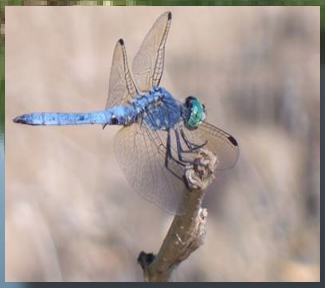
Herpetofauna and Aquatic Macro-invertebrate Use of the Kino Environmental Restoration Project (KERP)

Tucson, Pima County, Arizona



Prepared for
Pima County Regional Flood Control District

Prepared by
EPG, Inc.

JANUARY 2007

Pima County Regional
FLOOD CONTROL
DISTRICT

MEMORANDUM

Water Resources
Regional Flood Control District

DATE: January 5, 2007

TO: Distribution

FROM: Julia Fonseca
Environmental Planning Manager

SUBJECT: Kino Ecosystem Restoration Project Report

The Ed Pastor Environmental Restoration Project/Kino Ecosystem Restoration Project (KERP) is becoming an extraordinary urban wildlife resource. As such, the Pima County Regional Flood Control District (PCRFCD) contracted with the Environmental Planning Group (EPG) to gather observations of reptiles, amphibians, and aquatic insects at KERP. Water quality was also examined.

The purpose of the work was to provide baseline data on current wildlife use of the KERP site, and to assess water quality for post-project aquatic wildlife conditions. I additionally requested sampling of macroinvertebrates at Agua Caliente Park and Sweetwater Wetlands in hopes that the differences in aquatic wildlife among the three sites might provide insights into the different habitats offered by KERP.

The results

One of the most important wildlife benefits that KERP provides is aquatic habitat without predatory bullfrogs and non-native fish. Most other constructed ponds and wetlands in Tucson, such as the Sweetwater Wetlands and Agua Caliente pond, are full of non-native predators which devastate native fish, amphibians and aquatic reptiles.

The KERP Wetlands may provide an opportunity for reestablishing declining native herpetofauna. Provided that non-native fish, bullfrogs or crayfish are not introduced, KERP appears to provide adequate habitat for Sonoran Mud Turtles (*Kinosternon sonoriense*), Lowland Leopard Frogs (*Rana yavapaiensis*), and Mexican Gartersnakes (*Thamnophis eques*) and Southwestern Woodhouse Toad (*Bufo woodhousii australis*). At present, the native Great Plains Toad is the dominant amphibian at KERP. These toads are an important part of the diet of these resident birds at times during the summer monsoon season. As many as 300 Couch's Spadefoots were introduced on July 5, after EPG's initial surveys.

Among reptiles, Western Whiptails were ubiquitous at KERP, but other species were lacking. The site should also be able to support additional lizard species, based on vegetation characteristics and the presence of water. Some of these lizards may occur there, but in numbers too low to be detected during short surveys.

One notable observation at the KERP Wetlands with relevance for herpetofauna is the almost complete lack of small animal burrows. No evidence of pocket gophers (*Thomomys* spp.), kangaroo rats (*Dipodomys* spp.), woodrats (*Neotoma* spp), or other small burrowing mammals was documented during surveys; the only burrows observed being those artificially constructed for burrowing owls.

Most herpetofauna are cryptic by nature, and utilize burrows and other cover for refuge. The amphibian species noted at the wetlands are both capable of digging their way into moist soil. However, the lack of burrows and other holes in the ground may represent a limiting factor. Rodents, if introduced, could present an additional food resource for burrowing owls and other species as well.

Another unique feature of KERP is the abundance of broad, low-gradient shores. Shores provide habitat for waterfowl, other vertebrate species, and many shore-inhabiting families of insects. Riparian constructions occur along portions of the storm channel interior to the KERP site and particularly downstream (south) of Inlet B. This design provides valuable habitat diversity that would not occur on the site if wetland habitats are maximized.

Agua Caliente Park has a lesser quantity of shore habitat available, and significant shore habitat is primarily available there only seasonally. Due to the presence of dense stands of aquatic macrophytes, there is only minimal shore habitat present at the constructed ponds at the Sweetwater Wetlands.

With approximately equal sampling effort expended at all three of the sites, the KERP site appears, based on number of taxa alone, to support a greater (by approximately 40 percent) aquatic macroinvertebrate species diversity. The water body that showed the greatest species diversity at Agua Caliente Park was a seasonal cienega immediately west of Pond 1. Seven different species of mosquitoes were recorded at the KERP site during the sampling performed by EPG. Mosquito larval density was not observed to be high anywhere on the site. One species of concern that was not detected by EPG at KERP was the native tadpole shrimp. These species are active predators of mosquitoes during the monsoon season, and had been observed in the basin in previous years.

Chlorine and ammonia-N were below detectable limits for all samples. The dissolved oxygen readings for almost all sampling events were super-saturated, indicating a high rate of photosynthesis with excess dissolved oxygen as a by-product.

Management recommendations

1. Control the existing, small infestations of saltcedar (*Tamarisk* spp.), buffelgrass (*Pennisetum ciliare*), and Malta star thistle (*Centaurea melitensis*) through Kino Stadium District landscaping crews, supplemented with summer youth.
2. Monitor for invasive animal species such as American Bullfrogs, fish, and crayfish should be performed on an annual basis. Check for tadpole shrimp during monsoon season in seasonal pools.
3. Continue to discourage access to the wetlands by the general public with the exception of use of the perimeter trails.
4. Encourage AGFD to examine whether habitat components are present for introduction of native fauna to the wetlands.
5. Encourage further investigations regarding whether some form of rodent introduction would improve habitat conditions for herpetofauna, or whether there are limiting soil conditions.
6. Discuss with Kino Stadium District whether a trash rack at the KERP inlet could make trash removal easier.
7. Examine 24-hour changes in dissolved oxygen during the summer and into fall, in the wetlands proper, to see if there are times during the night when oxygen available might temporarily be low.

Distribution with report:
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HERPETOFAUNA AND AQUATIC MACRO-INVERTEBRATE USE OF THE KINO ECOSYSTEM RESTORATION PROJECT (KERP)

Tucson, Pima County, Arizona

Prepared for

PIMA COUNTY REGIONAL FLOOD CONTROL DISTRICT

Prepared by

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January 2007

Introduction

The Pima County Regional Flood Control District (PCRFCD) contracted with the Environmental Planning Group (EPG) to gather observations of herpetofauna and sample aquatic macro-invertebrates at the Ed Pastor Environmental Restoration Project/Kino Ecosystem Restoration Project (KERP). KERP is located in the Ajo Detention Basin adjacent to Sam Lena Park at the northwest corner of Ajo Way and Country Club Road in Tucson, Arizona (Figure 1). KERP was developed by PCRFCD in cooperation with the U.S. Army Corps of Engineers between 1998 and 2002.

Goals for the KERP site include the restoration of wetland and riparian vegetative communities that will be representative of the historical/optimal conditions for such habitat in the region. Habitats at the KERP site are being developed to be beneficial to certain sensitive species, including the Burrowing Owl (*Athene cunicularia*), already present on the site, and Abert's Towhee (*Pipilo aberti*), two priority vulnerable species of the Sonoran Desert Conservation Plan (Fonseca 2006).

Purpose

The purpose of the observations and sampling was to provide baseline data on current herpetofauna and aquatic macro-invertebrate use of the KERP site. The results will be incorporated into management for the property.

Scope of work

The original scope of the work included a comparison of pre- and post-monsoon herpetofauna and aquatic macro-invertebrate use of the site. This was to be accomplished through observations of herpetofauna and sampling of macro-invertebrates before the onset of the monsoon, and again after the monsoon had been in operation for a length of time. The lag time would allow fauna, such as Spadefoot Toads (*Scaphiopus couchii* and *Spea* spp.) and tadpole shrimp (*Triops longicaudatus*), among others, to respond to the rains, and be documented by subsequent observations. Sampling of two other aquatic sites in Pima County was planned to provide a comparison with the aquatic macro-invertebrate fauna present at the KERP site. Water quality sampling was scheduled to augment and aid in the interpretation of the wildlife observation and sampling results. Water sampling was to be performed both before and after the initiation of the monsoon.

Methods

Water Quality

The intent of the water quality sampling of the ponds was to provide a comparison between pre- and post-monsoon start-up water chemistry values. Only the post monsoon values were obtained for 2006. Data sets were obtained on September 28 and October 11th and 18th, 2006. Samples were taken in the Deep Pond adjacent to Ajo Way and in the Irrigation Pond just to the west of the Deep Pond. Access to sampling sites was by boat. A HydroLab4® data display and sonde was used for samplings taken on September 28 and October 18th. Physio-chemical variables recorded using the HydroLab unit were; water temperature, specific electrical conductivity, pH, dissolved oxygen as mg/liter and percent saturation. A YSI dissolved oxygen meter and probe were used for the sampling on October 11th since the Hydrolab was unavailable due to annual servicing requirements. Physio-chemical variables were taken from the surface to the bottom at each site for samplings that used the HydroLab, and from the surface to a depth of approximately three meters

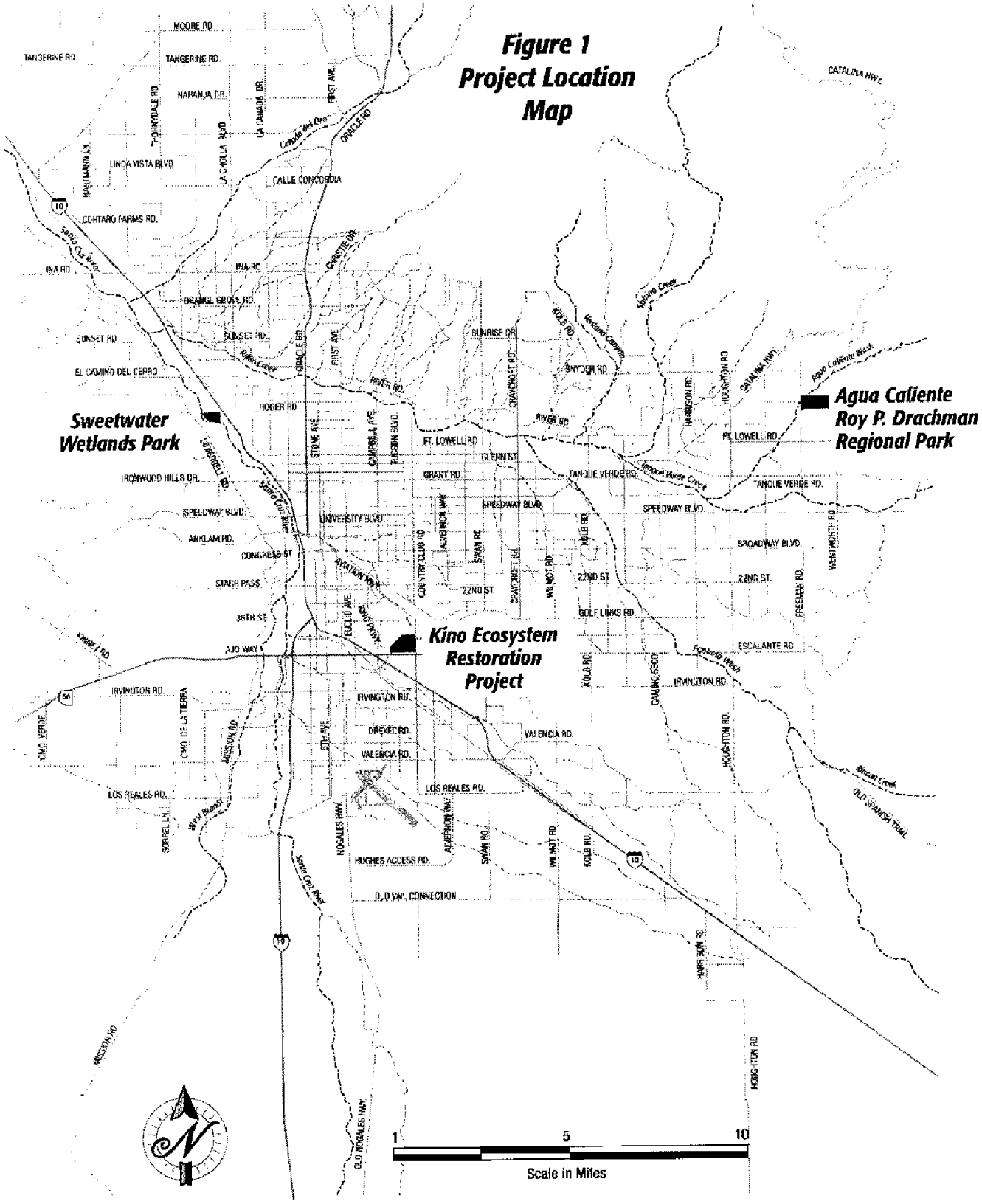
Figure 1
Project Location
Map
Sweetwater
Wetlands Park
Agua Caliente
Roy P. Drachman
Regional Park
Kino Ecosystem
Restoration
Project
MOORE RD
TANGERINE RD
NARANJA DR
LINDA VISTA BLVD
LA CAÑADA BLVD
CALLE CONCORDIA
ORACLE RD
FIRST AVE
CATALINA HWY
CORTARO FARMS RD
INA RD
ORANGE GROVE RD
SUNSET RD
EL CAMINO DEL CERRO
ROGER RD
SUNRISE DR
SNYDER RD
RIVER RD
FT. LOWELL RD
GLENN ST
GRANT RD
TANQUE VERDE RD
IRONWOOD HILLS DR
SPEEDWAY BLVD
ANKLAM RD
CONGRESS ST
STAMP PASS
UNIVERSITY BLVD
AVIATION PKWY
22ND ST
GOLF LINKS RD
BROADWAY BLVD
ESCALANTE RD
AJO WAY
IRVINGTON RD
DREXEL RD
VALENCIA RD
LOS REALES RD
HUGHES ACCESS RD
OLD YAQ. CONNECTION
OLD SPANISH TRAIL
HOUGHTON RD
HARRISON RD
FREEMAN RD
WENTWORTH RD
KOLB RD
SWAN RD
WILMOT RD
ALVERNON WAY
NOGALES HWY
OLD NOGALES HWY
MISSION RD
SORRELL LN
CAMINO DE LA TIERRA
CAMINO SECO
Santa Cruz River
Rillito Creek
Tanque Verde Creek
Pantano Wash
Rincon Creek
Agua Caliente Wash
1
5
10
Scale in Miles

when the YSI unit was used. A surface sample was taken from each site and tested for the presence of chlorine (both free and total) and ammonia-N. The sample was tested for chlorine on site, and kept chilled on ice for transport to the laboratory for the ammonia-N determination. Turbidity was determined by Secchi disk. Because the HydroLab unit was not functioning properly for the October 11th sampling, data was obtained manually with a depth calibrated line. The data recorded for the October 11th sampling consisted of temperature, dissolved oxygen (mg/l), ammonia, chlorine, and turbidity. All water samples were taken at approximately the same time of day (mid-afternoon) to preclude variations in readings that could result from changes in water temperature or flow rates over time.

Fauna

Two visual encounter surveys (VES) were to be performed for amphibians and reptiles at the KERP site during daylight on two separate days, extending into early to mid-evening hours before the start of the monsoon season. An additional two VES were to be performed after the onset of the summer rains. Each VES survey was conducted during a four-hour survey period during the day and another four-hour period between 1800 and 2200 hours. Anuran call surveys were performed in conjunction with the evening VES surveys during the monsoon sampling period. Calling toads and frogs were identified to species based on calls heard.

Aquatic macro-invertebrates were to be sampled twice before and twice after the onset of the monsoon season using kick and sweep net techniques for daytime sampling and long-wave ultraviolet (UV) lights for passive nighttime sampling. Some aerial netting of invertebrates such as odonata (dragonflies and damselflies), shore fly species and mosquitoes was performed, but efforts were primarily concentrated on aquatic netting. The ponds at the Roy P. Drachman/Agua Caliente Park and the City of Tucson-Sweetwater Wetlands sites were also sampled in the same manner for comparison (Figure 1).

Samples of macro-invertebrates obtained during daytime sampling at each of the three sites were composited for each individual site from discrete samples taken at each of the water bodies on the site that had water at the time of sampling. Water levels of various water bodies at both the KERP and Agua Caliente sites varied during some of the site visits. Since the Sweetwater Wetlands site receives input from the Roger Road Sewage Treatment Plant on a regular basis, water levels at that site were consistent during all visits.

The water bodies at the KERP site consist of a series of riparian (Figure 2), wetland (Figure 3), and open water habitats (Figure 4) that are supported primarily by reclaimed water, secondarily by seasonal water inflow from a concrete-lined drainage that enters the property from the east, and on-site rainfall. Daytime samples were made at most of the water bodies on the site during each of the two sampling efforts. Both nighttime post-monsoon start-up samplings were taken immediately north of the southwest end of Pond C. The single nighttime pre-monsoon sampling was performed on the south shore of Pond C.

Figure 2. Constructed riparian stream corridor just upstream of the deep pond. Note the wide, low-gradient shore habitat. View is looking northeast (June 29, 2006).

Figure 3. Wetland habitat at south end of Pond B. Note the wide, low-gradient shore habitat. View is looking ESE (September 6, 2006).

Figure 4. Open water habitat at Pond C. View is looking to the west (June 29, 2006).

The water bodies at Agua Caliente Park currently consist of a series of three spring-fed ponds, Pond 1 (Figure 5), Pond 2 (Figure 6), and Pond 3 (Figure 7). Seasonally ponded waters (cienegas) are present immediately west of Pond 1 (Figure 8) and elsewhere within the park. Daytime samples were made at each of the three ponds and the small cienega west of Pond 1. Both night samplings were taken adjacent to Pond 1.

Figure 5. Pond 1 at Agua Caliente Park. Note the absence of shore habitat. View is looking north (August 24, 2006).

Figure 6. Pond 2 at Agua Caliente Park. Note grasses growing in mid-pond and common cocklebur (*Xanthium strumarium*) growing along near shore. View is to the WSW (August 24, 2006).

Figure 7. Pond 3 at Agua Caliente Park. Note suspended solids causing clouded condition of water. View is looking to the north (August 24, 2006).

Figure 8. Cienega just west of Pond 1 at Agua Caliente Park. View is looking south (August 24, 2006).

The water bodies at the Sweetwater Wetlands consist of an array of eleven ponds, two settling basins, and four recharge basins. Daytime samples were taken variously in eight of the ponds and one settling basin. No samples were taken from the shallow, regularly-disturbed recharge basins since it was felt that no additional species would be obtained from such samples. Both night samplings were taken at Pond 4 (the Gazebo Pond; Figure 9).

Figure 9. Gazebo Pond at Sweetwater Wetlands. View is looking to the southwest (August 30, 2006).

Aquatic insects that are attracted to UV lights typically reach the lights by flying to them. Since these insects are airborne before they arrive at the lights, and each of the three project sites sampled is not very large, we assumed that there was ample time for these insects to reach the lights within the two hour sampling period. We therefore assumed that sampling at a single location was adequate to obtain a representative sample of species that are present at each site. No effort was made to sample multiple areas within sites.

Results

The official onset of the annual monsoon at Tucson, as defined by the National Oceanic and Atmospheric Administration (NOAA), occurs when the average daily dew point is 54 degrees or greater for three consecutive days. The monsoon start date is the first of the three consecutive days (NOAA 2006). The monsoon officially began on June 28 this year. The average historic start date foe the local monsoon is July 3 (NOAA 2006). The first sampling for this project was performed on June 29, 2006, technically after the start of the monsoon season, but this was unknown at the time since the monsoon start date was not verified until June 30, when the recorded conditions met the criteria. Because of the response time of the fauna to the effects of the monsoon season, the

sampling performed on June 29th, while technically within the monsoon period, would not be measurably different than if sampling had been performed earlier, as intended. Pre-monsoon water samples were not taken.

Water Quality

Data obtained during the three sampling periods are shown in Tables 1a-f below. Chlorine (Cl_2) and Ammonia-N were below detectable limits for all samples. No chlorophyll-a or other algae work was performed but the ponds were very green on all occasions. The dissolved oxygen readings for almost all sampling events were super-saturated, indicating a high rate of photosynthesis with excess dissolved oxygen as a by-product. Because there is no 24-hour or "Diel" data available, dissolved oxygen levels at night are impossible to determine, but this is the critical time for aquatic fauna as dissolved oxygen levels drop, often precipitously, as carbon dioxide assimilated during photosynthesis is put back into the water during respiration thereby decreasing dissolved oxygen levels (Walker 2006).

Based on the limited data available from these sampling events it is impossible to determine water quality (or habitat suitability) for aquatic life. To make such a determination would require much more frequent sampling to cover temporal variability. Other than an apparent excess of algal biomass, there were no readily visible signs of water quality issues that can be derived from the water samplings performed. Future work should include monthly Diel profiles through the summer and into fall. (Walker 2006).

Table 1a. Water samples taken at the KERP Deep Pond on September 29, 2006 at 1430 hours.

Sampling depth, meters	Water Temp., ºC	Specific Electrical Conductivity, µS/cm	Hydrogen Ion Concentration (pH)	Dissolved Oxygen, mg/l	Dissolved Oxygen, % Saturation
0.1	26.32	1964	8.12	6.82	84.8
0.2	25.45	1969	8.08	7.00	86.0
0.3	25.31	1974	8.01	6.75	83.2
0.4	25.25	1975	7.97	6.69	82.1
0.5	25.15	1977	7.94	6.58	80.4
1.0	25.07	1977	7.92	6.71	81.8
2.0	25.03	1975	7.91	6.65	81.9
3.0	24.90	1979	7.89	6.49	78.9
5.0	24.77	1976	7.87	6.45	79.0
8.0	24.55	1988	7.76	6.11	73.7
9.0	24.52	1983	7.75	6.03	73.2
10.0	24.49	2000	7.73	5.86	71.6
11.0	24.46	2034	7.69	5.50	66.8
12.0	24.43	2099	7.60	5.22	63.1
13.0	24.37	2082	7.49	3.92	47.1
14.0	24.30	2076	7.36	3.34	41.2

Turbidity (Secchi) = 7.49 NTU.

Table 1b. Water samples taken at the KERP Irrigation Pond on September 29, 2006 at 1515 hours.

Sampling depth, meters	Water Temp., ºC	Specific Electrical Conductivity, µS/cm	Hydrogen Ion Concentration (pH)	Dissolved Oxygen, mg/l	Dissolved Oxygen, % Saturation
0.1	26.86	2014	9.22	12.43	156.3
0.2	26.74	2017	9.27	13.02	167.3
0.3	26.11	2012	9.36	13.98	173.1
0.4	26.10	2013	9.33	14.11	175.0
0.5	25.76	2012	9.30	13.87	172.1
1.0	25.28	2012	9.18	13.14	161.9
2.0	24.49	2029	8.94	11.03	135.3
3.0	24.43	2032	8.90	10.11	123.2
4.0	24.37	2045	8.86	9.48	115.1
5.0	24.37	2047	8.85	9.26	111.7

Turbidity (Secchi) = 7.12 Nephelometric turbidity units (NTU).

Table 1c. Water samples taken at the KERP Deep Pond on October 11, 2006 at 1500 hours.

Sampling depth, meters	Water Temp., ºC	Specific Electrical Conductivity, µS/cm	Hydrogen Ion Concentration (pH)	Dissolved Oxygen, mg/l	Dissolved Oxygen, % Saturation
0.0	24	No data	No data	11.5	No data
0.6	24	No data	No data	10.0	No data
1.2	24	No data	No data	9.5	No data
1.8	24	No data	No data	9.5	No data
2.4	24	No data	No data	9.75	No data
3.0	24	No data	No data	10.0	No data

Turbidity (Secchi) = 7.77 NTU.

Table 1d. Water samples taken at the KERP Irrigation Pond on October 11, 2006 at 1512 hours.

Sampling depth, meters	Water Temp., ºC	Specific Electrical Conductivity, µS/cm	Hydrogen Ion Concentration (pH)	Dissolved Oxygen, mg/l	Dissolved Oxygen, % Saturation
0.0	31	No data	No data	12	No data
0.6	24	No data	No data	11.8	No data
1.2	24	No data	No data	11.8	No data
1.8	23	No data	No data	10.1	No data
2.4	23	No data	No data	9.0	No data
3.0	23	No data	No data	8.8	No data

Turbidity (Secchi) = 6.72 NTU.

Table 1e. Water samples taken at the KERP Deep Pond on October 18, 2006 at 1504 hours.

Sampling depth, meters	Water Temp., ºC	Specific Electrical Conductivity, µS/cm	Hydrogen Ion Concentration (pH)	Dissolved Oxygen, mg/l	Dissolved Oxygen, % Saturation
Surface	22.30	2277	8.49	9.14	96.2
0.5	22.33	2278	8.47	9.18	97.2
1.0	22.32	2278	8.45	9.13	96.4
2.0	22.12	2283	8.36	9.09	92.6
3.0	22.00	2284	8.31	9.02	89.9
4.0	21.97	2284	8.28	8.69	88.1
5.0	21.93	2286	8.25	8.57	85.9
6.0	21.91	2285	8.22	8.42	86.6
7.0	21.81	2289	8.18	7.92	82.7
8.0	21.75	2290	8.14	7.91	82.7
9.0	21.73	2290	8.13	7.96	83.2
10.0	21.72	2290	8.12	7.58	80.0
11.0	21.72	2292	8.11	7.60	80.2
12.0	21.70	2291	8.11	7.53	82.6

Turbidity (Secchi) = 6.88 NTU.

Table 1f. Water samples taken at the KERP Irrigation Pond on October 18, 2006 at 1525 hours.

Sampling depth, meters	Water Temp., ºC	Specific Electrical Conductivity, µS/cm	Hydrogen Ion Concentration (pH)	Dissolved Oxygen, mg/l	Dissolved Oxygen, % Saturation
Surface	22.56	2164	9.21	9.57	115.1
0.5	22.59	2163	9.21	9.89	118.4
1.0	21.64	2172	9.11	9.16	104.7
2.0	21.28	2179	9.03	7.55	89.8
3.0	21.16	2179	8.98	7.02	85.0
4.0	21.13	2183	8.97	6.55	80.9
5.0	21.14	2197	8.92	6.43	77.5

Turbidity (Secchi) = 9.23 NTU.

Amphibians and Reptiles

Amphibian and reptile surveys were conducted mornings and evenings on June 29, 2006; September 15, 2006; and September 25, 2006 (Table 2a). In 26 hours of survey time, 29 adult, 162 juvenile, and more than 1000 larval Great Plains Toads were documented in the KERP study area (Table 2b). One adult Couch's Spadefoot, and more than 30 Western Whiptails were also observed.

Table 2a. Survey effort for herpetofauna at KERP Wetlands, corner of Ajo and Country Club roads, Tucson.

Date	Time Start	Time End	Daylight/Night-time	Total Minutes
29 June, 2006	0800	1215	Daylight	255
29 June, 2006	1810	2215	Night-time	245
15 September, 2006	1115	1340	Daylight	145
15 September, 2006	1910	2230	Night-time	200
25 September, 2006	0845	1342	Daylight	297
25 September, 2006	1957	0052	Night-time	295

Table 2b. Herpetofauna Recorded at Kino Ecosystem Restoration Project (KERP)

Taxon	Common Name	Life stage	Number	Survey #
Bufo cognatus	Great Plains Toad	Tadpole	>1000	1
Bufo cognatus	Great Plains Toad	Juvenile	3	1
Bufo cognatus	Great Plains Toad	Adult	20[1]	1
Aspidoscelis tigris	Western Whiptail	Adult	>15	1
Bufo cognatus	Great Plains Toad	Juvenile	3	2
Bufo cognatus	Great Plains Toad	Adult	12	2
Bufo cognatus	Great Plains Toad	Juvenile	3	3
Aspidoscelis tigris	Western Whiptail	Adult	>15	3
Bufo cognatus	Great Plains Toad	Juvenile	2	4
Bufo cognatus	Great Plains Toad	Juvenile	45	5
Bufo cognatus	Great Plains Toad	Adult	1	5
Bufo cognatus	Great Plains Toad	Juvenile	108	6
Bufo cognatus	Great Plains Toad	Adult	1	6
Scaphiopus couchii	Couch's Spadefoot	Adult	1	6

[1]Of these, approx. 15 were dead and partially eaten at entrances of Burrowing Owl burrows.

Great Plains Toads (Figure 10) were observed throughout the site, including under cover near water margins, foraging on soil and on bike paths and trails, and in manicured grasses of the adjacent park. Reproduction (larvae) was only observed in one area of the study site, in shallow, slowly moving water at UTM = 506353E by 3560779W (NAD 27 datum) on June 29, 2006. Juveniles were found during each survey (large juveniles were found during daylight on the first survey day) indicating that recruitment of Great Plains Toads is successful in the area and was successful in 2005. An interesting finding was 12 to 15 dead and desiccated Great Plains Toads at

the entrances of artificial burrows inhabited by Burrowing Owls (*Athene cunicularia*) (Figure 11). Apparently, Great Plains Toads constitute part of the diet of these resident birds at times when toads are active. Only one Couch's Spadefoot was observed, that during the night survey of September 25, 2006. No other amphibians were documented.

Figure 10. Adult Great Plains Toad documented at KERP wetlands, (June 30, 2006).

Figure 11. Dead Great Plains Toad (foreground) found at entrance to artificial Burrowing Owl (*Athene cunicularia*) burrow.

Western Whiptails were observed in close proximity to waters during daylight surveys on June, 29, 2006 and September 15, 2006. At least 15 were observed each day, but the fast-moving nature of the lizards, combined with the amount of leaf litter in areas frequented by the lizards, made exact counts difficult. No other lizard species or other reptiles were observed.

Macro-invertebrates

Sampling representing the pre-monsoon condition was performed at the KERP site only once, on June 29, 2006, and consisted of both daytime and nocturnal (UV light) sampling. Additional pre-monsoon sampling was not possible since the monsoon had started by the time sampling for the project was initiated. Because of this pre-monsoon sampling at the two comparison sites was not performed. Sampling for macro-invertebrates after the onset of the monsoon season was performed at KERP and the two comparison sites as listed in the following table.

Table 3a. Post-monsoon initiation macro-invertebrate sampling schedule for 2006.

Site	Day Sampling 1	Day Sampling 2	Night Sampling 1	Night Sampling 2
KERP	08-29-06	09-06-06	08-29-06	09-14-06
Agua Caliente Park	08-24-06	08-31-06	08-31-06	09-11-06
Sweetwater Wetlands	08-30-06	09-19-06	09-06-06	09-15-06

Results of the daytime and nocturnal (UV) pre-monsoon initiation samplings at the KERP site have been composited in Table 3b below. Post-monsoon start-up sampling results (day and night)

have been composited for each of the three sites in Tables 3c-e below. Table 3f is a comparison of taxa recorded at the three sites. A total of 83 taxa representing 36 families of aquatic macro-invertebrates were recorded from the KERP site. Samplings at the ponds at Agua Caliente Park revealed 51 taxa representing 29 families of aquatic macro-invertebrates, and 46 taxa in 28 families at the Sweetwater Wetlands site.

The composited tables list the common names, habitat, relative abundance at the site, and trophic relationships. Common names for insect orders and families are from Triplehorn and Johnson (2005), common names for species of odonata are from the Arizona Odonates website (Bailowitz et al. 2003), and non-insect taxa common names are primarily from the Integrated Taxonomic Information System (ITIS 2006). Habitat information for various taxa is primarily from Merritt and Cummins (1996). Habitats are defined as follows:

- Benthic (B) – Pond floor, bottom dwellers.
- Pelagic (P) – Open water column, free-swimming organisms.
- Stream (ST) – Habitat where waters flow over a gradient.
- Epineustonic (E) – Living on the surface tension of the water body.
- Macrophyte (M) – Using large aquatic plants for perching.
- Shore (SH) – Living between the waters edge and the high water mark.

Trophic relationships were obtained primarily from Merritt and Cummins (1996), but supplemental information was taken from Spindler (2001) and other sources. Trophic levels are defined as follows:

- Piercer/Herbivore (PH) – Feeder on aquatic macrophytic plants.
- Shredder (SH) – Consumes vegetation accumulated on bottom of water body.
- Scraper (SC) – Adapted for grazing on periphyton and associated materials.
- Omnivore (OM) – Feeding variously on animal or plant sources.
- Collector/gatherer (CG) – Benthic feeders of fine particulate organic matter.
- Collector/filterer (CF) – Filter fine particulate organics from the water.
- Predator (PR) – Engulfers (Odonata) and piercing suckers (mainly aquatic Hemiptera).
- Parasite (PA) – Symbiotic relationship where one species benefits to the detriment of the host.

Abundance was estimated from the frequency of occurrence and numbers of a taxon sampled, and is only a relative value.

Most specimens were identified to genus, and for some, particularly the odonata and mosquito species, identification was taken to species where possible. Species identification for many adult odonates can be made visually and does not require the use of keys. Mosquitoes were identified to species due to ease of identification and their importance as vectors of disease. It was thought this information would be of value. Some taxa were identified only to the family or a higher level,

primarily because dissection or slide mounting techniques would be required to get to genus, and such efforts were beyond the scope of this project.

A question mark after a taxon indicates some uncertainty of the identification. There were several reasons for these uncertainties. Typically these were due to difficulty seeing or interpreting morphological features of juvenile specimens, making the taxonomic key difficult to use. Occasionally a specimen was imperfect (missing a diagnostic feature) and the identification was halted at the level that could be positively determined. Sometimes a key would lead to a taxon that is not known to occur in the area, and the identification then becomes questionable. However, many invertebrate species are highly mobile and may be brought in to aquatic sites as eggs on migrating waterfowl or may be carried long distances by storms. The high mobility of people also moves many invertebrates such as mosquitoes to other areas. Because of such factors, current records are not always complete, and mobile species are sometimes found locally, often as isolated populations.

Habitats and trophic relationships listed in the composited tables are for aquatic or shore-inhabiting life stages, and do not include adult stages that occur outside of the aquatic or shore habitats, such as in the odonata and many dipterous taxa.

Most taxa were obtained during daytime sampling as juveniles or adults. However, a significant number of taxa were taken only at lights during the night sampling efforts, and this shows the importance of those additional efforts. Some of the taxa taken at lights have small populations or obscure juvenile forms, which are not readily obtained by aquatic netting techniques. Such species include the spongillaflies (*Climacia* sp.), mayflies (*Acerpenna* sp., *Fallceon quilleri*, and *Caenis* sp.), caddisflies (order trichoptera), and small dipterous species such as the Chironomidae (midges) and Ceratopogonidae (biting midges). Adult midges generally do not require time-consuming slide preparation and are considerably easier to identify than the juvenile forms in that respect.

Table 3b. Composited pre-monsoon macro-invertebrates recorded at the KERP site.

Taxon	**Common Name**	**Habitat[1]**	**Relative Abundance[2]**	**Trophic Relationship[3]**
Class: Gastropoda	Snails	Varies	C	Varies
Family: Planorbidae	Fresh-water snails	----	----	SC
Gyraulus sp. ?	Gyros	B	C	SC
Planorbella sp.	----	B	C	SC
Class: Clitellata	Leeches and allies	----	----	----
Subclass: Hyrudinea	Leeches	----	----	PR
Family: Erpobdellidae	Fresh-water leeches	B/ST	U	PR
Mooreobdella sp.	----	B/ST	U	PR
Family: Glossiphoniidae	Fresh-water leeches	B	C	PR
Placobdella/Oligobdella sp. ?	----	B	C	PR
Class: Arachnida	----	----	----	----
Order: Acariformes	----	----	----	----
Family: Eylaidae?	----	P	C?	PA/PR
Eylais sp.?	----	P	C?	PA/PR

Taxon	Common Name	Habitat[1]	Relative Abundance[2]	Trophic Relationship[3]
Class: Arachnida	----	----	----	----
Order: Acariformes	----	----	----	----
Family: Mideidae?	----	P	C?	PA/PR
Midea sp.?	----	P	C?	PA/PR
Class: Insecta	Insects	Varies	A	Varies
Order: Odonata	Dragonflies and damselflies	Varies	C	PR
Family: Aeshnidae	Darners	M	C	PR
Anax sp.	Darners	M	C	PR
Family: Libellulidae	Common skimmers	Varies	C	PR
Orthemis ferruginea	Roseate skimmer	B	C	PR
Pachydiplax longipennis	Blue dasher	B	C	PR
Pantala sp.	Gliders	B	C	PR
Family: Coenagrionidae	Narrow-winged damselflies	Varies	C	PR
Hesperagrion heterodoxum	Painted damsel	M	C	PR
Ischnura sp.	Forktails	M	C	PR
Telebasis salva	Desert firetail	M	C	PR
Order: Orthoptera	Grasshoppers, crickets, and katydids	Varies	U	Varies
Family: Tetrigidae	Pygmy grasshoppers	SH	U	SH/CG
Paratettix mexicanus	----	SH	U	SH/CG
Order: Hemiptera	True bugs	Varies	C	Varies
Family: Nepidae	Waterscorpions	M	U	PR
Ranatra sp.	----	M	U	PR
Family: Belostomatidae	Giant water bugs	M/B/P	C	PR
Belostoma sp.	----	M/B/P	C	PR
Family: Corixidae	Water boatmen	P	C	PR
Corisella sp.	----	P	U	PR
Family: Notonectidae	Backswimmers	P	A	PR
Buenoa sp.	----	P	A	PR
Notonecta sp.	----	P	C	PR
Family: Mesoveliidae	Water treaders	M/E	C	PR
Mesovelia sp.	----	M/E	C	PR
Order: Coleoptera	Beetles	Varies	C	Varies
Family: Dytiscidae	Predaceous diving beetles	Varies	C	PR
Cybister sp.	----	P/M	U	PR
Laccophilus sp.	----	P/M	C	PR
Neobidessus sp.	----	P/M	C	PR
Family: Hydrophilidae	Water scavenger beetles	Varies	C	Varies
Berosus sp.	----	P/M	C	PH/CG/SH
Enochrus sp.	----	B	C	CG/PH
Hydrophilus sp.	----	P/B/M	U	CG/PH
Tropisternus sp.	----	P/M/ST	C	PR/CG/PH
Family: Heteroceridae	Variegated mud-loving beetles	SH	C	CG
Heterocerus sp.	----	SH	C	CG

Taxon	Common Name	Habitat[1]	Relative Abundance[2]	Trophic Relationship[3]
Class: Insecta	Insects	Varies	A	Varies
Order: Diptera	Flies	Varies	C	Varies
Family: Tipulidae	Crane flies	B	U	Varies
Ornithodes brevirostris ?	----	B	C?	?
Family: Culicidae	Mosquitoes	P	U	Varies
Anopheles (*barberi*?)	----	P	U	CF
Culex coronator	----	P	C	CF
Culex (*reevsi*?)	----	P	U	CF
Family: Ceratopogonidae	Biting midges	Varies	U	Varies
Undet. genus	----	Varies	U?	Varies
Family: Chironomidae	Midges	Varies	C	Varies
Cryptochironomus sp.?	----	B	C	PR
Goeldichironomus holoprasinus	----	B	C	CG
Monodiamesa sp.?	----	B	U	CG?
Orthocladius sp.	----	B	U?	CG
Tanypus sp. #1	----	B	C?	PR/CG
Tanypus sp. #2	----	B	C?	PR/CG
Tanypus sp. #3	----	B	C?	PR/CG
Order: Trichoptera	Caddisflies	Varies	U	Varies
Family: Limnephilidae	Northern caddisflies	B	U	SH/CG/SC
Undet. genus	----	B	U	?
Class: Malacostraca	----	----	----	----
Order: Amphipoda	Amphipods	----	----	----
Family: Hyalellidae	----	B/P	C	OM
Hyalella sp.	----	B/P	C	OM
Order: Diplostraca	Cladocerans	P	U?	CF
Family: Sididae	----	P	U?	CF
Diaphanosoma ?	----	P	U?	CF

[1]Habitats: B = Benthic
P = Pelagic
ST = Stream
E = Epineustonic
M = Macrophyte
SH = Shore

[2]Relative Abundance: P = Profuse
A = Abundant
C = Common
U = Uncommon
R = Rare

[3]Trophic Level: PH = Piercer/herbivore
SH = Shredder
SC = Scraper
OM = Omnivore
CG = Collector/gatherer
CF = Collector/filterer
PR = Predator
PA = Parasite

Table 3c. Composited post-monsoon initiation macro-invertebrates recorded at KERP.

Taxon	Common Name	Habitat[1]	Relative Abundance[2]	Trophic Relationship[3]
Class: Hydrozoa	Hydrozoans	----	----	----
Family: Hydridae	----	B/M	U?	PR
Hydra sp.	----	B/M	U?	PR
Class: Gastropoda	Snails	Varies	C	Varies
Family: Physidae	----	B	U?	CG
Family: Planorbidae	Fresh-water snails	----	----	SC
Gyraulus sp. ?	Gyros	B	C	SC
Class: Clitellata	Leeches and allies	----	----	----
Subclass: Hyrudinea	Leeches	----	----	PR
Family: Erpobdellidae	Fresh-water leeches	B/ST	U	PR
Mooreobdella sp.	----	B/ST	U	PR
Family: Glossiphoniidae	Fresh-water leeches	B	C	PR
Actinobdella sp.	----	B	U	PR
Alboglossiphonia heteroclite?	----	B	U	PR
Placobdella/Oligobdella sp. ?	----	B	C	PR
Class: Arachnida	----	----	----	----
Order: Acariformes	----	----	----	----
Family: Amoenacaridae ?	----	B/P	C	PA/PR
Amoenacarus sp. ?	----	B/P	C	PA/PR
Family: Hydrachnidae ?	----	B/P	C	PA/PR
Hydrachna sp. ?	----	B/P	C	PA/PR
Class: Insecta	Insects	Varies	A	Varies
Order: Ephemeroptera	Mayflies	Varies	C	Varies
Family: Baetidae	Baetid mayflies	B	C	Varies
Acerpenna sp. ?	----	B	U?	CG
Callibaetis sp. (*pictus* ?)	----	B	C	CG
Order: Odonata	Dragonflies and damselflies	Varies	C	PR
Family: Aeshnidae	Darners	M	C	PR
Anax sp.	Darners	M	C	PR
Family: Libellulidae	Common skimmers	Varies	C	PR
Pantala flavescens	Wandering glider	B	C	PR
Pantala sp.	Gliders	B	C	PR
Family: Lestidae	Spread-winged damselflies	M/B	U	PR
Lestes sp.	Spreadwings	M/P	U	PR
Family: Coenagrionidae	Narrow-winged damselflies	Varies	C	PR
Enallagma sp.	Bluets	M	U?	PR
Telebasis salva	Desert firetail	M	C	PR
Order: Orthoptera	Grasshoppers, crickets, and katydids	Varies	U	Varies
Family: Tetrigidae	Pygmy grasshoppers	SH	U	SH/CG

Taxon	Common Name	Habitat[1]	Relative Abundance[2]	Trophic Relationship[3]
Class: Insecta	Insects	Varies	A	Varies
Order: Orthoptera	Grasshoppers, crickets, and katydids	Varies	U	Varies
Family: Tetrigidae	Pygmy grasshoppers	SH	U	SH/CG
Paratettix mexicanus	----	X	U	SH/CG
Family: Belostomatidae	Giant water bugs	M/B/P	C	PR
Belostoma sp.	----	M/B/P	C	PR
Family: Corixidae	Water boatmen	P	C	PR
Corisella sp.	----	P	U	PR
Family: Notonectidae	Backswimmers	P	A	PR
Buenoa sp.	----	P	A	PR
Notonecta sp.	----	P	C	PR
Family: Mesoveliidae	Water treaders	M/E	C	PR
Mesovelia sp.	----	M/E	C	PR
Order: Neuroptera	Lacewings and allies	Varies	U	Varies
Family: Sisyridae	Spongillaflies	B	U	PR
Climacia sp.	----	B	U	PR
Order: Coleoptera	Beetles	Varies	C	Varies
Family: Dytiscidae	Predaceous diving beetles	Varies	C	PR
Cybister sp.	----	P/M	U	PR
Hydaticus sp.	----	P/M	U	PR
Hydroporus sp.	----	P/M	C	PR
Laccophilus sp.	----	P/M	C	PR
Family: Hydrophilidae	Water scavenger beetles	Varies	C	Varies
Berosus sp.	----	P/M	C	PH/CG/SH
Enochrus sp.	----	B	C	CG/PH
Tropisternus sp.	----	P/M/ST	C	PR/CG/PH
Family: Heteroceridae	Variegated mud-loving beetles	SH	C	CG
Heterocerus sp.	----	SH	C	CG
Order: Diptera	Flies	Varies	C	Varies
Family: Culicidae	Mosquitoes	P	U	Varies
Aedes fulvuspallens	----	P	C?	CG/CF
Aedes sp.	----	P	C?	CG/CF
Culex tarsalis	----	P	U	CF
Psorophora confinnis	----	P	U	PR/CF
Family: Ceratopogonidae	Biting midges	Varies	U	Varies
Atrichopogon sp. #1	----	B/M	U	?
Atrichopogon sp. #2	----	B/M	U	?
Family: Chironomidae	Midges	Varies	C	Varies
Ablabesmyia sp.	----	B	U?	PR/CG
Dicrotendipes sp.	----	B	U	CG
Tanypus sp.	----	B	C?	PR/CG
Family: Dolichopodidae	Long-legged flies	SH	C	PR
Achradocera sp. or *Chrysotus* sp.	----	SH	C	PR
Chrysotus sp. #1	----	SH	C	PR
Chrysotus sp. #2	----	SH	C	PR
Medetera sp.	----	SH	C	PR
Parasyntormon sp.	----	SH	C	PR
Thrypticus sp.	----	SH	C	PR

Taxon	Common Name	Habitat[1]	Relative Abundance[2]	Trophic Relationship[3]
Class: Insecta	Insects	Varies	A	Varies
Order: Diptera	Flies	Varies	C	Varies
Family: Sphaeroceridae	Small dung flies	SH	C	OM
Leptocera sp.	----	SH	C	OM
Family: Ephydridae	Shore flies	Varies	C	Varies
Parydra sp.	----	SH	C	Varies
Typopsilopa sp.	----	SH	C	CG
Family: Anthomyiidae	Anthomyiid flies	Varies	C?	Varies
Fucellia sp.	----	SH	C?	PR
Class: Malacostraca	----	----	----	----
Order: Amphipoda	Amphipods	----	----	----
Family: Hyalellidae	----	B/P	C	OM
Hyalella sp.	----	B/P	C	OM
Class: Oligochaeta	Earthworms	----	----	----
Family: Naididae ?	----	B	U?	C/G
Undet. family	----	B	U?	C/G

[1]Habitats: B = Benthic
P = Pelagic
ST = Stream
E = Epineustonic
M = Macrophyte
SH = Shore

[2]Relative Abundance: P = Profuse
A = Abundant
C = Common
U = Uncommon
R = Rare

[3]Trophic Level: PH = Piercer/herbivore
SH = Shredder
SC = Scraper
OM = Omnivore
CG = Collector/gatherer
CF = Collector/filterer
PR = Predator
PA = Parasite

Table 3d. Composited post-monsoon initiation macro-invertebrates recorded at Agua Caliente Park.

Taxon	Common Name	Habitat[1]	Relative Abundance[2]	Trophic Relationship[3]
Class: Gastropoda	Snails	Varies	U	Varies
Family: Hydrobiidae?	----	B	U	SC
Family: Physidae	----	B	U	CG
Family: Planorbidae	Fresh-water snails	B	----	SC
Menetus sp.	----	B	U?	SC
Planorbella ?	----	B	R ?	SC
Class: Insecta	Insects	Varies	A	Varies
Order: Ephemeroptera	Mayflies	Varies	U	Varies
Family: Baetidae	Baetid mayflies	B	U	Varies
Acerpenna sp. ?	----	B	U	CG
Callibaetis sp. (*pictus* ?)	----	B	C	CG
Fallceon quilleri	----	B	U	?
Family: Caenidae	Caenid mayflies	B	U	Varies
Caenis (*bajaensis* ?)	----	B	U	CG/SC
Order: Odonata	Dragonflies and damselflies	Varies	C	PR
Family: Aeshnidae	Darners	M	C	PR

Taxon	Common Name	Habitat[1]	Relative Abundance[2]	Trophic Relationship[3]
Class: Insecta	Insects	Varies	A	Varies
Order: Odonata	Dragonflies and damselflies	Varies	C	PR
Family: Aeshnidae	Darners	M	C	PR
Anax sp.	Darners	M	C	PR
Family: Libellulidae	Common skimmers	Varies	----	PR
Libellula saturata	Flame skimmer	B	C	PR
Pachydiplax longipennis	Blue dasher	B	?	PR
Pantala sp.	Gliders	B	C	PR
Family: Coenagrionidae	Narrow-winged damselflies	Varies	C	PR
Telebasis salva	Desert firetail	M	C	PR
Undet. genus (*Nehallenia* ?)	----	M	U?	PR
Order: Hemiptera	True bugs	----	----	----
Family: Belostomatidae	Giant water bugs	M/B/P	C	PR
Undet. genus	----	M/B/P	C	PR
Family: Notonectidae	Backswimmers	P	U	PR
Buenoa sp.	----	P	U	PR
Family: Mesoveliidae	Water treaders	M/E	U	PR
Mesovelia sp.	----	M/E	U	PR
Family: Hydrometridae	Water measurers	E	C	PR
Hydrometra sp.	----	E	C	PR
Family: Saldidae	Shore bugs	SH	U	PR
Isocytus sp.	----	SH	U	PR
Order: Neuroptera	Lacewings and allies	Varies	U	Varies
Family: Sisyridae	Spongillaflies	B	U	PR
Climacia sp.	----	B	U	PR
Order: Coleoptera	Beetles	Varies	C	Varies
Family: Noteridae	Burrowing water beetles	P/B/M	U	PR/CG
Family: Dytiscidae	Predaceous diving beetles	Varies	C	PR
Laccophilus sp. #1	----	P/M	C	PR
Laccophilus sp. #2	----	P/M	C	PR
Neobidessus/*Liodessus* sp. ?	----	P/M	U?	PR
Family: Hydrophilidae	Water scavenger beetles	Varies	U	Varies
Berosus sp.	----	P/M	C	PH/CG/SH
Chaetarthria sp.	----	P/B	U	?
Enochrus sp.	----	B	U	CG/PH
Epimetopus sp.	----	?	U	?
Hydrophilus sp.	----	P/B/M	U	PR/CG
Paracymus sp.	----	B	U	?
Tropisternus sp.	----	P/M	U	PR/CG/PH
Family: Heteroceridae	Variegated mud-loving beetles	SH	U	CG
Heterocerus sp.	----	SH	U	CG
Order: Diptera	Flies	Varies	C	Varies
Family: Tipulidae	Crane flies	B	U	Varies
Elliptera sp.	----	B	U	?
Gonomyia sp.?	----	B	U	?
Family: Chaoboridae	Phantom midges	P/B	U	PR
Chaoborus sp.	----	P/B	U	PR

Taxon	Common Name	Habitat[1]	Relative Abundance[2]	Trophic Relationship[3]
Class: Insecta	Insects	Varies	A	Varies
Order: Diptera	Flies	Varies	C	Varies
Family: Culicidae	Mosquitoes	P	C	Varies
Anopheles franciscanus	----	P	U	CF
Anopheles pseudopunctipennis	----	P	U	CF
Culex peus	----	P	U	CF
Culex (*tarsalis*?)	----	P	U?	CF
Family: Ceratopogonidae	Biting midges	Varies	U	Varies
Corisella sp.	----	B	U	CG/SC
Family: Chironomidae	Midges	Varies	C	Varies
Alotanypus or *Derotanypus* sp.	----	B	U	?
Coelotanypus sp.?	----	B	C	PR
Demicryptochironomus cuneata	----	B	C	CG
Endochironomus sp.	----	B/P	C	SH/CG/CF
Goeldichironomus holoprasinus ?	----	B	C	CG
Partica sp. (or *Pagastia* sp.) ?	----	B?	U?	?
Psectrocladius sp.	----	B	U	CG/SH
Stichtochironomus sp.	----	B	U	CG/SH
Undet. sp. (Chironomini)	----	B	U	CG
Family: Stratiomyidae	Soldier flies	B/P	U?	CG
Undet. genus	----	B/P	U?	?
Family: Phoridae	Humpbacked flies	B	C?	CG/PR
Dohrniphora sp.	----	B	C?	CG/PR
Family: Sphaeroceridae	Small dung flies	SH	U?	CG
Thoracochaeta sp. ?	----	SH	U?	CG
Family: Ephydridae	Shore flies	Varies	C	Varies
Brachydeutera sp.	----	B/P	C	CG
Paralimna sp.	----	B	C	CG
Scatella sp.	----	B/M	C	CG/SC
Family: Muscidae	House fly and allies	SH	C?	CG
Fannia sp.	----	SH	C?	CG
Order: Trichoptera	Caddisflies	----	----	----
Family: Hydropsychidae	Net-spinning caddisflies	B/ST	U	CF/PR
Class: Malacostraca	----	----	----	----
Order: Amphipoda	Amphipods	----	----	----
Family: Hyalellidae	----	B/P	R	OM
Hyalella sp.	----	B/P	R	OM
Class: Branchiopoda	Branchiopods	----	----	----
Order: Anomopoda	----	P	C	CG
Family: Moinidae	----	P	C	CG
Moinodaphnia sp.	----	P	C	CG

[1]Habitats: B = Benthic
P = Pelagic
ST = Stream
E = Epineustonic
M = Macrophyte
SH = Shore

[2]Relative Abundance: P = Profuse
A = Abundant
C = Common
U = Uncommon
R = Rare

[3]Trophic Level: PH = Piercer/herbivore
SH = Shredder
PR = Predator
SC = Scraper
PA = Parasite
OM = Omnivore
SP = Saprophagous
CG = Collector/gatherer
CF = Collector/filterer

Table 3e. Composited post-monsoon initiation macro-invertebrates recorded at: Sweetwater Wetlands

Taxon	Common Name	Habitat[1]	Relative Abundance[2]	Trophic Relationship[3]
Class: Hyrudinea	Leeches	----	----	----
Family: Glossiphoniidae	Fresh-water leeches	B	U	PR
Helobdella sp.	----	B	U	PR
Class: Arachnida	Spiders, mites and allies	----	----	----
Order: Acariformes	Mites and ticks	Varies	----	Varies
Family: Hydrachnidae	----	B/P	C	PA/PR
Hydrachna sp.	----	B/P	C	PA/PR
Family: Pionidae?	----	B/P	C	PA/PR
Najadicola sp.?	----	B/P	C	PA/PR
Undet. Family	----	B/P	C	?
Class: Insecta	Insects	Varies	A	Varies
Order: Ephemeroptera	Mayflies	Varies	U	Varies
Family: Baetidae	Baetid mayflies	B	U	Varies
Callibaetis sp. (*pictus* ?)	----	B	U	CG
Order: Odonata	Dragonflies and damselflies	Varies	C	PR
Family: Aeshnidae	Darners	M	C	PR
Anax sp.	Darners	M	C	PR
Family: Libellulidae	Common skimmers	Varies	C	PR
Pachydiplax longipennis	Blue dasher	B	C	PR
Pantala sp.	Gliders	B	C	PR
Family: Coenagrionidae	Narrow-winged damselflies	Varies	C	PR
Hesperagrion heterodoxum	Painted damsel	M	U?	PR
Telebasis salva	Desert firetail	M	C	PR
Order: Hemiptera	True bugs	Varies	C	Varies
Family: Nepidae	Waterscorpions	M	U	PR
Ranatra sp.	----	M	U	PR
Family: Belostomatidae	Giant water bugs	M/B/P	C	PR
Belostoma sp.	----	M/B/P	C	PR
Family: Notonectidae	Backswimmers	P	U	PR
Buenoa sp.	----	P	U	PR
Notonecta sp.	----	P	U	PR
Family: Mesoveliidae	Water treaders	M/E	U	PR
Mesovelia sp.	----	M/E	U	PR
Family: Hydrometridae	Water measurers	E	U	PR
Hydrometra sp.	----	E	U	PR
Family: Saldidae	Shore bugs	SH	U	PR
Rupisalda sp.	----	SH	U	PR
Family: Veliidae	Riffle bugs	E	R	PR
Microvelia sp.	----	E	R	PR
Order: Coleoptera	Beetles	Varies	U	Varies
Family: Dytiscidae	Predaceous diving beetles	Varies	U	PR
Brachyvatus sp.	----	P/B/M	U	PR

Taxon	Common Name	Habitat[1]	Relative Abundance[2]	Trophic Relationship[3]
Class: Insecta	Insects	Varies	A	Varies
Order: Coleoptera	Beetles	Varies	U	Varies
Family: Dytiscidae	Predaceous diving beetles	Varies	U	PR
Eretes sp.	----	P/B/M	U	PR
Thermonectus sp.	----	P/B/M	U	PR
Family: Hydrophilidae	Water scavenger beetles	Varies	C	Varies
Enochrus sp.	----	B	C	CG/PH
Tropisternus sp.	----	P/M	C	PR/CG/PH
Family: Heteroceridae	Variegated mud-loving beetles	SH	U	CG
Heterocerus sp.	----	SH	U	CG
Order: Diptera	Flies	Varies	C	Varies
Family: Tipulidae	Crane flies	B	U	Varies
Gonomyia sp. ?	----	B	C	?
Family: Culicidae	Mosquitoes	P	C	Varies
Aedes sp.	----	P	U	CG/CF
Culex declarator	----	P	U	CF
Culex erythrothorax	----	P	U	CF
Culex tarsalis	----	P	C	CF
Family: Ceratopogonidae	Biting midges	Varies	C	Varies
Atrichopogon sp.	----	B/M	U	?
Bezia sp.	----	B/P	U	PR
Dasyhelea sp.	----	B	C	CG/SC
Forcipomyia sp.	----	B/M	U	SC
Family: Chironomidae	Midges	Varies	C	Varies
Cryptochironomus sp.	----	B	C	PR
Dicrotendipes sp.	----	B	C	CG/SC
Procladius sp.	----	B	U	PR/CG
Tanypus sp.	----	B	C	PR/CG
Undet. genus	----	?	U	?
Family: Syrphidae	----	Varies	C	Varies
Eristalis sp.	Rat-tailed maggot	B	C	CG
Family: Ephydridae	Shore flies	Varies	C	Varies
Brachydeutera sp.	----	B/P	C	CG
Paralimna sp.	----	B	C	CG
Scatella sp.	----	B/M	C	CG/SC
Class: Malacostraca	----	----	----	----
Order: Amphipoda	Amphipods	----	----	----
Family: Hyalellidae	----	B/P	C	OM
Hyalella sp.	----	B/P	C	OM
Class: Branchiopoda	Branchiopods	----	----	----
Order: Diplostraca	Cladocerans	P/B	U?	CG
Undet. Family				
Class: Oligochaeta	Earthworms	----	----	----
Family: Lumbriculidae	----	B	U?	CG
Undet. genus #1	----	B	U?	CG
Undet. genus #2	----	B	U?	CG

Taxon	Common Name	Habitat[1]	Relative Abundance[2]	Trophic Relationship[3]
Class: Oligochaeta	Earthworms	----	----	
Family: Naididae	----	B	C	CG
Undet. genus	----	B	C	CG

[1]Habitats: B = Benthic
P = Pelagic
ST = Stream
E = Epineustonic
M = Macrophyte
SH = Shore

[2]Relative Abundance: P = Profuse
A = Abundant
C = Common
U = Uncommon
R = Rare

[3]Trophic Level: PH = Piercer/herbivore
SH = Shredder
SC = Scraper
OM = Omnivore
CG = Collector/gatherer
CF = Collector/filterer
PR = Predator
PA = Parasite

Table 3f. Comparative table of macro-invertebrates recorded by site

Taxon	Common Name	KERP	Agua Caliente	Sweetwater
Class: Hydrozoa	Hydrozoans	X		
Family: Hydridae	----	X		
Hydra sp.	----	X		
Class: Gastropoda	Snails	X	X	
Family: Hydrobiidae?	----		X	
Undet. genus	----		X	
Family: Physidae	----	X	X	
Undet. genus	----	X	X	
Family: Planorbidae	----	X	X	
Gyraulus sp. ?	Gyros	X		
Menetus sp.	----		X	
Planorbella sp.	----	X	X ?	
Class: Clitellata	Leeches and allies	X		X
Subclass: Hyrudinea	Leeches	X		X
Family: Erpobdellidae	Fresh-water leeches	X		
Mooreobdella sp.	----	X		
Family: Glossiphoniidae	Fresh-water leeches	X		X
Actinobdella sp.	----	X		
Alboglossiphonia heteroclite?	----	X		
Helobdella sp.	----			X
Placobdella/Oligobdella sp.	----	X		
Subclass: Oligochaeta	Earthworms	X		X
Family: Lumbriculidae	----			X
Undet. genus #1	----			X
Undet. genus #2	----			X
Family: Naididae	----	X		X
Undet. genus	----	X		X
Class: Arachnida	Spiders, mites and allies	X		X
Order: Acariformes	Mites and ticks	X		X
Family: Amoenacaridae ?	----	X		

Taxon	Common Name	KERP	Agua Caliente	Sweetwater
Class: Arachnida	Spiders, mites and allies	X		X
Order: Acariformes	Mites and ticks	X		X
Family: Amoenacaridae ?	----	X		
Amoenacarus sp. ?	----	X		
Family: Eylaidae ?	----	X		
Eylais sp. ?	----	X		
Family: Hydrachnidae ?	----	X		X
Hydrachna sp. ?	----	X		X
Family: Mideidae ?	----	X		
Midea sp.	----	X		
Family: Pionidae?	----			X
Najadicola sp.?	----			X
Undet. Family	----			X
Class: Insecta	Insects	X	X	X
Order: Ephemeroptera	Mayflies	X	X	X
Family: Baetidae	Baetid mayflies	X	X	X
Acerpenna sp. ?	----	X		
Callibaetis sp. (*pictus* ?)	----	X	X	X
Fallceon quilleri	----		X	
Family: Caenidae	Caenid mayflies		X	
Caenis (*bajaensis* ?)	----		X	
Order: Odonata	Dragonflies and damselflies	X	X	X
Family: Aeshnidae	Darners	X	X	X
Anax sp.	Darners	X	X	X
Family: Libellulidae	Common skimmers	X	X	X
Libellula saturata	Flame skimmer		X	
Orthemis ferruginea	Roseate skimmer	X		
Pachydiplax longipennis	Blue dasher	X	X	X
Pantala flavescens	Wandering glider	X		
Pantala sp.	Gliders	X	X	X
Family: Lestidae	Spread-winged damselflies	X		
Lestes sp.	Spreadwings	X		
Family: Coenagrionidae	Narrow-winged damselflies	X	X	X
Enallagma sp.	Bluets	X		
Hesperagrion heterodoxum	Painted damsel	X		X?
Ischnura sp.	Forktails	X		
Telebasis salva	Desert firetail	X	X	X
Undet. genus (*Nehallenia* sp. ?)	----		X	
Order: Orthoptera	Grasshoppers, crickets, and katydids	X		
Family: Tetrigidae	Pygmy grasshoppers	X		
Paratettix mexicanus	----	X		
Order: Hemiptera	True bugs	X	X	X
Family: Nepidae	Waterscorpions	X		X
Ranatra sp.	----	X		X

Taxon	Common Name	KERP	Agua Caliente	Sweetwater
Class: Insecta	Insects	X	X	X
Order: Hemiptera	True bugs	X	X	X
Family: Belostomatidae	Giant water bugs	X	X	X
Belostoma sp.	----	X	X	X
Family: Corixidae	Water boatmen	X		
Corisella sp.	----	X		
Family: Notonectidae	Backswimmers	X	X	X
Buenoa sp.	----	X	X	X
Notonecta sp.	----	X		X
Family: Mesoveliidae	Water treaders	X	X	X
Mesovelia sp.	----	X	X	X
Family: Hydrometridae	Water measurers		X	X
Hydrometra sp.	----		X	X
Family: Veliidae	Riffle bugs			X
Microvelia sp.	----			X
Family: Saldidae	Shore bugs		X	X
Isocytus sp.	----		X	
Rupisalda sp.	----			X
Order: Neuroptera	Lacewings and allies	X	X	
Family: Sisyridae	Spongillaflies	X	X	
Climacia sp.	----	X	X	
Order: Coleoptera	Beetles	X	X	X
Family: Noteridae	Burrowing water beetles		X	
Pronoterus sp.	----		X	
Family: Dytiscidae	Predaceous diving beetles	X	X	X
Brachyvatus sp.	----			X
Cybister sp.	----	X		
Eretes sp.	----			X
Hydaticus sp.	----	X		
Hydroporus sp.	----	X		
Laccophilus sp. #1	----	X	X	
Laccophilus sp. #2	----		X	
Neobidessus sp.	----	X		
Neobidessus sp./*Liodessus* sp. ?	----		X	
Thermonectus sp.	----			X
Family: Hydrophilidae	Water scavenger beetles	X	X	X
Berosus sp.	----	X	X	
Chaetarthria sp.	----		X	
Enochrus sp.	----	X	X	X
Epimetopus sp.	----		X	
Hydrophilus sp.	----	X	X	
Paracymus sp.	----		X	
Tropisternus sp.	----	X	X	X
Family: Heteroceridae	Variegated mud-loving beetles	X		X
Heterocerus sp.	----	X		X
Order: Diptera	Flies	X	X	X
Family: Tipulidae	Crane flies	X	X	X
Elliptera sp.	----		X	

Taxon	Common Name	KERP	Agua Caliente	Sweetwater
Class: Insecta	Insects	X	X	X
Order: Diptera	Flies	X	X	X
Family: Tipulidae	Crane flies	X	X	X
Gonomyia sp.	----	X ?	X	X ?
Ornithodes brevirostris ?	----	X		
Family: Chaoboridae	Phantom midges		X	
Chaoborus sp.	----		X	
Family: Culicidae	Mosquitoes	X	X	X
Aedes fulvuspallens	----	X		
Aedes sp.	----	X		X
Anopheles (*barberi*?)	----	X		
Anopheles franciscanus	----		X	
Anopheles pseudopunctipennis			X	
Culex coronator	----	X		
Culex declarator	----			X
Culex erythrothorax	----			X
Culex peus	----		X	
Culex (*reevsi*?)	----	X		
Culex tarsalis	----	X	X	X
Psorophora confinnis	----	X		
Family: Ceratopogonidae	Biting midges	X	X	X
Atrichopogon sp. #1	----	X		X
Atrichopogon sp. #2	----	X		
Bezia sp.	----			X
Dasyhelea sp.	----		X	X
Forcipomyia sp.	----			X
Undet. genus	----	X		
Family: Chironomidae	Midges	X	X	X
Ablabesmyia sp.	----	X		
Alotanypus or *Derotanypus* sp. ?	----	X		
Coelotanypus sp.	----	X	X	
Cryptochironomus ?	----	X		X
Demicryptochironomus cuneata	----		X	
Dicrotendipes sp.	----	X		X
Endochironomus sp.	----		X	
Goeldichironomus holoprasinus	----	X		
Monodiamesa sp.?	----	X		
Orthocladius sp.	____	X		
Pagastia sp. (or *Partica* sp.)	----		X	
Procladius sp.	----			X
Psectrocladius sp.	----	X		
Stichtochironomus sp.	----	X		
Tanypus sp. #1	----	X		X
Tanypus sp. #2	----	X		
Tanypus sp. #3	----	X		
Undet. genus 1	----			X
Undet. genus 2 (Chironomini)	----		X	
Family: Stratiomyidae	Soldier flies		X	
Undet. genus	----		X	
Family: Dolichopodidae	Long-legged flies	X		
Achradocera sp. or *Chrysotus* sp.	----	X		
Chrysotus sp. #1	----	X		

Taxon	Common Name	KERP	Agua Caliente	Sweetwater
Class: Insecta	Insects	X	X	X
Order: Diptera	Flies	X	X	X
Family: Dolichopodidae	Long-legged flies	X		
Chrysotus sp. #2	----	X		
Medetera sp.	----	X		
Parasyntormon sp.	----	X		
Thrypticus sp.	----	X		
Family: Phoridae	Humpbacked flies		X	
Dohrniphora sp.	----		X	
Family: Syrphidae	Flower flies			X
Eristalis sp.	Rat-tailed maggot			X
Family: Sphaeroceridae	Small dung flies	X		
Leptocera sp.	----	X		
Thoracochaeta sp. ?	----	X		
Family: Ephydridae	Shore flies	X	X	X
Brachydeutera sp.	----		X	X
Paralimna sp.	----	X		X
Parydra sp.	----	X		
Scatella sp.	----		X	X
Typopsilopa sp.	----	X		
Family: Anthomyiidae	Anthomyiid flies	X		
Fucellia sp.	----	X		
Family: Muscidae	House fly and allies		X	
Fannia sp.	----		X	
Order: Trichoptera	Caddisflies	X	X	
Family: Hydropsychidae	Net-spinning caddisflies		X	
Undet. genus	----		X	
Family: Limnephilidae	Northern caddisflies	X		
Undet. genus	----	X		
Class: Malacostraca	----	X	X	X
Order: Amphipoda	Amphipods	X	X	X
Family: Hyalellidae	----	X	X	X
Hyalella sp.	----	X	X	X
Class: Branchiopoda	Branchiopods	X	X	X
Order: Anomopoda	----		X	
Family: Moinidae	----		X	
Moinodaphnia sp.	----		X	
Order: Diplostraca	Cladocerans	X		X
Family: Sididae	----	X		
Diaphanosoma ?	----	X		
Undet. Family	----			X

In addition to invertebrates and herpetofauna, lists were kept of all wildlife species observed by site (Table 4). Herpetofauna records for Agua Caliente Park (except for bullfrog) are unpublished records from E. Stitt/EPG. A list of plant species identified on the KERP site is included as Appendix A. It is noted in the plant list which species were already recorded from the site by Pima County.

Table 4. Comparative Table of Observed Vertebrate Fauna by Site

Common Name	Taxon	KERP	Agua Caliente	Sweetwater
MAMMALS				
Desert Cottontail	*Sylvilagus audubonii*	X	X	
Black-tailed Jack Rabbit	*Lepus californicus*	X		
Rock Squirrel	*Spermophilus variegatus*	X		
Bat	Undetermined bat species	X	X	
Cotton Rat	*Sigmodon* sp.	X		X
Domestic Dog	*Canis familiaris*	X		
Raccoon	*Procyon lotor*			X
Skunk	*Mustela* sp.	X		
BIRDS				
Black-crowned Night-heron	*Nycticorax nycticorax*	X		X
Mallard (Wild)	*Anas platyrhynchos*	X	X	X
Mallard (Domestic white)	*Anas platyrhynchos*	X		
Ruddy Duck	*Oxyura jamaicensis*	X		X
Turkey Vulture	*Cathartes aura*		X	
Cooper's Hawk	*Accipiter cooperii*	X		
Red-tailed Hawk	*Buteo jamaicensis*	X		
Gambel's Quail	*Callipepla gambelii*	X		
Sora	*Porzana carolina*	X		
American Coot	*Fulica americana*	X	X	X
Killdeer	*Charadrius vociferous*	X		X
Black-necked Stilt	*Himantopus mexicana*	X		
Rock Dove	*Columba livia*	X		
Mourning Dove	*Zenaida macroura*	X		
White-winged Dove	*Zenaida asiatica*	X		
Great Horned Owl	*Bubo virginianus*		X	
Burrowing Owl	*Athene cunicularia*	X		
Lesser Nighthawk	*Chordeiles acutipennis*	X		
Gila Woodpecker	*Melanerpes uropygialis*	X	X	
Western Kingbird	*Tyrannus verticalis*	X		
Cliff Swallow	*Petrochelidon pyrrhonota*	X		
Barn Swallow	*Hirundo rustica*	X		
Verdin	*Auriparus flaviceps*	X	X	
Northern Mockingbird	*Mimus polyglottos*	X		
Curve-billed Thrasher	*Toxostoma curvirostre*	X	X	
Common Yellowthroat	*Geothlypis trichas*	X		
Red-winged Blackbird	*Agelaius Phoeniceus*	X		
Great-tailed Grackle	*Quiscalus mexicanus*	X		
Brown-headed Cowbird	*Molothrus ater*	X		
House Finch	*Carpodacus mexicanus*	X		
AMPHIBIANS				
Great Plains Toad	*Bufo cognatus*	X	X	
Couch's Spadefoot	*Scaphiopus couchii*	X		
American Bullfrog	*Rana catesbeiana*		X	X
REPTILES				
Map Turtle	*Graptemys sp.*		X	
Red-eared Slider	*Trachemys scripta*		X	
Painted Turtle	*Chrysemys picta*		X	
Softshell Turtle	*Apalone sp.*		X	

Common Name	Taxon	KERP	Agua Caliente	Sweetwater
REPTILES				
Desert Spiny Lizard	*Sceloporus magister*			X
Western Whiptail	*Aspidoscelis tigris*	X		
Tree Lizard	*Urosaurus ornatus*		X	
FISH				
Mosquitofish	*Gambusia affinis*			X

Discussion

Water Quality Parameters

Since water quality analyses at the KERP site were so limited during the initial site investigations, a definitive statement regarding water quality as it relates to aquatic wildlife habitat suitability cannot be made. However, the low ammonia-N and high oxygen values obtained are positive indications that the overall water quality is probably good. Monthly diel profiles of oxygen levels, at least during the summer and early fall seasons would give valuable insight into water quality for aquatic wildlife. Additional water quality parameters that would be of use in determining suitability of site waters for aquatic wildlife include quantitative analysis for chlorophyll-a, phosphate (as P), alkalinity (as $CaCO_3$), nitrate (as N), nitrite (as N), and arsenic (Walker 2006).

Herpetofauna

Two amphibian species, Great Plains Toad and Couch's Spadefoot, were documented from the KERP wetlands; however, reproduction was only noted for Great Plains Toads. Tadpoles and empty egg strings were already present in one slower-flowing section of the wetlands on the first survey day, following very light rains in the previous week (0.28") from June 26 through 29. Despite seemingly ideal conditions in other waters at the site, no breeding activity was documented, nor calling amphibians heard, during rains on the evening of June 29, 2006.

As many as 300 Couch's Spadefoots were introduced on July 5, after our initial surveys, as part of another project (Dr. Phil Rosen, pers. comm.). We observed spadefoots in very low numbers (one observed) at KERP, and no evidence of breeding activity was observed. Moderate numbers calling and on roads were observed in 2006 and previous years by Phil Rosen. Whether they will breed in the perennial water at KERP remains unknown. Typically, spadefoots use ephemeral rain pools for breeding, but Dr. Rosen has observed spadefoots calling in KERP ponds. Areas at KERP that receive periodic overflows of stormwater during runoff events were not studied for this report, but are the most auspicious sites for successful reproduction by spadefoots (Phil Rosen, pers. comm.).

Among reptiles, Western Whiptails were ubiquitous at KERP, but other taxa were lacking. Other lizards that tend to maintain populations in urban settings but that were not documented at the study site include the Desert Spiny Lizard (*Sceloporus magister*) and the Tree Lizard (*Urosaurus ornatus*), and the Regal Horned Lizard (Phrynosoma solare). Additionally, areas of open habitat within the city, such as at KERP, normally support the Zebra-tailed Lizard (Callisaurus draconoides) and, often, the Side-blotched Lizard (Uta stansburiana) and the Sonoran Spotted

Whiptail (Aspidoscelis sonorae). The site should also be able to support additional lizard species, based on vegetation characteristics and the presence of water. Some of these lizards may occur there, but in numbers too low to be detected during short surveys.

One notable observation at the KERP Wetlands with relevance for herpetofauna is the almost complete lack of small animal burrows. No evidence of pocket gophers (*Thomomys* spp.), kangaroo rats (*Dipodomys* spp.), woodrats (*Neotoma* spp), or other small burrowing mammals was documented during surveys; the only burrows observed being those artificially constructed for burrowing owls. Most herpetofauna are cryptic by nature, and utilize burrows and other cover for refuge. The amphibian species noted at the wetlands are both capable of digging their way into moist soil. However, the lack of burrows and other holes in the ground may represent a limiting factor relative to the abundance and diversity of other herpetofauna that may establish and persist at the KERP Wetlands. Rodents, if introduced, could present an additional food resource for burrowing owls and other species as well.

In addition to the release of Couch's Spadefoots into the area, the KERP Wetlands may provide an opportunity for reestablishing declining native herpetofauna. Provided that exotic wetland species can be excluded (see below), KERP provides adequate habitat for Sonoran Mud Turtles (*Kinosternon sonoriense*), Lowland Leopard Frogs (*Rana yavapaiensis*), and Mexican Gartersnakes (*Thamnophis eques*). All have suffered extensive declines throughout Arizona primarily due to loss of perennial surface flows, predation from and competition with non-native species, and other factors, thus repatriation of these species at KERP may provide unique insights into conditions necessary and for the development of protocols for other repatriation efforts. It must be stated that resultant populations, if established, will remain isolated within a larger urban matrix, with possible exception of leopard frogs. The least controversial and possibly most successful amphibian for introduction would be the southwestern Woodhouse Toad (*Bufo woodhousii australis*), which is extiripated near Tucson but available down by Tubac or Tumacacori (Phil Rosen, pers. comm.). These live in more perennial waters than the other anurans, except for the lowland leopard frog.

Introduced Aquatic Species

Large, urban, ponded areas such as the KERP wetlands are magnets for introduced aquatic species. Some species, such as Red-eared Sliders (*Trachemys scripta*) and American Bullfrogs, originally native to North America east of the Rocky Mountains, now have worldwide distributions as a result of their release as unwanted pets (turtles) or being introduced as game animals (Bullfrogs). Other species that have become introduced throughout southwestern wetlands include Softshell Turtles (*Apalone* spp.), Tiger Salamanders (*Ambystoma tigrinum*), mosquitofish (*Gambusia affinis*), sunfish (*Lepomis* spp.), bass (*Micropterus* spp.) and crayfish (*Oronectes virilis*). Monitoring of the KERP Wetlands should be done diligently, and all preceding species should be "on the radar" during subsequent survey and monitoring efforts.

Macro-invertebrates

Most macroinvertebrate species that occur within a given aquatic habitat are typically evident either as juveniles or adults, during both the pre and post-monsoon periods. The four post-monsoon start-up samplings (two days and two nights) performed at each of the three aquatic sites, along with the single pair of pre-monsoon samplings (one day and one night) at the KERP site

should provide a reasonable accounting of a majority of aquatic macro-invertebrates that occur at these sites. Only species that are monsoon obligates, such as tadpole shrimp, would be evident only during a short emergence, feeding and mating period in response to the monsoon season.

KERP Aquatic Habitat Diversity

Water bodies at the KERP site provide a variety of aquatic habitats for macroinvertebrate and other animal species. The storm flow channel, where stormwater runoff enters the property from the east, provides seasonally intermittent flows that feed an interconnected series of ponds and mesoriparian reconstructions. Water depth for most of the water bodies on the site is relatively shallow. Emergent vegetation, primarily species of bulrush, are common along shorelines. The single exception is the southeast deep pond (Figure 12), which has a depth of at least 46 feet, and is designed to take both stormwater through a control gate at its north end, or may receive pumped, reclaimed water. The deep pond is lined with gunnite (concrete) and does not currently provide bottom habitat suitable to support emergent aquatic vegetation. However, this pond provides a permanent open water source that is important to certain waterfowl, and which does not require

Figure 12. Deep Pond at KERP showing open water habitat. View is looking southwest (June 29, 2006).

periodic vegetation removal to maintain the open water condition. Riparian constructions occur along portions of the storm channel interior to the KERP site, and particularly downstream (south) of Inlet B, which feeds into Pond B. This design provides valuable habitat diversity that would not occur on the site if wetland habitats are maximized.

Vegetation growing along shorelines, such as grasses and other annual plants, that extend into the littoral zone of water bodies provide perching habitat and cover for many species of aquatic invertebrates, including waterscorpions (family Nepidae), giant water bugs (family Belostomatidae), predaceous diving beetles (family Dytiscidae), and various species of dragonfly and damselfly larvae. Based on the sampling performed, waterscorpions appear to be uncommon

at the KERP site, and were only observed once on knotgrass (*Paspalum distichum*) that extended into the water at the east shore of Pond C. Additional perching and cover habitat is similarly provided by trees that have blown down and are lying in the water. A negative component of such habitat is that it also supports mosquito larvae, which are important vectors of diseases transmissible to humans. There is currently an active water recirculation and preventive larviciding program in place for the control of mosquito larvae at the KERP site. Seven different species of mosquitoes were recorded at the KERP site during the sampling performed for this report. Mosquito larval density was not observed to be high anywhere on the site.

An important component of the KERP site is the abundance of broad, low-gradient shores (Figures 2 and 3), which provide habitat for waterfowl, other vertebrate species, and many shore inhabiting families of insects. Several families of flies, including the long-legged flies (family Dolichopodidae), shore flies (family Ephydridae), and small dung flies (family Sphaeroceridae) are important dipterous families using shore habitat for breeding and foraging at the KERP site. These groups provide a food source for waterfowl, fish and predatory insect species such as dragonflies (Figure 13). Other shore inhabiting insect families include pygmy grasshoppers (family Tetrigidae), pygmy mole crickets (family Tridactylidae), shore bugs (family Saldidae), toad bugs (family Gelastocoridae), riffle bugs (family Veliidae), variegated mud-loving beetles (family Heteroceridae), tiger beetles (family Cicindelidae), and others. Some of these groups were present at KERP or the other two sites, but the flies were dominant at KERP (at least 11 species), primarily due to the abundance of low-gradient shore habitat. Pygmy mole crickets, toad bugs, and tiger beetles were not found at any of the three sites. With the abundance of shore habitat present at KERP, representatives of each of these groups could all potentially be supported at the site.

Figure 13. Blue dasher dragonfly (*Pachydiplax longipennis*, family Libellulidae) at the KERP site (September 6, 2006).

In contrast, Agua Caliente Park has a lesser quantity of shore habitat available (Figure 5), primarily due to the steepness, and resultant narrow width, of the embankments (Figure 6). Significant shore habitat is primarily available there only seasonally when water levels drop with evaporation after the winter rains, and again late in the monsoon season. This increases the effective width of "shore" habitat of ponds 2 and 3. However, the window of opportunity for utilization of this expanded habitat is limited, and many species cannot benefit from it due to life cycles that are too long. Due to the presence of dense stands of aquatic macrophytes, there is only minimal shore habitat present at the constructed ponds at the Sweetwater Wetlands (Figure 9).

Interestingly, although tadpole shrimp have been recorded at the KERP site previously, none were observed during any of the post-monsoon samplings. It is possible that the adult activity period for this species was very brief, and may have been missed during the limited on site samplings.

With approximately equal sampling effort expended at all three of the sites, the KERP site appears, based on number of taxa alone, to support a greater (by approximately 40 percent) aquatic macroinvertebrate species diversity.

Differences in aquatic macroinvertebrate taxa in waters at the KERP site between the pre-monsoon and post-monsoon samplings are probably tied to warmer water temperatures and the influx of rainwater into the basin. Many aquatic macroinvertebrate taxa eggs hatch with the change in temperature and water chemistry. Some of the taxa that were sampled post-monsoon were probably present as immatures during the pre-monsoon, but due to low populations were not picked up in the earlier sampling. Examples of these would include the two species of mayflies and the spongillafly. Other species such as the shore-inhabiting diptera were probably present as eggs, larvae or pupae in shore sediments during the pre-monsoon period. The suites of pre and post-monsoon mosquito taxa were completely different. It is not known whether this reflects a real difference, or is coincidental. The two genera of aquatic mites present during the pre-monsoon were different that the two genera found in the post-monsoon seasons. It is likely that these differences are tied to the change in conditions related to the monsoon, but not enough data was obtained to make this a definitive statement. Aquatic mite taxa are usually diverse in freshwater habitats, and there were probably several other taxa present, both pre and post-monsoon, which were not documented. This is primarily due to their small size and the limitations of the sampling methods.

Agua Caliente Park

Four aquatic habitats were sampled at the Agua Caliente Park site. Pond 1 is a fairly deep pond with abrupt embankments that provide essentially no shore habitat for invertebrates (Figure 5). Additionally, there is an abundance of non-native fish species present (including carp, white amur, largemouth bass, green sunfish, bluegill, at least two species of cichlids, and probably catfish and other species; L. Smith, pers. comm..) in the pond that put heavy stresses on available macroinvertebrate fauna. Prior to about 2002, ponds 2 and 3 were full year round, supported by the on site springs. Drought during recent years has reduced the flow of the springs, resulting in these ponds containing varying amounts of water, which is dependent on seasonal rains. This current condition somewhat limits the aquatic fauna that these ponds can support. The late monsoon condition of Pond 3 is shown in Figure 14. The severity of the drought resulted in Pima County drilling a well to support Pond 1.The water body that showed the greatest species diversity was a seasonal cienega immediately west of Pond 1.

Figure 14. Late monsoon (August 24, 2006) condition of Pond 3 at Agua Caliente Park showing temporarily expanded shore habitat. View is looking to the southwest.

Overall, the waters within Agua Caliente Park have a reasonable balance of aquatic macroinvertebrate taxa present, but only in the waters other than Pond 1. Pond 1 has a less diverse macroinvertebrate fauna, and numbers are also apparently low due to the abundance of fish species. Groups that were conspicuous in their absence included leeches (class clitellata), aquatic earthworms (class oligochaeta), and aquatic mites (class arachnida).

Dragonflies and damselflies are abundant at Agua Caliente Park, but species diversity does not appear to be as great as that at the KERP site. The apparent absence of water boatmen (Hemiptera: Corixidae) at Agua Caliente Park and the Sweetwater Wetlands was a surprise, since these are typically common animals, and are relatively tolerant of poor water quality. Shore-inhabiting fly species were not common at Agua Caliente Park, and this probably reflects the limited shore habitat, and ephemeral presence of waters in the ponds that do provide some shore habitat.

Sweetwater Wetlands

The ponds at the Sweetwater Wetlands have minimal shore habitat, primarily due to the presence of dense stands of sedges that crowd against the banks (Figure 9). The Sweetwater Wetlands had the lowest apparent aquatic macroinvertebrate species diversity, but only slightly lower than the Agua Caliente site. The evident lack of any snail species was very surprising, especially considering that most species are relatively tolerant of poor water quality. Snails are probably present, but evidently are not common, since not a single snail was found during the two daytime samplings at the site. Due to the very minimal shore habitat present at the Sweetwater Wetlands there is a definite paucity of aquatic macroinvertebrate species that require this habitat type.

Summary

A total of 132 taxa were recorded for the three sites combined. Fifty-one (51) of the 83 taxa (61%) recorded at KERP were not recorded at either of the other sites. There were 27 taxa at Agua Caliente Park and 15 taxa at the Sweetwater Wetlands that were unique to those sites. This represents 53% and 33% of their total aquatic macroinvertebrate taxa respectively.

Pollution tolerance values for aquatic (stream) macroinvertebrates in Arizona were developed by the Arizona Department of Environmental Quality (ADEQ) (Spindler 2001) based on Hilsenhoff (1982). Using existing literature, ADEQ assembled a list of tolerance values for aquatic macroinvertebrates from 0 (intolerant) to 10 (highly tolerant). These values are used as one of the metrics in calculating a biotic index for the evaluation of water quality. While pollution tolerances for aquatic invertebrates do vary some at the species level, the differences within any given genus, based on the available literature (ADEQ 2001), does not appear to vary greatly. Because of this, use of pollution tolerance levels at the generic level for aquatic macroinvertebrates is commonly practiced. Also, the use of these established values for the same genera in lentic (calm, ponded) waters (most waters in this study) should be valid.

Mayflies (order ephemeroptera) and caddisflies (order trichoptera) are insect groups that are important indicators of water quality in aquatic habitats. Mayflies (Baetidae: *Callibaetis* sp.) were present in moderate numbers at all three of the sites, but *Callibaetis* sp. is one of the few genera that are relatively pollution tolerant (pollution tolerance value of 9; Spindler 2001). The only other mayfly recorded was a single specimen of *Caenis* sp. (family Caenidae) at Agua Caliente Park, which is also a fairly pollution tolerant taxon (pollution tolerance value of 7; Spindler 2001). Only a couple specimens of caddisflies were recorded; one from KERP, a species of northern caddisfly (family Limnephilidae), and at Agua Caliente Park a net-spinning caddisfly (family Hydropsychidae) was captured. Since hydropsychid caddisflies are typically from lotic (fast running-water) habitats, the Agua Caliente specimen is probably associated with the springs present on the site. There were no caddisflies found at the Sweetwater Wetlands, and this is most likely a water quality issue. Pollution tolerances of the caddisflies found at KERP and Agua Caliente Park are not known, as the specimens were only identified to the family level, and tolerances vary at the family level.

Species of midges (family Chironomidae) are an important element in freshwater ecosystems, providing food for fish and other aquatic fauna. There is also a lot of available information on the pollution tolerances of the various genera of this large family. Tolerances vary the full spectrum depending on the genus considered. There are at least 13 species of midges present at the KERP site, and only one (*Orthocladius* sp.) is moderately tolerant to pollution (Spindler 2001). All of the remaining taxa are in the high tolerance range. The lack of low-tolerant species may indicate a less than optimal condition of the water at the site for aquatic life. The tolerance values for the midge taxa at the other two sites is similar.

Aquatic macroinvertebrate species that are classically associated with lower water quality are syrphid flies of the genus *Eristalis*, the larvae of which are known as rat-tailed maggots. These were common at the Sweetwater Wetlands, but were not seen at either KERP or the Agua Caliente Park site. Other pollution tolerant groups include some leeches, which are present as several species at KERP and a single species at the Sweetwater Wetlands.

Recommendations for Restoration

To maintain native plant and animal communities and species diversity at the KERP site invasive plant species should be aggressively controlled. Currently saltcedar (*Tamarisk* spp.), buffelgrass (*Pennisetum ciliare*), and Malta star thistle (*Centaurea melitensis*) are all present in small areas of the site. Control of these species at this time would not require extensive control efforts, but buffelgrass and tamarisk will rapidly take over the site if not effectively controlled. Control of saltcedar is particularly important to maintain the quality of the aquatic habitat components of the site.

Likewise, monitoring for invasive animal species such as American Bullfrogs, fish, and crayfish should be performed on a regular basis. To reduce the potential for the introduction of non-native invasive fish and amphibians access to the wetlands by the general public should be discouraged, with the exception of use of the perimeter trails for non-invasive recreational use such as biking, walks, and birding activities. Cursory surveys should be performed occasionally with binoculars to detect non-native turtles and bullfrogs, should they become established. The latter species will probably first be detected by vocalizations.

The KERP wetlands provide a unique opportunity for native species re-introductions. We applaud the experimental introduction of Couch's Spadefoots into the study area, and suggest that other native wetland obligates, particularly Sonoran Mud Turtles, Lowland Leopard Frogs, and Mexican Garter Snakes, be considered for repatriation should suitable founder populations be found. Because of the isolated nature of the wetlands, genetic considerations, although important, may be less important here than at other potential sites nearer to established populations where genetic mixing may have undesired consequences. However, such reintroductions should not be performed without conducting focused studies to determine whether cover, prey, and other habitat components are present for the species in question.

Storm water runoff that enters the KERP site via the concrete-lined basin inlet beneath Country Club Road at the east side of the site carries a large amount of trash onto the site. Pima County may wish to consider placing some sort of grating at the channel ingress to the site to capture the bulk of this debris. Periodic cleaning of the grating would minimize trash input to the site from this source. Once such a control feature is in place, a cleanup of the interior of the site would improve habitat for wildlife.

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APPENDIX A

Plant species observed by EPG on the KERP site. Species that were already on the Pima County plant species list for the site are listed as "Yes" in the right-hand column.

Latin Name	Common Name	Species on PC KERP List
Acacia constricta	Whitethorn acacia	Yes
Acacia farnesiana	Sweet acacia	No
Ambrosia deltoidea	Triangle bursage	Yes
Atriplex canescens	Fourwing saltbush	Yes
Atriplex lentiformis	Quailbush	Yes
Atriplex polycarpa	Desert saltbush	Yes
Baccharis salicifolia	Seepwillow	Yes
Baccharis sarothroides	Desert broom	Yes
Centaurea melitensis	Malta starthistle	Yes
Cynodon dactylon	Bermuda grass	Yes
Dyssodia sp.	Dogweed	Yes
Echinochloa Crus-galli	Barnyard grass	Yes
Eleocharis sp.	Spikerush	Yes
Encelia farinosa	Green brittlebush	Yes
Eragrostis cilianensis	Stink grass	No
Eucalyptus sp.	Eucalyptus	Yes
Euphorbia sp.	Spurge	Yes
Fraxinus sp.	Ash	Yes
Helianthus annuus	Annual sunflower	Yes
Isocoma tenuisecta	Burro weed	Yes
Juncus sp.	Rush	Yes
Larrea tridentata	Creosote bush	Yes
Melilotus indicus	Annual yellow sweetclover	Yes
Nicotiana trigonophylla	Desert tobacco	No
Opuntia engelmannii	Engelmann prickly pear	No
Parkinsonia aculeata	Mexican palo verde	Yes
Parkinsonia florida	Blue palo verde	No
Paspalum distichum	Knotgrass	Yes
Phalaris sp.	Canary grass	Yes
Polygonum pennsylvanica	Smartweed	No
Polypogon monspeliensis	Annual rabbit's-foot grass	No
Populus fremontii	Fremont cottonwood	Yes
Portulaca oleracea	Common purslane	No
Proboscidea sp.	Devil's claw	No
Prosopis sp.	Honey ? mesquite	No
Prosopis velutina	Velvet mesquite	Yes
Rumex sp.	Dock	No
Salix exigua	Coyote willow	Yes
Salix sp.	Willow	Yes
Senna covesii	Desert senna	Yes
Solanum elaeagnifolium	Silverleaf nightshade	Yes

Latin Name	Common Name	Species on PC KERP List
Sonchus sp.	Sowthistle	No
Sorghum halepense	Johnson grass	Yes
Sphaeralcea ambigua	Globemallow	Yes
Sporobolus cryptandrus	Sand dropseed	Yes
Tamarix chinensis	Saltcedar	Yes
Typha sp.	Cat-tail	No
Vitex agnus-castus	Lilac chaste tree	No
Xanthium strumarium	Cocklebur	Yes
Zinnia acerosa	Desert zinnia	Yes