 7, 2004, 35-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-7d. Vegetation Plot T-2, Tamarisk-Willow Association, view south, April 7, 2004, 55-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-8a. Vegetation Plot T-7, Tamarisk-Willow Association, view north, April 9, 2004, 35-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-8b. Vegetation Plot T-7, Tamarisk-Willow Association, view north, April 9, 2004, 55-m lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-8c. Vegetation Plot T-7, Tamarisk-Willow Association, view south, April 9, 2004, 35-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.

Figure E-8d. Vegetation Plot T-7, Tamarisk-Willow Association, view south, April 9, 2004, 55-mm lens. Black and white board is 25 x 50 cm and 4 m from lens.