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INTRODUCTION

Wetlands and riparian areas provide important functions in the landscape. These functions include floodwater storage, fish and wildlife habitat, water quality polishing, and sediment retention. Relative to surrounding non-wetland areas, these ecosystems are rare in the Mojave Desert. Moreover, the presence of permanent water attracts a diverse biotic community that would not otherwise be found in the desert. In Southern Nevada, there are only a few areas that support extensive wetland and riparian conditions. These areas include the Colorado River, Virgin River, Muddy River, Meadow Valley Wash, and Las Vegas Wash (Wash). The Wash is the most substantial riparian area in the Las Vegas Valley and it is the primary drainage channel for the 1,600 square-mile watershed. During the last few hundred years, the most significant flows in the Wash came from periodic stormwater runoff from the valley. Currently, however, the Wash has a consistent base flow of more than 150 million gallons per day which comes from a combination of highly treated wastewater discharge, urban runoff, and groundwater seepage.

As the state of the Wash transitioned toward a riverine system, a variety of consequences resulted. For example, when base flow discharge was small, the Wash supported around 2,000 acres of wetlands. These wetlands were highly valued for their ability to remove unwanted nutrients from water as well as for providing habitat for endangered marsh birds (Alcorn 1988). Since this period of extensive wetland establishment, stormwater erosion has incised the stream channel and scoured much of the floodplain. Consequently, lateral saturation had been reduced thereby resulting in wetland losses, habitat degradation, and diminished ecological functioning.

The Southern Nevada Water Authority (SNWA) assembled a citizen advisory committee to evaluate water quality issues in the Wash, Las Vegas Bay, and Lake Mead in 1997. These efforts resulted in the establishment of the Las Vegas Wash Coordination Committee (LVWCC), a 30-member multi-stakeholder group consisting of federal, state, and local agencies, the university, private businesses, environmental groups, and citizens. In 2000, the LVWCC drafted a long-term management plan, the Las Vegas Wash Comprehensive Adaptive Management Plan (CAMP), to facilitate stabilization and enhancement activities along the Wash. On the ground activities have been implemented over the past several years to effectuate the goals of the CAMP. These activities include constructing low head dams (weirs) in the stream channel and armoring the banks of the stream with rock. After erosion control facilities are built, wetland, riparian, and upland plants are used to help protect the Wash from erosion as well as to improve the functional attributes of the ecosystem.

Revegetation is a critical component of the overall plan to protect and enhance the Wash. Plants help prevent erosion because their roots bind loose soil particles on the surface and in deep subsurface horizons. Root systems thereby act as soil anchors during scouring events (i.e., floods). Besides being beneficial for erosion control, revegetation benefits a variety of wildlife species that occur along the Wash and it increases aesthetic values. Diverse physiognomic and floristic characteristics provide a wide range of suitable habitat conditions for wildlife. Because the Wash was not historically a riverine system, it does not have an abundance of source plants that are native to these conditions. Moreover, during its transitional period, exotic species such as salt cedar (Tamarix ramosissima) invaded the area and became the dominant species.
Consequently, a variety of native plants are used in revegetation projects to restore the Wash to a natural-type condition.

1.1 Purpose and Scope
The primary purpose of this report is to document the status of SNWA’s revegetation efforts along the Wash by reporting data collected by SNWA between 2003 and 2007 as part of a comprehensive vegetation monitoring program. Vegetation monitoring results in 2002 and 2003 that were derived from methods other than that described in this report were previously documented by SNWA (2005) and are therefore not included in this report. A variety of other monitoring programs have been conducted to help elucidate the importance that revegetation projects provide to wildlife (Rice 2007, O’Farrell and Shanahan 2006, Shanahan 2005, Shanahan 2005a, Van Dooremolen 2005), however, these data are also not included in this report. Since 2003, monitoring activities have been conducted on progressively larger land areas; more than 38 acres were monitored in 2003 and more than 165 acres were monitored in 2007. These activities have been conducted on revegetation project sites located within the boundaries of the Clark County Wetlands Park (Wetlands Park; Map 1).

1.2 Need for Revegetation and Vegetation Monitoring
Revegetation projects along the Wash are conducted for a few important reasons. Revegetation is a compensatory mitigation requirement for Clean Water Act (CWA) Section 404 permits issued by the U.S. Army Corps of Engineers (Corps) to SNWA for erosion control projects occurring in jurisdictional waters of the U.S. Section 404 of the CWA established a program to regulate the discharge of dredged or fill material into waters of the U.S., including wetlands and for Wash erosion control projects. Fill material is often in the form of rock or concrete material that is used while constructing grade control or bank stabilization facilities. Section 404 permits also require that revegetation projects are monitored for success. Consequently, several performance indicators must be monitored so that performance criteria have been achieved. Performance criteria should include, obtaining 80% plant survival and a maximum invasive species cover value of 20%. Species composition must also be evaluated.

The Nevada Division of Environmental Protection (NDEP) which derives duties through state and federal implementing regulations (i.e., Chapter 445A of the Nevada Revised Statutes and Section 402 of the CWA) also requires revegetation to occur for Wash projects. NDEP issues stormwater general permits for construction activities such as building erosion control facilities and permits require that final site stabilization is achieved. Vegetation cover serves as a form of final stabilization and NDEP defines this form of final stabilization as “….perennial vegetative cover with a density of 70% of the native background vegetative cover….establishing at least 70% of the natural cover of the native vegetation….. (e.g., if the native vegetation covers 50% of the ground, 70% of 50% would require 35% total cover)….” Vegetation monitoring is an important tool to document vegetation cover and that permit conditions are achieved.

Besides permit required revegetation, revegetation projects are also required because of federal and state grants that are received by SNWA to help fund the erosion control program. Granting agencies or institutions require that revegetation projects are successful and therefore specific criteria are measured during monitoring to ensure compliance with these requirements. Success is documented through vegetation monitoring and these data are provided to grantors through reporting mechanisms. For program consistency, all revegetation sites are monitored annually.
Map 1: Location of Las Vegas Wash revegetation sites within the Clark County Wetlands Park.
and with the same methods. Consequently, monitoring results in this report are summarized cumulatively.

1.3 Program Funding
There are two major sources of funding for revegetation projects along the Wash; they include funding derived from grants and the Wash Capital Improvement Plan (Wash CIP). The Wash CIP exclusively funds revegetation activities that are stipulated in federal or state permits (e.g., wetland permits) that are obtained by SNWA as part of weir construction. In contrast, grant funds are used to revegetate non-weir areas. Most of the revegetation projects that have been implemented along the Wash have been funded through various grants (Table 1).

<table>
<thead>
<tr>
<th>Funding Source</th>
<th>Year Planted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2000 to 2002</td>
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<td>Southern Nevada Public Lands Management Act V</td>
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</tr>
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</table>

Table 1: Acres of revegetation planted from 2000 to 2007.

2.0 MATERIALS AND METHODS

2.1 Monitoring Period and Naming Convention
Monitoring was conducted between August and October in 2003 through 2007, as appropriate. Because most revegetation activities take place in the spring and fall, the first monitoring period is either six months after or nearly a year from the original planting event. In either case, at least one growing season passes before monitoring occurs. Monitoring results are reported in terms of growing seasons since planting. For example, if a site was planted in spring of 2003, it would be monitored in the summer/fall of 2003 and this date would be reported as the first growing season. If a site was planted in the fall of 2003, it would likely not be monitored that fall; its first monitoring would be the summer/fall of 2004, which would also be reported as first growing season data. Data are reported by growing season so that trends among sites of the same age are more easily evaluated.

With nearly 170 acres of actively monitored revegetation sites scattered across an approximately six-mile reach of the Wash, the need for a simple yet easily understandable site naming convention to accurately distinguish one site from another is essential. Site names are the basic currency for which monitoring information is communicated and they are used extensively in this report. The term “revegetation site” is used commonly in this report and it is defined here as
a contiguous planning area where revegetation has occurred. Revegetation sites are given unique colloquial names by first identifying the weir structure that is generally closest to the site. If the site is not near a weir or it was planned separately from a weir construction project, then sites are simply given an alphanumerical designation (e.g., S108, shorthand for Site 108). Four primary descriptors are used to construct revegetation site names when they are in association with a weir. First, the name of the weir that is closest to the site is listed, but without the term “weir” added to the name (e.g., Bostick Weir becomes Bostick). Second, the site is described as being upstream or downstream of the weir (e.g., Upstream Bostick or Downstream Bostick). Third, the site is described as being generally to the north or south side of the weir (e.g., Upstream Bostick North, Upstream Bostick South, etc.). Fourth, additional descriptors such as the terms “bank,” “emergent,” “upper plateau,” “lower plateau,” etc., are included as suffixes to further describe the sites location (e.g., Upstream Bostick South Bank, Downstream Bostick South Emergent, etc.). Once revegetation site names are prepared, an acronym is constructed and it serves as the “site code” (e.g., Upstream Bostick South Bank becomes UBSB). A list of all revegetation sites and site codes used in this report is found in the table of contents.

Revegetation sites are often large and unusually configured and because of these factors, site monitoring is often conducted on subdivided areas of a revegetation site. For example, the Upstream Powerline South Plateau site was divided into four smaller areas to aid in monitoring. For this report these divided areas are referred to as “monitoring areas” or “monitored areas.” Monitoring areas are defined as discrete areas of limited size where monitoring feasibly occurs. Besides subdividing revegetation sites because they are large or unusually configured, revegetation sites are also subdivided if they contain wetland and non-wetlands components (see Map 2 for a graphical representation of the site naming convention).

2.2 Wetland and Non-Wetland Areas
Each acre of revegetation that is used as compensatory mitigation for a section 404 permit must typically meet the Corps definition of a wetland. Consequently, jurisdictional determinations (JDs) were made for all monitored areas in 2006 and 2007 according to the Corps’ 1987 Wetland Delineation Manual. Once determinations were made, sites were delineated by using geographic information system software and ortho-referenced aerial imagery. Wetland sites are typically found along the banks of the Wash and within the Wash channel itself and both actively planted and passively created wetlands can be used by SNWA to meet mitigation requirements. Prior to 2006, revegetation sites were not deliberately monitored as separate wetland and non-wetland components unless the entire revegetation site was of one type. As of 2007, there were a total of 31 wetland areas being monitored. Revegetation sites or monitoring areas that were not determined to be wetlands according to the Corps’ 1987 Wetland Delineation Manual are considered non-wetlands. In limited circumstances, non-wetland areas may be used to meet the Corps mitigation requirements if the areas are contributing to the function of the nearby wetlands. As of 2007, there were a total of 139 non-wetland monitoring areas totaling 133.2 acres.

2.3 Major Sites
Revegetation sites have been grouped into broad categories known as “major sites” (Map 2). These sites are generally associated with weirs, however, there are some sites not associated with weirs. The latter sites are typically large or of unique purpose. Major sites contain one or more
Map 2: Illustrated depiction of Las Vegas Wash revegetation site naming convention.
revegetation sites and they are grouped together to facilitate data analyses. For major sites that contain more than one revegetation site or monitoring area, data are averaged. Brief descriptions of the major sites are provided below.

2.3.1 Weir Sites

2.3.1.1 Bostick Weir
The Bostick Weir, completed in 2003, is currently the largest weir along the Wash with a permanent footprint of approximately 7.8 acres. Bostick Weir is a confined rock rip-rap structure that was first planted with vegetation in 2003. There are 11 revegetation sites monitored at the Bostick Weir; 4 wetland sites, 6 non-wetland sites, and 1 site that includes both non-wetland and wetland monitoring areas.

2.3.1.2 Calico Ridge Weir
The Calico Ridge Weir was completed in early 2005. The structure is designed as a two-stage weir, using a confined rock riprap type, modified chevron weir configuration. It is approximately 400 feet long and has a low flow elevation of 1,491 feet above mean sea level. The structure has a permanent footprint of 3.8 acres and it has created substantial acreage in the impoundment for wetland plants to establish. There are 6 revegetation sites associated with the Calico Ridge Weir; 2 wetland sites, 1 non-wetland site, and 3 sites that include both wetland and non-wetland monitoring areas.

2.3.1.3 Demonstration Weir
The Demonstration Weir, completed in 1999, is a rock riprap structure. Large areas in the channel were planted with emergents soon after construction. The south bank was graded to a 3:1 slope and was planted in the spring of 2003. There is one revegetation site associated with this weir and it has both wetland and non-wetland components.

2.3.1.4 Historic Lateral Weir
The Historic Lateral Weir is located just upstream of the Bostick Weir. The weir was designed as a three stage, dumped rock riprap chute spillway, and was constructed in 2000. Revegetation activities occurred in the spring and fall of 2001. Revegetation sites associated with the structure are located upstream of the weir. There are three revegetation sites at this weir; one is a wetland type, and two have both wetland and non-wetland monitoring areas associated with them.

2.3.1.5 Monson and Visitor Center Weirs
The Monson and Visitor Center Weirs are confined rock riprap weirs that were constructed in the spring of 2002 with revegetation activities occurring the following fall. The Monson Weir is approximately 800 feet upstream of the Visitor Center Weir. The Monson Weir has a permanent footprint of 1.87 acres and the Visitor Center Weir has a permanent footprint of 2.94 acres for a combined footprint of 4.81 acres. Because of their proximity, revegetation sites were planned and implemented together to serve as mitigation for both structures. There are two revegetation sites associated with the Monson and Visitor Center Weirs. Both are a combination of non-wetland and wetland monitoring areas.
2.3.1.6 Pabco Road Weir
The Pabco Road Weir is a rock gabion structure with a concrete cap and it is located near the center of the Wetlands Park. The weir was completed in 2000 and revegetation activities were conducted at sites spread along the north and south banks of the Wash from spring of 2001 through spring of 2002. There are a total of 6 revegetation sites along Pabco Road Weir; 3 wetland sites, 1 non-wetland site, and 2 sites that consist of both wetland and non-wetland areas.

2.3.1.7 Powerline Crossing Weir
The Powerline Crossing Weir is located along the lower Wash, approximately 0.5 miles upstream of the channel intake structure for the Lake Las Vegas Resort development. This weir was completed in 2006 and measures 8-feet high by 320-feet wide and also includes a pedestrian bridge which provides the first point where the public can cross over the Wash within the Wetlands Park. The structure has a permanent footprint of 4.87 acres. There are 7 revegetation sites associated with the Powerline Crossing Weir; 5 wetland sites and 2 non-wetland sites.

2.3.1.8 Rainbow Gardens Weir
The Rainbow Gardens Weir is located along the lower Wash, upstream of the Powerline Crossing Weir. The weir was completed in June 2004, and it is a roller compacted concrete structure founded on drilled concrete piles. The structure has a permanent footprint of 1.00 acres. In comparison to other weirs, the Rainbow Gardens Weir has a small footprint but the impoundment is large. Four revegetation sites are located adjacent to the Rainbow Gardens Weir; 2 wetland sites and 2 non-wetland sites.

2.3.2 Non-Weir Sites

2.3.2.1 Cottonwood Cells
The Cottonwood Cells site was first planted in 2002 as a nursery for future salvaging of cottonwood poles for revegetation efforts, however, poles have yet to be collected from the Cottonwood Cells sites. Indicative of the name, the dominant species planted at the site was cottonwood (Populus fremontii). There are two revegetation sites within the Cottonwood Cells site and both are considered wetland revegetation sites.

2.3.2.2 Site 108
Site 108, nearly 60 acres, is located on the southern edge of the Wetlands Park. This site is the largest contiguous revegetation site that has been planted along the Wash. Located less than one mile west of the Pabco Road Weir, Site 108 is unique not only for its size but also because it is not associated with a weir. It is one of only three non-weir major sites and although it is designated here as a major site, it is also considered a revegetation site as well. Site 108 is relatively distant from the Wash; however, it has excellent depth to groundwater because it is above a shallow groundwater seepage zone just north of the City of Henderson Water Reclamation Facility. The elevated groundwater in this area is capable of supporting a wide variety of species; however, the groundwater salinity is high. Data was collected from 66 monitoring areas, each about an acre in size.
2.3.2.3 Site 111
Site 111 was planted in 2007 and it is the second largest contiguous revegetation site, measuring slightly more than 15 acres. Although the site is not considered a wetland, the eastern portion of the site, located immediately west of the Cottonwood Cells site, has a high groundwater table. Site 111 was divided into 27 areas, each about an acre, for monitoring purposes.

2.4 Monitoring Techniques
Various monitoring techniques have been and are currently being used to monitor revegetation efforts at the Wash. Multiple techniques are used because several attributes of the revegetated areas must be measured. Moreover, adaptive management approaches determine which techniques work best at the time and as sites age, techniques often change. Ending in 2003, site performance was evaluated by monitoring every plant on a site. This method proved to be inefficient as the number of monitoring sites and plants along the Wash increased (e.g., Site 108 alone contains more than 18,000 plants). Consequently, more efficient methods were developed in 2003 to measure vegetation cover and species richness across revegetation sites (SNWA 2005; see sections below). Species codes have been used on figures to evaluate individual species performance and Appendix A lists the scientific and common names of plants and the associated codes that are used in this report.

2.4.1 Vegetation Cover
Vegetation cover is an attribute collected on all sites to determine the percentage of the site that is covered by a particular species and by all species combined. This is perhaps the most important site attribute measured because these data are used for mitigation reporting to the Corps because it is a reflection of site performance. Moreover, cover data are used to measure the success of planting methods and species specific success, thereby informing future revegetation planning efforts. For this report, success is defined as a site that contain less than 20% noxious weed cover and a temporal trend of increasing native vegetation cover. In lieu of increasing cover values, sites with greater than 80% native cover were also considered a success. Noxious weeds are those species listed by the State of Nevada on the Noxious Weed List (NDOA 2008).

Two methods have been used to determine vegetation cover, the line-intercept method (Barbour et al. 1999) and the cover class method (Braun-Blanquet 1932 in Mueller-Dumbois and Ellenberg 1974). Vegetation cover data collected from 2003-2005 were derived from the line-intercept method while cover data from 2006-2007 were from the cover class method. For the line-intercept method, three to five random transects were laid out across each site parallel to the dominant hydrology gradient and then the portion of the line that overlapped the canopy of a plant was measured for distance. This value was then divided by the total length of the transect and multiplied by 100 to make a percentage.

The cover class sampling method involves visually estimating the percentage each species covers a site. It was used on 30-foot diameter relevé plots at the center of each monitoring area within Site 108 and Site 111 but was used on a whole site basis for all other monitoring areas. Using the cover class method, each species, and the site as a whole, is given a rank which corresponds to a range of cover values (Table 2). In order to analyze the data and compare the results with data derived from the line-intercept method, the mid-point of the range of cover values in the...
cover class method was used. This results in the maximum value being 87.5%, even if a site has 100% cover.

Cover data are evaluated for individual revegetation sites and for major site groupings. Major site data are presented as averages of all the revegetation sites or monitored areas that make up the major site. If the major site is made up of two or more revegetation sites or monitoring areas then a weighted cover average has been calculated. Weighted averages are calculated by using the acreage of each monitoring area as the weight. This was done because site size often changes from year to year. For example, flood events deposit sediments that may increase the size of a site, erosion usually decreases the size of a site, and delineator bias may either increase or decrease the site’s size. For these reasons, acreage-weighted averages are much more helpful in comparing data over time. Total vegetation cover and total species cover has been reported for each site. Standard error values (i.e., standard error of the mean) have been calculated for line-intercept data and are graphically represented as error bars on figures. Error bars were also constructed for data derived from the cover class method, however, these estimates of variability are represented as cover rank ranges (e.g., error bars for Cover Rank 4 would be represented on the low level as 50% and on the high level as 75%).

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<tbody>
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<td>0.1%</td>
</tr>
<tr>
<td>t</td>
<td>&lt;1%</td>
<td>0.5%</td>
</tr>
<tr>
<td>1</td>
<td>1%-5%</td>
<td>2.5%</td>
</tr>
<tr>
<td>2</td>
<td>5%-25%</td>
<td>15%</td>
</tr>
<tr>
<td>3</td>
<td>25%-50%</td>
<td>37.5%</td>
</tr>
<tr>
<td>4</td>
<td>50%-75%</td>
<td>62.5%</td>
</tr>
<tr>
<td>5</td>
<td>75%-100%</td>
<td>87.5%</td>
</tr>
</tbody>
</table>

Table 2: Cover class ranks and corresponding cover ranges and midpoints.

Relative cover values have been calculated from line-intercept and cover class methods for revegetation sites and cumulatively for major sites. Growth forms (e.g., tree, shrub, graminoid, etc.) are first attributed to the species data by using the U.S. Department of Agriculture’s PLANTS Database (USDA, NRCS 2008). Relative cover is then calculated by summing cover for all species within a particular growth form and dividing this sum by the total sum of cover for all species on a site. For example, if there are three growth forms on a monitoring area and each has a summed cover of 25%, they would each be described as having 33% relative cover for that site. The relative cover value is a measurement of how the physiognomy (i.e., structure) of a site changes over time and space.

2.4.2 Species Richness
Species richness data were collected on all revegetation sites and monitoring areas. Species richness is simply the number of species that are found on a site and success was defined as any site that had increasing richness or richness greater than a pre-revegetation condition. Extensive random pedestrian transects were traversed on each site so that species occurrence was thoroughly documented. Scientific and common names generally follow Baldwin et al. (2002) and the PLANTS Database (USDA, NRCS 2008; Appendix B).

2.4.3 Survivorship
Sites were monitored for shrub and tree plant survival (i.e., survivorship) over the first few years to document the proportion of live intentionally planted plants on a site. Survival data were not
collected for graminoid or forb/herb species because sampling methods were not appropriate for monitoring these growth form types. Sites with greater than 80% survival values were considered a success. Survivorship data were collected using belt transect (Barbour et al. 1999) and relevé methods (Mueller-Dumbois and Ellenberg 1974). For monitoring areas within Site 108 and Site 111, 30-foot diameter relevé plots were established and all plants rooted within the plot were documented as live or dead. For all other sites, belt transects were used. The line-intercept transect served as the centerline of the belt transect and live and dead plants that were rooted within three feet of either side of the centerline were recorded.

These techniques were used generally for the first two to three growing seasons to determine survivorship. After the second or third growing season, observer bias increases to a critical point so that it becomes increasingly difficult to determine which plants have been planted and which ones have self-propagated. Therefore, survivorship information is not collected on mature sites (greater than three years old).

2.4.4 Diversity
The Shannon Index (H or simply “diversity”; Shannon 1948 in Spellerberg and Fedor 2002) was used to determine species diversity on revegetation sites or other monitored areas. This diversity index considers both species richness found on a monitoring area as well as their relative abundances. This index, therefore, evens out rare species data. For this report, H was calculated by using percent cover data rather than frequency of occurrence data. High H values indicate that a site is more diverse than a site with low H values.

2.4.5 Wetland Prevalence Index
Wetland Prevalence Index (WPI) values were calculated according to Wentworth and Johnson (1986) using 2006 and 2007 cover data for each revegetation site. This index is a useful tool to help evaluate the likelihood that a site is a wetland. Tiner (1999) refers to this as the “wetlandness” of a site with the likelihood that a site is a wetland decreasing as the WPI increases. WPI values are first calculated by attributing wetland indicator status (Reed 1988) values for each species on a site. The following indicator values were used for calculating site WPI: obligate wetland (OBL) = 1.0, facultative wetland (FACW) = 2.0, facultative (FAC) = 3.0, facultative upland (FACU) = 4.0, and upland (UPL) = 5.0. Species without an indicator (No Indicators) were not used in calculating WPI values. Sites were considered wetlands if WPI ≤ 2.0 and sites were likely wetlands if 2.0 < WPI < 2.5 but additional data would be needed to confirm this designation (Tiner 1999). If sites had 2.5 ≤ WPI < 3.5 they may or may not be wetlands and if sites had 3.5 ≤ WPI < 4.0 then they were not likely a wetland. Upland sites had WPI ≥ 4.0 (Tiner 1999). To be conservative, sites were considered to be a non-wetland if WPI > 2.0. WPI values were only calculated for the 2006 and 2007 data since jurisdictional determinations/delineations were performed on sites in these years. Therefore, WPI is a useful tool to validate the accuracy of a jurisdictional determination/delineation.

2.4.6 Repeat Photography
Photographs of sites were taken in all years. These photos serve as useful tools to visually represent temporal site changes. Photos document several important site characteristics that may or may not be acquired by using the methods described previously. For example, photos can be used to document changes in hydrology, human/animal usage, land use changes, etc. Moreover,
subtle changes in vegetation cover, species diversity, and plant structure can often be determined with repeat photography.

### 3.0 RESULTS AND DISCUSSION

The following few sections describe vegetation monitoring results (i.e., cover, survival, richness, and diversity) for each revegetation site and for groupings of revegetation sites called major sites. WPI values have also been reported on a major site basis to evaluate trends in site “wetlandness” and to document the usefulness of this tool for mitigation reporting. From 2003 to 2007, the number of areas monitored and the acreage of monitoring areas increased eight fold and four fold, respectively (Table 3). The total area monitored in 2007 was nearly 170 acres and

<table>
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<th>Major Site</th>
<th>Acreage 2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
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<td>27</td>
<td>34</td>
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<td>182</td>
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</table>

Table 3: Cumulative acreage monitored and number of monitoring areas by year and major site.

the average size of a monitoring area was slightly greater than an acre. By 2007, vegetation monitoring was conducted at 11 major sites, 8 of which were associated with weirs and 3 were not. Although there were 182 monitoring areas in 2007, there were only 45 named revegetation sites. This accounting discrepancy is because Site 108 and Site 111 are considered revegetation sites as well as major sites and combined, these two sites had 110 monitoring areas. The remaining 27 monitoring areas are subdivisions of revegetation sites.
Average cover from 2003 to 2007 across all monitoring areas increased from the first growing season through all subsequent growing seasons (Figure 1). Both wetland and non-wetland site cover increased as well (Figure 2 and Figure 3). Non-wetland sites increased in cover much more slowly than wetland sites with data from the seventh growing season showing that non-wetland site cover was less than wetland site cover from the first growing season. Like cover, survivorship increased with site age (Figure 4). Because there were only two sites represented in survivorship data for the fourth and fifth growing seasons, these data are not necessarily indicative of program performance. Likewise, survival data from the first growing season was substantially affected by poor site survival at the Powerline Crossing Weir which had a combined survival rate of less than 50%.

Invasive species cover across all sites monitored was low with all sites well below the 20% performance criteria (Figure 5). The highest percentage of invasive species cover, mostly from salt cedar, was documented in the sixth growing season. These data are representative of three revegetation sites with most of the cover attributed from one of the Cottonwood Cell revegetation sites. Species richness data were not similar to cover or survival data because no trends were documented for richness data (Figure 6). Species richness, however, does appear to be a positive indicator of performance on sites because new and different native species are found during most monitoring events (J. Eckberg, pers. obs.). These data also point to the fact that mortality must be occurring, otherwise richness trends would be generally increasing. Further analysis should be conducted to determine if mortality is specific to individual species, specific areas or another reason. Understanding the underlying causes of richness declines will potentially save money and labor on future plantings.

3.1 Bostick Weir
There are 11 revegetation sites adjacent to the Bostick Weir with monitoring activities beginning on all sites in 2004 or 2005 (Map 3; Table 4). By 2007, many of these sites were in their fourth growing season and therefore these sites are relatively old compared to other revegetation sites. Many of the revegetation sites were rather small (<1 acre); however, one site was large (>5 acres). Although site area has been reported according to the number of growing seasons that a site has been planted (Table 4), more than 18 acres of revegetation sites were monitored in 2007.

Only one site (i.e., Upstream Bostick South [UBS]) had to be divided for monitoring purposes and this was done because a portion of the site was determined to be a wetland. Not including these data, nearly 10 acres and 40% of the number of Bostick Weir sites were determined to be wetlands. Data derived from wetland determinations in 2006 and 2007 closely matched wetland designations using WPI scoring methods (Table 4). For example, 80% of the sites that were determined as wetland had WPI≤2.0 (Table 4). Furthermore, the remaining 20% of sites had WPI scores extremely close to 2.0 (i.e., 2.02 and 2.04). These data show the significance of using the WPI method to document wetland status on Bostick Weir sites.

Average total cover for all Bostick Weir revegetation sites has increased over time to a maximum of nearly 60% (Figure 7). The most dramatic increase in cover was between the first and second growing seasons with more than a five-fold increase reported. Cover increased about 15% between the other growing seasons. Species richness trends were somewhat different than trends in cover data. Richness decreased after the second growing season; however, only four
Map 3: Aerial photograph of delineated Bostick Weir revegetation sites.
species separate the highest and lowest values (Figure 8). Regardless, Bostick Weir sites show a high level of richness. High richness values were also reflected in the relative cover values for the different growth forms on the sites (Figure 9). Relative cover data show that graminoids (i.e., grasses and grass-like plants) quickly became an important cover component in the first couple years. As the sites aged, however, relative graminoid cover was reduced because of increases in shrub and tree cover. Likely, the quick increase in graminoid cover was a result of common reed (*Phragmites australis*), bulrush (*Schoenoplectus* spp.), and cattails (*Typha domingensis*) because all of these species grow quickly. Overall, Bostick Weir revegetation sites appear to be successful because cover is increasing, richness is certainly higher than the monoculture of salt cedar (*Tamarix ramosissima*) that was previously on the site, and survival was 95.6% and 92.5% for the first and second growing seasons, respectively.

### Wetland Status Acreage for Each Growing Season Monitored WPI^2

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1Wetland status in 2006 and 2007 resulting from a JD (i.e., jurisdictional determination) conducted according to the Corps’ 1987 Wetland Delineation Manual. “wet” = wetland and “non-wet” = non-wetland.
2Wetland Prevalence Index (WPI) value. WPI ≤ 2.0 = wetland, 2.0 < WPI ≤ 2.5 = likely wetland, 2.5 < WPI < 3.5 = may be wetland, 3.5 ≤ WPI < 4.0 = not likely a wetland, and WPI ≥ 4.0 = upland (Tiner 1999).
pr = previously reported data
n/a = not applicable

**Table 4:** Acreage and wetland status for Bostick Weir revegetation sites from 2003 to 2007.

### 3.1.1 Bostick

Bostick (B) is the largest of all the Bostick Weir sites with nearly seven acres monitored in 2007 (Table 4). This site is located on the Bostick Weir itself where there is an abundant supply of near surface water. Consequently, the WPI scores show that this site is a wetland (Table 4). Total cover for both years of monitoring was 87.5%, the mid-point value of the 75-100% cover class. Although data were not collected during the first two growing seasons, it appears that graminoids and trees are important components of cover on this site (Figure 10). In fact, the dominant species in both 2006 and 2007 was Goodding’s willow (*Salix gooddingii*; Figure 11), a typical wetland tree commonly found in riparian areas in the Lower Colorado River Basin. The
most common graminoids were common reed and cattails with only common reed cover increasing from 2006 to 2007. Relative cover data show that as common reed cover increased quailbush (Atriplex lentiformis) cover decreased. This likely is a result of a shift towards wetter hydrology. A hydrologic shift would also explain the decreasing WPI scores (i.e., increasing wetlandness) observed on this site.

Species richness decreased from 26 to 21 and species diversity decreased from 1.81 to 1.54 over the two year monitoring period. Although richness was decreasing, these values are still much greater than what was observed on the site pre-revegetation. Very few noxious species were reported on this site. For example, salt cedar was only observed in 2007 with 0.1% cover, red brome (Bromus rubens) had a cover of 0.5% in 2006 but was not found in 2007, and Johnson grass (Sorghum halepense) covered 0.5% of the site in 2006, but also was not found in 2007.

### 3.1.2 Bostick North

Bostick North (BN) is located on the north side of the Wash adjacent to the Bostick Weir. BN was monitored each year between 2003 and 2007 and the size of the site over this period was consistent (Table 4). During the last two years of monitoring, the site was determined to be a non-wetland and the WPI scores validate this determination (Table 4). WPI scores in 2006 were the highest reported, indicating that this site is an exceptionally dry area. Survival rates from the first and second growing season were, 89.7% and 76.7%, respectively. Since the second growing season value was below 80% and survival trends are in decline, these data show that the site is not successful. Irrigation was not regularly provided in the fourth growing season which may have contributed to the poor survival rate. Other data should be evaluated to determine if the site is fully unsuccessful.

Cover data show that the site is successful even though there appears to be a slight decrease in cover from the second growing season to the third (Figure 12). The likely cause of this trend is that data from the third growing season are presented as midpoints of the cover class. For example, these data represent the 5-25% class but are displayed as a mean of 15% with ±10% error bars. Therefore, the observed difference between seasons two and three may be an artifact of sampling method resolution. The number of species found on the site decreased from 10 after the first growing season to 8 after the fourth, with the highest number of 17 after the second (Figure 12). While the number of species decreased between the third and fourth growing seasons, diversity increased from 1.21 to 1.37 therefore showing that the site was somewhat successful. The site was mostly dominated by trees and shrubs in all years with lesser amounts of subshrubs and forb/herbs (Figure 13). Notable trends in richness appear to be contributed in part by the presence/absence of forb/herbs. The dominant species were fourwing saltbush (Atriplex canescens) in 2006 and a combination of creosote bush (Larrea tridentata) and honey mesquite (Prosopis glandulosa var. torreyena) in 2007 (Figure 14). No noxious species were reported on this site.

Monitoring data from BN are somewhat mixed because of the poor survival rates reported. For example, these data show that BN was not meeting the success criteria for survival but other data show that BN was meeting it for cover. Since survival measurements were not taken on the site after the first couple years, it is impossible to know if these observed trends continued. Additional years of monitoring will be able to evaluate site success more clearly. If cover data
were to decline, the successfulness of the site may be uncertain. As this is not the case, the site does appear to be generally successful.

3.1.3 Upstream Bostick North

Upstream Bostick North (UBN) has generally decreased in size over the four year monitoring period, but only by a tenth of an acre (Table 4). UBN is a non-wetland site first monitored in 2004, after the first growing season. WPI scores also show that UBN is not likely a wetland (Table 4). Cover and richness had a strong negative correlation (Figure 15) and it does not appear that one growth form is dominating the site at the expense of another (Figure 16). Consequently, these data show that all species on the site appear to be growing well and without much competition. For example, 10% cover was observed after the first growing season and by the fourth growing season cover was over 60%. Although it appears that richness, a quasi-indicator of diversity, has been affected by increases in cover, diversity data do not support this statement. Diversity increased slightly from 1.78 in the third growing season to 1.94 in the fourth.

The composition of growth forms found on UBN was almost entirely trees and shrubs with a negligible amount of subshrubs and forb/herbs (Figure 16). Furthermore, the dominant shrub and dominant species as measured by cover in 2006 was fourwing saltbush (Figure 17). By 2007 fourwing saltbush shared cover dominance with four other species; quailbush, creosote bush, honey mesquite, and Goodding’s willow (Figure 17). The only noxious species found at UBN was salt cedar, covering 0.10% in both 2006 and 2007. The survival rate after the first growing season was 95.1% and was 93.3% after the second. These and other data show that UBN is a highly successful site. Not only were survival rates well above 80% but cover was regularly increasing.

3.1.4 Upstream Bostick North Bank

Upstream Bostick North Bank (UBNB) is upstream of UBN and this site is much closer to the water than UBN. WPI values confirm that this is a wetland site (Table 4) and although it is small (~0.75 acres), UBNB serves as important bio-armoring for an adjacent bank protection facility. Beginning in 2006, only two years of monitoring data were collected from UBN and survival data were not measured in either year. Total cover over these years remained constant at 87.5%. Species richness trends were slightly different since values decreased across the two monitoring years from 17 to 15. Concomitant with this decrease was a decrease in diversity from 1.09 to 1.07, however, richness and diversity declines appear to be negligible. UBNB was dominated by one graminoid species, common reed (Figure 18 and Figure 19). A lesser component of graminoid cover was provided by cattails and an inconsequential amount of noxious species cover was found on the site. For example, salt cedar was 0.5% cover in 2006 and 0.1% cover in 2007. Monitoring data show that UBNB is a successful site, however, the types of species found on this site are not desirable. Some desirable species like cottonwoods (Populus fremontii) and Goodding’s willows were observed on the site but they had minimal cover (Figure 19). UBNB was not originally planned as a revegetation site and therefore minimal effort was expended on the site. For example, only minimal plants were planted (<20), no irrigation was used, and no maintenance was provided. These monitoring data illustrate the resulting outcome of low-effort scenarios.
3.1.5 Upstream Bostick North Emergent
Upstream Bostick North Emergent (UBNE) was a relatively recent addition to the list of Bostick Weir revegetation sites. It was created in 2005, well after the weir was completed, and it was first monitored after the second growing season (Table 4). UBNE was a wetland site and nearly 1.5 acres were monitored by 2007 (Table 4). UBNE was planted originally with an abundance of bulrush species (*Schoenoplectus* spp.) and lesser amounts of trees and shrubs. First season hydrology was adequate to support obligate wetland plants but the hydrology became less wet with time. Survival was not recorded on this site because of the dominance of graminoids used in the planting design. Total cover data show that the site is successful with 87.5% cover documented after the first and second growing seasons. Cover, however, was dominated by graminoids, mostly common reed with lesser amount of cattails (Figures 20 and 21). The prevalence of common reed on the site is indicative of the hydrologic shift that occurred there since common reed are often invaders of moderately wet sites.

Richness decreased from 33 to 25 species in the two monitoring years which may have been because of the common reed expansion (Figure 21). Decreases in diversity were also noted; 2.01 in 2006 to 1.88 in 2007. Another potential explanation for the decline in richness and the lack of native species found on the site was that salt cedar was prevalent with a cover of 15% in both years. Other noxious species were also reported including tall whitetop (*Lepidium latifolium*), silver leaf nightshade (*Solanum elaeagnifolium*), and Johnson grass, however, they were all below 1% cover. Maintenance activities at UBNE were minimal and in this way, maintenance efforts were similar to those provided to UBNB. There were, however, clear differences between these sites. For example, a substantial number of plants (>200) were planted on UBNE, specifically bulrush plants. Unique to UBNE was that the site was created with dredged soil from downstream of the Pabco Road Weir. Prior to dredging, the soil was extensively covered by common reed and it appears that this resulted in a dominance of common reed on UBNE in 2006 and in 2007 (Figure 21). Furthermore, observations of UBNE after the site was created showed that an extensive number of common reed culms and roots were mixed in with the soil. These broken fragments were likely the source of the common reed observed (see Ailstock et al. 2001). Although cover values for UBNE indicate that the site is successful, the site is not entirely desirable. Increasing growth trends by willows (*Salix* spp.) do appear to be positive; however, the extensiveness of common reed suggests that UBNE will not be free of this undesirable species without targeted management prescription.

3.1.6 Downstream Bostick North
Downstream Bostick North (DBN) was monitored between 2004 and 2007 and it was confirmed as a non-wetland site in 2006 and 2007 (Table 4). DBN is the second smallest Bostick Weir revegetation site at just under 0.5 acres. Survival after the first growing season was 100% but then decreased to 88.2% after the second growing season. Although there was a decrease in survival, the second season values were still considerably greater than the 80% success criteria. Total cover on the site increased from 7.01% after the first growing season to 37.5% after the third and fourth growing seasons (Figure 22). Increasing cover was mostly attributed to shrub growth forms (Figure 23) and specifically by three species; creosote bush, quailbush, and fourwing saltbush (Figure 24). Trees were a minimal component of relative cover (Figure 24). Although cover increased over the four monitoring years, species richness decreased (Figure 22). Diversity, however, increased from 1.13 to 1.48 between the third and fourth growing seasons.
Importantly, no noxious species were found on the site during any monitoring period. DBN was a somewhat successful site because of increasing trends in cover. A decrease in richness, generally a characteristic of a non-successfully performing site, was offset by diversity increases. These trends have been observed on other non-wetland sites (e.g., UBN) which may suggest that fewer species (i.e., those that are performing well) should be planted at future project sites. Additional years of data and results from other sites may show if these trends are consistent programmatically.

3.1.7 Bostick South
Bostick South (BS) has been monitored for three consecutive years beginning in 2005 (Table 4). This site was a non-wetland site in 2006 and 2007 and it was slightly less than 0.5 acres each year it was monitored. Survival was 94.8% and 93.2% after the first and second growing seasons, respectively, indicating that the site is successful. Another positive trend towards success was that cover increased substantially over the three years of monitoring (Figure 25). Relative cover values show that growth forms are generally growing equally, particularly during the last two years of monitoring (Figure 26). Growth forms consisted mostly of trees and shrubs in all years (Figure 26) and cover for most species remained constant, however, a notable increase in broom baccharis (*Baccharis sarothroides*) and minor increases in desert willow (*Chilopsis linearis*) and cottonwood cover in 2007 were observed (Figure 27). Like DBN, BS had decreasing trends in species richness but increasing trends in diversity (i.e., from 1.52 in 2006 to 1.79 in 2007). Richness trends, however, were not consistently decreasing which suggests that the trend has leveled off.

3.1.8 Upstream Bostick South
Upstream Bostick South (UBS) consists of non-wetland and wetland components and the majority of this acreage is within the non-wetland portions of the site (Table 4). Monitoring data for these components are described cumulatively here and separately below. Total site area increased by an acre over the four year monitoring period although these gains were attributed to an increasing wetland fraction on the site (Table 4). During the first and second growing seasons, UBS was monitored as one contiguous area but after the second growing season, the site was split into its constituent parts for monitoring.

Total cover for UBS increased by more than six fold over the four year monitoring period (Figure 28). Species richness increased over the first few growing seasons but then returned to a value near that observed in the first year (Figure 28). UBS is one of the most species rich sites, with most of this richness attributed to the wetland portions (see sections below). Several growth forms are distributed on the site and in relative equal cover portions during some years (Figure 29). Survivorship for the first and second growing seasons was 97.9% and 100%, respectively.

**Non-Wetland Area** – WPI values corroborate the non-wetland designation of this monitoring area, albeit the site is trending towards a more wetland status (Table 4). Cover for the non-wetland monitoring area increased from 37.5% after the third growing season to 62.5% after the fourth which is a successful trend. Increases in species richness (16 to 21) and diversity (1.65 to 1.82) were also noted. A small fraction of species richness, however, was contributed to noxious species including salt cedar (0.1% in 2006 and 2.5% in 2007), silver leaf nightshade (2006 with a cover of 0.5%), and tall whitetop. Together these noxious weeds made up less than 20% of the...
recorded species richness and less than 4% cover in each year. During the last monitoring event, the highest relative cover value (>60%) was observed for tree growth forms (Figure 30) and screwbean mesquites (*Prosopis pubescens*) were responsible for this trend (Figure 31).

**Wetland Area** – Although only 6% of UBS was a wetland during the first growing season, wetlands became an increasingly more important component of the site by the last monitoring season (>40%; Table 4). WPI scores are indicatively wetland and in 2006 this area was the most wetland like of all Bostick Weir revegetation sites. Since data were not collected specifically for this wetland area prior to 2006, we are unsure if these conditions were part of a long-term trend. In fact, sampling methods were partially changed in 2006 to evaluate the contribution of wetland characteristics on revegetation sites. Cover data show that the wetland area was a substantial component of the total site cover; total wetland cover of 87.5% was observed in both years with the majority of this as trees (Figure 32). Cover was actually closer to 100% (S. Shanahan pers. obs.) but since the midpoint cover class values was used and not the range (i.e., 75-100%), these data are conservative. Cover appears to have increased at the detriment of both species richness and diversity. For example, richness decreased from 38 species in the third growing season (2006) to 28 species in the fourth (2007) and diversity decreased from 2.48 to 2.21 over the same period. Minimal cover of noxious weeds were observed on the site (<4%; Figure 33). UBS wetland areas appear to be quite successful even though diversity and richness values were decreasing. Structurally the area is quite diverse (Figure 32) and therefore it provides good habitat values for many wildlife species (S. Shanahan pers. obs.).

### 3.1.9 Upstream Bostick South Bank
Upstream Bostick South Bank (UBSB) is a non-wetland site (Table 4) located south of UBS. Site size has been relatively constant but this was mostly evident during the last two monitoring seasons (Table 4). Cover and species richness have been stagnant over the last two monitoring years (Figure 34) and during all monitoring events the site was dominated by trees (Figure 35). Mesquites (*Prosopis* spp.) were the major contributor to the relative cover value reported (Figure 36). Of special note was that a vine, coyote melon (*Cucurbita palmata*), was found on the site after the second growing season (2006). Although not rare in the landscape, this has been a rare occurrence for revegetation sites. Survivorship on UBSB was 100% in the first two growing seasons and noxious weeds, although observed in all years, were less than 2% cover in all years. UBSB has been maintained at low effort levels since 2006 which likely is reflected by the performance of vegetation on the site. Irrigation was no longer applied to UBSB after 2006 and the data show that UBSB, although not decreasing in cover, was not as successful as other sites. Future years of data collection will elucidate these trends further.

### 3.1.10 Downstream Bostick South
Much like UBSB, Downstream Bostick South (DBS) was a non-wetland site that was first monitored in 2005 (Table 4). During the last two monitoring years DBS was either the most or second most upland-type site as reflected by high WPI scores (Table 4). DBS was a small site (<0.25 acres) and this was consistent from year to year (Table 4). Despite the small size, tremendous survival success was observed; 91.6% survival after the first growing season and 96% after the second. Total cover also showed that the site was a success because it increased substantially over the monitoring period, however, species richness decreased (Figure 37). Furthermore, diversity decreased from 1.67 to 1.14 from the second to the third growing seasons. These trends have been reported elsewhere (see DBN and UBN) and they likely represent

programmatic trends on these site types. Shrubs were the dominant growth form observed during all three years of monitoring and by the last monitoring year they made up more than 80% of cover on the site (Figure 38). Fourwing saltbush was the primary reason for this trend (Figure 39). Noxious weeds were not found on DBS also showing that the site was successful.

3.1.11 Downstream Bostick South Emergent

Like other wetland sites, Downstream Bostick South Emergent (DBSE), had an extensive amount of vegetation cover on the site (Photographs 1 and 2) with 87.5% cover reported for 2006 and 2007. Survivorship data were not collected on DBSE because of the dominance of wetland-type plants on the site that grow in multi-stem forms. The size of the site remained constant across the two years of monitoring at 0.66 acres and WPI scores confirm that the site is a wetland (Table 4). It also appears that DBSE is becoming more wetland-like with age (Table 4). DBSE is one of the most species rich Bostick Weir revegetation sites with 34 species found in the second growing season but only 22 species were found in the third. The decrease in richness appears to result from equal reductions in growth form types represented because relative cover data show that growth forms were mostly consistent from year to year (Figure 40). Increases in tree cover (absolute cover not relative cover) provided by Goodding’s willow were also observed (Figure 41). This increase in cover was offset by increases in common reed and marsh fleabane (Pluchea odorata) which was partially why relative cover remained consistent from year to year (Figure 41). It is interesting to note that Goodding’s willows were not found in 2006 which shows that this species naturally recruited on the site in 2007. This is further validated by the fact that Goodding’s willows were not part of the original planting design. Goodding’s willows were not planted on other
Bostick Weir revegetation sites (e.g., site B) and some of these sites showed cover values of >50% during the third growing season. This evidence shows that Googling’s willows have been successfully recruiting in the Wash. DBSE has been the only site where desert grape (Vitis arizonica) have been found. However, it appears that it was likely washed away in a flood event since it was not found in 2007.

3.2 Calico Ridge Weir

There were six revegetation sites associated with the Calico Ridge Weir and they were each planted by the 2005 growing season (Map 4; Table 5). Nearly 70% of the sites were monitored in 2005 and all sites were monitored in 2006 and 2007. By 2007, more than 16 acres were monitored including more than five acres of wetlands and approximately 12 acres of non-wetlands (Table 5). Calico Ridge Weir revegetation sites were found in and along the Wash channel and at various floodplain terraces. These sites were distributed on all sides of the weir including on the weir and upstream in the weir impoundment. Wetland sites were found exclusively in the upstream impoundment of the weir and along the toe edge of bank protection facilities upstream and downstream of the weir. Wetland sites were nearly six feet lower in elevation than adjacent non-wetland sites. For tracking and monitoring purposes, wetland and non-wetland components of sites were evaluated separately for the 2006-2007 sampling events. Consequently, WPI scores tracked jurisdictional determination results for both monitoring years (Table 5).

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<td>0.42</td>
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<td>16.37</td>
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¹Wetland status in 2006 and 2007 resulting from a JD (i.e., jurisdictional determination) conducted according to the Corps’ 1987 Wetland Delineation Manual. “wet” = wetland and “non-wet” = non-wetland.

²Wetland Prevalence Index (WPI) value. WPI ≤ 2.0 = wetland, 2.0 < WPI < 2.5 = likely wetland, 2.5 ≤ WPI < 3.5 = may be wetland, 3.5 ≤ WPI < 4.0 = not likely a wetland, and WPI ≥ 4.0 = upland (Tiner 1999).

pr = previously reported

nd = no data

n/a = not applicable

Table 5: Acreage and wetland status for Calico Ridge Weir revegetation sites from 2003 to 2007.
Map 4: Aerial photograph of delineated Calico Ridge Weir revegetation sites.


23
Average total cover of all Calico Ridge Weir revegetation sites increased three fold over the three year monitoring period (Figure 42). The most substantial increase in cover was observed between the first two years with a minor amount of change the last year. Trends in average species richness were dissimilar to cover trends at Calico Ridge Weir but were similar to trends reported at Bostick Weir revegetation sites. Average richness was highest during the second growing season but decreased sharply the following year (Figure 43). Overall, however, richness was still greater than prior revegetation conditions. For example, most areas were historically dominated by salt cedar. Relative cover trends were not consistent among years (Figure 44). Shrubs substantially dominated sites in the first growing season but than were a relatively equal component of the community observed in the third growing season (Figure 44). Survival rate data for the first two growing seasons were 92.3% and 84.2%, respectively. These data and the cover data previously reported show that Calico Ridge Weir revegetation sites are successful.

3.2.1 Calico
Calico (C) is an approximately one acre wetland site located on the Calico Ridge Weir (Table 5). There are two equal portions of this site on the north and south sides of the weir separated by an unvegetated low-flow rock rip-rap spillway. In 2006 these areas were monitored separately and in 2007 they were monitored together. Data were normalized on an acreage-weighed basis for comparison between years. Planting efforts that were performed on this site were low and consisted of using <100 sandbar willows (Salix exigua). Cover data show that the site has been successful even though planting effort was low. For example, cover was 87.5% in both monitoring years. The majority of cover on the site was from graminoids (i.e., common reed), however, trees (i.e., Goodding’s willow) were also an important cover component (Figure 45 and 46). The dominance of common reed on this site is not unusual since this species is an aggressive invader of wet areas along the Wash. The dominance of Goodding’s willow, however, was unusual since this species was not originally planted on the site. A similar trend was observed on site B and combined these data show that Goodding’s willows have been successfully recruiting along the Wash. These are positive trends that indicate that the Wash system is functioning similar to a natural riparian corridor. Seep willow (Baccharis salicifolia) was another desirable species that were not originally planted on this site and although it did not contribute substantially to cover (Figure 46), the fact that it recruited on the site was positive. Species diversity trends on site C were similar to other sites in that there was a decrease of 28 species after the second growing season to 18 after the third. Diversity decreased as well from 1.73 to 1.55 between the two monitoring years.

3.2.2 Upstream Calico North
Upstream Calico North (UCN) was planted in 2005 and has been monitored for three consecutive years (Table 5). Site size has changed little over the monitoring period at just over two acres. UCN was monitored as a single site in 2005 but was split into wetland and non-wetland monitoring areas in 2006 and 2007. Total cover was 19.3% during the first growing season and was 40.7% in the second growing season. Cover data were not collected on the wetland portion of UCN in 2007; therefore, total cover could not be extrapolated across the whole site. Species richness decreased from 27 in the first growing season to 21 in the second and diversity data were not calculated. Survival data show that the site was successful after the first growing season (83.3%), but then was unsuccessful in the following year (62.5%). Since cover was increasing and survival was decreasing, it appears that the plants that were able to
survive were growing successfully. Most of this growth was coming from one species, fourwing saltbush (Figure 47; see section below).

**Non-Wetland Area** – The non-wetland portion of UCN represents more than 90% of the site during each year it was monitored (Table 5). These areas were planted originally with containerized plants and a hydroseed mixture. Monitoring occurred in 2006 and 2007 and cover increased dramatically over this period from 37.5% to 62.5%. This increase in cover was because of fourwing saltbush (Figure 47). Fourwing saltbush was the dominant species used in the hydroseed mixture and due to a wet winter in 2005 many of these seeds germinated. It appears that the outplantings were not as successful as the seeded plantings; however, since fourwing saltbush was also outplanted, these conclusions are not entirely clear. Species richness decreased from 15 species to 11 species over two monitoring years and diversity decreased from 0.69 to 0.16. These relatively low diversity values show how fourwing saltbush was affecting the site.

**Wetland Area** – Wetland portions of UCN were monitored in 2006 and WPI scores show that the site was strongly wetland-like (Table 5). Total cover was 87.5% with most of this cover attributed to common reed (50-75%). Other important cover components were tules (*Schoenoplectus acutus*) and sandbar willows (Figure 48). Little maintenance effort was provided to this wetland area after it was outplanted with sandbar willows and transplanted tules from the Pahranagat National Wildlife Refuge. The dominance of common reed on this site was a reflection of this lack of effort in removal of this species or addition of native species. Although common reed presence is not entirely desirable, the mixture of species cover and growth forms on the site was important as wildlife habitat and stabilizing the adjoining bank protection facility.

### 3.2.3 Downstream Calico North

2005 was the first year that Downstream Calico North (DCN) was monitored and it was also the year that the site was planted. Like UCN, DCN was outplanted with various containerized plants and hydroseeded with a fourwing saltbush dominated mixture. DCN was slightly over an acre each monitoring year and it had high WPI scores showing that it was a definitive non-wetland site (Table 5). Total cover did not follow typical trends since it was highest in the first and third growing seasons and lowest in the second growing seasons (Figure 49). These trends do not firmly indicate that the site is successful, however, the upward cover trends reported during the last two monitoring events suggests that the site is rebounding well. The low cover values during the second growing season may also be a result of mortality. For example, after the first growing season survival was 100%, but then decreased to 76.9% after the second growing season. The mortality indicated likely manifested as low cover values in 2006. Shrubs, particularly fourwing saltbush, were responsible for the increase in cover (Figure 50 and 51). In fact, fourwing saltbush covered the site ten-fold more than any other species (Figure 51). Richness trends were similar to other sites in that richness decreased from 17 species in the first growing season to 10 in the third (Figure 49). Concomitant with this trend was that diversity also decreased from 1.21 to 0.44. Site diversity was mostly represented by only two species: fourwing saltbush and honey mesquite.

### 3.2.4 Upstream Calico South
Upstream Calico South (UCS) was monitored as a single site in 2005 and as separate wetland and non-wetland components in 2006 and 2007. Overall, the size of the site has been increasing over the three year monitoring period (Table 5). Along with this increase was an increase in cover and species richness (Figure 52). Survivorship data show that UCS is a successful site with 100% survival after the first growing season and 97.4% after the second. Survivorship data, however, mostly reflect performance on the non-wetland portions of UCS because wetland plants were not adequately counted using belt-transect methods.

Non-Wetland Area – Portions of UCS that were designated as non-wetlands were validated by WPI scores and these areas contributed to site size the most (Table 5). Total cover in 2006 and 2007 was 37.5% and this was due almost entirely to fourwing saltbush (Figure 53). Fourwing saltbush dominance was also reported on non-wetland areas of DCN and UCN. The extensive cover of fourwing saltbush on these sites was a result of the hydroyseed mixture used and likely an above average winter rainfall that led to excellent seed germination. For example, Plummer et al. (1966) showed that fourwing saltbush required cool temperatures and adequate rainfall to germinate. Unlike other sites, however, species richness at UCS non-wetland areas increased from 17 to 20 and diversity increased 1.00 to 1.34.

Wetland Area – Wetland portions of UCS contributed to less than a half acre of the total size of the site (Table 5). This wetland area had the lowest WPI score in 2006 and 2007 of any Calico Ridge Weir revegetation site and these data show that the site is an obligate wetland site. Total cover was 87.5% in both years which shows that the site was successful. Species richness decreased from 13 to 9 while diversity increased from 1.27 to 1.44. Several species contributed to cover on the site but sandbar willow was the dominant species during both monitoring years (Figure 54). Likely, cover values were a reflection of planting effort because a couple hundred sandbar willows were originally planted on the site. Also planted on the site were tules, however, they represented minimal cover. It appears that both common reed and cattails have out competed tules on this site (Figure 54). Goodding’s willows were an increasing cover component in 2007 and since this species was not originally planted on the site, it shows that it was recruiting there.

3.2.5 Downstream Calico South

Downstream Calico South (DCS) was first monitored in 2005 after the first growing season. In 2005, DCS was monitored as one contiguous area; however, since the site consisted of non-wetland and wetland areas they were monitored independently of each other in the second and third growing seasons. DCS is the largest Calico Ridge Weir revegetation site at slightly over six acres (Table 5). Cover data show that the site was successful with increasing cover between the first two years and then a plateau of cover values the last year (Figure 55). Species richness had similar trends (Figure 55). Most compelling of all performance measures that indicate the site was successful was that survival was 85.7% after the first growing season and 100% after the second growing season.

Non-Wetland Area – A jurisdictional determination and WPI scores showed that more than 80% of DCS was non-wetland (Table 5). Cover was relatively high at 37.5% in 2006 and 2007; however, the majority of this cover was from fourwing saltbush (Figure 56). Both species richness (from 8 to 11) and diversity (from 0.37 to 0.91) increased between 2006 and 2007.
These values were still relatively low compared to other sites. DCS, like other Calico Ridge Weir revegetation sites, was planted with containerized plants and hydroseeded. Hydroseed has been proven to be an important component of revegetation on these sites as indicated by the dominance of fourwing saltbush. Therefore, future revegetation efforts should closely consider seeding techniques over planting potted plants.

**Wetland Area** – Nearly one acre of DCS were wetlands (Table 5). Cover was nearly 100% but since the midpoint of the cover class range was used, the reported value for both monitoring years was 87.5%. Species richness decreased from 23 to 18 but diversity increased from an index of 1.56 to 1.83. The dominant species in 2006 (the second growing season) was common reed; however, cover declined by 2007 (Figure 57). Desirable species like Goodding’s willows and sandbar willows were a much larger component of cover in 2007 than in 2006. Similar trends in cover by Goodding’s willow have been reported on other sites.

### 3.2.6 Upstream Calico Emergent

Upstream Calico Emergent (UCE) was the largest Calico Ridge Weir wetland site at nearly 2.5 acres (Table 5; Photographs 3 and 4). The site was monitored in 2006 and 2007 and cover was 87.5% in both years. Although UCE was planted almost entirely with tules in 2005, a few species had greater cover than tules by 2007. For example, Goodding’s willows, cattails, and common reed each had cover greater than tules in 2007 (Figure 58). The extensive cover of Goodding’s willows on UCE was a result of an excellent natural recruitment year and these data have been observed at other wetland sites (see B, DBSE, etc.). Decreases in tule cover may be attributed to competition with cattails because between 2006 and 2007, cover values for these two species reversed (Figure 58). Other observed trends on UCE were that species richness decreased substantially from 15 species in the second growing season to just 6 in the third and diversity decreased from 1.27 to 1.08.

### 3.3 Cottonwood Cells

The Cottonwood Cell sites were originally intended to be small scale on-site nurseries that would supply an inexpensive source of cottonwood poles for revegetation efforts in the Wash. However, timing requirements for salvaging cottonwood poles (i.e., January/February) have yet to coincide with many project planting timelines. Therefore, the cells have grown extensively and they have yet to be fully used for their intended purpose. Furthermore, over time, the cells’ importance for serving as nurseries lessened because other nursery areas began to develop along the Wash. The two cells are immediately adjacent to one another (Map 5); however, they were planted at two different
time periods. For this reason, no analyses have been performed for the sites together; rather, sites have been evaluated individually.

### 3.3.1 Cottonwood Cell 1

Cottonwood Cell 1 (CC1) was first monitored in 2006 (Photograph 5), five growing seasons after it was planted. Monitoring data were not collected during the first five years because the site was not considered a revegetation site. With time, however, that designation was attributed to this site. CC1 is the larger of the two sites at nearly an acre (Table 6). Jurisdictional determinations for the site show that it was a wetland site and WPI scores confirm this (Table 6). Differences in wetlandness were likely resulting from the prevalence of facultative wetland species like quailbush. Furthermore, although data were not specifically collected on the site prior to 2006, the site was historically much more wetland like then these data suggest (S. Shanahan pers. obs.).

Total cover increased from 62.5% to 87.5% over the two monitoring years and as would be expected cottonwoods were the dominant species (Figure 59). Other species, however, were also important components of cover on the site (Figure 59). Although cover increased, species richness decreased from 12 to 9. These data show that as the site matured and as it became less wetland-like, richness decreased. However, diversity values increased from 1.38 to 1.67 suggesting that the remaining species on the site are becoming much more even. Common reed and salt cedar exhibited extensive cover increases from 2006 to 2007.

![Photograph 5: Cottonwood Cell 1 in October 2006.](image-url)

<table>
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<tr>
<th>Site Code</th>
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<th>Acreage for Each Growing Season</th>
<th>Wetland Status</th>
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<tr>
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</tr>
</tbody>
</table>

¹Wetland status in 2006 and 2007 resulting from a JD (i.e., jurisdictional determination) conducted according to the Corps’ 1987 Wetland Delineation Manual. “wet” = wetland and “non-wet” = non-wetland.

²Wetland Prevalence Index (WPI) value. WPI<2.0 = wetland, 2.0≤WPI<2.5 = likely wetland, 2.5≤WPI<3.5 = may be wetland, 3.5≤WPI<4.0 = not likely a wetland, and WPI≥4.0 = upland (Tiner 1999).

pr = previously reported

n/a = not applicable

**Table 6: Acreage and wetland status for Cottonwood Cell revegetation sites from 2003 to 2007.**
Map 5: Aerial photograph of delineated Cottonwood Cell revegetation sites.
(Figure 59) and they should be monitored closely in subsequent years because they may negatively impact the capacity of the site to be used as a nursery. Salt cedar trends were particularly noteworthy since cover was between 5% and 25% by 2007. Without maintenance, CC1 may be affected by these undesirable species.

3.3.2 Cottonwood Cell 2
Cottonwood Cell 2 (CC2) was half the size of CC1 and it was planted three years after CC1 was planted (Table 6). The first monitoring year for this wetland site, however, was not until 2006, after the second growing season (Figure 60). CC2 was more wetland like than CC1 but in 2007 WPI scores were increasing, indicating that it was becoming less wetland like. Over this same period, total cover increased from 62.5% to 87.5% which shows that the site is performing successfully. Species richness was also increasing with eight species detected in 2006 and ten species detected in 2007. As would be expected on a site that was planted exclusively with cottonwoods, CC2 had low diversity (0.21 in 2006 and 0.29 in 2007) and cottonwoods were the dominant species on the site (Figure 60). CC2 continued to be a good nursery for pole salvaging. Average tree height by 2007 was approximately 20 feet and with many lateral branches present, substantial material could be salvaged from this location (S. Shanahan pers. obs.).

3.4 Demonstration Weir
Only one Demonstration Weir revegetation site was monitored for the purpose of this report (Map 6; Photographs 6 and 7). These data are provided below.

3.4.1 Upstream Demonstration South
Upstream Demonstration South (UDS) was originally planted in 2003 and it was monitored from 2003 to 2007. Total site size varied little over the five year monitoring period with a maximum size of 3.33 acres achieved by 2007 (Table 7). UDS consisted of both non-wetland and wetland components and during 2003-2005 these areas were monitored together while in 2006-2007 they were monitored separately. Separate monitoring data for the two sub-areas are presented in the next two sections while cumulative data are presented here. UDS total cover increased by more than three fold over the five years of monitoring (Figure 61) showing that the site was successful. Species richness trends, however, showed a decrease with 21 species detected in the first growing season to 16 in the fifth (Figure 61). Survivorship data show that UDS was successful

<table>
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<th>Site Code</th>
<th>1st Growing Season (year)</th>
<th>Acreage for Each Growing Season Monitored</th>
<th>Wetland Status</th>
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<tr>
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<td>3.13 3.24 3.32 3.30 3.33</td>
<td></td>
</tr>
</tbody>
</table>

| No. of Sites | 2 2 2 2 2 |

1Wetland status in 2006 and 2007 resulting from a JD (i.e., jurisdictional determination) conducted according to the Corps’ 1987 Wetland Delineation Manual. “wet” = wetland and “non-wet” = non-wetland.

2Wetland Prevalence Index (WPI) value. WPI≤2.0 = wetland, 2.0<WPI<2.5 = likely wetland, 2.5≤WPI<3.5 = may be wetland, 3.5≤WPI<4.0 = not likely a wetland, and WPI≥4.0 = upland (Tiner 1999).

Table 7: Acreage and wetland status for Demonstration Weir revegetation sites from 2003 to 2007.
Map 6: Aerial photograph of delineated Demonstration Weir revegetation sites.
because survival was 94.7%, 98.2%, and 100% after the first, second, and third growing seasons, respectively.

**Non-Wetland Area** – Non-wetland portions of UDS had greater than 60% of the total site area; however, the trend was that non-wetland acreage was giving way to wetland acreage over time (Table 7). Cover data show that the non-wetland area was successful with an increase in cover of 15% to 37.5% over the two years of monitoring. These cover values were similar to those reported on other upland revegetation sites (see DCN, DCS, etc.). A negligible decrease in richness was reported with nine species in 2006 and eight species in 2007. Despite this decline, diversity increased from 0.98 to 1.28 in the same two years. In both years of monitoring, creosote bush and quailbush dominated cover on the site with 15% cover reported each in both years (Figure 62).

**Wetland Area** – Wetland portions of UDS have been increasing in size over the monitoring period (Table 7). Since total UDS size has been relatively constant, wetland area increases are resulting from plants growing into non-wetland areas. Total cover data show that the wetland was successful because there was 87.5% cover and unchanged species richness (11 species) in both years. Diversity, however, decreased slightly from 1.39 to 1.32. Two species were mostly responsible for covering the site in 2006; they include quailbush and sandbar willow (Figure 63). By 2007, increasing cover of two desirable species, sandbar willow and screwbean mesquite, were observed suggesting that the site was performing successfully (Figure 63).

### 3.5 Historic Lateral Weir

Three revegetation sites were monitored from 2003 to 2007 in association with the Historic Lateral Weir (Map 7). Total monitoring area per growing season fluctuated between 10.5 and 12 acres during most years (Table 8). Area monitored during growing season six decreased by five acres because of a decrease in monitoring acreage at one site (Table 8). Two of the three
Map 7: Aerial photograph of delineated Historic Lateral Weir revegetation sites.
monitoring areas consisted of both wetland and non-wetland components and in total there were 4.68 acres of wetlands and 5.96 acres of non-wetlands by 2007. WPI scores matched jurisdictional determinations on all sites which further showed the validity of using WPI methods for compliance reporting.

Total cover increased nearly four fold over the monitoring period; however, a slight decrease in cover was noted between the sixth and seventh growing seasons (Figure 64). These data show that Historic Lateral Weir revegetation sites are successful. Trends in species richness were not similar to cover trends. For example, richness peaked after the fourth growing season but it decreased each year thereafter (Figure 65). Total richness, however, was still high and certainly higher than the pre-revegetation conditions. Relative cover data of the different growth forms show that shrubs were an important component on sites in most years (Figure 66). Trees appeared to be important cover components as sites aged and forb/herb cover was important at moderate ages. Survival data for Historical Lateral Weir revegetation sites were some of the highest reported: 100%, 97.8%, and 100% after the third, fourth, and fifth growing seasons, respectively.

### Table 8: Acreage and wetland status for Historic Lateral Weir revegetation sites from 2003 to 2007.

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</tr>
</tbody>
</table>

1Wetland status in 2006 and 2007 resulting from a JD (i.e., jurisdictional determination) conducted according to the Corps’ 1987 Wetland Delineation Manual. “wet” = wetland and “non-wet” = non-wetland.

2Wetland Prevalence Index (WPI) value. WPI$\leq 2.0$ = wetland, $2.0 < WPI < 2.5$ = likely wetland, $2.5 \leq WPI < 3.5$ = may be wetland, $3.5 \leq WPI < 4.0$ = not likely a wetland, and $WPI \geq 4.0$ = upland (Tiner 1999).

pr = previously reported

### 3.5.1 Upstream Historic Lateral North

Upstream Historic Lateral North (UHLN) was the largest Historic Lateral Weir revegetation site with more than 6.5 acres monitored during most growing seasons (Table 8). UHLN was originally planted in 2001 and it was monitored from 2003-2007. Monitoring data were also collected on this site in 2001-2002 (SNWA 2005) but these data are not included here. UHLN consists of both wetland and non-wetland monitoring areas and data from these sites were only collected separately during 2006 and 2007 (see section below). Total site cover increased dramatically over the monitoring period (Figure 67) which shows that the site is performing successfully (Photographs 8 and 9). A decrease in cover from the sixth to the seventh growing season was reported (Figure 67). This decrease could be an artifact of the difference in site
acreage that was monitored between 2006 and 2007. For example, the polygons that were delineated around UHLN in 2006 included highly-vegetated areas. In 2007, these polygons were expanded to include areas that were not as vegetated. Consequently, the size, configuration, and composition of the site changed between these two years which led to higher cover values being reported in 2006. UHLN was one of the most species rich sites and an increasing trend was noted over the monitoring period (Figure 67). Survivorship data that were collected during the fifth growing season (i.e., 100% survival) show that UHLN was performing well.

*Non-Wetland Area* – Non-wetland portions UHLN were mostly consistent in size; however, from 2006 to 2007, the area monitored increased nearly four-fold. The increase in size was a result of site delineation methods and not a true reflection of site change (see above). Therefore, data from 2006 are not comparable to their corresponding 2007 data. For example, cover decreased from 87.5% in 2006 to 62.5% in 2007 as a result of site delineation changes. These changes were most represented by a decrease in quailbush cover (Figure 68). The 2006 to 2007 trends in species richness (4-24) and diversity (0.29 to 1.64) were likely not representative either. WPI values, however, should be reflective and they confirm that the site is a non-wetland (Table 8).

*Wetland Area* – Wetland areas were minor monitoring components for the UHLN site contributing less than 30% of the monitoring area by 2007 (Table 8). WPI values show that the wetland designation is appropriate and cover data show that the areas are performing well (>87.5% cover in both years). Cover consisted mostly of Goodding and sandbar willows, however, common reed and seepwillow were also important cover components. By 2007, salt cedar was problematic on the site with 15% cover documented (Figure 69). Other noxious species found on the site included Maltese star-thistle (*Centaurea melitensis*), tall whitetop, and...
silver leaf nightshade. All four of these noxious species were found in 2006, but only salt cedar and tall whitetop were found in 2007. The number of species found on the site decreased substantially from 37 species in the sixth growing season to only 17 in the seventh. Diversity slightly decreased as well, from 1.84 to 1.71.

3.5.2 Upstream Historic Lateral South
Upstream Historic Lateral South (UHLS) was first monitored in 2003 and site size decreased over the five-year monitoring period to less than one acre by 2007 (Table 8). The monitored area after 2005 was intentionally reduced because vegetation was substantially lacking on the site. Less of the site was monitored in these years because several flood events had scoured out much of the site leaving nothing but bare soil. Site boundaries are therefore biased towards heavily vegetated areas. These same methods were used on the UHLN non-wetland areas.

WPI scores for UHLS show that this was the most wetland site of all Historic Lateral Weir sites. Cover data show that the site was successful with the highest cover values reported during the last two monitoring years (Figure 70). These data, however, are affected by the change in site size. Although survivorship shows that the site was successful; in the third, fourth and fifth growing seasons survival was 100%, 95.7% and 100%, respectively, and species richness (Figure 70) and diversity (1.39 to 1.30) decreased. Both cover and species richness trends were partially explained by the dramatic drop in size in 2006 and 2007 (growing seasons six and seven) of the site.

Growth forms have changed substantially throughout the five monitoring years (Figure 71). The site was dominated by forbs/herbs in the fourth and fifth growing seasons but it was dominated by shrubs in the sixth and seventh seasons. Sandbar willows were the dominant cover components in 2006 and 2007 but lesser amounts of other desirable species were also present (Figure 72). UHLS is generally a successful site; however, it was reduced in size by more than 50% over the entire monitoring period. Sites that are affected by flood scour will likely similarly result in changes to site size.

3.5.3 Upstream Historic Lateral South Bank
Upstream Historic Lateral South Bank (UHLSB) was monitored from 2003 to 2005 as a single site and from 2006 to 2007 as separate wetland and non-wetland components (Table 8). Data from the last two years of monitoring are presented in the section below. Jurisdictional wetland determinations and WPI scores show that designations for UHLSB were accurate (Table 8). Although the site remained mostly a consistent size, an increase in acreage was observed from 2003 to 2004 (Table 8). Cover also increased over the five monitoring years (Figure 73). Although species richness was higher in the seventh growing season compared to the third it was lower than the other seasons (Figure 73). Survivorship on UHLSB was measured at 100% in the third, fourth and fifth growing seasons showing that the site was performing successfully.

Non-Wetland Area – The non-wetland monitoring area decreased in size over the two years that it was monitored independent of the wetland area, from 1.12 acres to 0.87 acres. Cover increased from 37.5% to 62.5%, while the number of species stayed constant at 17. Diversity decreased inconsequentially from 1.59 to 1.57. The dominant species in both monitoring years was quailbush (Figure 74). Other important cover components included catclaw acacia,
seepwillow, and broom baccharis. Each of these species exhibited substantial growth over a short period of time considering that they had low or no cover values in the previous year.

Wetland Area – The wetland monitoring area has slightly increased in size over the two monitoring years from 1.46 acres in 2006 (the sixth growing season) to 1.79 acres in 2007 (the seventh growing season). Total cover for each year of 87.5% shows that the site was successful. Species richness decreased from 20 species in the sixth growing season to 12 in the seventh, whereas diversity slightly increased from 1.63 to 1.70 over the same period. Sandbar willows had the highest cover in 2006 and they shared the highest cover values with quailbush in 2007 (Figure 75). A substantial cover of salt heliotrope was also observed in both monitoring years (Figure 75) with most of this cover occurring in sandy substrates.

3.6 Monson and Visitor Center Weirs
Two revegetation sites are located adjacent to the Monson and Visitor Center Weirs (Map 8). Each of these sites has five years of monitoring data. Similar to other revegetation sites, the Monson and Visitor Center Weir sites were each monitored as one contiguous area from 2003-2005 and separately as wetland and non-wetland components in 2006-2007. Overall, cover has increased from 2003-2007 (Figure 76) but a slight decrease was observed between 2006 and 2007. The decrease in cover, however, was a direct result of Clark County purposely removing plants on one of the sites in order to open up the areas viewshed and access. Without this intended management action, cover would likely have been greater than 80% by 2007. Species richness results showed a somewhat similar trend as cover since it was increasing for the first four years but then decreased by the last year (Figure 77). Richness, however, was much higher than pre-existing conditions. Shrubs were important component of site cover in all years with an increasing importance of tree cover over the last two years (Figure 78). Trends in tree cover should continue as the Monson and Visitor Center Weir site mature.

3.6.1 Downstream Monson North
Downstream Monson North (DMN) site acreage was dominated by non-wetland components in all years (Table 9) and total site size varied little except during the last year. As previously described, this site was monitored as a single area for the first three years and as two independent areas during the last two years. Total site cover has increased nearly ten-fold over the five monitoring years (Figure 79) showing that the site is performing well. Species richness was increasing over all years except the last year (Figure 79). Survivorship data were exceptionally high with the combined wetland and non-wetland areas having 90.7% after the first growing season, 89.2% after the second, and 80.0% after the third.

Non-Wetland Area – The non-wetland monitoring area decreased in size from 3.48 acres in the fourth growing season to 3.04 acres in the fifth and cover was the same in both years at 62.5%. WPI values confirm the status of this area (Table 9). Although cover was not greater than 80%, 62.5% cover for a non-wetland area is relatively high. Species richness decreased by one species (from ten to nine) but diversity increased slightly from 0.99 to 1.16 in the two monitoring years. Quailbush was one of the most important components of cover during both monitoring years; however, fourwing saltbush was also important (Figure 80). Minor contributions to cover were observed for creosote bush, honey mesquite, and the invasive salt cedar. Noxious species cover, however, was well below performance standard thresholds.
Map 8: Aerial photograph of delineated Monson and Visitor Center Weir revegetation sites.
**Wetland Area** – Although wetland portions of DMN were only monitored independently the last two years, these areas have been increasing in size since 2003 (Table 9). It appears that the wetland areas are growing into the non-wetland area which is validated by a concomitant decrease in non-wetland acreage (Table 9). WPI scores strongly indicate that these areas are wetlands and these data are confirmed by the jurisdictional determination data (Table 9). Since several wetland areas were monitored, these data were weighted by acreage values to cumulatively evaluate wetland portions of DMN. This analysis showed that cover was high for both years at 87.5%. Somewhat unusual, species richness decreased by almost half (from 21 to 11); however, diversity slightly increased from 1.71 to 1.80. Decreasing richness trends have been noted elsewhere and these data appear to be common on sites that have >80% cover. Cover was mostly dominated by two species in 2006, Goodding’s willows and cattails (Figure 81). By 2007, quailbush was an important cover component. WPI scores show an increase from 2006 to 2007 and these data reflect the increase of quailbush and decrease of cattails on the site. Although not a major cover contributor, sandbar willows were found on the area in both years. California bulrush, an important cover component in 2006, had negligible cover in 2007. Although other bulrush species increased in cover, the growth of common reed likely limited California bulrush expansion. Noxious weed cover was <20% but salt cedar cover was approaching this value (Figure 81).

**Table 9: Acreage and wetland status for Monson and Visitor Center Weir revegetation sites from 2003 to 2007.**

<table>
<thead>
<tr>
<th>Site Code</th>
<th>1st Growing Season (year)</th>
<th>Acreage for Each Growing Season Monitored</th>
<th>Wetland Status</th>
<th>WPI²</th>
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<tr>
<td></td>
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¹Wetland status in 2006 and 2007 resulting from a JD (i.e., jurisdictional determination) conducted according to the Corps’ 1987 Wetland Delineation Manual. “wet” = wetland and “non-wet” = non-wetland.

²Wetland Prevalence Index (WPI) value. WPI≤2.0 = wetland, 2.0<WPI<2.5 = likely wetland, 2.5≤WPI<3.5 = may be wetland, 3.5≤WPI<4.0 = not likely a wetland, and WPI≥4.0 = upland (Tiner 1999).

3.6.2 Downstream Monson South

Downstream Monson South (DMS), like DMN, is made up of both non-wetland and wetland components that were only monitored separately after 2005. Overall, DMN has increased by nearly 0.5 acres over the five years of monitoring with most of these gain in the wetland areas (Table 9). Cover values were reflective of management actions on the site (Figure 82). After the second and fourth growing seasons, substantial quailbush cover was removed from the site (see below). Post-removal monitoring in growing seasons three and five show that these plants are rebounding. Management actions should, therefore, expect to be continued annually unless a dramatic transitional shift occurs. Species richness shows a similar trend as cover over the years.
(Figure 82). Lastly, survivorship values of >95% were observed in the first three growing seasons (Photographs 10 and 11).

**Non-Wetland Area** – The non-wetland monitoring area slightly increased in size over the two years that it was monitored independently of the wetland site (Table 9). Cover decreased dramatically from 87.5% in the fourth growing season to 37.5% in the fifth and these data are reflective of management actions on the site. Species richness decreased by one species (from 12 to 11) but diversity increased from 1.34 to 1.75. In 2006, quailbush was the dominant species with more than four times the cover of any other species (Figure 83). Cover decreased substantially by 2007 because quailbush was intentionally removed leading up to the monitoring event. Quailbush removal appears to have benefitted both creosote bushes and screwbean mesquites (Figure 83).

**Wetland Area** – WPI scores show that DMS wetland areas were becoming less wetland like (Table 9) possibly because too much non-wetland components were included in the monitored area. These areas were, however, increasing in size (Table 9). Cover values show that these areas are successful with 87.5% cover recorded in both years. Similar to DMN wetland areas, species richness decreased by 50% (from 22 to 11) but diversity increased slightly from 1.88 to 1.91. One of the most dominant species in both years was common reed (Figure 84). In 2006 cattails were codominant with common reed but in 2007 quailbush was codominant with common reed (Figure 84). WPI scores appear to reflect the reversal of codominance between these species. Future years of monitoring should focus on closely deliniating wetland boundaries so that WPI scores are <2.0. Probably the least encouraging aspect of the 2007 monitoring year was that salt cedar, a noxious weed, had a cover of 15%. Three other noxious species were also found on the site; tall whitetop, Johnsongrass, and silver leaf nightshade. Overall, this area was successful, but there appears to be a few characteristics that should be monitored more closely.
3.7 Pabco Road Weir
There are six revegetation sites associated with the Pabco Road Weir (Map 9; Table 10) and they were all planted between 2001 and 2002. Seven years of data show that cover fluctuates (Figure 85). This trend, however, was primarily due to Upstream Pabco North since it was the only site that had growing season one data (see Section 3.7.4). Moreover, Upstream Pabco North was one of two sites having data for the second growing season. No obvious trends were observed for species richness because some years had high values and some years had low values (Figure 86). Richness was, however, much greater than the richness associated with the pre-existing condition. Growth forms on the site have changed considerably based on the age of the site (Figure 87). For example, tree cover appears to be important at early and middle aged sites but not as much during other site ages. Survival data showed tremendous site success; 85.7% after the second growing season, 94.8% after the third, 94.1% after the fourth, and 95.3% after the fifth. Data from Upstream Pabco South is not included with this Pabco Road Weir assessment (see Section 3.1.7.3).

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1Wetland status in 2006 and 2007 resulting from a JD (i.e., jurisdictional determination) conducted according to the Corps’ 1987 Wetland Delineation Manual. “wet” = wetland and “non-wet” = non-wetland.
2Wetland Prevalence Index (WPI) value. WPI$\leq$2.0 = wetland, 2.0<WPI<2.5 = likely wetland, 2.5$\leq$WPI<3.5 = may be wetland, 3.5$\leq$WPI<4.0 = not likely a wetland, and WPI$\geq$4.0 = upland (Tiner 1999).

pr = previously reported
nd = no data
n/a = not applicable

Table 10: Acreage and wetland status for Pabco Road Weir revegetation sites from 2003 to 2007.
Map 9: Aerial photograph of delineated Pabco Road Weir revegetation sites
3.7.1 Pabco North

Pabco North (PN) was monitored from 2003-2007 and site acreage increased over this period (Table 10). Both wetland and non-wetland components were monitored but only independently from each other in 2006 and 2007. Cover values increased over the monitoring period with the highest reported value >65% (Figure 88). Unlike many other sites, species richness increased concurrently with cover (Figure 88). Along with successful cover and richness values, survival also indicates site success with a rate of survival measured as 95.8% after the third growing season, 91.7% after the fourth, and 96.9% after the fifth.

Non-Wetland Area – The non-wetland monitoring area remained essentially the same size in the two years it was monitored separately and WPI scores confirm that the site was not a wetland (Table 10). Cover increased from 37.5% to 62.5%, species richness increased from 19 to 21, and diversity increased from 2.00 to 2.05. There were three species that were equally dominant in 2006; quailbush, honey mesquite, and screwbean mesquite and in 2007, quailbush became the only dominant species (Figure 89). Noxious weed cover was low with salt cedar and tall whitetop cover at 0.5% each in 2007.

Wetland Area – PN wetland areas increased in size over all years and WPI scores show that the areas are becoming more wetland like (Table 10). Cover values show these areas to be successful with 87.5% cover documented in both monitoring years. Species richness decreased from 29 to 20 and diversity also decreased from 2.13 to 1.67. There were four species that were equally dominant in 2006 (Figure 90); common reed, cottonwood, sandbar willow, and Goodding’s willow. In 2007, there were just two dominant species; sandbar willow and Goodding’s willow. Since site acreage increased by nearly 0.25 acres from 2006 to 2007, willows were likely responsible for this added acreage.

3.7.2 Pabco South

Pabco South (PS) was planted in the spring of 2001 and monitoring data was collected from 2003-2007 (Photographs 12 and 13). PS is a relatively small site with smaller sub-components of wetland and non-wetland areas. Although PS has been generally the same size during the five-year monitoring period most of the site is considered a non-wetland (Table 10). Moreover, WPI scores strongly agree with jurisdictional determination data (Table 10). Cover data show that the site was successful with an increasing trend noted for the monitoring period (Figure 91). The last two years of monitoring documented the highest cover values with greater than 40% cover in each year (Figure 91). Species richness trends were similar to cover trends except that by the last growing season, richness values dropped by more than ten species (Figure 91). Like cover, survival shows that PS was successful with a survival rate of 87.5% after the third growing season, 97.7% after the fourth, and 93.8% after the fifth.

Non-Wetland Area – The non-wetland monitoring area of PS has been relatively constant in size, at over one acre (Table 10). These areas are dominated by non-hydrophytic plants and therefore WPI scores confirm that the site was not a wetland (Table 10). Cover in the first two years that this area was monitored independently was 37.5% and species richness remained relatively constant (18 species in 2006 and 17 in 2007). The majority of cover on this area was from two equally dominant species, creosote bush and honey mesquite (Figure 92). The relatively high cover and species richness for this area shows that the site is performing successfully. These
data are encouraging because a couple years of suboptimal performance were previously documented for the site. It appears that with age, sites become more successful.

*Wetland Area* – During the last two monitoring years, the wetland component of PS decreased in size by nearly 50% (Table 10). This decrease was a result of bank erosion that was occurring on the eastern portion of the site. Although the site decreased in size, total cover of the site was 87.5% in both years showing that it was successful. Species richness decreased a negligible amount from 19 in the sixth growing season to 18 in the seventh. However, 7 of the 18 species found on the site in 2007 were not found on the site in 2006. One species, of particular importance was sandbar willow. This species had the highest cover value in both monitoring years (Figure 93).

**3.7.3 Upstream Pabco South**

Three distinct areas (i.e., Upstream Pabco South 1, Upstream Pabco South 2, and Upstream Pabco South Lower Plateau) were monitored as part of the Upstream Pabco South (UPS) site. Over the five years of data collection, these areas were inconsistently monitored because in early years they were monitored separately and in later years they were monitored cumulatively or two at a time. Standard monitoring methods were difficult to apply at UPS because several years of flooding altered the configuration of the areas resulting in borders that were no longer discernable during the monitoring event. For this reason, monitoring data were combined even though the Upstream Pabco South Lower Plateau site is considered a revegetation site and not just a UPS monitoring area. Data were collected from all years except 2005 when a flood had severely altered the site. Although UPS was generally less than one acre, UPS was consistently classified as a wetland (Table 10). Total cover in 2006 was 84.8% which increased slightly to 87.5% in 2007. Species richness increased as well (from 30 to 35) while diversity decreased slightly from 2.23 to 2.19. Although the dominant species in both years was sandbar willow, Goodding’s willow, cottonwood, cattail and common reed were also
important cover components (Figure 94). Monitoring data show that UPS was a successful site and additional data collected beyond the scope of this report validate this assessment. For example, bird monitoring that was performed in the spring and summer of 2008 documented the occurrence of one male endangered southwestern willow flycatcher (Empidonax traillii extimus) for a one month period on UPS. Although vegetation monitoring data from 2008 are not included in this report, this occurrence shows that revegetation efforts on the Wash are successfully attracting wildlife species of conservation concern - a core success criterion for any riparian revegetation project in the Lower Colorado River basin.

3.7.4 Upstream Pabco North
Upstream Pabco North (UPN) was monitored in 2003, 2006, and 2007 because in 2004 and 2005 the site was reconfigured then revegetated to allow for less frictional flood flows across the Pabco Road Weir. Therefore, monitoring data from 2003 are presented here for informational purposes only and they are not used to evaluate site performance or trends. In addition, 2006 was presented as the first growing season and 2007 as the second because the site was reconfigured prior to 2006. In 2003, UPN was nearly 1.5 acres but after it was reconfigured it was greater than two acres (Table 10). Over the last two monitoring years, UPN grew by nearly a quarter acre. Also over this period, WPI scores and jurisdictional determinations show that UPN was a wetland site (Table 10). In 2006 and 2007 cover was high at 87.5% and four species had equal cover contributions in 2006 whereas in 2007 only one species had the highest cover (Figure 95). Richness and diversity decreased; from 43 to 23 and from 2.29 to 1.92, respectively. UPN was a successful site after the first year of planting. Hydrology on the site was ideal for a variety of hydrophytic plants in 2006, however, site hydrology was altered by 2007 so that less of the area was available for hydrophytes. Flooding in the area was responsible for these hydrologic shifts and as a consequence WPI scores are increasing as is the cover of common reed.

3.7.5 Upstream Pabco South Upper Plateau
Upstream Pabco South Upper Plateau (UPSUP) is a non-wetland revegetation site that was planted in the spring of 2002 and first monitored for this report after the second growing season in 2003 (Table 10). The size of the site decreased over the five years of monitoring by about a quarter acre. Although site size decreased, cover increased substantially with time (Figure 96). There were, however, no clear trends with species richness at UPSUP because these values were high in some years and low in others. The increase in species richness from the fifth to the sixth growing season likely resulted in the increase in diversity (1.48 to 1.91) over the same period (Figure 96). A few species contributed to the greatest cover in 2006 including, cottonwood, honey mesquite, and screwbean mesquite (Figure 97). By 2007, velvet ash (Fraxinus velutina) became an important cover component. Survivorship was measured after the second, third and fourth growing seasons as 85.7%, 90.5% and 96.8%, respectively. UPSUP was a successful site that had high cover values and survival rates.

3.7.6 Downstream Pabco South
Downstream Pabco South (DPS) is located in the floodplain directly downstream of the Pabco Road Weir. Because of its landscape position it is constantly affected by erosion and deposition from flood flows. DPS was planted in 2001 and it has been monitored in all years except for 2005. Site size has fluctuated from more than 4.5 acres to less than three acres (Table 10). Over
the last two monitoring years, DPS was confirmed as a wetland site by both WPI scores and jurisdictional determination data (Table 10). Like most other wetland sites, DPS exhibited increasing cover trends and besides a sharp rise in species richness in the fourth growing season, species richness has been relatively constant (Figure 98). Relatively constant richness likely resulted in the modest gain in diversity from the sixth to the seventh growing seasons (from 1.56 to 1.72) as the remaining species expanded in cover. Sandbar willows had the greatest cover for all species in 2006 but by 2007 Goodding’s willows and cottonwoods were equal in cover (Figure 99). Minimal cover from noxious weeds was documented. Survivorship was measured at 100% in the third growing season and 96.6% after the fourth. DPS was the largest wetland site associated with the Pabco Road Weir. Considerable time has passed since the site was planted and many flood events have occurred since that time. Monitoring data show that DPS was a successful site even though it has been reconfigured by floods many times.

3.8 Powerline Crossing Weir
There are eight revegetation sites associated with the Powerline Crossing Weir (Map 10). All of the sites were planted in 2007; therefore, all monitoring data represent the first growing season. Average cover for all eight revegetation sites was 38.7% and the average species richness was 13.5. The primary growth form found on the sites was graminoids, primarily a result of the abundance of species from the genus *Schoenoplectus* (Figure 100). Average survival for all Powerline Crossing Weir sites combined was 42.6% after the first growing season. These data do not reflect that Powerline Crossing Weir sites were successful; however, additional detail provided in the sections below indicates that some sites were successful.

3.8.1 Upstream Powerline North Emergent
Upper Powerline North Emergent (UPLNE) was the largest wetland site although it was only less than an acre in size (Table 11). Cover was measured at 15% and species richness and diversity were 31 and 2.76, respectively. The dominant species on the site was Olney three-square (*Schoenoplectus americanus*; Figure 101). There were two noxious species found; salt cedar with a cover of 2.5%, and tall whitetop with a cover of 0.5%. Survivorship was 23.8% after the first growing season. UPLNE is currently unsuccessful in terms of total cover and survivorship with the reduced survivorship mostly attributed to high soil salts on the northern portion of the site. Additional plantings may need to be conducted in order to achieve success at this revegetation site. Survivorship data for wetland sites like UPLNE, however, are somewhat difficult to interpret since survivorship measures do not accurately reflect the survival of graminoids that are planted on these site types. Indications of success, therefore, should more closely evaluate cover values. If future years of monitoring show an increase in cover then success would be confirmed.

3.8.2 Downstream Powerline North Bank
Downstream Powerline North Bank (DPLNB) is the smallest revegetation site associated with the Powerline Crossing Weir (Table 11). The WPI score confirms the jurisdictional determination that this site is a wetland (Table 11). Cover was measured at 62.5% with tules being the dominant species of the seven species found on DPLNB. There were no noxious species found on the site.
Map 10: Aerial photograph of delineated Powerline Crossing Weir revegetation sites.
3.8.3 Downstream Powerline South Bank
Downstream Powerline South Bank (DPLSB) is only slightly larger in area than DPLNB (Table 11) and it is also a wetland site both in terms of its jurisdictional determination and its WPI score (Table 11). Also like DPLNB, cover of the site was measured to be 62.5% with tules being the dominant species (Figure 103). There were nine species recorded on the site with one noxious species, salt cedar. Salt cedar had a cover of just 0.1% and therefore was not a potential problem in terms of achieving success on the site.

3.8.4 Upstream Powerline North Wet
Upstream Powerline North Wet (UPLNW) site was a confirmed wetland site with a WPI score near 1.0 (Table 11). Located on the northern end of the weir and measuring just over a tenth of an acre (Table 11) there were 14 species found on the site in its first growing season. Cover was 87.5% with tules being the dominant species (Figure 104). While this can be interpreted as the site being successful, future years of monitoring will determine if the success can be sustained.

3.8.5 Upstream Powerline North Plateau
With a WPI score over 4.0 (Table 11), Upstream Powerline North Plateau (UPLNP) is clearly an upland site. UPLNP had a cover of just 9.4% in its first monitoring year which took place just five months after its planting. Although UPLNP is just over four acres (Table 11), the site covers a large area and was not monitored as a single site. Therefore, the site was broken up into five smaller monitoring areas. Total cover for three of the five monitoring areas was 2.5% and 15% for the remaining two areas. The total survival rate was 63.6%. Fourwing saltbush was the most dominant of the 18 species found on the site (Figure 105). The site was known to have high salinity levels in the soil; therefore, fourwing saltbush was abundantly planted because of its salinity tolerance. These results demonstrate that this site was unsuccessful; however, this site

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No. of Sites: 8

1Wetland status in 2006 and 2007 resulting from a JD (i.e., jurisdictional determination) conducted according to the Corps’ 1987 Wetland Delineation Manual. “wet” = wetland and “non-wet” = non-wetland.

Wetland Prevalence Index (WPI) value. WPI≤2.0 = wetland, 2.0<WPI<2.5 = likely wetland, 2.5<WPI<3.5 = may be wetland, 3.5<WPI<4.0 = not likely a wetland, and WPI≥4.0 = upland (Tiner 1999).

Table 11: Acreage and wetland status for Powerline Crossing Weir revegetation sites from 2003 to 2007.
was still being irrigated and maintained often (Photograph 14). Future monitoring will determine its future success.

3.8.6 Upstream Powerline South Plateau
The largest revegetation site along the Powerline Crossing Weir is Upstream Powerline South Plateau (UPLSP) measuring close to eight acres (Table 11). UPLSP is similar to UPLNP in many ways including similar soils and salinity levels. These conditions likely resulted in low vegetation cover (8.9%) and this was similar to cover values that were documented at UPLNP. As with UPLNP, UPLSP is too large to monitor as one contiguous site and therefore it was split into four monitoring areas. Three of the four monitoring areas had a total cover of 2.5% with the remaining area at 15% cover. Of the 14 species found on the site, the dominant species on the site was fourwing saltbush (Figure 106). Salt cedar was the only noxious species found on the site and it had a 0.5% cover. Survivorship was 40.5% after the first growing season. The two main indicators of success, cover and survivorship, were poor. Additional plantings, a high level of maintenance, and continued monitoring will be necessary to ensure success of this site.

3.8.7 Upstream Powerline North Bank
Upstream Powerline North Bank (UPLNB) is a small non-wetland site adjacent to UPLNP. Only two species were found on the site in the first monitoring season, fourwing saltbush and quailbush. As with the other non-wetland sites along Powerline Crossing Weir, the soils were very saline and these two species were perhaps the most adapted to this condition. Fourwing saltbush was planted on the site while quailbush germinated on the site independently. Cover for UPLNB was only 0.5% with each of the two species making up half of species composition.

3.8.8 Upstream Powerline South Bank
The Upstream Powerline South Bank (UPLSB) is a small non-wetland site, less than a quarter of an acre, adjacent to the south side of the wash channel. Cover was measured at 62.5% with 13 species being recorded and a diversity of 1.24. There were two codominant species found on the site: tules and cottonwoods (Figure 107). The tules were harvested from the Pahranagat National Wildlife Refuge and the cottonwoods were pole plantings from trees previously established along the Wash. Survival was not recorded in this first year of monitoring, this will need to be done in future monitoring years in order to classify this site as successful or not.

3.9 Rainbow Gardens Weir
Rainbow Gardens Weir has four revegetation sites associated with it and all of these sites are located either upstream of the weir or on the south side of the Wash (Map 11). All four sites were monitored for the first time in 2006. These monitoring years represent the first and second
growing seasons for two of the sites and the second and third growing seasons for the remaining two sites (Table 12). Total cover for Rainbow Gardens Weir sites has increased by nearly 50% (Figure 108). A similar trend exists for species richness since 11 species were documented after the first growing season and 26 were documented after the third. The relative cover of growth forms was variable across the monitoring years and it appeared to be affected by the wetland/non-wetland status of the site. For example, high forb/herb growth form relative cover in the first growing season (Figure 109) was mostly affected by one non-wetland site and the dominance of splitgrass (*Schismus barbatus*) on that site. The second and third growing seasons have a more evenly distributed representation of each growth form.

<table>
<thead>
<tr>
<th>Site Code</th>
<th>1st Growing Season (year)</th>
<th>Acreage for Each Growing Season Monitored</th>
<th>Wetland Status</th>
<th>WPI&lt;sup&gt;2&lt;/sup&gt;</th>
<th>JD&lt;sup&gt;1&lt;/sup&gt;</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>RI</td>
<td>2005</td>
<td>nd 2.40 2.94</td>
<td>wet</td>
<td>1.58</td>
<td>1.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>URSB</td>
<td>2006</td>
<td>0.08 0.14 n/a</td>
<td>non-wet</td>
<td>3.00</td>
<td>2.95</td>
<td></td>
<td></td>
</tr>
<tr>
<td>URSE</td>
<td>2005</td>
<td>nd 1.06 1.11</td>
<td>wet</td>
<td>1.67</td>
<td>1.55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>URSP</td>
<td>2005</td>
<td>2.05 2.04 n/a</td>
<td>non-wet</td>
<td>3.33</td>
<td>3.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>2.13 5.64 4.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of Sites</td>
<td></td>
<td>2 4 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>1</sup>Wetland status in 2006 and 2007 resulting from a JD (i.e., jurisdictional determination) conducted according to the Corps’ 1987 Wetland Delineation Manual. “wet” = wetland and “non-wet” = non-wetland.

<sup>2</sup>Wetland Prevalence Index (WPI) value. WPI<sub>≤</sub>2.0 = wetland, 2.0<sub>&lt;</sub>WPI<sub>&lt;</sub>2.5 = likely wetland, 2.5<sub>≤</sub>WPI<sub>&lt;</sub>3.5 = may be wetland, 3.5<sub>≤</sub>WPI<sub>&lt;</sub>4.0 = not likely a wetland, and WPI<sub>≥</sub>4.0 = upland (Tiner 1999).

nd = no data

n/a = not applicable

Table 12: Acreage and wetland status for Powerline Crossing Weir revegetation sites from 2003 to 2007.

### 3.9.1 Upstream Rainbow South Bank
Jurisdictional determinations of Upstream Rainbow South Bank (URSB) show that it was a non-wetland site, and WPI scores also indicated that the site was not a wetland (Table 12). URSB was the smallest of all Rainbow Gardens Weir revegetation sites at approximately a tenth of an acre (Table 12). During the first growing season cover measured 62.5% and this measurement did not change in 2007. More than 95% of the cover was from quailbush in both monitoring years (Figure 110). The prevalence of quailbush on the site also explains the non-wetland WPI score. Species richness dropped by two-thirds in the two monitoring years from nine species in the first growing season to only three in the second. The reduction in richness is a common occurrence on sites where quailbush cover has increased. Moreover, URSB was intentionally unmanaged after it was planted to test the level of quailbush encroachment effect. Diversity was 0.29 in the first growing season and dropped to 0.20 in the second. Survivorship data were not collected at URSB because, by the first monitoring season, the intentionally planted plants exhibited nearly complete mortality from high soil salts and quailbush encroachment. Although survivorship data suggest that URSB was not successful, the presence and extent of quailbush (a native species) shows that the site was still properly functioning.
Map 11: Aerial photograph of delineated Rainbow Gardens Weir revegetation sites.
3.9.2 Upstream Rainbow South Emergent

Upstream Rainbow South Emergent (URSE) was first monitored in 2006, the second growing season (Photograph 15). The site slightly increased in size over the two years (Table 12) and it was identified as a wetland site by both WPI scores and jurisdictional determination data (Table 12). Cover on the site increased from 37.5% to 62.5% as species richness decreased from 33 to 26. There were two codominant species in 2006 (Figure 111), tules and Goooding’s willows. In 2007, seven species were equally dominant with 15% cover each; alkali aster (*Aster subulatus* var. *ligulatus*), common reed, sandbar willow, Goooding's willow, tule, salt cedar, and cattail. All of these species except for tules and Goooding’s willows had less than 5% cover in 2006. Overall, URSE was a successful site even though salt cedar cover was relatively high. Since the 2007 monitoring event, management efforts have been implemented to reduce salt cedar cover.

3.9.3 Upstream Rainbow South Plateau

Upstream Rainbow South Plateau (URSP) was determined to be a non-wetland revegetation site which was confirmed by WPI scores (Table 12). URSP was planted in the fall of 2005 and first monitored in 2006 after one growing season. Cover data from 2006 are somewhat spurious because total cover was documented as 2.5% (the midpoint of the 1-5% cover class) but splitgrass cover was 15% (the midpoint of the 5-25% cover class) during the same period (Figure 112). The discrepancy between these two values highlights the difficulty of attributing cover classes to vegetation cover that appears to be at the upper/lower limit of the class range. Therefore, for 2006, it appears that splitgrass cover was more likely near 5%. In 2007, total site cover was 15% which, depending on how the 2006 data are interpreted, could represent an increase or no change. Since the 2007 cover data were not lower than any 2006 measurement, than these data conservatively represent no change. Species richness slightly increased from 13 in the first growing season to 16 in the second. Survivorship was only measured after the first growing season and had 73.5% survival. The dominant species in 2006 was splitgrass, while splitgrass was codominant with creosote bush in 2007 (Figure 112). URSP data show that the site was not entirely successful. For example, 80% survival was not achieved in 2006 but it is unknown if this trend continued in 2007 because data were not collected that year.

3.9.4 Rainbow Islands

The Rainbow Islands (RI) revegetation site is a wetland site that was created in 2005 and first monitored in 2006 (after the second growing season). This site is located within the Wash channel itself and was created mostly by natural soil deposition in the impoundment upstream of the Rainbow Gardens Weir (Photograph 16). RI is located adjacent to URSE and as these sites age the shared border may become more difficult to distinguish; therefore, they may need to be monitored together (see UPS for similar scenario). RI was the largest Rainbow Gardens Weir site and it increased by more than a half acre in size between the two growing seasons (Table 12). Cover for both years of monitoring was 62.5% with more than half of the cover being
attributed to Gooding’s willow in both years (Figure 113). Cattails were equally dominant with Gooding’s willows in 2006 but decreased from 37.5% to 15% cover in 2007. Increases in site size, therefore, were likely attributed to gains in Gooding’s willow cover. Species richness declined from 39 in the second growing season to 26 in the third while diversity increased slightly from 2.04 to 2.14. A few noxious species were found on the site including tall whitetop, Johnsongrass, and salt cedar, each with less than 5% cover in both monitoring years.

3.10 Site 108
Site 108 (S108) is a unique site because it is the largest contiguous revegetation site along the Wash (Map 12; Table 13). It is not directly associated with any of the erosion control structures and was funded entirely by federal and state grants. S108 was funded from four different sources; NDEP, the Nevada Division of State Parks (NDSP), and the Southern Nevada Public Lands Management Act (SNPLMA) Rounds IV and V. The areas were planted in the spring and fall of 2006 based on their funding source and monitoring was conducted on 66 monitoring areas for the first time in 2007. The areas funded by NDEP were planted in the spring of 2006, however, these areas were not monitored in 2006. Therefore, 2007 monitoring data represent two growing seasons for NDEP funded areas and only one growing season for the others.

<table>
<thead>
<tr>
<th>Sub-Site Code</th>
<th>1st Growing Season (year)</th>
<th>Acreage for Each Growing Season Monitored</th>
<th>Wetland Status</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
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<tr>
<td>NDEP</td>
<td>2006</td>
<td>nd</td>
<td>7.75</td>
</tr>
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<td>NDSP</td>
<td>2007</td>
<td>13.91</td>
<td>n/a</td>
</tr>
<tr>
<td>SNPLMA IV</td>
<td>2007</td>
<td>14.32</td>
<td>n/a</td>
</tr>
<tr>
<td>SNPLMA V</td>
<td>2007</td>
<td>20.14</td>
<td>n/a</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>48.37</td>
<td>7.75</td>
</tr>
</tbody>
</table>

1Wetland status in 2006 and 2007 resulting from a JD (i.e., jurisdictional determination) conducted according to the Corps’ 1987 Wetland Delineation Manual. “wet” = wetland and “non-wet” = non-wetland.

2Wetland Prevalence Index (WPI) value. WPI\(\leq 2.0\) = wetland, \(2.0 < \text{WPI} \leq 2.5\) = likely wetland, \(2.5 < \text{WPI} < 3.5\) = may be wetland, \(3.5 < \text{WPI} < 4.0\) = not likely a wetland, and \(\text{WPI} \geq 4.0\) = upland (Tiner 1999).

nd = no data

n/a = not applicable

Table 13: Acreage and wetland status for Site 108 revegetation sub-sites from 2003 to 2007.
Map 12: Aerial photograph of delineated Site 108 revegetation monitoring areas.
The following sections are organized by funding source to describe site conditions in the first monitoring year. These areas are referred to as sub-sites. Because only one year of monitoring has been conducted, no temporal trends were established. Overall trends, however, show that total cover has not yet reached 80% and survivorship is less than 80% on most sub-sites. These data may change in subsequent years because S108 will continue to be irrigated in future monitoring years. A couple conditions were common across all sub-sites, they include the prevalence of surface salts and large patches without plant material. In addition, there was a high percentage of salt cedar debris cover remaining on the site after the initial clearing. These conditions may or may not be contributing to the low survival rate and slow growth rate of the plant material. Additional years of monitoring are needed to confirm/refute this conclusion.

**NDEP** – There were nine monitoring areas within this sub-site and it was the smallest of the four S108 sub-sites (Table 13). After the second growing season, total cover was 30.5% with alkali sacaton (*Sporobolus airoides*) being the dominant species of the 16 found in the area (Figure 114; Photograph 17). Cover for the nine monitoring areas range from 2.5% to 62.5%, with five of the areas having a cover of 37.5%. The monitoring area with just 2.5% cover was located on the southern end of the site and had a substantial amount of visible salts on the soil surface. Likely, soil salt was contributing to the low cover values. Survivorship data (82.8%) show that this sub-site was successful. Moreover, four of the monitoring areas had 100% survival. WPI scores show that this sub-site was a non-wetland (Table 13).

**NDSP** – The NDSP sub-site consists of 17 monitoring areas. Total cover for this sub-site after the first growing season was 58.4% and survival was 75.3%. Survivorship across the 17 monitoring areas, however, did vary from 32% to 100%. Cover also varied among the monitoring areas from 2.5% to 87.5% with six of the areas having 87.5%. Like the NDEP sub-site, the monitoring area with the lowest cover (2.5%) at the NDSP sub-site was located on the southern end of the site. Also like the NDEP sub-site, this sub-site was dominated by alkali sacaton which covered over 50% of the area (Figure 115) and WPI scores indicate that the sub-site was not a wetland (Table 13).

**SNPLMA IV** – Eighteen monitoring areas within S108 were funded by the fourth round of SNPLMA. Total cover for these monitoring areas was 31.3% after the first growing season. Cover, however, did range from 0.1% to 87.5%. The area with 0.1% cover had two species found within its boundaries and was located on the southern end of S108 and has a noticeably high level of salts on the soil surface. High soil salt likely resulted in relatively low cover
While low cover would indicate that this sub-site was currently unsuccessful, survival was 49.2%. This indicates that the sub-site contains salt tolerant species which may likely increase in cover in upcoming years. Survival ranged from 5% to 100% with just one area having 100% cover. Based on WPI values (Table 13), this sub-site would not be considered a wetland. Moreover, individual monitoring area WPI scores ranged from 2.5 to 4.7 with just four areas over the 3.5 threshold.

**SNPLMA V** – The largest of the four S108 sub-sites, SNPLMA V consists of 22 monitoring areas. This sub-site had the lowest cover values of all S108 sub-sites at 24.8% (Figure 117). Cover, however, did range from 2.5% to 87.5% across the monitoring areas. The overall WPI score (Table 13) indicated that the sub-site was not a wetland and individual monitoring area WPI scores ranged from 2.97 to 4.61 which are also non-wetland like values. Although average cover was relatively low, a 74.5% survival rate was encouraging. Five monitoring areas had 100% survival after the first growing season with the lowest survival rate of any monitoring area being a very unsuccessful 11%.

### 3.11 Site 111

Site 111 (S111) is the second largest revegetation site along the Wash and it was monitored in 2007 (Map 13; Table 14). The site was planted in the spring of 2007 and therefore only had one year of monitoring data. Like S108, S111 was too large to monitor as a single site so it was divided into 25 individual monitoring areas. Acreage weighted averaging of these 25 sites was used to calculate total vegetation cover and total species cover. Species richness was relatively high at 25 species found on the site, with a corresponding diversity value of 2.11. The species that most covers the site was honey mesquite (Figure 118); however, the dominance of species among monitoring areas varied. For example, cover from creosote bush and fourwing saltbush was highest toward the north of the site and cover from cottonwoods and willows were highest towards the eastern end of the site. Although the spatial differences in species cover are a legacy of the planting design that was used, they also reflect wetness gradients on the site. Overall, S111 can not be confidently classified as a wetland site because average WPI scores were \( \geq 2.5 \) and \(< 3.5\). Conservatively, S111 was a non-wetland site overall. WPI scores for each monitoring area confirm that there are multiple wetness types including xeric upland areas, mesic areas

<table>
<thead>
<tr>
<th>Site Code</th>
<th>1st Growing Season (year)</th>
<th>Acreage for Each Growing Season Monitored</th>
<th>Wetland Status</th>
<th>WPI²</th>
</tr>
</thead>
<tbody>
<tr>
<td>S111</td>
<td>2007</td>
<td>15.11</td>
<td>non-wet</td>
<td>2.92</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>15.11</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1Wetland status in 2006 and 2007 resulting from a JD (i.e., jurisdictional determination) conducted according to the Corps’ 1987 Wetland Delineation Manual. “wet” = wetland and “non-wet” = non-wetland.

2Wetland Prevalence Index (WPI) value. WPI\(\leq2.0\) = wetland, 2.0\(<\)WPI\(\leq2.5\) = likely wetland, 2.5\(\leq\)WPI\(\leq3.5\) = may be wetland, 3.5\(<\)WPI\(\leq4.0\) = not likely a wetland, and WPI\(\geq4.0\) = upland (Tiner 1999).

Table 14: Acreage and wetland status for the Site 111 revegetation site from 2003 to 2007.
Map 13: Aerial photograph of delineated Site 111 revegetation monitoring areas.
along shallow washes, and semi-hydric areas with shallow groundwater. WPI scores over the 25 monitoring areas range from 1.67 (considered to be a wetland area) to 4.48 (an indicator that the area is non-wetland).

Total cover for the site was 10% (Photograph 18), well below the 80% cover threshold used to determine site success. Total cover, however, varied among the monitoring areas with the highest cover values observed on the southeastern portion of the site. The highest cover value for any monitoring area was 37.5%, a value shared by three monitoring areas. These three areas are adjacent to each other in the eastern side of the site in the center and southern portions. A shallow wash passes through two of these areas with the third having topographic depressions where water collects from irrigation or precipitation. Although relatively low cover values were reported at S111, future years will likely show increasing cover as long as noxious species are controlled. For example, S111 was the only site where giant reed (*Arundo donax*) was found. (These species could quickly spread and dominate the site if not controlled.) Common reed was also a concern because it was the third most common cover component on the site (Figure 109). Without proper control, common reed may out-compete desirable species for resources (i.e., space, water, minerals, etc.). If during future years of monitoring, cover does not increase, additional plantings may be necessary to achieve successful cover values. Survivorship data show that S111 was not meeting minimum levels of performance. The total survival for the entire site was 78.1% in the first monitoring year which is slightly below the threshold of 80% indicating success. Survivorship data for the monitoring areas show a somewhat different result. Four sites had survival of 100% in the first monitoring year, including the monitoring area with the lowest WPI score of 1.67. The lowest survival rate was 36% on a monitoring area in the northern end of the site. This site had just four species on it with less than 1% cover. Due to S111 being a very large site, overall survivorship data are encouraging. Additional years of monitoring after further maintenance will determine the long-term performance of the site.

### 4.0 RECOMMENDATIONS

Monitoring data show that the majority of revegetation sites were successful or along a trajectory of success. Some of the major trends that were documented or other important information that was collected at these sites included: (1) total vegetative cover increased with time unless management actions were performed to intentionally remove material, (2) wetland sites were covered more quickly by vegetation than non-wetland sites, (3) several years of growth were
required for a non-wetland site to achieve 80% cover, (4) wetland sites were typically covered by more than 80% in the first growing season, (5) species richness and vegetation cover were negatively correlated, (6) species richness and diversity was higher than pre-revegetation conditions, (7) sites that had WPI scores less than 2.0 were wetland sites according to the Corps’ 1987 Wetland Delineation Manual, (8) survivorship was greater than 80% after the second year of growth and this value increased with time, and (9) undocumented changes in vegetation structure occurred.

Vegetation monitoring was conducted for a variety of reasons including for regulatory purposes, grant requirements, and to simply evaluate revegetation program effectiveness. Based on the data collected herein and in order to continue to meet the goals of the LVWCC, several recommendations for the vegetation monitoring program and the revegetation program in general are provided:

(1) WPI methods should be used to document wetland sites along the Wash. This method was simple and straightforward and it correlated exceptionally well with approved wetland designation methods.

(2) Species richness trends should not be used to evaluate site success. Rather, species richness should be monitored to evaluate the occurrence of desirable native plants and undesirable noxious weeds for a site. These data should then be used to direct management actions such as where to perform weed removal. For species richness to be used as a proper measurement of success, two trends should be achieved; native species richness that is greater than pre-revegetation conditions or native species richness equal to the richness of the site when it was first revegetated.

(3) Survivorship data should not be used to measure the success of a wetland site. Wetland sites are often planted with clonal, rhizomal, or otherwise multi-stemmed growth forms and therefore they are not easily counted. Instead of evaluating survivorship data on wetland sites, success should focus on evaluating native species cover.

(4) Measurements of height should be collected from revegetation sites because these data are important to characterize structural characteristics that are important to wildlife.

(5) Monitoring should be conducted for a minimum of two years to evaluate performance trends.

(6) Common reed removal should be more aggressive on wetland sites because this species quickly invades wetland revegetation sites.

(7) Monitoring techniques should adapt to site conditions, but they should be consistently applied so that results can be evaluated together.

(8) Field based monitoring should generally be completed to evaluate site performance; however, remotely sensed data should be evaluated as an alternative tool to measure success.
(9) Seeding techniques should be used more often than container planting techniques on non-wetland sites since high cover values are achieved more quickly.

(10) Survivorship performance criteria should be reduced from 80% to 75% and this criterion should only be used during the first two planting seasons.

(11) Revegetation sites should be managed based on the dominant conditions affecting the site. For example, sites that have a high likelihood of germinating from prolific species located on adjacent stands should not be planted. Management actions should be focused on sites where germination by native plants is least likely to occur.

5.0 LITERATURE CITED


Appendix A
Plant species codes
List of species codes, scientific names and common names of plant species recorded in vegetation monitoring

<table>
<thead>
<tr>
<th>Species Code</th>
<th>Scientific Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACBA</td>
<td>Acacia baileyana</td>
<td>Cootamundra wattle</td>
</tr>
<tr>
<td>ACGR</td>
<td>Acacia greggii</td>
<td>Catclaw Acacia</td>
</tr>
<tr>
<td>AMAL</td>
<td>Amaranthus albus</td>
<td>Tumbleweed</td>
</tr>
<tr>
<td>AMDU</td>
<td>Ambrosia dumosa</td>
<td>Burro bush / White Bursage</td>
</tr>
<tr>
<td>ANCA</td>
<td>Anemopsis californica</td>
<td>Yerba Mansa</td>
</tr>
<tr>
<td>ARDO</td>
<td>Arundo donax</td>
<td>Giant reed</td>
</tr>
<tr>
<td>ASSU</td>
<td>Aster subalatus var. ligulatus</td>
<td>Alkali aster</td>
</tr>
<tr>
<td>ATCA</td>
<td>Atriplex canescens ssp. canescens</td>
<td>Four-wing saltbush</td>
</tr>
<tr>
<td>ATCO</td>
<td>Atriplex confertifolia</td>
<td>Shadscale</td>
</tr>
<tr>
<td>ATEL</td>
<td>Atriplex elegans var. fasciculata</td>
<td>Wheelscale</td>
</tr>
<tr>
<td>ATHY</td>
<td>Atriplex lentiformis</td>
<td>Quail bush</td>
</tr>
<tr>
<td>ATPO</td>
<td>Atriplex polycarpa</td>
<td>Allscale</td>
</tr>
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<td>Atriplex torreyi</td>
<td>Torrey's saltbush</td>
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<tr>
<td>BAEM</td>
<td>Baccharis emoryi</td>
<td>Emory waterweed</td>
</tr>
<tr>
<td>BAHY</td>
<td>Bassia hyssopithylla</td>
<td>Bassia</td>
</tr>
<tr>
<td>BMU</td>
<td>Baileya multiradiata</td>
<td>Desert marigold</td>
</tr>
<tr>
<td>BAPL</td>
<td>Baileya pluriradiata</td>
<td>Wooly desert marigold</td>
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<td>Baccharis salicifolia</td>
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<td>Broom baccharis</td>
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<td>BRMA</td>
<td>Bromus rubens</td>
<td>Red brome</td>
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<tr>
<td>BRMU</td>
<td>Bromus rubens</td>
<td>Red brome</td>
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<td>Maltese star-thistle</td>
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<td>Lamb's quarters</td>
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<td>CHAM</td>
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