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1.0 EXECUTIVE SUMMARY

This document describes in detail the specific opportunities and constraints associated with the various restoration actions that could potentially be implemented at the three-pond system known as Teichert Ponds in Chico, Butte County, California. For ease of comparison with a previous document, the *Teichert Ponds Restoration and Management Plan* (Jones and Stokes, May 2004) (the JSA Plan), this opportunities and constraints analysis largely follows the JSA Plan's organization. While the JSA Plan included an opportunities and constraints analysis of its own, this document differs in that it discusses specific methods which may be utilized to implement the concepts presented in the JSA Plan.

The Teichert Ponds site comprises approximately 30.6 acres and is located south of East 20th Street and adjacent to State Route 99. The elevation fluctuates within a few feet of 215 feet above mean sea level. The topography is mostly flat, with minor variations due to human activity, such as the berm on the border of Little Chico Creek and stockpiles of gravelly soil in the northeastern portion of the site. The deep, well-drained soils are classified by the Natural Resource Conservation Service as Almendra Loam and Chico Loam, both of which arose from loamy alluvium. Water enters the site via direct precipitation, a groundwater connection in Pond 1, and nuisance flows from the surrounding urban area. All water eventually travels through Pond 3 to exit the site through a culvert into Little Chico Creek. The flora is dominated by invasive exotic plants, primarily tree-of-heaven, Himalayan blackberry, and pyracantha, though native cottonwoods, willows, and valley oaks are also present. The fauna is composed of common animals often found near human habitation. The only special-status species, either plant or animal, known to be present is the Western Pond Turtle.

Hydrology enhancements refer to the changes that alter water flow through the site and increase human control of said flow. They consist largely of raising the existing berms and installing water control structures in them. Additionally, methods to divert stormwater to Pond 1 are discussed. These alterations create the opportunity to implement and maintain the proposed ecological restoration by providing the necessary infrastructure. Most constraints to the hydrology enhancements stem from the need to dewater Ponds 2 and 3 in order to create structurally sound buttresses for the enlarged berms. Dewatering could potentially raise biological, logistical, and financial concerns, while simultaneously enabling several enhancements to water quality, habitat, and mosquito control that would not otherwise be available.

Water quality enhancements consist of converting Pond 2 to a treatment wetland, controlling algal mats and invasive aquatic plants, installing a trash rack at nuisance water inlets, and establishing biological controls. Converting Pond 2 to a treatment wetland includes recontouring the pond bottom to create a sediment basin, forebay, and micropool. The costs of dewatering and removing snags form a constraint, while creation of the treatment wetland provides the opportunity to increase water quality and ease the logistics of future maintenance. Controlling algae and aquatic plants enhances the habitat value of the ponds and facilitates mosquito control. Each of 6 potential control methods is discussed. Stakeholders agree that the benefits of a trash rack outweigh the costs of regular maintenance it requires. This analysis focuses on the various merits and demerits of three potential locations for a rack: either at the mouth of the large stormwater pipes, in the cement-lined channel, or at the entrance to Pond 2. Placing the rack at the mouth of the large stormwater pipes currently appears to best balance opportunities and constraints. The biological controls considered are shading the shoreline and introducing grass carp. The former is recommended due to the many expected benefits and relatively few costs, while the latter would likely provide few benefits and is also prohibited by the California Department of Fish and Game.

Habitat enhancements consist of removing invasive exotic terrestrial vegetation, establishing native vegetation of three habitat types (emergent wetland, riparian, and valley oak woodland), installing basking structures and nest boxes, and altering the existing topography. Each invasive exotic plant species has qualities that make it more or less susceptible to various control methods. Shallow-rooted plants may be removed manually, especially by volunteers, while deeper-rooted plants may be controlled better by herbicides. Establishment of native plants can also utilize volunteer labor, and the presence of native species in the vicinity allows propagation of local genotypes. Fertilization is likely unnecessary, while mycorrhizal inoculum may benefit the installed plants. Beaver protection cages are recommended for riparian species, but woody plants in more upland habitats will likely require only screens. Drip irrigation will favor deep roots, enabling irrigation to cease after three or fewer years. Basking structures and nest boxes provide valuable habitat for little cost, although receiving formal credits for giant garter snake mitigation depends on the United States Fish and Wildlife Service. Altering topography to create islands appears to be unfavorable. Recontouring pond edges to provide 2:1 slopes at summer elevations and 5:1 slopes at winter elevations may be an acceptable compromise between mosquito control and wetland retention.

The pond restoration activities provide many opportunities to facilitate mosquito control. Removing terrestrial and aquatic invasive exotic plants increases access to mosquito habitat by humans and mosquitofish. Installing water control structures enables fluctuation of water levels to dehydrate mosquito larvae and pupae. Recontouring the pond bottom decreases mosquito habitat by increasing the slope of summer shorelines.

Coordination with Caltrans on several topics could be beneficial for Caltrans, the City, and the local environment. Routing stormwater from State Route 99 into the treatment wetland will likely increase its quality before it enters Little Chico Creek. However, constraints to this action depend on the current water flow, which is unknown. Simultaneous control of tree-of-heaven on both Caltrans and City property is expected to reduce the reinfestation rate of both parcels. Planting native vegetation on the right-of-way is likewise expected to benefit each area more than if only one were restored. Again, the possibility of using the site for compensatory mitigation depends on the USFWS. In all cases of cooperation, cost sharing to accomplish mutual goals on the two adjacent parcels can be favorable for both parties.

2.0 INTRODUCTION

In the 1960s, Teichert Aggregate mined gravel for the construction of state highways from a site just south of Little Chico Creek in the City of Chico, Butte County, California. Three pits were created. One filled with groundwater after equipment operators ruptured the aquifer during mining operations. The other two began to collect surface runoff, becoming *de facto* detention basins without further human effort. As development continued in the region, the design of the storm drain system was allowed by the City to be modified so that storm drainage would discharge directly into the ponds, rather than directly into Little Chico Creek. The ownership of these bodies of water, which are collectively called Teichert Ponds, was transferred several times from the 1960s to 1999, when the City of Chico acquired fee title. Throughout these successive changes of ownership, the ponds have provided opportunities for passive recreation and education to residents of Chico, albeit without permission for trespass.

Despite the past and current benefits gained from the Teichert Ponds, the site has never achieved its potential. The lack of control over water flow has hindered its role in stormwater detention and water quality enhancement. Aggressive growth by invasive exotic upland and aquatic weeds has greatly limited its habitat value. Beavers have cut down trees and caused others to die via flooding. Some of the unauthorized public uses have degraded its visual appearance. To address these issues, the City of Chico contracted with Jones and Stokes, a Sacramento-based environmental consulting firm, to produce a conceptual plan for the restoration and management of the ponds. City representatives identified several goals of the desired plan, which are summarized as follows:

- improve water quality,
- improve landscape aesthetics,
- restore and enhance habitat,
- establish a long-term management plan,
- maintain stormwater detention and treatment functions, and
- retain future options for public access.

The preferred conceptual design is published as the *Teichert Ponds Restoration and Management Plan* (Jones and Stokes, May 2004) (the JSA plan).

In contrast to the opportunities and constraints analysis in the JSA plan, which was performed at the policy level, the analysis presented here focuses on the practical details of implementing the conceptual plan. Therefore, the organization of this analysis follows that of the plan, presenting the opportunities and constraints of each recommended action in sequence. Many details influencing the opportunities and constraints were determined through site-specific studies carried out by two subconsultants to Restoration Resources: H.T. Harvey and Associates, Inc. (HT Harvey), and Civil Engineering Solutions, Inc. (Civil Solutions).

3.0 SITE DESCRIPTION

This description is intended to provide only a summary of the site's characteristics. Please see the JSA plan for a comprehensive review of the region's physical setting. In addition, the project's implementation plan (Restoration Resources, estimated date of release 2007) provides more detailed documentation of existing conditions, including comprehensive results and graphics for the on-site studies completed.

3.1 Location

The three interconnected bodies of water currently known as Teichert Ponds are located in the southern region of the City of Chico, Butte County, California. A relatively small border of land surrounds the ponds and brings the property's total size to approximately 30.6 acres. The western boundary is the State Route (SR) 99 right-of-way. Little Chico Creek runs just north of the project site. The southern and eastern boundaries are somewhat irregular, bounded by recent residential and commercial development. Near the northeastern corner, a finger of private land extending from Creek Hollow Drive juts into the property.

3.2 Microtopography

Historically, the site was part of the floodplain for Little Chico Creek, and as such was relatively level. The mining activities of Teichert Aggregates created the three ponds below the grade existing at that time. Currently, the elevation of the dirt trail around the ponds descends quickly from about 226' at Creekhollow Drive to 213'. The trail gradually increases to about 217' adjacent to SR 99, and oscillates between this and 216' as it leads to the inlet. Most of the land on site is between 212' and 217'. Notable exceptions are the stockpiles of gravelly soil near the entrance, the berm along the channel of Little Chico Creek, and the land next to houses on the eastern site boundary.

3.3 Soils

The native alluvial material deposited by Little Chico Creek is characterized by a high gravel content, leading to a coarse texture almost throughout its deep profile. Indeed, the prevalence of gravel was the primary interest of Teichert Aggregate, whose mining activities produced large quantities of this material for the construction of SR 99.

Current soil types on the site have been classified by the Natural Resources Conservation Service (NRCS). Aside from open water, soils on the site were identified as Almendra Loam (0 to 1% slopes) and Chico Loam (0 to 1% slopes). The Almendra Loam is found on the majority of the site, with the Chico Loam surrounding only the southern half of Pond 2. The two soil types are quite similar, sharing a common genesis in loamy alluvium. Both are deep and well-drained. Depending on the proximity of summer water, these soils are suitable for nonwoody wetland plants, riparian vegetation, and valley oak woodlands.

3.4 Hydrology

Water enters the ponds via surface runoff, groundwater, precipitation, and seepage from the creek. Water leaves the ponds via overland and subsurface flow into the creek, and via evapotranspiration. The direction of subsurface flow between the creek and the ponds changes seasonally, and is primarily dependent on the amount and intensity of rainfall. Pond 1 is primarily fed by groundwater, with precipitation contributing in the winter and spring. When water levels are high in the winter, water overtops the berm between Ponds 1 and 2, allowing free mixing. In recent years, summer water inputs have also been sufficient to overtop this berm. Ponds 2 and 3 are fed by irrigation and stormwater runoff, precipitation, and overflow from Pond 1.

3.5 Plants

Most vegetation on site is both nonnative and invasive. Thick stands of tree-of-heaven (*Ailanthus altissima*) are on the northern and eastern uplands. Himalayan blackberry (*Rubus discolor*) forms monotypic stands in wetter areas. Parrot's feather (*Myriophyllum spicatum*) grows in dense mats in the ponds.

Some nonnative plants on site are not invasive, such as the domesticated fruit and nut trees. However, fig (*Ficus* spp.) can be invasive in certain situations, and should be monitored informally on this site to detect signs of population expansion.

The native plants on site consist largely of common, fast-growing species capable of rapid colonization, such as cottonwood (*Populus fremontii*) and willows (*Salix* spp.) Many saplings of the slower-growing valley oak populate the northern part of the site. Several large dead trees, likely cottonwoods or black willows, are standing or recently fell along the shore of Ponds 2 and 3, possibly killed by rising water levels. No native species of concern were detected on site. A protocol-level survey for elderberry shrubs (*Sambucus mexicana*) was conducted in May 2006, and a thorough survey for rare plants took place in June 2006. The amount of effort spent in attempting to detect plant species of concern provides reliable evidence that these plants do not currently inhabit the site.

3.6 Animals

Western pond turtle (*Clemmys marmorata*) was the only animal species of concern observed on site. The lack of elderberry shrubs and vernal pools preclude the presence of any species restricted to these habitats. While suitable breeding habitat appears to be present for raptors, none were discovered nesting on site during the breeding bird surveys conducted from May to June 2006.

Except for birds, common animal species were not surveyed formally. Bullfrogs, treefrogs, salamanders, newts, fence lizards, gopher snakes, and common garter snakes are likely present. Urban mammals, such as rats, mice, cottontail rabbits, hares, opossums, raccoons, skunks, and feral cats are also likely to use or possibly breed on the site. Over the years, visitors have seen several common fish species as well as gray squirrels, beavers, and river otters. The formal avian survey detected many common birds breeding on site, and several species of migrants or vagrants were observed both during the surveys and anecdotally on numerous site visits across the seasons.

4.0 HYDROLOGY ENHANCEMENTS

4.1 Isolation of Pond 1

Isolation of Pond 1 via raising the berm between Ponds 1 and 2 is recommended due to Pond 1's potential for high water quality. This potential exists because Pond 1 is primarily fed by a spring on the pond bottom, rather than by urban runoff. A pond within an urban area that does not directly receive urban pollutants represents too rare an opportunity to forfeit. In addition, modification of the existing berm creates the opportunity to construct the berm so that it can support the machinery which may be helpful in maintenance of the water control structure.

Constraints to raising Pond 1's berm are logistical, monetary, and biological. Earthwork would require the removal of existing snags in the area of work, which represents a financial cost as well as loss of basking and roosting habitat. Further analysis of log removal is presented in section 6.8. A logistical constraint is the need to identify a source of soil to add to the berm. If a balance of cut and fill is not achieved on site, this constraint could also be monetary and biological. Buying and importing fill from elsewhere is expensive and may potentially cause environmental concerns at the borrow site. While not recommended by the JSA plan, dewatering of Pond 2 is judged necessary by Civil Solutions in order to raise the berm between Ponds 1 and 2. This is because engineering calculations indicate a buttress on Pond 2's side is required to provide the berm with enough strength, and a buttress cannot be constructed underwater. The dewatering raises constraints of all three types. It represents a logistical constraint not only because the existing water must be pumped out, but also because a diversion route for the continuous inflow of nuisance water must be designed and constructed. Dewatering represents a monetary constraint because the design and implementation of the system are additional costs, as compared to projects with no dewatering. As mentioned in the JSA plan, dewatering represents a biological constraint due to the potential negative effects on the aquatic environment.

Despite the constraints that dewatering imposes, it also provides numerous opportunities for additional restoration activities discussed later in this analysis. During the time that a pond is dewatered, it can be recontoured and deepened. Proposed grade changes will enhance water quality by converting Pond 2 to a treatment wetland (section 5.1). Shoreline recontours primarily benefit the control of invasive aquatic vegetation (section 5.2) and mosquitoes (section 7.4.). Pond deepening primarily benefits the control of invasive aquatic vegetation and algae (section 5.2). Removal of snags allows certain logs to be retained and reinstalled in ways conducive to wildlife but not mosquitoes (section 6.8). Deepening a pond for water quality may provide a source of fill for raising the berm between Ponds 1 and 2.

While not mentioned in the JSA plan, attendees of the site visit on October 3, 2006, suggested further isolating Pond 1 from urban water sources by diverting water from the residential outfalls to the cement channel. This creates the opportunity to divert potentially nutrient-rich and/or sediment-rich water from Pond 1, and send it instead to the detention basins and treatment wetland which are described in section 5.1. The water could be conveyed through a ditch or a pipe. Constraints on the ditch depend on the ditch's size and location. A large ditch on the flatter land will likely require fill of the freshwater emergent wetland currently occupying some of that area. A large ditch also necessitates disposal of the removed soil. The soil could be used to create a small maintenance road next to the ditch, thereby eliminating transportation costs but potentially incurring further fill of wetlands. For a relatively small cost, the soil could be used at a different location on site for raising berms. The largest cost would result from transportation and disposal of the soil off-site. Using a pipe to convey the water from the residential community to the cement-lined channel has a different set of opportunities and constraints. Opportunities include the ability to avoid filling wetlands and the lack of removed soil. Constraints include a potential increase in maintenance costs to remove clogs and trash, and in repair costs due to vandalism.

Also not mentioned in the JSA plan but suggested at the site visit is the creation of an outlet directly from Pond 1 into Little Chico Creek. This option would create the opportunity for finer control of water levels in all three ponds, possibly increasing the ability to manage the pond levels for mosquito control. However, the distance of Pond 1 from the creek represents a constraint. Plans for the maintenance of any ditches and/or culverts would need to be included in the regulatory permits, and the maintenance itself represents an additional cost to the City of Chico.

4.2 Restoration of Connection Between Ponds 2 and 3

The JSA plan presents two options for the link between Ponds 2 and 3. The weir/standpipe provides greater opportunities than the low-flow channel, because the standpipe allows for greater manipulation of Pond 2's water elevation. These manipulations may prove useful in mosquito control. No constraints were identified for this action.

4.3 Installation of Water Control Structure at Outlet

The JSA plan suggests using either a flap or a screw gate at the outlet of the ponds into Little Chico Creek. A screw gate provides the opportunity for greater control over water levels, and is therefore recommended by Restoration Resources.

The presence of beavers in the pond system necessitates a structure at the outlet to hinder beaver activity. The exclosure suggested by the JSA plan may provide the advantage of increased durability, but initial materials costs may be higher than other existing devices. The design of the structure to discourage beavers from blocking the outlet will require communication between Chico's General Services Department and the design team. Ease of maintenance is one constraint on the structure's design, though the existing access ramp provides an opportunity in that it precludes the necessity to build one. In addition, it is desirable to prevent the sound of running water, because this is one of the primary cues that trigger dam-building behavior in beavers.

At the site visit on October 3rd, it was suggested that the small peninsulas around the outlet be removed. This action would allow greater flexibility in the design and size of a beaver exclusion device. It would also negate the possibility that beavers, faced with the difficulty of damming an exclusion device, instead build a dam across the short distance between peninsula tips. Disadvantages to the removal of the peninsulas include the probable removal of at least one native tree. This potential impact would at most be temporary, due to the substantial native tree planting included in habitat enhancements.

5.0 WATER QUALITY ENHANCEMENTS

5.1 Conversion of Pond 2 to a Treatment Wetland

The JSA plan notes that a 5.3-acre treatment wetland is sufficient, although all parties involved agree that demolishing the existing berm only to build a new one incurs excessive costs and provides no benefits. Therefore, the existing berm will remain in place and merely undergo alterations to allow humans better control of water levels in Ponds 2 and 3. The modifications to this berm will allow for maintenance vehicle access.

Just as raising the berm between Ponds 1 and 2 requires dewatering Pond 2 to construct a buttress, raising the berm between Ponds 2 and 3 will require dewatering of Pond 3 to construct a buttress. In addition, dewatering is necessary to construct the forebay and micropool features recommended by the JSA plan. The dewatering faces the same opportunities and constraints described in section 4.1. The grade changes for water quality enhancement mentioned in section 4.1 are a sediment basin at the inlet to Pond 2, a forebay next to the sediment basin, and a micropool just before the control structure leading to Pond 3. The purpose of the basin is to concentrate sediment deposition in a relatively small, easily dredged area. The purpose of the forebay is to reduce nutrient loads via wetland vegetation. The purpose of the micropool is to collect and calm water around the entrance to the water control structure leading to Pond 3, so as to minimize erosion at this point. Additional recontours for the purposes of habitat enhancement are discussed in section 6.9.

The sediment basin will provide the opportunity to minimize dredging maintenance costs by concentrating dredging at one relatively small location. It will also provide a biological opportunity in that the entire body of Pond 2 need not be disturbed by dredging on a regular basis, if at all, in the medium- to long-term. An additional opportunity for maintenance exists due to the upcoming permitting of the Teichert Ponds restoration project. Dredging infrastructure and activities can be wrapped into the permit. The City of Chico’s General Services Department desires language allowing unencumbered, unrestricted, mechanized access and maintenance at any time of the year, at all points of water entrance (inlets, pipes, trash racks, etc.) and exit, including no encumbrance on excavating soil from underwater, should the need arise.

The forebay will provide the opportunity to reduce nutrient loads via wetland plants and nitrogen-releasing bacteria. While it is expected that dredging will not need to be as regular nor as frequent in the forebay as the sediment basin, some sediment trapping will occur. This provides a biological opportunity by further reducing the need to dredge the main pond, although dredging the forebay incurs a smaller constraint of occasional maintenance.

The micropool is intended to collect and hold water at the gate between Ponds 2 and 3. This minimizes the potential erosion that could occur at this juncture.

Constraints to recontouring the pond bottom are monetary, political, and biological. In addition to the cost of dewatering that is shared with the construction of the berm between Ponds 1 and 2, recontouring brings the cost of surveys to determine the depth of the aquifer cap. This cap must not be ruptured in Ponds 2 and 3, because doing so would severely restrict the future ability to control pond depth. Such a rupture could also create a path for pollution to enter the ground water. The permitting opportunity for maintenance associated with the sediment basin faces political constraints, in that agencies will likely specify locations of and methods for allowed maintenance, rather than agreeing to a *carte blanche* lack of restrictions. The biological constraints on recontouring include potential impacts to aquatic organisms beyond those of dewatering, and the likelihood of spreading invasive aquatic vegetation (i.e., parrot's feather and water primrose). Recontouring also requires the removal of snags from the area of work. Section 6.8 discusses the opportunities and constraints of this action.

The existing plan for a bike path along the western boundary of the property provides an opportunity for maintenance activities. The bike path should be designed and constructed to support the heavy equipment anticipated for dredging and other needs. Access to this path depends on ownership of the land up to the edge of the concrete-lined channel, which remains undetermined at the time of publication of this analysis. If the City of Chico owns the land, then the opportunity for easy access is granted. If Kohl's owns the land, then the company could serve as an opportunity by allowing passage, or as a constraint if passage is denied.

5.2 Control of Algal Mats and Invasive Aquatic Plants

While Ponds 2 and 3 will likely be dewatered, which was not recommended by the JSA plan, the dewatering will probably not aid control of algae or invasive aquatic plants. This is due to the reasons presented in the JSA plan, namely that the groundwater would prevent death through dehydration, and both parrot's feather and water primrose have robust root systems that resprout readily.

The improvements to hydrology and water quality discussed above are also expected to reduce the concentration of aqueous nutrients. This is the preferred long-term management strategy for algal mats. Unfortunately, the reduction of aqueous nutrients is not expected to have an immediate effect on rooted weeds such as parrot's feather and water primrose. This is because sediment is their primary source of nutrients, and nutrient reduction in sediment is quite difficult.

Manual removal is constrained by the high cost of labor. Nevertheless, some infested areas are so shallow that mechanized means of removal (discussed below) are impossible. In these cases, manual removal may be the only option, if stakeholders decline to use herbicides. Algae are generally not the primary problem in shallow areas, and so algal control will likely avoid manual methods.

A boat-mounted weed harvester provides the benefit of mechanized technology, avoiding the high cost of large labor crews. Both species of rooted weeds as well as algal mats can be removed by the harvester. The harvester also does not require permits from natural resource agencies. Constraints involved with this method include the need to thoroughly remove the numerous snags present in Ponds 2 and 3 (discussed further in section 6.8). Additionally, the harvester cannot reach extremely shallow areas. An access route would need to be found for the harvester and the associated trucks involved in removing the cut plant material.

In many pond systems, blue dye is added to the water to reduce the amount of light penetrating the water, thereby reducing algal growth. The effectiveness of this method is constrained by the constant flow of water through the ponds in this system.

Residence time has not been established quantitatively, but it is expected to be quick enough that the time between dye applications is prohibitively short.

Herbicides provide the benefit of controlling below-ground organs, and for that reason may provide longer-lasting control than harvesting. In addition, no constraints due to water depth apply. Anticipated constraints to herbicide use are monetary and possibly social. Herbicide application while the ponds are hydrologically connected to Little Chico Creek would require obtaining an NPDES permit, which includes expensive herbicide-specific water quality testing. The permit and associated water quality tests could be avoided by only applying herbicides when there is no outflow. Social constraints could arise from community resistance to the use of synthetic herbicides.

Although not discussed in the JSA plan, attendees at the site visit suggested deepening the main portions of Ponds 2 and 3. Combined with recontouring the summer shoreline to a 2:1 slope, deepening the pond provides the opportunity to further minimize available habitat for invasive aquatic weeds. In addition, deeper ponds are expected to decrease the amount of filamentous algae. This is because the algae begins growing on the pond bottom, and needs light to penetrate to the bottom for rapid growth. Deeper water blocks more light and thereby reduces algal growth. The soil removed from these operations could be used to build up berms between ponds, or possibly to help create a small maintenance road along the eastern boundary of the site. Constraints to this action are largely biological.

5.3 Installation of Trash Rack

There are three potential locations for a trash rack. One would be at the head of the channel, replacing the grate at the mouth of the pipe. This location would facilitate maintenance, because a piece of equipment could be stationed on the hardened surface directly behind the channel's head. Potential disadvantages to this location are that debris entering through the flap gate would not be collected, and costs may be incurred in the replacement of the existing grate. The second location, ten feet from the existing grate, was recommended by the JSA plan. This location could decrease installation costs, because no modifications to the existing grate would be necessary. However, it would also not trap debris entering from the flap gate, and the existing grate would either require continued maintenance if left unaltered, or a different grate with larger holes would need to be installed. The third location is at the boundary between the channel and the future sediment basin. The advantage of this location is that debris from both the pipe and the flap gate would be trapped. This location shares a disadvantage with the second, in that either the existing grate would need continued maintenance, or it would need to be replaced so that debris would pass through to the new rack.

We recommend placing the trash rack at the head of the channel. In either of the other two locations, efficient mechanized maintenance would likely be more difficult. Also, unless the existing grate were replaced, maintenance would need to take place in two locations each time. Furthermore, Kohl's has completed a paved access pad at the head of the channel. Installing the trash rack at any other location may require additional access facilities.

As mentioned in section 5.1, the permitting activities associated with this restoration provide the opportunity to include maintenance activities. The same request by General Services and the same constraints to that request apply here as well as in section 5.1. The question of land ownership next to the channel could also facilitate or constrain maintenance of the trash rack.

5.4 Establishment of Biological Controls

The JSA plan recommends shading shallow water along the shore with riparian plants. In addition to lowering water temperature and therefore the rate of algal growth, shading the shoreline offers the opportunity to increase the dominance of native plants on site. Potential constraints on this activity include the necessary investment of time and resources to propagate, install, and establish the plants. This is not viewed as an appreciable constraint, given the existing intent to restore native habitats (see section 6.0). Another constraint could be the need to choose species which can survive periods of shallow inundation. As described in section 7.4, one potential topographic design consists of 2:1 slopes at summer water elevations (to maximize mosquitofish access to mosquito larvae), and 5:1 slopes at winter water elevations (to maximize seasonal marsh habitat). Therefore, the woody plants shading the shoreline at the summer elevations would need to tolerate winter flooding.

The JSA plan also suggested using grass carp as a biological control for parrot's feather. This may not be a viable option due to Section 6455(b) of the California Fish and Game Code, which prohibits the use of grass carp in waters with an open fresh water connection to other waters of the state. Though a grate of some sort will likely remain over the outlet to Little Chico Creek, it is unknown whether the California Department of Fish and Game will consider this an adequate preventative technique. As cautioned by the JSA plan, the efficacy of grass carp on parrot's feather is likely minimal, and desirable vegetation may be consumed.

6.0 HABITAT ENHANCEMENTS

6.1 Removal of Nonnative Terrestrial Vegetation

Enhancement of vegetation communities begins with the removal of nonnative invasive plants. An opportunity exists here to communicate with local invasive plant control groups and learn of techniques tried in the region. An initial constraint arises from concerns about breeding birds. To avoid impacting the reproductive success of birds, wildlife biologists at H.T. Harvey recommended conducting initial clearing activities between September 1 and January 31 (H.T. Harvey 2006). No constraints on the timing of subsequent control were recommended.

Removal of invasive plants provides extensive opportunities for volunteer involvement. Ms. Susan Mason, volunteer coordinator for Friends of Bidwell Park, advised on the site visit of October 3, 2006, that privet, black locust, and pyracantha are the most likely candidates for volunteer removal. Disadvantages to volunteer labor include unpredictability in personnel numbers, and therefore the amount of work able to be completed. The removal methods used by volunteers are also limited to manual techniques, or potentially cut-stump treatments with herbicides.

Manual removal is largely restricted to volunteer crews or the California Conservation Corps (CCC), due to the large time investment necessary. However, the technique is still effective for species with shallow root systems that tend to not resprout. Seedlings and saplings of privet fall within this category. Volunteer participation also yields the opportunity for local residents to become more involved with their community and more aware of ecological issues. The City has had past success with the CCC, but this group is in high demand. Consequently, it can be difficult to receive a spot in their schedule.

Systemic herbicides offer the opportunity to kill plant organs deep underground. A variety of application methods exist and have been used on the species present at Teichert Ponds. These methods include foliar spray, cut-stump, basal bark, and drill-inject treatments. Depending on the species, herbicides used may include glyphosate (Roundup), triclopyr (Garlon), and/or imazapyr (Stalker). Constraints on herbicide use may include biological restrictions on timing, the need for trained applicators, and objection from the community. Large trees killed by drill-inject treatments may incur future costs for removal.

Long-term maintenance is an unavoidable constraint on invasive exotic weed control. Existing plants may resprout, new ones may germinate from the seed bank, or propagules may disperse to the site and establish. Privet, Himalayaberry, and pyracantha are all dispersed by birds. Tree-of-heaven is dispersed by wind. The tree-of-heaven individuals on the right-of-way for State Route 99 were completely removed in late 2006, reducing the immediate concern about seeds from this parcel. If Caltrans does not provide follow-up treatments of resprouts, then the new seeds will hinder control efforts on City property.

6.2 Enhancement of Riparian Vegetation

Vegetation enhancement consists of planting trees, shrubs, vines, and/ or herbaceous species and maintaining the plantings during an establishment period. Individual plants of some riparian species can be grown from cuttings gathered on site. The remainder can be bought from a nursery. Growing plants from on-site cuttings ensures local genotypes, but additional resources must be expended for the collection, care, and storage of the plants until installation. The species available are also limited to those currently present around the ponds. Buying plants from a nursery may result in genotypes from other regions, but no additional resources such as storage space or containers must be procured. A wider variety of species would be available. In this case, it may be desirable to combine the two sources, and to use volunteers for propagation of cuttings. The prevalence of wild grape in the vicinity of the project provides a good opportunity for propagating this species by cuttings. Cottonwood, mulefat, and willows are also present on site and can be propagated by cuttings.

Installation may or may not involve fertilizer, mycorrhizal inoculum, or wire mesh cages. The soil at this site, especially in the riparian areas, is likely not low in nutrients. While fertilizer costs are minimal in comparison to plant installation as a whole, the assumed abundance of nutrients provides an opportunity to avoid this expenditure. The cost of mycorrhizal inoculum is likewise minimal, but given the likely benefit of inoculum, we provisionally recommend its use. Wire mesh cages are recommended due to the assumed presence of small rodents. The larger cages used to protect plants from beavers are more expensive. Because of this constraint, they are usually installed only if evidence of beaver herbivory is seen on site. At Teichert Ponds, the periodic damming of the outlet indicates that beavers are present, and that large cages will be necessary in at least some areas.

Important components of irrigation include methods, frequency, intensity, and duration. The cost of manual watering is often prohibitive due to the large labor investment needed. Instead, a drip system that pumps water from the ponds is preferred. Frequency and intensity are interconnected. The low-frequency, high-volume irrigation events that are preferred for native vegetation provide the opportunity for fewer maintenance visits per month as compared to traditional landscaping. The number of years of irrigation can vary among riparian sites. At Teichert Ponds, plants installed very close to the summer shoreline might not need irrigation at all. Other riparian plants may only need one or two summers of irrigation.

The blue elderberry (*Sambucus mexicana*) is a common species found in riparian communities in the Sacramento Valley. Its showy floral displays and the resulting prolific berries benefit both human aesthetics and wildlife forage needs. However, current legislation protecting the valley elderberry longhorn beetle (VELB) may conflict with the need for mechanized maintenance in some areas of the site. If elderberries are planted, then specific locations for them should be determined with the help of staff at the City of Chico, and a “Safe Harbor Agreement” should be established with the US Fish and Wildlife Service prior to planting.

6.3 Enhancement of Oak Woodland Vegetation

The opportunities and constraints for oak woodland enhancement are very similar to those for riparian enhancement. In addition to the points addressed above regarding the source of plantings (on-site cuttings vs. nursery stock), oak woodland enhancement may face an additional biological constraint. Several tree species characteristic of oak woodlands do not reproduce from cuttings as easily as the cottonwoods and willows in riparian communities. Oaks can, however, be installed as acorns, which can easily be done by volunteers. Acorn planting is constrained by the need for a good acorn crop and by the low survival rate.

As with riparian enhancement, site conditions likely provide the opportunity to omit fertilizer at the time of installation. Mycorrhizal inoculum may again be desirable, and wire cages likely necessary. Beaver cages are less likely to be necessary for oak woodland vegetation, because beavers tend to prefer riparian species, and the oak woodland plants are farther from the water.

Also as with riparian enhancement, irrigation should be applied through a drip system taking water from the ponds. Frequency and intensity should be comparable as well. In contrast, the drier conditions of oak woodland impose a constraint on duration not shared by riparian communities. A standard duration is three summers.

6.4 Establishment of Native Perennial Grasses

The JSA plan recommends seeding disturbed soil in the riparian zone. While this is necessary, additional benefits may be obtained by also incorporating native grass establishment into the enhancement of riparian and oak woodland communities. Ecological benefits include restoration of a complete plant community, rather than only the overstory species. Native grasses provide an abundance of food, shelter, and nesting sites to wildlife. Perennial native grasses provide better erosion control after the first year than common invasive exotic annuals. The perennial grasses also green up sooner in the fall than invasive annuals, and remain green longer into the spring. Once established, the perennial grasses may help to prevent reinfestations of ruderal weeds, by virtue of occupying the sites otherwise open to colonization.

The constraint to including native perennial understories is the initial installation and establishment cost. Native grass seed is more expensive than standard erosion control mixes of invasive exotic annuals. Costs are also incurred for maintenance during a one- to three-year establishment period. Maintenance is typically either mechanical (mowing) or chemical. In cases where grasses are planted among installed trees and shrubs, riding mowers can be used to efficiently mow between the woody plants. Troublesome dicot weeds can be spot treated with a broadleaf-specific herbicide, minimizing herbicide materials and labor costs.

6.5 Enhancement of Wetland Vegetation

Typical native wetland plants, such as cattails, rushes, and bulrushes, reproduce reliably from fragmentation of rhizomes. This provides the opportunity for minimal or no time spent in a nursery environment. The initial installation should probably use plant stock that was given time to recover from the shock of cutting. However, small-scale infill at later dates can easily be completed by volunteers using plants gathered and split apart on site. Nursery-grown plugs can provide the opportunity to establish several important but not locally abundant species. Planting these plugs in select patches is a cost-effective way to increase plant species diversity on site.

The installation of wetland vegetation is relatively simple and fast, providing the opportunity for decreased costs as compared to riparian or oak woodland vegetation. No fertilizer, inoculum, or wire cage is needed. In addition, costs are also lower for maintenance, because these plants do not require irrigation. However, each species requires a specific annual hydrologic regime and must be installed along appropriate contours.

6.6 Installation of Nest Boxes

The JSA plan suggests installing nest boxes for wood ducks, American kestrels, barn owls, swallows, oak titmice, northern flickers, and house wrens. The installation of nest boxes for brown bats would provide additional opportunities for volunteers to learn about ecology. Bats using the boxes would yield further benefits by serving as a biological control for mosquitoes.

Installing nest boxes provides a good opportunity for volunteers, including children, to invest in their community and learn about local ecology. Materials for the boxes can be donated by local businesses, and construction can be accomplished in school shops or by youth organizations as volunteer projects. Nest boxes also facilitate further opportunities for education and research for biologists interested in monitoring nest success or conducting bird banding.

Constraints to the installation of nest boxes consist largely of maintenance needs. Waste needs to be removed, nest material may need to be replaced, and occasionally a box may need repair or replacement. These activities could be performed by volunteers.

6.7 Construction of Giant Garter Snake Habitat

The documentation of a giant garter snake (GGS) in the vicinity of Chico has increased the attention given to this species by the United States Fish and Wildlife Service when reviewing discretionary projects in this region. A Biological Opinion will likely need to be acquired for GGS as part of the Section 404 permit from the U.S. Army Corps of Engineers. At this point in time, the probability of GGS occurring on site is minimal, due to the lack of preferred habitat elements. These elements include safe shoreline basking locations, nest sites, and overwintering refugia. Adding these elements to the project design may benefit a future GGS population, as well as ease the permitting process. Constraints to these habitat improvements include the cost of materials and labor for installation. Generally, no maintenance of these habitat elements is necessary.

6.8 Enhancement of Open Water Habitat

Open water is the defining feature of a pond complex, and plays a central role in the suitability of the site for turtles, fish, amphibians, and waterfowl. Many restoration actions already discussed, such as improvement of water quality and removal of invasive exotic aquatic plants, directly result in the enhancement of open water habitat.

The primary feature of open water discussed here is the presence of logs in the ponds. A compromise in the prevalence of these logs is necessary because the logs affect the various long-term goals and short-term logistics of the project in opposite ways. Currently, the many existing dead trees throughout the ponds are believed to provide habitat value as basking areas for turtles, roosting perches for birds, and refuges for small fish. Unfortunately, the logs also provide sheltered microsites for mosquito larvae. In addition, several restoration activities, such as raising berms, creating basins, recontouring the shoreline, and mechanically removing invasive aquatic plants, are incompatible with the presence of logs.

We recommend removing all dead trees from the ponds initially, but storing a subset of them on site for subsequent replacement. Approximately ten to fifteen logs could be chosen which have several branches at one end and a single trunk on the other. The logs would be installed so that the branches are underwater, providing refuge habitat for fish, and the single trunk would extend above the water at no more than a 45-degree angle. The trunk will provide basking habitat for turtles and roosting perches for birds while minimizing habitat for mosquito larvae. Placing the logs 5-15 horizontal feet away from the shore will also minimize mosquito usage. Embedding the end of some branchless logs into the shoreline will provide additional niches for reptiles and amphibians, in addition to stabilizing the logs against fluctuating water levels.

6.9 Alteration of Topography

The JSA plan discusses the creation of islands and undulating shorelines, but does not recommend these measures, because they would require the dewatering that was believed to be unnecessary. As explained in section 4.1, dewatering is in reality required in order to create the proper structural integrity of raised or widened berms. Dewatering also provides the opportunity to create islands or otherwise modify the pond topography with very little additional cost.

Islands may provide nesting birds and other animals with sites safe from most terrestrial predators and human disturbance. Islands may also provide an aesthetic benefit to people. Drawbacks of islands include the additional shallow-water habitat favored by invasive aquatic vegetation and mosquitoes, plus an increase in the difficulty of maintenance and monitoring activities associated with them. Also, island creation is by definition a permanent fill of existing wetlands, and could therefore complicate the permitting process. The constraints of islands may outweigh the opportunities in this case, and island creation must be reviewed carefully as the habitat development plan progresses.

Undulating shorelines would likely result in a net loss of wetlands, given the lack of dry land on site. To avoid this and the resulting permitting complications, the contour where uplands meet wetlands should remain mostly consistent with existing conditions. In contrast, we suggest recontouring the bottom of Ponds 2 and 3 so that winter water elevations intermittently cover seasonal wetlands with about a 5:1 slope, while at lower summer elevations the slope be increased to 2:1 to decrease mosquito habitat and increase the efficacy of mosquitofish. The edge between 5:1 slopes and 2:1 slopes may be undulating to increase habitat heterogeneity. At locations of GGS basking structures, the 5:1 slope may be omitted entirely to allow snakes quick escape from predators into deep water. This scenario increases the opportunities for wetland acreage and habitat value while retaining mosquito control.

7.0 MOSQUITO CONTROL

Mosquito monitoring and control will be the responsibility of the Butte County Mosquito and Vector Control District (BCMVCD), but the design of the restoration activities at Teichert Ponds will attempt to incorporate as many features as possible to inhibit mosquito reproduction and to facilitate sampling and control.

7.1 Monitoring of Mosquito Populations

Monitoring of mosquito populations can be facilitated by control of the non-native Himalayan blackberry which currently blocks human access to the shoreline along much of the ponds' perimeter. Removal of these blackberry bushes will increase the opportunities to sample mosquitoes. Constraints to this action include the difficulty and cost of controlling this spined weed. Certain small birds and mammals will temporarily lose a source of food and shelter, until native blackberries are installed and established.

In the future, native willows may grow along the water's edge. Management of dense willow thickets may be necessary to retain the opportunities for mosquito sampling. However, this management would also cause an undesirable reduction in shelter and nest sites for birds. An ecologically viable compromise may be reached by clearing only the minimal amount of willow biomass necessary to reach the water.

Mosquito monitoring may also be facilitated by recontouring the ponds to increase the slope of the shoreline at summer water elevations. The increased slope would provide a less marshy, muddy pond edge, allowing monitors to more easily approach the water. The opportunities and constraints of recontouring are discussed in detail in section 5.1.

7.2 Fluctuation of Water Levels

The JSA plan recommends fluctuation of summer water levels as a control technique for mosquitoes. Installation of water control structures, rather than solely overflow weirs, creates the opportunity to exercise this technique. If implemented, mosquito populations should be effectively reduced due to dehydration. This technique may conflict with the goal of keeping the shoreline in the shade to reduce algal growth, especially in the first years after restoration while the woody plants are still small.

7.3 Application of Larvicide

The application of larvicide is not part of the restoration project at Teichert Ponds. If larvicide is necessary, its application will be handled by the BCMVCD, which is expected to request reimbursement directly from the City of Chico. The application will be implemented with ground equipment only, never with airplanes, due to the human health issues involved with aerial applications in residential areas, as well as the impracticality of such an activity. Larvicide applications are facilitated by easy access to all areas of the shoreline. Willows, a valuable component of pond ecosystems due to the vegetation diversity, wildlife habitat, shoreline shade, and erosion control they provide, unfortunately can hinder larvicide applications if they grow thickly at the water's edge. A possible compromise between access and habitat value is to plant only willow species that have a more tree-like growth habit in place of those that form dense thickets. Planting native riparian vegetation of some kind is necessary, because if desirable plants are not established, then other less desirable plants establish themselves.

7.4 Additional Design Features

In addition to the three items above which were called out in the JSA plan, representatives from the BCMVCD provided input at the site visit regarding design features that would facilitate mosquito control.

Several existing design features are desirable for mosquito control. The planned control of parrot's feather and water primrose will help mosquitofish to reach mosquito larvae. The BCMVCD does note that in addition to the initial restoration activities discussed here, ongoing invasive plant control activities must take place to prevent the reinfestation of cleared areas. The planned isolation of Pond 1, removal of snags, and installation of the trash rack are also desirable for mosquito control. The opportunities and constraints of these activities are discussed under their own sections.

Two additional design features were recommended by the BCMVCD to discourage mosquitoes. First, areas which are currently too shallow for mosquitofish should be deepened. There is an opportunity to implement this feature when recontouring the shorelines as described in section 6.8. If the shorelines are recontoured in this way, there would be no additional constraints involved with deepening the existing shallow areas. Second, BCMVCD recommended incorporating a low-flow channel into any constructed seasonal wetlands. This feature is easily compatible with the creation of seasonal marsh at winter water elevations.

Representatives from the BCMVCD also stressed the importance of grading shorelines to a 2:1 slope in order to minimize mosquito habitat. While this increases the opportunity for mosquito control, it decreases the opportunity for wetland acreage. A compromise is suggested here where shorelines at water elevations in the summer are graded at a 2:1 slope, while higher areas at the winter shoreline elevation are graded at a 5:1 slope. This scenario allows for both mosquito control and wetland acreage. A potential constraint arises from the need to monitor water levels informally during the summer and adjust screw gates if necessary, as well as ensure that the outlet into Little Chico Creek has not been dammed by beavers. Final design of the water level management structures will take into account the need to minimize regular maintenance activities. Constraints associated with the overall process of recontouring are discussed in section 5.1.

8.0 COORDINATION WITH CALTRANS

The opportunities and constraints surrounding coordination with Caltrans are largely political and therefore subject to change.

8.1 Treatment of Stormwater Runoff

The JSA plan does not identify what route stormwater takes as it leaves the surface of SR 99. This information needs to be obtained before concrete opportunities for the stormwater's treatment can be identified. Pond 2 may be able to serve as a treatment wetland for this water, if it can be delivered to the cement-lined channel or the planned sediment basin. In order to avoid forfeiting this opportunity, the path of water from SR 99 should be determined before significant progress on project design is made.

8.2 Control of Nonnative Plants

As mentioned in section 6.1, the tree-of-heaven on the SR 99 right-of-way was controlled in late 2006. Follow-up treatments are essential for long-term success. If resprouts are left to grow, then the right-of-way could act as a seed source to recolonize Teichert Ponds. Likewise, trees currently on City property could disperse seeds to the Caltrans land. Costs for controlling this species on both parcels could potentially benefit from an economy of scale effect. Therefore, coordination with Caltrans is worth pursuing in this matter.

8.3 Installation of Native Plants

Native plants tend to grow more slowly than invasive exotics such as tree-of-heaven. Because of this, installing native plants on the SR 99 right-of-way could reduce vegetation maintenance costs for Caltrans. Again due to a potential economy of scale effect, coordination with Caltrans is worth pursuing.

8.4 Use of Site for Environmental Mitigation

Combining stormwater detention ponds with mitigation credit for special-status species, such as GGS, is reviewed on a case-by-base basis by the US Fish and Wildlife Service. Connections to existing GGS habitat increases the likelihood of credit approval. Restoration Resources coordinated the approval of GGS credit in a detention pond in Sutter County, on a site where GGS was recently observed. If Restoration Resources successfully coordinates the approval of GGS credit for Teichert Ponds, then the City of Chico would hold the credits and could either apply them to its own mitigation needs or sell them to another party. During the permitting process, Restoration Resources will approach the Service with the request for GGS credit, supported by conceptual designs for GGS habitat within the pond system. Based on the Service's response, use of the ponds as GGS credit may be pursued further or abandoned.

8.5 Sharing Costs

Sharing costs provides a direct monetary benefit to both entities involved. If work is to be performed on Caltrans property, then it would be beneficial to seek an agreement to share costs.