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INTEGRATED PEST MANAGEMENT PLAN

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Summary

Guiding Principles

Following the lead of other public entities such as the City of Irvine and Irvine Unified School District, Irvine Ranch Water District (IRWD or District) is implementing this Integrated Pest Management (IPM) Plan, which focuses on long-term prevention or suppression of pests while protecting human health, the environment, and nontarget organisms. The District — steward of numerous facilities, wetlands and habitat, much of which is maintained in a native, natural state — adopts this organic-first policy for landscaping and pest control, with specific limitations on the use of pesticides and chemicals.

This IPM Plan includes the following components:

- A framework for implementing IPM practices at IRWD facilities and properties
- Consistency with other Orange County-area agencies' IPM approaches
- Training of staff to encourage a mindset of progressive pest-management principles
- Making the Integrated Pest Management program public (transparency)
- Monitoring and reporting of actions associated with implementation of the IPM Plan

Core Elements

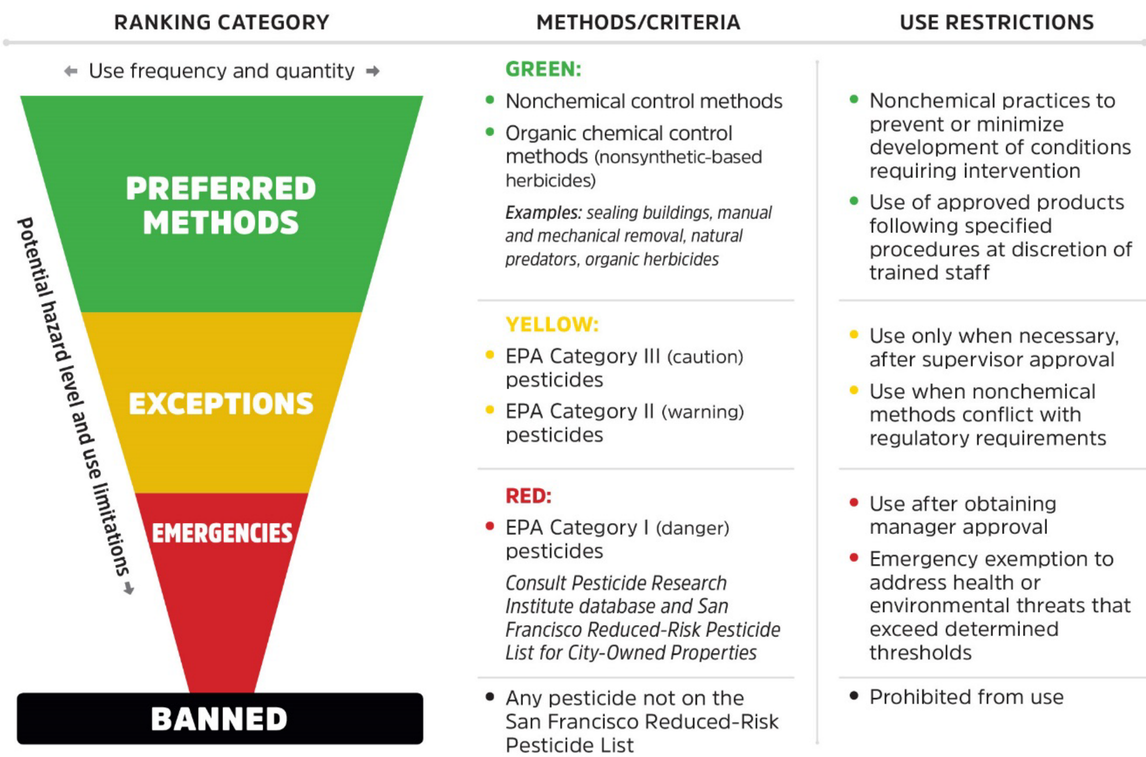
The focus of this IPM Plan is on the pesticides (rodenticides and herbicides) that are used to control insect pests and noxious weed infestations at IRWD facilities. The purpose of this plan is to guide the use of environmentally sensitive pest management strategies and least-toxic control methods at facilities maintained and managed by IRWD. IPM is defined as managing pests (plants, fungi, insects, animals) in a way that protects human health and the surrounding environment in an economically responsible way through the most effective, least-risk option. Core elements of IPM include:

- Pest prevention to avoid the use of pesticides or other pest-control methods
- Nonchemical methods as first choice for pest control
- Use of nonsynthetic-based herbicides, referred to in this plan as organic
- Use of chemicals and pesticides only in target locations and for targeted species

- Never use EPA Category I or II pesticides or glyphosate in parks, playgrounds or other areas where the public congregates
- Routine inspection, reporting and monitoring
- Transparent communication

When pest prevention is unsuccessful or when noxious weeds have already established, the approach to eliminate these species from an area should follow a systematic decision-making process. As depicted in **Figure 1**, use of nonchemical control methods should first be exercised. When physical control methods are not an option, organic control methods may be needed. High-potential-hazard pesticide applications may only be considered in emergency situations that present a public health or environmental threat.

Figure 1: IRWD Pesticide Ranking and Use Categories



1.0 Introduction

Integrated pest management (IPM) is a process for efficiently managing pests while protecting human health and environmental quality. IPM is a long-term, science-based, decision-making system that uses a specific methodology to manage damage from target pests. IPM requires monitoring site conditions before, during, and after treatment to determine if objectives are being met and if methods need to be revised. IPM requires that nonchemical methods be considered before resorting to chemical methods (i.e., pesticides, herbicides, insecticides). If chemical methods are necessary to meet a pest-control objective, the potential for harm to the public, workers, wildlife and water quality are carefully considered, as are effects on the environment and nontarget organisms; and then the least toxic and most effective, efficient, and target-specific method is chosen.

IPM promotes the use of a range of preventative and nonchemical approaches to control pest populations and stave off infestation. If an infestation with unacceptable impacts occurs, warranting additional treatment, an IPM approach will favor the use of "least-toxic" pesticides. The targeted application of a toxic pesticide is allowed only after all other reasonable nonsynthetic options are exhausted. This plan outlines preventative best practices and pest-control strategies approved for use at IRWD facilities and properties.

This IPM program emphasizes pest prevention as a first approach, followed by actions to discourage or reduce pest populations from reaching levels where active control may be required. Tolerance levels are described to help staff determine when pest populations have reached levels where active pest control should be considered. Pest treatment options are provided, including the most effective and most environmentally friendly options by pest type. Monitoring and adaptive management principles are provided to help ensure improvements in efficiency and effectiveness of pest control over time.

2.0 IPM Guidelines

This plan will guide staff in defining, preventing, and managing pests on IRWD's managed lands.

2.1 Goals

IPM Goal 1 — Minimize the impact of site-management practices on the local environment, and minimize the exposure of the public, staff, maintenance personnel and wildlife to potentially hazardous chemical, biological and particle contaminants.

IPM Goal 2 — Control pests through consistent implementation of IPM principles to protect and restore the natural environment and provide for human safety and enjoyment while visiting and working on IRWD lands.

2.2 Objectives

IPM Objective 1 — To limit potential human health challenges associated with pest activity.

IPM Objective 2 — To limit aesthetic and economic damage to IRWD facilities associated with pest activity.

IPM Objective 3 — To prevent the establishment and spread of pests within IRWD facilities and in the adjoining landscape, while minimizing impacts on sensitive biological resources, including nesting birds, state- and federally protected plants and wildlife, native vegetation communities, wetlands and regulated water bodies, and water quality.

IPM Objective 4 — To manage pest populations in a manner consistent with the City of Irvine Public Works Department's Integrated Pest Management, the Irvine Unified School District's Progressive Pest Management Program, the IRWD Natural Treatment System Master Plan, and the Nature Reserve of Orange County Best Management Practices for Implementation of Invasive Plant Control for Resource Management.

IPM Objective 5 — To conserve and promote beneficial organisms and natural processes that inherently suppress potential pest populations.

2.3 Strategies

IPM Strategy 1 — Implement long-term management of pests through sustainable prevention or control practices, using a systematic approach that prioritizes nonchemical management practices and organic chemicals. Use of EPA Category I-III nonorganic chemicals (as defined in Section 4.7) will be through an environmentally sensitive and targeted approach as deemed necessary to protect public health, protect the environment, or avoid significant economic loss when pests cannot be managed feasibly by other methods.

IPM Strategy 2 — Take appropriate actions to prevent the introduction of new pest species to IRWD facilities, especially new invasive plants in natural areas.

IPM Strategy 3 — Implement pest prevention practices to avoid the use of pesticides or other pest-control methods. Use nonchemical methods as a first choice for pest control, and limit the use of chemical methods to situations where nonchemical methods are ineffective, conflict with environmental laws and regulations, or are cost prohibitive. When chemical pesticides are required, emphasize very-low-potential-hazard, organic pesticides and only use more potentially hazardous pesticides as necessary to protect public health and financial feasibility.

IPM Strategy 4 — Manage pests using a systematic approach that includes:

1. Develop tolerance levels for pests within IRWD facilities to determine when to undertake pest control.
2. Identify the pest, determine its life cycle and disruptive potential, and identify relevant site conditions before implementing a pest-control activity.
3. Incorporate a landscape-scale perspective to manage native habitats, while choosing site-specific strategies and times of treatment that provide the best combination of protecting resources, human health, and nontarget organisms and that are efficient and cost-effective in controlling the target pest. Wherever feasible, direct the control method narrowly at the most vulnerable point in the target organism's life cycle to avoid broad impacts.
4. Monitor results and modify control methods over time as site conditions and treatment techniques change and as needed to obtain an effective level of control.
5. Use the least environmentally disruptive method(s) to control identified pests. Where the use of pesticides is necessary, apply according to the label using all safety precautions and take all measures needed to protect the environment, the health and safety of visitors, employees and neighbors, and the surrounding natural areas — including water and soil resources.

6. Plan for repeat treatments, while implementing a combination of nonchemical, organic chemical, and nonorganic chemical methods as indicated by the pest's regenerative capabilities.
7. If eradication of a pest from a distinct location is not feasible, apply measures to achieve containment, sustained control, slow down a pest's rate of spread, or minimize pest damage.

IPM Strategy 5 — Monitor pest occurrences and results of control actions and use adaptive management to improve results, while using innovative management practices through collaboration with colleagues in the region and elsewhere who are managing similar issues.

3.0 Coverage Area

IRWD owns, operates and maintains more than 170 facilities in Orange County, including wetlands and habitat, much of which is maintained in a native, natural state. IRWD's facilities are variably accessible to the public. For example, as described below, the San Joaquin Marsh and Wildlife Sanctuary includes educational facilities and walking trails that are open to the public. Treatment facilities such as the Michelson Water Recycling Plant have limited public access areas. Storage facilities such as Rattlesnake Reservoir and Syphon Reservoir are secured with fencing and not open to the public.

3.1 San Joaquin Marsh

The IRWD San Joaquin Marsh and Wildlife Sanctuary encompasses more than 300 acres of coastal freshwater wetlands, half of which have been restored to a natural state. The wetlands are a critical component of IRWD's Natural Treatment System, as they naturally clean urban runoff from San Diego Creek and help to protect the environmentally sensitive Upper Newport Bay. After interacting with the bulrush and other plants for seven to ten days, up to 70% of the nitrogen is removed. The cleaner water is returned to the creek to continue its journey to Upper Newport Bay and the ocean. The Marsh is full of educational opportunities serving as a living laboratory for students, teachers and the public. In cooperation with Discovery Cube Orange County and the local chapter of the National Audubon Society, people can enjoy a variety of wildlife educational programs and tours, including an active school field trip program.

3.2 Rattlesnake Reservoir

Rattlesnake Reservoir is a recycled water storage reservoir owned and operated by IRWD. It formerly was used to supply water for agricultural irrigation. The reservoir retains most dry and wet weather flows.

3.3 San Joaquin Reservoir

San Joaquin Reservoir was built in 1966 and was originally used as a drinking water reservoir by seven cities and water districts. The reservoir is currently used to store recycled water. It provides 3,080 acre-feet (about one billion gallons) of seasonal storage. Operation of the reservoir maximizes storage during the winter months when irrigation demands are lower. Water is then withdrawn in the summer months to provide landscape irrigation water for Irvine, Newport Coast and portions of Newport Beach.

3.4 Sand Canyon Reservoir

Sand Canyon Reservoir is adjacent to the Strawberry Farms Golf Club near the San Diego (I-405) Freeway. The reservoir has a surface area of 42 acres, a storage capacity of 768 acre-feet and an average depth of 18 feet. The watershed area is approximately 6.7 square miles (4,288 acres). The reservoir is used for both seasonal and operational storage.

3.5 Syphon Reservoir

Syphon Reservoir, in northern Irvine, began operations in 1949 and historically was used to store irrigation water. It has been integrated into the IRWD recycled water system as a seasonal storage facility, with a capacity of 535 acre-feet (174 million gallons).

3.6 Natural Treatment System

IRWD's Natural Treatment System is a cost-effective, environmentally sound method for treating dry-weather runoff. Natural Treatment System sites are modelled after the successful system of natural treatment ponds that remove nitrogen, phosphorus and bacteria from surface water entering the IRWD San Joaquin Marsh. The Natural Treatment System sites work much like the San Joaquin Marsh, only using smaller man-made wetlands placed strategically throughout the San Diego Creek Watershed. Low-flow natural and urban runoff, as well as smaller storm flows, are diverted into these man-made wetlands, where contaminants are removed and prevented from reaching the Upper Newport Bay.

4.0 Procedures

A successful IPM program relies on a systematic approach in controlling target organisms, which begins with ongoing prevention through organic and nonsynthetic approaches for controlling invasive species that can threaten natural environments. Identifying a pest problem at an early stage is critical for controlling pest infestations, which can be accomplished by training maintenance personnel on pest identification. Moreover, the local environment for which a pest problem exists must be taken into consideration when identifying the threshold of pest tolerance and the best approach for implementing control methods (i.e., nonchemical, organic or chemical). For example, IRWD facilities that provide public access, such as some portions of the San Joaquin Marsh, have a greater potential of human exposure to chemical pesticides than facilities with limited public access. Similarly, natural areas that support native habitats for endemic flora and fauna are more susceptible to chemical pesticide controls than IRWD facilities, which are more compatible with chemical pesticides because they are situated in urban areas or support limited natural habitat. Pest-control methods should be consistent with IPM guidelines that are being implemented by other local entities, such as the City of Irvine, Irvine Unified School District, and the U.S. Fish and Wildlife Service and California Department of Fish and Wildlife Orange County Natural Community Conservation Plan (NCCP)/Habitat Conservation Plan (HCP) areas. Last, the chosen approach for controlling pests must not conflict with local, state or federal regulations that protect sensitive biological resources, such as the federal Migratory Bird Treaty Act of 1918, the Clean Water Act, and the state and federal Endangered Species Acts.

4.1 Prevention

IPM focuses first on preventative actions. Preventative actions include modifying human behavior and land use practices to minimize conditions that favor invasive species infestation and establishment. When combined with landscape-level invasive-species monitoring and early detection/rapid-response methods, this approach ensures that invasive species can be managed when the populations are small, and before they are too large to manage using nonsynthetic strategies. The following procedure will be implemented as Best Management Practices (BMPs) for preventing the uncontrollable spread of invasive plant and wildlife species.

4.1.1 Invasive Plant Species

- To ensure sanitation and prevention of contamination, all personnel working in infested areas will take appropriate precautions not to carry or spread weed seed or sudden-oak-death-associated spores outside of the infested area. Such precautions will consist of — as necessary based on site conditions — cleaning of soil and plant materials from tools, equipment, shoes, clothing, or vehicles before entering or leaving the site.
- All staff and contractors will be properly trained to prevent spreading weeds and pests to other sites.
- IRWD staff will appropriately maintain facilities where tools, equipment, and vehicles are stored free from invasive plants.
- IRWD staff will inspect rental equipment and project materials (especially soil, rock, erosion-control material, and seed) to confirm as much as possible that they are free of invasive plant material before their use at a worksite.
- Suitable onsite disposal areas will be identified to prevent the spread of weed seeds.
- Invasive plant material will be rendered nonviable when being retained onsite. Staff will desiccate or decompose plant material until it is nonviable (partially decomposed, very slimy, or brittle). Depending on the type of plant, disposed plant material can be left out in the open as long as roots are not in contact with moist soil, or can be covered with a tarp to prevent material from blowing or washing away.
- Monitor all sites where invasive plant material is disposed onsite and treat any newly emerged invasive plants.
- When transporting invasive plant material offsite for disposal, the plant material will be contained in enclosed bins, heavy-duty bags, or a securely covered truck bed. All vehicles used to transport invasive plant material will be cleaned after each use.

4.1.2 Invasive Wildlife

- Eliminate food sources and places of refuge.
- Stringent waste disposal practices should be observed — secure all waste in closed containers and not just plastic bags.
- Keep grounds free of high weeds, trash, old equipment and debris, because these conditions create ideal harborage for rodents.
- Maintain building exteriors in good repair with no holes or openings larger than ¼ inch, including windows, doors, fans, vents, etc., to keep pests from entering the building.
- A gravel strip around foundations at least 2 feet wide and 6 inches deep of 1-inch gravel or larger discourages rodent burrowing and other insect nesting.
- Remove and avoid planting ivy or vines, which provide shelter and food sources for rats and other urban pests.
- Doors are particularly vulnerable to rodent entry, so ensure that external doors and windows close tightly with no gaps at the bottom.
- Various items can be installed to prevent rodents from climbing downspouts and pipes, including flap valves or screens in downspouts, 12-inch-diameter downward-facing cones or 18-inch-diameter discs, or a 12-inch band of glossy paint on exterior vertical pipes. Galvanized sheet metal can be used to create climbing barriers and exclude rats from travelling up vertical posts.

4.2 Identification

Preventing the introduction of invasive species is the first line of defense against invasions. However, even the best prevention practices will not stop all invasive species introductions. Early detection is a critical element in successful and economical eradication of weeds and exotic pests before they become permanently established in new localities.

Early detection monitoring can be accomplished by staff or contractors. The use of existing natural resource management and maintenance staff provides the best value for IRWD. With limited training, existing staff resources can be used and repurposed for early detection monitoring at minimal additional cost although it will not be a comprehensive effort. Detecting a new arrival can sometimes be a challenge since very few people have adequate training to identify foreign and unfamiliar species. However, IRWD staff and contractors can be trained to be familiar with IRWD habitats to identify and report invasive pest species.

Early detection and identification programs should include:

- Identification of potential threats in time to allow control or mitigation measures to be taken. All sites should be monitored monthly to note any new infestations. Yellow sticky traps should be placed in any areas with the potential for ecologically harmful insects, so harmful insects can be identified before signs and symptoms are observed;
- Detection of invasive species in time to allow efficient and safe eradication or control decisions to be made;

- Response to invasions to prevent the spread and permanent establishment of invasive species; and,
- Adequate and timely information to decision-makers, the public, and/or partner agencies concerned about the status of invasive species within an area.

Ranking of typical pathways of invasive species introductions within IRWD facilities:

1. Dissemination from nearby established populations
2. Introduced disturbances into natural areas
3. Vehicles and heavy equipment from outside IRWD
4. Materials importation for construction (e.g., soil, gravel, straw wattles, etc.)
5. Work activities along rights-of-way adjacent to IRWD facilities
6. Work activities of IRWD employees or contractors
7. Visitors hiking off established trails
8. Adverse change in weather, such as prolonged drought or precipitation
9. Wildlife
10. Grazing lessees/livestock

4.3 Thresholds

Tolerance levels vary greatly for invasive species; some species have much greater impacts on the environment than others, or they may be so completely mixed with native species that control methods would result in unacceptable damage to native habitats or rare species, or simply be technologically impossible. IRWD's IPM approach for invasive species begins with establishing site-specific conservation goals, leading to a determination of the targeted actions with which specific individuals or populations can be managed to achieve the stated goals. In addition, thresholds for control methods may vary from facility to facility depending on the surrounding landscape (i.e., urbanized or undeveloped) and the potential for humans and wildlife to be negatively affected, such as by chemical control methods. For example, IRWD facilities that provide for no or limited public access have a higher tolerance for chemical pesticide applications to control pest infestations than facilities with public access.

Tolerance levels and treatment methods for invasive species are based on the potential of the invasive species to degrade wildlife habitat and other natural resources to the extent that the long-term stability and resiliency of natural areas are compromised. Staff must consider worker health and safety, visitor safety, and the technical feasibility of meaningful control (i.e., a cost/benefits analysis). Because many of IRWD's invasive species populations are present throughout the entire region, scale is an important variable in determining the feasibility and need for control and the selection of a treatment method. Unlike pest management in structural landscapes, invasive species tolerance levels must factor in the scale at which a management tool is both appropriate and effective. Treatments such as removal by hand may have minimal negative unintended impacts when a few individuals are removed, but substantially greater impacts (e.g., soil erosion, damage to nontarget species, or injury to staff) when the same treatment is applied to large areas. Similarly, the control of large populations of invasive species, most notably non-native plants, using mechanical control methods can be cost prohibitive, impractical, and dangerous. The population size and habitat conditions for which each management technique is useful and appropriate is discussed below. Tolerance levels not only differ by species, but also by location and spatial scales. All treatment method selections will balance the net negative impacts between the natural environment and humans.

Tolerance levels for insipient and widespread invasive plants in common, widespread natural communities (e.g., yellow star-thistle [*Centaurea solstitialis*] in annual grasslands) will be established on a case-by-case basis by comparing the anticipated benefit against the cost and potential for success of the target invasive control efforts. When tolerance levels are exceeded, IRWD staff will assess whether active control is feasible by conducting a quick cost/benefit analysis. If staff determines that control is technically feasible and can be accomplished using existing staff and viable budgeting parameters, the area will be targeted for treatment.

California Invasive Plant Council (Cal-IPC) (cal-ipc.org) has established a system for ranking noxious weeds as high, moderate, or limited. These rankings take into consideration economic, ecological, and human health effects. Plant species designated as invasive will receive focused attention and will be considered priority species, with the greatest priority on designated high species, followed by moderate, limited, and unlisted noxious weeds, respectively. Species on Cal-IPC's "Watch" list should also be prioritized among other non-natives, because although these species are not currently listed as invasive in California, assessment has found them to be a high risk for becoming invasive.

4.4 Maintenance

All areas that have been determined to have invasive plant species and other problematic non-native plants should be maintained at regularly scheduled intervals. Maintenance is crucial to ensure weeds and other pests do not spread and become a larger problem. Maintenance should be determined, in large part, by the species that need to be managed in any given area. Seasonal timing is crucial to reduce the seedbank, which, depending on the species, can remain viable in the soil for as little as one year to as long as 50 years or more (such as Russian thistle [*Salsola ragus*] or black mustard [*Brassica nigra*], respectively). Plants should be removed, cut, or otherwise treated before the species sets seed. Seasonal timing is crucial, as various species set seed at different times.

While the large majority of species set seed in spring or summer, some species do set seed in fall and even winter. For any weed species, the best time to manage for the species is as early in the vegetative state as possible, preferably during the seedling phase. During this time, the root system is smaller and easier to remove in its entirety, thus decreasing the chances it will regrow; in addition, managing a plant early in the vegetative state ensures the plant is farther from flowering and setting seed. If this is not possible, many annuals and younger perennials can be cut with a string trimmer or mowed after bolting, and before flowering. Most species will require a *minimum* of two (often requiring more) trimming or cutting events to ensure the plant does not set seed.

Maintenance of natural lands, drainages, facilities, and other IRWD properties is essential to minimize the need for chemical control once a hardy invasive has established in an area.

4.5 Monitoring

IPM requires monitoring site conditions before, during, and after treatment to determine if objectives are being met and if methods need to be revised. Tracking and monitoring of these ongoing projects will be important to determine if treatment is effective and at what stage treatment methods should be adjusted. Timing is crucial to control plant populations because weeds must be removed, cut, or treated at or before flowering to ensure seed does not set. Sites should be visited monthly. At these monthly events, the following should be recorded: date of examination, pests found, size and extent of the infestation, location of the infestation, control options used, effectiveness of the control options, and labor and material costs. Ongoing pest control projects will be summarized in an Annual IPM Report and tracked for staffing, costs, and adaptive management (effectiveness of selected pest control) purposes.

4.6 Nonchemical Control Methods [**Preferred**]

Small infestations of invasive species generally permit the greatest number of treatment method options for successful eradication. Many times, hand removal of individuals is the control method with the greatest selectivity and cost effectiveness with the least indirect impacts. Individual specimens or small patches identified incidentally or during regular monitoring can often be immediately removed. For vegetation removal, hand digging, cutting, or pulling are all examples of selective hand removal. For vertebrate species, hand removal usually means trapping and relocation. Small-scale removal is most effective on newly established and small populations with limited distributions.

4.6.1 Physical Control

A variety of physical methods exist to treat non-native plant species, including manual removal, mechanical removal, mulch, solarization, and flaming. These methods are often used in combination to best control non-native plant species. Physical control methods — such as trapping — can also be applied to animal pests.

4.6.1.1 Manual Removal

Manual removal involves hand-pulling and the use of hand tools such as shovels or hoes. Hand-pulling or using manual hand tools can be very effective with plant species that cannot survive once the root crown is removed from the ground. Success at removing the root crown can depend on clay content and moisture of the soil, as well as the root structure of the species.

Some invasive species can be killed via hand-pulling, as can many other species when the plant is young and its root structure is not fully developed (Bossard et al. 2000). Seedlings can be successfully controlled via hand-pulling; for mature individuals, hand digging should be incorporated to ensure the majority of the root is removed. The above-ground parts should be removed with string trimers or loppers and the crown and top portion of the roots dug out with a shovel; the remains should be removed from site to prevent resprouting.

Although manual removal of weeds can be used to control many non-native infestations, it can be labor-intensive and costly; therefore, it is best used for interspersed weeds throughout native habitat or to control small, weedy patches. Removing invasive species via hand pulling or hand tools is most effective when the seedlings first emerge. Deep-rooted invasives are difficult to remove once the roots are established. When using manual removal, extra caution should be taken in newly established restoration sites or in the vicinity of small or delicate native forbs because of soil disturbance and trampling that may occur, especially if performed by multiple people (e.g., large crews).

4.6.1.2 Mechanical Removal

Mechanical removal includes the use of chainsaws, mowers, and string trimmers. Mechanical removal is necessary to remove trees, large shrubs, stumps, and extensive root systems, as well as to cut large infestations of annual weeds before seed set. Deep-rooted plants such as the Brazilian peppertree (*Schinus terebinthifolius*), eucalyptus (*Eucalyptu*s spp.), tamarisk, and other invasive trees and shrubs can be controlled either by removal of the entire above- and below-ground plant and root system or a combination of mechanical removal, stump grinding, and/or chemical application (Bossard et al. 2000). Because some species such as the Brazilian peppertree can crown sprout, the entire stump must be either completely removed and the stump chipped, or cut and painted with an herbicide (nonsynthetic preferred). Above- and below-ground biomass should be chipped and left in place to allow for nutrient cycling and carbon sequestration. Care must be exercised to not damage areas of natural habitat during mechanical removal.

Some annual grasses and forbs, including thistles (*Centaurea* spp., *Carduus* spp., *Silybum* spp., etc.) can be well controlled with mowing and string trimming. This method is relatively fast and cost effective. However, if conducted too early in the season, this method will not inhibit growth and the plants will grow back. Only after the plant has flowered will mechanical removal of the above-ground plant weaken the plant enough that regeneration cannot occur. This method is best performed when no more than 2% to 5% of flower heads are seeding to avoid seed deposition into the soil (Bossard et al. 2000). Mowing or string trimming may be needed up to three times in the first year of treatment. However, in subsequent years, a single treatment should be sufficient.

Published studies have shown that in highly invaded, degraded systems, mowing may be only partially successful in controlling weeds, and therefore, sometimes this method is used in combination with herbicides to better control annual weeds (Cox and Allen 2008). For example, mowing or trimming may be used to reduce the seed bank before active habitat restoration, which may include herbicide use. It is important to note, however, that in areas with extensive, well-established infestations, the seed bank may persist for a significant time, and mowing may be required for several years before active restoration efforts.

Mechanical weed abatement is a nonsynthetic method; however, it can be labor-intensive and costly. Often, controlling non-natives through physical means requires multiple methods to be used in conjunction with one another. For example, the UC Weed Research and Information Center recommends hand pulling Mexican fan palms and Canary Island date palms when they are very young. Larger trees should be cut at the base with a chainsaw, followed by solarization of the remaining trunk.

4.6.1.3 Mulch

Mulch limits weed development by limiting light transmittance and by promoting healthy soil temperature and moisture. Mulch can take many forms: living plant ground cover; a loose covering of organic or inorganic matter such a wood chips, leaves, straw, rocks, or shredded rubber; or sheets of artificial or natural material. Mulch appropriate for native habitat management would consist of organic materials. Mulch offers many benefits including reducing evaporation and maintaining soil moisture, maintaining soil temperature, preventing erosion, enriching the soil, and reducing weed development.

Mulches must be free of weed seed and disease. Hay should be avoided because the seeds may sprout, resulting in the introduction of unwanted weed species. Grass clippings should be avoided since the grass may have been treated with herbicides or remnants of other synthetic-based lawn products.

Compost has been used as an effective weed barrier. Unfinished compost applied to the soil will use soil nitrogen, robbing any emerging plants of the nitrogen source, effectively killing emerging seeds. Once the composting process has finalized, these nutrients eventually become available to plants as the material is further degraded and those nutrients are slowly released. Finished compost, applied as a mulch, is also commonly used. Compost promotes improved soil structure and water holding capacity, reduces erosion, sequesters toxins, and can degrade toxic chemicals. Ultimately, adding a carbon source improves carbon sequestration and provides a long-term food source to build the soil biota responsible for nutrient cycling. To be effective in the suppression of annual weed emergence, mulch must be at least three inches deep and replenished annually.

The disadvantage of using mulch is that it is heavy and hard to transport. Labor costs can be high in transporting it to remote locations and spreading it over large areas. In addition, as the material breaks down, it may need to be reapplied periodically until native plants grow in enough to outcompete the weeds. Also, while mulch has been proven to minimize annual weed development, it has not been proven effective against deep-rooted perennial weeds that have already emerged (Bond and Grundy 2001). Mulch may also be less effective to suppress very dense infestations of annual weeds.

4.6.1.4 Soil Solarization

Soil solarization is another form of physical control; it uses radiant heat captured by the sun to produce high temperatures to kill weed seeds, seedlings, pathogens, and other soil-borne pests. This method involves covering an area with a clear plastic tarp for four to six weeks during a hot, sunny time of the year, with the aim of heating up the top 18 inches of soil. The soil must be moistened before laying tarp to increase heating. Solarization leaves no toxic residue, can kill pathogens, and can have a composting effect if properly prepared, increasing the rate of organic material breakdown. Post-solarized soil has been shown to increase the rate of plant growth and plant health, which is attributed to decreased weed competition and increased availability of soluble nutrients (Stapleton et al. 2008).

Appropriate soil-heating is essential to ensure weed seed and pathogen mortality. The top 6 inches of soil receives the greatest effect and, when done properly, can reach 140°F, while temperatures at

18 inches reach between 90°F to 98°F (Stapleton et al. 2008). However, most pathogens and weeds are killed after soil temperatures are maintained at about 130°F for three consecutive days.

Because the effective depth of control may be limited, hard-seeded annual weeds and perennials with buried vegetative organs are unlikely to be killed. If there is no soil disturbance after treatment, weed control may remain effective for two seasons (Bond and Grundy 2001). Soil temperatures should be monitored during solarization to ensure effectiveness of the treatment. In addition, solarization may also result in the mortality of beneficial soil organisms, and the treatment should be followed up by re-inoculation of the soil biota, through application of compost tea made with local microbiota. This method could be useful for fields of non-native grasses and non-native annuals, especially if restoration were to follow.

Limitations to solarization include cost, climate, degradation, and changes in hydrologic flow (Elmore et al. 1997, Rubin et al. 2007). Solarization of large areas could be cost prohibitive — the overall cost depends on the size of the area, type and thickness of plastic used, and method of application and removal.

4.6.1.5 Flaming

Flame weeding is the use of an open flame, usually propane-fueled, to kill or damage weeds. The objective of flame weeding is not to burn up the weeds, but rather to vaporize the water in the surface cells. This causes the weeds to dry up within a few hours to a day.

Flame treatment does not kill established perennial weeds, and usually grasses and larger broadleaf weeds will recover as well if completed while plants are still growing and have not set flowers. Flaming is not effective for species with protected growing points, rhizomes, or other extensive root systems. Nevertheless, flame weeding is quick and relatively easy, and it is a highly effective and precise way to remove small broadleaf weeds. It does not change the soil conditions that resulted in the colonization of that particular weedy species and, therefore, is a short-term solution.

To kill small weeds, the flame should pass over the weeds at about a normal walking speed. Hand-held flame weeders are available for about the price of a string trimmer. Care must be taken when conditions are dry, as to not cause a brush fire when using this technique in flammable vegetation. Due to Southern California's history of fires, extreme caution should be used when performing this method. Flaming is only appropriate when the soil is wet enough that a fire could not be started.

4.6.1.6 Trapping

Snap traps can be used to control an undesirable population of rodents in open areas, such as the San Joaquin Marsh. Snap traps can be baited with attractants including food and cotton string. Peanut butter or honey can be used to stick other foods to the trigger. Snap traps can also be placed in cardboard or plastic boxes designed to hold snap traps. Both roof and Norway rats are leery of new things in their environment, so traps should be in place for several days before being set. After being set, traps should remain in place for a week before being moved to a new location. Traps should be set along rodent runways to be most effective. The trigger side of the trap should be on the wall side or shrub side.

4.6.2 Natural Predators

Natural predators that limit pests are key components of IPM programs. Important natural enemies of insect and mite pests include predators, parasites, and pathogens; whereas, natural enemies of rodent pests include raptors, such as owls and hawks. Biocontrol provided by these living organisms, collectively called "natural predators," is especially important for reducing animal pests. Theoretically, any organism that is potentially destructive to a weed might find use as a weed-control agent. From the practical standpoint, however, the most effective biological weed control agents used to date are those host-specific phytophagous organisms, like certain species of insects, that limit their attacks to a single or a few closely related weed species (Roy van Driesche, Mark Hoddle, Ted Center, 2008). Use of natural enemies for biological control of rangeland and wildland weeds (e.g., St. Johnswort) is also effective. Plant pathogens, nematodes, and vertebrates also have many natural enemies, but this biological control is often harder to recognize, less well understood, and/or more difficult to manage.

Proper identification of pests, and distinguishing pests from natural enemies, is essential for effective biological control. Careful observation of the mites and insects on plants is essential to help discern their activity. It is important to consult publications to learn about the specific pests and their natural enemies in the landscape.

Preserve existing natural enemies by choosing cultural, mechanical, or selective chemical controls that do not harm beneficial species. It is important to know that only about 1% of all insects and mites are harmful to humans. Most pests are attacked by multiple species of natural enemies, and their conservation is the primary way to successfully use biological control. Judicious (i.e., selective, well-timed) pesticide use, ant control, and habitat manipulation are key conservation strategies.

When pesticides are used, apply them in a selective manner. Treat only heavily infested areas with "spot" applications instead of entire plants. Choose insecticides that are more specific in the types of invertebrates they kill, such as *Bacillus thuringiensis* (Bt) that kills only caterpillars that consume treated foliage.

4.7 Organic Chemical Control Methods [**Preferred**]

Organic herbicides are best used in conjunction with optimizing cultural practices such as improving soil health and timing of seeding/plant establishment. The United States Environmental Protection Agency (EPA) maintains a list of inert ingredients that can be used in pesticide products that are exempt from Federal regulation under the Minimum Risk Exemption regulations in 40 CFR 152.25(f) (epa.gov/sites/production/files/2015-01/documents/ section25b_inerts.pdf). Nonsynthetic-based herbicides that are alternatives to well-known glyphosate and fluazifop-P-butyl (commonly under the commercial names Roundup and Fusilade, respectively), tend to treat mainly above-ground biomass. These nonsynthetic-based herbicides — referred to in this plan as organic — typically work best on newly emerged weeds, and are often best suited for weeds that are less than 6 inches in height. For more mature weeds, higher application rates or concentrations are needed. Thus, after an initial germination treatment, spot treatments later in the season may become necessary to minimize persisting perennial weeds. A single application once (or twice) a year is typically not sufficient.

The following are effective approaches when using organic-based herbicides:

- Use targeted rather than broadcast spray coverage.
- Add the high label amount of surfactant/adjuvant to improve control.
- Treat when weeds are small (two to five leaves) or at flowering stage.
- Repeat applications for larger weeds and perennial species.
- Use lower concentrations at high spray volumes (i.e., 10% concentration at 70 gallons per acre), which is more effective than high concentrations at low spray volumes (i.e., 20% concentration at 35 gallons per acre).

4.7.1 Pre-Emergent and Post-Emergent Organic Herbicides

There are two categories of herbicides — pre-emergent and post-emergent. Pre-emergent herbicides are applied to the soil in locations with known annual weeds, prior to sprouting to prevent the germination of seeds. Post-emergent herbicides are applied directly to the weed after it emerges. Pre- and post-emergent herbicides use several modes of action and contain various active ingredients and formulations. Commonly used pre-emergents made from soy or cornmeal gluten can be used to prevent annual grasses and broadleaf weeds. Organic post-emergent herbicides fall into several categories including natural acids (d-limonene, vinegar, citric acid), herbicidal soaps, iron-based herbicides, salt-based herbicides, phytotoxic oils (clove, peppermint, pine, citronella), or combination products that include ingredients from multiple categories.

4.7.1.1 Natural Acid Herbicides

Natural acid herbicides work by causing the above-ground biomass to dry up. When a natural acid herbicide is applied during the appropriate growth stage, the plant will not recover and will die. It does not kill roots or below-ground meristem. Younger plants have thinner cuticles so a better kill is achieved when plants are young. Higher concentrations of the product are recommended for older plants and weeds — such as ivy and perennials — with a thick cuticle. Acetic acid (vinegar)-based herbicides can be a potential hazard to humans, domestic animals, and wild animals because of the corrosive nature of the products. Herbicides containing acetic acid are toxic to fish, aquatic invertebrates and birds, and may affect endangered species. Therefore, they are not recommended for use. However, d-Limonene-based herbicides are classified by the EPA as “practically non-toxic to birds, fish and mammals” and “highly biodegradable.” This product is safe for humans, wildlife, and the environment and is effective when treating annuals, broadleaves, graminoids (herbaceous plant with grass-like leaves), and perennials. Citrus-based herbicides can be used to control a variety of species, including poison ivy, poison oak, and poison sumac (Geocities 2006). Due to the formulation of this product (plant-based, nonsynthetic), it is exempt from EPA regulations.

4.7.1.2 Salt-Based Herbicides

Salt-based herbicides are not recommended because of their detrimental effects on soil salinity, and because they are not biodegradable. Also not recommended are herbicidal soaps (ammoniated soap of fatty acids or potassium soap of fatty acids), which work by stripping the surface coating of leaves, causing desiccation or dehydration. Herbicidal soaps are toxic to spiders, insects, aquatic invertebrates, and microbes, and contain high levels of salt.

4.7.1.3 Iron-Based Herbicides

Iron-based herbicides are used primarily to treat broadleaf weeds. Unlike other organic products, iron-based herbicides result in whole plant death, not just above-ground biomass. Iron is a naturally occurring mineral that does not biodegrade. It is not acceptable for use around water and its toxicity is unknown. This treatment option should be used minimally and with caution.

4.7.1.4 Phytotoxic Oils

Phytotoxic oils (clove, geranium, garlic, thyme, peppermint, pine, citronella, lemongrass, cinnamon oil, etc.) are botanically based, derived from plants or fish. Many oil-based fertilizers are exempt from EPA regulations, and therefore toxicity to plants, animals, and microbes have not been tested but are presumed to be harmless. The effectiveness of this as a weed treatment is still in early stages of study.

4.8 Chemical Control Methods [**Exceptions** , **Emergencies** , **Banned**]

EPA Category I-III pesticides will be used — in a targeted manner — only when pests cannot be managed by other methods, and only if deemed by District staff to be necessary to protect public health, regulated habitat, or financial feasibility. The use of EPA Category I-III pesticides comes as a last resort, only after nonchemical methods, such as physical treatment options, soil enhancements, natural predators, or organic herbicides have been used or appropriately assessed for potential for success.

To be consistent with Orange County NCCP/HCP pest control guidelines, applications of chemical pesticides should always be done with methods that minimize impacts to nontarget species and movement of the herbicide outside of the targeted area. This can be accomplished using targeted applications such as low-drift nozzles or spray shields, and by holding spray wands low to the ground (always below chest height). For woody plants, cut-stump, frill, or similar application methods can be used to eliminate drift, overspray, and excess environmental exposure.

4.8.1 Prioritized Chemical Pesticides

When pesticides are needed, the following prioritized approach should be followed: (1) Organic pesticides; (2) Water Quality Act (Clean Water Act) Allowed Pesticides; and (3) EPA Category I-III-labeled pesticides only when deemed by a licensed California pest-control adviser to be necessary to protect public health or avoid significant economic loss. When determining which herbicides to use under the prioritized approach, IRWD staff should also consider the risk versus benefit of EPA label warnings in the context of wildland applications. Many herbicides labeled as EPA Category I "danger" are considered so because of acute risk of irreversible eye damage to the applicator, not because they are systemic toxicants or a danger to habitats or wildlife. Triclopyr (Garlon) for example, comes in two forms: Garlon 3A, labeled "danger" because of applicator eye risk and Garlon 4, labeled Category III "caution," though it poses greater potential ecological risk under certain conditions than the Category I "danger" form of the chemical (Natural Communities

Coalition 2018). It should be noted that there is no correlation between an herbicide's toxicity rating and its effectiveness in controlling invasive plant species.

In ranking chemical hazards, IRWD will use the following resources:

- The *San Francisco Environment (SFE) Guide to San Francisco's Reduced Risk Pesticide List* and *San Francisco Reduced-Risk Pesticide List for City-Owned Properties*. The SFE criteria incorporate Clean Water Act, California Proposition 65, and EPA signal word criteria. SFE also maintains a current reduced-risk pesticides list, which lists products specifically identified for use by San Francisco governmental agencies.
- Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) section 25b minimum risk pesticides criteria.
- EPA *Office of Pesticide Programs Label Review Manual*, Chapter 7. Defines signal word category criteria. EPA categories IV and III are both within San Francisco Environment "lowest" hazard category for toxicity. EPA categories II and I are incorporated into SF Environment "moderate" and "highest" hazard categories, respectively.
- Pesticide Research Institute *Pesticide Product Evaluator* database. Evaluates products per the SF Environment criteria. Indicates EPA signal words categories.

4.8.1.1 Water Quality Act (Clean Water Act) Allowed Pesticides

Several of IRWD's facilities are subject to Section 301(a) of the Clean Water Act, which provides that "the discharge of any pollutant by any person shall be unlawful" unless the discharge is in compliance with certain other sections of the Act. 33 U.S.C. 1311(a). The Clean Water Act defines "discharge of a pollutant" as "(A) any addition of any pollutant to navigable waters from any point source, (B) any addition of any pollutant to the waters of the contiguous zone or the ocean from any point source other than a vessel or other floating craft." Water Quality Act allowed pesticides will state on the label that they are approved for use in and around water.

4.8.1.2 EPA Category III (Caution) Labeled Pesticides [Exceptions]

EPA Category III "caution" labeled pesticides should be used only if deemed by IRWD staff to be necessary to protect public health, regulated habitat or financial feasibility.

4.8.1.3 EPA Category *II (Warning) Labeled Pesticides* [Exceptions]

EPA Category II "warning" labeled pesticides should be used only if deemed by a licensed pest-control adviser and IRWD staff to be necessary to protect public health or regulated habitat, or to avoid significant economic loss, and only when other methods do not adequately control the pest. Pesticides with the "warning" label shall not be used on parks, public fields, or playgrounds.

4.8.1.4 EPA Category I (Danger) Labeled Pesticides [Emergencies]

EPA Category I "danger" labeled pesticides should be used only if deemed by a licensed pest-control adviser and IRWD staff to be necessary to protect public health or habitat or avoid significant economic loss, and only when other methods do not adequately control the pest. Pesticides should only be used when other methods fail to provide adequate control of pests and just before pest populations cause unacceptable damage, because overuse of pesticides can cause beneficial organisms to be killed and pest resistance to develop. Pesticides with the “danger” label shall not be used on parks, public fields, or playgrounds.

4.8.1.5 Hazardous Pesticides [Banned]

Banned chemicals are those known to cause acute toxicity to the environment. Most of these chemicals have been either banned or limited in use in California; and their use in wildlife habitat has not been permitted. Examples of these limitations include the Clean Water Act’s 303(d) list. IRWD is committed to never using banned, hazardous chemicals at its facilities. IRWD bans any pesticides that are not included on the current *San Francisco Reduced-Risk Pesticide List.*

4.8.2 Approved Pesticides

Pesticides shall be approved by IRWD for their area of oversight prior to use, and must be used in compliance with all federal, state and local pesticide laws, including organic products. A written recommendation of proposed pesticide, including commercial name, concentrations, allocation rates, usage, and re-entry time shall be prepared by a licensed California pest-control adviser and be based on a site-specific schedule. Copies of Safety Data Sheets and specimen labels shall be given to the Facilities Manager before pesticide use on IRWD property.

Chemical pesticides are considered a last resort under the principles of integrated pest management. Chemical pesticides are to be used by IRWD after nonchemical options have been exhausted, or where there is low risk to people, wildlife and water quality, with a preference for use of a Low Potential Hazard (Category III “caution”) pesticide.

Category III “caution” pesticide is of Low Potential Hazard, because the product is labeled as not toxic to fish, birds, bees, wildlife, or domestic animals, and contains:

- No known, likely, or probable carcinogens
- No reproductive toxicants (CA Prop 65 list)
- No ingredients listed by the EPA as known, probable, or suspect endocrine disrupters
- Active ingredients that have a soil half-life of thirty days or less

Nonrodent pesticides are also considered Low Potential Hazard if they are used in self-contained baits and placed in inaccessible locations. However, rodent baits are not considered least toxic under any circumstances.

Category II “warning” products are of Moderate Potential Hazard and to be used when exceptions are warranted to protect public health and safety, to avoid significant economic loss, when chemical methods conflict with existing regulatory requirements, or in the event that both preventative methods and least-toxic pesticides prove to be ineffective at pest control.

Category I “danger” products are High Potential Hazard and not intended for use except when there is a concern for public safety and in situations where the use of a Category II product is inadequate or unsafe.

4.8.3 Management of Approved Pesticides

Chemicals shall only be applied by persons possessing a valid California Qualified Applicator license/certificate; or a Structural Pest Control License (where applicable). Applications shall follow all governing regulations. Records of all pesticide use shall be kept per California Department of Pesticide Regulations, or the California Structural Pest Control Board. Care should be taken to avoid nontarget areas. Precautionary measures shall be employed to keep the public from entering and area that was sprayed until it is determined to be safe. A list of approved pesticides will be developed and maintained by IRWD. These shall undergo annual review based on information provided in an Annual IPM Report

4.9 Adaptive Management Strategies

Adaptive management encompasses the following steps: establishing assessment criteria or performance measures, collecting information, evaluating the program, and undertaking program modifications to make the program safer, more effective, and efficient. Adaptive management is a tool that allows natural resource managers to make good decisions and effective action plans based on limited information, and provides a means of reducing uncertainty over time through assessing the results of an action and changing subsequent actions. Adaptive management is often described as learning by doing. Given the types and rates of change observed on IRWD preserves resulting from global, regional, and local factors (many of which are beyond IRWD’s control), adaptive management is an important tool to help IRWD implement IPM in the face of change and uncertainty.

New methods of invasive plant control are continually emerging for potential use in land management. IRWD staff should regularly field test and evaluate new methods and products to improve control and standards of care over time. Changes in herbicide regulations, labeling, and application methods should be actively monitored and incorporated into this IPM. Cal-IPC and University of California Division of Agriculture and Natural Resources (UC ANR) are relevant resources that provide updates on adaptive management techniques for California invasive species.

5.0 Application

Across categories of species, whether annual grass, perennial tree, or rodent, the key to controlling the invasion of the species is prevention and maintenance. Proper prevention techniques, as discussed in Section 4.1, will minimize the need for further management applications. However, when these techniques do not offer enough control additional methods will be implemented.

5.0.1 Noxious Weed Control

The most important factor in controlling noxious weeds is to prevent the introduction of such species. Prevention practices such as cleaning equipment and work boots from all seeds and plant material before leaving the area of infestation contribute to the prevention of weed introduction. When using mechanical removal to control weeds, weeds should be cut prior to setting seed, either during flowering or just prior, depending on the species. These weed seeds should be securely bagged and removed from the site, taking care to keep weed seeds contained in the disposal process. In addition, sites that have been disturbed by heavy equipment are left susceptible to weeds. When possible, native plants should be planted and/or seeded in such areas. Native plants, when mature, can out-compete weed species and are the natural environment's best defense against non-native species success in an area.

However, when prevention is unsuccessful or when noxious weeds have already established, the approach to eliminate these species from an area should follow the IRWD Pesticide Ranking and Use Categories (**FIGURE 1**). Use of nonchemical control methods should first be exercised. Physical control such as hand-pulling, mowing or cutting, or the use of solarization are all often successful means of control and are preferred in this IPM. However, physical control methods may not be an option, either because such methods have been tried and were proven unsuccessful, or because of a need to quickly or completely eliminate the weed. In this case, organic control methods may be used. See Section 4.7.1 for the preferred organic control methods.

Nonorganic and higher-potential-hazard herbicides should be used as a last resort, and only if deemed necessary to protect public health or avoid significant economic loss. Supervisor approval as well as approval and direction of a licensed pest-control adviser is required for use of such herbicides. Proper procedures such as labeling, mixing, and personal protective equipment must be followed depending on the specifications provided on the Material Safety Data Sheet (MSDS) of each herbicide. Once an area or weed is treated, the approach should be reassessed and should aim to return to nonchemical methods if possible.

The first step in determining that noxious weed control is needed starts with conducting a visual inspection to determine the need to schedule spraying, removal, or mowing of obstructive vegetation. Vegetation growth is highly dependent upon weather. The warmer temperatures in spring and the rainfall during winter months encourage vegetation growth. Wide variations in herbicide use may occur from year to year due to weather. Formal inspections of IRWD facilities for vegetation conditions are scheduled annually by trained IRWD maintenance personnel. Specific vegetation control methods and target areas are determined based on visual inspections. These include spraying or mechanical control methods. Pre-emergent herbicides are applied on bare ground and access roads at IRWD facilities in the early winter before a rain. This prevents seed germination and the rapid weed growth normally observed in spring and summer. **TABLE 1** below summarizes the methods, criteria and equipment used to control noxious weeds at IRWD facilities.

TABLE 1: VEGETATION CONTROL METHODS

Application Method	Criteria	Equipment
Hand methods — weed cutting	Use in small areas or areas that vehicular mounted mowers or grinders cannot reach	Weed trimmer, pole saw, or hedge trimmer
Mowing	Use on slopes or in basins	Skid steer and excavator with mower attachments
Discing	Use in basin floors and channel bottoms	Bulldozer with disk implement
Grinding	Use on giant reed and tamarisk to reduce stocks to a mulch	Skid steer or tractor with grinder implement
Backpack hand spraying	Apply in small areas or areas that vehicle hoses or boom sprayers cannot reach	Backpack mounted sprayer
Vehicle spraying	Apply in areas such as along channels, levees, basins and dams in wet areas	Truck with spray hose attachment

5.0.2 Aquatic Invasive Plant Control

Prevention methods are similar to that of other noxious weeds. However, in addition to the control methods mentioned above, it is important to control the spread of weeds that propagate vegetatively (as well as by seed). The chance of aquatic dispersal is high because vegetative parts can easily be carried long distances by water downstream, resulting in rapid spread. When using mechanical removal, extra caution should be used when removing species that can propagate vegetatively, such as giant reed (*Arundo donax*). Manual removal is the preferred method of eliminating aquatic weeds, either by hand removal or by using heavy equipment. When manual removal is not an option, herbicides that have been approved for aquatic use may be considered. Many organic herbicides such as natural acid herbicides, salt-based herbicides, and iron-based herbicides are not safe to use in or around water. Phytotoxic Oil-based herbicides are generally considered safe for aquatic use but labels should be checked to ensure the product is safe before use. As a last resort, nonorganic herbicides may be used if necessary to protect public health or avoid significant economic loss. Herbicide labels must state that the product is safe to use in aquatic environments and the product should be chosen with the lowest potential hazard ranking possible that would still be effective in proper control of the weed species. Once an area or weed is treated, the approach should be reassessed and should aim to return to nonchemical methods if possible.

5.0.3 Fungi Control

There are more than 100,000 species of fungi worldwide; many of these species are beneficial to the environment, but approximately 10%, or 10,000 species, cause plant or animals disease (Green and Gouge 2015). Typically, the best method to prevent or control fungi is by limiting moisture. Reduce irrigation or increase light to the source of the fungi if possible. If these management actions do not control the fungi, organic herbicides may be used. Nonorganic and higher-potential-hazard fungicides should be used as a last resort, and only if deemed necessary to protect public health or avoid significant economic loss. Supervisor approval as well as approval and direction of a licensed pest control adviser is required for use of such fungicides. Proper procedures such as labeling, mixing, and personal protective equipment must be followed depending on the specifications provided on the MSDS of each fungicide. Once an area is treated, the approach should be reassessed and should aim to return to nonchemical methods if possible.

5.0.4 Invertebrate Control

Invertebrates include bees, snails, caterpillars, spiders, and flies. Some invertebrate presence should be expected, both in the natural environment and in and around buildings. Typically, the presence of invertebrates does not cause harm to the environment. However, control may be necessary. If plant damage by invertebrates is greater than 10% of a species or population, reduce suitable habitat by limiting irrigation and reducing soil when possible. For invertebrates such as snails, slugs, or caterpillars, prune or hand clean plants regularly to remove pests and eggs. Hard sprays with water can also be effective to rid plants of pests. When plant damage is apparent on more than 50% of a species or population, consider replacing the damaged individual with a less susceptible species.

As a last resort, nontoxic baits can be used, following the instructions on the label. These bait traps should be specific to the target species to the full extent possible. Diatomaceous earth (nontoxic silica dust) is another last resort option because it is nonselective and kills a wide array of insects by absorbing the outer waxy coating on an insect’s body, causing death by dehydration. However, once an area is treated, the approach should be reassessed and should aim to return to preventative and physical methods if possible. IPM staff should not attempt to remove bee hives or nests. If a bee nest in an area presents a potential hazard to the public, consult a bee handler for the removal and relocation of the nest.

For invertebrate control inside human-made structures, early management actions should include properly disposing of food waste; properly storing food; ensuring screens are intact; ensuring gaps around windows and doors are sealed; and ensuring other openings into and within the building that could allow entry are sealed. Targeted efforts to remove the pest are best, such as vacuuming. Nontoxic methods such as sticky fly traps or diatomaceous earth may be used as a last resort.

5.0.5 Rodent Control

Maintenance measures such as removing food waste, sealing all entry holes in structures, and keeping vegetation maintained adjacent to facilities, are crucial to providing rodent control. If an undesirable rodent population persists in open areas (e.g., San Joaquin Marsh), owl boxes should be installed. Owls are an excellent form of rodent control. A single barn owl eats two to three rodents a night. According to a study done by the California Department of Fish and Wildlife, one nesting pair of California barn owls could consume as many as 2,000 gophers, rats, and mice in a single year, increasing proportionally with a larger family size. The barn owls’ diet consists largely of gophers, rats, and mice. Owls roost year-round, keeping the predator nearby (Reader 2012). Owl boxes should be placed with foraging habitat nearby; this consists of open habitats such as grassy slopes or open fields. Owl boxes should be purchased or built using proper specifications (refer to Cornell Lab of Ornithology) to ensure that owls will find the box attractive for roosting and that there is sufficient space in the box, as barn owls can have as many as 12 eggs or more.

The entry and exit hole must be large enough to enter the box and high enough to protect young from falling out.

Barn owls are sensitive to disturbance during nesting and will abandon a nest if disturbed during their nesting period (April-May). Care should be taken to not use load equipment, such as chainsaws and mowers within approximately 300 feet during active nesting.

In some instances, rodenticides are necessary for maintaining public safety on IRWD facilities, such as to control rodents that burrow unto earthen dams, with the potential to compromise the dam's structural integrity. There are options for using nonsynthetic rodenticides, such as EcoClear Products that are effective in controlling rodents (and insects) and are safe for people, pets and wildlife (ecoclearproducts.com/rodent-control). Sticky traps are considered inhumane and should never be used.

5.0.6 Algae Control in Reservoirs

Algae and algal blooms are a very serious concern in facilities that support open water, as their occurrence can have ecological, aesthetic, and human health impacts. In waterbodies used for water supply, algae and algal blooms can cause physical problems or can cause taste and odor problems in waters used for drinking. Blooms involving toxin-producing species can pose serious threats to animals and humans. Algal growth is influenced mainly by water composition, temperature and light intensity. Under certain conditions, algae can cause nuisance effects in freshwater, such as excessive accumulations of foams, scums, and discoloration of the water. When the numbers of algae (and its nutrients) in a lake or a river increase explosively, an "algal bloom" is the result (Water Encyclopedia 2018). Reservoirs and lakes, ponds, and slow-moving rivers are most susceptible to blooms.

While the best way to prevent algae and algal blooms is to reduce nutrients that enter the reservoir in the first place, control methods are available for prevention and to treat once they have occurred (EPA 2018). Ways to prevent algae in facilities that contain open waters include:

- **Aeration** - Aerators operate by pumping air through a diffuser near the bottom of the reservoir, resulting in the formation of plumes that rise to the surface and create vertical circulation cells as they propagate outward from the aerator. This mixing of the water column disrupts the behavior of cyanobacteria to migrate vertically in addition to limiting the accessibility of nutrients.
- **Mechanical circulation** - Mechanical mixers are usually surface-mounted and pump water from the surface layer downward or draw water up from the bottom to the surface layer. This mixing of the water column disrupts the behavior of cyanobacteria to migrate vertically in addition to limiting the accessibility of nutrients.
- **Water level drawdown** - In facilities that contain controlled waterbodies, drawing down the water level to the point where cyanobacteria accumulations are exposed above the waterline. Reinjection of water into the system provides a benefit as well.

- **Algaecides** - Algaecides are chemical compounds applied to a waterbody to kill cyanobacteria. Several examples are: Copper-based algaecides (copper sulphate, copper II alkanolamine, copper citrate, etc.), Potassium Permanganate, chlorine, and lime.

6.0 Performance Measures

These criteria are intended to quantitatively and qualitatively measure and evaluate changes in IRWD's IPM program over time:

- Compliance with the *San Francisco Reduced-Risk Pesticide List for City-Owned Properties.*
- Demonstrated use of lower pesticide worker health/exposure classifications, as measured by totaling use of pesticides using the U.S. EPA Classifications I, II, III, and IV.
- Reduction of pesticide use in buildings (i.e., areas often used by people, where the potential for human exposure to pesticides is greater than in other areas). IRWD will seek to comprehensively oversee all pesticide use in and around IRWD buildings, which is expected to result in an overall reduction of pesticide use in buildings, and in particular, eliminate use of pesticides not appropriate for use around staff or visitors, or which can inadvertently escape into the surrounding wildland environment. Pesticide use in buildings will be measured in units of product used per treatment area (each building), or by units of product used per total square footage for IRWD buildings.
- Reduction in per-acre herbicide use at individual sites in natural areas over time. IRWD will seek a reduction in per-acre use of herbicides over time at individual sites, but acknowledges that in some instances, use will initially increase, followed by a reduction in herbicide use when the pest is eliminated or reduced. As an example, as new properties are acquired or new invasive plant infestations are discovered, overall herbicide use may initially go up; however, it is anticipated to drop over time as pests are controlled or eliminated at such sites.
- Preservation of biodiversity and natural resource values in natural areas or areas that support habitat for endemic plants and wildlife. IRWD staff will provide an annual qualitative assessment of natural resources conditions of IPM projects in areas that provide habitat for native flora and fauna in an Annual IPM Report.
- An annual summary of staff training, public outreach, and educational activities related to IPM.

7.0 Records and Reporting

Monitoring the effectiveness of the IPM plan over time requires diligent tracking of several items: pest populations and locations; management strategies employed; quantities and types of chemicals and products used; and the outcome of pest management activities. IRWD shall maintain records that include this information:

1. Date, time and location of pesticide application
2. Target pest
3. Prevention and other nonchemical methods of control used

4. Type and quantity of pesticide used, including trade name and active ingredient
5. Name of the pesticide applicator
6. Application equipment used
7. Summary of results

8.0 Responsible Parties

Natural Resource Manager and **Facilities Manager** are responsible for overseeing the implementation of the IPM plan, ensuring contractor compliance, and supervising record keeping and performance measurement. The Natural Resource Manager, Facilities Manager, and selected vendor are responsible for record keeping and performance measurement. The compiled records from all parties will be synthesized by the IRWD **Operations Department** as part of an annual IPM review.

Landscape Maintenance Coordinator and **Senior Wetlands Specialist** are responsible for quality-assurance/quality-control processes. These positions shall verify that the plan is being implemented consistently and correctly, that performance persists over time, and that performance measurement methods truly reflect actual outcomes.

All pest control vendors contracted to work at IRWD facilities are responsible for adhering to this policy.

TABLE 2: RESPONSIBLE PARTIES

Title	Area of Responsibility
Natural Resources Manager	Coordination and implementation
Facilities Manager	Coordination and implementation
Landscape Maintenance Coordinator	Quality Assurance/ Quality Control
Senior Wetlands Specialist	Quality Assurance/ Quality Control

9.0 Health and Safety

It is IRWD's policy to protect the health, safety and welfare of employees and the community. Successful health and safety management requires an effective policy, organization and arrangements, which reflect the commitment of senior management. To maintain that commitment, IRWD will continually measure, monitor and revise where necessary an annual plan to ensure that health and safety standards are adequately maintained.

The IRWD Safety Department will implement IRWD's health and safety policy and recommend any changes to meet new circumstances. IRWD looks upon the promotion of health and safety measures as a mutual objective for its employees. It is therefore the policy of management to do all that is reasonably practicable to prevent personal injury and damage to property. Also, IRWD aims to protect everyone, including visitors and members of the public, insofar as they come into contact with our activities, from any foreseeable hazard or danger.

All employees have duties under the Health and Safety at Work etc. Act 1974 and are informed of their personal responsibilities to take due care of the health and safety of themselves and to ensure that they do not endanger other people by their acts or omissions. IRWD will ensure a systematic approach to identifying hazards, assessing the risks, determining suitable and sufficient control measures and informing employees of the correct procedures needed to maintain a safe working environment. IRWD will provide, so far as reasonably practicable, safe places and systems of work, safe handling of materials and substances, adequate safety equipment, and appropriate information, instruction, training and supervision.

10.0 Exceptions and Emergencies

10.1 Exceptions

Exceptions for using Category III “caution” (Low Potential Hazard) or Category II “warning” (Moderate Potential Hazard) pesticides may be warranted when chemical methods conflict with existing regulatory requirements, or in the event that both preventative methods and least-toxic pesticides prove to be ineffective at pest control. Examples of exceptions may include control of rodents that burrow into earthen dams, which could compromise the dam’s structural integrity while creating a public safety risk; or at facilities buffered from urban areas and with no public access and low-risk environmental concerns (e.g., lacking native habitats); or to reduce impacts to nesting birds by minimizing human presence.

10.2 Emergencies

In general, chemical controls should be used as a last resort or in emergency situations. Exclusion methods are heavily preferred over any chemical means. A pest outbreak is considered an emergency when it poses an immediate threat to public health or will cause significant economic or environmental damage if treatment is prolonged.

11.0 Qualifications and Training

All pest-control contractors hired for IRWD facilities will submit a description of their staff IPM training and education programs. Early detection monitoring can be accomplished by staff or contractors. Use of existing natural resource management and maintenance staff provides the best value for IRWD. With limited training, existing staff resources can be used and repurposed for early detection monitoring at minimal additional cost, although it will not be a comprehensive effort. In addition to new invasive species, other resource management targets such as rare plants and animals may also be discovered through this type of observation.

Any people applying pesticides must be trained prior to the use of each pesticide, regardless of toxicity, unless they possess a current Qualified Applicators Certificate or Qualified Applicators License. These individuals are required to have general pesticide safety training annually. In California, any business that provides pesticide management services for hire must have a pest-control business license. The **Natural Resource Manager** and **Facilities Manager** are the main points of contact for IRWD regarding pest management and ensure staff are familiar with the IPM Plan.

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