

Las Vegas Wash Coordination Committee

Upper Diversion Weir Planting Plan



Southern Nevada
Water Authority

November 2008



www.lvwash.org



**Upper Diversion Weir
Planting Plan**

**SOUTHERN NEVADA WATER AUTHORITY
Las Vegas Wash Project Coordination Team**

Prepared for:

U. S. Army Corps of Engineers
St. George Regulatory Field Office
321 N. Mall Drive, L-101
St. George, UT 84790

Prepared by:

Southern Nevada Water Authority
Las Vegas Wash Project Coordination Team
100 City Parkway, Suite 700
Las Vegas, NV 89106

November 2008

Upper Diversion Weir Planting Plan

Table of Contents

	Page No.
Table of Contents	<i>i</i>
List of Figures	<i>ii</i>
List of Appendices	<i>ii</i>
1.0 PURPOSE AND GOALS OF THE PLANTING PLAN	1
2.0 PROJECT SUMMARY	1
2.1 Site Location	1
2.2 Site Conditions	3
2.2.1 Vegetation	3
2.2.2 Soils	3
2.2.3 Wildlife	3
3.0 REVEGETATION DESIGN	4
3.1 Phase 1 Revegetation	5
3.2 Phase 2 Revegetation	5
4.0 PROJECT IMPLEMENTATION	5
4.1 Planting Methods and Materials	5
4.2 Invasive Species Management	7
4.2.1 Salt Cedar	7
4.2.2 Tall Whitetop and Giant Reed	8
4.3 Irrigation	8
5.0 PROJECT MAINTENANCE AND MONITORING	9
5.1 Maintenance	9
5.1.1 Replanting and Contingency	9
5.2 Monitoring	9
5.2.1 Vegetation	9
5.2.2 Water Quality	10
5.2.3 Additional Biological Resources	10

List of Figures

	Page No.
Figure 1. Clark County Wetlands Park Boundary.....	2
Figure 2. Upper Diversion Weir Location.....	2

List of Appendices

Appendix A	Plants Observed Along the Las Vegas Wash
Appendix B	Wildlife Observed Along the Las Vegas Wash
Appendix C	Upper Diversion Weir Planting Design
Appendix D	Upper Diversion Weir Irrigation Design

1.0 PURPOSE AND GOALS OF THE PLANTING PLAN

A variety of erosion control activities are currently being implemented along the Las Vegas Wash (Wash) as part of a comprehensive stabilization and ecological restoration strategy. These activities include the construction of weirs and bank stabilization structures. Because these structures are constructed within the boundaries of jurisdictional waters of the U.S., they are subject to regulatory compliance as outlined by the Clean Water Act. Erosion control structures that are constructed along the Wash are typically permitted under the nationwide permit program. Nationwide permits (NWP) are a type of general permit issued by the U.S. Army Corps of Engineers (Corps) and are designed to regulate with little, if any, delay or paperwork certain activities having minimal impacts to jurisdictional waters of the U.S. Current stabilization activities in the Wash are permitted under NWP 27 (stream and wetland restoration activities) and NWP 3 (maintenance). Although stabilization activities are permitted under the NWP program, post-construction mitigation is required, and mitigation activities typically consist of planting native vegetation on areas adjoining the erosion control structure. This plan was developed to meet Corps requirements for erosion control activities engaged by the Southern Nevada Water Authority (SNWA) along the Wash.

The purpose of this plan is to describe the revegetation strategies to be implemented at the recently completed Upper Diversion Weir. Not only do these revegetation activities help us meet our regulatory requirements, but they also provide for additional erosion control and habitat for the diverse fauna found in the Wash ecosystem. The general goals for this and other revegetation activities along the Wash are to develop ecologically functioning wetland, riparian, and upland areas that are self-sustaining in the long-term. Revegetation activities are coordinated by staff from SNWA's Las Vegas Wash Project Coordination Team as part of wetland mitigation requirements specified by the Corps.

Specific activities required to successfully revegetate areas along the Wash are described herein. Typically these activities include removal of non-native invasive species, investigation of soil condition, identification of the subsurface hydrologic condition, and planting native vegetation. Also included in this document are brief descriptions of monitoring strategies for revegetation sites, water quality, and an array of biological resources found along the Wash. Revegetation site monitoring provides us with an indication of site success while monitoring additional biological resources provides us with an indication of proper ecosystem functioning.

2.0 PROJECT SUMMARY

2.1 Site Location

The Upper Diversion Weir is located within the Clark County Wetlands Park (Figures 1 and 2). It is located along the lower Wash, approximately 5.5 miles upstream of the channel intake structure for the Lake Las Vegas Resort development.



Figure 1: Clark County Wetlands Park Boundary.



Figure 2: Upper Diversion Weir Location.

2.2 Site Conditions

2.2.1 Vegetation

The Upper Diversion Weir is unique to other weirs constructed along the Wash as there was a permanent diversion channel constructed parallel to the Wash to support between 40-60% of normal flows as well as excess stormwater flows. Prior to construction, the Upper Diversion Weir site was fully bordered on the north and south by riparian and wetland vegetation. Riparian plant species that were found near the site include salt cedar (*Tamarix ramosissima*) and quailbush (*Atriplex lentiformis*), while wetland species include common reed (*Phragmites australis*) and southern cattail (*Typha domingensis*). On the historical floodplain, creosote bush (*Larrea tridentata*) and salt cedar dominate. Other plants, however, have been observed in the vicinity of the site (Appendix B).

2.2.2 Soils

Soils data is important to investigate prior to developing site revegetation strategies. Soil composition and profile are important indicators for determining the potential success of a revegetation project as it can detail the subsurface conditions that plants will be exposed to. Soil texture (i.e., the amount of sands, silts, and clays) and below ground moisture gradients can often be the limiting factors for plant survival and growth. Along the Wash, soil descriptions and analyses can be helpful to determine their suitability, limitations, and management for specific uses. Soil texture for most of the planting site is a sandy loam to silty loam. These textures offer good drainage conditions for revegetation activities. Soil hydrology differs substantially across the planting areas with greater than ten feet depth to water on the upland areas and less than five feet depth to water on the lower planting areas. For this reason, plants to be used in these areas will need to vary.

2.2.3 Wildlife

Studies by Bradley and Niles in the early 1970s identified the presence of 2 fish, 6 amphibians, 29 reptiles (1 tortoise, 13 lizards, and 15 snakes), 39 mammals (1 shrew, 10 bats, 16 rodents, 2 rabbits, 9 carnivores, and 1 ungulate), and 161 birds along the Wash corridor (Appendix C). These data were compiled from a variety of sources including biological inventory studies, personal records and notes, and published literature. Quantitative information collected from this historical account may prove useful for comparative purposes. As a result of increasing water flows, habitat that is available to animals has changed dramatically since this time. Wetland habitat, consisting primarily of emergent vegetation (i.e., cattails, bulrush, etc.), has been reduced more significantly than transitional vegetative communities such as saltbush scrub and mixed shrub-woodlands.

Current systematic biological inventory studies have shown that wildlife communities along the Wash have been altered, however, many of the species that were found in the 1970s are still found along the Wash today. Further, some taxa that have been observed recently were previously not recorded along the Wash. Of the 231 species that were reported by Bradley and Niles, 67% of them have been observed during current inventory studies. As of 2006, recent studies indicate that there are 7 fish, 2 amphibians, 15 reptiles (13 lizards and 2 snakes), 26 mammals (1 shrew, 10 bats, 9 rodents, 2 rabbits, 4 carnivores), and 128 birds along the Wash corridor.

3.0 REVEGETATION DESIGN

The Wash plays an important role in the ecological integrity of the region. Prior to modern settlement of the Las Vegas Valley, the Wash was a typical ephemeral desert wash. Vegetation was characteristic of a desert drainage. As the population of Las Vegas grew, the discharge of reclaimed water into the Wash increased. With the addition of this new and seemingly replenishable supply of water in the Wash, the once ephemeral desert wash underwent dramatic changes. Hydrologic changes resulted in permanent surface water flows and elevated groundwater levels, which caused a transition from xeric and mesic plant communities to more hydric plant communities. The Wash slowly started to transform from a desert wash to a desert riparian ecosystem. During this change, pioneering plants, many of which are non-native, came to dominate. Revegetation activities along the Wash do not attempt to restore the pre-settlement desert vegetation nor the post-settlement non-native vegetation; rather, these activities attempt to create similar native vegetative conditions found along many of the riparian drainages of the lower Colorado River basin.

Typical native vegetation found in the lower Colorado River basin includes Fremont cottonwood (*Populus fremontii*), willows (*Salix* spp.), mesquites (*Prosopis* spp.), arrowweed (*Pluchea sericea*), wolfberry (*Lycium* spp.), seepwillow (*Baccharis salicifolia*), saltbush (*Atriplex* spp.), cattails (*Typha* spp.), and bulrush (*Schoenoplectus* spp.). These species are found in areas where hydrologic and edaphic conditions permit. Revegetation sites along the Wash provide suitable environmental conditions for these species as well as for other more desert adapted species like creosote bush and white bursage (*Ambrosia dumosa*). Revegetation sites are generally designed to maximize native vegetative coverage, while also providing for physiognomic features that mimic native riparian conditions.

Hydrologic and edaphic conditions near the Upper Diversion Weir are suitable to plant much of the native vegetative features that are typical of a southwestern riparian area. Three distinct planting conditions in order of decreasing water availability, wetland, riparian, and upland, are found adjacent to the Upper Diversion Weir. Wetland areas are located within and adjacent to the channel where saturated soils or standing water is present. Plants that can be planted here include alkali bulrush (*Schoenoplectus maritimus*), Olney's threesquare (*S. americanus*), California bulrush (*S. californicus*), hardstem bulrush (*S. acutus*), common threesquare (*S. pungens*), baltic rush (*Juncus balticus*), and Cooper's rush (*J. cooperi*). Riparian areas were created during the construction of the diversion channel in the form of shelves in between the waters edge and the upland area. Plants that can be planted in this area include Fremont cottonwood, Gooding willow (*Salix goodingii*), sandbar willow (*Salix exigua*), seepwillow, salt grass (*Distichlis spicata*), yerba mansa (*Anemopsis californica*), and wolfberry. Where groundwater depths have become too deep for riparian plants to use, xeric upland plants start to dominate. Plants that are used to revegetate these areas include creosote bush, white bursage, catclaw acacia (*Acacia greggii*), desert willow (*Chilopsis linearis*), broom baccharis (*Baccharis sarothroides*), fourwing saltbush (*Atriplex canescens*), shadscale (*A. confertifolia*), screwbean mesquite (*Prosopis pubescens*), alkali sacaton (*Sporobolus airoides*), honey mesquite (*Prosopis glandulosa* var. *torreyana*) and desert saltbush (*A. polycarpa*). To meet mitigation requirements, upland followed by riparian and wetland acreage will be planted.

3.1 Phase 1 Revegetation

The first phase of revegetation at the Upper Diversion Weir was accomplished during a “Green-Up” volunteer planting day. This revegetation effort focused on the desert upland matrices on the north and south sides of the diversion channel. The desert upland area is approximately 12.5 acres in size. The site was planted on September 27, 2008. The desert upland matrices for the north and south side described above were utilized for this revegetation effort and included, creosote bush, white bursage, four-wing saltbush, globe mallow, alkali sacaton, screwbean mesquite, honey mesquite, and catclaw acacia.

3.2 Phase 2 Revegetation

The second phase of revegetation at the Upper Diversion Weir includes the planting of riparian and wetland areas. Riparian areas will be planted in December 2008 and included Goodding’s and sandbar willows, Fremont cottonwood, yerba mansa, and seepwillow among others. Wetland areas are already being passively established by cattails and supplemental plantings will take place in December 2008 – January 2009 with a variety of bulrush species. These wetland areas include approximately 0.7 acres.

4.0 PROJECT IMPLEMENTATION

4.1 Planting Methods and Materials

Data gathered from past and present monitoring activities have helped us refine our planting methods and materials. This includes determining the best period of the year to plant and a list of plants that perform well in our area (see species lists under Revegetation Design). Through these efforts, we have identified that late September through early November and late February through early April are the best planting periods of the year. Vegetation planted during these periods is helped by above average precipitation that generally falls during the summer and winter months in Las Vegas. The exception to this is pole plantings or transplants which do best in times of dormancy, specifically late November through early February. Upper Diversion Weir planting events have been conducted or otherwise planned during these peak periods of success.

Riparian and upland plants that have been or will be used to revegetate the Upper Diversion Weir are primarily containerized stock, pole cuttings, and plugs. One-gallon stock is typically used for shrub species and poles are often used for the cottonwood and willow species. Since wetland plants typically grow as multiple stems, saltgrass, threesquare and California bulrush are be planted as plugs from flats of various sizes. There are two local nurseries where we normally purchase plant material for our planting projects: the Nevada Division of Forestry Nursery at Floyd Lamb State Park and the National Park Service Nursery at Lake Mead National Recreation Area. If desirable species are not available from either nursery, local commercial native plant nurseries are used. Prior to planting, sites were roughed up with a soil scrapper. This is done because areas within construction easements are often very compacted and they are sprayed with dust suppressant after weir completion. These conditions harden the surface of the soil and do not beneficially contribute to native plant recruitment.

After the soil surface was prepared and an irrigation strategy was designed (see discussion below), holes were pre-dug using shovels and a Bobcat[®] skid-steer loader with an attached auger. Depressions were created around shrubs and trees so that moisture is retained close to the plant.

Trees were interspersed within a planting zone and were spaced approximately 5-15 feet apart (depending on type). Shrubs and other low vegetation were planted at closer distances in tree interspaces. Planting densities at our revegetation sites range from 100-700 plants per acre, depending on site configuration. The greatest success that we have observed is from sites that have been planted densely and with a diverse species palette. Therefore our strategy for the Upper Diversion Weir was to plant densities around 300-700 plants per acre with as many species as possible. Although high-density plantings may be most successful in the short-term, long-term competition between species will likely reduce total plant survivability. This is to be expected but by crafting revegetation strategies for high diversity and density, the most well adapted species will ultimately dominate. This “shotgun” approach has proven effective at our mitigation sites, since underlying obscured site conditions are not always determined prior to implementation.

The Upper Diversion Weir revegetation sites are located on both the north and south sides of the Wash. For ease of planting, the site was broken down into five matrices and eighteen polygons based on the hydrologic and edaphic conditions determined at the site. A detailed revegetation design is located in Appendix C. The revegetation plan shows big galleta grass (*Pleuraphis rigida*) being used, however adequate quantity of this species was not available in time for planting so alkali sacaton was substituted.

Matrix A - North Side (Polygons 1-7)

This area is characterized by deep groundwater depths which will support xeric upland plants. Therefore, the desert upland matrix consists of a diversity of native drought tolerant species, including creosote bush, white bursage, fourwing saltbush, alkali saltbush, desert broom, wolfberry, globe mallow, screwbean mesquite and honey mesquite. Polygons 1, 2, 3, 6 and 7 all have washes that cross the polygon from east to west draining into the diversion channel. These areas had more plants dedicated to them mimicking natural plant densities in surrounding areas. Five gallon containers of honey mesquite and screwbean were planted at a random spacing for a total density of 182 and 232 trees per acre, respectively only in wash areas. Five gallon containers of creosote bush were planted in random groupings 15 feet on center at densities of 74 shrubs per acre. One gallon containers of the remaining plants were randomly placed throughout the remaining areas.

Matrix B - North Side (Polygons 8-11)

Like Matrix A, this area is characterized by deep groundwater depths which will support xeric upland plants. Unlike the polygons in Matrix A, there are no washes crossing the polygons and the areas extend further away from the diversion channel. Therefore fewer plant types were suitable to be planted in this area. Honey and screwbean mesquite make up the majority of the plants with 184 and 226 plants per acre, respectively. The remaining plants were four-wing saltbush which was planted at 56 plants per acre and wolfberry at 67 plants per acre.

Matrix C - Upland Island (Polygons 12-14)

This area has similar soil and hydrologic conditions as Matrices A and B but is bordered on the east by the diversion channel and on the west by the Wash. Five species were selected to be planted in this area, desert broom, creosote bush, honey mesquite, screwbean mesquite and alkali sacaton. Honey mesquites in 15-gallon containers were planted at a density of 40 trees per acre,

these larger trees will help take up space that could be colonized by invasive species. Creosote bush and screwbean mesquites were 5-gallon containers planted at 40 plants per acre. Alkali sacaton and desert broom were both 1-gallon plants planted at 119 and 40 plants per acre, respectively.

Matrices D and E - Riparian Shelves (Polygons 15-18)

These two polygon areas are closer to the water and have the hydrology that will support riparian plants such as yerba mansa, sandbar willow, seepwillow, cottonwoods and Goodding's willow. Yerba mansa, sandbar willow, and seepwillow will be planted from one gallon containers while pole cuttings will be used to plant cottonwood and Goodding's willow trees.

4.2 Invasive Species Management

The federal government defines an "invasive species" as: (1) non-native (or alien) to the ecosystem under consideration, and (2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health. Once plants have been provided water, sunlight, air, minerals, and space, competition with other plants for these resources may be the only impediment towards achieving a successful planting site. Typically, invasive species out-compete native species for resources and therefore displace native species to marginal habitats. This often results in the decline of native taxa. At revegetation sites along the Wash, invasive species are controlled by a variety of methods. These activities allow the optimal conditions for native plants to succeed. The Nevada Noxious Weed List outlines particularly harmful species in our state and it serves as the list of species that we manage at our planting sites. Some of these species have been reported along the Wash and management strategies for their control are discussed herein.

4.2.1 Salt Cedar

Salt cedar is a highly invasive non-native species that has been present in the Wash for over 30 years. It is currently the most dominant tree taxa found along the Wash and estimates of its infestation exceed 1,500 acres. The primary goal for managing salt cedar is to prevent the invasion of this taxa into newly revegetated areas. Since salt cedar is typically cleared around erosion control structure facilities, we are able to control its re-infestation by implementing a variety of suppression techniques. A summary of the techniques used to control salt cedar along the Wash during pre- and post-construction of erosion control structures is as follows.

Chemical application techniques have proven to be effective in controlling salt cedar. Garlon[®] 4 (triclopyr; Dow AgroSciences, Indianapolis, IN) herbicide can be applied basally to the cut stumps of salt cedar trees. This method involves cutting the tree at ground level with a chain saw, and then immediately spraying the remaining stump with the herbicide. The material can then be moved to a stockpile location to await permanent disposal (i.e., by controlled burn). For extensive infestations, mechanical clearing can be an effective control technique. Mechanical clearing is achieved by removing the plants root crown from the soil using a root plow. This method can be followed up by herbicide applications if required. Another form of mechanical clearing is achieved by simply hand-pulling re-sprouting plants. This technique is labor intensive, however, under the right circumstances it can be quite effective. These methods may be used to control salt cedar at the Upper Diversion Weir planting sites.

4.2.2 Tall Whitetop and Giant Reed

Tall whitetop (*Lepidum latifolium*) and giant reed (*Arundo donax*), non-native invasive weeds found in many western riparian drainages, have only recently been found in the Wash. Tall whitetop infests considerably more acreage than giant reed but because their distributions in the Wash are still somewhat limited, there is an aggressive campaign to remove them before they further spread. Herbicide application to the foliage is the method of choice for controlling these species. Rodeo[®] (glyphosate; Dow AgroSciences, Indianapolis, IN) and Escort[®] (metsulfuron methyl; DuPont, Wilmington, DE) is applied as needed to reduce the infestation. If tall whitetop or giant reed is found on Upper Diversion Weir planting sites, they will be controlled by these methods.

4.3 Irrigation

Supplemental irrigation is important for plant establishment since precipitation near the Wash is generally less than five inches a year. Wetland plants, however, do not require supplemental irrigation as long as they are in saturated or standing water conditions. Wetland plants will not be planted away from these areas, therefore supplemental irrigation is not required. Instead, our irrigation strategies primarily concentrate on riparian and upland plants. Riparian plants quickly develop extensive root systems that exploit groundwater sources, which allow them to depend less on supplemental irrigation. Upland plants, however, require extensive irrigation to become established.

The site will be irrigated with a system typically used in large-scale agriculture that can be re-used and moved to other revegetation locations at the end of the project. The water for irrigation will be pumped out of the Wash using a John Deere[®] motor with a six cylinder Cornell Pump (172 HP at 1886 RPM) mounted on an axle tank trailer with a ten inch diameter suction and eight inch diameter discharge. The pump pad and ramp will be located midway along the east side of the diversion channel. Six inch diameter mainline CERTA-LOK piping will transport the water from the pump to multiple three inch diameter above ground CERTA-LOK lateral lines spaced approximately 45 feet apart. The pipe crosses the diversion channel under the weir bridge to the island. The lateral lines will transport the water to Nelson R2000 WF Rotator heads with a three-inch take off assembly on a 30 by 40 foot grid. The rotator heads will be connected to flexible hose heads and movable posts in order to reposition the heads as needed during plant growth. The spray radius of each head is 25 feet, therefore spraying overlaps to ensure that the entire site receives complete coverage.

Each lateral line will have a shutoff valve located on the mainline in order to control the amount of water available to each section. There will also be a mainline isolation valve which controls the delivery of water to an entire section of lateral lines. These shut-off and isolation valves will be useful to isolate areas that require more or less irrigation without having to reassemble the entire system. Also, they will be useful in the case of a water leak or irrigation malfunction, by terminating water flow to a section under repair prevents an unnecessary waste of water. The irrigation design is located in Appendix D.

5.0 PROJECT MAINTENANCE AND MONITORING

5.1 Maintenance

5.1.1 Replanting and Contingency

Although this planting plan aims to create functioning wetland, riparian, and upland areas that are self-sustaining in the long-term, it is possible that environmental (e.g. flood events) and/or anthropogenic (e.g. vegetation destruction by off highway vehicle users) disturbances reduce the success of planted vegetation. Further, although every effort is made to pair plants with locations that appear to provide edaphic and hydrologic conditions favorable for their survival, it is possible that other, more obscured site conditions do not permit plant success. For this reason additional vegetation may need to be planted during future periods.

If permit requirements of 80% survival of native species planted with less than 20% encroachment of invasive species is not reached within the two year monitoring period, further mitigation activities will be developed and implemented at the site to ensure the objective of developing long-term, self-sustaining wetlands that are not dependent on further human intervention after the establishment period is reached.

5.2 Monitoring

5.2.1 Vegetation

In order to determine the effectiveness of revegetation activities, a variety of general vegetation parameters could be measured. Parameters that will be monitored for Wash revegetation projects, and have been approved by the Corps, include species composition, percent cover, survival rates, and encroachment of non-native weeds.

In order to determine species composition, field personnel walk random transects within the boundaries of the revegetation site until the n th species is found. This method allows for a complete inventory of all plants on a revegetation site.

Percent cover is an important characteristic to monitor in a stand of vegetation because it can serve as a criterion for relative dominance within the community. Cover is expressed as a percentage value and in a multi-layered community it can often exceed 100%. In a multi-layered community it may be important to separate cover estimates into different strata. In order to determine percent cover for revegetation sites, line-intercept, cover class and/or aerial photographic interpretation methods are used. In the line-intercept method, a tape is stretched between two stakes, and the canopy of a species that vertically projects over the tape is measured along its length. The total length of tape that is intercepted by the vertical projections of a species by the total length of tape is the percent cover. Line-intercepts are of sufficient length to reflect the community and allow for an accurate estimate of percent cover by species. Line-intercept data also provides an estimate of cover for both native (i.e., planted and passive) and non-native weed encroachment. As community physiognomy changes, the line-intercept method may prove too difficult to implement and other methods may have to be used (e.g., cover estimates from aerial photographs, Braun-Blanquet cover class, etc.). Methodologies to determine percent cover are dictated by site conditions.

Revegetation sites are often deemed a success by the number of plants that survive after plantings have stopped and a period of time has passed since intensive management. This is a general indicator that plants will continue to survive in the environment after revegetation

activities have been completed. An appropriate method of measuring survival for a revegetation project is to simply count the number of planted plants that remain viable during the growing season. Using this method, survival can be expressed as a percentage where the number of plants that are viable is divided by the total number of plants on a site and then multiplied by 100. This survivability measure can be compared from growing season to growing season and ultimately expressed as a rate of survival.

The procedures for which survivability and survival rates are estimated is as follow. In order to determine post-planting survivability and survival rates, estimations are made using strip-transect methods and/or random point sampling. Strip-transects are of sufficient length and width to accurately estimate survivability measures and random sample points are identified with the aid of geographic information system software. As community physiognomy changes, the strip-transect and/or random point sampling method may prove too difficult to implement and other methods may have to be used (e.g., infra-red aerial photographic interpretation, plot sampling, etc.). Methodologies to determine survivability and survival rate are dictated by site conditions.

5.2.2 Water Quality

Wash water quality is an important feature to monitor since we use this water to irrigate our revegetation sites. Water in the Wash comes from a variety of sources in the Las Vegas Valley, including stormwater, urban runoff, shallow groundwater, and reclaimed water. Each water source has a unique chemical signature. For example, shallow groundwater is typically high in salt content while reclaimed water is not. In an effort to monitor water quality for this program and other watershed management initiatives, SNWA engages in a comprehensive monitoring program. Water quality monitoring includes real-time mainstream, monthly mainstream, and quarterly tributary monitoring. A variety of water quality parameters are evaluated including nutrients, metals, temperature, pH, dissolved oxygen, and electrical conductivity. Monitoring data provides us with valuable information to facilitate successful irrigation strategies at our revegetation sites.

5.2.3 Additional Biological Resources

Revegetation activities may potentially benefit many of the biological resources found along the Wash (Appendix B). In order to document these benefits, multiple fish and wildlife monitoring studies have been implemented. Species that are currently being monitored include birds and bats, however, other monitoring activities that have been completed include studies for amphibians, small mammals, reptiles, and fish.

Birds are the most probable taxa to quickly benefit from the construction of erosion control structures and subsequent revegetation activities. Habitat values for water dependent species will increase in the ponded areas behind the erosion control structures, while riparian and wetland revegetation activities adjacent to the channel will improve habitat for other taxa. This is important since 80% of the breeding bird population in North America and 50% of the protected migratory bird population rely on riparian zones. In the southwestern U.S., most riparian areas are in decline as a result of anthropogenic disturbances or water resource management. Unique ecosystem enhancement projects like that found along the Wash aim to reverse these trends.

Appendix A
Plants Observed Along the Las Vegas Wash

List of species detected by Bradley and Niles (1973) and Shanahan and Silverman (2006). Species presence is indicated by a 1. Family and species names follow the Integrated Taxonomic Information System (www.itis.usda.gov). Species names reported by Bradley and Niles (1973) have been updated here to reflect taxonomic changes.

Family	Scientific Name	Family Common Name	Species Name	Common Name	Bradley and Niles (1973)	Shanahan and Silverman (2006)
Amaranthaceae		Amaranth Family	<i>Amaranthus albus</i>	Tumbleweed		1
			<i>Amaranthus blitoides</i>	Prostrate amaranth		1
			<i>Amaranthus powellii</i>	Amaranth		1
			<i>Tidestromia oblongifolia</i>	Honey sweet	1	1
Asteraceae		Aster Family	<i>Acroptilon repens</i>	Russian knapweed		1
			<i>Ambrosia dumosa</i>	Burro bush	1	1
			<i>Amphipappus fremontii</i>	Chaff bush		1
			<i>Aster subulatus</i> var. <i>ligulatus</i>	Alkali aster		1
			<i>Atrichoseris platyphylla</i>	Gravel ghost		1
			<i>Baccharis emoryi</i>	Emory waterweed		1
			<i>Baccharis salicifolia</i>	Seep willow		1
			<i>Baccharis sarothroides</i>	Broom baccharis		1
			<i>Baccharis sergiloides</i>	Squaw waterweed	1	
			<i>Baileya multiradiata</i>	Desert marigold	1	1
			<i>Brickellia atractyloides</i>	Brickellia		1
			<i>Calycoseris wrightii</i>	White tackstem		1
			<i>Chaenactis carphoclinia</i>	Pebble pincushion		1
			<i>Chaenactis fremontii</i>	Fremont pincushion	1	1
			<i>Chaenactis macrantha</i>	Pincushion	1	1
			<i>Chaenactis stevioides</i>	Pincushion	1	
			<i>Chrysothamnus paniculatus</i>	Black band rabbitbrush	1	1
			<i>Conyza canadensis</i>	Horseweed		1
			<i>Conyza coulteri</i>	Horseweed		1
			<i>Eclipta prostrata</i>	False daisy		1
			<i>Encelia farinosa</i>	Brittle bush	1	1
			<i>Encelia virginensis</i>	Brittle bush		1
			<i>Enceliopsis argophylla</i>	Silver-leaf daisy		1
			<i>Erigeron divergens</i>	Fleabane		1
			<i>Eriophyllum lanatum</i>	Woolly sunflower		1
			<i>Eriophyllum wallacei</i>	Woolly daisy		1
			<i>Filago arizonica</i>	Filago		1
			<i>Geraea canescens</i>	Desert sunflower		1
			<i>Gnaphalium luteo-album</i>	Cudweed		1
			<i>Gutierrezia sarothrae</i>	Snake weed	1	
			<i>Helianthus annuus</i>	Sunflower	1	1
			<i>Hymenoclea salsola</i> var. <i>fasciculata</i>	Cheesebush		1
			<i>Hymenoclea salsola</i> var. <i>salsola</i>	Cheesebush	1	1
			<i>Isocoma acradenia</i> var. <i>eremophila</i>	Goldenbush	1	1
			<i>Lactuca</i> cf. <i>biennis</i>	Prickly lettuce		1
			<i>Lactuca serriola</i>	Prickly lettuce		1
			<i>Machaeranthera pinnatifida</i> ssp. <i>gooddingii</i>	Goodding aster		1
			<i>Malacothrix glabrata</i>	Desert dandelion		1
			<i>Perityle emoryi</i>	Rock daisy		1
			<i>Peucephyllum schottii</i>	Pygmy cedar		1

List of species detected by Bradley and Niles (1973) and Shanahan and Silverman (2006). Species presence is indicated by a 1. Family and species names follow the Integrated Taxonomic Information System (www.itis.usda.gov). Species names reported by Bradley and Niles (1973) have been updated here to reflect taxonomic changes.

Family	Scientific Name	Family Common Name	Species Name	Common Name	Bradley and Niles (1973)	Shanahan and Silverman (2006)
Asteraceae		Aster Family	<i>Pluchea odorata</i>	Salt marsh fleabane		1
			<i>Pluchea sericea</i>	Arrow weed	1	1
			<i>Prenanthes exiguus</i>	Bright white		1
			<i>Psathyrotes ramosissima</i>	Velvet turtleback	1	1
			<i>Psilostrophe cooperi</i>	Paper flower		1
			<i>Rafinesquia neomexicana</i>	Desert chicory/New Mexico Plumeseed		1
			<i>Senecio flaccidus</i> var. <i>monoensis</i>	Mono ragwort	1	
			<i>Sonchus asper</i>	Spiny sow thistle		1
			<i>Sonchus oleraceus</i>	Sow thistle		1
			<i>Stephanomeria cinerea</i>	Wirelettuce	1	
			<i>Stephanomeria pauciflora</i> var. <i>pauciflora</i>	Wire lettuce	1	1
			<i>Stylocline micropoides</i>	Desert nest straw		1
			<i>Xanthium strumarium</i>	Cocklebur	1	1
			Azollaceae		Mosquito Fern Family	<i>Xylorhiza tortifolia</i>
<i>Azolla</i> sp.	Mosquito fern					1
Bignoniaceae		Bignonia Family	<i>Chilopsis linearis</i> ssp. <i>arcuata</i>	Desert willow	1	1
Boraginaceae		Borage Family	<i>Amsinckia menziesii</i> var. <i>intermedia</i>	Rancher's fireweed		1
			<i>Amsinckia tessellata</i> var. <i>tessellata</i>	Devil's lettuce		1
			<i>Cryptantha angustifolia</i>	Narrow-leaved cryptantha	1	1
			<i>Cryptantha barbiger</i>	Bearded cryptantha		1
			<i>Cryptantha dumetorum</i>	Cryptantha		1
			<i>Cryptantha holoptera</i>	Winged cryptantha		1
			<i>Cryptantha inaequata</i>	Cryptantha		1
			<i>Cryptantha maritima</i>	Cryptantha		1
			<i>Cryptantha micrantha</i>	Purple-rooted cryptantha	1	
			<i>Cryptantha nevadensis</i>	Cryptantha	1	1
			<i>Cryptantha pterocarya</i> var. <i>cycloptera</i>	Wing-nut cryptantha		1
			<i>Cryptantha pterocarya</i> var. <i>pterocarya</i>	Wing-nut cryptantha		1
			<i>Cryptantha recurvata</i>	Cryptantha		1
			<i>Cryptantha utahensis</i>	Scented cryptantha		1
			<i>Heliotropium curassavicum</i>	Salt heliotrope		1
			<i>Pectocarya heterocarpa</i>	Comb-bur		1
			<i>Pectocarya linearis</i>	Comb-bur		1
			<i>Pectocarya platycarpa</i>	Comb-bur		1
Brassicaceae		Mustard Family	<i>Plagiobothrys jonesii</i>	Jones popcornflower		1
			<i>Brassica tournefortii</i>	Sahara mustard		1
			<i>Descurainia pinnata</i> ssp. <i>glabra</i>	Tansy mustard	1	1
			<i>Descurainia sophia</i>	Flixweed		1
			<i>Dithyrea californica</i>	Spectacle pod	1	
			<i>Draba cuneifolia</i> var. <i>integrifolia</i>	Draba		1
			<i>Guillenia lasiophylla</i>	California mustard		1
			<i>Lepidium flavum</i>	Pepperweed	1	
			<i>Lepidium fremontii</i> var. <i>fremontii</i>	Desert alyssum	1	1
			<i>Lepidium lasiocarpum</i>	Shaggyfruit pepperweed		1

List of species detected by Bradley and Niles (1973) and Shanahan and Silverman (2006). Species presence is indicated by a 1. Family and species names follow the Integrated Taxonomic Information System (www.itis.usda.gov). Species names reported by Bradley and Niles (1973) have been updated here to reflect taxonomic changes.

Family	Scientific Name	Family Common Name	Species Name	Common Name	Bradley and Niles (1973)	Shanahan and Silverman (2006)			
Brassicaceae		Mustard Family	Lepidium latifolium	Broad-leaved pepperweed		1			
			Lesquerella tenella	Bladder pod		1			
			Malcolmia africana	African mustard		1			
			Rorippa nasturtium-aquaticum	Water Cress		1			
			Sisymbrium irio	London rocket		1			
			Stanleya pinnata	Prince's plume	1				
			Streptanthella longirostris	Streptanthella	1	1			
			Cactaceae		Cactus Family	Cylindropuntia echinocarpa	Golden cholla	1	1
						Cylindropuntia ramosissima	Diamond cholla		1
						Echinocactus polycephalus	Cottontop cactus	1	1
Mammillaria tetrancistra	Fish-hook cactus					1			
Opuntia basilaris var. basilaris	Beavertail	1				1			
Sclerocactus johnsonii (=Echinomastus johnsonii)	Pineapple cactus					1			
Nemacladus glanduliferus var. orientalis	Thread plant					1			
Campanulaceae		Bellflower Family							
Chenopodiaceae		Goosefoot Family				Allenrolfea occidentalis	Iodine bush	1	1
			Atriplex canescens ssp. canescens	Fourwing saltbush	1	1			
			Atriplex confertifolia	Shadscale	1	1			
			Atriplex elegans var. fasciculata	Wheelscale		1			
			Atriplex hymenelytra	Desert holly		1			
			Atriplex lentiformis var. lentiformis	Quail bush	1	1			
			Atriplex polycarpa	Allscale	1	1			
			Bassia hyssopifolia	Bassia	1	1			
			Chenopodium album	Lamb's quarters		1			
			Chenopodium ambrosioides	Mexican tea		1			
			Chenopodium berlandieri	Lamb's quarters		1			
			Chenopodium glaucum	Lamb's quarters		1			
			Krascheninnikovia lanata	Winterfat	1				
			Salsola paulsenii	Russian thistle		1			
			Salsola tragus	Russian thistle	1	1			
			Suaeda moquinii	Bush seepweed	1	1			
			Convolvulaceae		Morning Glory Family	Convolvulus arvensis	Bind weed		1
			Cyperaceae		Sedge Family	Carex sp.	Sedge	1	
						Cyperus erythrorhizos	Nut-sedge		1
						Eleocharis cf. montevidensis	Spike-rush		1
						Eleocharis sp.	Spike-rush		1
Schoenoplectus acutus var. occidentalis	Tule					1			
Schoenoplectus americanus	Olney three-square					1			
Schoenoplectus californicus	California tule					1			
Schoenoplectus maritimus	Bulrush					1			
Schoenoplectus pungens	Common three-square					1			
Schoenoplectus sp.	Bulrush	1							
Ephedraceae		Joint-Fir Family				Ephedra funerea	Death Valley joint-fir	1	
						Ephedra nevadensis	Death Valley joint-fir	1	
						Ephedra torreyana	Torrey joint-fir		1

List of species detected by Bradley and Niles (1973) and Shanahan and Silverman (2006). Species presence is indicated by a 1. Family and species names follow the Integrated Taxonomic Information System (www.itis.usda.gov). Species names reported by Bradley and Niles (1973) have been updated here to reflect taxonomic changes.

Family	Scientific Name	Family Common Name	Species Name	Common Name	Bradley and Niles (1973)	Shanahan and Silverman (2006)
Euphorbiaceae		Spurge Family	Euphorbia albomarginata	Rattlesnake weed	1	
			Euphorbia micromeria	Sonoran sand-mat		1
			Euphorbia prostrata	Spurge		1
Fabaceae		Legume Family	Acacia greggii	Catclaw	1	1
			Dalea mollissima	Dalea		1
			Lotus rigidus	Rock pea	1	
			Lupinus sp.	Lupine	1	
			Medicago sativa	Alfalfa		1
			Melilotus alba	White sweet-clover		1
			Melilotus indica	Yellow sweet-clover	1	1
			Prosopis alba	White mesquite		1
			Prosopis glandulosa var. glandulosa	Honey mesquite		1
			Prosopis glandulosa var. torreyana	Honey mesquite	1	1
			Prosopis pubescens	Screw-bean mesquite	1	1
			Psoralea arguta var. fremontii	Indigo bush	1	1
			Senna armata	Desert senna		1
Geraniaceae		Geranium Family	Erodium cicutarium	Red-leaf filaree	1	1
			Erodium texanum	Texas filaree		1
Hydrophyllaceae		Waterleaf Family	Eucrypta micrantha	Eucrypta		1
			Nama pusillum	Nama		1
			Phacelia coerulea	Phacelia	1	
			Phacelia crenulata var. ambigua	Purple phacelia		1
			Phacelia curvipes	Phacelia	1	
			Phacelia fremontii	Fremont phacelia	1	
			Phacelia ivesiana	Phacelia		1
			Phacelia neglecta	Phacelia		1
			Phacelia palmeri	Palmers phacelia		1
			Phacelia petrosa	Talus phacelia		1
			Phacelia rotundifolia	Round-leaf phacelia		1
			Phacelia pulchella var. gooddingii	Goodding phacelia		1
Juncaceae		Rush Family	Juncus balticus	Wire rush		1
			Juncus cooperi	Cooper rush		1
Krameriaceae		Krameria Family	Krameria erecta	Range rhatany	1	1
Lamiaceae		Mint Family	Marrubium vulgare	Horehound	1	
Lemnaceae		Duckweed Family	Lemna sp. (ca. minor)	Duckweed		1
Liliaceae		Lily Family	Androstemonium breviflorum	Lily		1
			Yucca schidigera	Mojave yucca	1	
Loasaceae		Loasa Family	Mentzelia involucrata var. involucrata	Stick-leaf		1
			Mentzelia nitens	Stick-leaf	1	
			Mentzelia obscura	Stick-leaf		1
			Mentzelia pterosperma	Stick-leaf		1
			Mentzelia tricuspidata	Stick-leaf		1
			Mentzelia albicaulis	Stick-leaf		1
			Petalonyx nitidus	Shining sandpaper plant		1

List of species detected by Bradley and Niles (1973) and Shanahan and Silverman (2006). Species presence is indicated by a 1. Family and species names follow the Integrated Taxonomic Information System (www.itis.usda.gov). Species names reported by Bradley and Niles (1973) have been updated here to reflect taxonomic changes.

Family	Scientific Name	Family Common Name	Species Name	Common Name	Bradley and Niles (1973)	Shanahan and Silverman (2006)
Malvaceae		Mallow Family	<i>Eremalche rotundifolia</i>	Desert five-spot		1
			<i>Malva parviflora</i>	Cheeseweed		1
			<i>Sphaeralcea ambigua</i> var. <i>rugosa</i>	Desert mallow	1	1
			<i>Sphaeralcea emoryi</i>	Emory mallow		1
Moraceae		Mulberry Family	<i>Morus alba</i>	White mulberry		1
Nyctaginaceae		Four O'Clock Family	<i>Allionia incarnata</i>	Pink windmills		1
			<i>Mirabilis bigelovii</i> var. <i>bigelovii</i>	Four o'clock		1
Oleaceae		Olive Family	<i>Fraxinus latifolia</i>	Oregon ash		1
			<i>Fraxinus velutina</i>	Velvet ash		1
			<i>Menodora spinescens</i>	Menodora	1	
Onagraceae		Evening Primrose Family	<i>Camissonia boothii</i> ssp. <i>condensata</i>	Woody bottle washer		1
			<i>Camissonia brevipes</i> ssp. <i>brevipes</i>	Sun cup	1	1
			<i>Camissonia brevipes</i> ssp. <i>pallidula</i>	Sun cup		1
			<i>Camissonia chamaenerioides</i>	Brown-eyed primrose		1
			<i>Camissonia claviformis</i> var. <i>aurantiaca</i>	Brown-eyed primrose		1
			<i>Camissonia multijuga</i>	Froststem suncup	1	
			<i>Camissonia refracta</i>	Evening primrose		1
			<i>Camissonia walkeri</i> ssp. <i>tortilis</i>	Evening primrose		1
			<i>Oenothera caespitosa</i> var. <i>crinita</i>	Evening primrose		1
Papaveraceae		Poppy Family	<i>Arctomecon californica</i>	Las Vegas bearpoppy		1
			<i>Argemone polyanthemus</i>	Crested prickly poppy	1	
			<i>Eschscholzia californica</i>	California poppy		1
			<i>Eschscholzia glyptosperma</i>	Desert poppy		1
			<i>Eschscholzia minutiflora</i> ssp.	Miniature poppy	1	1
Plantaginaceae		Plantain Family	<i>Plantago major</i>	Common plantain		1
			<i>Plantago ovata</i>	Desert plantain	1	1
Plumbaginaceae		Plumbago Family	<i>Limonium californicum</i>	Sea lavender	1	1
Poaceae		Grass Family	<i>Achnatherum hymenoides</i>	Indian rice grass	1	
			<i>Aristida adscensionis</i>	Six-weeks three-awn		1
			<i>Aristida purpurea</i>	Purple three-awn		1
			<i>Arundo donax</i>	Giant reed		1
			<i>Bromus madritensis</i> ssp. <i>rubens</i>	Foxtail chess		1
			<i>Cenchrus spinifex</i>	Coastal sandbur	1	
			<i>Chloris virgata</i>	Finger grass		1
			<i>Cynodon dactylon</i>	Bermuda grass	1	1
			<i>Dasyochloa pulchella</i> (= <i>Erioneuron pulchellum</i>)	Fluff grass	1	1
			<i>Distichlis spicata</i>	Saltgrass	1	1
			<i>Echinochloa crus-gallii</i>	Barnyard grass	1	1
			<i>Festuca arundinacea</i>	Tall fescue	1	
			<i>Leptochloa uninerva</i>	Mexican sprangletop	1	1
			<i>Leymus cinereus</i>	Great Basin wildrye	1	
			<i>Muhlenbergia asperifolia</i>	Mist grass	1	1
			<i>Panicum capillare</i>	Witchgrass	1	1
			<i>Panicum</i> cf. <i>hirticaule</i>	Panic grass		1

List of species detected by Bradley and Niles (1973) and Shanahan and Silverman (2006). Species presence is indicated by a 1. Family and species names follow the Integrated Taxonomic Information System (www.itis.usda.gov). Species names reported by Bradley and Niles (1973) have been updated here to reflect taxonomic changes.

Family	Scientific Name	Family Common Name	Species Name	Common Name	Bradley and Niles (1973)	Shanahan and Silverman (2006)
Poaceae		Grass Family	<i>Paspalum distichum</i>	Ditchgrass		1
			<i>Phragmites australis</i>	Common reed	1	1
			<i>Pleuraphis rigida</i>	Galleta grass	1	1
			<i>Polypogon monspeliensis</i>	Rabbit's foot grass		1
			<i>Polypogon viridis</i>	Bent grass		1
			<i>Schismus barbatus</i>	Splitgrass		1
			<i>Setaria pumila</i>	Bristlegrass		1
			<i>Sorghum halapense</i>	Johnsongrass	1	1
			<i>Sporobolus airoides</i>	Alkali sacaton	1	1
			<i>Sporobolus contractus</i>	Spike dropseed	1	
			<i>Sporobolus cryptandrus</i>	Sand dropseed	1	
			<i>Vulpia octoflora</i> var. <i>hirtella</i>	Six weeks fescue		1
Polemoniaceae		Phlox Family	<i>Aliciella leptomeria</i>	Sand gilia	1	
			<i>Gilia cana</i>	Gilia		1
			<i>Gilia clokeyii</i>	Clokey's gilia		1
			<i>Gilia latifolia</i>	Broad-leaf gilia		1
			<i>Gilia scopulorum</i>	Rock gilia		1
			<i>Ipomopsis polycladon</i>	Spreading gilia		1
			<i>Langloisia setosissima</i> var. <i>setosissima</i>	Bristly langloisia	1	1
			<i>Linanthus bigelovii-jonesii</i>	Linanthus		1
			<i>Linanthus demissus</i>	Desert linanthus		1
Polygonaceae		Buckwheat Family	<i>Chorizanthe brevicornu</i>	Brittle spineplant	1	1
			<i>Chorizanthe corrugata</i>	Corrugated spineplant		1
			<i>Chorizanthe rigida</i>	Rigid spineplant	1	1
			<i>Eriogonum deflexum</i> var. <i>deflexum</i>	Buckwheat	1	1
			<i>Eriogonum inflatum</i> var. <i>inflatum</i>	Desert trumpet	1	1
			<i>Eriogonum insigne</i>	Buckwheat		1
			<i>Eriogonum microthecum</i>	Slender buckwheat	1	
			<i>Eriogonum nidularium</i>	Whisk broom buckwheat	1	
			<i>Eriogonum reniforme</i>	Kidneyleaf buckwheat	1	
			<i>Eriogonum thomasii</i>	Thomas buckwheat		1
			<i>Eriogonum trichopes</i> var. <i>trichopes</i>	Little trumpet		1
			<i>Oxytheca perfoliata</i>	Cup and saucer plant	1	
			<i>Polygonum arenastrum</i>	Common knotweed		1
			<i>Polygonum lapathifolium</i>	Willow weed	1	1
			<i>Rumex hymenosepalus</i>	Wild rhubarb	1	
			<i>Rumex stenophyllus</i>	Dock		1
Portulacaceae		Purslane Family	<i>Portulaca oleracea</i>	Common purslane		1
Ranunculaceae		Ranunculus Family	<i>Delphinium parishii</i>	Parish larkspur		1
Resedaceae		Reseda Family	<i>Oligomeris linifolia</i>	Mignonette		1
Rhamnaceae		Buckthorn Family	<i>Ziziphus obtusifolia</i>	Greythorn	1	
Rutaceae		Rue Family	<i>Thamnosma montana</i>	Turpentinebroom	1	
Salicaceae		Willow Family	<i>Populus fremontii</i>	Fremont cottonwood		1
			<i>Salix exigua</i>	Sandbar willow		1

List of species detected by Bradley and Niles (1973) and Shanahan and Silverman (2006). Species presence is indicated by a 1. Family and species names follow the Integrated Taxonomic Information System (www.itis.usda.gov). Species names reported by Bradley and Niles (1973) have been updated here to reflect taxonomic changes.

Family	Scientific Name	Family Common Name	Species Name	Common Name	Bradley and Niles (1973)	Shanahan and Silverman (2006)			
Salicaceae		Willow Family	Salix gooddingii	Goodding willow		1			
			Salix laevigata	Red willow		1			
			Salix sp.	Willow	1				
Saururaceae		Lizard's-tail Family	Anemopsis californica	Yerba Mansa		1			
Scrophulariaceae		Figwort Family	Antirrhinum filipes	Twining snapdragon		1			
			Mohavea breviflora	Golden desert snapdragon		1			
Solanaceae		Nightshade Family	Veronica anagallis-aquatica	Water speedwell		1			
			Datura wrightii	Sacred datura	1	1			
			Lycium andersonii var. andersonii	Anderson thornbush	1	1			
			Lycium fremontii	Fremont's desert thorn		1			
			Lycium pallidum var. oligospermum	Rabbit thorn	1				
			Lycium sp.	Thornbush		1			
			Nicotiana glauca	Tree tobacco		1			
			Nicotiana obtusifolia	Desert tobacco		1			
			Physalis crassifolia	Ground cherry		1			
			Solanum americanum	Nightshade		1			
			Solanum elaeagnifolium	Silver-leaf nightshade		1			
			Tamaricaceae		Tamarisk Family	Tamarix ramosissima	Salt cedar	1	1
			Typhaceae		Cattail Family	Typha domingensis	Southern cattail	1	1
Ulmaceae		Elm Family	Ulmus pumila	Siberian elm	1	1			
			Ulmus sp.	Elm		1			
Viscaceae		Mistletoe Family	Phorodendron californicum	Desert mistletoe	1	1			
Vitaceae		Grape Family	Vitis arizonica	Desert grape	1	1			
Zannichelliaceae		Horned Pond Weed Family	Zannichellia palustris	Horned pond weed		1			
Zygophyllaceae		Caltrop Family	Larrea tridentata	Creosote bush	1	1			
			Tribulus terrestris	Puncturevine		1			
Grand Total					111	248			

Appendix B
Wildlife Observed Along the Las Vegas Wash

List of species detected by Bradley and Niles (1973) and Shanahan et al. (2007). Species are listed alphabetically from left to right and presence is dictatd by a 1. Species names reported by Bradley and Niles (1973) have been updated here to reflect taxonomic changes.

Class	Family	Scientific Name	Family Common Name	Species Name	Common Name	Bradley and Niles (1973)	Shanahan et al. (2007)				
	Ardeidae		Bitterns & Herons	Egretta thula	Snowy Egret	1	1				
				Ixobrychus exilis	Least Bittern		1				
				Nycticorax nycticorax	Black-crowned Night-Heron	1	1				
	Bombycillidae		Waxwings	Bombycilla cedrorum	Cedar Waxwing		1				
				Bombycilla garrulus	Bohemian Waxwing	1					
	Caprimulgidae		Nightjars	Chordeiles acutipennis	Lesser Nighthawk	1	1				
				Phalaenoptilus nuttallii	Common Poorwill		1				
	Cardinalidae		Cardinals, Grosbeaks & Buntings	Passerina amoena	Lazuli Bunting	1	1				
				Passerina caerulea	Blue Grosbeak	1	1				
				Passerina cyanea	Indigo Bunting		1				
				Pheucticus melanocephalus	Black-headed Grosbeak	1	1				
Cathartidae			New World Vultures	Cathartes aura	Turkey Vulture	1	1				
	Charadriidae		Plovers	Charadrius alexandrinus	Snowy Plover	1	1				
				Charadrius montanus	Mountain Plover						
				Charadrius semipalmatus	Semipalmated Plover	1	1				
				Charadrius vociferous	Killdeer	1	1				
							Stilts & Avocets	Himantopus mexicanus	Black-necked Stilt	1	1
								Recurvirostra americana	American Avocet	1	1
					Columbidae		Doves	Columbia livia	Rock Pigeon		1
								Zenaida asiatica	White-winged Dove		1
								Zenaida macroura	Mourning Dove	1	1
					Corvidae		Crows & Jays	Aphelocoma californica	Western Scrub-Jay	1	1
Corvus corax	Common Raven	1	1								
Gymnorhinus cyanocephalus	Pinyon Jay		1								
Cuculidae			Roadrunners	Geococcyx californianus	Greater Roadrunner	1	1				
	Emberizidae		Emberizids	Amphispiza belli	Sage Sparrow	1					
				Amphispiza bilineata	Black-throated Sparrow	1	1				
				Chondestes grammacus	Lark Sparrow		1				
				Junco hyemalis	Dark-eyed Junco		1				
				Melospiza lincolni	Lincoln's Sparrow	1	1				
				Melospiza melodia	Song Sparrow	1	1				
				Passerculus sandwichensis	Savannah Sparrow	1	1				
				Passerella iliaca	Fox Sparrow		1				
				Pipilo aberti	Abert's Towhee	1	1				
				Pipilo chlorurus	Green-tailed Towhee	1					
				Pipilo fuscus	Canyon towhee		1				
				Pipilo maculatus	Spotted Towhee		1				
				Poocetes gramineus	Vesper Sparrow		1				
				Spizella breweri	Brewer's Sparrow	1	1				
				Spizella passerina	Chipping Sparrow	1	1				
				Zonotrichia leucophrys	White-crowned Sparrow	1	1				
					Falconidae		Falcons	Falco columbarius	Merlin		1
								Falco mexicanus	Prairie Falcon	1	1
								Falco peregrinus	Peregrine Falcon		1
Falco sparverius	American Kestrel	1	1								
	Fringillidae		Finches	Carduelis pinus	Pine Siskin		1				
				Carduelis psaltria	Lesser Goldfinch	1	1				
				Carduelis tristis	American Goldfinch		1				
	Gaviidae		Loons	Carpodacus mexicanus	House Finch	1	1				
				Gavia immer	Common Loon	1					

List of species detected by Bradley and Niles (1973) and Shanahan et al. (2007). Species are listed alphabetically from left to right and presence is dictatd by a 1. Species names reported by Bradley and Niles (1973) have been updated here to reflect taxonomic changes.

Class	Family	Scientific Name	Family Common Name	Species Name	Common Name	Bradley and Niles (1973)	Shanahan et al. (2007)			
	Hirundinidae		Swallows	Hirundo rustica	Barn Swallow	1	1			
				Petrochelidon pyrrhonota	Cliff Swallow	1	1			
				Progne subis	Purple Martin	1				
				Riparia riparia	Bank Swallow	1	1			
				Stelgidopteryx serripennis	Northern Rough-winged Swallow	1	1			
				Tachycineta bicolor	Tree Swallow	1	1			
				Tachycineta thalassina	Violet-green Swallow	1	1			
				Icteridae		Blackbirds	Agelaius phoeniceus	Red-winged Blackbird	1	1
							Euphagus cyanocephalus	Brewer's Blackbird	1	1
							Icterus bullockii	Bullock's Oriole		1
Icterus parisorum	Scott's Oriole	1								
Molothrus ater	Brown-headed Cowbird	1	1							
Quiscalus mexicanus	Great-tailed Grackle		1							
Sturnella neglecta	Western Meadowlark	1	1							
Xanthocephalus xanthocephalus	Yellow-headed Blackbird	1	1							
Laniidae		Shrikes	Lanius excubitor				Northern Shrike	1		
			Lanius ludovicianus				Loggerhead Shrike	1	1	
Laridae		Gulls and Terns	Chlidonias niger	Black Tern	1					
			Hydroprogne caspia	Caspian Tern	1					
			Larus argentatus	Herring Gull	1					
			Larus californicus	California Gull	1					
			Larus delawarensis	Ring-billed Gull	1	1				
			Larus philadelphia	Bonaparte's Gull	1					
			Sterna forsteri	Forster's Tern	1	1				
Mimidae		Mockingbirds & Thrashers	Mimus polyglottos	Northern Mockingbird	1	1				
			Oreoscoptes montanus	Sage Thrasher	1					
			Toxostoma bendirei	Bendire's Thrasher		1				
			Toxostoma crissale	Crissal Thrasher	1	1				
			Motacillidae		Pipits	Anthus rubescens	American Pipit	1	1	
Odontophoridae	New World Quail	Callipepla gambelii				Gambel's Quail	1	1		
Parulidae		Wood-Warblers	Dendroica coronata	Yellow-rumped Warbler	1	1				
			Dendroica palmarum	Palm Warbler		1				
			Dendroica petechia	Yellow Warbler	1	1				
			Dendroica townsendi	Townsend's Warbler	1	1				
			Geothlypis trichas	Common Yellowthroat	1	1				
			Icteria virens	Yellow-breasted Chat	1	1				
			Oporornis tolmiei	MacGillivray's Warbler	1	1				
			Vermivora celata	Orange-crowned Warbler	1	1				
			Vermivora luciae	Lucy's Warbler	1	1				
			Wilsonia pusilla	Wilson's Warbler	1	1				
			Passeridae		Old World Sparrows	Passer domesticus	House Sparrow	1	1	
			Pelecanidae		Pelicans	Pelecanus erythrorhynchos	American White Pelican	1	1	
			Phalacrocoracidae		Cormorants	Phalacrocorax auritus	Double-crested Cormorant	1	1	
Picidae		Woodpeckers	Colaptes auratus	Northern Flicker	1	1				
			Picoides scalaris	Ladder-backed Woodpecker	1	1				
Podicipedidae		Grebes	Sphyrapicus nuchalis	Red-naped Sapsucker		1				
			Aechmophorus clarkii*	Clark's Grebe		1				
			Aechmophorus occidentalis	Western Grebe	1	1				
			Podiceps auritus	Horned Grebe						
			Podiceps nigricollis	Eared Grebe	1	1				

List of species detected by Bradley and Niles (1973) and Shanahan et al. (2007). Species are listed alphabetically from left to right and presence is dictatd by a 1. Species names reported by Bradley and Niles (1973) have been updated here to reflect taxonomic changes.

Class	Family	Scientific Name	Family Common Name	Species Name	Common Name	Bradley and Niles (1973)	Shanahan et al. (2007)
	Podicipedidae		Grebes	Podilymbus podiceps	Pied-billed Grebe	1	1
	Ptilonotidae		Silky Flycatchers	Phainopepla nitens	Phainopepla	1	1
	Rallidae		Rails, Gallinules & Coots	Fulica americana	American Coot	1	1
				Gallinula chloropus	Common Moorhen	1	1
				Porzana carolina	Sora	1	1
				Rallus limicola	Virginia Rail	1	1
	Regulidae		Kinglets	Regulus calendula	Ruby-crowned Kinglet	1	1
				Regulus satrapa	Golden-crowned Kinglet	1	1
	Remizidae		Verdins	Auriparus flaviceps	Verdin	1	1
	Scolopacidae		Sandpipers	Actitis macularia	Spotted Sandpiper	1	1
				Calidris bairdii	Baird's Sandpiper	1	
				Calidris mauri	Western Sandpiper	1	1
				Calidris melanotos	Pectoral Sandpiper	1	
				Calidris minutilla	Least Sandpiper	1	1
				Catoptrophorus semipalmatus	Willet	1	
				Gallinago delicata	Wilson's Snipe	1	1
				Limnodromus scolopaceus	Long-billed Dowitcher	1	1
				Limosa fedoa	Marbled Godwit	1	
				Numenius americanus	Long-billed Curlew	1	
				Phalaropus lobatus	Red-necked Phalarope	1	
				Phalaropus tricolor	Wilson's Phalarope	1	
				Tringa flavipes	Lesser Yellowlegs	1	1
				Tringa melanoleuca	Greater Yellowlegs	1	1
				Tringa solitaria	Solitary Sandpiper	1	1
	Strigidae		Typical Owls	Aegolius acadicus	Northern Saw-whet Owl		1
				Asio flammeus	Short-eared Owl	1	
				Asio otus	Long-eared Owl		1
				Athene cucularia	Burrowing Owl		1
				Bubo virginianus	Great Horned Owl	1	
	Sturnidae		Starlings	Sturnus vulgaris	European Starling	1	1
	Sylviidae		Gnatcatchers	Poliptila caerulea	Blue-gray Gnatcatcher	1	1
				Poliptila melanura	Black-tailed Gnatcatcher	1	1
	Thraupidae		Tanagers	Piranga ludoviciana	Western Tanager	1	1
				Piranga rubra	Summer Tanager		1
	Threskiornithidae		Ibises	Plegadis chihi	White-faced Ibis	1	1
	Trochilidae		Hummingbirds	Archilochus alexandri	Black-chinned Hummingbird		1
				Calypte anna	Anna's Hummingbird		1
				Calypte costae	Costa's Hummingbird		1
				Selasphorus platycercus	Broad-tailed Hummingbird	1	1
				Selasphorus rufus	Rufous Hummingbird		
	Troglodytidae		Wrens	Campylorhynchus brunneicapillus	Cactus Wren	1	
				Cistothorus palustris	Marsh Wren	1	1
				Salpinctes obsoletus	Rock Wren	1	1
				Thryomanes bewickii	Bewick's Wren	1	1
				Troglodytes aedon	House Wren	1	1
				Troglodytes troglodytes	Winter Wren		1
	Turdidae		Thrushes	Catharus guttatus	Hermit Thrush	1	1
				Myadestes townsendi	Townsend's Solitaire	1	
				Sialia currucoides	Mountain Bluebird	1	1
				Sialia mexicana	Western Bluebird	1	1

List of species detected by Bradley and Niles (1973) and Shanahan et al. (2007). Species are listed alphabetically from left to right and presence is dictatd by a 1. Species names reported by Bradley and Niles (1973) have been updated here to reflect taxonomic changes.

Class	Family	Scientific Name	Family Common Name	Species Name	Common Name	Bradley and Niles (1973)	Shanahan et al. (2007)
	Turdidae		Thrushes	Turdus migratorius	American Robin	1	1
	Tyrannidae		Tyrant Flycatchers	Contopus cooperi	Olive-sided Flycatcher	1	1
				Contopus sordidulus	Western Wood-Pewee	1	1
				Empidonax difficilis	Western Flycatcher	1	
				Empidonax hammondii	Hammond's Flycatcher	1	
				Empidonax oberholseri	Dusky Flycatcher	1	1
				Empidonax wrightii	Gray Flycatcher		1
				Myiarchus cinerascens	Ash-throated Flycatcher	1	1
				Myiarchus tyrannulus	Brown-crested Flycatcher		1
				Sayornis nigricans	Black Phoebe	1	1
				Sayornis saya	Say's Phoebe	1	1
				Tyrannus forficatus	Scissor-tailed Flycatcher	1	
				Tyrannus verticalis	Western Kingbird	1	1
				Tyrannus vociferans	Cassin's Kingbird	1	1
	Tytonidae		Barn Owls	Tyto alba	Barn Owl		1
	Vireonidae		Vireos	Vireo bellii	Bell's Vireo		1
				Vireo gilvus	Warbling Vireo		1
				Vireo plumbeus	Plumbeous Vireo		1
				Vireo solitarius	Solitary Vireo	1	
Fishes	Centrarchidae		Sunfishes	Lepomis cyanellus	Green sunfish		1
	Cyprinidae		Carp and Minnows	Cyprinella lutrensis	Red shiner		1
				Cyprinus carpio	Common carp	1	1
				Pimephales promelas	Fathead minnow		1
	Ictaluridae		Bullhead Catfish	Ameiurus melas	Black bullhead		1
	Loricariidae		Armored and Suckermouth Catfish	Hypostomus plecostomus	Suckermouth catfish		1
	Poeciliidae		Livebearers	Gambusia affinis	Mosquitofish	1	1
Mammals	Bovidae		antelopes, bovids, cattle, goats, sheep	Ovis canadensis	Bighorn sheep	1	1
	Canidae		coyotes, dogs, foxes, jackals, wolves	Canis latrans	Coyote	1	1
				Urocyon cinereoargenteus	Gray fox	1	
				Vulpes macrotis	Kit fox	1	
	Castoridae		beavers	Castor canadensis	Beaver		1
	Felidae		cats	Lynx rufus	Bobcat	1	
	Geomysidae		Pocket gophers	Thomomys umbrinus	Pocket gopher	1	
	Heteromyidae		Kangaroo mice and rats, pocket mice	Chaetodipus penicillatus	Desert pocket mouse		1
				Dipodomys deserti	Desert kangaroo rat	1	
				Dipodomys merriami	Merriam's kangaroo rat	1	1
				Perognathus formosus	Long-tailed pocket mouse	1	1
				Perognathus longimembris	Little pocket mouse	1	1
	Leporidae		Hares and rabbits	Lepus californicus	Black-tailed jack rabbit	1	1
				Sylvilagus audubonii	Desert cottontail	1	1
	Mephitidae		skunks	Mephitis mephitis	Striped skunk	1	
				Spilogale gracilis	Spotted skunk	1	
	Molossidae		Free-tailed bats	Eumops perotis	Greater western mastiff bat		1
				Nyctinomops macrotis	Big free-tailed bat	1	1
				Tadarida brasiliensis	Brazilian free-tailed bat	1	1
	Muridae		Campagnols, mice, rats, rats, voles	Mus musculus	House mouse	1	1
				Neotoma lepida	Desert woodrat	1	1
				Ondatra zibethica	Muskrats	1	
				Onychomys torridus	Southern Grasshopper Mouse	1	1
				Peromyscus boylii	Brush mouse	1	

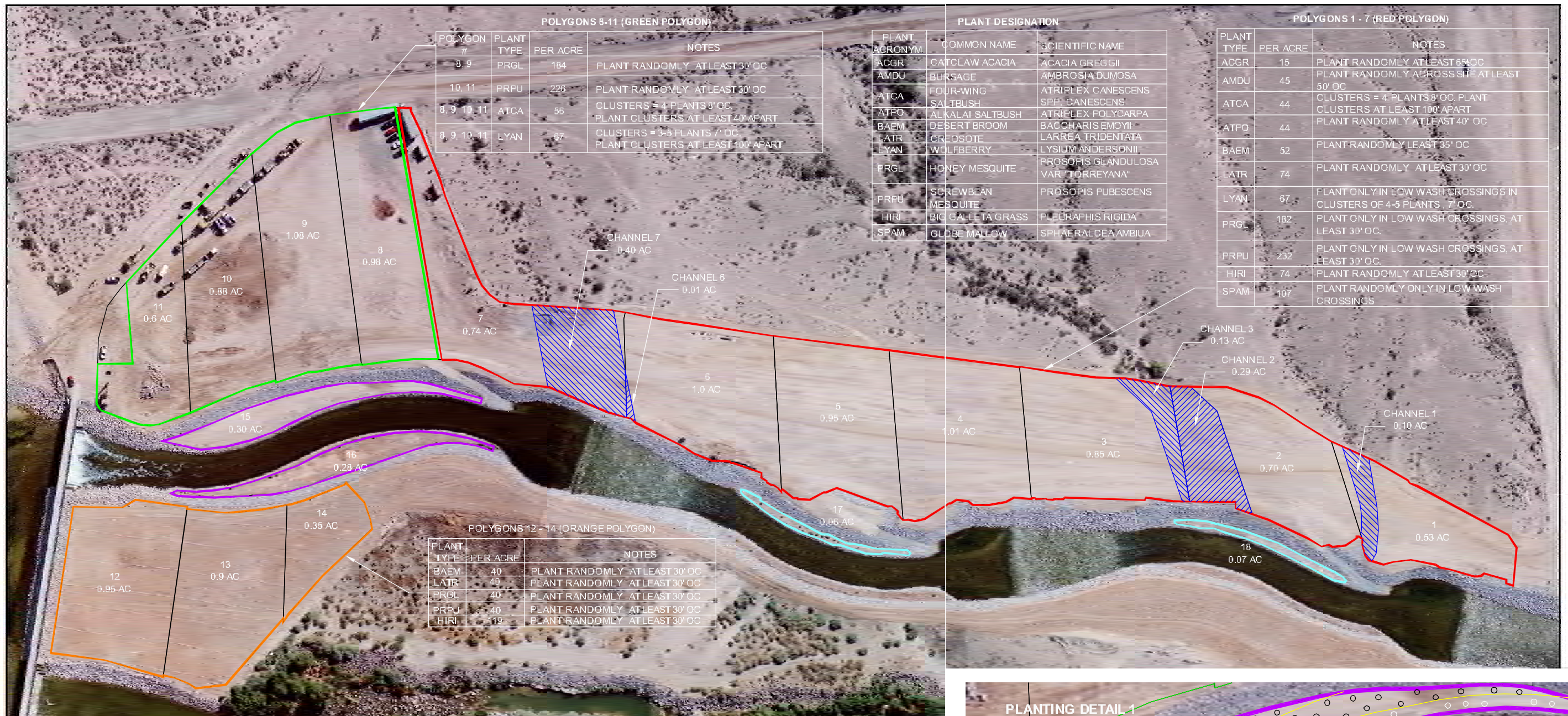
List of species detected by Bradley and Niles (1973) and Shanahan et al. (2007). Species are listed alphabetically from left to right and presence is dictatd by a 1. Species names reported by Bradley and Niles (1973) have been updated here to reflect taxonomic changes.

Class	Family	Scientific Name	Family Common Name	Species Name	Common Name	Bradley and Niles (1973)	Shanahan et al. (2007)				
	Muridae		Campagnols, mice, rats, rats, voles	Peromyscus crinitus	Canyon mouse	1					
				Peromyscus eremicus	Cactus mouse	1	1				
				Peromyscus maniculatus	Deer mouse	1					
				Reithrodontomys megalotis	Western Harvest Mouse	1					
	Mustelidae			mustelids	Taxidea taxus	Badger	1				
					Macrotus californicus	California leaf-nosed bat	1	1			
	Phyllostomidae			New World leaf-nosed bats	Bassariscus astutus	Ring-tailed cat	1	1			
					Procyon lotor	Raccoon	1	1			
	Sciuridae			Chipmunks, marmots, squirrels	Ammospermophilus leucurus	White-tailed antelope squirrel	1	1			
					Spermophilus tereticaudus	Round-tailed ground squirrel	1	1			
	Soricidae			Shrews	Notiosorex crawfordi	Desert shrew	1	1			
					Vespertilionidae		Vespertilionid bats	Antrozous pallidus	Pallid bat	1	1
	Corynorhinus townsendii	Pacific Western big-eared bat	1	1							
	Eptesicus fuscus	Big brown bat	1	1							
	Idionycteris phyllotis	Allen's big-eared bat	1	1							
	Lasionycteris noctivagans	Silver-haired bat	1	1							
	Lasiurus blossevillii	Western red bat		1							
	Lasiurus borealis	Red bat	1								
	Lasiurus cinereus	Hoary bat	1	1							
	Lasiurus xanthinus	Western yellow bat		1							
	Myotis californicus	California myotis	1	1							
	Myotis ciliolabrum	Western small footed bat		1							
	Myotis thysanodes	Fringed myotis		1							
Myotis yumanensis	Yuma bat		1								
Pipistrellus hesperus	Western pipistrelle	1	1								
Reptiles	Colubridae		Typical snakes	Chionactis occipitalis				Western shovel-nosed snake	1		
				Hypsiglena torquata				Spotted night snake	1		
				Lampropeltis getula	Common king snake	1	1				
				Masticophis flagellum piceus	Red racer	1	1				
				Phyllorhynchus decurtatus	Spotted leaf-nosed snake	1					
				Pituophis catenifer deserticola	Great Basin gopher snake	1	1				
				Rhinocheilus lecontei	Long-nosed snake	1					
				Salvadora hexalepis	Western patch-nosed snake	1					
				Sonora semiannulata	Western ground snake	1					
				Trimorphodon biscutatus (=lambda)	Arizona lyre snake	1					
				Crotaphytidae			Collared Lizards and Leopard Lizard	Crotaphytus bicinctores	Great Basin collared lizard	1	1
								Gambelia wislizenii	Long-nosed leopard lizard	1	1
				Eublepharidae			Eublepharid Geckos	Coleonyx variegatus	Western banded gecko	1	1
								Heloderma suspectum	Gila monster	1	
				Helodermatidae			Gila monster	Dipsosaurus dorsalis	Desert iguana	1	1
								Sauromalus obesus	Chuckwalla	1	
	Leptotyphlopidae			Slender Blind Snakes, Thread Snakes	Leptotyphlops humilis	Western blind snake	1	1			
					Callisaurus draconoides	Zebra-tailed lizard	1	1			
	Phrynosomatidae			North American Spiny Lizards	Phrynosoma platyrhinos	Desert horned lizard	1	1			
					Sceloporus magister	Desert spiny lizard	1	1			
					Urosaurus graciosus	Long-tailed brush lizard	1				
					Uta stansburiana	Side blotched lizard	1	1			
					Cnemidophorus tigris tigris	Great Basin whiptail lizard	1	1			
Arizona elegans					Glossy Snake	1					
Testudinidae			Tortoises	Gopherus agassizii	Desert tortoise	1					

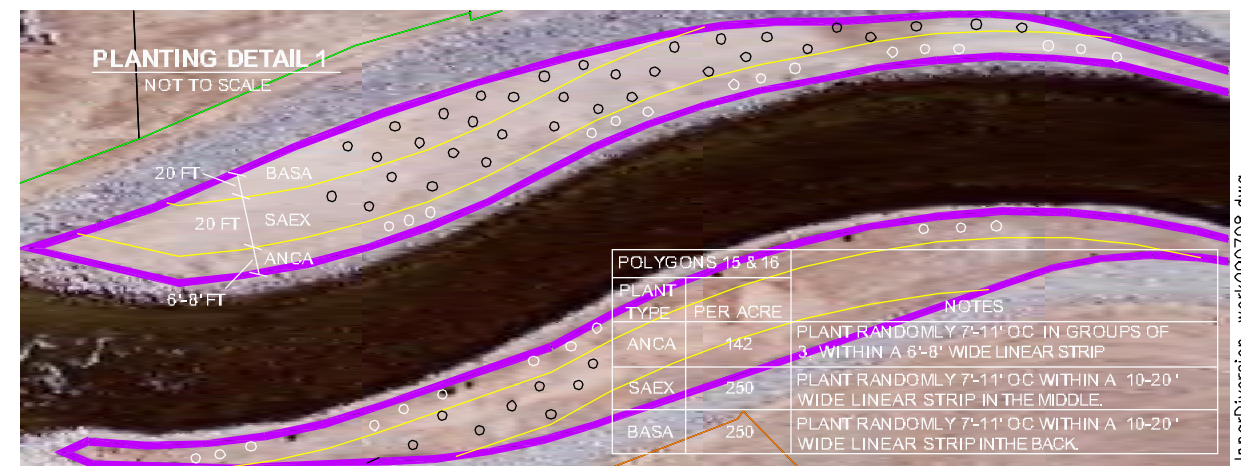
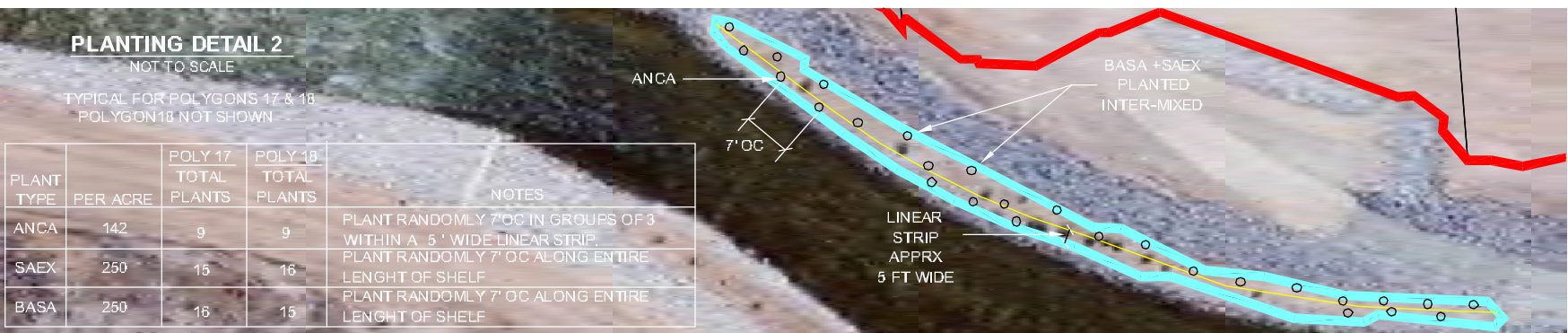
List of species detected by Bradley and Niles (1973) and Shanahan et al. (2007). Species are listed alphabetically from left to right and presence is dictatd by a 1. Species names reported by Bradley and Niles (1973) have been updated here to reflect taxonomic changes.

Class	Family	Scientific Name	Family Common Name	Species Name	Common Name	Bradley and Niles (1973)	Shanahan et al. (2007)
Reptiles	Viperidae		Vipers	Crotalus cerastes cerastes	Mojave desert sidewinder	1	1
				Crotalus mitchellii ssp.pyrrhus	Speckled rattlesnake	1	1
				Crotalus scutulatus	Mojave rattlesnake	1	
	Xantusiidae		Night Lizards	Xantusia vigilis vigilis	Yucca night lizard	1	1

Appendix C
Upper Diversion Weir Planting Design



POLYGONS 12-14 (ORANGE POLYGON)		
PLANT TYPE	PER ACRE	NOTES
BAEM	40	PLANT RANDOMLY AT LEAST 30' OC
LATR	40	PLANT RANDOMLY AT LEAST 30' OC
PRGL	40	PLANT RANDOMLY AT LEAST 30' OC
PRPU	40	PLANT RANDOMLY AT LEAST 30' OC
HIRI	119	PLANT RANDOMLY AT LEAST 30' OC

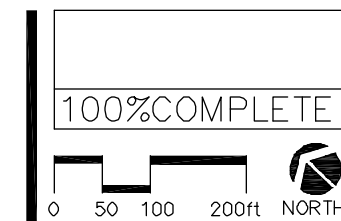


Fred Phillips Consulting, LLC
 401 SOUTH LEROUX STREET
 FLAGSTAFF, AZ
 86001
 TEL 928 773 1530
 FAX 928 774 4166
 Ecosystem Restoration Land Planning

WATER TECH AG SUPPLY
 2610 EAST 16TH STREET
 YUMA, AZ
 85365
 TEL 928 341 8000
 FAX 928 341 9342

REV.	COMMENT	DATE

Southern Nevada Water Authority
 Upper Division Revegetation Site
 LAS VEGAS, NEVADA

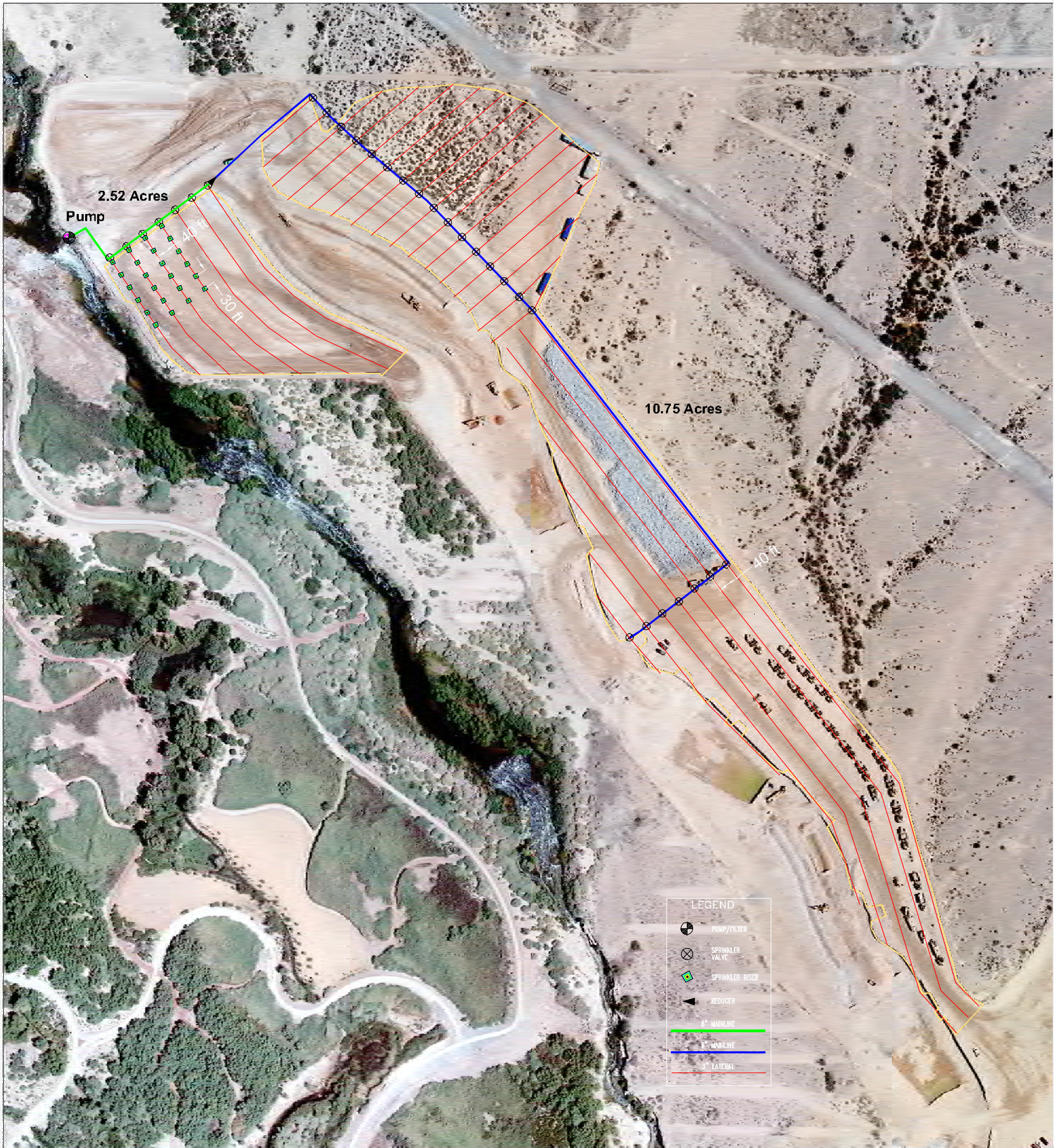


DATE: SEPTEMBER 19, 2008
 JOB NO.:
 DRAWN BY: AH/DB
 DESIGNED BY: FOP
 CHECKED BY: FOP
 DRAWING TITLE: PLANTING DETAIL 1

SHEET NO.:
 1 of 2

UpperDivision_work090708.dwg

Appendix D
Upper Diversion Weir Irrigation Design



Southern Nevada Water Authority Upper Diversion Revegetation Site- 13 Acres

LAS VEGAS, NEVADA

Fred Phillips Consulting, LLC

401 SOUTH LEROUX STREET
FLAGSTAFF, AZ
86001

TEL 928 773 1530
FAX 928 774 4166
Ecosystem Restoration Land Planning

DATE: JULY 25, 2008

JOB NO.:

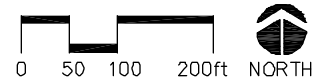
DRAWN BY: AH

DESIGNED BY: FOP

CHECKED BY: FOP

DRAWING TITLE: IRRIGATION DESIGN

SHEET NO.:



1 of 1