STONE LAKES RESTORATION PROJECT
ADAPTIVE MANAGEMENT PLAN
SERRA PROPERTY

Prepared for:

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LIST OF ATTACHMENTS

LIST OF ACRONYMS AND ABBREVIATIONS

BMP	best management practice
DISB	Delta Independent Science Board
DU	Ducks Unlimited
GGS	giant garter snake
msl	mean sea level
Project	Stone Lakes Restoration Project – Serra Property
SLNWR	Stone Lakes National Wildlife Refuge
SYMVCD	Sacramento Yolo Mosquito and Vector Control District
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service

1 INTRODUCTION

The Stone Lakes Restoration Project – Serra Property (Project) will restore and enhance freshwater emergent seasonal wetlands for wildlife benefits on the approximately 50-acre site. The Project goal is to maximize faunal diversity (predominantly birds) through a diversity of constructed wetland types, plant associations and support food web development. Ultimately the outcome of the Project will be the restoration of approximately 25-acres of seasonal wetland and enhancement of approximately 25-acres of existing low-quality wetland. These restored and enhanced wetlands will be managed to provide optimum conditions for wetland dependent species such as waterfowl, neo-tropical migratory birds, shorebirds and other water birds such as greater sandhill cranes, and to some extent giant garter snake (GGS). These wetlands will also provide other critical functions such as hydrologic and water quality functions and services.

The Project is located east of Stone Lake and adjacent to the Stone Lakes National Wildlife Refuge (SLNWR). Land adjacent to the project area consists of Stone Lake, riparian and wetland habitat in the Stone Lakes NWR and privately-owned agricultural land consisting predominantly of row crops. The site location is shown on Figure 1. The proposed construction Site Plan is presented as Figure 2.

1.1 PROJECT BACKGROUND

The Project focuses on the restoration of palustrine emergent wetlands. Restoration of wetlands will be accomplished by constructing containment berms, contouring shallow swales, loafing and foraging islands, and installing new infrastructure such as water control structures. The Project will construct berms to manage water surface elevations in the single wetland unit. In addition, habitat features such as habitat loafing islands will give wildlife nesting and resting opportunities.

1.2 SITE HISTORY

The Serra Property is located in the historic Beach-Stone Lakes Basin. Beginning in the mid-1800s several land use changes modified the Beach-Stone Lakes Basin and the land within the Study Area. Levees were built around the Sacramento River and other Delta Islands. The South Pacific Railroad was built bisecting the basin, allowing the near drainage of the lakes. Most recently Interstate 5 was built along the eastern edge of the basin, promoting urban growth near the Study Area.

By the mid-1960s the Beach-Stone Lakes Basin was of interest to the United States Army Corps of Engineers (USACE) as a potential site to build flood water conveyance channels. At that time a new development was also proposed at nearby North Stone Lake. In response to the growing interest in the area, the State of California and the County of Sacramento purchased approximately 2,600 acres of the basin in the 1970s. In July of 1992 the United States Fish and Wildlife Service (USFWS) completed an Environmental Impact Statement establishing the 18,000-acre boundary of SLNWR. Approximately 6,000 of these 18,000 acres are actively managed by USFWS. An Elevation Habitat Map is presented as Figure 3.

2 PROJECT CONSTRUCTION

During construction of the Project, a perimeter berm, interior water conveyance swales, potholes, and habitat islands will be constructed. Water control structures will be installed and improved. It is anticipated that the Project will excavate approximately 35,000 cubic yards from various locations within the Project site and relocate that material in different areas to recontour the existing Project area and build the necessary project features. No material will be exported, and a cut/fill balance will be achieved. Details of planned improvements to water management infrastructure and construction of additional infrastructure required to manage the Project as emergent wetlands are described below.

A new perimeter berm, constructed 2-feet above the existing ground surface and 12-feet wide, will be utilized to allow for water levels to be maintained at the optimal management elevation. The existing elevation of the Project site ranges from approximately 3 to 9-feet above mean sea level (msl). The perimeter berm will have approximately 1.5-feet of freeboard. Materials to create the perimeter berm will be obtained onsite from the creation of swales, potholes, and field recontouring.

Water currently enters the site through a 12-inch overflow valve that draws water from a pump station located on the border of Stone Lake. Rip rap protection will be added to t the existing overflow valve to reduce erosion potential. Water levels within the Project area are currently controlled by dilapidated sandbags at the lowest elevation of the Project site. These sandbags will be removed and replaced with a prefabricated water control structure. Approximately 35 water control structures will be installed. The interior of the site will feature conveyance swales to facilitate water and vegetation management capabilities. When the Project is completed, water is proposed to be maintained in the project area from fall to spring, effectively creating a seasonal wetland.

Water will be conveyed within the Project swale network via gravity flow from the higher elevation overflow valve discharge location to the lower elevation water control structure outfall location. The water level in the Project area can be raised, lowered, or removed through the outlet water control structure that drains to Stone Lake. The Project area will be a mosaic of open water, swales and emergent vegetation comprised predominantly of species such as California bulrush (Schoenoplectus californicus) and narrow leaved cattails (Typha angustifolia).

Interior water conveyance swales will be excavated in the Project area to provide water delivery and circulation to desired areas of the Project. The conveyance swales will provide numerous wetland and wildlife benefits. Material excavated from swale construction will provide material for the perimeter berm and habitat islands.

The swales will be managed to encourage the growth of submerged aquatic and floating wetland vegetation and discourage the growth of invasive species. Open water areas will provide waterfowl with areas to land, loaf, and feed. If water is maintained in the swales throughout late spring early summer, the presence of semi-permanent open water may increase the amount of waterfowl breeding and brood rearing in the Project area.

Conveyance swales will have an approximately 12-foot bottom width with gradual 5:1 side slopes. A gradual swale side slope will allow for easy wildlife movement across the swales while reducing swale erosion by encouraging vegetation growth along the swale's edges. Depth of swale excavation will vary depending on location within the Project area to allow for adequate gravity flow of water through the Project area. Swale excavation depths will range from approximately 0.5 to 2-feet below ground surface. In addition to the swales, larger open water areas will also be created through excavation. These larger open water areas will be connected to the conveyance swales and are similarly designed to depths ranging from approximately 0.5 to 1.5-feet below ground surface. The large open water areas may serve as waterfowl brood rearing areas in the spring and loafing/storm-shelter locations in the winter. Material excavated from these features will be incorporated into the perimeter berm or used to construct habitat islands.

As part of creating varying topography and diverse emergent wetland vegetation communities within the project area, habitat islands will be established in multiple locations. Habitat islands will vary in size, shape, and elevation. The subtle change in micro-topography as a result of the habitat islands will create habitat diversity and greater hydro-geomorphic interspersion.

2.1 CONSTRUCTION SCHEDULE AND METHODS

A source has not yet been identified to fund construction activities. Construction activities would likely be performed between May 1st and October 1st due to GGS permitting requirements. Earth moving activities would be performed by a contractor who will likely use tractors with tow behind scrapers excavate and construct the Project features described above. An excavator or backhoe would likely be used for tule transplanting, to install rip rap erosion protection, and to install the prefabricated water control structure. A bulldozer or grader would likely be used to for finish grading of berm, island, swale, and pothole side slopes.

Initial site preparation for the Project may include the removal of existing vegetation through stripping. Stripped material would remain on-site and would be placed along berm side slopes. Alternatively, existing vegetation may be disced prior to earth moving operations. Initial site preparation may also include the removal or invasive plant species such as sandbar willow (*salix exigua*). This site preparation will take place within the entire Project boundary as the area will be recontoured to eliminate the existing slope. The site preparation will include the foundation for berm construction to minimize the plant material within the berm that would compromise the permeability of the berm.

The Project will be completely enclosed by a perimeter berm that will prevent the discharge of storm runoff. Best management practices (BMPs) for erosion control and hazardous materials handling will be implemented during construction. Any spills of hazardous materials would be cleaned up immediately and reported to the responsible resource agencies within 24 hours. Any such spills, and the success of the cleanup efforts, shall also be reported in post-construction compliance reports. Measures will be taken to minimize windborne transport of fine particles to adjacent areas. A storm water permit issued by the State Water Resources Control Board will be obtained prior to project construction.

3 RESTORATION AND MANAGEMENT

The Project goals are to maximize faunal diversity (predominantly birds) through a variety of wetland types, plant associations, and support food web development. The Project objectives are to:

- Provide infrastructure and site conditions to promote shallow flooded wetland habitat suitable for shorebirds, waterfowl and sandhill cranes;
- Improve water conveyance and management to improve wetland habitat conditions through vegetation diversity and reduction of undesirable invasive species.

The water level will be managed to encourage the establishment and maintenance of annual, perennial, emergent, and submerged aquatic vegetation. Subsequently, these vegetation communities will provide habitat for a variety of wetland dependent wildlife. Water management provides the means to vary water levels within this unit to distribute nutrients, decrease stagnant conditions, provide quality habitat, and minimize vector production.

3.1 NATURAL RESOURCES AND MANAGEMENT

Management of the Site will have two main goals: to maintain seasonally flooded emergent wetlands with an abundance of food resources for wintering waterfowl and to provide wetland habitat for a variety of other wetland dependent species.

3.2 EXISTING HABITAT CONDITIONS

Existing habitat conditions on the site are included in the Wetland Delineation Report (DU, 2019) and the Special-Status Plant Survey Report (WRA, 2019).

3.3 DESIRED HABITAT CONDITIONS

The desired habitat conditions include a restored wetland with seasonally flooded emergent vegetation dominated by desirable moist soil plant species such as smartweed, watergrass, spangled-top, swamp timothy, round stem bulrush and cattails with a diverse mosaic of vegetated and open water habitat types. Berms will attain a cover of grasses with shrubs and trees which may be planted on the berm slopes. Berms will be maintained for site access. Tule (round-stem bulrush and cattails) patches which currently exist in the central portion of the property will be used to transplant tules to restored wetland habitat throughout the property. Habitat areas will be designed to maximize habitat value while minimizing the maintenance required to manage for invasive weeds.

The project has been designed with recommendations from the Sacramento Yolo Mosquito and Vector Control District (SYMVCD). Additional consultations with SYMVCD may be conducted directly by the landowner. This collaboration will allow the SYMVCD to implement a wide variety of effective mosquito control options, if they become necessary. Mosquito control BMPs as identified in the Central Valley Joint Venture "Technical Guide to Best Management Practices for Mosquito Control in Managed Wetlands" (Kwasny, 2004), have been incorporated into the engineering design as well as the Habitat and Water Management Plan (Appendix A).

3.4 WATER USE

As discussed above, water to the site will be provided by a pump station adjacent to Stone Lake. Water will be conveyed within the wetland system via gravity flow beginning with swales with higher flow line elevations and proceeding to lower elevation flow lines until ultimately exiting the site at the newly installed water control structure.

It is anticipated that water will begin to be brought onto the site in late fall to maintain an approximate water elevation 0.5-feet above the ground surface. This water level will be maintained through winter until the spring. Periodic flood up events may occur in spring through fall to facilitate growth of desired species or to eliminate invasive species.

3.5 RESTORATION POTENTIAL

Habitat restoration project features and post-restoration habitat following temporary impact recovery are shown on Figure 4. The overall Project will be an improvement of water supply, conveyance, and water management capabilities. Enhancement of approximately 25-acres of low-quality existing wetland and restoration 25-acres of seasonal wetland will occur. The Project will also provide a functional lift by diversifying habitats through varied topography of swales and potholes, allow the site to be more efficiently managed, and will be more productive migratory bird habitat.

Additional benefits of the Project include potentially sequestering atmospheric carbon. According to the Delta Plan Policy ER P2, the location of the restoration site is appropriate for the type of restoration proposed. See the

4 ADAPTIVE MANAGEMENT

Adaptive management is a structured approach to environmental management and decision-making in the face of uncertainty. It involves taking risks, assuming that plans may not always turn out as intended, having a contingency plan, and continuing to evaluate progress toward goals. It provides a pathway for undertaking actions when knowledge about a system is incomplete and then modifying the approach as knowledge is gained and uncertainty is reduced. Adaptive management makes learning more efficient and improves management practices.

Adaptive management fosters flexibility in management actions through an explicit process. It entails having clearly stated goals, identifying alternative management practices or objectives, framing hypotheses about ecological causes and effects, systematically monitoring outcomes, learning from the outcomes, sharing information with key players and decision-makers, and being flexible enough to adjust management practices and decisions (DISB, 2016). Conceptual models often are used in adaptive management programs to integrate available knowledge and to provide synthesis and a means of developing and exploring promising management actions before they are attempted as field experiments or pilot projects.

Adaptive management may reduce uncertainty when management actions are thought of as experiments. By using a structured design that includes appropriate controls or references, monitoring, and replication, observed outcomes can be disentangled from a welter of potentially confounding factors (Zedler, 2005). As a result, one can have a good idea of why a management action did or did not work as expected.

The Delta Reform Act requires that adaptive management be used in science-based management of the Delta and its resources. A state or local agency that proposes to undertake a covered action, prior to initiating the implementation of that covered action, is required to submit a written certification to the Delta Stewardship Council, with detailed findings demonstrating that the covered action is consistent with the Delta Plan (Water Code Section 85225).

4.1 BEST AVAILABLE SCIENCE

Nearly 95 percent of historic wetlands have been lost in California's central valley, thereby putting greater pressure on the remaining wetlands to provide much needed resources for wetland dependent species. While certain types of agricultural activities can offset some of the wetland losses related to species life cycle needs, seasonal wetlands play a critical role in supporting ecosystem and life processes for many wetland dependent species. The restoration and creation of new wetland habitat is vital to the long-term success of several listed and endangered species as well as non-listed wetland dependent species.

Throughout project planning and implementation, DU is committed to utilizing the best available science to design and construct the project. The property owner is committed to manage and monitor the site. Adaptive management of the Project will be based on the utilization of input from monitoring data in conjunction with adaptive review of whether restoration goals and objectives are being achieved.

Ongoing research related to waterfowl biology and habitat management continues to progress and provides greater insight on how to manage habitat. A list of current best available science is provided as Appendix B.

4.2 INTERVENTION AND RESPONSE

While it is not anticipated that major modification to the site will be needed, an objective of this plan is to guide monitoring to identify any thresholds that may compromise the Project objectives, and to propose potential management responses or further focused monitoring efforts. Project objectives, the expected outcomes related to those objectives, the metrics by which progress towards meeting the objectives is measured, as well as thresholds for undertaking a management response if goals are not being met or problems occur which require intervention are presented in Table 1.

4.3 RESPONSIBLE PARTIES

DU is responsible for completing the 65-percent level engineering design and obtaining the necessary environmental permits for the project. At this time, a source has not been identified to fund the final design or construction implementation. The property owner would be responsible for monitoring the site, following completion of construction activities, to verify that the project is maintained as a functioning seasonal wetland. DU routinely makes staff available to property owners of completed projects to assist in habitat management and serve as a technical advisor. Additional potential technical advisor resources include staff of the Stone Lakes National Wildlife Refuge as well as the Cosumnes River Preserve. There are other nearby private duck clubs that often are willing to network, trouble shoot, and serve in a technical advisory capacity.

4.4 ADAPTIVE MANAGEMENT PROCESS

The goal of this project is to restore and enhance wetland habitat by providing infrastructure and site conditions to promote shallow flooded seasonal wetland habitat suitable for waterfowl, shorebirds, and sandhill cranes.

The Serra Property is a small privately-owned single parcel of land. Small privately-owned properties typically do not have a strong science foundation. The property has surveys of existing physical and biological conditions as well as cultural resources.

Adaptive management is defined in the Delta Reform Act as “a framework and flexible decision-making process for ongoing knowledge acquisition, monitoring, and evaluation leading to continuous improvements in management planning and implementation of a project to achieve specified objectives” (Water Code section 85052). The three phase nine step process consists of identifying a problem, coming up with a plan or action to resolve the problem that is consistent with the goals and objects of the project and supporting information, implementing that plan/action and then evaluate the results of the planned action. The Delta Stewardship Council’s Adaptive Management Wheel Figure 1B-1 of the Delta Plan Appendix 1B - Adaptive Management is presented as Figure 5 in this document. The process can be very formal for large scale projects or problems having full monitoring plans and teams of scientists to small informal evaluation process were no documentation of the process occurs and is conducted by a landowner or manager. A balanced approach on the smaller side of the scale is anticipated for this particular restoration project.

Monitoring is being conducted to establish baseline conditions for the Serra Property to aid in the post evaluation process to better determine the success of the proposed restoration project. As previously stated, DU staff are willing to perform limited site visits, meet with landowner, and provide input following construction activities to help property owners maximize their habitat potential.

Generally, results from monitoring are analyzed and used to assess progress toward project goals, maintenance practices and areas of improved, and changes to maintenance practices that could provide more optimal habitat conditions.

Communication of project results provides learning opportunities for groups and partners with a shared interest in waterfowl habitat restoration. Although not a grant requirement, project status and findings can be shared with partner agencies in a collaborative effort to improve future project design and post-construction maintenance activities. Any rare or especially interesting findings resulting from project construction and post-construction observations may be shared at public forums such as the Central Delta Corridor Partnership, Bay-Delta Science Conference, and Natural Resource Conservation Service Wetland Managers Meeting.

5 WETLAND HABITAT MANAGEMENT

Proper water management in any managed wetland is essential to provide quality wetland conditions that support the desired functions and values. Water depths, timing of inundation, and duration of inundation dictate the ultimate vegetation community present in any wetland. In a managed wetland, a pre-determined hydrologic regime can be implemented to produce a desired vegetation community and ultimately provide the conditions necessary to support the desired wildlife community. This section references A Guide to Wetland Habitat Management in the Central Valley developed by the California Department of Fish and Game and the California Waterfowl Association (Smith, 1995). This section serves as a management tool for the property owner to use to achieve optimal habitat conditions.

5.1 MOIST SOIL MANAGEMENT

Seasonal wetlands should be flooded in the fall with standing water continuously maintained throughout the winter until drawdown occurs in the spring. Moist soil plants germinate on exposed mudflats of seasonal wetlands when surface water is drained during the spring and summer months. Some of these plants produce seeds and/or tubers that are important food for waterfowl. A combination of moist soil plants and robust emergent vegetation such as cattails and tules usually results from management practices in Central Valley seasonal wetlands. A primary goal of moist soil management is to provide an abundance and diversity of seeds, aquatic invertebrates, and other moist soil foods for wintering waterfowl. Invertebrates are protein rich byproducts of moist soil management that serve as an important food source for waterfowl during later winter and spring.

5.2 MOIST SOIL PLANTS

The wildlife value of a moist soil plant is generally based on its seed production capability, the nutritional quality of its seeds, and the invertebrate habitat the plant provides. Management practices that encourage a diversity of highly valuable moist soil plants are considered most effective. Watergrass, swamp timothy, and smartweed are the most important moist soil plants in the Central Valley due to their documented value as a food source for wintering waterfowls. A variety of other wetland plants are needed to provide additional nutrition, cover, and thermal protection. Some moist soil plants are not good seed producers or produce seeds with modest nutritional value but have a complex leaf structure and harbor rich invertebrate communities.

5.3 DRAWDOWN AND SOIL DISTURBANCE

Moist soil plants are easily propagated in most seasonal wetlands through effective water management and soil disturbance. The primary factors that affect the type and abundance of moist soil plants are found in seasonal wetlands are the timing of spring drawdown and the length of time since soil disturbance (the "successional stage"). The seeds of each plant species germinate best at a specific soil temperature under specific successional conditions. Therefore, as plants compete for dominance, the wetland can be managed to favor specific plants by timing drawdowns to coincide with optimum germination conditions and periodic discing to maintain the successional stage required by the target vegetation. Climatic conditions vary year to year, and by location. The drawdown dates described here will generally induce germination of the target waterfowl food plant.

5.4 DRAWDOWN RATES

The rate of drawdown affects moist soil plant composition, seed production, soil-salt levels, and the duration of food availability to waterfowl. Slow drawdowns (2 – 3 weeks) cause invertebrates to become concentrated in the shallow water and allow waterfowl optimum foraging conditions for a prolonged period. Slow drawdowns also typically result in high vegetation diversity and if executed during mid to late spring may enhance seed production. Rapid drawdowns (3 – 5 days) may produce extensive stands of waterfowl food plants if timed correctly, but do not provide wildlife the extended shallow water habitat associated with slow drawdowns. Rapid drawdowns late in the growing season should be followed by a summer irrigation to provide a good seed crop. Although slow drawdowns are generally better for wildlife, there is no right or wrong way to drain a seasonal wetland. The rate of drawdown should be based on site specific knowledge.

5.5 IRRIGATIONS

Spring and summer irrigations are very important in moist soil management. Most waterfowl food plants will not attain maximum seed production without at least one irrigation. Swamp timothy is the only waterfowl food plant that may be grown successfully without an irrigation; however, irrigations greatly enhance seed production if timed correctly. Irrigation schedules for smartweed and watergrass vary with annual weather patterns. These plants should be observed for signs of wilting to determine proper irrigation dates. Additional considerations for irrigations include availability and cost of water as well as potential mosquito production. See

5.6 FALL FLOODING

Early fall flooding (August and September) is particularly important for locally raised mallards and early migrant pintails and is highly recommended if feasible. Generally, most wetland units should be flooded prior to October 15. Seasonal wetlands should maintain water in their ponds until spring drawdown.

5.7 WATER DEPTH

Dabbling ducks such as mallards, pintails, and green-winged teal cannot effectively feed on the seeds and invertebrates found on pond bottoms if the water is deeper than 12 inches. Water depths of 4 to 10 inches are preferred for feeding. In order to provide feeding habitat for dabbling ducks, shallow water must be maintained.

5.8 VEGETATION CONTROL

Some plants reduce the value of a wetland to waterfowl if they become overly abundant. Tules and cattails can eventually fill in a pond and eliminate open water. Dense stands of tules and cattails should not occupy more than 60% of a pond. The primary tools for tule and cattail control are discing and mowing. Mowing is only effective when followed by discing and 2 to 3 months of exposure to the sun. Discing also disturbs the soil and provides favorable conditions for invasion by valuable moist soil waterfowl food plants.

The depth of discing varies with soil structure, soil moisture, implement weight, tractor size, and speed. Most stubble discs have blades that range from 26 to 36 inches in diameter and make cuts that are 7 to 10 inches deep. Stubble discs are necessary for most types of pond bottom discing; however, a finish disc and ring-roller can be used afterward to break up dirt clods and make walking easier. Deep stubble discing can adversely affect the water holding capacity of a wetland if the disc breaks through the shallow clay pond bottom and into the underlying sandy soil. Finish discs typically have blades that range from 18 to 24 inches in diameter and make cuts that are 4 to 6 inches deep. Finish discs often suffice for discing low growing vegetation such as picklegrass and swamp timothy, but are ineffective for controlling cattails, tules, and other robust wetland plants.

Summer irrigations occasionally cause watergrass, smartweed and other moist soil plants to occur in very dense stands. Waterfowl use of these areas may be impeded unless openings are created prior to fall flooding. With the use of a finish disc, managers can create strips, channels, and potholes in otherwise dense vegetation. The appropriate time to create such openings is in July or August.

6 REFERENCES CITED

DISB, 2016. Improving Adaptive Management in the Sacramento-San Joaquin Delta, Delta Stewardship Council, Sacramento, CA.

DU, 2019. Wetland Delineation for the Stone Lakes Wetland Restoration Project, Sacramento County, California, July 29.

Kwasny et al., 2004. Central Valley Joint Venture, Technical Guide to Best Management Practices for Mosquito Control in Managed Wetlands, June.

Smith et al., 1995 A Guide to Wetland Habitat Management in the Central Valley, California Department of Fish and Game and California Waterfowl Association.

WRA, 2019. Special-Status Plant Survey Report, Stone Lakes Wetland Restoration Project, Sacramento County, California, September.

Zedler, 2005. Ecological Restoration: Guidance from Theory. San Francisco Estuary and Watershed Science, Volume 3, Issue 2, September.

FIGURES

Figure 1. Site Location Map

Legend

Serra Property Project Area

Primary Delta

Secondary Delta

Figure 2 - Site Plan

US-CA-575-1

STONE LAKES RESTORATION PROJECT SERRA PROPERTY

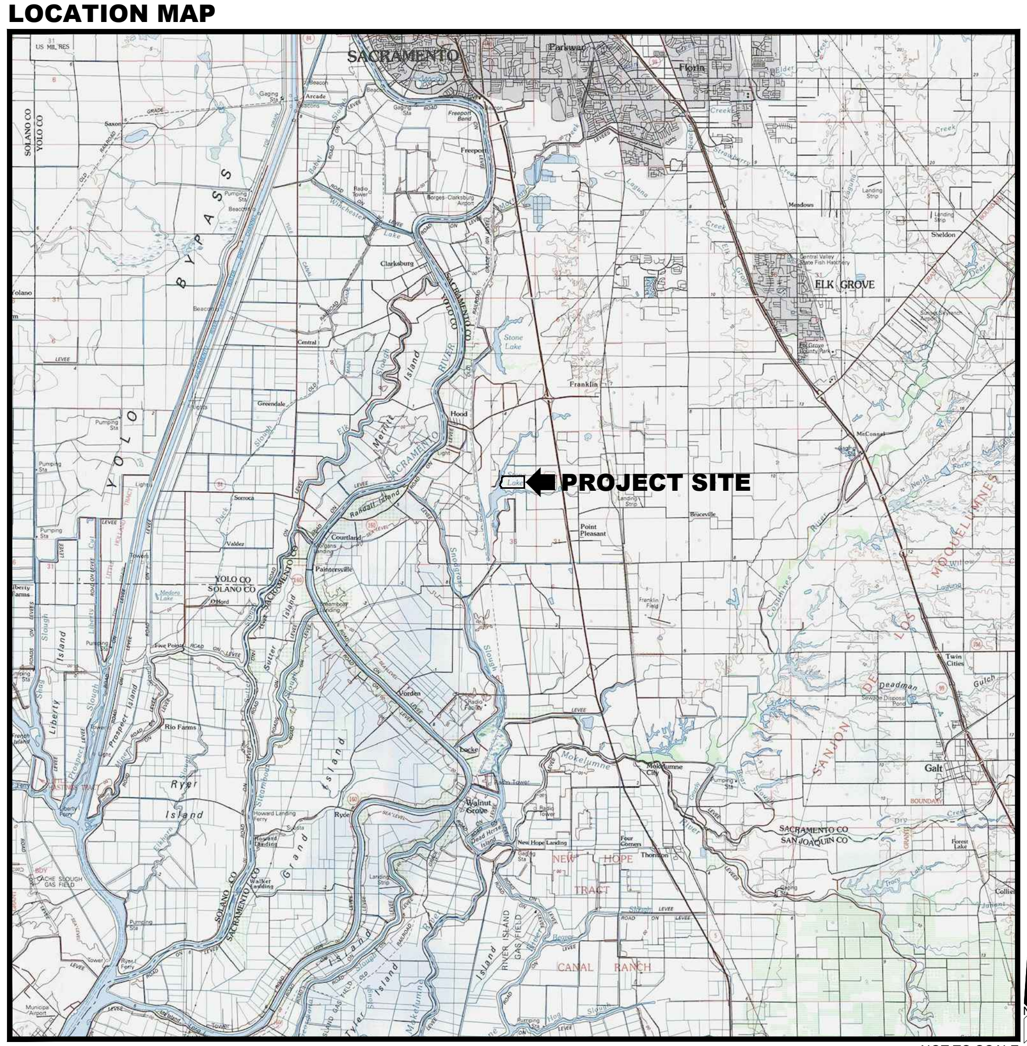
DUCKS UNLIMITED

U.S. FISH & WILDLIFE SERVICE — DEPARTMENT OF THE INTERIOR

SACRAMENTO - SAN JOAQUIN DELTA CONSERVANCY
A California State Agency

PROP 1
GOVERNOR EDMUND G. BROWN, JR.
WATER BOND 2014
RELIABILITY | RESTORATION | RESILIENCE

LOCATION MAP



NOT TO SCALE

VICINITY MAP

SURVEY DATUM

Horizontal and Vertical Control:
The horizontal datum for this survey is the California Coordinate System of 1983, Zone 2 (0402), NAD 83, Epoch Date 2010.00 in U.S. Survey Feet. The vertical datum for this survey is the North American Vertical Datum of 1988 (NAVD88) computed using GEOID12. Both datums were derived from GPS observations collected on May 28, 2019. Said observations were fixed to local area National Geodetic Survey (NGS) Control Point "HOOD" (PID JS4258), respectively.

MAP DATA

Contour Interval: 1 Foot

Aerial Photo: 2016 NAIP

SHEET INDEX

EMERGENCY CONTACT INFORMATION

In case of fire: CALL 911
Then contact:
Bart McDermott - Stone Lakes National Wildlife Refuge
(916) 775-4421

PROJECT DIRECTORY

Ducks Unlimited, Inc.
Western Regional Office
3074 Gold Canal Drive
Rancho Cordova, Ca. 95670-6116
Ph. (916) 852-2000

80% DESIGN

Unauthorized Changes & Uses
The engineer preparing these plans will not be responsible for, or liable for, unauthorized changes to or uses of these plans. All changes must be in writing and must be approved by the preparer of these plans.

Utility Notification Center
CALL BEFORE YOU DIG

PRELIMINARY
NOT FOR CONSTRUCTION

REVISIONS			
REV. NO.	DESCRIPTION	DATE	APPROVED
5			
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3			
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DUCKS UNLIMITED

PROJECT NO. US-CA-575-1 DATE: 12/9/2019
STONE LAKES
RESTORATION PROJECT
SERRA PROPERTY
APPROVED BY:

DESIGNED BY: AT
DRAWN BY: JS
SURVEYED BY: DU
CHECKED BY: BW
SHEET NO.

GENERAL NOTES:

1. Ducks Unlimited makes no representations as to the existence or nonexistence of utilities. It is the responsibility of the contractor to comply with the provisions of all applicable utility notification regulations. The contractor will be liable for any damage to utilities caused by construction activities.
2. The engineer does not represent that the location of utilities shown on the plans are exact or complete. It shall be the responsibility of the contractor to determine the presence of, actual locations of and make provisions for all watercourses and utilities. The contractor shall verify location, depth and height. Their verification shall be coordinated by the contractor with the appropriate utility company.
3. The contractor shall exercise extreme caution when working in the vicinity of overhead power lines. Verify location in the field and protect in place.
4. At least 2 working days prior to beginning any digging or excavation work, the contractor shall notify underground service alert (a.k.a. USA North) at www.usanorth.org or by phone at 811 or 1-800-227-2600, to determine locations of existing utilities.
5. In accordance with generally accepted construction practices, the contractor will be solely and completely responsible for the conditions of the job site including safety of all persons and property during performance of the work. The contractor shall ensure that all work is performed in accordance with occupational safety laws, including the design and construction of proper shoring of trenches. The duties of the project engineer do not include review of the adequacy of the contractor's safety in, on, or near the job site.
6. It is the responsibility of the contractor to be knowledgeable about the project specifications and permits. All work shall be completed in compliance with the contract documents. The contractor shall have copies of the most current approved plans, specifications and permit conditions on site during all work operations.
7. The project site and adjacent areas contain sensitive habitat areas for protected wildlife, and may include endangered species. The contractor shall protect wildlife and water quality, and minimize possible air, waterway, and subsoil contamination or pollution or other undesirable effects.
8. Should it appear that the work to be done, or any matter relative thereto, is not sufficiently detailed or explained on these plans or in the specifications, the contractor shall contact the construction manager for such further explanations as may be necessary.
9. Should the contractor find any discrepancies between the conditions existing in the field and the information shown on the drawings, he shall notify the construction manager before proceeding with construction.

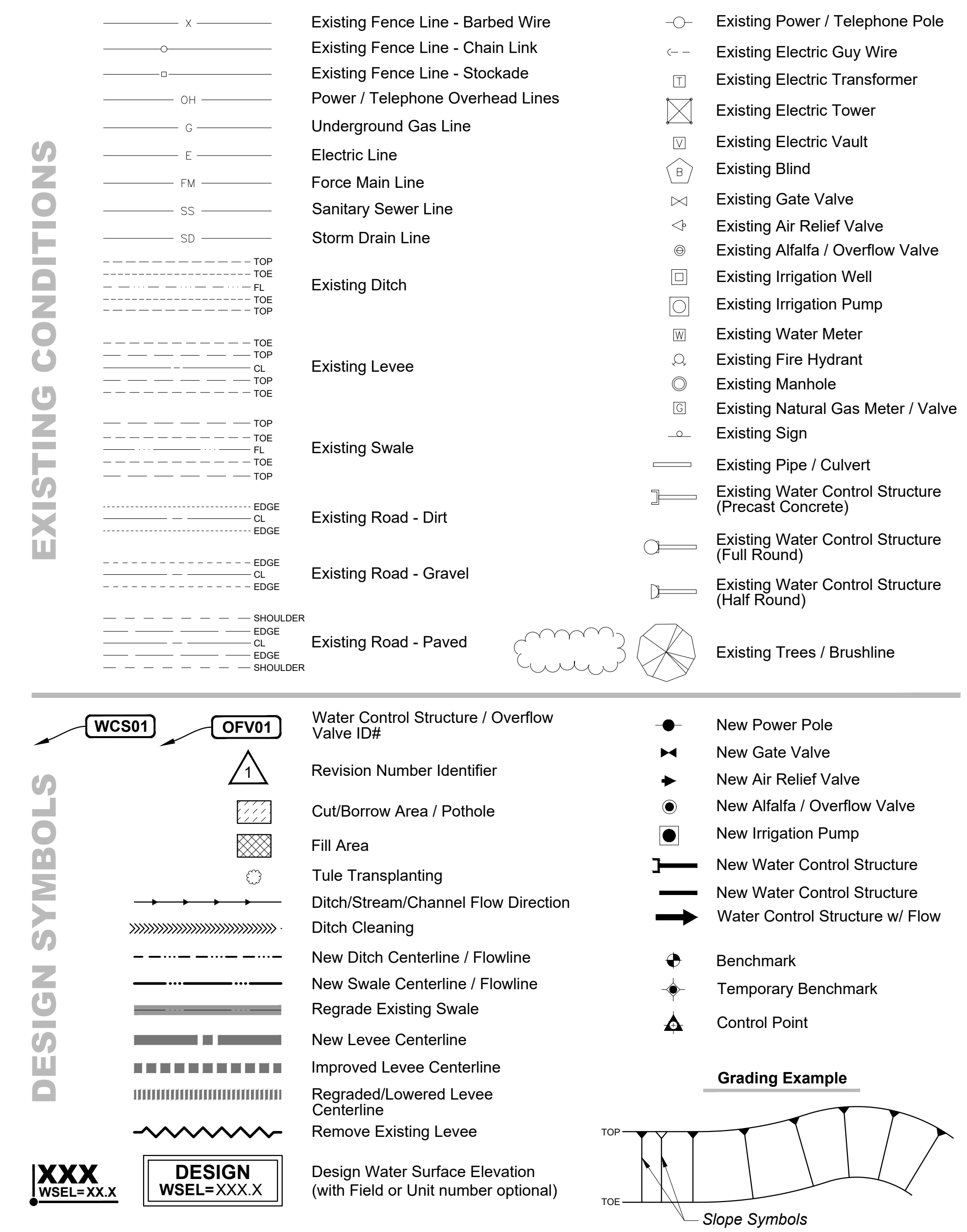
SURVEY POINT DESCRIPTORS

CTBM	Bench Mark (permanent)	RDSH	Road Shoulder
CTBT	Bench Mark (temporary)	RDSN	Road Sign
CTCP	Survey Control Point (permanent)	RDTO	Road, Toe of Slope
CTCT	Survey Control Point (temporary)	RDTP	Road, Top of Slope
DIFL	Ditch Flowline	SDMH	Storm Drain, Manhole
DIGB	Ditch Grade Break	SDPI	Storm Drain, Pipe Invert
DITO	Ditch Toe	SDPT	Storm Drain, Pipe Top
DITP	Ditch Top	SSMH	Sanitary Sewer, Manhole
ELBX	Electric, Box or Pullbox	SWFL	Swale Flowline
ELGY	Electric, Guy Wire	SWGB	Swale Grade Break
ELPP	Electric, Power Pole	SWTO	Swale Toe
ELSN	Electric, Warning Sign	SWTP	Swale Top
ELTR	Electric, Transformer	TFBL	Topo Feature, Building
ELTW	Electric, Tower	TFBR	Topo Feature, Brush
ELVT	Electric, Vault	TFCO	Topo Feature, Concrete (pad, slab, etc.)
FNAP	Fence Angle Point	TFFL	Topo Feature, Flowline
FNCR	Fence Corner	TFGB	Topo Feature, Grade Break
FNGT	Fence Gate	TFGS	Topo Feature, Ground Shot
FNLN	Fence Line	TFRK	Topo Feature, Rock Or Rocky Area Boundary
IRCO	Irrigation Concrete Pad	TFTL	Topo Feature, Tree line
IRCP	Irrigation Control Panel	TFTO	Topo Feature, Grade Break at Toe
IRPI	Irrigation Pipe Invert	TFTP	Topo Feature, Grade Break at Top
IRPM	Irrigation Pump	TFTR	Topo Feature, Tree
IRPT	Irrigation Pipe Top	WAEW	Edge of Water
IRVL	Irrigation Valve	WAHW	High Water Mark
IRWL	Irrigation Well	WAUW	Under Water Ground Shot
LVCL	Levee Centerline	WAWS	Water Surface
LVGB	Levee Grade Break	WCFL	Water Control Structure, Flowline/Invert at Structure
LVTO	Levee Toe of Slope	WCFR	Water Control Structure, Frame Top
LVTP	Levee Top of Slope	WCHW	Water Control Structure, Headwall
RDCL	Road, Centerline	WCPI	Water Control Structure, Pipe Invert at Outlet
RDED	Road, Edge of Dirt Road	WCPT	Water Control Structure, Pipe Top at Outlet
RDEG	Road, Edge of Gravel Road	WCST	Water Control Structure, Top of Structure
RDEP	Road, Edge of Paved Road	WCWW	Water Control Structure, Wing Wall
RDGB	Road Grade Break		

ABBREVIATIONS

AB	Aggregate Base	MIN	Minimum	WCS	Water Control Structure
AC	Acre	MISC	Miscellaneous	WS	Water Surface
APPROX	Approximate	(N)	New	WSEL	Water Surface Elevation
BM	Benchmark	N	North	WWF	Welded Wire Fabric
CAP	Corrugated Aluminum Pipe	NIC	Not In Contract	X:1	Slope, Horizontal:Vertical
CC	Center to Center	NTS	Not To Scale		
CF	Cubic Foot	OC	On Center		
CFS	Cubic Foot Per Second	OD	Outside Diameter		
CL, ℄	Centerline	OFV	Overflow Valve		
CMP	Corrugated Metal Pipe	PIP	Pressure Irrigation Pipe		
CMPA	Corrugated Metal Arch Pipe	PP	Power Pole		
CONC	Concrete	PSI	Pounds per Square Inch		
CP	Control Point	PT	Pressure Treated		
CY	Cubic Yard	PVC	Polyvinyl Chloride		
DEMO	Demolish	QTY	Quantity		
DIA, Ø	Diameter	R	Right		
Dp	Pipe Diameter	RCB	Reinforced Concrete Box		
Dr	Riser Diameter	RD	Road		
DU	Ducks Unlimited, Inc.	REF	Reference Dimension		
D/S	Downstream	REQD	Required		
E	East	ROW	Right Of Way		
EG	Existing Ground	S	South		
EL	Elevation	SCH	Schedule		
EX, EXIST	Existing	SS	Stainless Steel		
FG	Finished Grade	SDR	Standard Dimension Ratio		
FL	Flowline	SF	Square Feet		
FRG	Final Rough Grade	SHT	Sheet		
FT	Foot, Feet	SP	Special		
FTG	Fitting, Footing	SPECS	Specifications		
GA	Gauge	SY	Square Yard		
GB	Grade Break	STA	Station		
H	Height	STD	Standard		
HDPE	High-Density Polyethylene	TBD	To Be Determined by Engineer		
HR	Half Round	TBM	Temporary Benchmark		
ID	Inside Diameter	TE	Top Elevation		
IE	Invert Elevation	TEMP	Temporary		
IG	Initial Grade	TOI	Top of Island		
IN	Inch, Inches	TOL	Top of Levee		
INV	Invert	TOB	Top of Berm		
IPS	Iron Pipe Size	TYP	Typical		
L	Length, Left	USA	Underground Service Alert		
LBF	Pounds-Force	U/S	Upstream		
LF	Linear Feet	VLV	Valve		
MAINT	Maintenance	W	Width, West (where applicable)		
MAX	Maximum	W /	With		

LEGEND & STANDARD SYMBOLS (Symbols do not represent actual scale / size of object)



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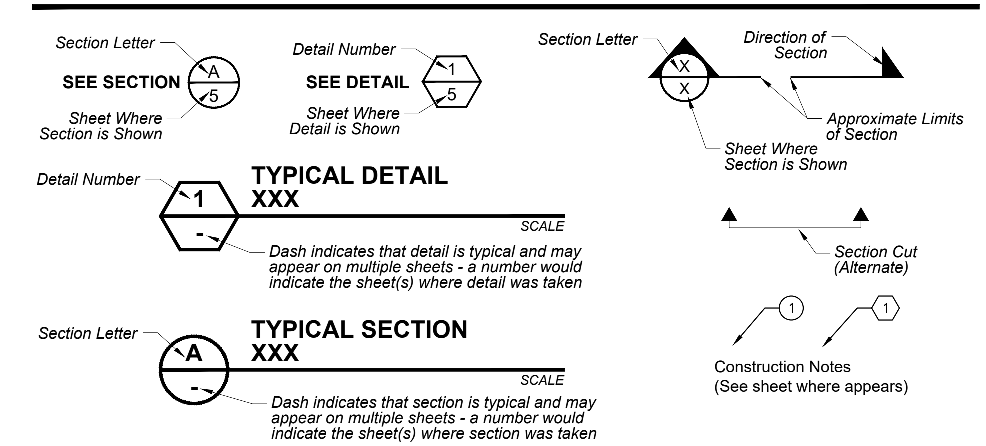

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DUCKS UNLIMITED

PROJECT NO. US-CA-575-1 DATE: 12/9/2019

STONE LAKES RESTORATION PROJECT SERRA PROPERTY

DEFINITIONS & LEGEND

DESIGNED BY: AT
DRAWN BY: JS
SURVEYED BY: DU
CHECKED BY: BW
SHEET NO. **2 of 6**

N GRID NORTH

0 600 1200 FEET
HORIZONTAL SCALE

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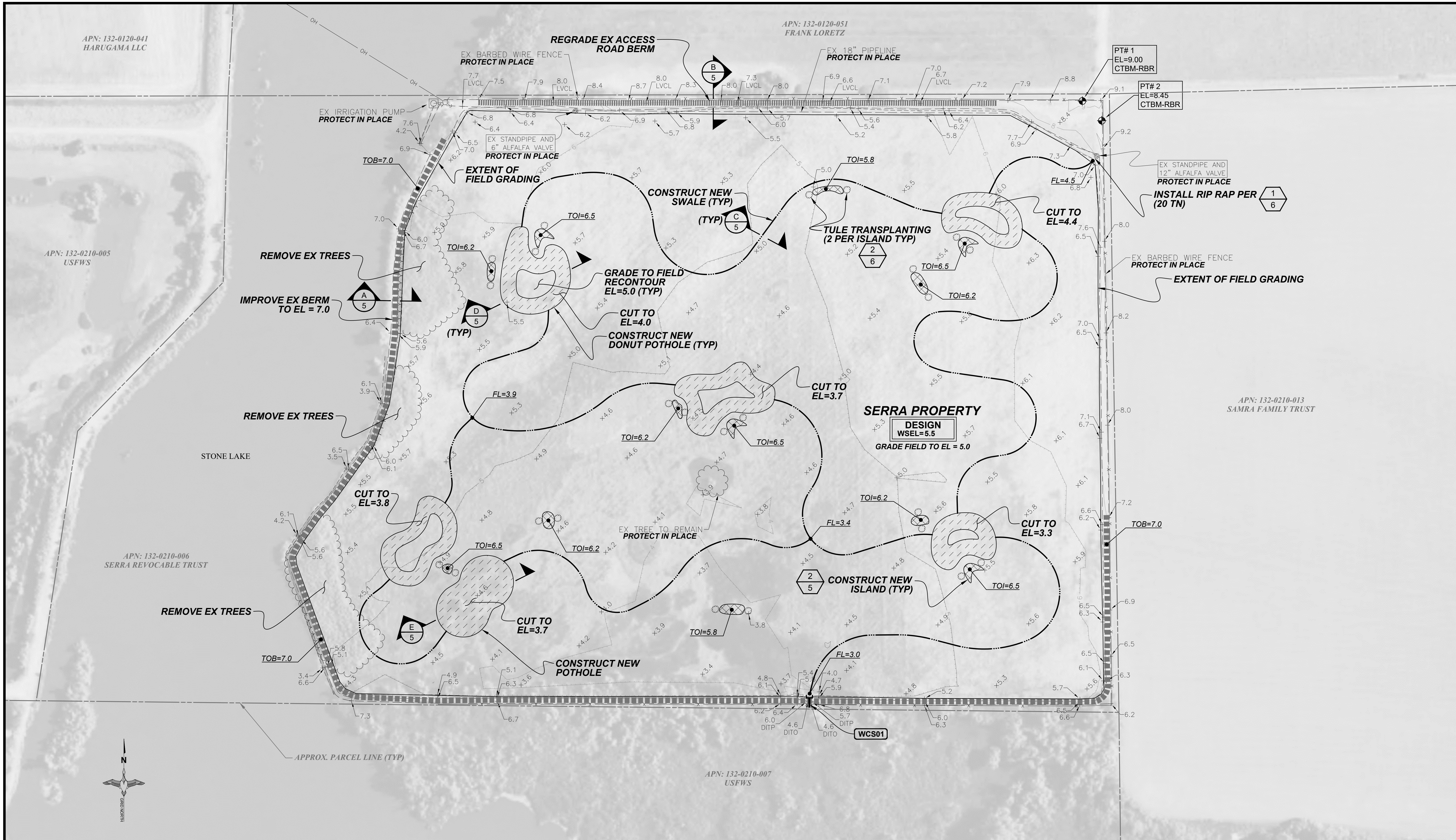

0 100 200 FEET
HORIZONTAL SCALE

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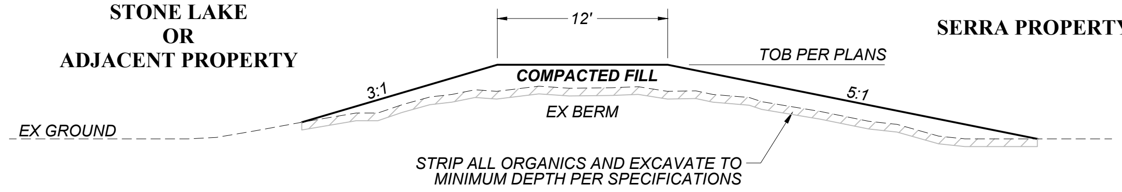
		SURVEYED BY: DU
		CHECKED BY: BW
SITE PLAN		SHEET NO. 4 of 6



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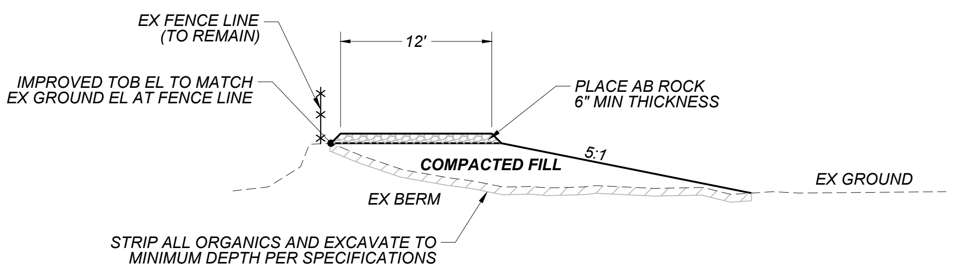

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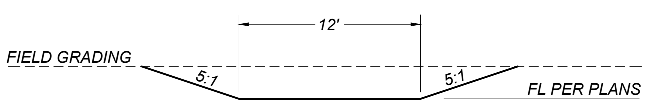

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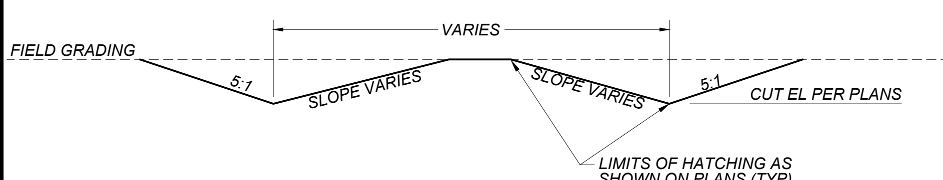

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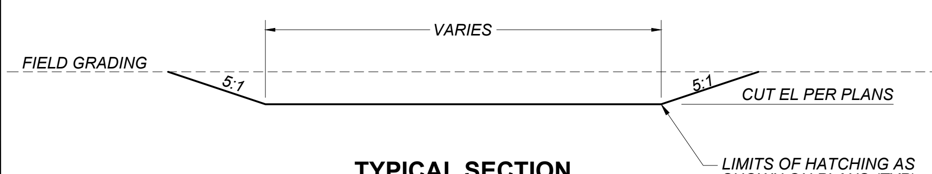

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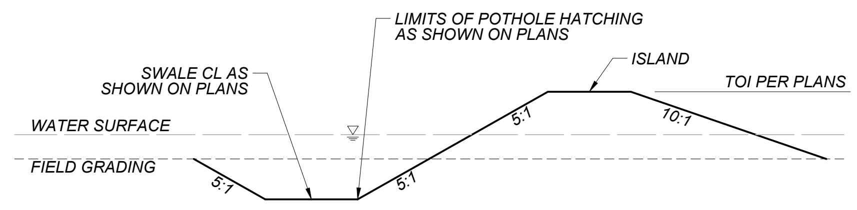

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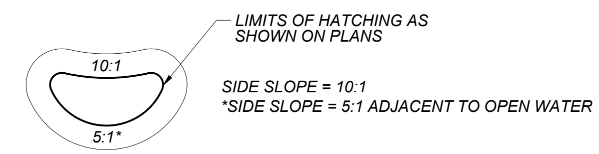

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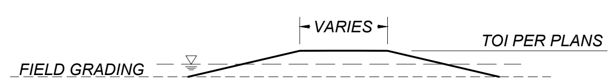

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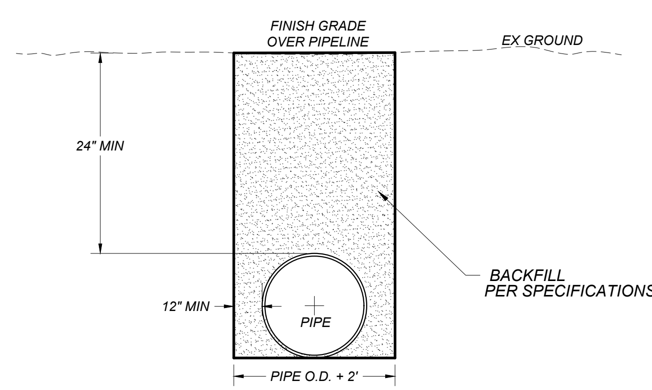

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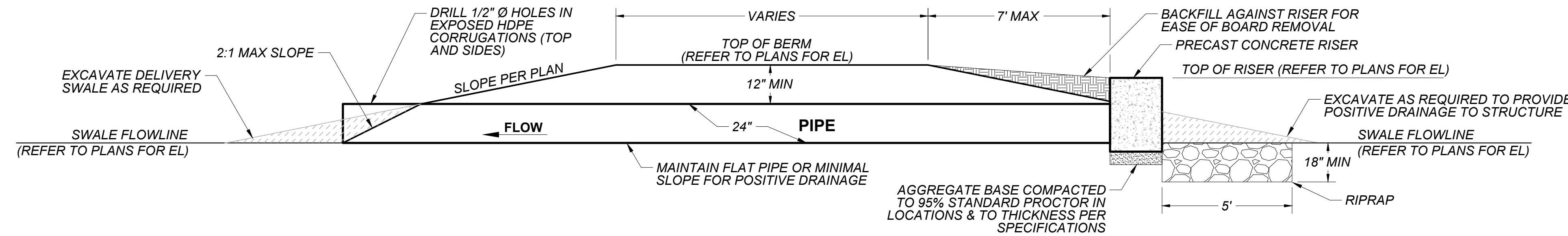

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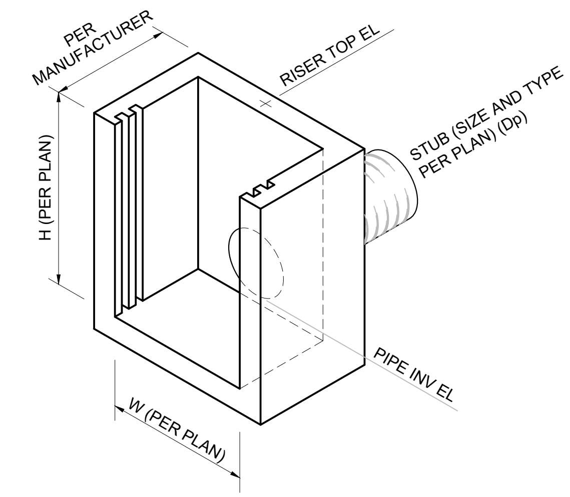

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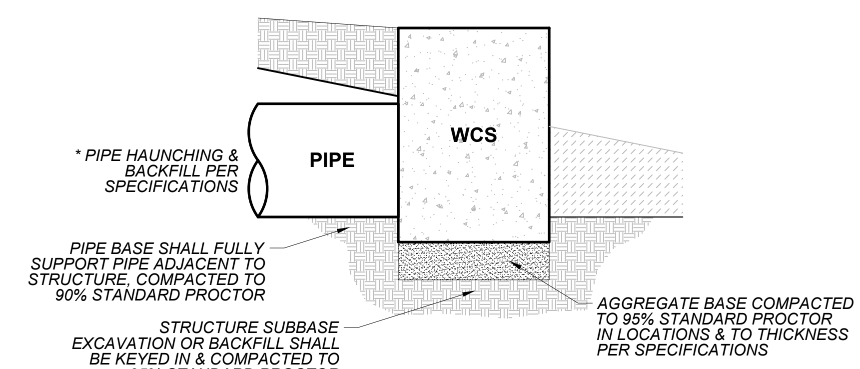

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PROJECT NO. US-CA-575-1 DATE: 12/9/2019

STONE LAKES
RESTORATION PROJECT
SERRA PROPERTY

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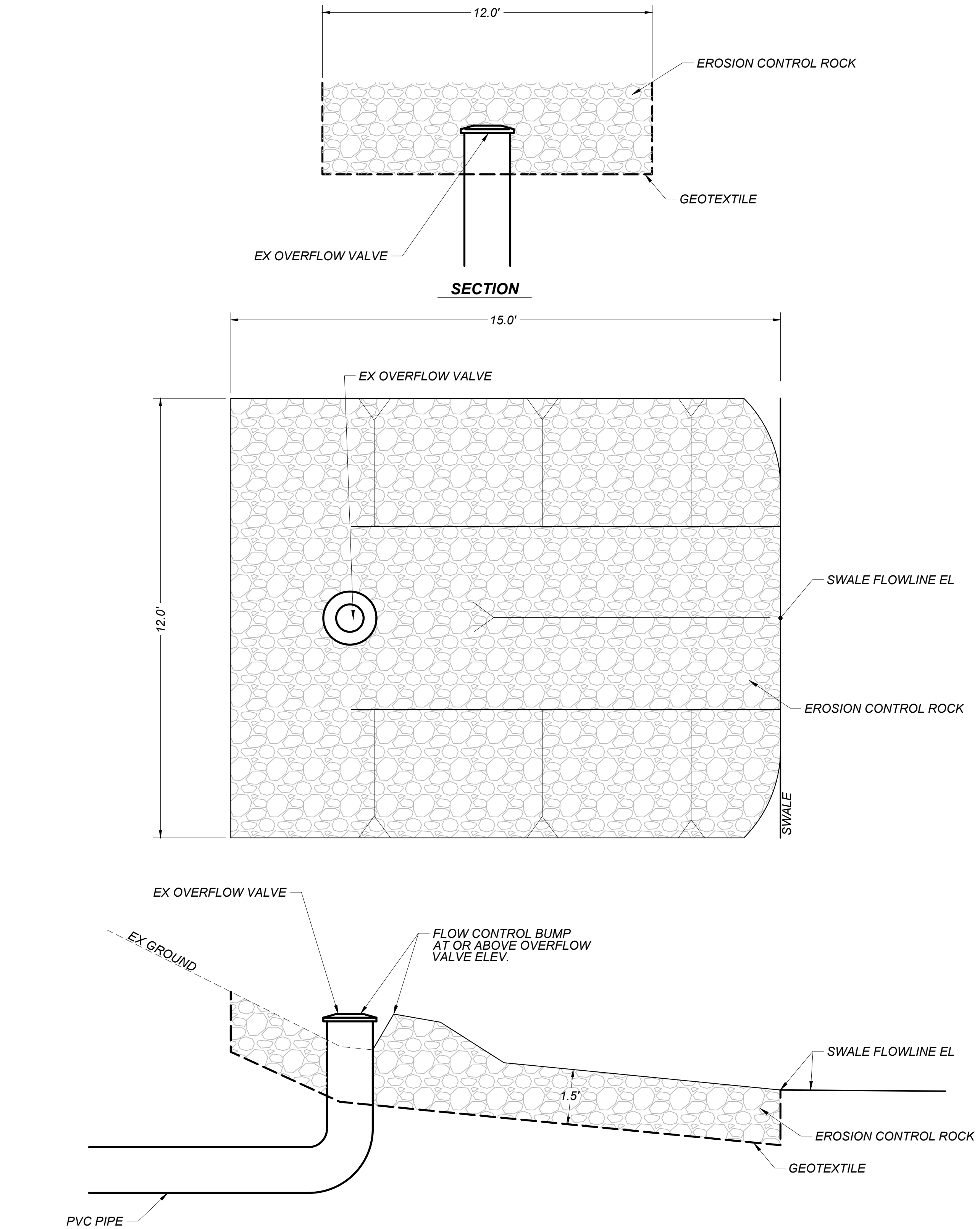
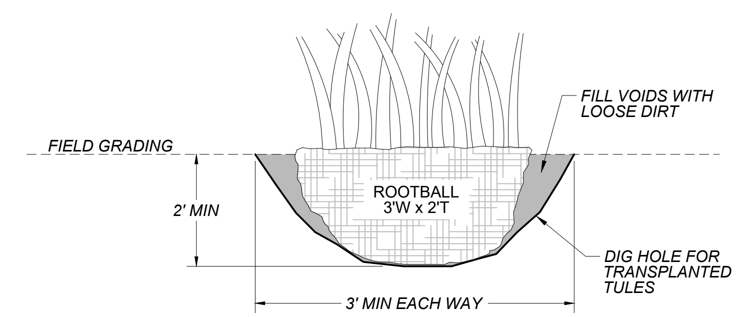


1 / -
TYPICAL DETAIL
EXISTING OVERFLOW VALVE EROSION CONTROL
NOT TO SCALE

WATER CONTROL STRUCTURE TABLE

WCS#	W (FT)	H (FT)	Dp (IN)	L (FT)	PIPE INVERT EL (FT MSL)	BERM TOP EL (FT MSL)	RIP RAP INLET (TN)	RIP RAP OUTLET (TN)
WCS01	3.0	5.0	24.0	40	2.5	7.0	10	-



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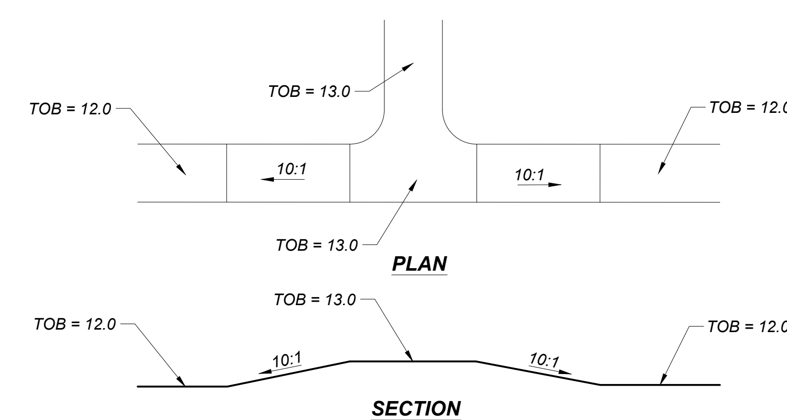

NOTES:

1. HIGHER ELEVATION TO BE CONSTRUCTED THROUGH INTERSECTION OF BERMS.
2. ELEVATIONS FOR EXAMPLE ONLY.

3 / -
TYPICAL DETAIL
BERM TRANSITION
NOT TO SCALE

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PROJECT NO. US-CA-575-1 DATE: 12/9/2019

STONE LAKES RESTORATION PROJECT SERRA PROPERTY

DETAILS

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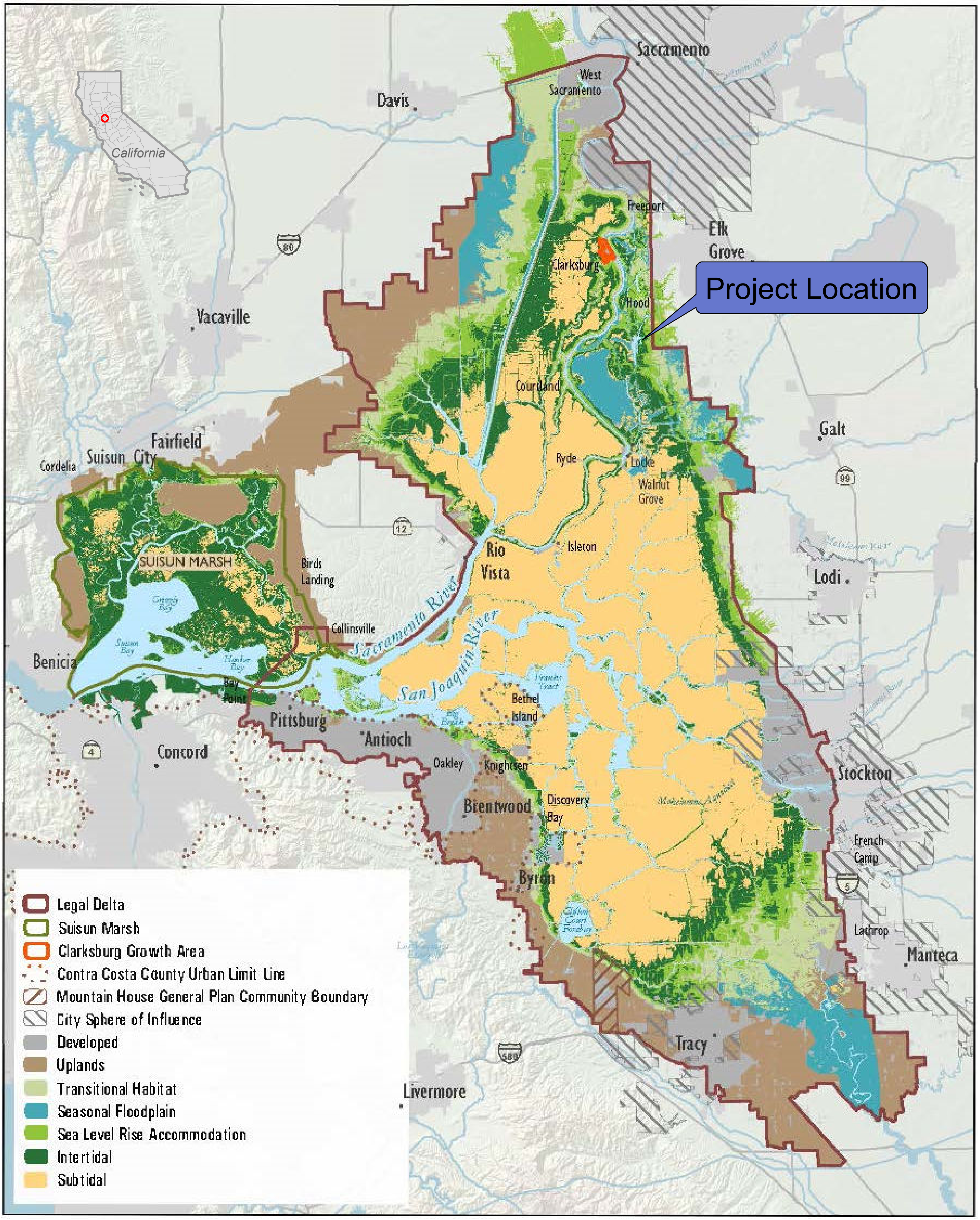

Figure 3. Elevation Habitat Map

Legend

Primary Delta

Figure 4. Serra Property Habitat Restoration Project Features and Post-Restoration Habitat

Legend

- Serra Property Project Area
- Managed Seasonal Wetland
- Swale-Open Water
- Submerged aquatic Island
- Habitat Islands

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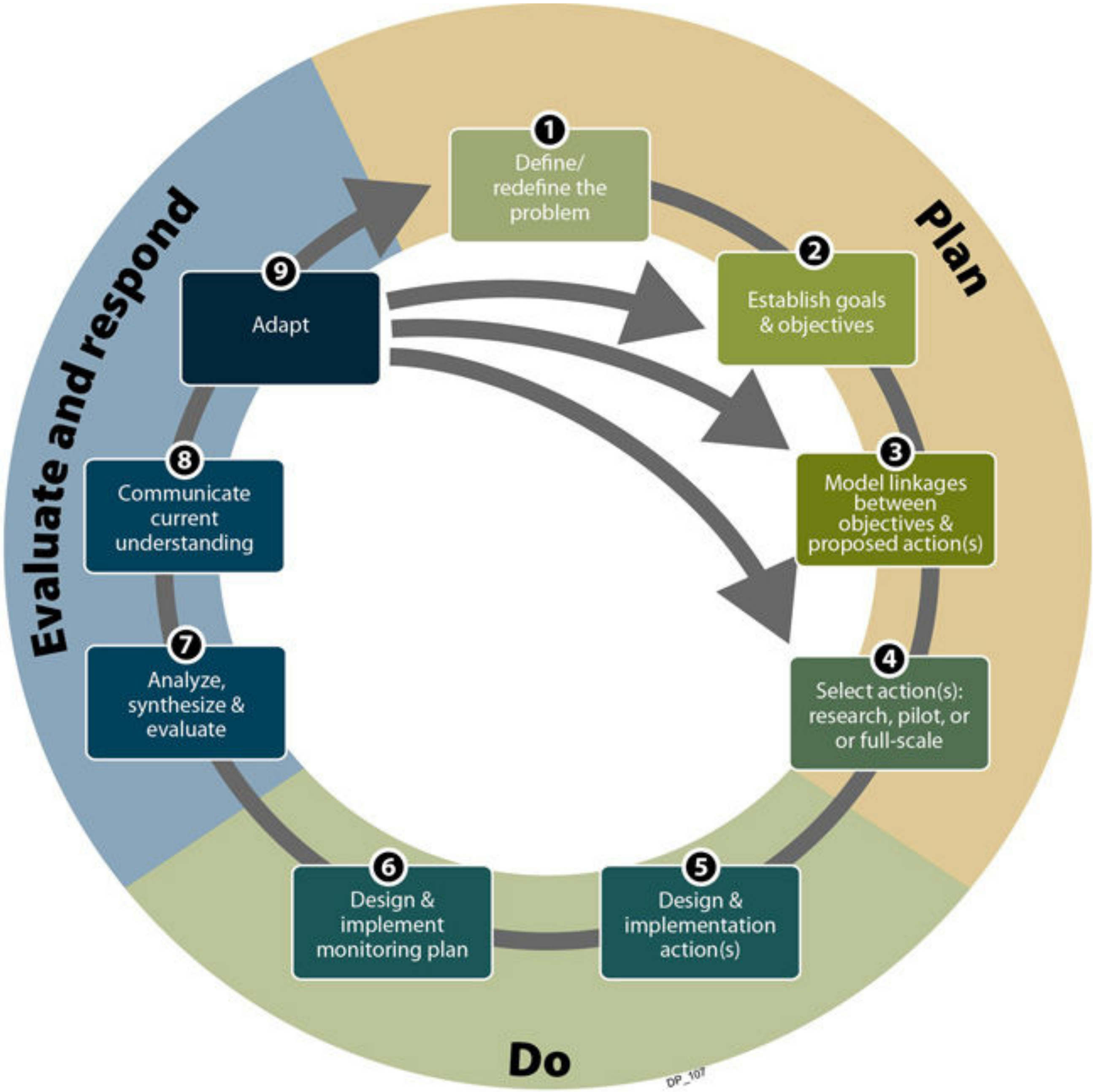

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Figure 5. Adaptive Management Wheel
(Figure 1B-1 of the Delta Plan Appendix 1B Adaptive Management)

TABLES

Table 1. Wetland Restoration Metrics and Monitoring

Stone Lakes Restoration Project - Serra Property

Objective	Performance Measure	Measurement Method	Adaptive Management Triggers and Practices
Restore ~25 acres of seasonal wetland	Post Construction site flooding generally from October to February.	Annual site inspections.	
Enhance ~25 acres of seasonal wetland	Post Construction site flooding generally from October to February.	Annual site inspections.	
Produce carbohydrates for wintering waterfowl	Greater than 10% average aerial coverage (of desirable species) Year 1, Greater than 30% average aerial coverage Year 2 and Greater than 50% aerial coverage by year 5.	Conduct point sampling of $1m^2$ area in several locations throughout the site. Record species and % cover of sqaure meter.	Manipulate water levels within project area to achieve growth of desired species. Consider draw down dates and rates.
			Disk or mow select problem areas to promote growth of desired species as necessary.
			If desireable plants are stressed consider whether spring or summer irrigation(s) are appropriate.
Maintain optimal water levels	Average water depth of (not including swales) of 4 to 12 inches.	Monitor staff gauge on water control structure.	If water levels are low. 1) determine if precipitation events in future will be adequate to bring water levels into optimum range. If not, utilize pump on Stone Lakes to bring water levels into optimum range.
			If water levels are too high, check water control structure for bloackages. Remove blockage if necessary.

APPENDICES

Appendix A

Central Valley Joint Venture Technical Guide to Best Management Practices for Mosquito Control in Managed Wetlands

Excerpts pertaining to permanent wetlands from:

CENTRAL VALLEY JOINT VENTURE
TECHNICAL GUIDE TO BEST MANAGEMENT PRACTICES FOR MOSQUITO CONTROL IN MANAGED WETLANDS

Dean C. Kwasny[1], Mike Wolder[2], and Craig R. Isola[2]

BEST MANAGEMENT PRACTICES

The BMPs in this document are habitat-based strategies that can be implemented when needed for mosquito control in managed wetlands. These strategies represent a range of practices that wetland managers can incorporate into existing habitat management plans or in the design of new wetland restoration or enhancement projects. Ideally, BMPs can be used to decrease the production of mosquitoes and reduce the need for chemical treatment without significantly disrupting the ecological character, habitat function, or wildlife use in managed wetlands. It should be recognized that BMPs function as a first line of defense in deterring mosquito production and can be used in combination with other Integrated Pest Management (IPM) tools such as, biological controls, larvicides (Appendix A), and adulticides (Appendix B) when necessary.

In many cases, BMPs overlap with commonly used habitat management practices to conserve water and manage wetland vegetation for wildlife (Batzer and Resh 1992a, Batzer and Resh 1992b, Resh and Schlossberg 1996). Not all BMPs will be appropriate for a given wetland location or set of circumstances. Therefore, habitat managers are encouraged to work closely with both their local MVCD and agency biologists to select BMPs based on their potential effectiveness for regional or site specific conditions, and habitat management strategies. The implementation of BMPs will likely be limited by cost and personnel constraints, potential impacts on wetland habitat, and wildlife response to these measures.

In the following section, BMPs have been classified into five categories. These categories are not listed in order of importance and may be used in combination.

- Water Management Practices
- Vegetation Management Practices
- Wetland Infrastructure Maintenance
- Wetland Restoration and Enhancement Features
- Biological Controls

Following each category is a table summarizing the BMPs that outlines strategies, mosquito control objectives, advantages, and disadvantages (Tables 1 through 6).

Water Management Practices

Water management is one of the wetland manager's greatest tools for reducing mosquito populations (Table 1). However, it requires that water is readily available, of sufficient quantity and quality, and that the conveyance infrastructure is adequate to permit rapid flooding or drainage. In some instances, circumstances outside the control of wetland managers may limit the ability to implement water management BMPs. Such circumstances may include when agriculture drain water or delivered water is available for flooding, limited water quantity or poor water quality, and undersized water delivery or drainage infrastructure. In managed wetlands where these limitations are not an issue, the following water management practices should be considered.

<u>Timing of Flooding</u>: The timing of wetland flooding can greatly influence mosquito production (Fanara and Mulla 1974; Batzer and Resh 1992a). Delayed flooding may reduce mosquito production by shifting flooding schedules later in the year, when temperatures are cooler and mosquito production is less of a problem. Delayed flooding should be considered for wetlands with historic mosquito problems and those in close proximity to urban areas. However, delayed flooding means that less wetland habitat is available for wildlife during times of the year such as August and

September when wetlands are particularly limited. Delayed flooding may also have limited applicability for some properties that are required to take water on a “when available” schedule and have little control over the timing of flooding. Delayed flooding may be especially difficult for State and Federal areas that are obligated to provide “early” habitat to reduce crop depredation by waterfowl.

Given the limited feasibility of delayed flooding on some properties, phased flooding of wetlands may be useful to allow habitat managers to provide some level of early flooded habitat while delaying flooding on a portion of a property. Phased flooding involves flooding habitat throughout the fall and winter in proportion to wildlife need and takes into consideration other wetland habitat that may be available in surrounding areas.

For wetlands that are flooded early (August - early September) or in close proximity to urban areas, the use of vegetation and water management BMPs should be a high priority (Tables 1 and 2). *BMPs: Delayed or phased fall flooding, Early fall flood-up planning (see Table 1 for additional explanation)*

Speed of Wetland Flooding: As a general rule, the faster water can be applied during fall flooding and spring/summer irrigation, the fewer generations of mosquitoes will be hatched. Slow feather-edge flooding, although beneficial to foraging waterbirds, can produce multiple, staggered hatches of floodwater mosquitoes and, if treatment is necessary, often requires MVCDs to visit wetlands over a number of days for control activities (Garcia and Des Rochers 1983). Such an intensive treatment effort is expensive and results in additional disturbance to wildlife.

BMPs: Rapid fall flooding, Rapid irrigation (see Table 1 for additional explanation)

Water Control: Once wetlands have been flooded, it is important for wetland managers to ensure that pond elevations do not fluctuate except during planned draw-down or periods of low mosquito production (i.e. winter months). Fluctuating water levels tend to expose wetland edges to drying and provide suitable habitat for floodwater mosquitoes to lay eggs (Garcia and Des Rochers 1983). When water levels are subsequently raised, a new cohort of mosquitoes may be hatched. Water levels should be maintained by checking water levels frequently, and adding water to offset any losses. A constant maintenance flow of water will also help maintain steady water levels, improve water quality, and reduce stagnation.

If possible, wetlands can be flooded to deeper water depths during the fall and allowed to recede during the cooler winter months to provide shallow water depths for foraging waterbirds. Deeper water depths (24 inches) at initial flooding have been shown to significantly reduce mosquito densities at Grizzly Island Wildlife Area (Batzer and Resh 1992a, b).

When flooding wetlands, water sources containing mosquito predators should be used to help colonize wetlands with predacious insects or mosquitofish that are passively transported by water from upstream locations (Collins and Resh 1989). Predator populations can be maintained in permanent waterways used to flood seasonal wetlands. In the Suisun Marsh, where water is readily available for flooding, seasonal wetlands are often initially flooded, and if mosquitoes become abundant, water levels are drawn down to concentrate mosquito larvae in ditches for biological control, larvicide treatment, or to drown larvae through turbulent water movement (Chappell pers. comm). Following this action, wetlands are immediately re-flooded.

BMPs: Maintain stable water levels, Circulate water, Use deep initial flooding, Subsurface irrigate, Utilize water sources with mosquito predators for flooding, Flood and drain wetland (see Table 1 for additional explanation)

<u>Frequency and Duration of Irrigation</u>: Spring and summer irrigation is a common wetland management practice used to increase seed production and biomass of moist-soil plants (Naylor 2002), and reduce competition from undesirable plants in seasonal wetlands. The need to irrigate seasonal wetlands should be assessed closely by wetland managers. During years with above average spring precipitation, irrigations may not be necessary to maximize moist-soil plant production. When possible, managers should shorten the duration of irrigation to 4 to 10 days to reduce the likelihood of hatching floodwater mosquitoes and eliminate the possibility of creating habitat for standing water mosquitoes. However, shorter irrigations may not always be feasible, especially when growing more water intensive plants such as watergrass and smartweed, or when conducting flooding to control undesirable plant species. In the case of weed control, plants should be monitored and water held only long enough to eliminate weeds. The necessary timing can be determined when weeds have turned black or have disintegrated. Finally, following wetland irrigations, water should be drawn down into waterways containing mosquito predators that can consume any mosquito larvae which may have hatched.

BMPs: Reduce number of irrigations, Use rapid irrigation, Draw down and irrigate in early spring, Irrigate prior to field completely drying, Drain irrigation water into ditches or other water sources with mosquito predators, Use subsurface irrigation (see Table 1 for additional explanation)

Table 1. Water Management Practices to reduce mosquito production in managed wetlands.

Best Management Practice	**Strategies**	**Mosquito Control Objective**	**Advantages**	**Disadvantages**
Delayed or phased fall flooding	Delay flooding of some wetland units until later in the fall. Delay flooding units with greatest historical mosquito production and/or those closest to urban areas.	To delay initiation of floodwater mosquito production in seasonal wetlands by reducing the amount of mosquito habitat available during optimal breeding conditions (warm summer/early fall weather). Reduce the time available for standing water mosquito production in seasonal wetlands.	Depending on flood date, can reduce the need or amount of additional treatment. Delayed flooding can provide "new" food resources for wildlife later in the season when wetlands are finally flooded.	Reduces the amount of habitat for early fall migrants and other wetland-dependent species, and may increase potential for waterfowl depredation on agricultural crops (especially rice). Flooding is often dictated by water availability or contractual dates for delivery. Delayed flooding may still produce mosquitoes in warm years. Private hunting clubs can't lease blinds that aren't flooded.
Early fall flood-up planning	Apply BMPs to wetlands identified for early flooding. To the extent possible, areas targeted for early fall flooding should not be near urban centers and should not have a history of heavy mosquito production.	To reduce the early season production of mosquitoes or to reduce their encroachment on urban areas.	Allows for the provision of early flooded habitat while minimizing mosquito production and conflicts with urban areas.	Some additional effort required to monitor and identify suitable areas. Requires the extensive use of BMPs to ensure mosquitoes are not produced.
Rapid fall flooding	Flood wetland unit as fast as possible. Coordinate flooding with neighbors or water district to maximize flood-up rate.	To minimize number of mosquito cohorts hatching on a given area.	Reduces the need for multiple treatments needed by synchronizing larval development and adult emergence. In turn, reduces wildlife disturbance by MVCDs.	Requires coordination & ability to flood quickly. Reduces slow, feather-edge flooding that is heavily utilized by waterbirds.
Rapid irrigation	4-10 day irrigation (from time water enters the pond to complete draw-down).	Shorten irrigation period to reduce time available for mosquitoes (especially *Culex tarsalis* and *Anopheles freeborni*) to complete lifecycle.	Provides some level of wetland irrigation while reducing the time available for mosquitoes to complete lifecycle.	Requires ability to rapidly flood & drain wetland. If flooding is used for weed control, rapid irrigation may not be feasible.

Maintain stable water level (summer and early fall flooding)	Ensure constant flow of water into pond to reduce water fluctuation due to evaporation, transpiration, outflow, and seepage.	To reduce conditions for additional floodwater mosquito production in summer and fall.	Provides a stable wetland environment for breeding wildlife during spring and summer. Discourages undesired excessive vegetative growth which could also become additional mosquito breeding substrate.	Requires regular monitoring and adjustments to water control structures. May be difficult if water availability is intermittent or unreliable. Reduces mudflat habitat that is attractive to shorebirds and waterfowl.
Water circulation	Provide a constant flow of water equal to discharge at drain structure.	To keep water fresh and moving to deter stagnant conditions for mosquito production; reduces water level fluctuation and potential production of floodwater mosquitoes.	Discourages warm water conditions associated with avian botulism outbreaks.	Requires landowner to purchase additional “maintenance” water. May be difficult if water availability is intermittent or unreliable.
Deep initial flooding (18-24”)	Flood wetland as deep as possible at initial flood-up.	To reduce shallow water habitat for mosquito breeding. May provide more open water by over-topping vegetation, thereby facilitating mosquito predation or wind action that drowns larvae.	Potentially slows mosquito development by eliminating warm, shallow water habitat.	Requires additional water and infrastructure adequate to flood deeply. Reduces shallow water foraging habitat for shorebirds and waterfowl.
Utilize water sources with mosquito predators for flooding wetlands	Flood wetlands with water sources containing mosquito fish or other invertebrate predators. Water from permanent ponds can be used to passively introduce mosquito predators.	To inoculate newly flooded wetlands with mosquito predators.	May establish mosquito predators faster than natural colonization.	Requires source of water with already established mosquito predators. Not applicable to wetlands flooded with well water.
Drain irrigation water into ditches or other water bodies with abundant mosquito predators	Drain irrigation water into locations with mosquito predators as opposed to adjacent seasonal wetland or dry fields.	To reduce the amount of larvae through natural predation and minimize the number of adults that emerge.	Already a common wetland management practice.	Must have ditch or water body with established predator population available to accept drain water.

Flood & drain wetland	Flood wetland and hatch larvae in pond. Drain wetland to borrow or other ditch where larvae can be easily treated, drowned in moving water, or consumed by predators. Immediately reflood wetland.	Hatches mosquito larvae and moves them to a smaller area for treatment before they can emerge as adults.	Can eliminate or reduce the need for additional mosquito control efforts.	Additional cost to purchase water to re-flood wetland. Timing is critical. Requires monitoring and is labor intensive.
Reduce number of irrigations	Evaluate necessity of irrigation, especially multiple irrigations, based on spring habitat conditions and plant growth. Eliminate irrigations when feasible.	To eliminate unneeded additional irrigations which could provide potential habitat for mosquitoes.	Reduces potential need for additional mosquito control. Saves water and manpower costs. Discourages excessive growth of undesirable vegetation (i.e. joint and bermuda grass)	May reduce seed production or plant biomass with less irrigation.
Early spring draw-down and irrigation	Draw-down wetland in late March or early April. Irrigate in late April or early May when weather is cooler and mosquitoes are less of a problem.	To reduce need for irrigation in June, July, and August, when potential for mosquito production would be higher.	Wetland irrigation can be accomplished without creating potential mosquito problems. May allow moist-soil plants to take advantage of natural rainfall during the spring.	Reduces shallow wetland habitat for migratory shorebirds and waterfowl in April and May, during a major migration period. Newly germinated wetland plants may be impacted by cold weather conditions. May stimulate germination and growth of undesirable wetland plants.
Don't let field completely dry and crack between spring draw-down and irrigation	Irrigate wetland before soil completely dries.	To eliminate necessary drying period for floodwater mosquito to lay eggs.	May reduce mosquitoes produced from irrigation	Requires close monitoring of soil moisture to correctly time irrigation.
Subsurface irrigation	Maintain high ground water levels by keeping boat channels or deep swales permanently flooded.	To reduce amount of irrigation water during mosquito breeding season.	Reduce need for surface irrigation while maintaining soil moisture to promote moist-soil plant production.	Requires deep swales or boat channels to be effective. Requires additional pipes in channels for equipment access. May not produce intended irrigation result if water table is naturally low. Requires that water be maintained longer than normal in swales. May promote unwanted vegetation growth in swales or promote irrigation of non-target plants in wetland.

Wetland Infrastructure Maintenance

Wetland infrastructure is the foundation for habitat management. A properly functioning water delivery and drainage system, well maintained levees, correctly operating water control structures, and efficient pumps are key to avoiding the unnecessary production of mosquitoes through simple neglect (Table 3). Time and money invested in these proactive maintenance activities will reduce mosquito production and help landowners avoid additional costs of controlling mosquitoes and unwanted vegetation when fall flooding or irrigating wetlands.

Levee and Water Control Structure Inspection and Repair: Levees and water control structures should be inspected on an annual basis to identify problem areas that may inadvertently leak water and produce mosquitoes. This includes identifying weak spots or rodent damage in levees that may seep water during flooding. Water control structures should be water-tight and properly sealed to prevent seepage.

Ditch and Swale Cleaning: Vegetation in water delivery ditches and swales can be problematic by creating habitat for mosquitoes or by simply impeding the flow of water that facilitates rapid flooding or drainage. Typical maintenance activities of water delivery and drainage ditches include the use of herbicides or periodic dredging to remove problem vegetation that inhibits water flow. Ditches and swales should be cut to grade to prevent the unintentional trapping of water. Likewise, silt that accumulates in front of outlet structures should be removed so it does not trap water in drainage swales.

Pump Tests and Repair: If wetland managers use pumps for flooding, periodic pump testing should be conducted to make sure pumps are operating at optimum efficiency. This will ensure that pumps are providing maximum output, and will facilitate rapid flooding.

Table 3. Wetland infrastructure maintenance activities used to reduce mosquito production in managed wetlands.

Best Management Practice	Strategies	Mosquito Control Objective	Advantages	Disadvantages
Levee Inspection & Repair	Walk or drive levees, flag problem spots, repair as needed. Consider design elements to improve integrity of levee (see levee design in Table 4).	To reduce mosquito habitat/production caused by seepage into adjacent fields or dry ponds.	Allows for early identification of problem spots. Helps conserve water and reduces growth of unwanted vegetation.	Requires annual monitoring and funding for repairs.
Water Control Structure Inspection, Repair, & Cleaning	Inspect structures and repair or replace as needed. Remove silt and vegetation build-up in front of structures. Adequately close, board or mud-up controls.	To reduce mosquito habitat/production caused by seepage into adjacent ponds or drainage ditches. Remove silt blockages that may trap water and impede drainage.	Enhances water management capabilities and limits unwanted vegetation or standing water.	Requires annual monitoring and funding for cleaning or repair.
Ditch Cleaning	Periodically remove silt or vegetation from ditches to maintain efficient water delivery and drainage.	To allow for rapid flooding/drainage & reduce vegetation substrate for breeding mosquitoes.	Enhances water management capabilities and limits unwanted vegetation or standing water.	Requires funding for ditch cleaning. Excessive vegetation removal on ditch banks can result in negative impacts to nesting birds and other wildlife.
Pump Tests & Repair	Test pump efficiency and make any necessary repairs to maximize output.	Could identify output problems and if corrected, allow managers to flood more rapidly.	May promote faster irrigation and flood-up if output can be improved.	Requires pump test. May be costly to repair or replace pump/well.

Wetland Restoration and Enhancement Features

All well planned wetland restoration and enhancement projects begin with an initial survey and design phase. It is during this phase that landowners and restoration biologists have the opportunity to discuss design features with MVCDs and incorporate BMPs to reduce mosquito production. Time spent at the design stage can save thousands of dollars in annual operation and maintenance costs and prevents problems resulting from poor water management and unintended mosquito production. Wetland design typically focuses on aspects of water control that promote vegetation beneficial to wildlife, conserve water, and allow for periodic vegetation control. In turn, water control is also an important mosquito BMP (Sacramento-Yolo Mosquito and Vector Control District 2008, Contra Costa Mosquito and Vector Control District 2001). **Wetland design features to reduce mosquito production:** Wetland design features that reduce mosquito production include independent flooding and drainage capabilities of wetland units, size considerations in the design of wetland units to facilitate rapid flooding, and the incorporation of design features that promote habitats for mosquito predators and allow those predators access to mosquitoes. Water delivery ditches, water control structures, and levees should be designed and built to specifications that prevent wind and water erosion, provide equipment access for maintenance activities, and reduce damage caused by burrowing animals (Table 4). These design features will facilitate other mosquito BMPs such as water and vegetation management practices, infrastructure maintenance, and natural mosquito predation.

BMPs: Independent water management, Adequately sized water control structures, Swale construction, Wetland size consideration, Ditch design, Levee design & compaction, Deep channels or basins constructed in seasonal wetlands, Permanent water reservoir that floods into seasonal wetlands

Appendix B

Additional Wetland Management Habitat Guidance Documents