San Pablo Bay National Wildlife Refuge *Lepidium latifolium* Control Plan

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INTRODUCTION

The San Pablo Bay National Wildlife Refuge (Refuge) is one of seven National Wildlife Refuges located in the San Francisco Bay Area. The refuge lies along the northern border of San Pablo Bay and extends from the mouth of the Petaluma River east to Mare Island (Figure 1). This region contains some of the largest contiguous tracts of undeveloped baylands within the San Francisco Estuary (estuary). The estuary supports a diverse set of native flora and fauna unique among estuaries of the Pacific Coast and provides important stopover and wintering grounds for thousands of migratory shorebirds and waterfowl. A characteristic feature of San Pablo Bay is the presence of large contiguous areas of tidal marsh dominated by pickleweed (*Sarcocornia pacifica*). Pickleweed provides habitat for many species including the state threatened California black rail (*Laterallus jamaicensis*) and the federal and state endangered salt marsh harvest mouse (*Reithrodontomys raviventris*).

Threats to environments of San Pablo Bay include habitat loss, pesticide use, increasing predator populations, urban development, and invasive species. Invasive species are considered one of the leading threats to the refuge and adjacent lands. Likewise, invasive species threaten environments throughout the estuary, from sub-tidal environments to uplands. Invasive plant threats to tidal environments of the estuary include four non-native cordgrass species (*Spartina* spp.) and perennial pepperweed (*Lepidium latifolium*). Invasive Spartina species have invaded tidal marsh throughout much of the southern and central portions of the estuary. Surveys conducted by the Invasive Spartina Project have found only isolated occurrences of *S. anglica* and *S. densiflora* within the San Pablo Bay region since 2002. The primary invasive plant threat to tidal marsh of San Pablo Bay to date is perennial pepperweed. It is unknown when pepperweed invaded marshlands of San Pablo Bay or how rapidly it spreads in this environment.

BACKGROUND

Description and Purpose of the Refuge

The San Pablo Bay National Wildlife Refuge is part of the San Francisco Bay National Wildlife Refuge Complex. The 13,190 acre refuge is located along the northern portion of San Pablo Bay and was established in 1970 to provide habitat for migratory birds and endangered species. Environments of the refuge include tidal marsh, tidal mudflat, sub-tidal open bay, and seasonal freshwater wetland. The Bayland Ecosystem Habitat Goals (Goals Project 1999) call for restoration of tidal wetlands and, where possible, enhancement of riparian vegetation and marsh-upland transitions in this North Bay subregion.

Since it's establishment, the refuge has engaged in planning and implementation of tidal marsh restoration projects to rehabilitate or restore diked baylands that were converted to agricultural use during the late 1800's and early 1900's. Tidal restoration projects are also underway on adjacent lands managed by the California Department of Fish and Game (CDFG) and Sonoma Land Trust (SLT). Projects in the restoration phase include Tolay Creek (USFWS/CDFG), Sonoma Baylands (SLT/State Coastal Conservancy), Tubbs Island Setback (USFWS), and the Napa-Sonoma Marshes Wildlife Area (CDFG). Large-scale projects still in the planning phase include the Sears Point Restoration (SLT) and Cullinan Ranch (USFWS). These projects share a similar goal of reestablishing functional estuarine systems containing native flora and fauna, such as pickleweed (*Salicornia virginica*) and Pacific cordgrass (*Spartina foliosa*). A significant threat to successful tidal marsh restoration is the post-construction colonization and spread of invasive plant species

Special Status Species

Special status species known to occur on the Refuge and immediately adjacent tidal baylands are listed below

Federal or state listed threatened or endangered:

- California clapper rail (*Rallus longirostris obsoletus*)(FE, SE)
- California black rail (*Laterallus jamaicensis*)(ST)
- Salt marsh harvest mouse (*Reithrodontomys raviventris halicoetes*)(FE, SE)
- Delta smelt (*Hypomesus transpacificus*)(FT, ST)

FE = federally endangered, FT= federally threatened, SE = state endangered, ST = state threatened

Other Sensitive Species

- Northern harrier (*Circus cyaneus*) (SSC)
- Salt marsh common yellowthroat (*Geothlypis trichas sinuosa*)(SSC)
- San Pablo song sparrow (*Melospiza melodia samuelis*) (SSC)
- Suisun shrew (*Sorex ornatus sinuosus*) (SSC)
- Sacramento splittail (*Pogonichthys macrolepidotus*)(SSC)
- Masosn’s lilaeopsis (*Lilaeopsis masonii*) (SR)

SSC = State Species of Concern, SR = State Rare

Non-native Invasive Species Threat

According to the National Invasive Species Council, invasive species impact nearly half of the species currently listed as threatened or endangered under the U.S. Federal Endangered Species Act. Executive Order 13112 defines an invasive species as “a species that is non-native (or alien) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health”(1999). The California Invasive Plant Council (Cal-IPC) defines invasive non-native plants as “plants that 1) are not native to, yet can spread into, wildland ecosystems, and that also 2) displace native species, hybridize with native species, alter biological communities, or alter ecosystem processes” (CalIPC 2006).

Nonnative plant species of greatest concern in the estuary include *L. latifolium* (Trumbo 1994, Grossinger *et al*. 1998) and *Spartina alterniflora* (smooth cordgrass) (Strong & Daehler 1995, Grossinger *et al.* 1998). Smooth cordgrass populations have yet to colonize the refuge. *Lepidium latifolium* is of great concern because of its ability to form near monocultures and exclude the native vegetation required by other tidal marsh-dependent species. Areas of active restoration may be at even greater risk of invasion than adjacent intact wetlands since *L. latifolium* recruitment is accelerated by bare ground (Spenst, 2006), potentially affecting several refuge and adjacent restoration projects (e.g., Tolay Creek, Tubbs Island Setback, Guadalcanal Village, and Sonoma Baylands). Recent surveys of *L. latifolium* in San Pablo Bay show that it is found at most tidal marsh restoration sites of San Pablo Bay (Giselle Block, unpublished data). Because of *L. latifolium*'s highly invasive nature, the biological threats it poses to marsh habitat restoration, the structural and chemical threats it poses to marsh soil accretion and salinity, and its potential for control is high (Spenst, 2006), *L. latifolium* is a high-ranking priority for control efforts on the refuge.

Lepidium latifolium is a highly invasive herbaceous perennial in the Brassicaceae family (Figure 2). This Eurasian herb was introduced into the U.S. in the 1930's and is now found throughout the western United States. *Lepidium latifolium* appears to be adapted to conditions of moderate salinity (Spenst 2006), but is not an obligate halophyte. It has been known to grow in freshwater, brackish, saline, and alkaline environments and across a wide range of habitats including riparian areas, wetlands, marshes, meadows and floodplains (Young *et al*. 1995, Bossard *et al*. 2000, Renz & Blank 2004, Howald 2000). The US Bureau of Land Management and 10 western states classify *L. latifolium* as a noxious weed (Chen *et al*. 2005). It is ranked "high" (a composite scoring of ecological impact, invasive potential, and distribution) by the California Invasive Plant Council (2006), and is listed among the Class B noxious weeds by the California Department of Food and Agriculture due to its highly invasive and ubiquitous nature.

Distribution

Lepidium latifolium is found throughout the estuary, with concentrations varying by subregion (Grossinger *et al*. 1998). Its abundance has increased exponentially in the San Francisco Bay area (Grossinger *et al*. 1998, May 1995, Trumbo 1994) since its initial invasion. *Lepidium latifolium* occurred sporadically around the edges of the estuary in the 1950s. May (1995) noted that *L. latifolium* invasion is generally restricted to areas with freshwater input in the southern estuary, and is most abundant in the northern estuary, where salinity levels are lower. A survey (Grossinger *et al*. 1998) found *L. latifolium* in the following areas within the estuary:

<u>North Bay</u>

- Potrero Hills area (especially Rush Ranch), along tidal channels and the upland margin of tidal marshes
- Contra Costa shoreline marshes along natural channels and mosquito control ditches
- Suisun Marsh (especially Grizzly Island Wildlife Area), in high tidal marsh areas and diked seasonal wetlands
- Southampton Bay
- Montezuma Slough

- Mare Island
- San Pablo Bay, in marshes of the northeastern shore
- Tolay Creek, lower reach
- Petaluma River, lower reach marshes
- Petaluma Marsh, along berms, levees and creek banks
- Hamilton Air Field, marsh bordering air field
- Miller Creek

Central Bay

- Strawberry Creek (Berkeley), on the beaches at the creek mouth
- Pt. Pinole
- China Camp
- Arrowhead Marsh (San Leandro Bay), in the higher intertidal marshes
- Hayward area, marshes with restricted tidal influence
- Old Alameda Creek, surrounding areas

South Bay

- Coyote Creek, adjacent marshes
- Warm Springs Marsh, on dikes and in *Salicornia* marsh
- Alviso Slough
- Guadalupe Slough
- Charleston Slough

Ecology

Lepidium latifolium can form complete monocultures and displace native species in riparian and wetland areas, where it is most aggressive (Eiswerth *et al*. 2005, Renz & Blank 2004). Monocultures and the dense thatch they produce can inhibit emergence of annual plants by blocking the penetration of light to the soil surface (Renz 2000). Populations of several rare plants, including soft bird's beak (*Cordylanthus mollis* ssp. *mollis*), Suisun Marsh thistle (*Cirsium hydrophilum* var. *hydrophilum*), and Suisun Marsh aster (*Aster lentus*), are threatened by the invasion of *L. latifolium* into hundreds of acres at Grizzly Island Wildlife Area in the Suisun Marsh (May 1995, Howald 2000). Progressive invasion of *L. latifolium* since 1975 onto the berms, levees, and creek banks of Petaluma Marsh has resulted in the replacement of coyote bush (*Baccharis pilularis*) in these areas (Grossinger *et al*. 1998). *Lepidium latifolium* is found growing in pickleweed (*Salicornia* spp.) dominated plains adjacent to tidal channels in the Alviso Slough area (May 1995). Although *L. latifolium* generally prefers higher elevations than *Salicornia* spp. (May 1995, Kramer *et al*. 1995), marsh accretion over time (as documented by Kramer and others (1995) in a restored tidal marsh) may result in increased habitat suitable for *L. latifolium*.

Spautz and Nur (2004) tested for correlations between *L. latifolium* presence and the presence of other species or marsh habitat characteristics in San Pablo Bay, Suisun Bay, and San Francisco Bay. At San Pablo Bay they found *L. latifolium* growing with *Baccharis pilularis*, which grows on marsh edges or levees. Invasions were positively associated with the presence of *Juncus* and *Scirpus* species. More saline portions of the study area, with populations of *Salicornia virginica*, *Distichlis spicata*, *Frankenia salina*, and *Grindelia stricta*, had fewer *L. latifolium* populations. In all locations, *L. latifolium* populations were associated with areas of high plant species richness and diversity.

Although direct impacts of *L. latifolium* on wildlife have not yet been fully determined, its invasion into *Salicornia* spp. dominated marshes does pose a threat to the habitat of the endangered salt marsh harvest mouse, California black rail, and California clapper rail (Howald 2000). Researchers are concerned that as the invasion progresses, growing populations of *L. latifolium* will exclude grasses and native vegetation which may reduce food resources for wildlife (Howald 2000, Spautz and Nur 2004).

Reproduction & Expansion

Lepidium latifolium reproduces and expands clonally and through abundant seed production. It has been suggested that individual plants can produce up to 8000 seeds per inflorescence per year (Young *et al*. 1997). Miller *et al*. (1986) found 96-100% germination rates for Susanville, Litchfield, and Reno seed sources. Spenst *et al*. (submitted) found 60-100% viability, depending on seed source, one season after seed set from seeds collected in three tidally influenced sites in the San Francisco estuary. Seeds are transported by wind, water, and waterfowl (Howald 2000, Roye *et al*. 2003), and can maintain their viability under field conditions for at least two years, and possibly longer (Spenst, 2006). Blank and Young (2002) report that in a dry lake bed, a single stem develops into a clonally integrated population several meters in diameter within two years, with infestations reaching stem densities of >100 /m^2. The rate of expansion along the leading edge of the infestation rarely exceeds 2 meters per year (Roye *et al*. 2003), but rates of up to 3 meters per year have been recorded in freshwater riparian floodplain infestations (Hogle, unpublished data). Rates of spread have been measured in freshwater areas at 44 – 129% a year over a two-year period, which, if sustained, would result in population doubling in less than ten years (Renz 2002). Although seed production and viability are high, clonal reproduction has previously been believed to be the dominant form of spread due to the infrequent finding of seedlings in the field (Renz 2000). Spenst *et al*. (2004) found that although *L. latifolium* has very high mortality rates in early developmental stages, the prolific rate of seed production readily allows for colonization from seed, particularly in freshwater environments, and model predictions based on experimentally derived life history data indicate that population growth occurs under conditions found at San Pablo Bay NWR (Leininger and Foin. in preparation).

Lepidium latifolium invasion success in estuarine environments is generally associated with lower aqueous salinity levels, higher elevations, sandier soils, and less frequent inundation (May 1995, Grossinger *et al*. 1998). This is supported by recent research findings that seed production rates (Leininger and Foin, submitted), germination (Spenst *et al*. submitted) and recruitment rates (Spenst 2006, Spenst *et al*. 2004) were all highest under freshwater conditions. Dispersal profiles between a tidal freshwater site and a tidal saline site within the San Francisco Delta were not significantly different (Leininger and Foin, in preparation). This suggests that freshwater sites are more susceptible to *L. latifolium* invasion than saline sites because of the greater reproductive potential of freshwater populations. While salinity is an important factor affecting the spread of *Lepidium latifolium*, model predictions, calibrated from field data at San Pablo Bay

NWR suggest that the rate of spread is more strongly influenced by the percent bare ground and amelioration from flooding (Leininger and Foin, in preparation). The rate of spread via root fragmentation is not known. San Pablo Bay NWR is a polyhaline site (terminology from Cowardin *et al*. 1979), so an intermediate invasion response would be expected. San Pablo Bay NWR is also frequently inundated by tidal flooding, which reduces seed set and reproductive potential (Leininger and Foin, submitted). This suggests that the refuge may have some inherent resistance to *Lepidium latifolium* invasion, even though continued expansion is predicted (Leininger and Foin, in preparation). Bare ground opened by wrack deposition or tidal scour enables *L. latifolium* recruitment.

Physical & Chemical Impacts

Lepidium latifolium can impact the physical and chemical characteristics of soils. Infestations facilitate soil erosion along waterways, especially during flooding or other high water events, due to low root densities and easily fragmented roots (Renz 2000). *Lepidium latifolium* has been found to reduce soil compaction within 5 to 10 years of establishment (Roye 2003, Renz and Blank 2004), which can diminish soil retention (Eiswerth *et al*. 2005). Based on seasonal freshwater wetland models, *L. latifolium* may alter soil composition by concentrating salts at the surface (Young *et al*. 1995, Blank and Young 1997, 2002). Dense thatch from old stems, which die back in fall and winter, can last for several seasons and alters carbon/nitrogen ratios of surface soils (Renz 2000, Blank and Young 2002). *Lepidium latifolium* changes the canopy structure and root architecture of invaded areas, particularly when it achieves high densities.

History of Physical Control Methods

Experimental efforts to control *L. latifolium* using physical means have included burning, mowing, disking or tilling, flooding, and manual removal. Multiple studies have shown that burning, mowing, disking, or tilling alone are ineffective at controlling *Lepidium latifolium* (Table 1). All of these methods led to increased or unchanged densities after 1 year (Renz 2002, Howald 2000, Young *et al*. 1998, DiTomaso, personal communication). *Lepidium latifolium* distribution significantly increased following disking at Grizzly Island Wildlife Area (Howald 2000). For this reason physical control methods are not considered viable unless combined with other methods.

Flooding has been successful at controlling *L. latifolium,* but only when plants are inundated for extended periods of time. *Lepidium latifolium* showed reduced growth with prolonged flooding exceeding 50 days during the growing season, but was still able to survive and reproduce in these conditions (Chen *et al*. 2002), while continuous flooding for two growing seasons was successful in eradicating *L. latifolium* (Fredrickson *et al*. 1999). The relationship between flooding and *L. latifolium* abundance may be less constrained in tidal systems where tidal flushing action provides nutrients and oxygen to plants (Mitsch & Gosselink 1993).

Manual removal is difficult due to deep underground root growth of *Lepidium latifolium*, which may reach depths of 3 meters or more (Blank & Young 2002). These roots are easily fragmented, tolerate desiccation (Renz 2000), and can regenerate from fragments as short as 2.5 cm (Wotring *et al*. 1997). Hogle (unpublished data) has shown that hand pulling of isolated groups of 1-5 individual stems was approximately 50% effective one year later. Don Edwards San Francisco Bay National Wildlife Refuge started hand pulling *Lepidium latifolium* in 1997 (Grossinger *et al*. 1998), but results are unknown. Efforts to remove large *Lepidium latifolium* infestations by hand pulling and covering with cardboard are underway in Sebastopol, California, with results pending (Anna Sears, personal communication). Physical control methods are summarized in Table 1.

Physical control has not been documented as providing satisfactory control of *Lepidium latifolium* in any estuarine environments. Results of manual removal have been reported only in terrestrial and/or freshwater environments. As noted in Table 1, the only successful physical control of *L. latifolium* was though continuous inundation for 2 growing seasons. In tidal environments, continuous inundation is not an option. Anecdotally, hand pulling of *L. latifolium* is not effective due to the incredible amount of labor and the heavy soil disturbance required to remove both above and below-ground vegetation (which, as mentioned earlier, can reach >3 meters deep). All other attempts at manual control were either ineffective or results have not yet been determined.

History of Chemical Control Efforts

Studies using herbicides to control *L. latifolium* include the use of chlorsulfuron, glyphosate, tryclopyr, metsulfuron methyl, imazapyr, and 2, 4-D (Trumbo 1994, Young *et al*. 1998, Renz 2000, Renz 2002, Spenst 2006).

In nonaquatic systems, imazapyr, chlorsulfuron and metsulfuron methyl provide the best long-term control of *L. latifolium*. Renz (2002) tested chlorsulfuron, glyphosate, tryclopyr and 2, 4-D for control of *Lepidium latifolium*, and concluded that of all herbicides tested, "chlorsulfuron at 1.5 oz/A (0.052 kg/ha) (Telar® at 2 oz/A with 0.1% silicone based or 0.25% nonionic surfactant) provided the best long-term control". Cox (1997) reported near 100% control from metsulfuron methyl in Idaho. Chlorsulfuron and metsulfuron belong to the same family of sulfonylurea herbicides, have relatively long soil residence times, and are not registered for aquatic use. Cox (1997) found that the terrestrial formulation of imazapyr (Arsenal®) was nearly 100% effective in control of *L. latifolium* after 3 and 4 years, respectively, at two different Idaho sites.

Studies of chemical control methods in freshwater environments show that timing, method, and amount of herbicide needed for control may vary with the density and size of the stand. In seasonal, freshwater flood plain environments, application of either glyphosate or 2,4 D resulted in an 88% reduction in *L. latifolium* cover in low density stands (Renz 2002). In high density stands (>85% *L. latifolium* cover), a mowing pre-treatment and higher application rates (3.33 ai/ha) were required to achieve moderate control (80% biomass reduction) using glyphosate. When using chlorsulfuron at low or high rates (0.052 or 0.104 ai/ha), effective control was achieved with or without mowing (>99%) (Renz 2002). Chemical control methods are summarized in Table 2.

Recent studies in tidal/brackish systems have found that repeated application of glyphosate-based herbicides can reduce but not necessarily eliminate populations of *Lepidium latifolium* (Spenst, 2006). Until recently, aquatic formulations of glyphosate were the only herbicides registered for estuarine use. As discussed below, an aquatic formulation of imazapyr is now available for estuarine use and may prove effective in the control of *L. latifolium* in tidal/brackish environments.

SITE ASSESSMENT AND PATCH PRIORITIZATION

Site Assessment

Since *L. latifolium* is widespread throughout the refuge, all known populations of the refuge may not be treatable within a short time frame (e.g., 1-year) simply due to logistical problems related to available manpower, accessibility, and budget constraints. To acquire the greatest return in treatment dollars, it is logical to select treatment sites with the greatest potential for success, and the greatest overall impact. To accomplish this, the *L. latifolium* patches on the refuge are being mapped across the refuge using a global positioning system (GPS) and the Weed Information Mapping System (WIMS). Refuge staff trained volunteers to use the WIMS system and to identify *L. latifolium* in the field. Between 2005 and 2006 the refuge team mapped all patches of *L. latifolium* in tidal environments from the mouth of the Petaluma River east to Sonoma Creek (Figures 3-7). Refuge lands east of Sonoma Creek will be mapped in 2007. Data collected for each patch included parameters such as location, size, density, and landform of where the patch is located (i.e. levee, roadside, stream edge, etc.). The WIMS data was then input into a geographic information system (GIS) along with preexisting GIS layers such as refuge boundaries, streams, roads, and levees. Using GIS, the data was queried to examine patterns of *L. latifolium* distribution and develop treatment prioritization criteria. The prioritization criteria will help identify where control efforts are a priority when resources are limiting and all patches cannot be treated within a given year. Results of recent mapping efforts are summarized in Table 3. This data provided the information necessary to prioritize the patches at San Pablo Bay NWR, and thereby maximize the efficacy and efficiency of *L. latifolium* control efforts.

Patch Evaluation

Lepidium latifolium is frequently associated with areas of disturbance. Disturbance areas include roads, levees, streams or channels, and areas of tidal deposition (wrack line). *Lepidium latifolium* is infrequently seen colonizing open and intact mud flats, presumably due to anoxia and salinity stresses. Likewise, *Lepidium latifolium* is rarely seen colonizing undisturbed marshlands suggesting that high native vegetation cover can suppress or slow potential *L. latifolium* invasion if left intact. Areas of the marsh that are disturbed by the rising and falling of the tides and associated wrack deposition include channels, levees and the low marsh-high marsh interface (San Pablo Bay). These areas accounted for greater than 83% of total gross acres mapped in 2005 and 2006. Due to the tidal action present at San Pablo Bay NWR, native vegetation is frequently disturbed both through tidal channel scouring and deposition of entrained material during high tide events, opening this area to invasion. Tidal marsh restoration sites also provide opportunities for spread of *L. latifolium*, especially along site perimeters where tidal deposition takes place and soils contain higher proportions of sand. All tidal restoration sites of San Pablo Bay have been colonized by *L. latifolium* including Tolay Creek, Guadalcanal, Tubbs Island Setback, Sonoma Baylands.

Lepidium latifolium tends to spread out from existing populations. Colonizing plants act propagule sources for further invasion. Since *Lepidium latifolium* seeds have no specialized adaptations to aid in long distance wind dispersal, the majority of seeds fall within 5 meters of the parent plant (Leininger & Foin, submitted). Long distance dispersal of *Lepidium latifolium* propagules may be facilitated by people (e.g., machinery), wildlife, or water. Seed or root fragments are also carried by water. *Lepidium latifolium* also spreads rapidly along roadways and levees due both to high disturbance rates at these sites as well as the source of human and wildlife vectors present. Populations arising from long distance dispersal events may then form satellite populations that, which may greatly increase the rate of spread. When prioritizing control of *L. latifolium* patches it is important to consider patch location in relation to these vector sources.

Patch Prioritization

The prioritization of *L. latifolium* patches is presented here as a guide which can be applied as needed. During some years, resources may be limited and all patches within a defined area cannot be treated. In these cases we will identify which patches should receive priority for treatment. A range of risk factors were developed to assign priorities. These factors and methods of prioritization are discussed below.

The current distribution of *Lepidium latifolium* patches at San Pablo Bay NWR encompasses a multitude of habitat types and site conditions. Using GPS units and WIMS, 513 unique *Lepidium latifolium* weed occurrences were assessed in the field in during 2005 and 2006. Each occurrence was identified by a unique weed occurrence key. The first step in prioritizing patches consisted of grouping nearby occurrences into treatment patches. Weed occurrences were grouped together by combining all occurrences within 10 meters of each other into treatment patches using a 10 meter buffer calculated in a GIS. This exercise resulted in 251 distinct treatment patches (Figure 8).

Treatment patches were assigned priority codes based on their location and spatial relationship to one another. Prioritization was accomplished by iterative sorting of a spreadsheet containing the treatment patch identification number and associated data including number of patches within 40 meters, distance to road or drivable levee, distance to stream or channel, environment (WIMS "main distribution" descriptor), and restoration site.

Of the 251 treatment patches, 93 of the patches were located within restoration sites (Tolay Creek, Sonoma Baylands, and Tubbs Setback). These 93 patches were assigned the highest priority for treatment because of the effort already invested in the rehabilitation of these areas, and due to their high invasion potential (high incidence of bare ground at the restoration areas favors *L. latifolium* recruitment more so than adjacent intact marsh). This was accomplished by creating a subset of the treatment patches occurring within restoration sites and sorting these independently from the rest of the treatment patches using the methods described below.

Treatment patches were first prioritized for potential invasion risk based on their distance to nearest patch. If a patch is isolated, it has a high potential to act as a new invasion locus. By eliminating these outlying patches (also known as satellites), we hope to minimize invasion potential, herbicide use, and labor costs before these outlying patches become larger and more systemic problems. We considered patches to be isolated if they were greater than 40 meters from the nearest adjacent *Lepidium latifolium* patch. Based on this prioritization, all isolated patches would be treated, starting with the small patches, followed by larger patches.

Patches near roads and levees are the second priority because they are often heavily disturbed, which makes them more susceptible to *Lepidium latifolium* invasion. They are also targeted because of their proximity to human and wildlife dispersal vectors, which can greatly increase the rate of spread of *Lepidium latifolium*. From a logistical perspective spray crews can easily reach these areas with minimal effort. All patches within 10 meters of the roads and levees will be treated. When treating these patches the entire patch will be treated even if portions of the patch are further than 10 meters from the road or levee. Patches near roads and levees are prioritized based on their distance from the refuge entrance at Highway 47. This is done because, due to the orientation of the roads in the refuge, offsite seed sources dispersed via roadways will enter primarily from this boundary.

Patch prioritization is then focused along streams and channels, giving greatest priority to *L. latifolium* patches within 10 meters of the stream or channel edges. Like roads, streams are areas of natural disturbance, and a stream or channel may act as a vector by facilitating long distance dispersal. Special care is necessary for the treatment of channel edge patches to ensure sufficient drying time of the herbicide. Spray crews should consult a tide chart to coordinate spraying times with ebbing tide events (see Recommended Control Options).

Since *L. latifolium* tends to favor drier soil conditions and has greater reproductive potential under drier conditions, all remaining patches are assessed based on their relative height in the marshland. Ideally this would be accomplished by using elevation to prioritize data. Unfortunately the elevation data set was incomplete and extrapolation via GIS would have had poor precision. Therefore the WIMS "main distribution" descriptor was used to prioritize the patches (e.g., road, levee, channel). *Lepidium latifolium* can readily invade disturbed areas, and prefers drier soils. Therefore, priority was given to all "road" patches and was followed in descending order by "levee", "tidal marsh", "channel", "wrack line", and "open water". Again, special care should be taken so that treatment will correspond with an ebbing tide to allow for adequate drying time.

The resulting patch prioritization (APPENDIX I) provides a guideline for treating *L. latifolium* to achieve the greatest benefit from each treatment dollar when resources are limiting. This prioritization is intended as a guideline. Often field conditions are variable and unforeseen circumstances require flexibility and adaptation. Implementation of these guidelines with consideration of site and condition-specific constraints will further serve to increase treatment efficacy and efficiency. The patch prioritization is stored as a GIS shapefile within the refuge GIS database for invasives.

Following control of all known *L. latifolium* populations, monitoring and control of new infestations will be an ongoing stewardship activity. Potential sources of new propagules include off-site sources dispersing along Tolay Creek and associated channels, waterborne influx from San Pablo Bay, human dispersal along roads within the refuge, and windborne dispersal from adjacent properties. Since these sources will continue to be a source of seed influx until the neighboring populations are eradicated, infestations from these sources will require continued maintenance and monitoring. If new satellite patches are detected, they should be treated as quickly as possible and should take precedence over all other patches. Areas requiring particular attention are roadsides, stream edges, wrack lines, restoration sites, and refuge boundaries.

At San Pablo Bay NWR, some *Lepidium latifolium* patches may exist in sensitive wildlife habitat. Due to endangered species concerns these patches will not be treated unless treatment is permitted under the Endangered Species Act. Likewise, treatment methods and staff should be trained to minimize their marsh impact as well as to identify signs of endangered species. If unknown populations of endangered species are located, actions will be taken in accordance with the appropriate Fish and Wildlife Service permit.

CONTROL OPTIONS AND MANAGEMENT PLAN

Control Options for San Pablo Bay NWR

Annual herbicide treatment of *L. latifolium* populations at San Pablo Bay NWR is recommend based on the efficacy shown during recent studies in the estuary. Spenst (2006) tested multi-treatment glyphosate efficacy and native species recovery at tidal oligohaline, polyhaline, and euhaline sites. Of the three sites, both efficacy and native recovery were highest at the refuge, attributable to its greater flooding depth and larger native propagule pool. Spenst (2006) found that in the growing season following two subsequent annual glyphosate treatments, *L. latifolium* cover was reduced, but native cover in treated plots resembled pre-treatment cover values, and the remainder of the plot was bare ground following *L. latifolium* removal. The opened sites were not pre-empted by other invasive species at the refuge, suggesting that native species would be able to recolonize the sites. Native recovery would be benefited by selective herbicide application where possible, specifically targeting *L. latifolium* and other invasive plant species. These results indicate that the refuge offers ideal conditions for *L. latifolium* control. In addition, revegetation requirements will be minimized in comparison to other sites. Although mowing has been shown to increase herbicide efficacy (Renz 2002), tidal marshes present a unique challenge for *L. latifolium* removal because mowing is not always practical or desirable due to difficult terrain and endangered species concerns. Spenst (2006) found that label rate glyphosate applied with R11 surfactant, and Prospreader spreader sticker was effective at reducing average *L. latifolium* cover in high density plots (~82% cover) to less than 3% cover within the refuge when treated once per year for two consecutive years. While glyphosate treatment resulted in an eight-fold reduction of *L. latifolium* cover in high density stands (Spenst 2006), this level of control would necessitate continued treatment of the infested areas. This finding is consistent with the results of other studies (Cox 1997, Howald 2000). Although glyphosate is non-selective and can damage any vegetation that it contacts during application, careful application of glyphosate to target plant foliage via hand application with booms or backpack sprayers can reduce impacts on adjacent, desirable vegetation.

The herbicide Habitat® (active ingredient imazapyr) was recently registered for aquatic use in California and may hold promise for control of *L. latifolium* (Renz 2000, DiTomaso, personal communication). Imazapyr is a non-selective, slow-acting herbicide, which can take several weeks before results are visible (Leson & Associates 2005). The aquatic formulation, Habitat®, is purportedly the same formulation as Arsenal®, but without any surfactants (Leson & Associates 2005). Habitat® applications at very low concentration rates have resulted in successful control in estuarine conditions, and are currently being used to control of *Spartina alterniflora* in the Estuary (Leson & Associates 2005).

Imazapyr has several biological and practical advantages over glyphosate in an estuarine environment. Imazapyr has a faster drying time (at least 1 hour) than glyphosate (at least 6 hours), and remains active until adsorbed by the plant or washed off, whereas glyphosate readily adsorbs to soil particles and thus becomes inactive on “dirty” plants (Leson & Associates 2005). Imazapyr is effective at much lower spray volumes than glyphosate, thus increasing the efficiency of application by reducing the number of tank refills necessary during treatment. Finally, imazapyr treatments have been shown to be more cost-effective than glyphosate treatments in estuarine environments (Leson & Associates 2005).

Imazapyr appears to have a positive synergistic effect when used in combination with glyphosate (DiTomaso, personal communication). For example, salt cedar (*Tamarix* spp.) has been successfully controlled using a mixture of 0.6% imazapyr and 0.6% glyphosate plus 0.25% nonionic surfactant (McDaniel & Taylor 1999). Mixing these herbicides would combine the advantage of visible “brown-down” of vegetation within 7 days from the fast-acting glyphosate with the advantages of imazapyr discussed above (Leson & Associates 2005). The Invasive Spartina Project (ISP) proposed use of tank-mixed combinations of imazapyr and glyphosate for the treatment of *S. alterniflora*, varying concentrations of each herbicide depending on site conditions (Leson & Associates 2005). In 2005 and 2006, however, all imazapyr treatment in the estuary was done using Habitat® alone. The apparent success of imazapyr in controlling *L. latifolium* in terrestrial areas (Cox 1997), and its effectiveness in controlling *S. alterniflora* in the San Francisco Estuary, warrants testing the efficacy of Habitat® for *L. latifolium* control in California’s tidal wetlands. If successful, imazapyr may reduce or negate the need for frequent retreatment of *L. latifolium* and would significantly reduce impacts associated with treatment (e.g., disturbance).

Recommended Control Options

Herbicide applications should take place when *L. latifolium* is actively growing and has reached the late bud-to-flower stage of growth, typically occurring April to May. This promotes translocation and also allows for easy detection and identification of target plants. Where practicable, application should be timed to coincide with ebbing tides to protect non-target vegetation, to allow a minimum of 6 hours dry time for glyphosate/imazapyr mixture applications, and at least 1 hour dry time for imazapyr applications. Cool, cloudy weather and low temperatures may require increased drying times, and may reduce herbicide treatment effectiveness (BASF 2004). Allow at least 7 days after herbicide application before disturbing vegetation (BASF 2004).

Herbicide will be applied only to areas where *Lepidium latifolium* is known to exist. Application rates will be set at 2 pints Habitat® per acre per year. If follow up application is required, rates will not exceed the maximum label rate of 6 pints Habitat® per acre (1.5 lb. ai (imazapyr) per acre) per year. All treated areas accessible to the public will be posted with signs to keep visitors away from treated areas for 7 days after herbicide treatment. All herbicide application will be carried out during calm wind conditions to prevent drift and unintended spray to non-target species. Herbicide may be applied by either spray (as described below), spot spray, or wicking for small patches. Wicking applications must use the same application rate as described below, and may be preferred, where practical to implement, due to the increased ability for selective application to target plants.

Glyphosate/Imazapyr Mixture Application Guidelines

For wick applicators (i.e. Ben Meadows "Side Swipe") and high-volume hand-held sprayers, such as backpack sprayers, apply a tank-mixed solution of 1.5 gallons (1 1/2%) of Rodeo® plus 2 pints (0.25%) Habitat® per 100 gallons of spray solution. Mix with clean freshwater. Add 1 quart methylated seed oil surfactant (Competitor®) or nonionic surfactant (Liberate® or Cygnet Plus®) per 100 gallons of spray solution. Foam reducing agents, colorants, or dyes may be used at the recommended label rate at the pesticide applicator's discretion.

Equipment should be calibrated to deliver up to, but not more than, 100 gallons of spray solution per acre. Uniformly cover and penetrate the plant's foliage. Apply on a spray-to-wet basis. Do not spray to the point of runoff. Care should be taken to avoid spray or drift onto nontarget species.

When using a broadcast sprayer (e.g. boom sprayer), apply a tank-mixed solution of 3 pints (1 1/2%) Rodeo® plus 2 pints (5%) Habitat® per 25 gallons of spray solution. Add 1 quart methylated seed oil surfactant (Competitor®) or nonionic surfactant (Liberate® or Cygnet Plus®) per 25 gallons of spray solution. Foam reducing agents, colorants or dyes may be used at the recommended label rate per the pesticide applicator's discretion. The higher Habitat® concentration is based on a lower per acre application rate. A mixing chart is provided in APPENDIX II.

Calibrate broadcast equipment to deliver a spray volume of 10 - 25 gallons of water/acre, using greater spray volumes (within this recommended range) to ensure coverage of areas with greater *L. latifolium* density. For best results, apply on a spray-to-wet basis using flat fan nozzles, and ensure large, even droplet size (no fine mist).

Imazapyr Application Guidelines

For wick applicators and high-volume hand-held sprayers, apply a tank-mixed solution of 2 pints (0.25%) Habitat® per 100 gallons of spray solution using fresh or brackish water. Add 1 quart methylated seed oil surfactant (Competitor®) or nonionic surfactant (Liberate® or Cygnet Plus®) per 100 gallons of spray solution. Foam reducing agents, colorants or dyes may be used at the recommended label rate per the pesticide applicator's discretion. A mixing chart is provided in APPENDIX II.

Calibrate hand-held spray equipment to deliver up to, but not more than, 100 gallons of spray solution per acre. Uniformly cover and penetrate the plant's foliage, adjusting volume of spray as necessary (not to exceed 100 gallons/acre) to ensure coverage in high density *L. latifolium* patches. Apply on a spray-to-wet basis; do not spray to the point of runoff.

When using a broadcast sprayer (e.g. boom sprayer), apply a tank-mixed solution of 2 pints (1%) Habitat® per 10 gallons of spray solution. Add 1.5 cups methylated seed oil surfactant (Competitor®) or nonionic surfactant (Liberate® or Cygnet Plus®) per 10 gallons of spray solution (3-4 qt/100 gal). Foam reducing agents, colorants or dyes may be used at the recommended label rate per the pesticide applicator's discretion.

Calibrate broadcast equipment to deliver a spray volume of 5 - 10 gallons of water/acre, using greater spray volumes (within this recommended range) to ensure coverage of areas with greater *L. latifolium* density. Apply on a spray-to-wet basis using flat fan nozzles, as recommended on the Habitat specimen label, or replace regular boom nozzles with "air-induction drop tips" made form stainless steel, as suggested by Leson & Associates (2005).

Adaptive Management Experimental Area

An adaptive management experimental area was developed where we will test the relative efficacy of the herbicides Habitat® (active ingredient imazapyr) and the glyphosate/imazapyr cocktail compared to the results of glyphosate treatments (Spenst 2006) and inflorescence removal (untreated "control" plots). The results of this experiment will be used to adjust the control plan, thereby implementing the most effective treatment method within each environment in which *L. latifolium* is found.

The adaptive management area boundary was selected to encompass lower Tolay Creek, where *L. latifolium occurs* in a diversity of environments (wrackline, channel, and levee). All *L. latifolium* within this adaptive management area boundary will be treated by one of three methods:

- Imazapyr only
- Imazapyr/glyphosate mix
- Inflorescence removal

Inflorescence removal is being used as an experimental control (a surrogate for "no treatment") to determine herbicide treatment efficacy compared to no treatment. All inflorescences in these plots will be removed prior to seed set to prevent dispersal and continued spread. Control plots will be flagged and monitored throughout the growing season to ensure that no new inflorescences develop.

The number of replicates for our experimental design was based on a statistical power analysis used to determine the sample size needed to detect a 20% difference in means between the three treatment methods with 95% confidence (alpha = 0.05). We used unpublished data from the Cosumnes River Preserve Perennial Pepperweed Control Experiment (2007) to estimate standard error in stem reductions per treatment type for broadcast herbicide treatment as ranging from 0.065 to 0.1. Applying these parameters, a total sample size of 12 (i.e. 4 replicates of 3 treatments) was estimated to have a 90-99% power to detect a 20% difference in means between three samples.

The location and treatment assigned to monitoring plots within the experimental area was designed using stratified random sampling in a GIS. All *L. latifolium* patches within the experimental area were identified from the 2005 inventory data. Polygons representing patch boundaries were merged by matching environment attribute (wrackline, channel and levee) to create the stratification for the experimental design. Hawth's Analysis Tools (Beyer 2004) were used to select 12 random points, with at least 10 meters of distance between each point, within each of the three environment types. Random sorting of these 12 points was used to allocate 4 replicates each of 3 treatment methods within each of the three environment types (Table 3, Appendix II).

The authors will establish permanent 1 x 1 meter monitoring plots at each of these 12 random points within each of the 3 environmental types in the experimental area. GPS units will be used to navigate to the random points. If the point is inappropriate when located in the field (inaccessible for monitoring or no longer contains *L. latifolium,* the authors will relocate the plot to the next closest patch of *L. latifolium*. In the event that adjacent patches are of equivalent distance, a random number table will be used to select the direction of the alternative patch location. Once located, plots will be identified with both GPS coordinates and PVC markers for ease of relocation.

PVC markers will be placed in opposing corners of the inner $1m^2$ quadrat in order to establish a permanent sampling location. Prior to treatment, visual estimates of *L. latifolium* percent cover and counts of stem number will be measured within the permanent quadrats.

All *L. latifolium* within the plot and in a surrounding buffer of at least 1.5 meters will be treated using the methods randomly assigned to each plot. The authors will use appropriate markers (temporary flagging or PVC markers) to indicate the boundaries of the treatment areas to ensure the appropriate treatment is applied to each plot and surrounding *L. latifolium* patch.

Post treatment monitoring will occur two months following treatment, prior to *L. latifolium* senescence, and again one year later. Two months after treatment, a visual assessment of treatment plots will be made to qualitatively assess herbicide impact. Parameters to be recorded will be determined based on visual assessment, and may include percent cover of *L. latifolium* in various states including live, dead, yellowing, stunted, etc. Post treatment monitoring one year after treatment will include both visual estimates of *L. latifolium* percent cover and counts of stem number within the permanent quadrats to allow a quantitative analysis of treatment efficacy.

Post treatment monitoring will also be conducted outside the experimental area. All treated patches will be randomly sampled and *L. latifolium* cover will be recorded one year following treatment. Clapper rail breeding areas will be excluded from sampling.

Management Area

Outside of the experimental area, we recommend using the herbicide Habitat® (active ingredient imazapyr) on all *L. latifolium* patches.

<u>Uplands</u>
When plants reach the bud to flowering stage, usually in April-May, dense infestations along the levee tops and roads will either be treated immediately or mowed prior to treatment. Immediate spraying is preferred if effective. If found after one year to be ineffective, initial mowing should be considered. If immediate spraying is found to be ineffective in year one, plants will be mowed at flowerbud stage to a 2 to 5 cm height from the soil surface, then allowed to regrow with a more dense architecture to increase leaf surface area (thus promoting herbicide uptake). Mowing along the road can be accomplished using existing refuge methods. To prevent the spread of invasive plants, the refuge will implement protocols for cleaning mowing equipment before transferring machinery to other work areas. Herbicide treatment should occur within three months after mowing. Herbicide should be applied when the mowed plants reach bud stage after regrowth. Previous research indicates that some stems may bolt and reach the bud stage while others may remain in the rosette stage for the rest of the season (Renz and DiTomaso, 2006). If plants do not reach bud stage, they may be sprayed at the vegetative stage.

In low-density populations or where mowing is impractical, herbicide can be applied directly to plants at the bud stage of development without prior mowing. Treatments should be carried out when no rain is predicted for several days, to allow for adequate drying times. Wicking or a boom sprayer can be used to treat populations along roads. A backpack sprayer or wicking can be used on less accessible populations.

Patches should be monitored no more than 2 months after initial application, and all individual plants which did not die from the first application should be spot sprayed.

Wetlands

Wetland areas are not conducive to mowing treatments. Therefore, all areas below the high water mark will be treated as above, but without mowing prior to treatment. As in uplands environments, all non-experimental patches will be treated with imazapyr alone. Wicking or a boom sprayer can be used to treat populations along roads. A backpack sprayer or wicking can be used on less accessible and/or smaller populations. Herbicide applications should be timed to allow maximum time before the next high tide, and should be conducted when no rain is predicted for at least 1 day. Treated areas should be informally monitored no more than 2 months after initial application, and all surviving individuals should be spot sprayed.

Herbicide Safety & Environmental Considerations

Conservation measures to reduce adverse effects of herbicides on estuarine wildlife, plants and associated habitat elements (e.g., native vegetation, water, invertebrates) are presented below.

Marsh Access: treatment, monitoring, re-vegetation

1) Vehicle and foot access pathways to *L. latifolium* through tidal marsh will be minimized and use of existing roads and trails for control work will be maximized. Shortest possible access paths through the marsh to treatment patches will be identified prior to marsh access. Control methods to be used in each area will be selected to minimize potential impacts to marsh habitat and listed species from control operations.

2) If breeding CA clapper rails are determined to be present in a marsh, marsh access using aquatic-tracked vehicles (ARGOS) will not be allowed in contiguous marsh areas within 700-ft (213-m) of an identified clapper rail calling center (also referred to as the "700-ft Buffer Area") to avoid nest destruction, nest abandonment, and harassment of breeding rails. If the intervening distance across a major slough channel or across a substantial physical barrier between the rail calling center and the proposed access area is greater than 200-ft (61-m), then access may proceed within the breeding season.

3) Aquatic-tracked vehicles (ARGOS) will not travel within 50-ft (15-m) of slough channels to avoid crushing high vegetation, such as gumplant, that grows along channels.

4) Boats will be used to access marsh areas (where feasible) to treat large areas of *L. latifolium* along slough edges (e.g., use of intelli-sprayer with 300-ft hoseline) to further reduce the necessity of walking long distances through the marsh.

5) Crews will be instructed to walk carefully through the marsh, avoiding high pickleweed cover (e.g., >1-ft) and wrack where salt marsh harvest mice are likely to nest or find cover.

6) All personnel entering the marsh will be trained to identify and avoid direct and indirect disturbance to endangered species and associated habitats. Training material will include

taped recordings of rail calls and the “Walking in the Marsh” protocol which addresses potential disturbance effects to rails and SMHM (Appendix II).

7) Before spray operations commence each year, a qualified clapper rail biologist familiar with the project area will familiarize the spray crew with the area and ensure that all crew members know the location of each “700-ft Buffer Area” for protection of nesting clapper rails. Crews will be instructed to avoid these areas unless accompanied by a qualified clapper rail biologist.

8) During the clapper rail breeding season, before crews are allowed to enter a clapper rail “700-ft Buffer Area” to conduct control work, the Refuge Biologist, or designee, will work with other qualified clapper rail biologists and the spray crew to develop a strategy for control that will minimize the amount of time the crew spends in each “700-ft Buffer Area” while conducting control. This planning session will include use of detailed maps showing *L. latifolium* locations within each “700 Buffer Area”.

9) During the clapper rail breeding season, a qualified clapper rail biologist such as a Refuge Biologist, will accompany spray crews into “700-ft Buffer Areas” and will supervise and guide control operations within these areas.

10) Crews will limit time within a clapper rail (CLRA) nesting area (call center + 700-ft buffer) to 30 minutes or less to minimize disturbance to adult rails and to avoid potential nest destruction or nest abandonment.

11) If clapper rail nests are encountered during control work, observers will immediately leave the vicinity of the nest and report findings to the refuge biologist.

12) If clapper rail adults are encountered during control work, observers will move away from the birds if they are giving alarm calls or otherwise appear agitated.

Herbicide Application/Treatments

13) Herbicides will be applied by a certified applicator and in accordance with application guidelines and the manufacturer label.

14) Herbicide applications would be timed to coincide with ebbing tides to protect non-target vegetation, to allow a minimum of 6 hours dry time for glyphosate/imazapyr mixture applications, and at least 1 hour dry time for imazapyr applications.

15) Herbicides will be applied directly to *L. latifolium* plants and at low or receding tide to minimize the potential application of herbicide directly on the water surface.

16) The Refuge will train all certified applicators to correctly identify *L. latifolium* and distinguish this species from native species in the action area.

17) Certified applicators will be provided with GPS units and detailed maps showing specific locations where treatments will occur.

18) Field-based mixing and filling operations shall be confined to areas appropriately leveed/bermed or otherwise protected to minimize spread or dispersion of spilled herbicide or surfactants into surface waters.

19) *Lepidium latifolium* patches will be accessed for treatment only one time per year (2007 and 2008).

Revegetation

20) Native plants will be restored (>3,000 plants annually) within the marsh-upland transition zone of the action area. Plantings will be focused in areas where *L. latifolium* removal has occurred. Seeds will be collected from native populations within 15 miles of the Refuge.

21) Revegetation activities along the marsh-upland transition zone will be supervised by the Refuge biologist or Refuge representative to assure that access into the marsh is prohibited. Supervision will include on-site presence during restoration activities.

22) Revegetation activities will occur during low tides (<4.5-ft NGVD).

23) Revegetation activities will occur during October and November, outside of the clapper rail nesting season.

24) When digging holes for planting, impacts to existing native vegetation should be minimized.

Monitoring

25) Monitoring of patches within clapper rail buffer areas (700-ft from call center) will be avoided during the CA clapper rail nesting season.

26) Persons conducting post-treatment monitoring will be trained to identify and avoid direct and indirect disturbance to endangered species. Training material will include taped recordings of rail calls and the "Walking In the Marsh" protocol (Appendix II).

27) If clapper rail or salt marsh harvest mouse nests or adults are encountered during monitoring, observers will immediately leave the vicinity and report findings to the Refuge biologist.

Revegetation Efforts

The refuge will revegetate treated areas along the transition zone, where marsh meets upland. Natural colonization by native halophytic plants is expected to occur naturally within the intertidal zone. Monitoring of treated plots will identify when intertidal plots are colonized and by which species. Stock for transition zone plantings was collected within 15 miles of the refuge and was propagated on refuge lands. Production and maintenance of plant stock is currently underway at the refuge. Local volunteers and community outreach programs will assist in the revegetation and planting efforts. Plantings should be focused into the most disturbed areas to help facilitate recolonization by native species.

MONITORING AND ADAPTIVE MANAGEMENT

The Refuge will report on their treatment efforts to allow correlation of methods with treatment success and to track pesticide use on the Refuge (e.g., pesticide use reports). Using GPS and/or marking up maps in the field at the time of application, applicators will indicate the location and extent of treated areas, and the type, spray rate and volume of herbicide, surfactant and colorants applied at each location. Applicators will also indicate the type of equipment used, including nozzle type. Reporting will be required within 30 days of both initial and 3-4 week follow-up treatment events. The information provided will be added to a GIS, allowing for the testing of correlations between methods and treatment success using both spatial and conventional statistical techniques.

The relative success of the herbicide treatments will be evaluated for efficacy at 2 months post treatment and at one year post treatment. Patch information (patch size, % cover of all vegetation, and stem counts of *L. latifolium*) will be recorded at all experimental plots using a GPS unit equipped with the Weed Information Management System (WIMS) data dictionary.

Efficacy data will be analyzed and results will be used to inform future management actions. Reduction in *L. latifolium* stem counts and impact on non-target vegetation cover will be compared for imazapyr only, imazapyr/glyphosate, and inflorescence removal treatments. Experimental results will also be compared to glyphosate efficacy, which has already been tested within the refuge (Spenst 2006). The treatment found to be most effective in reducing *L. latifolium* stem density and causing minimal collateral damage to surrounding vegetation will be used in subsequent years.

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Table 1. Effects of non-chemical control methods on *Lepidium latifolium*.

Method	**Effect on *Lepidium latifolium* (terrestrial or freshwater environment)**
Biological Control	Not attempted (Howald 2000)
Burning	None (Howald 2000)
Disking/Tilling	Increased cover to 100% (Howald 2000)
Hand Pulling	Not yet determined (Sears, personal communication)
Inundation	Successful if inundated for 2 growing seasons (Fredrickson *et al*. 1999)
Mowing	None (Renz 2002)
Tarping	Not yet determined (Hogle, Viers, Hutchinson & Waegell, unpublished data)

Table 2[a]. Herbicides used to control *Lepidium latifolium*.

Aquatic Herbicide	**Active Ingredient**	**Trade Name[b]**	**Test Location**	**Lepidium Control**	**Duration**	**Source**
No	Chlorsulfuron	Telar	seasonal wetlands riparian areas Grizzly Island, Lassen Co., CA	74-100% ~100% >95% 100%	- - - after 3 yrs	Renz 2002 Cox 1997 Howald 2000 Howald 2000
No	Glyphosate	Roundup	Grizzly Island	Good	After 1 yr	Howald 2000
No	Imazapyr	Arsenal	riparian areas, Idaho	~100%	After 4 yrs	Cox 1997
No	Metsulfuron methyl	Escort	riparian areas	~100%	After 2 yrs	Cox 1997
No	Tryclopyr	Garlon 4	Grizzly Island	Good	-	Trumbo 1997
No	Glyphosate + Metsulfuron methyl	Weedmaster + Escort	Idaho	100%	After 1 mo.	Cox 1997
Yes	2,4-D	Weedar 64	seasonal wetlands, Lassen Co., CA Lassen Co., CA	Inconsistent Good 0%	- after 1 yr after 2 yrs	Renz 2002 Howald 2000 Howald 2000
Yes	Glyphosate	Rodeo, Aquamaster	seasonal wetlands Lassen Co., CA Lassen Co., CA Grizzly Island	Inconsistent Good 0% good	- after 1 yr after 2 yrs after 1yr	Renz 2002 Howald 2000 Howald 2000 Howald 2000
Yes	Imazapyr	Habitat		Not tested		
Yes	Tryclopyr	Garlon 3a	Grizzly Island	good	-	Trumbo 1994

a. Adapted from Siemering *et al*. 2005
b. Not exhaustive of all possible trademark formulations.

Table 3. Upland and wetland weed occurrences in the San Pablo Bay NWR.

Environment	Number of Patches	Gross Area (acres)	Average Patch Size (m^2)	Average *L. latifolium* cover within patch
Marsh				
Marsh plain	68	8.87	528	27%
Channel/ditch	131	18.57	574	34%
Open water edge	11	0.35	128	7%
Low marsh wrackline*	45	5.77	519	41%
Upland				
Road	7	0.28	161	24%
Levee	251	25.04	404	27%
Totals	**513**	**58.88**		

*Tidal deposition of dead organic material at the interface of low marsh and the marsh plain.

Table 4. Adaptive management stratified random experimental design.

	Inflorescence removal	Imazapyr-only	Imazapyr/glyphosate
Wrackline			
# Monitoring Plots	4	4	4
Levee			
# Monitoring Plots	4	4	4
Channel			
# Monitoring Plots	4	4	4

Treatment plots were randomly located within each environmental type using a 10 meter buffer between potential plot locations. Treatment method was randomly assigned to the selected plots within each environment type.

FIGURE 1

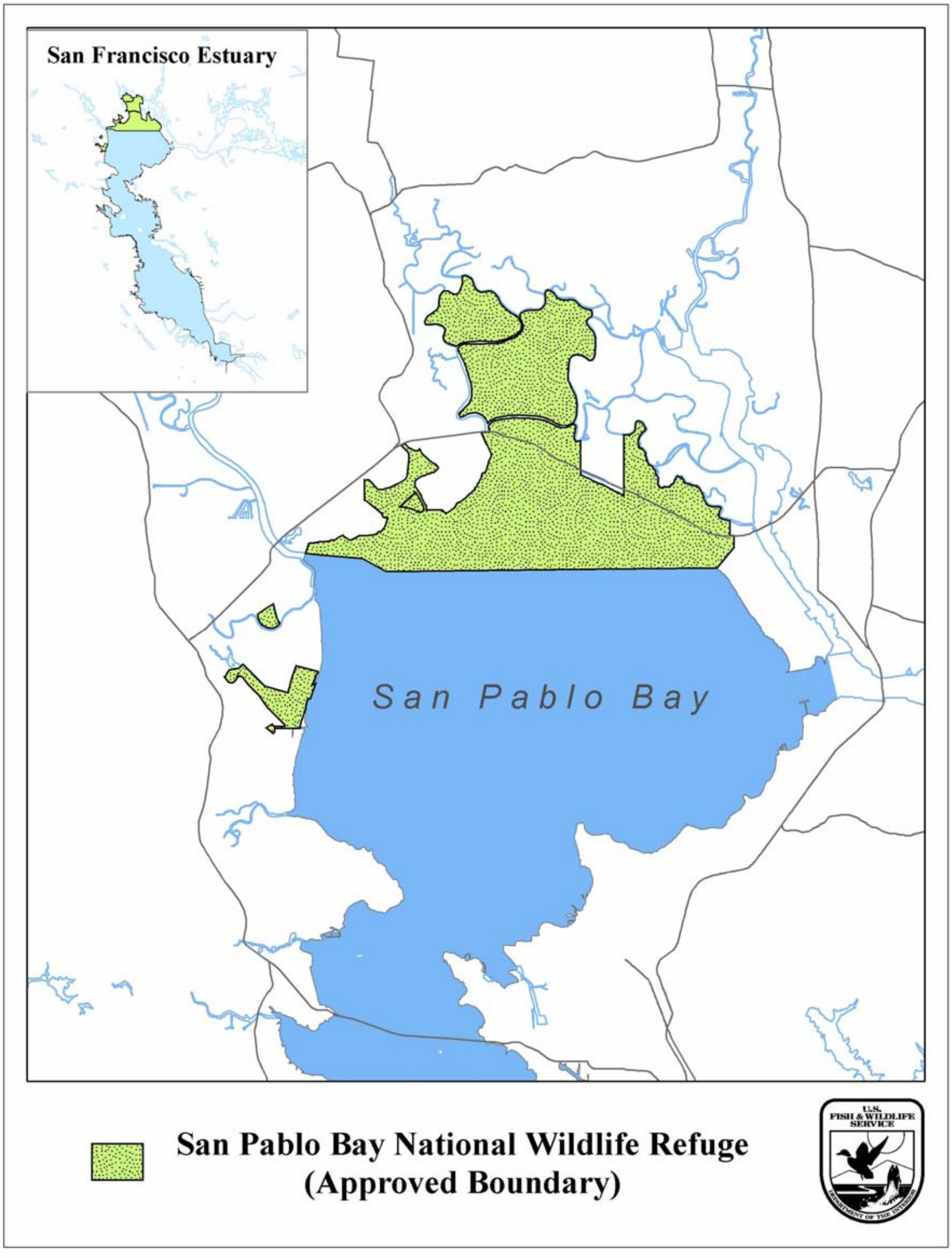

San Francisco Estuary
San Pablo Bay
San Pablo Bay National Wildlife Refuge
(Approved Boundary)
U.S. FISH & WILDLIFE SERVICE

FIGURE 2

Figure 2a. Adult *Lepidium latifolium* plant in bloom (© Leininger 2007)

Figure 2b. Wetland Infestation of *Lepidium latifolium* (© Leininger 2007)

Figure 2c. Detail of *Lepidium latifolium* flower in bloom (© Leininger 2007)

FIGURE 3

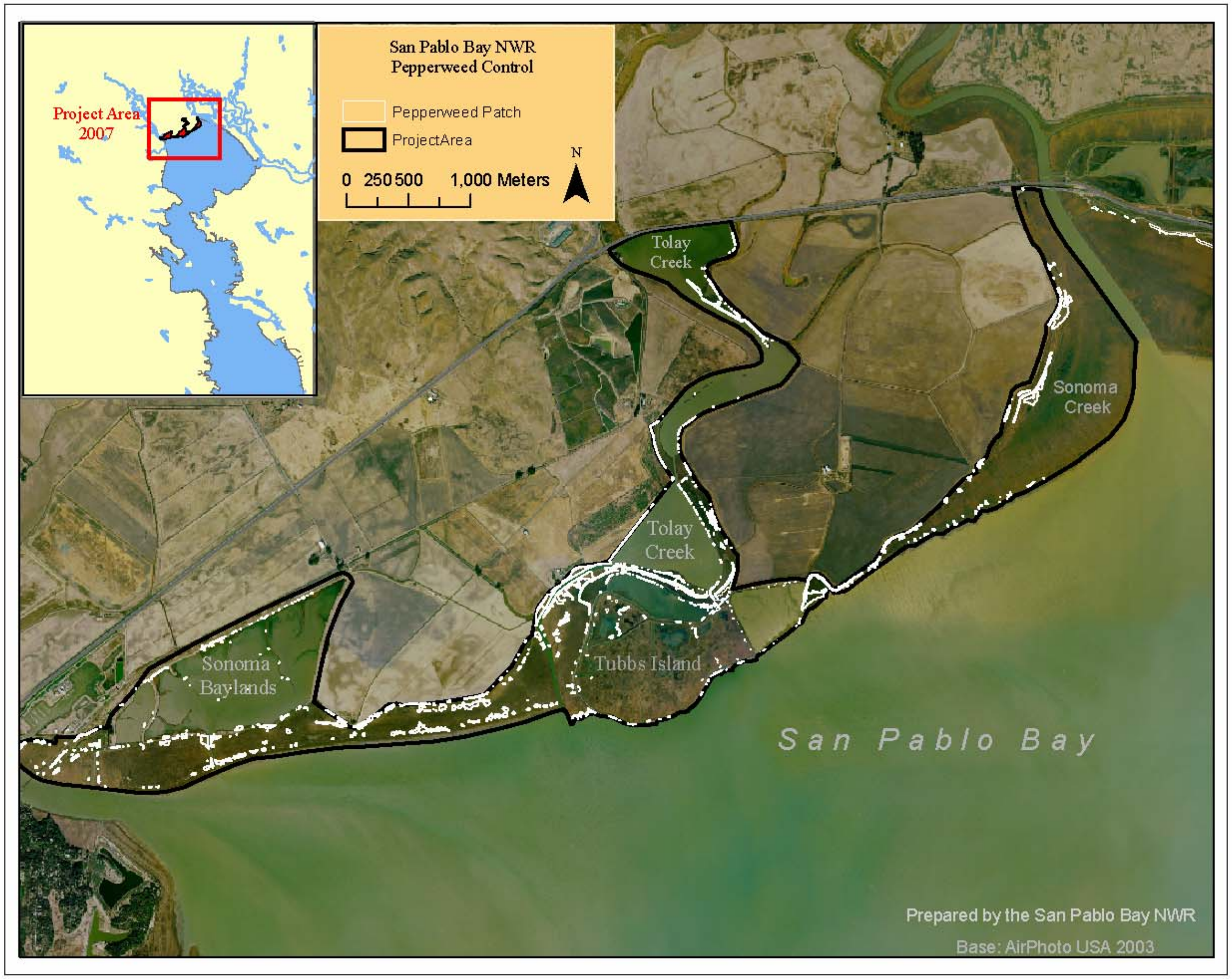

San Pablo Bay NWR
Pepperweed Control
Pepperweed Patch
ProjectArea
0 250 500 1,000 Meters
N
Project Area
2007
Tolay
Creek
Tolay
Creek
Sonoma
Creek
Sonoma
Baylands
Tubbs Island
San Pablo Bay
Prepared by the San Pablo Bay NWR
Base: AirPhoto USA 2003

FIGURE 4

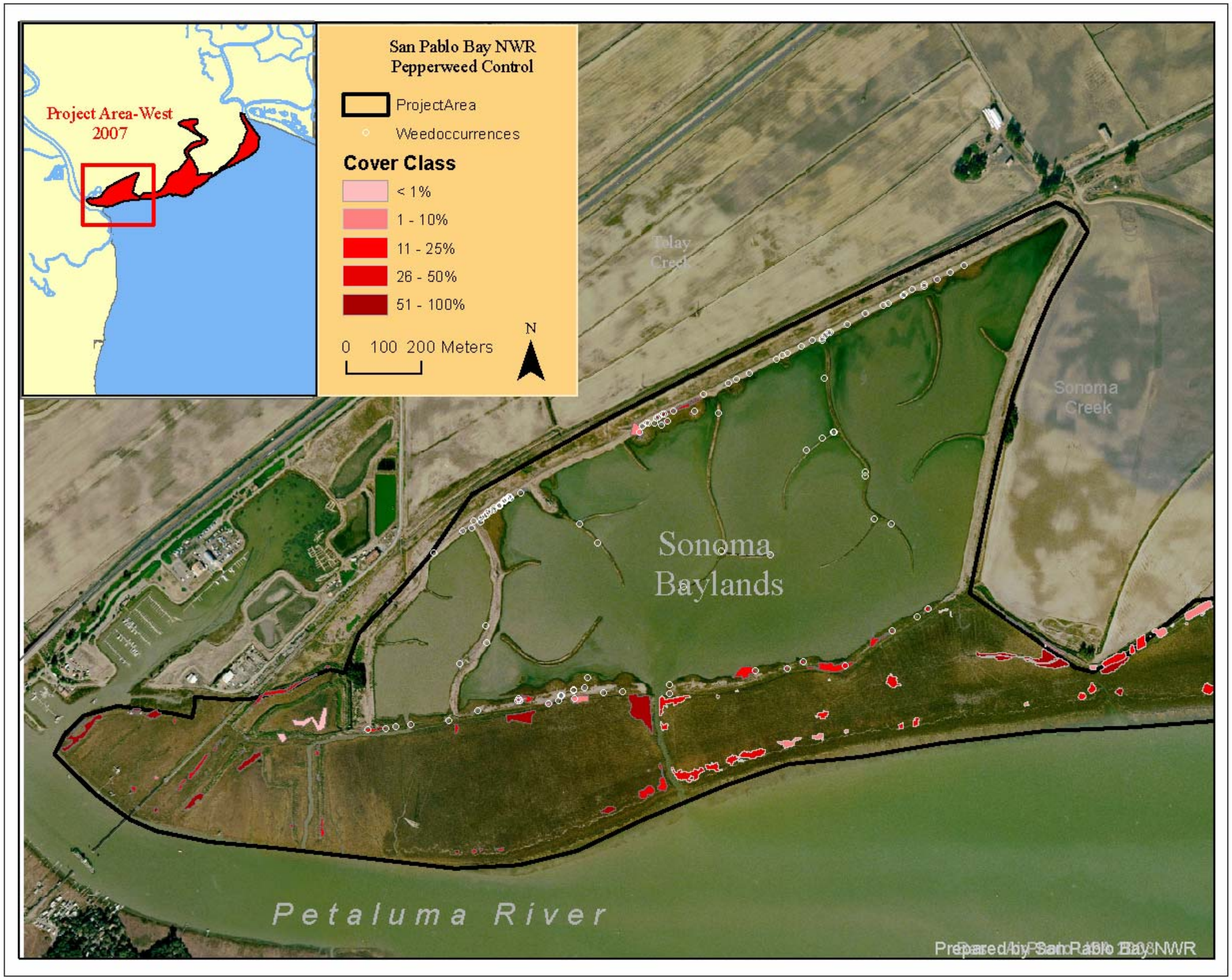
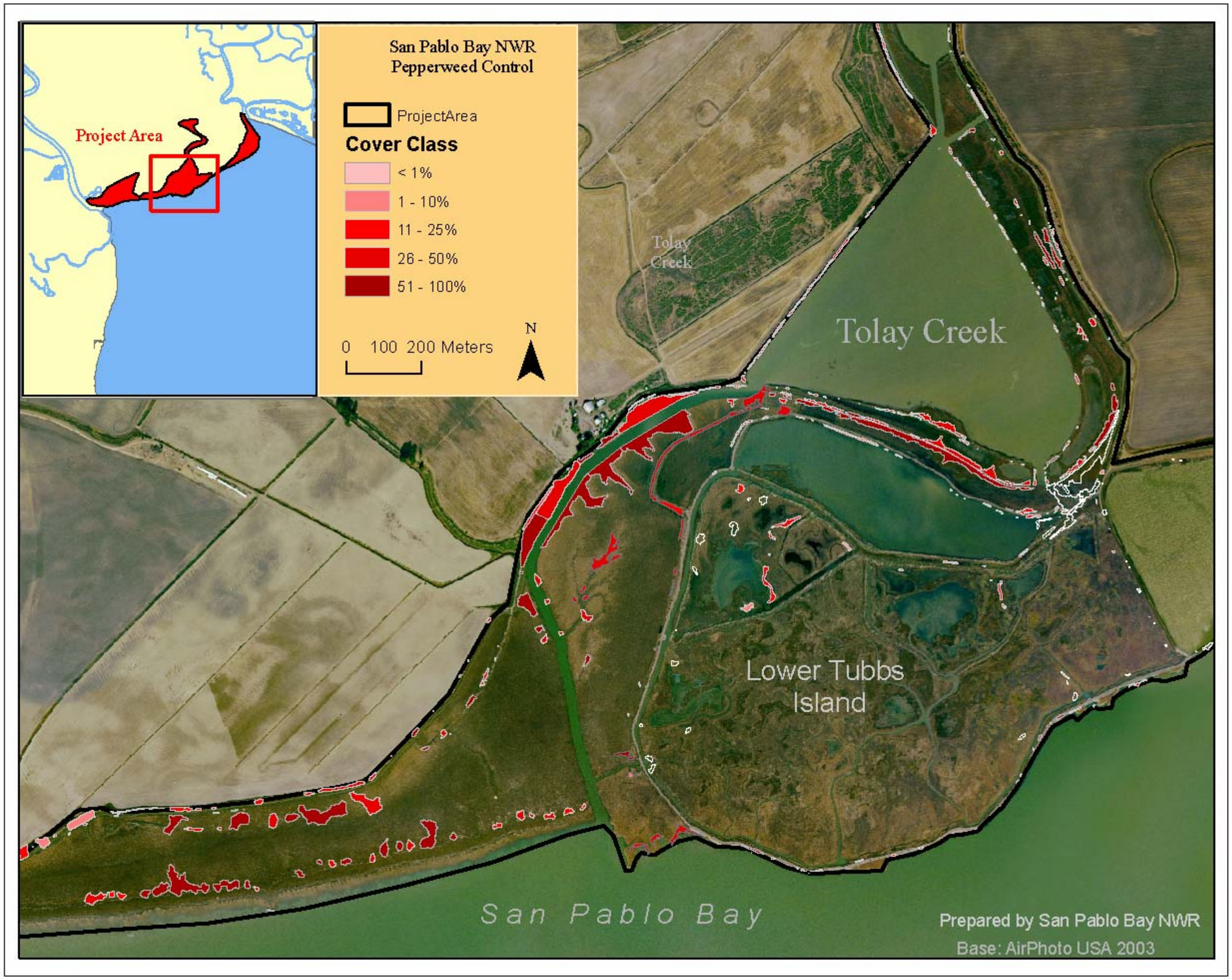
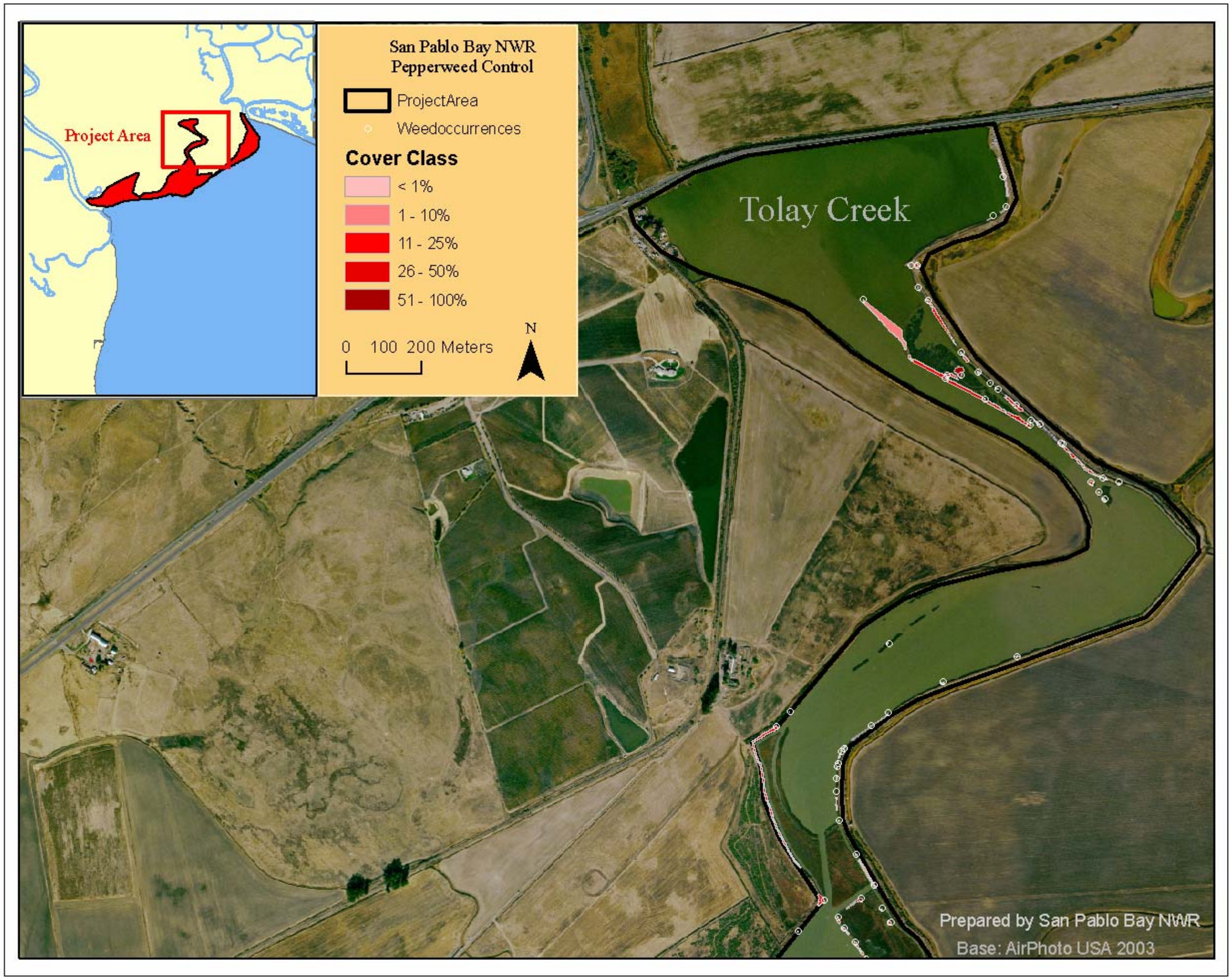

San Pablo Bay NWR
Pepperweed Control
ProjectArea
Weedoccurrences
Cover Class
< 1%
1 - 10%
11 - 25%
26 - 50%
51 - 100%
0 100 200 Meters
N
Project Area-West
2007
Tolay
Creek
Sonoma
Creek
Sonoma
Baylands
Petaluma River
Prepared by San Pablo Bay NWR

FIGURE 5



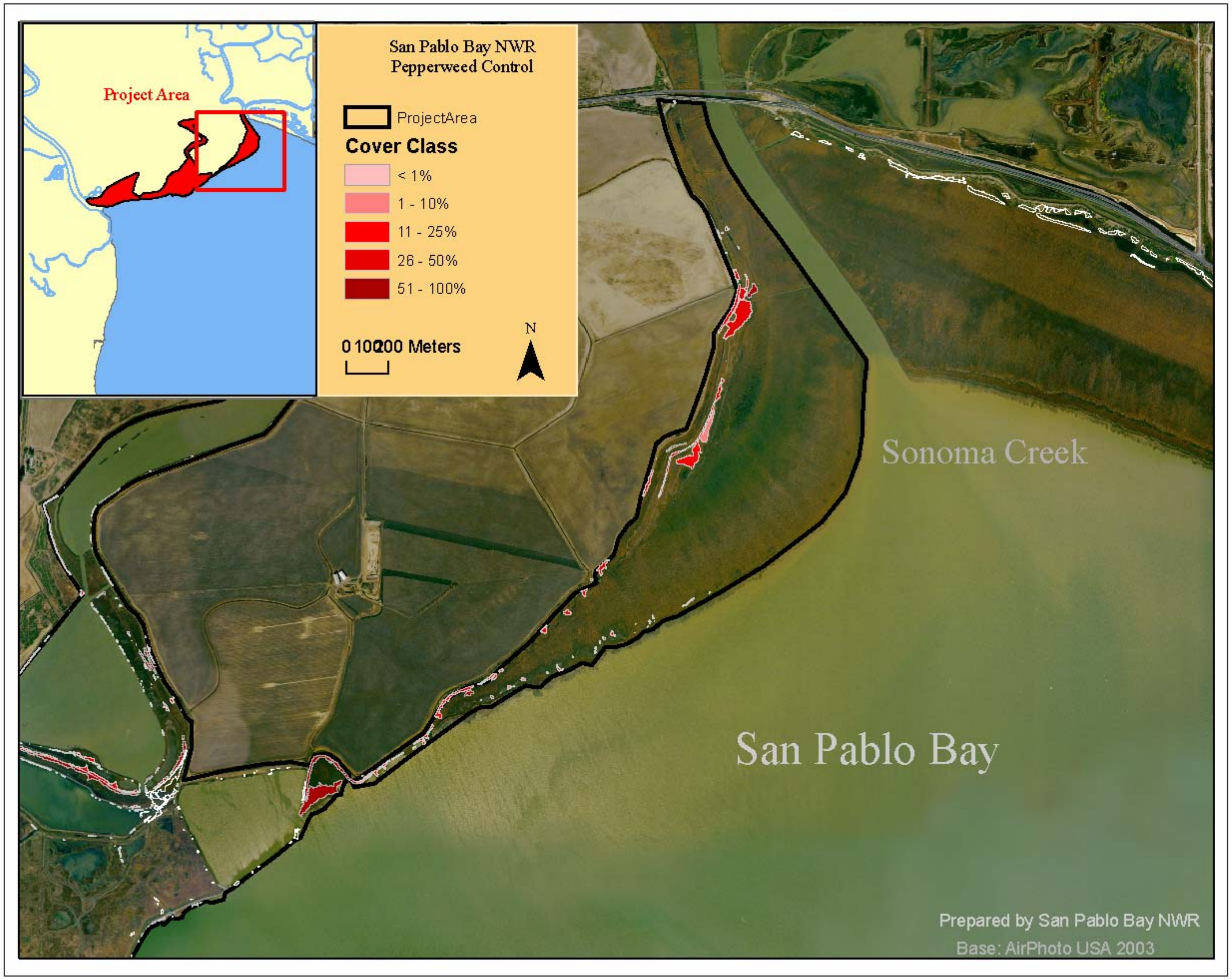
Project Area
San Pablo Bay NWR
Pepperweed Control
ProjectArea
Cover Class
< 1%
1 - 10%
11 - 25%
26 - 50%
51 - 100%
0 100 200 Meters
N
Tolay Creek
Tolay Creek
Lower Tubbs Island
San Pablo Bay
Prepared by San Pablo Bay NWR
Base: AirPhoto USA 2003

FIGURE 6



Project Area
San Pablo Bay NWR
Pepperweed Control
ProjectArea
Weedoccurrences
Cover Class
< 1%
1 - 10%
11 - 25%
26 - 50%
51 - 100%
0 100 200 Meters
N
Tolay Creek
Prepared by San Pablo Bay NWR
Base: AirPhoto USA 2003

FIGURE 7



Project Area
San Pablo Bay NWR
Pepperweed Control
ProjectArea
Cover Class
< 1%
1 - 10%
11 - 25%
26 - 50%
51 - 100%
0 100200 Meters
N
Sonoma Creek
San Pablo Bay
Prepared by San Pablo Bay NWR
Base: AirPhoto USA 2003

FIGURE 8


SPBNWR *Lepidium latifolium* Patch Treatment Priority
2005 Lepidium Patch
Treatment Priority
Top Priority (Restoration Site)
High Prioirty
Middle Priority
Lower Priority
Treatment Patch
Other Map Items
restoration site
road
levee
Arnold Dr
Sears Point Rd
Tolay Creek Rd
Noble Rd
Lakeville Hwy
Reclamation Rd
0
1,000
2,000
3,000
Meters

APPENDIX I

Priority code	Number of weed occurrences within treatment patch	WIMS weed occurrence key	Restoration Site	Weed occurrence Area (m²)	Distance to nearest road or drivable levee (m)	Distance to nearest channel (m)	WIMS vegetation description	Distinction	Lepidium Cover Class
1	1	0409281210127528	SBR	0.02	19.1	1.4	Open Water	wetland	< 1%
2	1	0506291207173285	TIS	0.45	4.5	14.8	Levee	upland	11 - 25%
3	1	0410061315213256	SBR	2.70	113.6	17.0	Levee	upland	1 - 10%
4	1	0506201258105356	TCR	14.09	102.8	0.0	Channel	wetland	1 - 10%
5	1	0503301154096724	TCR	16.33	13.6	24.2	Levee	upland	1 - 10%
6	1	050615131738467	TCR	25.29	15.2	4.5	Levee	upland	11 - 25%
7	1	0411161113327416	TIS	36.36	1.4	2.0	Levee	upland	1 - 10%
8	1	0510271156446272	TIS	39.29	247.7	23.5	Levee	upland	11 - 25%
9	1	0409281520256900	SBR	47.49	14.3	32.0	Levee	upland	1 - 10%
10	2	040722113922321	TIS	17.68	16.0	16.3	Levee	upland	< 1%
		0407221152392889	TIS	1.86	22.8	9.5	Levee	upland	< 1%
11	1	051101133702226	TIS	143.30	275.7	29.7	Levee	upland	1 - 10%
12	2	0511221020297868	SBR	39.51	34.4	13.9	Channel	wetland	26 - 50%
		0511221022006032	SBR	75.31	20.8	1.0	Tidal Marsh	wetland	1 - 10%
13	1	0506291315423635	TIS	149.30	3.0	12.1	Levee	upland	11 - 25%
14	4	0410061241055978	SBR	66.32	7.6	25.0	Levee	upland	1 - 10%
		0410061245139571	SBR	6.28	18.4	25.9	Levee	upland	1 - 10%
		0410061320437598	SBR	5.24	9.4	30.4	Levee	upland	1 - 10%
		0410061325196991	SBR	5.07	7.2	25.6	Levee	upland	11 - 25%
15	83	050427104716249	TIS	120.03	65.9	2.0	Channel	wetland	51 - 100%
		050527110132559	TIS	20.87	8.9	23.5	Levee	upland	11 - 25%
		050606133642604	TIS	29.56	50.5	1.0	Channel	wetland	51 - 100%
		050621132229864	TIS	9.05	107.4	1.0	Channel	wetland	26 - 50%
		050630130506976	TIS	39.28	69.3	1.4	Channel	wetland	26 - 50%
		050726115614577	TIS	197.40	2.0	9.5	Levee	upland	11 - 25%
		050726120259395	TIS	169.26	8.1	4.1	Levee	upland	26 - 50%
		050726130514827	TIS	91.58	0.0	8.1	Levee	upland	26 - 50%
		050726131212201	TIS	240.57	1.0	7.1	Levee	upland	11 - 25%
		0410141115559448	TIS	314.46	8.0	12.0	Levee	upland	11 - 25%
		0411181039038413	TIS	1415.43	35.5	22.0	Levee	upland	26 - 50%
		0411181101115238	TIS	1558.11	50.7	4.1	Channel	wetland	26 - 50%

Priority code	Number of weed occurrences within treatment patch	WIMS weed occurrence key	Restoration Site	Weed occurrence Area (m²)	Distance to nearest road or drivable levee (m)	Distance to nearest channel (m)	WIMS vegetation description	Distinction	Lepidium Cover Class
15	83	0411181119405651	TIS	708.56	16.3	24.0	Road	upland	26 - 50%
		0411181142208506	TIS	1440.63	130.8	64.1	Levee	upland	26 - 50%
		0411181223222449	TIS	902.69	22.6	25.9	Levee	upland	11 - 25%
		0411221233367114	TIS	4787.64	58.0	0.0	Channel	wetland	51 - 100%
		0503301358175588	TIS	335.87	13.0	1.0	Levee	upland	11 - 25%
		0503301415578571	TIS	89.72	19.2	1.0	Levee	upland	1 - 10%
		0503301421406585	TIS	692.58	9.8	5.0	Levee	upland	11 - 25%
		0503311105531926	TIS	386.39	11.7	1.0	Channel	wetland	26 - 50%
		0503311117039299	TIS	1675.63	16.6	9.1	Channel	wetland	26 - 50%
		0503311138151313	TIS	0.38	7.6	6.7	Channel	wetland	1 - 10%
		0503311143197296	TIS	69.61	1.0	8.5	Channel	wetland	1 - 10%
		0503311158569617	TIS	89.70	1.0	2.0	Channel	wetland	1 - 10%
		0503311204025107	TIS	105.48	1.0	5.4	Channel	wetland	11 - 25%
		0503311211137347	TIS	11.00	0.0	2.8	Channel	wetland	1 - 10%
		0504211111142199	TIS	11.47	27.9	35.7	Levee	upland	1 - 10%
		0504271058451879	TIS	137.03	55.0	3.2	Channel	wetland	51 - 100%
		0504271108479909	TIS	1234.40	47.9	5.4	Channel	wetland	51 - 100%
		0504271241417656	TIS	6360.25	69.9	2.8	Channel	wetland	51 - 100%
		0505131227394901	TIS	2783.13	63.5	4.0	Channel	wetland	51 - 100%
		0505251230404503	TIS	1430.30	78.0	0.0	Channel	wetland	26 - 50%
		0505251250243564	TIS	1385.62	53.4	8.6	Channel	wetland	51 - 100%
		0505251258389807	TIS	75.22	65.7	17.0	Channel	wetland	11 - 25%
		0505251302346621	TIS	18.02	77.1	16.1	Channel	wetland	11 - 25%
		0505251305439734	TIS	522.08	77.8	12.7	Channel	wetland	26 - 50%
		0505271115222761	TIS	178.29	11.2	43.0	Levee	upland	11 - 25%
		0505271127531438	TIS	23.76	1.0	4.0	Levee	upland	26 - 50%
		0505271134128526	TIS	380.49	17.0	20.1	Channel	wetland	26 - 50%
		0505271142373117	TIS	52.04	13.9	14.9	Channel	wetland	< 1%
		0505271146518209	TIS	49.93	3.0	2.0	Levee	upland	11 - 25%
		0505271150397072	TIS	67.09	2.0	3.6	Levee	upland	26 - 50%
		0505271213014240	TIS	10.78	3.2	16.5	Levee	upland	1 - 10%
		0505271215464400	TIS	43.54	4.0	15.8	Levee	upland	11 - 25%

Priority code	Number of weed occurrences within treatment patch	WIMS weed occurrence key	Restoration Site	Weed occurrence Area (m²)	Distance to nearest road or drivable levee (m)	Distance to nearest channel (m)	WIMS vegetation description	Distinction	Lepidium Cover Class
15	83	0505271220217902	TIS	51.62	6.0	14.0	Levee	upland	1 - 10%
		0506061310415615	TIS	3779.85	45.2	1.0	Channel	wetland	51 - 100%
		0506061325045012	TIS	7148.10	48.3	1.0	Channel	wetland	51 - 100%
		0506061344407574	TIS	219.67	43.7	0.0	Channel	wetland	26 - 50%
		0506211302484898	TIS	88.72	128.3	3.6	Channel	wetland	26 - 50%
		0506211310432792	TIS	181.82	141.6	1.4	Channel	wetland	51 - 100%
		0506211330512113	TIS	93.96	80.0	1.0	Channel	wetland	26 - 50%
		0506211347508323	TIS	551.59	38.6	13.2	Channel	wetland	51 - 100%
		0506211405198667	TIS	142.24	45.3	11.0	Channel	wetland	51 - 100%
		0506221127462493	TIS	0.58	3.2	1.0	Levee	upland	11 - 25%
		0506221132591847	TIS	4.82	1.0	6.0	Levee	upland	26 - 50%
		0506221138412181	TIS	837.99	7.3	13.0	Levee	upland	26 - 50%
		0506301227403696	TIS	161.40	43.7	16.0	Tidal Marsh	wetland	11 - 25%
		0506301243167871	TIS	112.93	63.1	4.0	Channel	wetland	26 - 50%
		0506301247295836	TIS	510.08	53.1	1.4	Channel	wetland	26 - 50%
		0506301253431743	TIS	297.67	49.3	0.0	Channel	wetland	51 - 100%
		0506301258495739	TIS	328.71	57.6	5.0	Channel	wetland	26 - 50%
		0506301308345299	TIS	663.93	73.8	1.0	Channel	wetland	51 - 100%
		0506301315053462	TIS	2718.20	78.8	1.4	Channel	wetland	26 - 50%
		0507061100488002	TIS	3.57	79.4	4.1	Levee	upland	26 - 50%
		0507061103274627	TIS	49.95	72.2	4.5	Levee	upland	26 - 50%
		0507061113068031	TIS	65.80	69.6	7.6	Levee	upland	11 - 25%
		0507061119044573	TIS	20.03	72.5	1.4	Levee	upland	26 - 50%
		0507070939415154	TIS	197.92	108.9	9.0	Channel	wetland	11 - 25%
		0507261040384702	TIS	710.41	2.8	10.6	Levee	upland	51 - 100%
		0507261058263403	TIS	5994.62	9.2	10.8	Levee	upland	26 - 50%
		0507261139178578	TIS	118.57	2.2	53.2	Levee	upland	11 - 25%
		0507261145481788	TIS	41.98	2.0	47.9	Levee	upland	26 - 50%
		0507261149415517	TIS	135.24	5.0	26.6	Levee	upland	26 - 50%
		0507261251385915	TIS	123.86	2.2	10.0	Levee	upland	26 - 50%

Priority code	Number of weed occurrences within treatment patch	WIMS weed occurrence key	Restoration Site	Weed occurrence Area (m²)	Distance to nearest road or drivable levee (m)	Distance to nearest channel (m)	WIMS vegetation description	Distinction	Lepidium Cover Class
15	83	0507261258543614	TIS	10.39	1.0	8.1	Levee	upland	11 - 25%
		0507261320004030	TIS	254.68	0.0	5.7	Levee	upland	1 - 10%
		0507261343464926	TIS	1137.68	3.6	2.2	Levee	upland	11 - 25%
		0507271432312919	TIS	368.36	5.0	9.9	Channel	wetland	51 - 100%
		0508021054289934	TIS	679.46	1.4	30.0	Levee	upland	11 - 25%
		0508021121003478	TIS	17.24	1.0	18.4	Levee	upland	51 - 100%
		0508021150519749	TIS	5025.62	24.4	8.9	Channel	wetland	26 - 50%
		0508021154344990	TIS	4310.05	25.1	11.4	Channel	wetland	51 - 100%
		0508021206234187	TIS	50.48	3.0	4.0	Channel	wetland	51 - 100%
16	1	0505271253503653	TIS	43.29	0.0	8.5	Levee	upland	11 - 25%
17	1	0506291405092122	TIS	64.57	0.0	13.9	Levee	upland	51 - 100%
18	4	0506291335082282	TIS	112.61	1.0	11.7	Levee	upland	11 - 25%
		0506291340565589	TIS	124.06	2.2	14.4	Levee	upland	51 - 100%
		0506291346329103	TIS	4.67	0.0	12.5	Levee	upland	26 - 50%
		0506291351217425	TIS	0.91	0.0	11.7	Levee	upland	51 - 100%
19	1	0505271108594769	TIS	57.56	0.0	9.5	Levee	upland	11 - 25%
20	1	0506291139565382	TIS	3.40	0.0	12.5	Levee	upland	11 - 25%
21	10	050902112402166	TIS	506.65	2.2	24.6	Levee	upland	11 - 25%
		0407221250437661	TIS	1.85	7.6	0.0	Levee	upland	< 1%
		0506291046152271	TIS	352.58	9.2	0.0	Levee	upland	26 - 50%
		0506291056361904	TIS	15282.76	16.8	25.0	Tidal Marsh	wetland	51 - 100%
		0508261317004453	TIS	220.89	0.0	20.4	Levee	upland	11 - 25%
		0509021139338906	TIS	518.12	1.0	20.1	Levee	upland	11 - 25%
		0509021156219201	TIS	19.42	18.8	37.0	Levee	upland	26 - 50%
		0509021203312606	TIS	672.28	0.0	18.4	Levee	upland	1 - 10%
		0509021421281928	TIS	2.64	4.5	29.0	Levee	upland	26 - 50%
		0509021425521790	TIS	8.85	4.5	26.3	Levee	upland	11 - 25%
22	3	0409301041412085	SBR	132.44	6.1	6.1	Levee	upland	1 - 10%
		0409301050017036	SBR	15.12	1.0	10.0	Levee	upland	1 - 10%
		0409301050193193	SBR	33.76	9.8	22.1	Road	upland	1 - 10%
23	4	0506291501572832	TIS	65.22	6.0	4.0	Levee	upland	11 - 25%

Priority code	Number of weed occurrences within treatment patch	WIMS weed occurrence key	Restoration Site	Weed occurrence Area (m²)	Distance to nearest road or drivable levee (m)	Distance to nearest channel (m)	WIMS vegetation description	Distinction	Lepidium Cover Class
23	4	0506291508319291	TIS	0.97	1.0	8.5	Levee	upland	51 - 100%
		0506291511204327	TIS	32.38	4.1	5.8	Levee	upland	26 - 50%
		0506291516157577	TIS	10.55	2.8	6.7	Levee	upland	11 - 25%
24	1	0506291429122991	TIS	58.17	1.0	10.0	Levee	upland	26 - 50%
25	2	0506291415441634	TIS	16.62	1.0	12.5	Levee	upland	26 - 50%
		0506291419152556	TIS	19.43	2.2	9.9	Levee	upland	51 - 100%
26	1	0506291410387892	TIS	18.74	1.0	14.8	Levee	upland	26 - 50%
27	1	0506301044237191	TIS	274.99	1.0	5.4	Levee	upland	26 - 50%
28	1	0506301024236908	TIS	11.58	2.0	2.2	Levee	upland	11 - 25%
29	1	0506291256308667	TIS	127.91	2.2	5.0	Tidal Marsh	wetland	26 - 50%
30	2	0409301054088309	SBR	774.71	3.0	8.9	Levee	upland	1 - 10%
		0409301112316636	SBR	7.05	18.7	29.4	Road	upland	1 - 10%
31	2	040930112753477	SBR	4055.80	23.0	8.0	Channel	wetland	51 - 100%
		0409301119387512	SBR	34.02	3.0	10.0	Road	upland	26 - 50%
32	1	0506291521168682	TIS	31.99	3.0	6.3	Levee	upland	26 - 50%
33	1	0506301038537840	TIS	41.23	3.6	4.5	Levee	upland	26 - 50%
34	3	0505271245372192	TIS	48.81	5.1	7.6	Levee	upland	1 - 10%
		0506291526187513	TIS	214.07	4.1	5.8	Levee	upland	51 - 100%
		0506291531213634	TIS	0.67	4.5	8.1	Levee	upland	51 - 100%
35	1	0410061335211230	SBR	18.67	5.0	25.6	Levee	upland	11 - 25%
36	1	0505271234082316	TIS	44.43	5.7	11.0	Levee	upland	1 - 10%
37	1	040930110036387	SBR	22.56	5.8	8.5	Road	upland	26 - 50%
38	3	0409281149334358	SBR	43.20	6.3	6.3	Open Water	wetland	< 1%
		0409281155214248	SBR	31.62	13.5	7.0	Open Water	wetland	1 - 10%
		0409281242404611	SBR	92.49	8.5	15.1	Levee	upland	11 - 25%
39	1	0409281538514096	SBR	4.70	6.3	24.8	Open Water	wetland	1 - 10%
40	1	0409281531556766	SBR	18.14	6.7	16.6	Levee	upland	1 - 10%
41	2	0506150855566448	TCR	41.08	7.1	9.2	Levee	upland	< 1%
		0507141335481480	TCR	70.69	6.7	24.6	Levee	upland	11 - 25%
42	1	0409301017241658	SBR	18.31	7.0	24.0	Levee	upland	< 1%
43	1	040928153522718	SBR	2.74	7.2	26.5	Open Water	wetland	1 - 10%
44	1	0410061356349195	SBR	21.68	7.2	43.1	Levee	upland	11 - 25%

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45	1	0410061353526103	SBR	6.00	7.6	27.9	Levee	upland	26 - 50%
46	14	0409011137113813	TCR	332.88	9.2	6.4	Levee	upland	< 1%
		0503241109501245	TCR	2.15	17.5	1.0	Channel	wetland	11 - 25%
		0503241117557161	TCR	57.24	9.9	7.8	Channel	wetland	1 - 10%
		0503241127035072	TCR	592.62	7.8	7.8	Channel	wetland	26 - 50%
		0503241224346722	TCR	44.11	11.7	2.0	Channel	wetland	11 - 25%
		0505031211537700	TCR	438.39	12.7	1.4	Tidal Marsh	wetland	11 - 25%
		0505031237462798	TCR	156.82	9.9	5.0	Tidal Marsh	wetland	26 - 50%
		0506161018368220	TCR	2372.71	137.1	5.8	Levee	upland	1 - 10%
		0506201014175213	TCR	932.79	28.8	2.2	Levee	upland	26 - 50%
		0506201036063092	TCR	195.99	79.9	2.0	Levee	upland	11 - 25%
		0506201037407436	TCR	777.67	55.4	5.1	Levee	upland	26 - 50%
		0506201042515381	TCR	1120.37	82.3	6.3	Levee	upland	11 - 25%
		0506201104442230	TCR	457.22	54.5	3.6	Tidal Marsh	wetland	51 - 100%
		0506201202022802	TCR	89.06	34.0	6.7	Channel	wetland	26 - 50%
47	2	0411161126312942	TIS	150.77	8.0	16.3	Levee	upland	26 - 50%
		0411161141167375	TIS	127.80	10.8	19.9	Levee	upland	26 - 50%
48	1	041006134859689	SBR	67.73	8.9	32.6	Levee	upland	1 - 10%
49	1	0507271029541266	TCR	293.01	8.9	3.6	Levee	upland	11 - 25%
50	1	0503241232518197	TCR	17.87	8.9	8.1	Channel	wetland	1 - 10%
51	1	0407221220383581	TIS	1.78	9.2	10.0	Levee	upland	< 1%
52	1	0410061345007104	SBR	21.27	9.8	28.1	Levee	upland	11 - 25%
53	1	0506291450193476	TIS	51.69	9.8	16.2	Levee	upland	26 - 50%
54	1	0506150835339202	TCR	75.90	10.0	6.0	Levee	upland	< 1%
55	1	0505131153478982	TCR	20.36	12.1	0.0	Levee	upland	< 1%
56	2	0505031225023550	TCR	1.71	14.4	0.0	Tidal Marsh	wetland	26 - 50%
		0506151044414998	TCR	20.76	12.0	1.0	Levee	upland	11 - 25%
57	4	0503301114573487	TCR	1.00	17.7	1.0	Levee	upland	26 - 50%
		0503301122219220	TCR	18.65	17.3	2.0	Levee	upland	1 - 10%
		0503301129464478	TCR	18.51	17.9	2.8	Levee	upland	1 - 10%
		0506211015057243	TCR	53.34	20.6	2.8	Levee	upland	1 - 10%

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58	1	0503301226379959	TCR	21.78	17.0	1.0	Levee	upland	11 - 25%
59	2	0505251041121280	TCR	22.08	12.0	1.0	Levee	upland	11 - 25%
		0505251056522125	TCR	401.69	10.8	1.0	Levee	upland	1 - 10%
60	1	0407221211322833	TIS	102.37	30.4	1.0	Levee	upland	1 - 10%
61	1	050503123133604	TCR	30.18	14.9	1.4	Tidal Marsh	wetland	1 - 10%
62	1	0503301239548170	TCR	80.30	17.0	2.0	Levee	upland	11 - 25%
63	4	0409281036481764	SBR	16.54	47.9	6.0	Channel	wetland	< 1%
		0409281101003622	SBR	130.02	17.3	3.0	Channel	wetland	11 - 25%
		0409281120283978	SBR	32.98	26.2	4.5	Channel	wetland	1 - 10%
		0409301443325907	SBR	16.20	28.2	6.3	Channel	wetland	11 - 25%
64	1	0503301247579860	TCR	3.54	17.1	3.6	Levee	upland	26 - 50%
65	1	0507271138068181	TCR	0.30	105.4	4.2	Levee	upland	51 - 100%
66	1	0506150822009174	TCR	571.36	11.4	5.0	Levee	upland	< 1%
67	2	0503301140399189	TCR	2.35	14.1	8.9	Levee	upland	11 - 25%
		0505251013448845	TCR	225.91	13.4	5.8	Levee	upland	< 1%
68	1	0510271106461058	TIS	114.61	62.0	5.8	Tidal Marsh	wetland	11 - 25%
69	1	0506150956309865	TCR	629.64	11.4	6.3	Levee	upland	11 - 25%
70	1	0507271124459314	TCR	1989.24	92.0	6.4	Levee	upland	11 - 25%
71	1	0510271058254114	TIS	46.32	18.4	7.1	Tidal Marsh	wetland	1 - 10%
72	1	0506150941535355	TCR	9.98	14.3	7.6	Levee	upland	< 1%
73	1	0506291327055325	TIS	17.60	11.2	7.8	Tidal Marsh	wetland	11 - 25%
74	1	0511011224377073	TIS	15.23	137.2	8.2	Levee	upland	1 - 10%
75	1	051101135252741	TIS	149.97	176.8	9.0	Levee	upland	1 - 10%
76	2	0506201213575826	TCR	5.22	50.7	9.2	Channel	wetland	11 - 25%
		0506201221501171	TCR	29.98	63.9	11.3	Channel	wetland	11 - 25%
77	1	0409301028592117	SBR	233.28	16.1	13.0	Road	upland	1 - 10%
78	4	0409281339565033	SBR	12.33	13.6	14.4	Levee	upland	1 - 10%
		0409281348341162	SBR	55.51	12.0	16.1	Open Water	wetland	1 - 10%
		0409281354299607	SBR	13.90	11.7	16.6	Levee	upland	1 - 10%
		0409301412173516	SBR	11.24	12.5	14.2	Levee	upland	11 - 25%
79	4	0409281448441833	SBR	22.49	24.2	18.0	Open Water	wetland	1 - 10%

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79	4	0409281458467233	SBR	187.60	14.3	31.0	Levee	upland	51 - 100%
		0409281507099799	SBR	463.17	17.5	37.4	Open Water	wetland	26 - 50%
		0409301423295150	SBR	24.15	35.7	14.0	Open Water	wetland	1 - 10%
80	1	0411161055056864	TIS	480.34	13.6	10.8	Levee	upland	51 - 100%
81	1	0511011317202067	TIS	281.93	53.3	13.4	Levee	upland	11 - 25%
82	1	0511011309248459	TIS	272.75	118.0	10.3	Levee	upland	11 - 25%
83	1	0410211145181820	TIS	986.36	56.6	13.9	Wrackline	wetland	26 - 50%
84	1	0409301108095053	SBR	19.90	44.9	17.7	Tidal Marsh	wetland	< 1%
85	1	0506301151273330	TIS	28.26	15.2	18.0	Tidal Marsh	wetland	1 - 10%
86	1	0511011224525081	TIS	378.22	202.5	41.8	Tidal Marsh	wetland	1 - 10%
87	1	0511011237529876	TIS	838.30	236.1	12.4	Tidal Marsh	wetland	11 - 25%
88	1	0511011246584470	TIS	12.03	232.9	38.3	Tidal Marsh	wetland	11 - 25%
89	2	0511011250549358	TIS	138.02	208.3	46.1	Tidal Marsh	wetland	11 - 25%
		0511011255311995	TIS	656.67	189.8	63.0	Tidal Marsh	wetland	11 - 25%
90	3	0510271115156018	TIS	60.62	34.1	23.5	Tidal Marsh	wetland	11 - 25%
		0510271122038658	TIS	273.23	48.0	20.1	Tidal Marsh	wetland	11 - 25%
		0510271132593703	TIS	8.26	98.6	44.2	Tidal Marsh	wetland	11 - 25%
91	1	0506291154371710	TIS	35.51	19.3	31.3	Tidal Marsh	wetland	11 - 25%
92	1	040928141018794	SBR	64.07	12.5	11.2	Open Water	wetland	1 - 10%
93	1	0409281437279371	SBR	698.80	21.1	28.9	Open Water	wetland	1 - 10%
94	1	0507261423142737		5.76	5.4	1.0	Levee	upland	11 - 25%
95	1	051122103631397		20.71	361.4	18.0	Tidal Marsh	wetland	11 - 25%
96	1	0511221247144263		89.62	169.6	91.8	Wrackline	wetland	1 - 10%
97	1	0507081307088089		90.42	7.6	122.4	Road	upland	26 - 50%
98	1	0506171246274339		139.99	138.1	5.4	Channel	wetland	11 - 25%
99	1	0408131004294745		295.23	169.8	49.3	Channel	wetland	51 - 100%
100	1	0508191405378890		550.81	31.8	99.9	Tidal Marsh	wetland	11 - 25%
101	1	0508191441226801		649.96	7.8	236.8	Levee	upland	11 - 25%
102	1	0511221235571468		728.72	250.4	104.6	Tidal Marsh	wetland	26 - 50%
103	1	0508171012303924		164.37	0.0	7.1	Levee	upland	11 - 25%
104	7	050823110449941		1149.72	25.0	12.1	Channel	wetland	51 - 100%

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104	7	0508171037057803		156.59	2.2	9.4	Levee	upland	1 - 10%
		0508171046266559		1202.56	0.0	9.4	Levee	upland	26 - 50%
		0508171101044311		152.36	4.5	5.8	Levee	upland	11 - 25%
		0508171126558033		728.80	2.8	12.1	Levee	upland	11 - 25%
		0508171133552141		4.23	1.0	11.7	Levee	upland	51 - 100%
		0508171136216299		664.11	2.8	13.4	Levee	upland	1 - 10%
		0508171143449093		40.52	1.4	8.9	Levee	upland	11 - 25%
105	6	05072913291677		1319.42	22.0	11.0	Tidal Marsh	wetland	51 - 100%
		0507291337087364		306.97	53.8	41.0	Tidal Marsh	wetland	26 - 50%
		0508031324128793		91.07	5.1	7.0	Levee	upland	11 - 25%
		0508031349471326		506.80	0.0	12.0	Levee	upland	11 - 25%
		0508031357235951		376.54	4.0	15.0	Levee	upland	11 - 25%
		0508031409388985		27.88	5.0	6.0	Levee	upland	11 - 25%
106	1	0508031310111542		239.99	0.0	8.0	Levee	upland	11 - 25%
107	7	0507291226167937		2303.75	36.4	27.9	Levee	upland	26 - 50%
		0507291236529787		4044.62	55.1	46.1	Tidal Marsh	wetland	51 - 100%
		0507291254164500		589.81	57.4	49.0	Tidal Marsh	wetland	51 - 100%
		0507291300457975		709.71	60.7	52.5	Tidal Marsh	wetland	26 - 50%
		0508031234407497		181.80	2.2	7.8	Levee	upland	26 - 50%
		0508031241495396		910.40	0.0	8.2	Levee	upland	26 - 50%
		0508031257429508		154.71	1.0	8.0	Levee	upland	26 - 50%
108	1	0508031211118092		25.78	0.0	8.1	Levee	upland	51 - 100%
109	1	050729114058792		340.73	0.0	50.8	Levee	upland	51 - 100%
110	1	050803113903688		10.62	0.0	8.1	Levee	upland	26 - 50%
111	1	0508031132492657		87.40	0.0	9.9	Levee	upland	26 - 50%
112	3	050331123831960		17.84	1.0	1.0	Channel	wetland	1 - 10%
		0503311230325440		5.87	0.0	2.0	Channel	wetland	1 - 10%
		0503311235254536		4.52	0.0	1.0	Channel	wetland	1 - 10%
113	5	0508171021117586		481.66	1.0	8.6	Levee	upland	1 - 10%
		0511171101469370		8.68	6.7	1.0	Levee	upland	1 - 10%
		0511171214293012		2035.91	118.4	11.2	Levee	upland	51 - 100%

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113	5	0511171231085502		534.82	117.9	2.0	Channel	wetland	51 - 100%
		0511171240336697		1294.60	66.0	1.0	Channel	wetland	51 - 100%
114	1	0508111118282120		1289.14	1.0	525.0	Levee	upland	11 - 25%
115	1	0507081219257928		37.21	1.0	205.4	Levee	upland	11 - 25%
116	1	0508031205548269		1.29	1.4	12.7	Levee	upland	51 - 100%
117	1	0508111149025428		1257.71	1.4	60.9	Levee	upland	26 - 50%
118	1	0507291125452033		11.11	2.0	44.3	Levee	upland	51 - 100%
119	2	0503311247479963		603.67	2.0	12.1	Channel	wetland	1 - 10%
		0505271205576338		12.39	3.2	9.8	Levee	upland	11 - 25%
120	3	0507080947274356		218.24	49.8	116.8	Levee	upland	26 - 50%
		0507081056412710		30.69	18.8	149.4	Tidal Marsh	wetland	26 - 50%
		0507081206553662		167.16	2.0	157.0	Levee	upland	1 - 10%
121	6	040901135955555		783.91	43.1	28.3	Levee	upland	26 - 50%
		0409011354178514		248.20	2.2	18.9	Levee	upland	11 - 25%
		0409140906119672		76.14	28.3	20.2	Levee	upland	11 - 25%
		0409140911265289		75.71	37.5	35.9	Levee	upland	11 - 25%
		0409140915405508		46.73	37.5	12.5	Levee	upland	1 - 10%
		0409140923094733		27.49	66.5	15.7	Tidal Marsh	wetland	11 - 25%
122	1	0508031221175144		216.66	2.2	7.8	Levee	upland	51 - 100%
123	1	0507291129395533		18.02	2.2	53.5	Levee	upland	26 - 50%
124	6	0508191326136129		186.70	2.2	148.3	Levee	upland	1 - 10%
		0508191332158659		974.99	8.5	120.4	Levee	upland	11 - 25%
		0508191504363797		221.04	9.4	153.4	Levee	upland	11 - 25%
		0508191511127253		795.23	8.9	144.8	Levee	upland	11 - 25%
		0508191540374686		587.83	30.4	100.2	Tidal Marsh	wetland	51 - 100%
		0508261220031059		1704.02	5.0	128.5	Levee	upland	11 - 25%
125	1	0508031229513361		5.90	2.8	12.0	Levee	upland	51 - 100%
126	3	050823141500872		48.39	17.5	5.8	Channel	wetland	26 - 50%
		0508171200482388		1543.84	3.0	13.6	Levee	upland	1 - 10%
		0508231056018333		34.55	16.1	4.5	Channel	wetland	26 - 50%

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127	2	0507291148483781		213.72	3.2	44.6	Levee	upland	26 - 50%
		0507291156013599		2.10	19.1	60.9	Levee	upland	11 - 25%
128	1	0503311243579033		43.28	3.2	5.1	Channel	wetland	1 - 10%
129	4	05082613290699		65.90	13.6	18.1	Tidal Marsh	wetland	1 - 10%
		0508261244289719		185.19	5.0	41.4	Levee	upland	11 - 25%
		0508261251414665		947.73	4.1	32.6	Levee	upland	11 - 25%
		0508261309201622		96.96	3.6	22.8	Levee	upland	1 - 10%
130	7	0507081012117416		1529.44	65.0	66.2	Levee	upland	51 - 100%
		0507081024084609		885.81	37.0	82.5	Levee	upland	26 - 50%
		0507201118182136		725.56	4.0	158.8	Levee	upland	26 - 50%
		0507201201119028		10500.42	27.5	36.0	Levee	upland	26 - 50%
		0507201229354448		0.00	35.1	219.4	Levee	upland	11 - 25%
		0507281028296929		1271.14	8.2	55.7	Tidal Marsh	wetland	26 - 50%
		0507281120333737		2845.59	3.6	62.0	Levee	upland	11 - 25%
131	1	0507291211529531		141.92	4.1	38.9	Levee	upland	51 - 100%
132	12	0503301319254771		2.97	11.7	4.0	Levee	upland	26 - 50%
		0503301327144652		240.62	12.4	4.0	Levee	upland	11 - 25%
		0505251118457651		1053.40	25.9	12.2	Wet Marsh	wetland	51 - 100%
		0505251129477586		846.82	40.7	4.1	Tidal Marsh	wetland	51 - 100%
		0505251149135744		105.27	37.6	2.2	Wet Marsh	wetland	11 - 25%
		0505251152499776		16.99	19.9	5.8	Wet Marsh	wetland	11 - 25%
		0505251157309670		147.97	53.3	5.7	Wet Marsh	wetland	26 - 50%
		0505251200498659		8.84	60.2	6.7	Wet Marsh	wetland	26 - 50%
		0506211115212644		15.09	12.4	4.0	Levee	upland	1 - 10%
		0506211121583900		49.51	4.1	12.2	Levee	upland	26 - 50%
		0506211131278565		5.85	10.3	2.2	Channel	wetland	11 - 25%
		0506211422558291		2.29	8.5	3.6	Levee	upland	51 - 100%
133	1	0507281258155941		1.17	4.1	578.0	Levee	upland	11 - 25%
134	1	0409011248132504		53.49	4.2	24.3	Levee	upland	11 - 25%
135	1	050726140456337		72.19	5.0	1.0	Levee	upland	11 - 25%
136	1	0507291133072766		325.72	5.1	49.9	Levee	upland	26 - 50%
137	2	0507291323586803		47.65	19.0	7.6	Channel	wetland	26 - 50%
		0508031318097739		34.23	6.7	5.0	Levee	upland	26 - 50%

Priority code	Number of weed occurrences within treatment patch	WIMS weed occurrence key	Restoration Site	Weed occurrence Area (m²)	Distance to nearest road or drivable levee (m)	Distance to nearest channel (m)	WIMS vegetation description	Distinction	Lepidium Cover Class
138	1	0505271223318057		368.06	7.3	15.7	Levee	upland	26 - 50%
139	1	0503301344533592		11.47	9.4	6.3	Levee	upland	26 - 50%
140	1	0503301314146424		16.33	10.2	0.0	Levee	upland	11 - 25%
141	2	0506171202234229		56.84	143.1	2.2	Channel	wetland	26 - 50%
		0506171205566154		146.04	137.4	0.0	Channel	wetland	11 - 25%
142	1	0506171219249347		47.29	114.8	0.0	Channel	wetland	26 - 50%
143	1	0507070952286956		0.32	125.9	0.0	Levee	upland	51 - 100%
144	1	0508161622454607		21.33	227.0	0.0	Channel	wetland	51 - 100%
145	1	0410061142342766		26.40	336.2	0.0	Channel	wetland	1 - 10%
146	1	0506171215048852		27.64	120.5	1.0	Channel	wetland	26 - 50%
147	5	0506171226581221		5.29	111.0	1.4	Channel	wetland	1 - 10%
		0506171229445597		15.22	98.5	5.0	Channel	wetland	11 - 25%
		0506171232218443		19.50	107.5	1.4	Channel	wetland	11 - 25%
		0506171236062717		32.70	108.5	2.2	Channel	wetland	11 - 25%
		0506211235006091		2.86	103.3	1.0	Channel	wetland	11 - 25%
148	4	050707095623920		128.77	120.6	1.0	Levee	upland	26 - 50%
		0507061403302180		161.93	92.7	5.0	Levee	upland	26 - 50%
		0507061410094671		107.38	106.1	4.0	Levee	upland	11 - 25%
		0507071001511019		1484.28	127.9	10.2	Levee	upland	26 - 50%
149	1	0506211256027700		9.71	117.0	1.0	Channel	wetland	11 - 25%
150	3	0411221203369567		193.73	175.8	1.0	Channel	wetland	11 - 25%
		0411221212329863		160.84	183.0	12.6	Channel	wetland	11 - 25%
		0411221223126783		121.94	156.8	14.0	Channel	wetland	26 - 50%
151	1	0408131126295591		84.84	151.3	1.0	Channel	wetland	26 - 50%
152	2	0511221054493739		1444.04	138.3	1.0	Channel	wetland	26 - 50%
		0511221107077787		280.95	133.5	11.4	Channel	wetland	26 - 50%
153	2	0409301136008483		837.74	226.7	1.0	Channel	wetland	11 - 25%
		0409301149408283		921.66	269.8	43.8	Wrackline	wetland	26 - 50%
154	1	0409301255188727		1648.51	18.1	2.0	Channel	wetland	51 - 100%
155	2	0506171135246945		88.38	54.8	2.8	Channel	wetland	26 - 50%
		0506171140468135		94.25	85.3	3.2	Channel	wetland	11 - 25%

Priority code	Number of weed occurrences within treatment patch	WIMS weed occurrence key	Restoration Site	Weed occurrence Area (m²)	Distance to nearest road or drivable levee (m)	Distance to nearest channel (m)	WIMS vegetation description	Distinction	Lepidium Cover Class
156	3	0506171145368624		161.85	131.2	2.8	Channel	wetland	26 - 50%
		0506171152491099		133.21	137.5	3.6	Channel	wetland	11 - 25%
		0506171158419493		55.67	147.8	2.8	Channel	wetland	26 - 50%
157	1	0506171253322369		346.49	60.4	2.8	Channel	wetland	11 - 25%
158	1	0506061130229227		132.41	90.0	2.8	Channel	wetland	26 - 50%
159	1	0507061123149789		3.65	79.4	3.0	Levee	upland	51 - 100%
160	1	0404211042574530		294.17	413.9	3.0	Tidal Marsh	wetland	1 - 10%
161	1	0409301304126058		213.08	23.0	3.0	Channel	wetland	26 - 50%
162	1	0506171127053111		247.23	61.3	3.2	Channel	wetland	51 - 100%
163	1	0511221045494849		24.32	272.1	3.2	Channel	wetland	11 - 25%
164	1	0409011338515828		95.04	43.8	3.2	Levee	upland	1 - 10%
165	1	0506171334202387		22.09	61.4	3.6	Channel	wetland	1 - 10%
166	2	0503301339045590		11.54	12.8	3.6	Levee	upland	11 - 25%
		0506171318251125		278.73	26.9	9.8	Channel	wetland	26 - 50%
167	2	0410211137595391		386.22	92.6	8.1	Wrackline	wetland	26 - 50%
		0411161022441814		440.85	115.7	3.6	Wrackline	wetland	11 - 25%
168	1	0409281029092242		10.56	69.6	4.0	Channel	wetland	1 - 10%
169	1	0506171240334347		68.94	115.9	4.1	Channel	wetland	11 - 25%
170	1	0507070935274935		13.31	140.7	4.1	Levee	upland	1 - 10%
171	2	0506171341201368		136.77	81.9	5.4	Channel	wetland	26 - 50%
		0506171345476962		5.41	75.0	4.5	Channel	wetland	1 - 10%
172	1	0409011205539180		343.91	153.3	4.5	Levee	upland	< 1%
173	1	051122104731225		51.44	221.0	5.0	Tidal Marsh	wetland	51 - 100%
174	2	0511221115093939		1642.85	238.4	5.7	Channel	wetland	26 - 50%
		0511221118162222		589.73	286.5	89.0	Wrackline	wetland	26 - 50%
175	1	0507061129357299		2.84	85.7	6.1	Levee	upland	26 - 50%
176	2	0409011215328965		3.52	118.1	16.8	Levee	upland	51 - 100%
		0409011236537275		72.06	81.3	6.3	Levee	upland	1 - 10%
177	1	0506171120282229		17.20	23.7	6.7	Channel	wetland	1 - 10%
178	2	0508261048508708		61.94	250.1	6.7	Tidal Marsh	wetland	11 - 25%
		0508261052182004		128.20	248.1	17.9	Tidal Marsh	wetland	26 - 50%

Priority code	Number of weed occurrences within treatment patch	WIMS weed occurrence key	Restoration Site	Weed occurrence Area (m²)	Distance to nearest road or drivable levee (m)	Distance to nearest channel (m)	WIMS vegetation description	Distinction	Lepidium Cover Class
179	1	0506171111429854		91.40	26.2	7.6	Channel	wetland	26 - 50%
180	1	040813113541560		337.64	56.5	7.6	Channel	wetland	26 - 50%
181	1	0507070929334124		7.89	136.5	8.5	Levee	upland	11 - 25%
182	3	050729130851164		1628.97	40.0	30.8	Tidal Marsh	wetland	51 - 100%
		0507291316052501		2.18	18.1	9.0	Channel	wetland	51 - 100%
		0507291318301151		60.86	19.0	9.0	Channel	wetland	51 - 100%
183	1	0508021247341509		1649.11	48.1	9.4	Channel	wetland	51 - 100%
184	2	050713120837919		25.82	36.1	58.9	Tidal Marsh	wetland	26 - 50%
		0507131149277733		1439.45	26.2	43.4	Levee	upland	26 - 50%
185	1	0409011332515380		179.34	152.2	27.8	Road	upland	26 - 50%
186	4	0409011159107607		1860.51	74.2	29.0	Levee	upland	< 1%
		0409011203449418		847.16	147.8	48.0	Levee	upland	< 1%
		0410061055149075		147.63	154.3	16.3	Levee	upland	11 - 25%
		0507131109411145		8.21	177.5	18.7	Levee	upland	51 - 100%
187	1	040901124541245		38.95	12.7	17.7	Levee	upland	26 - 50%
188	1	0409011209188017		15.50	146.4	17.1	Levee	upland	< 1%
189	1	0409140948411227		54.98	91.9	27.1	Levee	upland	11 - 25%
190	1	0409140939239785		1007.21	119.5	50.2	Levee	upland	51 - 100%
191	1	0507131220062331		66.78	95.0	121.0	Levee	upland	26 - 50%
192	3	040901131535672		113.52	136.5	52.6	Channel	wetland	51 - 100%
		0409011253493536		581.64	93.3	54.6	Levee	upland	51 - 100%
		0409011323134256		221.19	179.0	34.2	Channel	wetland	< 1%
193	1	0409011329147131		2101.64	169.4	43.1	Levee	upland	51 - 100%
194	1	0409140928174382		879.60	94.0	21.2	Levee	upland	51 - 100%
195	1	0409011343469051		102.31	12.0	59.9	Levee	upland	51 - 100%
196	1	04091410072262		68.70	324.6	17.5	Levee	upland	11 - 25%
197	1	0410061120376408		380.58	282.2	24.7	Levee	upland	11 - 25%
198	1	04111610414784		212.65	13.0	14.9	Levee	upland	1 - 10%
199	1	0508111210358230		452.66	18.4	41.8	Levee	upland	26 - 50%
200	1	0508111200144787		93.43	21.0	100.0	Levee	upland	26 - 50%
201	3	0508191119028603		5679.29	118.0	452.8	Levee	upland	11 - 25%
		0508191143254375		2931.31	88.5	397.9	Levee	upland	1 - 10%
		0508191317459411		4005.82	68.6	416.8	Levee	upland	26 - 50%

Priority code	Number of weed occurrences within treatment patch	WIMS weed occurrence key	Restoration Site	Weed occurrence Area (m²)	Distance to nearest road or drivable levee (m)	Distance to nearest channel (m)	WIMS vegetation description	Distinction	Lepidium Cover Class
202	1	0507281236493282		521.89	42.7	465.2	Levee	upland	51 - 100%
203	1	0507201257066187		0.00	58.0	186.2	Levee	upland	26 - 50%
204	1	0507080959014698		58.89	62.8	142.8	Levee	upland	26 - 50%
205	1	0409301325084627		75.06	363.0	47.2	Wrackline	wetland	51 - 100%
206	2	0409301326213763		108.17	361.1	56.9	Wrackline	wetland	11 - 25%
		0409301328577113		59.59	360.1	62.5	Wrackline	wetland	26 - 50%
207	1	0409301331579846		137.00	367.1	67.1	Wrackline	wetland	11 - 25%
208	1	0409301155053839		474.32	311.2	88.6	Wrackline	wetland	51 - 100%
209	2	0511221125118211		544.71	318.2	93.7	Wrackline	wetland	26 - 50%
		0511221133206566		1140.70	339.1	97.3	Wrackline	wetland	26 - 50%
210	1	0511221136285245		717.60	413.6	101.1	Wrackline	wetland	1 - 10%
211	1	0511221217145262		364.55	494.4	94.5	Wrackline	wetland	1 - 10%
212	1	0511221226287402		82.69	425.8	94.1	Wrackline	wetland	1 - 10%
213	1	0511221231353829		146.46	347.6	80.2	Wrackline	wetland	11 - 25%
214	1	0511221235289528		284.60	334.6	79.2	Wrackline	wetland	11 - 25%
215	2	0511171253027014		376.09	67.3	26.2	Wrackline	wetland	26 - 50%
		0511221255291267		277.80	89.7	53.7	Wrackline	wetland	11 - 25%
216	1	050823111538886		274.98	87.5	34.9	Wrackline	wetland	51 - 100%
217	3	0508231126462806		1073.07	196.5	93.1	Wrackline	wetland	26 - 50%
		0508231134498487		200.90	218.8	99.7	Wrackline	wetland	11 - 25%
		0508231140397414		290.74	220.0	97.7	Wrackline	wetland	11 - 25%
218	6	050816154303615		106.64	231.7	68.4	Wrackline	wetland	26 - 50%
		050823114714280		411.66	221.3	93.3	Wrackline	wetland	51 - 100%
		0508161546503075		253.47	220.1	80.5	Wrackline	wetland	51 - 100%
		0508161552239833		1286.95	213.0	88.4	Wrackline	wetland	51 - 100%
		0508231152454494		994.56	215.0	100.1	Wrackline	wetland	51 - 100%
		0508231200462706		3657.16	184.0	126.9	Wrackline	wetland	51 - 100%
219	1	0508161534287581		289.72	202.5	24.5	Wrackline	wetland	51 - 100%
220	3	050816152715235		125.99	187.7	69.4	Wrackline	wetland	51 - 100%
		0508161517291504		348.33	194.7	89.1	Wrackline	wetland	51 - 100%
		0508161522197332		248.79	198.0	88.6	Wrackline	wetland	26 - 50%

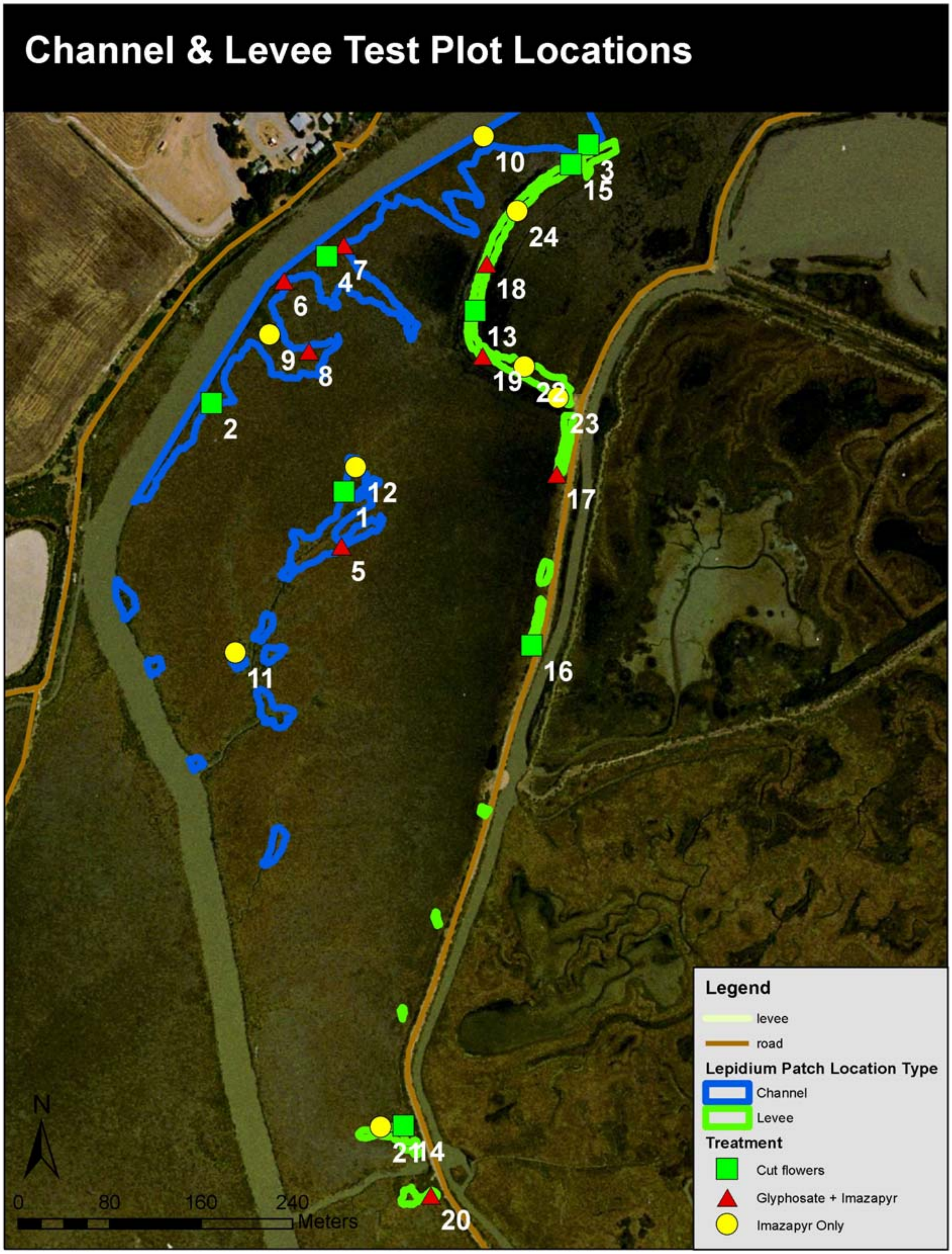
Priority code	Number of weed occurrences within treatment patch	WIMS weed occurrence key	Restoration Site	Weed occurrence Area (m²)	Distance to nearest road or drivable levee (m)	Distance to nearest channel (m)	WIMS vegetation description	Distinction	Lepidium Cover Class
221	5	0508161419537373		2218.98	205.1	115.0	Wrackline	wetland	51 - 100%
		0508161439107159		380.08	212.2	55.0	Wrackline	wetland	26 - 50%
		0508161445274014		370.11	196.8	29.0	Wrackline	wetland	51 - 100%
		0508161454066495		700.39	204.3	11.4	Wrackline	wetland	51 - 100%
		0508161512137171		242.81	208.1	52.2	Wrackline	wetland	26 - 50%
222	1	0404211032428298		7.66	300.2	35.5	Tidal Marsh	wetland	1 - 10%
223	1	0508161430479278		241.15	250.8	92.6	Wrackline	wetland	51 - 100%
224	1	05081616162421		253.46	282.8	16.1	Wrackline	wetland	11 - 25%
225	2	0508161626381628		407.95	301.6	47.9	Wrackline	wetland	26 - 50%
		0508161631199939		119.76	320.9	79.6	Wrackline	wetland	26 - 50%
226	1	050816163446393		362.73	287.3	64.6	Wrackline	wetland	26 - 50%
227	2	0508161640257937		302.84	220.5	50.4	Wrackline	wetland	11 - 25%
		0508231246078220		117.95	188.4	16.8	Channel	wetland	11 - 25%
228	1	0409301148291839		18.64	220.6	36.3	Tidal Marsh	wetland	1 - 10%
229	1	0511221217118133		422.71	444.3	117.5	Tidal Marsh	wetland	11 - 25%
230	2	0507291341597410		59.19	61.7	50.2	Tidal Marsh	wetland	26 - 50%
		0507291344498717		0.57	51.0	39.1	Tidal Marsh	wetland	51 - 100%
231	1	0506301144422558		20.48	18.7	25.0	Tidal Marsh	wetland	11 - 25%
232	1	0508191535263776		7.16	80.1	58.2	Tidal Marsh	wetland	1 - 10%
233	1	0508191531127791		139.37	81.0	73.8	Tidal Marsh	wetland	26 - 50%
234	1	05081915281161		12.74	93.2	59.7	Tidal Marsh	wetland	< 1%
235	1	0508191521097000		268.68	99.6	61.0	Tidal Marsh	wetland	1 - 10%
236	1	0508261017251775		233.70	108.9	67.1	Tidal Marsh	wetland	1 - 10%
237	1	0508261025258		64.21	160.3	65.2	Tidal Marsh	wetland	11 - 25%
238	1	0508261033034914		340.84	169.7	80.0	Tidal Marsh	wetland	11 - 25%
239	1	0508261039126638		30.51	197.6	87.6	Tidal Marsh	wetland	11 - 25%
240	1	0508261043516383		188.68	258.4	49.6	Tidal Marsh	wetland	11 - 25%
241	1	050826105600165		314.98	258.5	63.6	Tidal Marsh	wetland	11 - 25%
242	1	0508261102015095		2.46	272.3	13.4	Tidal Marsh	wetland	1 - 10%
243	4	0509091340523511		15.28	322.7	32.6	Tidal Marsh	wetland	1 - 10%
		0509091344399439		99.68	318.8	51.9	Tidal Marsh	wetland	1 - 10%
		0509091350125166		104.30	316.6	34.4	Tidal Marsh	wetland	1 - 10%
		0509091353451110		3.22	329.5	35.8	Tidal Marsh	wetland	1 - 10%

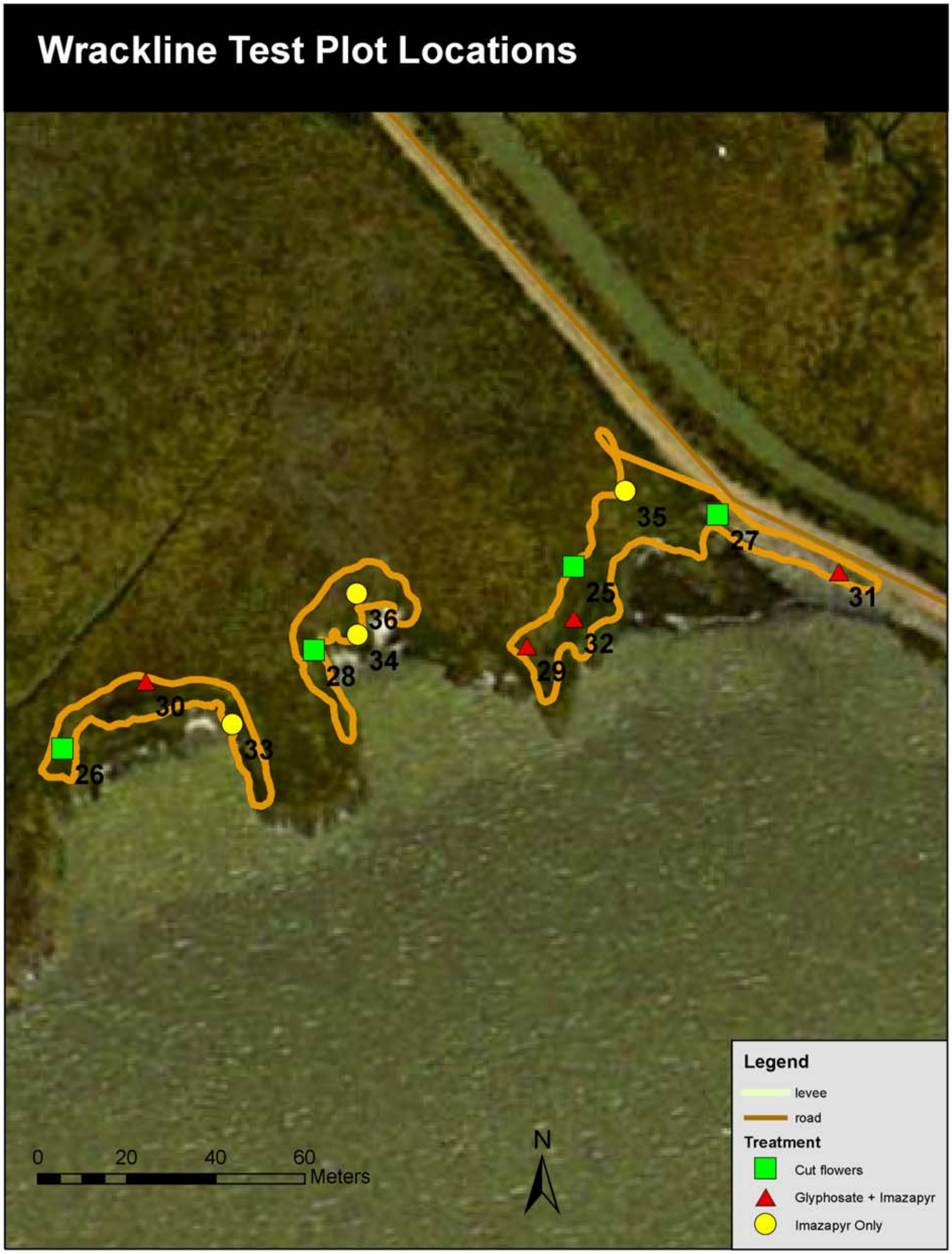
Priority code	Number of weed occurrences within treatment patch	WIMS weed occurrence key	Restoration Site	Weed occurrence Area (m²)	Distance to nearest road or drivable levee (m)	Distance to nearest channel (m)	WIMS vegetation description	Distinction	Lepidium Cover Class
244	1	0404211051243801		25.03	489.1	60.9	Tidal Marsh	wetland	1 - 10%
245	1	0408131020307156		514.33	200.4	15.3	Channel	wetland	26 - 50%
246	1	0411221139388445		2481.36	167.1	21.5	Channel	wetland	26 - 50%
247	2	050617130836167		5.49	61.8	24.2	Channel	wetland	1 - 10%
		0506171306017648		7.89	71.0	24.4	Channel	wetland	1 - 10%
248	2	0508021257528318		271.99	84.9	18.8	Channel	wetland	51 - 100%
		0508021303349291		240.83	105.9	16.6	Channel	wetland	26 - 50%
249	1	0409011351095002		35.73	38.9	26.4	Channel	wetland	1 - 10%
250	1	0410061107478206		77.46	198.1	22.0	Channel	wetland	1 - 10%
251	1	0410061122358860		0.53	227.7	20.6	Channel	wetland	51 - 100%

APPENDIX II

Adaptive management monitoring plot vegetation type stratifications, treatments, and locations.

Vegetation Type	Treatment	Plot ID	UTM 83 X	UTM 83 Y
Channel	Cut flowers	1	548081.8232	4219788.725
		2	547965.9119	4219866.257
		3	548295.9103	4220093.057
		4	548066.976	4219994.946
	Glyphosate + Imazapyr	5	548079.6298	4219740.879
		6	548029.2786	4219973.441
		7	548081.8154	4220004.838
		8	548051.3454	4219911.699
	Imazapyr Only	9	548016.6923	4219926.335
		10	548203.9433	4220100.087
		11	547986.7315	4219647.437
		12	548092.1471	4219810.109
Levee	Cut flowers	13	548196.8065	4219947.174
		14	548133.8841	4219232.928
		15	548280.6734	4220075.222
		16	548246.2299	4219653.808
	Glyphosate + Imazapyr	17	548267.9512	4219803.995
		18	548206.768	4219988.298
		19	548203.3792	4219907.314
		20	548158.1817	4219171.832
	Imazapyr Only	21	548113.8275	4219231.762
		22	548239.6417	4219898.228
		23	548269.3177	4219870.912
		24	548233.4753	4220034.437
Wrackline	Cut flowers	25	548256.0921	4219012.807
		26	548141.2489	4218971.910
		27	548288.4967	4219024.504
		28	548197.748	4218994.063
	Glyphosate + Imazapyr	29	548245.5773	4218995.004
		30	548159.9027	4218987.095
		31	548315.7558	4219011.637
		32	548256.1836	4219001.107
	Imazapyr Only	33	548179.4143	4218977.516
		34	548207.5367	4218997.47
		35	548267.668	4219029.819
		36	548207.3309	4219006.711


Channel & Levee Test Plot Locations
10
3
15
24
7
4
18
6
13
9
8
19
22
23
2
12
1
17
5
16
11
21
14
20
N
0
80
160
240
Meters
Legend
levee
road
Lepidium Patch Location Type
Channel
Levee
Treatment
Cut flowers
Glyphosate + Imazapyr
Imazapyr Only


Wrackline Test Plot Locations
35
27
25
31
36
32
34
29
28
30
33
26
0
20
40
60
Meters
N
Legend
levee
road
Treatment
Cut flowers
Glyphosate + Imazapyr
Imazapyr Only