

Las Vegas Wash Coordination Committee

Pittman Wash Pilot Wetlands Final Grant Report



September 2007



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**Pittman Wash Pilot Wetlands
Final Grant Report**

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U.S. Bureau of Reclamation

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September 2007

ACKNOWLEDGEMENTS

We would like to thank the U.S. Bureau of Reclamation for providing funding to the Southern Nevada Water Authority for this project under assistance agreement number 05FG300017. We would also like to extend our thanks to Marissa Foster and Caroline Baker for performing weekly site assessments and our thanks again to Marissa for assisting with vegetation monitoring. Our thanks go also to Robert Huening, Warren Turkett, and Eric Loomis for conducting water quality monitoring. We would also like to give our sincere appreciation to Paul Kuvelis and Michael Goff for getting this project started. Finally, we would like to thank Xiaoping Zhou, Seth Shanahan, and Keiba Crear for reviewing this report and the Las Vegas Wash Coordination Committee for their continued support for constructed wetlands research and the implementation of the Las Vegas Wash Comprehensive Adaptive Management Plan.

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1.0 INTRODUCTION

1.1 Background

The Las Vegas Wash (Wash) is the primary drainage channel for flows originating from the Las Vegas Valley (Valley) watershed located in Clark County, Nevada. The flows are a combination of stormwater, urban runoff, shallow groundwater, and reclaimed water (i.e., treated wastewater). Treated wastewater contributes approximately 85 percent of the total daily flow in the Wash. The remaining flow components are not treated prior to entering the Wash. Urban runoff, which currently accounts for approximately 10 percent of the flows in the Wash, courses over the streets of Las Vegas, picking up contaminants such as metals, motor oil, pesticides and pet waste. It flows in to the Valley's flood control channels and then enters the Wash. The water quality of this runoff is also a product of land use and of the geology of the area. The geology (soils and bedrock) in certain drainages contains selenium, a trace metalloid that can impact wildlife and human health. The Southern Nevada Water Authority (SNWA) has been collecting flow rate and water chemistry data in the Valley's urban runoff channels since 2000. What has been learned to date is that urban runoff has a direct impact on the water quality of mainstream flows in the Wash. The work that has been conducted indicates that there are some substances, including selenium, that are carried by the water that could be reduced by wetland systems prior to entering the Wash. SNWA water quality data has shown that 40 percent of the selenium in the Wash comes from urban runoff. As the Valley grows, so does the population. The population growth and land use changes may result in an increased volume of urban runoff and impacts to water quality in the Wash. Additionally, a portion of the treated wastewater flows may be removed from the Wash in the future as a result of an alternate discharge project. The potential reduction of treated wastewater, which currently dilutes the influence of urban runoff on Wash water quality, makes any treatment prior to the runoff entering the Wash much more beneficial.

Consequently, SNWA is examining the use of constructed wetlands as a possible treatment option. The use of wetland technologies to improve the water quality of urban runoff within the watershed is an approach supported by a variety of state and federal agencies. Ancillary benefits from creating wetlands are numerous, including habitat for fish and wildlife, flood and erosion control, water filtration, siltation control, and opportunity for recreation, education, and research.

This approach has not been extensively used in southern Nevada and the actual quantitative benefits are still undetermined. For this reason, a tributary water quality improvement demonstration wetlands project was constructed within the Pittman Wash flood control channel. Project partners include the City of Henderson, Clark County Regional Flood Control District, and U.S. Bureau of Reclamation (BOR), which provided a grant to help fund construction and the on-set of monitoring activities.

This report serves to fulfill final reporting requirements for that grant, assistance agreement number 05FG300017. The report describes work completed through the end of the grant period. The project and associated monitoring are still ongoing.

1.2 Goals

The primary purpose of the pilot project is to determine whether constructed wetlands can improve the water quality of urban runoff. Other goals include evaluating the feasibility of

operating constructed wetlands in an urban flood control channel, identifying challenges associated with this type of setting, optimizing design and construction technique, and comparing the effects of different wetland flow regimes.

2.0 CONSTRUCTION AND DESIGN

The pilot wetlands were constructed in Henderson, Nevada, in the Pittman Wash channel adjacent to the Arroyo Grande Sports Complex. Construction began on March 14, 2005, and was completed by May 14, 2005. The site was planted with emergent vegetation in June. Design (Appendix 1) and construction of the site were funded by a separate grant from BOR.

The pilot project, as fully constructed, covers approximately 0.3 acres of the floodplain immediately adjacent to the dry weather flow channel. There are two 0.06 acre cells, one with a surface flow (SF) regime, and another with a subsurface flow (SSF) regime (Figure 1). The SF cell has alternating open water zones (depth of 2-3 feet) and bulrush-vegetated beds. The SSF cell is filled with 0.75 inch gravel, and the entire surface is planted with bulrush. Three species of bulrush, *Schoenoplectus californicus*, *S. acutus*, and *S. americanus*, are planted in alternating bands in each wetland cell. Both cells are lined with four inches of clay to keep groundwater from influencing wetland water chemistry. Earth berms border the cells and another berm separates the cells. A ditch runs along the southeast border of the site.

Flows from the main channel enter the site via two three-inch pipes in the concrete wall bordering the channel. Water from these pipes enters a small channel at the top of the site. In this channel, each cell has a diversion structure through which the water enters and then flows through the given cell. Water exits each cell into a similar small channel and then returns to the main channel. A fence was built around the site to protect it from vandalism.

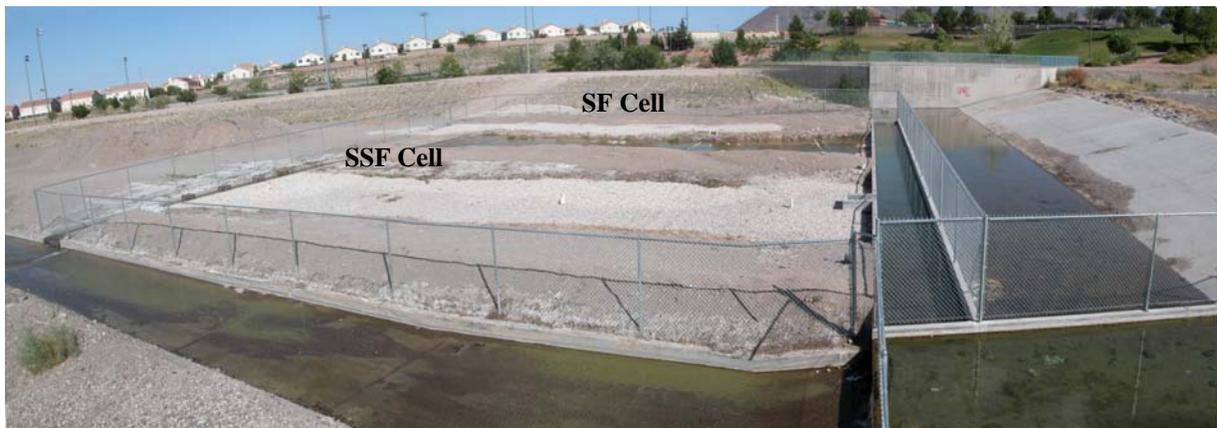


Figure 1: June 16, 2005, site overview looking southeast with the SSF cell in the foreground and the SF cell beyond it.

3.0 ESTABLISHING THE PILOT WETLANDS - CHALLENGES

The pilot project weathered its first storm events on July 24 and 27, 2005, receiving minor damage. The fence was damaged on the upstream side; the posts were bent horizontally and the fence was covered in debris. A layer of fine sediment was deposited over the site, partially filling in the first pond of the SF cell. Before the site could be repaired, another storm struck that caused significantly greater damage. The August 14 storm dropped 1.89 inches of rain at the gauge upstream of the site. The resulting flows deposited a large volume of sediment on the site, including several boulders more than a foot in diameter. The sediment ranged from 6 inches to nearly two feet deep, filling in the SF cell and the inflow and outflow channels and altering hydrology so that flows were diverted across the SSF cell and the SF cell was dry (Figure 2). A portion of the fence was gone, ripped out by the torrential flows.



Figure 2: Storm damage caused by the August 14, 2005, flood event. The image was taken from the same overlook as Figure 1. Sediment, storm debris and surface flows cover what should be the SSF cell in the foreground.

Following the August storm, the site required extensive maintenance. Our restoration contractor, Native Resources, began excavating the site in September. They had just finished clearing flood deposits and restoring wetland flows when another storm struck on October 18, 2005, that caused impacts similar to the August 14 event. Less than two days after the site's more than \$13,000 restoration was completed, the pilot project once again needed extensive work.

The series of storms from July through October highlighted the disadvantages of the site's location at the base of a slope in the center of a flood control channel. As nothing could be done to move the project, we examined the design to determine whether there was a way to modify the site to reduce flood damage. We determined that the height of the concrete walls bordering the site on the upstream (southwest) and dry weather channel (northwest) sides needed to be raised. The 2.5 and 1.25 foot walls, respectively, easily allowed storm flows to breach and scour over the site.

In March 2006, APC was hired to raise the height of these walls to four feet, in an effort to force storm flows to travel around (rather than over) the site. Once the concrete improvements were completed, Native Resources began clearing the October 2005 flood deposits. In June 2006, the

form of the site was fully restored and water from Pittman Wash was diverted through the reconstructed cells. Native Resources planted the cells with the alternating bands of bulrush on June 17, 2006, almost one year to the day after the initial planting effort.

The taller walls worked to divert flows from minor storms around the site. Larger storm flows were still able to breach the wall, but caused less damage. This was likely because more sediment was trapped behind the wall and thus less was free to be deposited onsite. The first real test came in October 2006, with a flood of similar magnitude to those which had previously caused so much damage. Impacts to the site were minor, including storm debris and slumping of the berms on the south corner and between the cells, and some sedimentation to the open water ponds in the SF cell. The slumping in the south corner and sedimentation occurred largely because storm flows were still able to cut around the concrete wall on the southeast border of the site, where the site is protected by a large earthen berm fortified by sandbags. Following the raising of the height of the concrete walls, storm maintenance costs declined to an average of approximately \$1,500 per storm event. The average prior to the fortifications exceeded \$13,000.

Once we were assured that the site was better protected against storms, we were able to concentrate on another challenge: saturation and standing water in the SSF cell (Figure 3).



Figure 3: October 12, 2006 site overview looking southeast with the SSF cell in the foreground. Note the standing water visible in the SSF cell.

Storm-deposited sediments had filled the interstices between the gravel and were preventing flows from moving through the cell. The bulrush was thriving in the cell as a result of the standing water and fine sediments, but the hydrology was not functioning as a SSF regime should. To address this challenge, in December 2006, Native Resources: removed the plants and

gravel from the cell; replaced the perforated pipe that carries water into and out of the cell; placed a layer of permeable cloth over the pipe to protect it from sedimentation; refilled the cell with clean gravel; and replanted the bulrush. In addition, blow out pipes were connected to the perforated pipes so that they could be easily cleared of sediments following storms events.

4.0 MONITORING

By February 2007, hydrology had been fully restored to each cell and the site had withstood storm flows, requiring only minor maintenance. Consequently, efforts shifted to monitoring. We created a monitoring plan for the project to ensure that monitoring would measure progress towards meeting the goals of the study. The following subsections highlight the monitoring conducted at the pilot project.

4.1 Site Inspections

Site inspections were used to ensure the successful establishment and proper function of the wetlands by identifying challenges quickly, thus allowing rapid action to be taken to correct them.

4.1.1 General

Wetland cells were visually inspected once per week, with observations recorded separately for each flow regime. The following data were recorded:

- General vegetation health (e.g., presence and number of dead plants, evidence of herbivory).
- Inflow and outflow function.
- Presence of weeds and other undesirable plant species (e.g., cattails).
- Wildlife observations (e.g., what species were using the wetlands, did they appear healthy).
- Presence of mosquitoes.
- Signs of vandalism and garbage.

Photo points of the site and of the individual cells were established, and photos were taken during each site inspection.

4.1.2 Storms

Site inspections were conducted within 2-3 days following a storm event to determine the extent of any damage. When safety permitted, staff visited the site during the storm to obtain photo documentation of the event from above the flood channel.

4.2 Water Quality

As a pilot project, the Pittman Wash wetlands were built to demonstrate whether constructed wetlands could improve the water quality of urban runoff. Thus, monitoring was conducted to assess the changes in water quality caused by the system. The Pittman Wash wetlands were sampled at three locations (Figure 4): the inlet, the surface flow outlet (surface outlet), and the outlet. Water samples were collected each month beginning in February 2007, and analyzed for nutrients, cations/anions, and metals. During each sampling event field parameters, including pH, dissolved oxygen, conductance, and temperature, were recorded using a Hydrolab multi-

probe water quality instrument. Hydrolab measurements were taken at the three water quality sampling locations and at four other sites within the wetlands, including three sites in the SSF cell and an additional site in the SF cell.

As one of the primary goals was to determine the impact of the pilot wetlands on normal (dry weather) urban runoff, sampling was not conducted for at least two days following storm events. Clark County Regional Flood Control District has several rain gauges in place along the Pittman Wash channel, including one less than 0.2 miles downstream of the pilot project site. These gauges allowed accurate estimates to be made regarding the timing and amount of rain impacting the site.

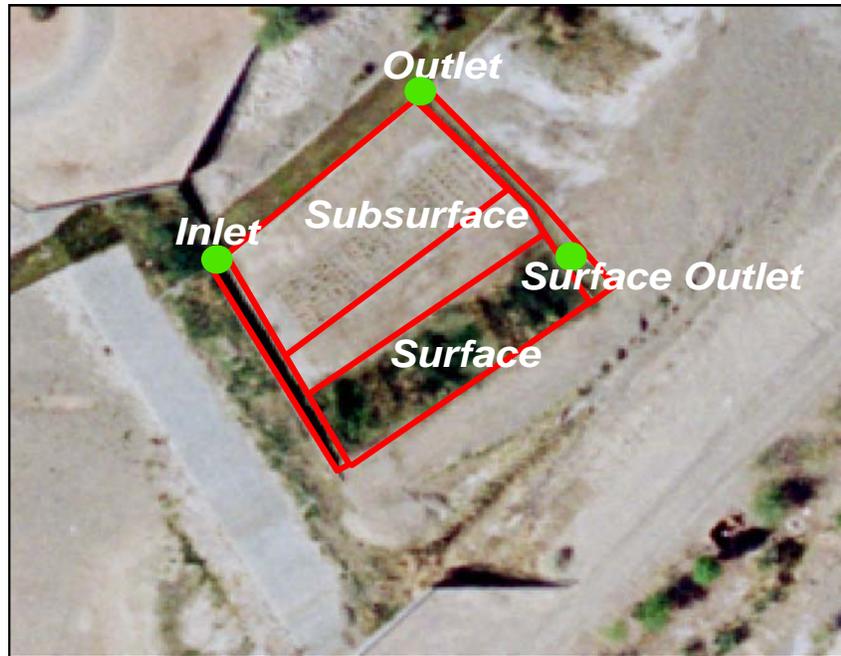


Figure 4: Water quality sampling locations.

4.3 Vegetation

Vegetation monitoring was conducted in May 2007. Total vegetation cover and cover per species were visually estimated for each cell. For the sub-surface cell, where the three species were present in distinctly separate bands, three samples of each of the three species of bulrush were randomly selected, yielding a total of nine samples. However, these bands were no longer present in the two planting beds within the surface cell. *S. americanus* had invaded the *S. acutus* and *S. californicus* zones, making distinction between the zones difficult. Therefore, two samples were randomly selected in each of the two planting beds, yielding a total of four samples.

Stem density for each species was obtained using 0.67 ft² quadrats. To determine stem density, all stems rooted in the quadrat were harvested and counted. Field staff noted whether each stem was live or dead to establish the average percentage of dead plant material per species. Ten live stems were randomly sub-sampled to determine average stem height and diameter. Stem length was measured from base to tip. Stem diameter was measured with a caliper at the thickest portion of the stem (near or at the base) and on the widest side and rounded to the nearest millimeter.

5.0 MONITORING RESULTS AND DISCUSSION

5.1 Water Quality

The Pittman Wash wetlands were sampled six times between the onset of monitoring in February and June 30, 2007 (Appendix B). The data revealed slight trends in water quality concentration changes between the inlet and the outlet. Mass removal data have yet to be analyzed. Similar changes were observed at the three locations for nutrients, anions, metals, and field parameters (Table 1). The most noticeable changes were seasonal variations due to increasing summer temperatures in the Valley and the effect of evaporation on water quality. Conductivity, major ions, and total dissolved solids (TDS) were generally higher in the hot summer months, which is expected due to the higher evaporation rate. Specific conductance increased at all three sample locations over the six months of sampling. Hydrolab data show that conductance and TDS in the SSF cell were much higher than in the SF cell. Additional contact with the substrate could be responsible for the increase, but further research is needed.

There was little variation in conductance between sample locations although the outlet has a higher six month average than the inlet and the surface outlet. The increase in conductance can be explained both by evapoconcentration and the contribution of the SSF cell flows to the outlet. All major anions showed slight increases in six month averages from the inlet to the outlet. TDS also showed a six month average increase from the inlet to the outlet as expected due to the effects of evapoconcentration and the increased TDS from the SSF cell. Table 1 summarizes the six month averages for major ions and field parameter from the Pittman Wash wetlands.

Parameter	Inlet	SF Outlet	Outlet
Temperature (°C)	20.87	18.71	19.06
pH units	7.91	7.81	7.78
Dissolved Oxygen (mg/L)	7.26	7.68	7.26
Specific Conductance (µS/cm)	3934.00	3954.67	3966.50
Ca (mg/L)	343	348	352
Na (mg/L)	318	320	322
K (mg/L)	25	25	25
SiO ₂ (mg/L)	34	35	34
Mg (mg/L)	168	172	175
HCO ₃ (mg/L)	183	180	187
CO ₃ (mg/L)	152	157	158
SO ₄ (mg/L)	1450	1483	1500
Br (mg/L)	990	1027	1008
Cl (mg/L)	532	538	548
F (mg/L)	0.6	0.6	0.7
ClO ₄ (µg/L)	28	28	26
Total Dissolved Solids (mg/L)	2983	3017	3033
Total Organic Carbon (mg/L)	1.09	1.02	1.04

Table 1: Average concentration data for major ions, perchlorate, total organic carbon and field parameters.

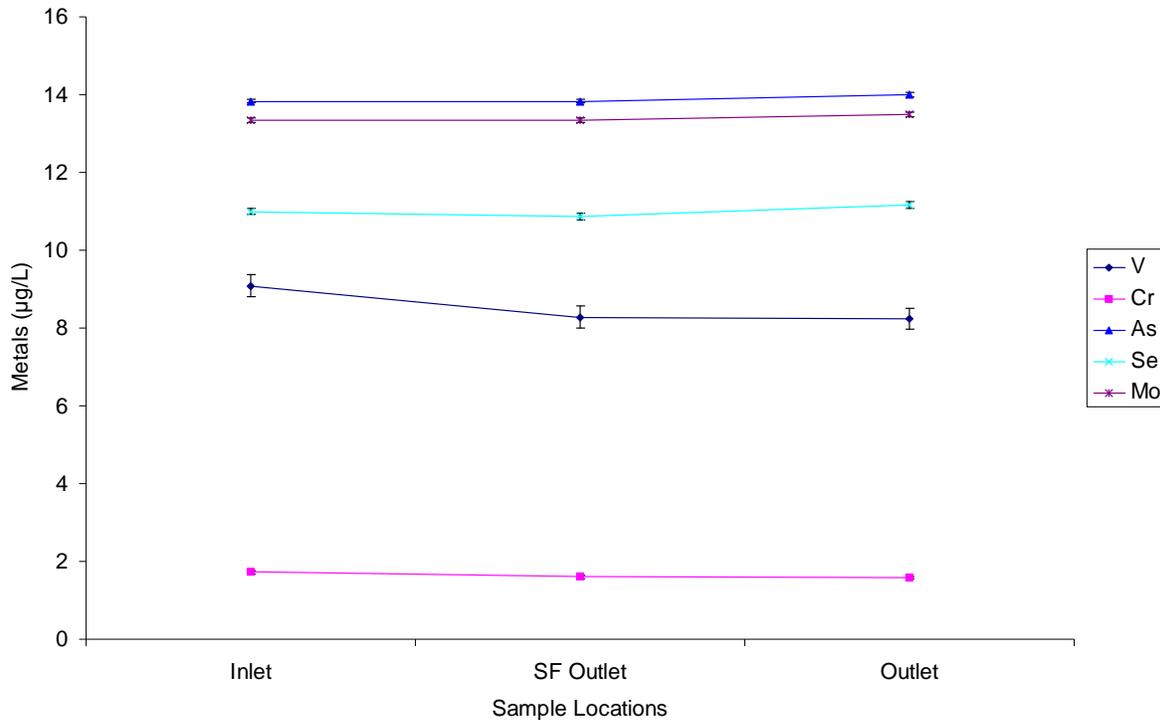


Figure 5: Average metal concentrations at the three sample locations of the Pittman Wash wetlands.

Nitrate was the only nutrient detected consistently in the Pittman Wash wetlands with ranges from eight to ten mg/L from all three locations over six months. Nitrate values remained consistent through the six months of sampling with very little variation between sites or sampling events. V, Cr, As, Se, and Mo were the only metals regularly detected. Sources of these metals are commonly from geologic units (rocks and minerals) and the combustion of fossil fuels. Concentrations remained similar between the inlet and the outlet over the six months of sampling, indicating a consistent flow of these metals through the system. Figure 5 shows the six month averages for all consistently detected metals for the inlet, surface outlet, and outlet. The figure reinforces the similarities in metal concentrations at each sample location and the similarities over the sampling period. These data indicate that the Pittman Wash wetlands currently play a limited role in reducing the metals or nitrate in the system. The continued establishment and maturation of emergent vegetation within the site may help increase the removal efficiency of metals and nutrients.

5.2 Vegetation

Average stem density, height, diameter and percentage of dead stems for the SSF cell are presented in Table 2. *S. americanus* displayed the greatest average stem density, the smallest stem diameter, and smallest height. The amount of dead material was high, more than 40 percent. This was likely overestimated as each piece of dead plant was counted as a stem.

Species	Avg. Stem Density (#/0.0625 m ²)	Avg. Stem Height (m)	Avg. Stem Diameter (mm)	Avg. % Dead Stems
<i>S. californicus</i>	42.7	0.85	8	48.2
<i>S. acutus</i>	49.7	0.89	8	19.4
<i>S. americanus</i>	266.3	0.65	4	40.7

Table 2: Average stem density, height, diameter, and percentage of dead stems for the three species of bulrush occurring in the SSF cell.

As dead stems are fragile and break easily, this likely resulted in several pieces from a single stem being counted as separate dead stems. *S. californicus* and *S. acutus* exhibited significantly lower average density than *S. americanus*, and larger average height and diameter; however, while *S. acutus* had a relatively low percentage of dead stems, *S. californicus*' percentage of dead stems was the highest of the three species. Although likely overestimated as well, the amount of dead *S. californicus* also reveals what was observed during weekly site inspections following the reconstruction of the SSF cell in the winter of 2007. Once standing water was cleared from the cell and the subsurface flows were restored, *S. californicus* struggled to reestablish, with live material accounting for less than 5% of the cover in the cell. Conversely, while *S. acutus* and *S. americanus* had not returned to cover levels observed when standing water was present, each accounted for 5-25% of the cover in the cell. Total vegetative cover in the cell was 25-50%. Visual observations showed that even with the large percentage of dead material, *S. americanus* is expanding more rapidly than the other species within the SSF cell, with numerous new shoots appearing through the gravel.

In the SF cell, *S. americanus* had expanded into the bands of *S. acutus* and *S. californicus*, becoming the dominant species in the cell. At the time monitoring was conducted, *S. americanus* was also filling in the center pond. The species accounted for 88% of the stems collected over the four random samples, and in two of the samples it was the only species present. *S. acutus* and *S. californicus* accounted for 8 and 4% of the stems, respectively. These values are indicative of the relative cover of each species in the planted areas within the cell. Total vegetative cover in the cell was 75-100% exclusive of open water areas, and 50-75%, when including open water. *S. americanus* was more robust in the SF cell than in the SSF cell, nearly doubling in average diameter and more than doubling in average height (Table 3). Average height for *S. acutus* and average height and diameter for *S. californicus* also increased over that observed in the SSF cell (Table 3). It should be noted here that given the reduced number of stems present for the latter species, averages were taken over a smaller sample size than in the SSF cell. Over the four samples, average stem density was 85.3 stems and percentage of dead stems was 16.0. By species, *S. americanus* had 8.8% dead material (n=262), *S. acutus* 52.2% (n=23) and *S. californicus* 25.0% (n=12).

Species	Avg. Stem Height (m)	Avg. Stem Diameter (mm)
<i>S. californicus</i>	1.27	10
<i>S. acutus</i>	1.48	8
<i>S. americanus</i>	1.48	7

Table 3: Average stem height and diameter for the three species of bulrush in the SF cell.

The wetlands location within an urban flood control channel made it particularly susceptible to invasion by weeds and escaped ornamentals. These species were observed during the weekly site inspections and inventoried during the vegetation monitoring effort. Species included *Bassia hyssopifolia*, *Aster subulatus*, *Conyza coulteri*, *Cynodon dactylon*, *Prosopis sp.*, *Tamarix ramosissima*, *Polypogon monspeliensis* and *Washingtonia robusta*. *Typha domingensis* had invaded the center pond in the SF cell and with the expanding *S. americanus*, was rapidly filling in even the deepest part of the pond. Many of these species were restricted to the berms separating and bordering the cells. However, some like *P. monspeliensis* and *T. ramosissima* were expanded into the SSF cell. *P. monspeliensis* in the SF and SSF cell and *A. subulatus* and *T. domingensis* in the SF cell were the only species besides the bulrush to exceed 1% cover values for the cells, falling within the 1-5% cover class.

Based on the monitoring data and qualitative observations made at the site, *S. americanus* outperformed *S. acutus* and *S. californicus* in both cells. One possible reason is the higher salinity tolerance of *S. americanus*. Water quality monitoring shows six month average conductance values near 4,000 $\mu\text{S}/\text{cm}$. Another possible explanation is that *S. americanus* prefers lower water depths than both *S. acutus* and *S. californicus*. The water level in the planting beds in the SF cell is 0-4 inches, and in the SSF cell the water is 2-4 inches below the surface of the gravel.

5.3 Wildlife Observations

Several bird species were observed using the wetlands during weekly site inspections and other monitoring efforts. Examples of species detected in the site include: mallard, ruddy duck, white-faced ibis, black-crowned night-heron, black-necked stilt, willet, Wilson's snipe, song sparrow, and yellow-headed blackbird. In the spring of 2006, killdeer nested and raised a brood of four chicks within the site.

6.0 RECOMMENDATIONS

Storm damage was an important part of testing the feasibility of this pilot project. The goals of the project include not only demonstrating whether constructed wetlands can be used to improve water quality in an urban flood control channel, but also identifying the challenges involved in working in such an environment. Flood maintenance has certainly been a challenge. Although average maintenance costs following storms were reduced by more than \$10,000 following the concrete wall fortification, the current cost of approximately \$1,500 shows that maintenance will likely need to occur periodically - given the number of storm events that can occur during the monsoon season. As a result, we recommend considering off-channel locations for future tributary projects.

The first six months of water quality monitoring showed little change between the water chemistry of the inlet and the outlet. In fact, certain parameters such as specific conductance and TDS increased. This appears to be at least partially due to input from the SSF cell. To further determine how the SSF cell is impacting water quality, we recommend that a sample location be added at the SSF outlet. We also recommend that future monitoring include measuring flows to determine mass loading. In addition, the challenges associated with the SSF cell (sedimentation, reduced vegetative growth, and increases in conductance and TDS) indicate that future tributary

treatment wetlands should focus on SF regimes. Also, it is possible that the small size (0.06 acres each) of the wetland cells does not provide adequate retention and thus contact time to improve water quality, but further research is needed.

In regards to vegetation, *S. americanus* thrived in both flow regimes, but especially in the SF, taking over open water areas including those deeper than the authors have observed *S. americanus* using in the past. Also, *T. domingensis* invaded the deeper open water areas, entering the project from an upstream source. If future pilot projects want to maintain open water ponds, we recommend deepening the ponds to at least six feet to prevent such invasions from occurring. Also, given the growth at this project, future efforts may want to concentrate specifically on *S. americanus*, but further research is needed to determine what role, if any, the species plays in improving water quality.