Appendix 2-A

Invasive Species Management Plan, Oroville Wildlife Area D Unit

Invasive Species Management Plan
Oroville Wildlife Area D Unit

Prepared for:
Department of Fish and Wildlife
Oroville Wildlife Area

Sutter Butte Flood Control Agency

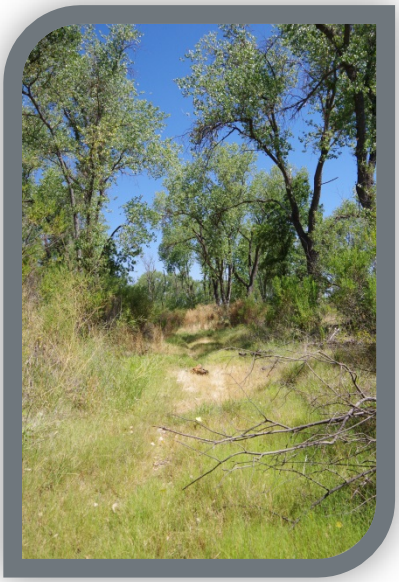
Prepared by:
River Partners
February 2016

Contents

INTRODUCTION

The Oroville Wildlife Area (OWA) is comprised of multiple units with the goal of protecting existing wildlife and fisheries resources, maximizing fish and wildlife values through habitat development, and providing public recreational use.

Recent flood planning and designing have identified the OWA D Unit as an excellent site for an integrated flood protection, ecosystem restoration, and recreation benefits project. To reduce the flood risk to the Thermalito Afterbay relief well system and diminish flood risk to downstream communities, a consortium of organizations (Sutter Butte Flood Control Agency, River Partners, and American Rivers) proposes the OWA Flood Stage Reduction and Habitat Restoration Project. This multi-phased project focuses on constructing large civil features (inflow weir, new permanent connection, culverts, berms), and improving floodplain connection. The project will also map and treat approximately 500 acres of water primrose and approximately 200 acres of terrestrial invasive species on and immediately adjacent to the D-Unit. Later phases will include planting riparian habitat and installing recreational amenities.



Purpose of the Plan

This plan is intended to serve as a first attempt to guide the Invasive species management efforts on the OWA D Unit.

The plan includes an overview of data needs, prioritization criteria for invasive species removal, an overview of management challenges and techniques, a tentative timeline for weed control treatments, and list of appropriate species for revegetation.

Project Setting

The Project Area is located on the east side of the Feather River within the OWA in Butte County, California. In total, the OWA is comprised of approximately 11,850 acres. The OWA is divided into 8 different areas, or 'units', named A thru H. The project lies within the 'D-Unit', located just west of Highway 70, and across the river from the Thermalito Afterbay outlet. The D Unit is approximately 1,500 acres.

Since the construction of Oroville Dam, the D Unit has been hydraulically disconnected from the Feather River. Once utilized as a borrow pit for the dam, the project area consists of a highly disturbed floodplain that includes extensive, isolated ridges and piles of rock left by gold dredging and drainage canals. Borrow operations leveled areas to an elevation roughly 3 feet above the summer flow level of the Feather River. At various locations these leveled areas are pocked with water-filled sloughs and deep excavations (DWR 1968).

The OWA D Unit is a basin that is entirely disconnected from the Feather River during times of low flow. A berm runs along the perimeter of the D Unit adjacent to the river. The height of the berm varies and is generally between 15 and 20 feet higher in elevation than the adjacent land. During times of high flow (greater than 35,000 cfs), water flows into and out of the D Unit via a system of inflow and outflow weirs. Within the interior of the D Unit, there is a network of existing canals and disconnected ponds. The bottoms of these interior canals and ponds are, in many places, lower in elevation than the adjacent Feather River.

The D Unit will be modified with the implementation of the OWA Flood Stage Reduction Project, which will reduce the stressors placed on salmonids, native wildlife and riparian habitats. The project will reconnect the Feather River to its historic floodplain, increase frequency of floodplain inundation, create shallow floodplain habitat for native fish, and treat invasive plant species. In combination with the current and future phase activities, this project will promote volitional use of floodplains by salmonids and reduce native fish entrapment potential while protecting public safety.

Existing Conditions

Today, existing vegetation is generally comprised of an overstory of cottonwood and willows with a mixed understory composed primarily of non-native forbs and grasses. There is minimal structural or species diversity due to a lack of native trees, mid-story native shrubs, and understory native forbs, grasses and rushes. Riparian woodlands are threatened by numerous invasive species including annual grasses, broom, giant reed, scarlet wisteria, Tree-of-Heaven, and Himalayan blackberry. Purple loosestrife and scarlet wisteria dominate wetland areas in which broom species are also found. Along the Feather River, dense stands of Tree-of Heaven, broom, and scarlet wisteria are observed. Water primrose forms dense mat across existing channel and ponds within the D Unit.

INVASIVE SPECIES MANAGEMENT PLANNING

Identify Extent of Invasive Species

Comprehensive invasive species mapping and monitoring will be initiated for the entire D Unit, including both terrestrial (e.g., scarlet wisteria, Tree-of-Heaven, purple loosestrife and broom species) and aquatic species (e.g., water primrose). This approach will be critical for quantifying the extent of invasive species and developing strategies to prioritize and eliminate source populations and prevent infestations, especially water primrose.

Terrestrial and aquatic invasive species will be mapped to create a baseline dataset for comparison as treatment progresses over the grant period and beyond. Survey-grade GPS will be used to record locations of individual plants and patches of invasive species, and all data will be organized and analyzed using ArcGIS. Existing knowledge of locations of invasive species on the D Unit will be used to maximize efficiency of invasive species mapping. As treatment of terrestrial invasive species progresses over time, various standard vegetation monitoring techniques will be employed to evaluate treatment effectiveness, including but not limited to: quadrat-based estimation of percent cover, transect surveys, GIS-based measurements of changes in patch size, stem counts, and repeat ground-based and/or aerial photography. Field data and mapping dataset will be submitted to be included in the CalFlora database and BIOS.

Long-term control of invasive species on the D Unit is predicated on effective treatment of invasive species on site, but also upstream of the project site on the Feather River. Unless upstream sources of invasive species are mapped, prioritized, and eventually treated, it is highly likely that invasive species will disperse downstream and recolonize the project site in the years following the conclusion of the grant period. During the grant period, River Partners will work with DFW, DWR, Butte County Ag Department and other stakeholders to map upstream locations and develop strategies to eliminate source populations of invasive species that are dispersing propagules downstream. Mapping would begin at upstream locations closest to the project site, and will proceed upstream as logistically possible within the grant period. This mapping will set the stage for eventual upstream invasive species control efforts that will contribute significantly to reducing future reinvasion of the D Unit.

Assess Potential Impacts

Invasive species are clearly identified as stressors on, and impediments to, the development and persistence of native California riparian habitat and associated ecological processes (Healey et al. 2004; Fremier et al. 2008). An important step in assessing the relative threats to natural areas

in the D Unit is determining the invasiveness of targeted invasive species and the feasibility of control versus eradication. Examples of such factors include the likelihood of spread, distance to propagule sources, and proximity to vectors of spread (e.g. rivers, roadways) and the potential impacts to the value of the habitats or areas that the invasive species may infest. Moreover, the probability of successfully controlling or eradicating species will depend on factors including population size, reproductive ability (e.g., seed set, vegetative reproduction, seed longevity, lengths of juvenile and reproductive phases), detectability, and control effectiveness and estimated cost.

Establish Goals for the Site

Prior to the initiation of an invasive species management program on the D Unit, goals must be set to define the level of invasive species control envisioned for the project area. Objectives are statements, which are specific, measurable, and achievable, and provide a link between a more general goal statement and specific steps. Overall, the long-term management strategy for the D Unit is to minimize or reduce DFW's maintenance work load required to treat new and existing infestations of targeted invasive species. Below is a list of goals and objectives for the D Unit:

- Goal 1: Improve the condition of riparian woodlands and wetlands within the D Unit.
    - Objective 1: Eliminate source plants and reduce seed production of invasive species.
    - Objective 2: Remove invasive vegetation biomass, creating openings in the vegetation cover for native regeneration to occur and facilitate ongoing removal and treatment of invasive plant resprouts and seed bank flushes.
- Goal 2: Improve habitat for native plants and wildlife.
    - Objective 1: Create more open water habitat.
    - Objective 2: Improve structural diversity to attract wildlife to nest and forage.

Specific objectives for each targeted invasive species are listed under each species profile.

Identify and Prioritize Invasive Species that Obstruct Meeting Goals

Invasive species management is expensive and it is impossible to control every weed, invasive or otherwise that occurs within the D Unit. The focus of control efforts is to develop a prioritization strategy has the maximum impact on reducing the extent of infestation. Treatments should be based on information collected from the comprehensive weed mapping to adjust approach and schedule of management activities.

In the short-term, high priority actions will be conducted to prevent or contain the spread of invasive species. High priority actions will:

- Focus on early detection and eradication of small infestations.
- Concentrate on weed species that, if left alone, would soon be uncontrollable and disruptive to the most highly valued areas of the site.
- Emphasize areas of high disturbance where mechanisms are in place to help disperse seeds of invasive species.
- Focus on species that alter ecosystem processes such as fire frequency, sedimentation, nutrient cycling and other processes. These species change conditions so that few native plants and animals can persist.
- Increase resistance methods to avoid re-establishment of invasive species.

Long-term management actions focus on invasive species control and habitat restoration. These activities will:

- Facilitate dynamics to shift towards favoring desired vegetation.
- Identify and alter processes that promote invasive species.

INVASIVE SPECIES MANAGEMENT CHALLENGES

Lack of Invasive Species Mapping

There has been no recent mapping of invasive species located within or upstream of the project area. Very little data exists on the extent and location of non-native invasive plant species that can aid in prioritizing control of target plant species. Collecting data on spatial distribution, patch density, age class, and other factors will allow for strategic and coordinated removal efforts that target multiple species and match formulations of chemical treatments to potentially reduce number of applications.

Overall Project Size

Invasive species control across the D Unit, which is approximately 1500 acres, will be a challenge. The size, topography, and limited access routes, coupled with lack of existing information on location and extent of invasive species will make it difficult to systematically and efficiently treat areas.

Coordination to Treat Upstream Locations

Floodplain reconnection associated with the OWA Flood Stage Reduction Project is desirable for providing rearing habitat and velocity refugia for native fish and the ecological functioning of riparian areas, but it also increases the vulnerability of the D Unit regarding reinfestation. With increased flood frequency, there will be more chances for seed dispersal and germination of invasive terrestrial and aquatic plant species from upstream locations. To reduce long-term maintenance of the D Unit, it will require contacting and meeting with multiple property owners and land managers to coordinate mapping and treating upstream populations of targeted invasive species. During the grant period, River Partners will collaborate with DFW, DWR, Butte County Ag Department and other stakeholders to develop treatment strategies consistent with the DWR Invasive Species Management Plan that was developed through the FERC relicensing effort.

INVASIVE SPECIES MANAGEMENT OPTIONS

Mechanical Treatment

Mechanical removal involves cutting and removal of invasive plants by hand or by machines. Hand crews can use clippers, loppers, weed wrenches, shovels and chainsaws to pull or remove weeds. Machines such as backhoes, excavators, and brush hogs are desired in large areas with mature plants, especially where hand removal is infeasible.

Chemical Treatment

Chemical treatment focuses on carefully timed applications of specific herbicides to target individual invasive plants. Pest Control Advisor selects appropriate herbicides and a Qualified

Applicator applies the herbicides for the target invasive species. Several applications may be necessary to suppress or kill invasive species, often in combination with mechanical treatment to remove biomass. Methods of herbicide applications can vary, and include basal bark sprays, foliar sprays, and cut and paint applications.

Biological Control Treatment

Biological control uses natural enemies to regulate populations of invasive species. Sometimes, the absence of natural enemies may be an important contributing factor to the invasiveness of some plant species. Natural enemies used in classical biological control of weeds include insects and mites, and sometimes nematodes and fungi. It may be a cost-effective approach, but the long-term efficacy of treatment and environmental impacts of releasing an organism to control are not fully understood.

Cultural Control Treatment

Cultural control is the manipulation of the vegetation structure and composition to discourage or limit invasive species. It includes revegetation of native plant species to suppress or prevent the establishment of invasive plants. Other examples of cultural control activities include maintaining a level of canopy closure that impedes shade intolerant invasive species or developing advanced regeneration that can compete with invasive plants.

IMPLEMENTATION

Invasive Control Presented by Individual Target Species

The following section prescribes treatments for each individual invasive species that DFW has identified as a target on D Unit of the OWA. Each species account describes specific characteristics of the plant; the location and extent of infestation; the damage or threat to the project area; control objectives; preferred control methods and control timing. The prescribed treatment(s) are based on a review of scientific literature, and on collective professional experience with similar projects and invasive species. The California Exotic Pest Plant Council (CalEPPC) classification and California Department of Food and Agriculture (CDFA) pest rating of targeted weed species can be found in Appendix I. A summary of maintenance and monitoring activities during invasive species life cycle is presented in Appendix II. To aid in timely maintenance, Appendix II lists timing of chemical and mechanical control methods, mapping and monitoring activities in relation to the life history of the species. Appendix II also contains a summary of the recommended herbicide applications (herbicides, rates, surfactants, application frequency and methods) for each targeted invasive species. Appendix III describes the various biocontrol agents that could potentially be used for purple loosestrife.

Water primrose (*Ludwigia peploides*)

Description

Water primrose (*Ludwigia peploides*) is an invasive macrophyte, an aquatic plant that grows in or near water and is emergent, submergent or floating. It occupies areas transitioning from aquatic to terrestrial environments. Water primrose is highly adaptable and can tolerate a wide range of environmental conditions (e.g., nutrient levels, substrate, water quality, and pH). Found along areas of full sun and wet margins with static or slow flowing waters, such as shallow ponds, canals, ditches, wetlands, water primrose establishes along the bank or channel bottom with prostrate stems growing out laterally and roots adventitiously at nodes. Shoots can grow erect up to 5 feet in height.

Location and Extent of Infestation in Project Area

Since the 1997 floods, which broke through the OWA levee on the east side of the river near the Pacific Heights Road entrance, a small flow of water has been passing through this area. Beavers have created a series of dams using this flow, which has spread the water across hundreds of acres of land that previously only flooded on a seasonal basis. Now this shallow water is standing year-round, providing ideal conditions for the growth of water primrose and its abundance has increased dramatically since this time. The excessive amount of primrose in these former seasonally flooded areas has spread across the deeper, perennial, fish bearing ponds to a point where the entire surface of the pond is covered with water primrose, sometimes to a height of over 1 m above the surface of the pond (DWR 2003).

In 2011 and 2012, DFW treated areas of the D-Unit with single aerial applications of Polaris (imazapyr) and Renovate 3 (triclopyr). Repeated herbicide applications will likely yield greater success.

Previous assessments estimate that there is ~350 acres of water primrose within the OWA D-Unit and occupies both shallow and deep water areas. However, it is suspected that the water primrose population is much greater. DFW observed that water primrose has been spreading from interior channels to the wetland ponds that DWR constructed. Thus, comprehensive weed mapping is integral in defining the current extent of infestation that will require treatment.

Damages/Threat

The most significant issue affecting the OWA fisheries has been the invasion of water primrose on the east side of the Feather River (DWR 2003). OWA is vulnerable because of low elevations that provide conditions suitable for infestation. Water primrose poses a threat to diversity of native plant and animal communities. In addition to growing over and outcompeting native aquatic vegetation, it can create dense mats accelerate sedimentation and that eliminates open-water habitat (reducing available habitat for waterfowl and migratory birds). When primrose decays, microbrial growth reduces dissolved oxygen in the water, impacting fish and invertebrate populations.

Populations can be produced by fragmentation of stems or rhizomes during all season, which facilitates their spread over large areas. Capsules of primrose can float and are mature at the end of autumn. Ultimately, the key to control and reduced long-term maintenance at the D Unit is treatment of both on-site and upstream infestations.

Objectives

- By Year 3, reduce cover of water primrose by 80%.
- Increase open water habitat by 80% after 3 years of treatment.

Preferred control methods

Mechanical treatment: Using a long-armed excavator, remove large infestations of water primrose from channels and pile biomass in upland areas (along the eastern boundary away from wetland areas) to desiccate and decompose. Another option is to haul biomass off-site.

Because water primrose invades low energy environments and prefers full sun, manipulating depth, flow and light availability may aid in limiting its development. Ideally, physical modifications that increase current velocity will discourage water primrose establishment. Although the new rock gabion weir will not increase flows or velocities within the interior channels or disconnected low spots across the floodplain, widening, deepening, and connecting channels may aid in preventing regrowth by increasing rooting depths for water primrose.

Chemical treatment(s): Herbicide treatment includes the foliar application of Garlon 3A (triclopyr, 1 quart/acre). Three applications per year are recommended. Because the OWA D Unit contains large open areas of water primrose in existing channels, aerial application may be an expedient and cost-effective method.

In areas where interior channels are narrow, channel slopes are steep or if native vegetation is too close, herbicide may be applied by boat or using a long hose. Treatments from a boat may be limited depending on the density of water primrose and how navigable the interior channels are. Because triclopyr breaks down rapidly and binds strongly to soil particles, care must be taken that churned-up sediment does not end up on the leaf surface.

Control Timing

Avoid chemical treatment in the fall and winter when plants go dormant and aboveground biomass is reduced. Match application periods when water primrose is actively growing and can translocate herbicides to the roots. Herbicide applications earlier in the season, such as March to May, may allow for improved penetration to the lower substrates of the plant. During

that timeframe, there should be substantial biomass that increases surface area for herbicide uptake.

Tree-of-Heaven (*Ailanthus altissima*)

Description

Tree-of-Heaven (*Ailanthus altissima*) is a rapidly growing non-native deciduous tree found along the river margins and disturbed areas that grow 30-60 feet high. It is shade intolerant and requires full sun for maximum growth. Growth rates decline in shadier areas.

Tree-of-Heaven can tolerate various environmental conditions (nutrient poor, compact soils, salts). Consequently, this species can germinate under extreme conditions as long as there is enough soil substrate to support germination with the exception of prolonged wet or flooded soils.

Infestations occur because this species is a prolific seed producer and it resprouts vigorously. Because of its ability to release allelochemicals, Tree-of-Heaven can inhibit the establishment of other plant species. As a result, it can successfully out-compete native vegetation, especially in riparian areas.

Location and Extent of Infestation in Project Area

Based on communications with DFW and site observations, there are large patches of Tree-of-Heaven along the Feather River. Driving along the access road, this invasive species is intermixed with elderberry. Although there has not been a comprehensive weed mapping effort on the D Unit, it is assumed that Tree-of-Heaven can be found in the interior interspersed within the existing native riparian woodlands.

Damages/Threat

Tree-of-Heaven poses a significant threat due to abundant seed production and high seed germination rate. It is a prolific seed producer with single seed samaras that are wind dispersed up to distances of 300 feet. Each tree can produce hundreds of thousands of seeds. Seeds can remain on tree for long periods. Despite high seed production, soil bank viability is low and seeds have a dormancy of less than a year. Thus, areas of recent disturbance are the most vulnerable to infestations.

Moreover, this species is especially dangerous due to vegetative reproduction. As branches and stems grow, roots simultaneously devote carbohydrate reserves to support the tree during droughts. Established trees with extensive root system permit plants to resprout rapidly and vigorously. The clonal reproduction, in combination with its allelochemicals, allows for dense thickets to develop and displace native vegetation.

Objectives

- Reduce cover of Tree-of-Heaven by 80% after 3 years of treatment.

Preferred control methods

Chemical treatment: Because the preferred method is the cut stump treatment, apply a 50% solution of Garlon 3A (triclopyr) and 50% crop oil using a backpack sprayer.

Control Timing

Herbicide application timing needs to consider tree growth and stress conditions (e.g., slowed growth prior to fall senescence or water stress facilitates herbicide effectiveness by favoring translocation to the plant roots).

Purple loosestrife (*Lythrum salicaria*)

Description

Purple loosestrife (*Lythrum salicaria*) is a perennial emergent aquatic plant that can grow 4-10 feet high depending on environmental conditions. The erect perennial herb grows from a persistent tap root that establishes stems annually. Mature plants can have 30-50 stems arising from a single rootstock forming a crown that reach 5 feet wide.

This species is a habitat generalist that can tolerate a wide range of conditions (soil pH, nutrients). However, it prefers partial to full sunlight. Productivity is significantly reduced at 40% of full light.

Location and Extent of Infestation in Project Area

This invasive herbaceous plant occurs along the large pond edges and interior canals. DFW has noted that this species is found within wetlands near the Hunter's gate and Pit 2 Pond.

Damage/Threats

Purple loosestrife possesses multiple qualities that enable it to effectively establish and persist. With an extended flowering season, generally from June to September, this species produces vast quantities of seed. A mature plant can have up to thirty flowering stems capable of producing an estimated 2-3 million seeds. It is capable of invading wetlands because seed dispersal is mostly by water, but can also be transported on feathers and fur of waterfowl and other wildlife. Furthermore, seed banks build and remain dormant until disturbance provides suitable conditions for germination.

It is well adapted to reproduce vegetatively in wetland environments. Characteristic of aquatic plants, purple loosestrife stems have aerenchyma tissues that makes them buoyant when submerged under water. It can disperse downstream and buried into the substrate. The buried stems develop adventitious roots that allow the plant to produce shoots or roots. Disturbance to the plant, such as stomping and breaking stems, and leaving these stems on moist soils will initiate bud growth and root development. Due to its ecology, purple loosestrife can form large homogenous stands that restrict native wetland plant species.

Objectives

- By Year 3, reduce cover of purple loosestrife by 80%.

Preferred control methods

Mechanical/manual treatment: Remove biomass by cutting or pulling out plants. If plants are in flower and seed set, cut off and remove flower stalk and seed heads.

Chemical treatment: A foliar application that includes a combination of Roundup (1.5 quarts/acre) and 2,4-D (1 pint per acre) mixed with a surfactant, Patrol, (2 quarts per 100 gallons) is recommended. Another alternative is a mixture of Roundup (1.5 quarts/acre) with Garlon 3A (1 quart/acre). Apply two times a year prior to the flower bud stage (approximately May-July).

Cultural treatment: Consider planting native vegetation in wetland areas to discourage regeneration of purple loosestrife. Native species to consider are Goodding's black willow (*Salix gooddingii*), Fremont cottonwood (*Populus fremontii*), buttonbush (*Cephalanthus occidentalis*), sandbar willow (*Salix exigua*), arroyo willow (*Salix lasiolepis*), Baltic rush (*Juncus balticus*), iris-leaved rush (*Juncus xiphioides*), common rush *(Juncus effusus*), tule (*Schoenoplectus acutus*) and mugwort (*Artemesia douglasiana*). Because purple loosestrife may be interspersed between existing native vegetation, these native species can be planted by cuttings or plugs to take advantage of these spaces.

Biological treatment: Several biological control agents have the potential to aid in the control of purple loosestrife. All four of the insect species introduced for purple loosestrife biocontrol are from the beetle family (two leaf beetles and two weevils). The leaf beetles are *Galerucella calmariensis* and *Galerucella pusilla;* one weevil is a root-mining weevil, *Hylobius transversovittatus,* and the other is a flower-feeding weevil, *Nanophyes marmoratus.* Adult and larvae feed on plant foliage. Larval feeding can be more damaging and result in complete defoliation of plants. Based on the lifecycle of these beetles and weevils, larvae and adults could be feeding of purple loosestrife and suppressing plants during their flowering stage. In early 2000s, *Galerucella spp.* was released near the project area.

Although biological control is possible, site factors make it challenging to implement and will not be used on this project. The project involves a lot of disturbance associated with treating other invasive weed species with mechanical and chemical treatment where herbicides are used frequently. These activities would potentially reduce or eliminate weevil and beetle populations, which would make this method ineffective. Furthermore, long term monitoring is required to track the growth of insect populations and efficacy of treatment.

Control Timing

Late spring and early summer herbicide treatments will aid in reducing the amount of seed produced.

Scarlet wisteria (*Sesbania punicea*)

Description

Scarlet wisteria (*Sesbania punicea*), native to South America, invades moist areas in regions with long, dry summers. This species is found along riparian corridors, coastal plains and disturbed sites such as roadsides, ditches and canals. The deciduous shrub or small tree can grow up to 12 feet tall. It produces fruit and flowers characteristic of the legume family. Scarlet wisteria produces coral or red flowers and has distinctive seed pods that can float on the water with wings that acts like sails.

Location and Extent of Infestation in Project Area

Because of its distinctive red flowers, Scarlet wisteria can be observed along the banks of the Feather River, existing ponds, wetlands and disturbed moist areas. Although a comprehensive weed mapping effort has not been completed, it is assumed there are larger populations of scarlet wisteria in the interior of the D Unit since seeds are dispersed by water.

Damage/Threats

Scarlet wisteria forms dense thickets that displace native riparian plants, increases hydraulic roughness and contributes to poor flood conveyance. Dense shrub thickets have approximately twice the roughness of open banks, herbaceous cover, and gravel bars (Marsh et al. 2001, Chin 2000). Subsequently, thick undergrowth of scarlet wisteria could increase flood stage.

Reproduction is solely by seed production. Scarlet wisteria yields abundant and long-lived seeds within buoyant pods that can travel great distances along river systems. The impenetrable seed pods, which allows for survival when transmitted along waterways, require scarification for germination. As the seed pods move down stream, it experiences abrasion and prepares for germination once it finds moist substrate.

This species is shade tolerant and can regenerate under the canopy of other scarlet wisteria plants. Because of this, it has the potential to maintain dominance after displacing native vegetation. This displacement translates into eliminating habitat used by native wildlife. Furthermore, all parts of the plant are poisonous to wildlife.

Objectives:

- By Year 3, reduce cover of scarlet wisteria by 80%.

Preferred control methods

Mechanical control: One of the most important activities would be to remove mature plants and control future seedlings prior to flower production. Cut scarlet wisteria trees to ground level in spring before it flowers. It will reduce the number of seeds produced and will deplete the plant's energy reserves. Efficacy increases because scarlet wisteria does not produce root sprouts when shoots are damaged.

The preferred method of control, especially for larger mature trees near riverbank, is mechanical removal by cutting trees to ground level, disposing the material, and following up immediately with painting herbicide on stump. Hand pull young trees or young plants in areas with high water table or waterlogged areas where pulling is relatively easy; especially if in small, isolated patches. Material should be disposed either through piling and burning on-site or moved off-site.

Chemical treatment: Hand spray applications that include a combination of Roundup (glyphosate, 2 quarts per acre) and Garlon 3A (triclopyr, 1 pint per acre) mixed with 1% crop oil two times a year. An alternative is Transline (clopyralid, 10 ounces/acre). Apply herbicides prior to the flower bud stage (approximately May-July).

Control Timing

Late spring and early summer herbicide treatments will aid in reducing the amount of seed produced.

Broom Species

Description

Spanish broom (*Spartium junceum*), Scotch broom (*Cytisus scoparius*) and French broom (*Genista monspessulana*) are perennial shrubs in the pea or legume family (Fabaceae). Brooms are long-lived woody shrubs that can grow up to 10 feet tall. Indicative of the legume family, brooms have green stems and yellow pea-like flowers.

The introduced ornamental plants were commonly used to stabilize soils. These broom species are usually found in disturbed places such as riverbanks, road cuts, but can colonize undisturbed grassland, shrubland and open canopy forest below 4,000 feet. They can establish on varied soil moisture condition and pH levels. Broom species are competitive in low-fertility soils because of mutualistic relationships with nitrogen fixing bacteria found in small nodules on roots.

Location and Extent of Infestation in Project Area

Broom species can be found along the banks of the Feather River and along the margins of large ponds within the northeast section of the D Unit.

Damage/Threats

Brooms are strong competitors and they can dominate a plant community by forming dense monospecific stands. They grow rapidly and shade out other seedlings effectively displacing native vegetation in disturbed areas. Broom seedlings have a competitive advantage because they can establish and tolerate up to 90 percent shade. Like most invasive species, brooms displace native vegetation on which wildlife depends for nesting and foraging.

Prolific seed production and multiple dispersal mechanisms allow brooms to persist by developing a substantial and long-lived seedbank. A medium-sized Scotch broom can produce over 12,000 seeds per year; whereas, one Spanish broom can yield 7,000-10,000 seeds in one season. Ballistic dispersal seems to be the primary method. Seed pods lose moisture as they

ripen, building pressure up in their cells and pods as a whole. Eventually the structure explodes and seeds fall out near the plant. The seeds can also be dispersed by ants, animals or mud clinging to road grading or maintenance machinery. The tough seed coat permits water dispersal. Abrasion associated with water transportation provides the scarification required for germination. Nevertheless, brooms species are known to have high seed viability with seeds surviving at least five years in the soil and possibly much longer.

Brooms also have adaptations closely associated with fire that permits these species to take hold (e.g., they can resprout from the root crown after fire). As brooms mature and old stems senesce, plants burn readily and carry fire to the tree canopy layer, increasing both the frequency and intensity of fires. Fire also stimulates seed germination.

Brooms contain alkaloids and hydroxytyramine, which make foliage and seeds toxic to wildlife. These compounds make the plant unpalatable to most herbivores; thereby, reducing foraging value for wildlife species.

Objectives:

- Reduce cover of broom species by 75% after 3 years of treatment.

Preferred control methods

Chemical treatment: Combine Roundup (glyphosate, 2 quarts per acre) and Garlon 3A (triclopyr, 1 quart per acre) with crop oil (2 quarts per 100 gallons). Apply 2 times per year. In non-aquatic locations, Garlon 3A may still be used because it is an amine formulation that does not volatize.

Giant Reed

Description

Giant reed (*Arundo donax*) is a bamboo-like perennial grass that grows in clumps and attains heights of 25 feet once established. Native to the Mediterranean region and eastern Asia, giant reed was introduced for erosion control and wind breaks. It is commonly found in riparian areas, floodplains, and ditches, on sites with low gradient slopes. Giant reed grows rapidly, about 4 inches per day and reaching a mature height of 25 feet in about 12 months (UC Riverside reference, 3). Despite having inflorescences of large terminal plume-like panicles that are 1 to 2 feet long, it does not appear that giant reed produces viable seed (UC Davis 2). Instead, plants reproduce only vegetatively from rhizomes and stem fragments.

Location and Extent of Infestation in Project Area

Giant reed is found in small, isolated patches throughout the site, although DFW has previously had California Conservation Corp crew clear and treat infestations.

Damage/Threats

Giant reed is one of the fastest growing plants in the world, which enables it to quickly invade new areas that have been disturbed by flood, fire or human activities. Because rhizome and stem fragments with a node can develop into a new plant, it permits this species to quickly colonize and suppresses native plant communities. As a result, it reduces habitat quality since it does not provide food or structure for wildlife.

Adapted to periodic fire regime, giant reed resprouts aggressively after fire. Senescenced giant reed canes are highly flammable and increases the probability of fire. Consequently, the species contributes significantly to higher fire frequency and intensity.

Large monoculture stands contain a high density of rigid stems that can also modify river hydrology.

Objectives

- By year 3, reduce cover of giant reed by 80%.

Preferred control methods

Mechanical treatment: Use a masticator to cut and shred large stands of giant reed in relatively easy accessible areas. Because this treatment macerates rhizomes, the material can be left on site. Where access is challenging, use crews with chainsaws to cut stands and haul material off site for disposal.

Mechanical control deals with the above ground biomass, but chemical treatment is necessary to deal with resprouts because of the extensive root system of giant reed. Monitor the cut areas to see if the cut stands resprouts and spray herbicide.

Chemical treatments: Combine Roundup (glyphosate, 1 quart per acre) and Goal (oxyfluorfen, 4 ounces per acre) with Patrol (2 quarts per 100 gallons). Foliar applications should occur 6 times per year.

MONITORING

Using an adaptive management approach provides a framework to evaluate project progress and respond to new information. Obtaining feedback between project planning, implementation, monitoring, and evaluation is essential to making recommendations on future maintenance activities that contribute to the short- and long-term site management, and ultimately project success. Monitoring will include evaluating the efficacy of control methods and assessing compliance with discharge permits.

Aquatic Invasive Species Mapping

Aquatic invasive species in interior canals and ponds on the D Unit will be mapped using high-resolution aerial photography obtained through use of an X8-M mapping drone manufactured by 3D Robotics. The X8-M is a fully automated platform for fast and accurate aerial data acquisition commonly used for monitoring conservation, construction, and agricultural projects. Flight paths are repeatable, ensuring that monitoring is consistent through time. The workflow for obtaining aerial photography is fully automated, including takeoff and landing, photo capture, geotagging, and post-processing. This method will allow for efficient mapping of invasive aquatic species in complex habitat across the D Unit, and is far more efficient than attempting to map and monitor aquatic species on foot. As treatment of aquatic invasive species progresses over time, aerial photography will be the primary means by which treatment effectiveness is evaluated (e.g., reductions in acres of water primrose and increases in open water over time). Additional methods may include transect surveys, boat surveys, and other methods.

Terrestrial Invasive Species Mapping

Data from baseline mapping of terrestrial plant species in project year 1 will be summarized by species at the scale of the D Unit using ArcGIS. Baseline data will be used to prioritize treatment locations and schedule, ensuring optimal return on investment in terms of invasive species control. Beginning in project year 1, baseline data will be updated as invasive species treatments are applied to track metrics including number of individuals (when species occur as discreet individuals), patch size (when species occur in patches), locations of new infestations, etc. This approach will facilitate spatially-explicit collection of additional data including date of treatment, type of treatment, additional treatment metadata (e.g., specific equipment used, rate of herbicide application, etc.).

Permanent Photo Documentation

Photo documentation sites will be established throughout the D Unit. These sites will be revisited over time to document changes in vegetation characteristics (e.g. species composition and cover).

Photo documentation points may also be established within non-native invasive plant species treatment areas to document changes in site conditions over the course of control efforts (i.e. before and after pictures).

Water Quality Sampling

Water quality monitoring will be an integral part of complying with DFW's Statewide General National Pollutant Discharge Elimination Systems (NPDES) Permit (CAG990005) for residual aquatic pesticide discharges to the Waters of the United States. River Partners will be a

discharger under DFW's general permit and will act in accordance with with the submitted Aquatic Pesticide Application Plan (APAP).

After the comprehensive weed mapping of the D Unit is concluded and prior to initiating the large scale aquatic herbicide treatments, River Partners will coordinate on aquatic herbicide treatments and evaluation of methods with DFW's pest control advisor, Joel Trumbo, and onsite manager, AJ Dill. River Partners will produce a more detailed water quality monitoring plan that describes specific treatment areas, acreages of treatment areas, application schedule, monitoring methods and analysis, and technical justifications for monitoring locations. The monitoring plan will provide details on reporting pesticide application logs and discharge monitoring reports to both DFW and State Water Resources Control Board.

Chico Environmental Science and Planning LLC will conduct the water quality monitoring and analysis for the OWA D Unit and upstream ponds. Chico Environmental will be contacted prior to each scheduled aquatic herbicide application (aerial and hand applications). Background, event and post-event monitoring samples (Table 1) for residual herbicide (herbicides and surfactants) monitoring will include grab sampling carried out over the course of the field seasons to analyze multiple water quality parameters (Table 2) as per the NPDES general permit. Samples will be taken from 3 locations (one from each of the ponds and on the southern end of the D Unit).

Table 1. Summary of Monitoring Frequency

Monitoring	Description
Background	Samples are collected upstream at the time of the application event, or in the application area just prior to (up to 24-hours in advance of) the application event.
Event	Samples are collected immediately downstream of the treatment area in flowing waters or immediately outside of the treatment area in non-flowing waters, immediately after the application event, but after sufficient time has elapsed such that treated water would have exited the treatment area.
Post-Event	Samples are collected within the treatment area within one week after application.

In addition to the collection of water samples, visual parameters (water body description, appearance of waterway and weather conditions) and physical readings (with the exception of turbidity, which will be analyzed by a lab) will be done at the sampling sites and recorded on the field data form shown in Appendix IV. All discharge monitoring reports will be submitted to DFW and State Water Resources Control Board.

Table 2. Monitoring Requirements per NPDES General Permit.

Sample Type	Constituent/ Parameter	Units	Sample Method	Minimum Sampling Frequency	Sample Type Requirement	Required Analytical Test Method
Visual	1. Monitoring area description (pond, lake, open waterway, channel, etc.)	Not applicable	Visual observation	1	Background, event, and post-event monitoring	Not applicable
	2. Appearance of waterway (sheen, color, clarity, etc.)					
	3. Weather conditions (fog, rain, wind, etc.)					
Physical	1. Temperature[2]	°F	Grab[4]	5	Background, event, and post-event monitoring	6
	2. pH[3]	Number				
	3. Turbidity[3]	NTU				
	4. Electric Conductivity[3] @ 25°C	µmhos/cm				
Chemical	1. Active Ingredient[7]	µg/L	Grab[4]	5	Background, event, and post-event monitoring	6
	2. Nonylphenol[8]	µg/L				
	3. Hardness (if copper is monitored)	µg/L				
	4. Dissolved Oxygen	µg/L				

[1] All applications at all sites.
[2] Field testing.
[3] Field or laboratory testing.
[4] Samples shall be collected at three feet below the surface of the water body or at mid water column depth if the depth is less than three feet.
[5] Collect samples from a minimum of six application events for each active ingredient in each environmental setting (flowing and non-flowing water) per year, except for glyphosate. If there are less than six application events in a year, collect samples during each application event for each active ingredient in each environmental setting (flowing and non-flowing water). If the results from six consecutive events show concentrations that are less that the receiving water limitations/trigger for an active ingredient in an environmental setting, sampling shall be reduced to one application event per year for that active ingredient in that environmental setting. If the yearly sampling event shows exceedance of the receiving water limitation/trigger for an active ingredient in an environmental setting, then sampling shall return to six application events for that active ingredient in each environmental setting. For glyphosate, collect samples from one application event from each environmental setting (flowing and non-flowing water) per year.
[6] Pollutants shall be analyzed using the analytical methods described in 40 C.F.R. part 136.
[7] 2,4-D, acrolein, dissolved copper, diquat, endothall, fluridone, glyphosate, imazamox, imazapyr, penoxsulan, and triclopyr.
[8] It is required only when surfactant is used.

REFERENCES

Cal-IPC Plant Assessment Form Sesbania punicea. (n.d.). Retrieved from http://www.cal-ipc.org/paf/site/paf/427

DiTomaso, J.M. G.B. Kyser et al. 2013. *Weed Control in Natural Areas in the Western United States*, Weed Research and Information Center, University of California. 544pp.

Giant Reed, Arundo donax (Poaceae). (n.d.). Retrieved from http://cisr.ucr.edu/giant_reed_arundo.html

Hunter, J. C., & Platenkamp, G. A. (2003). The Hunt for Red Sesbania Biology, Spread and Prospects for Control. *CalEPPC News, 11*(2), 4-6. doi:10.1037/e686352011-001

Invasive Plants of California's Wildland. (n.d.). Retrieved from http://www.cal-ipc.org/ip/management/ipcw/pages/detailreport.cfm@usernumber=39&surveynumber=182.php
Invasive Plants of California's Wildland. (n.d.). Retrieved from http://www.cal-ipc.org/ip/management/ipcw/pages/detailreport.cfm@usernumber=79&surveynumber=182.php
Invasive Plants of California's Wildland. (n.d.). Retrieved from http://www.cal-ipc.org/ip/management/ipcw/pages/detailreport.cfm@usernumber=52&surveynumber=182.php
Invasive Plants of California's Wildland. (n.d.). Retrieved from http://www.cal-ipc.org/ip/management/ipcw/pages/detailreport.cfm@usernumber=8&surveynumber=182.php

LeBlanc, J. W. (2001). Getting a Handle on Broom. *Regents of the University of California, Division of Agriculture and Natural Resources, 8049*. Retrieved from http://anrcatalog.ucanr.edu/pdf/8049.pdf

Non-native Invasive Freshwater Plants Purple Loosestrife (Lythrum salicaria). (n.d.). Retrieved from http://www.ecy.wa.gov/programs/wq/plants/weeds/aqua009.html

Purple loosestrife. (n.d.). Retrieved from http://www.invasiveplants.net/plants/purpleloosestrife.htm

Sesbania punicea (Brazilian rattlebox) Management Information. (n.d.). *Sesbania Punicea (Brazilian Rattlebox)*. Retrieved from http://www.issg.org/database/species/reference_files/sespun/sespun_man.pdf

Tree-of-Heaven. (n.d.). Retrieved from http://www.bcnwp.org/invasive-plants/tree-of-heaven

Tree-of-Heaven, Ailanthus altissima - Southeast Exotic Pest Plant Council Invasive Plant Manual. (n.d.). Retrieved from http://www.se-eppc.org/manual/ailanthus.html

Wilson, L. M., Schwarzlaender, M., Blossey, B., & Randall, C. B. (n.d.). *Biology and Biological Control of Purple Loosestrife* (Publication No. FHTET-2004-12). doi:10.2105/ajph.16.12.1235-a

APPENDIX I

CalEPPC and CDFA Pest Ratings for Targeted Invasive Species

Common Name	Scientific Name	CALEPPC Priority	CDFA Pest Ratings
Water primrose	*Ludwigia peploides*	-	A
Scarlet wisteria	*Sesbania punicea*	Red alert	B
Purple loosestrife	*Lythrum salicaria*	Red alert	B
Giant reed	*Arundo donax*	A-1	B
Tree-of-Heaven	*Ailanthus altissima*	A-2	C
Spanish broom	*Spartium junceum*	B	C
Scotch broom	*Cytisus scoparius*	A-1	C
French broom	*Genista monspessulana*	A-1	C

CalEPPC List Category:
A-Most Invasive Wildland Pest Plants; documented as aggressive invaders that displace natives and disrupt natural habitats. Includes two sub-lists; A-1 widespread pests that are invasive in more than 3 Jepson regions and List A-2: Regional pests invasive in 3 or fewer Jepson regions.

B-Wildland Pest Plants of Lesser Invasiveness; invasive pest plants spread less rapidly and cause a lesser degree of habitat disruption; may be widespread or regional.

Red Alert-Pest plants with the potential to spread explosively and infestation is currently small or localized. If found, alert CalEPPC, County Agricultural Commissioner or California Department of Food and Agriculture.

CDFA Ratings:
A-A pest of known economic or environmental detriment and is either not known to be established in California or it is present in a limited distribution that allows for the possibility of eradication or successful containment. A-rated pests are prohibited from entering the state because, by virtue of their rating, they have been placed on the of Plant Health and Pest Prevention Services Director's list of organisms "detrimental to agriculture" in accordance with the FAC Sections 5261 and 6461. The only exception is for organisms accompanied by an approved CDFA or USDA live organism permit for contained exhibit or research purposes. If found, entering or established in the state, A-rated pests are subject to state (or commissioner when acting as a state agent) enforced action involving eradication, quarantine regulation, containment, rejection, or other holding action.

B-A pest of known economic or environmental detriment and, if present in California, it is of limited distribution. B-rated pests are eligible to enter the state if the receiving county has agreed to accept them. If found in the state, they are subject to state endorsed holding action and eradication only to provide for containment, as when found in a nursery. At the discretion of the individual county agricultural commissioner they are subject to eradication, containment, suppression, control, or other holding action.

C-A pest of known economic or environmental detriment and, if present in California, it is usually widespread. C-rated organisms are eligible to enter the state as long as the commodities with which they are associated conform to pest cleanliness standards when found in nursery stock shipments. If found in the state, they are subject to regulations designed to retard spread or to suppress at the discretion of the individual county agricultural commissioner. There is no state enforced action other than providing for pest cleanliness.

APPENDIX II

Summary of Maintenance and Monitoring Activities during Invasive Species Life Cycle

2016 Maintenance and Monitoring Activities

Common Name	Scientific Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Water primrose	*Ludwigia peploides*					Flowering	Flowering	Flowering	Flowering	Flowering			
Scarlet wisteria	*Sesbania punicea*						Flowering	Flowering	Flowering	Flowering			
Purple loosestrife	*Lythrum salicaria*					Flowering	Flowering	Flowering	Flowering	Flowering			
Giant reed	*Arund donax*			Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	
Tree-of-Heaven	*Ailanthus altissima*				Flowering	Flowering	Flowering						
Spanish broom	*Spartium junceum*							Flowering	Flowering	Flowering	Flowering		
Scotch broom	*Cytisus scoparius*				Flowering	Flowering	Flowering						
French broom	*Genista monspessulana*			Flowering	Flowering	Flowering	Seeding						
Mapping/Monitoring													
	Aerial Herbicide Application												
	Herbicide Application												
	Mapping/Monitoring												
	Collect Seed Pods												
	Cutting/Hand Treatment												
	Excavation												

2017 Maintenance and Monitoring Activities

Common Name	Scientific Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Water primrose	*Ludwigia peploides*					Flowering	Flowering	Flowering	Flowering	Flowering			
Scarlet wisteria	*Sesbania punicea*						Flowering	Flowering	Flowering	Flowering			
Purple loosestrife	*Lythrum salicaria*					Flowering	Flowering	Flowering	Flowering	Flowering			
Giant reed	*Arund donax*			Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	
Tree-of-Heaven	*Ailanthus altissima*				Flowering	Flowering	Flowering						
Spanish broom	*Spartium junceum*							Flowering	Flowering	Flowering	Flowering		
Scotch broom	*Cytisus scoparius*				Flowering	Flowering	Flowering						
French broom	*Genista monspessulana*			Flowering	Flowering	Flowering	Seeding						
Mapping/Monitoring													
	Aerial Herbicide Application												
	Herbicide Application												
	Mapping/Monitoring												
	Collect Seed Pods												
	Cutting/Hand Treatment												
	Excavation												

2018 Maintenance and Monitoring Activities

Common Name	Scientific Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Water primrose	*Ludwigia peploides*					Flowering	Flowering	Flowering	Flowering	Flowering			
Scarlet wisteria	*Sesbania punicea*						Flowering	Flowering	Flowering	Flowering			
Purple loosestrife	*Lythrum salicaria*					Flowering	Flowering	Flowering	Flowering	Flowering			
Giant reed	*Arund donax*			Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	Flowering	
Tree-of-Heaven	*Ailanthus altissima*				Flowering	Flowering	Flowering						
Spanish broom	*Spartium junceum*							Flowering	Flowering	Flowering	Flowering		
Scotch broom	*Cytisus scoparius*				Flowering	Flowering	Flowering						
French broom	*Genista monspessulana*			Flowering	Flowering	Flowering	Seeding						
Mapping/Monitoring													
	Aerial Herbicide Application												
	Herbicide Application												
	Mapping/Monitoring												
	Collect Seed Pods												
	Cutting/Hand Treatment												
	Excavation												

Summary of Recommended Herbicide Applications for Targeted Invasive Species

Scientific Name	Common name	Herbicide	Active Ingredient	Herbicide Rate	Surfactant	Surfactant Rate	Number of Applications Per Year	Application Method
Ludwigia peploides	Water primrose	Garlon 3A	triclopyr	1 qt /acre	-	-	2-3	Aerial
Sesbania punicea	Scarlet wisteria	Roundup Garlon 3A	glyphosate triclopyr	2qt/acre 1qt/acre	crop oil	1%		
		Transline	aminopyralid	10 oz/acre			2	Foliar application
Lythrum salicaria	Purple loosestrife	Roundup Garlon 3A	glyphosate triclopyr	1.5 qt/acre 1 pt/acre	Patrol	2qt/per 100gal		
		Roundup Weedar	glyphosate 2,4-D amine	1.5 qt/acre 1 qt/acre	-	-	2	Foliar application
Arundo donax	Giant reed	Roundup Goal	glyphosate oxyfluorfen	1qt/acre 4 oz/acre	Patrol	2qt/per 100gal	6	Foliar application
Ailanthus altissima	Tree-of-Heaven	Garlon 3A	triclopyr	50%	crop oil	50%e	1	Paint on with brush
Spartium junceum *Cytisus scoparius* *Genista monspessulana*	Spanish broom Scotch broom French broom	Roundup Garlon 3A	glyphosate triclopyr	2qt/acre 1qt/acre	crop oil	2qt/per 100gal	2	Hand spray

Appendix III

Biocontrol Agents for Purple Loosestrife

Insect Type	Scientific Name	Common Name	Life Cycle and Impacts
Leaf beetle	*Galerucella calmariensis*	Black-margined loosestrife beetle	These two species are nearly identical species with coloring and lines along the thorax differing. Larvae feed on leaves and stems. Mature larvae move into litter beneath purple loosestrife plants to pupate. On flooded purple loosestrife plants, larvae pupate in the aerenchyma or spongy tissue of the plant. Adults emerge in mid-June. Depending on time of year, temperatures and day lengths, there may be a second generation that develops. Because of the short life cycle, larvae and adults can suppress flowering. Loosestrife plants are stripped of photosynthetic tissue without damaging the leaf cuticle and epidermis. Plants that regrow from defoliation are shorter and bushier than normal, unattacked plants.
Leaf beetle	*Galerucella pusilla*	Golden loosestrife beetle	
Weevil	*Hylobius transversovittatus*	Loosestrife root weevil	This is a long-lived species (two to three years or longer). Adult weevils appear shortly after purple loosestrife shoots sprout. Nocturnal and hides in the base of the plant. Young larvae feed on the outside of the root and mine into the center of the stem, where it feeds for one or two years. Mature larvae then moves to the upper part of the root to pupate. Adults emerge from June to October. Loosestrife root weevil is tolerant of wide range of environmental conditions. However, fluctuating water levels may make it difficult for females to lay eggs at the base of the plant. Nevertheless, loosestrife root weevils can be very destructive to roots; especially at high larval densities. May be most effective when combined with loosestrife leaf beetles.
Weevil	*Nanophyes marmoratus*	Loosestrife flower weevil	Adults overwinter in the leaf litter and emerge in May to early June to feed on young purple loosestrife leaves. As flower buds develop, adults move to the flower spikes to feed, mate and lay eggs. Larvae feed on developing ovaries and hollow out the flower bud. It removes the plants ability to flower. The attached buds senesce and drop the inflorescence to the ground where adult weevils emerge. The loosestrife flower weevil prevents flowering and reduces seed production. It may not be as effective if release in the same area that contains loosestrife leaf beetles. Because loosestrife leaf beetles defoliate purple loosestrife, it may prevent plants from flowering and consequently limits the ability of the loosestrife flower weevil.

Source: Wilson, L.M., Schwarzlaender, M., Blossey, B., and Randall, CB. 2004. Biology and Biological Control of Purple Loosestrife. Forest Health Technology Enterprise Team Publication FHTET-2004-12.

Appendix IV

California Department of Fish and Wildlife Notice of Intent General NPDES Permit No. CAG990005 and Aquatic Pesticide Application Plan