Appendix Q – Klamath Basin National Wildlife Refuge Complex Integrated Pest Management Program for Cooperative Farming, Habitat Restoration, and Maintenance Activities

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1.0 Background

IPM is an interdisciplinary approach utilizing methods to prevent, eliminate, contain, and/or control pest species in concert with other management activities on refuge lands and waters to achieve wildlife and habitat management goals and objectives. IPM is also a scientifically based, adaptive management process (see 43 C.F.R. 46.145) where available scientific information and best professional judgment of the refuge staff as well as other resource experts are used to identify and implement appropriate management strategies that can be modified and/or changed over time to ensure effective, site-specific management of pest species. Considering refuge resource objectives and the ecology of pest species, a tolerable pest population (threshold) is established and one or more pest management methods, or combinations thereof, is selected that is feasible, efficacious, and most protective of non-target resources (including native fish, wildlife, and plants), Service personnel, Service authorized agents, volunteers, and the public. Staff time and available funding are considered when determining feasibility/practicality of various treatments.

IPM techniques to address pests are presented as CCP strategies (see Appendix F) to achieve refuge resource objectives. Consistent with Service policy, the following IPM program elements have been incorporated into this CCP (see the Service Director's September 9, 2004 memo titled *Integrated Pest Management Plans and Pesticide Use Proposals: Updates, Guidance, and an Online Database*):

- Habitat and/or wildlife objectives that identify pest species and appropriate thresholds to indicate the need for and successful implementation of IPM techniques; and
- Monitoring before and/or after treatment to assess progress toward achieving objectives including pest thresholds.

Where pesticides are determined necessary to manage pests, this Appendix provides a structured procedure to evaluate potential effects of ground-based applications to refuge biological resources and environmental quality. Only pesticide uses that, with appropriate BMPs (as identified through the PUP process), would likely cause minor, temporary, or localized effects to refuge biological resources and environmental quality would be allowed for use on the refuges.

2.0 Pest Management Laws and Policies

Service policy states that plant, invertebrate, and vertebrate pests on units of the National Wildlife Refuge System can be controlled to ensure balanced wildlife and fish populations in support of refuge-specific wildlife and habitat management objectives (see 569 FW 1, Integrated

Pest Management). Pest control on Federal (refuge) lands and waters also is authorized under the following Federal statutes and executive orders:

- National Wildlife Refuge System Administration Act of 1966, as amended (16 U.S.C. 668dd-668ee);
- Plant Protection Act of 2000 (7 U.S.C. 7701 *et seq*.);
- Noxious Weed Control and Eradication Act of 2004 (7 U.S.C. 7781-7786, Subtitle E);
- Federal Insecticide, Fungicide, and Rodenticide Act of 1996 (7 U.S.C. 136-136y);
- National Invasive Species Act of 1996 (16 U.S.C. 4701);
- Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (16 U.S.C. 4701);
- Food Quality Protection Act of 1996 (7 U.S.C. 136);
- Executive Order 13148, Section 601(a);
- Executive Order 13112; and
- Animal Damage Control Act of 1931 (7 U.S.C. 426-426c, 46 Stat. 1468).

U.S. Department of the Interior policy defines pests as "…living organisms that may interfere with the site-specific purposes, operations, or management objectives or that jeopardize human health or safety" (see 517 DM 1, Integrated Pest Management Policy). Similarly, Service policy defines pests as "…invasive plants and introduced or native organisms, that may interfere with achieving our management goals and objectives on or off our lands, or that jeopardize human health or safety" (see 569 FW 1, Integrated Pest Management). U.S. Department of the Interior policy also defines an invasive species as "a species that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health" (517 DM 1) Throughout this CCP, the terms pest and invasive species are used interchangeably because both can prevent/impede achievement of refuge wildlife and habitat objectives and/or degrade environmental quality.

In general, control of pests (vertebrate or invertebrate) on the refuges would conserve and protect the Nation's fish, wildlife, and plant resources as well as safeguard environmental quality. Service policy also states that animal or plant species which are considered pests may be managed if the following criteria are met (569 FW 1):

- The pest causes a threat to human or wildlife health or private property, the acceptable level of damage by the pest has been exceeded, or Federal, state, or local governments have designated the pest as noxious;
- The pest is detrimental to a refuge resource management goal or objective; and
- Pest control would not interfere with achieving of site management goals and objectives or the purposes for which a refuge was established.

The specific justifications for pest management activities on a refuge are the following:

- Protect human health and well-being;
- Prevent substantial damage to important refuge resources;
- Protect newly introduced or re-established native species;
- Control non-native (exotic) species in order to support populations of native species;
- Prevent damage to private property; and
- Provide the public with quality, compatible wildlife-dependent recreational opportunities.

Service policy for habitat management plans provides the following additional guidance regarding management of invasive species on a refuge (see 620 FW 1, Habitat Management Plans):

- "We are prohibited by Executive Order, law, and policy from authorizing, funding, or carrying out actions that are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere."
- "Manage invasive species to improve or stabilize biotic communities to minimize unacceptable change to ecosystem structure and function and prevent new and expanded infestations of invasive species. Conduct refuge habitat management activities to prevent, control, or eradicate invasive species..."

Federal regulations describe how animal species that are damaging/destroying federal property and/or detrimental to the management program of a refuge may be controlled (see 50 C.F.R. 31.14, Official Animal Control Operations). For example, the incidental removal of a beaver that is damaging refuge infrastructure (e.g., clogging a water control structure) and/or negatively affecting habitat (e.g., removing woody species from existing or restored riparian habitat) may occur without a pest control proposal. We recognize beavers are native species and most of their activities on refuge lands represent a natural process beneficial for maintaining wetland habitats. Exotic nutria, whose denning and burrowing activities in wetland dikes causes cave-ins and breaches, can be controlled using the most effective techniques considering site-specific factors without a pest control proposal. Along with the loss of quality wetland habitats associated with breaching of impoundments, the safety of refuge staffs and the public (e.g., on auto tour routes) driving on structurally compromised levees and dikes can be threatened by sudden and unexpected cave-ins.

Trespass and feral animals may also be controlled on refuge lands. Dogs and cats running at large on a national wildlife refuge and observed in the act of killing, injuring, harassing, or molesting humans or wildlife may be disposed of in the interest of public safety and protection of wildlife (see 50 C.F.R. 28.43, Destruction of Dogs and Cats). Feral animals should be disposed of by the most humane method(s) available and in accordance with relevant Service directives and Executive Order 11643. Wildlife specimens may be donated or loaned to public institutions; however, donation or loan of resident wildlife species will only be made after securing state approval (see 50 C.F.R. 30.11, Donation and Loan of Wildlife Specimens). Surplus wildlife specimens may be sold alive or butchered, dressed and processed subject to Federal and state laws and regulations (50 C.F.R. 30.12, Sale of Wildlife Specimens).

3.0 Strategies

To fully embrace IPM, the following strategies, where applicable, would be carefully considered on the refuge for each pest species (569 FW 1):

- **Prevention.** This is the most effective and least expensive long-term management option for pests. It encompasses methods to prevent new introductions or the spread of established pests to un-infested areas. It requires identifying potential routes of invasion to reduce the likelihood of infestation. In order to identify appropriate BMPs for prevention, Hazard Analysis and Critical Control Points (HACCP) planning can be used to determine if current management activities on a refuge may introduce and/or spread invasive species. See http://www.haccp-nrm.org/ for more information about HACCP planning.

Prevention may include source reduction, using pathogen-free or weed-free seeds or fill; exclusion methods (e.g., barriers) and/or sanitation methods (e.g., wash stations) to prevent re-introductions by various mechanisms including vehicles, personnel, livestock, and horses. Because invasive species are frequently the first to establish in newly disturbed sites, prevention requires a reporting mechanism for early detection of new pest occurrences. A quick response can then be mounted to eliminate any new satellite pest populations. Prevention requires consideration of the scale and scope of land management activities that may promote pest establishment within un-infested areas or promote reproduction and spread of existing populations. Along with preventing initial introduction, prevention involves halting the spread of existing infestations to new sites (Mullin et al. 2000). The primary reason for prevention is to keep pest-free lands or waters from becoming infested. Executive Order 11312 emphasizes the priority for prevention with respect to managing pests.

Following are methods to prevent the introduction and/or spread of pests on refuge lands (USFS, 2005).

- Before beginning ground-disturbing activities (e.g., disking or scraping), inventory and prioritize pest infestations in project operating areas and along access routes. Identify pest species on-site or in the vicinity of a reasonably expected potential invasion. Where possible, begin project activities in un-infested areas before working in pest-infested areas.
- Use pest-free project staging areas. Avoid or minimize travel through pest-infested areas or restrict travel to those periods when spread of seeds or propagules of invasive plants is least likely.
- When appropriate, identify sanitation sites where equipment can be cleaned of pests. Where possible, clean equipment before entering lands at on-refuge approved cleaning site(s). This practice does not pertain to vehicles traveling frequently in and out of the project area that will remain on roadways. Where practical, collect seeds and plant parts of pest plants. Remove mud, dirt, and plant parts from project equipment before moving it into a project area.
- If operating in areas infested with pests, clean all equipment before leaving the project site.
- Where possible, refuge staffs, authorized agents, and volunteers need to inspect, remove, and properly dispose of invasive plant seeds and parts found on their clothing and equipment. Proper disposal means bagging the seeds and plant parts and then properly discarding of them (e.g., through incineration).
- Evaluate options, including closure, to restrict traffic on sites with on-going restoration of desired vegetation. Revegetate disturbed soil (except travel ways on surfaced projects) to optimize plant establishment for each specific site. As necessary, revegetation may include topsoil replacement, planting, seeding, fertilization, liming, and weed-free mulching. Use native plant materials, where appropriate and feasible. Where they are reasonably available, use certified weed-free or weed-seed-free hay or straw.

- Provide information, training, and appropriate pest identification materials to permit holders and recreational visitors. Educate them about pest identification, biology, impacts, and effective prevention measures.
- Require grazing permittees to utilize preventative measures for their livestock while on refuge lands.
- Inspect borrow material for invasive plants prior to use and transport onto and/or within refuge lands.
- Consider invasive plants in planning for road maintenance activities.
- Restrict off-road travel to designated routes.

Following are methods to prevent the introduction and/or spread of pests into refuge waters (USFS, 2005).

- Inspect boats (including air boats), trailers, and other boating equipment. Remove any visible plants, animals, or mud before leaving any waters or boat launching facilities. Drain water from motor, live well, bilge, and transom wells while on land before leaving the site. If possible, wash and dry boats, downriggers, anchors, nets, floors of boats, propellers, axles, trailers, and other boating equipment to kill pests not visible at the boat launch.
- Maintain an l00-foot buffer of aquatic pest-free clearance around boat launches and docks or quarantine areas when cleaning around culverts, canals, or irrigation sites. Inspect and clean equipment before moving to new sites or from one project area to another.

- **Mechanical/Physical Methods.** These methods remove and destroy, disrupt the growth of, or interfere with the reproduction of pest species. For plants species, these treatments can be accomplished by hand, hand tool (manual), or power tools (mechanical), and include pulling, grubbing, digging, tilling/disking, cutting, swathing, grinding, sheering, girdling, mowing, and mulching of the pest plants. Thermal techniques such as steaming, super-heated water, and hot foam may also be viable treatments.

  For animal species, mechanical/physical methods (including trapping) can be used to control pests as a refuge management activity. Federal regulations state that trapping can be used on a refuge to reduce surplus wildlife populations for a “balanced conservation program,” in accordance with Federal or state laws and regulations (see 50 C.F.R. 31.2). In some cases, non-lethally trapped animals can be relocated to off-refuge sites with prior approval from the state.

  Each of these tools can be efficacious to some degree and applicable to specific situations. In general, mechanical controls can effectively control annual and biennial pest plants. However, to control perennial plants, the root system has to be destroyed or it resprouts and continues to grow and develop. Mechanical controls are typically not capable of destroying a perennial plant’s root system. Although some mechanical tools (e.g., disking, plowing) may damage root systems, they may stimulate regrowth producing a denser plant population that may aid in the spread depending upon the target species (e.g., Canada thistle). In addition, steep terrain and soil conditions can be major factors that limit the use of many mechanical control methods.

Some mechanical control methods (e.g., mowing), which can be used in combination with herbicides, can be a very effective technique to control perennial species. For example, mowing perennial plants followed sequentially by treating the plant regrowth with a systemic herbicide often improves the efficacy of the herbicide compared to herbicide treatment only.

- **Cultural Methods.** These methods involve manipulating habitat to increase pest mortality by reducing its suitability to the pest. Cultural methods include water-level manipulation, mulching, winter cover crops, changing planting dates to minimize pest impact, prescribed burning (to facilitate revegetation, increase herbicide efficacy, and remove litter to assist in emergence of desirable species), flaming with propane torches, trap crops, crop rotations (including non-susceptible crops), moisture management, addition of beneficial insect habitat, reducing clutter, proper trash disposal, planting or seeding desirable species to shade or out-compete invasive plants, applying fertilizer to enhance desirable vegetation, prescriptive grazing, and other habitat alterations.

- **Biological Control Agents.** Classical biological control involves the deliberate introduction and management of natural enemies (parasites, predators, or pathogens) to reduce pest populations. Many of the most ecologically or economically damaging pest species in the United States originated in foreign countries. These newly introduced pests, which are free from natural enemies found in their country or region of origin, may have a competitive advantage over cultivated and native species. This competitive advantage often allows introduced species to flourish, and they may cause widespread economic damage to crops or out compete and displace native vegetation. Once the introduced pest species population reaches a certain level, traditional methods of pest management may be cost prohibitive or impractical. Biological controls typically are used when pest populations have become so widespread that eradication or effective control is difficult or no longer practical.

  Biological control has advantages as well as disadvantages. Benefits include reducing pesticide usage, host specificity for target pests, long-term self-perpetuating control, low cost/acre, capacity for searching and locating hosts, synchronizing biological control agents to hosts' life cycles, and the unlikelihood that hosts will develop resistance to agents. Disadvantages include limited availability of agents from their native lands, dependence of control on target species density, slow rate at which control occurs, biotype matching, the difficulty and expense of conflicts over control of the target pest, and host specificity when host populations are low.

  A reduction in target species populations from biological controls is typically a slow process, and efficacy can be highly variable. It may not work well in a particular area, although it works well in other areas. Biological control agents require specific environmental conditions to survive over time. Some of these conditions are understood; whereas, others are only partially understood or not understood at all.

  Biological control agents do not eradicate a target pest. When using biological control agents, residual levels of the target pest typically are expected; the agent population level or survival is dependent upon the density of its host. After the pest population decreases, the population of the biological control agent decreases correspondingly. This is a natural cycle. Some pest populations (e.g., invasive plants) tend to persist for several years after a biological control agent becomes established due to seed reserves in the soil, inefficiencies in the agents' search behavior, and the natural lag in population buildup of the agent.

The full range of pest groups potentially found on refuge lands and waters includes diseases, invertebrates (e.g., insects and mollusks), vertebrates, and invasive plants (the most common group). Often it is assumed that biological control can address many if not most of these pest problems. There are several well-documented success stories of biological control of invasive weed species in the Pacific Northwest including Mediterranean sage, St. Johnswort (Klamath weed), and tansy ragwort. Emerging success stories include Dalmatian toadflax, diffuse knapweed, leafy spurge, purple loosestrife, and yellow star thistle. However, historically, each new introduction of a biological control agent in the United States has only about a 30% success rate (Coombs et al., 2004).

Introduced species without desirable close relatives in the United States are generally selected as biological controls. Natural enemies that are restricted to one or a few closely related plants in their country of origin are targeted as biological controls (Center et al., 1997; Hasan and Ayres, 1990).

Introduced agents must be approved by the applicable authorities. Except for a small number of formulated biological control products registered by USEPA under FIFRA, most biological control agents are regulated by the U.S. Department of Agriculture (USDA)-Animal Plant Health Inspection Service, Plant Protection and Quarantine (APHIS-PPQ). State departments of agriculture and, in some cases, county agricultural commissioners or weed districts, have additional approval authority.

Federal permits (USDA-APHIS-PPQ Form 526) are required to import biocontrols agents from another state. Form 526 may be obtained from USDA-APHIS-PPQ (Biological Assessment and Taxonomic Support, 4700 River Road, Unit 113, Riverdale, MD 20737) or online at http://www.aphis.usda.gov/ppq/permits/bioligical/weedbio.html.

The Service strongly supports the development, and legal and responsible use of appropriate, safe, and effective biological control agents for nuisance and non-indigenous or pest species.

State and county agriculture departments may also be sources for biological control agents or they may have information about where biological control agents may be obtained. Commercial sources shall have an Application and Permit to Move Live Plant Pests and Noxious Weeds (USDA-PPQ Form 226 from USDA-APHIS-PPQ, Biological Assessment and Taxonomic Support, 4700 River Road, Unit 113, Riverdale, MD 20737) to release specific biological control agents in a state and/or county. Furthermore, certification regarding the biological control agent's identity (genus, specific epithet, sub-species and variety) and purity (e.g., parasite free, pathogen free, and biotic and abiotic contaminants) shall be specified in purchase orders.

Use of biological control agents on refuges is subject to Service policy on Exotic Species Introduction and Management (see 7 RM 8). In addition, the refuge staff will follow the

International Code of Best Practice for Classical Biological Control of Weeds (http://sric.ucdavis.edu/exotic /exotic.htm) as ratified by delegates to the X International Symposium on Biological Control of Weeds, Bozeman, MT, July 9, 1999. This code identifies the following:

- Release only approved biological control agents,
- Use the most effective agents,
- Document releases, and
- Monitor for impact to the target pest, non-target species and the environment.

Biological control agents formulated as pesticide products and registered by the USEPA (e.g., *Bti*) are also subject to PUP review and approval (see below).

A record of all releases shall be maintained with date(s), location(s), and environmental conditions of the release site(s); the identity, quantity, and condition of the biological control agents released; and other relevant data and comments such as weather conditions. Systematic monitoring to determine the establishment and effectiveness of the release is also recommended.

NEPA documents regarding biological and other environmental effects of biological control agents prepared by another Federal agency, where the scope is relevant to evaluation of releases on refuge lands, should be reviewed and, as appropriate, adopted for Service use. Possible source agencies for such NEPA documents include the U.S. Bureau of Land Management, U.S. Forest Service, U.S. National Park Service, U.S. Department of Agriculture-Animal and Plant Health Inspection Service, and the U.S. military services. It can be appropriate to summarize and incorporate through reference parts or all of relevant documents. Incorporating by reference (43 CFR 46.135) is a technique used to avoid redundancies in analyses. It can reduce the bulk of a Service NEPA document

- **Pesticides.** The selective use of pesticides is based upon pest ecology (including mode of reproduction), the size and distribution of its populations, site-specific conditions (e.g., soils and topography), known efficacy under similar site conditions, and the capability to utilize best management practices (BMPs) to reduce/eliminate potential effects to non-target species, sensitive habitats, and potential to contaminate surface and groundwater. All pesticide usage (including pesticide, target species, application rate, and method of application) must comply with the applicable federal (FIFRA) and state regulations pertaining to pesticide use, safety, storage, disposal, and reporting. Before pesticides can be used to eradicate, control, or contain pests on refuge lands and waters, pesticide use proposals (PUPs) are prepared and approved consistent with Service policy (569 FW 1). PUP records provide a detailed, time-, site-, and target-specific description of the proposed use of pesticides on the refuge. All PUPs are created, approved, approved with modification, or disapproved, and stored in the Pesticide Use Proposal System (PUPS), which is a centralized database accessible on the Service's intranet (https://systems.fws.gov/pups). Only Service employees are authorized to access PUP records through this database.

  Application equipment is selected to provide site-specific delivery to target pests while minimizing/eliminating direct or indirect (e.g., drift) exposure to non-target areas and degradation of surface and groundwater quality. Where possible, target-specific equipment (e.g., backpack sprayer or wiper) is used to treat target pests. Other target-specific equipment to apply pesticides includes soaked wicks or paint brushes for wiping vegetation and lances, hatchets, or syringes for direct injection into stems. Granular pesticides can be applied using seeders or other specialized dispensers. In contrast, aerial spraying (e.g., fixed wing or helicopter) is only be used where access is difficult (remoteness) and/or the size/distribution of infestations precludes practical use of ground-based methods. PUPS will specify the range of target-specific methods available to an applicator."

Because repeated use of one pesticide may allow resistant organisms to survive and reproduce, multiple pesticides with variable modes of action are considered for treatments on refuge lands and waters. This is especially important if multiple applications within years and/or over a growing season are likely to be necessary for habitat maintenance and restoration activities to achieve resource objectives. Integrated chemical and non-chemical controls also are highly effective, where practical, because pesticide-resistant organisms can be removed from the site.

Cost is not the primary factor in selecting a pesticide for use on a refuge. If the least expensive pesticide would potentially harm natural resources or people, then a different product is selected, if available. The most efficacious pesticide available with the least potential to degrade environmental quality (i.e., soils, surface water, and groundwater) and the least potential to affect native species and communities of fish, wildlife, plants, and their habitats would be acceptable for use on refuge lands in the context of an IPM approach.

- **Habitat restoration/maintenance.** Restoration and/or proper maintenance of refuge habitats associated with achieving wildlife and habitat objectives is essential for long-term prevention, eradication, or control (at or below threshold levels) of pests. Promoting desirable plant communities through the manipulation of species composition, plant density, and growth rate is an essential component of invasive plant management (Masters et al. 1996, Masters and Shelly 2001, Brooks et al. 2004). The following three components of succession can be manipulated through habitat maintenance and restoration: site availability, species availability, and species performance (Cox and Anderson 2004). Although a single method (e.g., herbicide treatment) may eliminate or suppress pest species in the short term, the resulting gaps and bare soil create niches that can be conducive to further invasion by the species and/or other invasive plants. On degraded sites where desirable species are absent or in low abundance, revegetation with native/desirable grasses, forbs, and legumes may be necessary to direct and accelerate plant community recovery, and achieve site-specific objectives in a reasonable time frame. The selection of appropriate species for revegetation is dependent on a number of factors including resource objectives and site-specific, abiotic factors (e.g., soil texture, precipitation/temperature regimes, and shade conditions). Seed availability and cost, ease of establishment, seed production, and competitive ability also are important considerations.

4.0 Priorities for Treatments

For many refuges, the magnitude of pest problems (i.e., the number, distribution, and sizes of infestations) is too extensive and beyond the available capital resources to effectively address during any single field season. To manage pests on the refuge, it is essential to prioritize treatment of infestations. Highest priority treatments are focused on early detection and rapid response to eliminate infestations of new pests. It is especially important for restoration and maintenance of biological integrity, diversity, and environmental health to target aggressive pests that may impact species, species groups, communities, and/or habitats associated refuge purpose(s), NWRS resources of concern (i.e., federally listed species, migratory birds, selected marine mammals, and interjurisdictional fish), and native species.

The next priority is treating established pests that appear in one or more previously un-infested areas. Moody and Mack (1988) demonstrated through modeling that small, new outbreaks of invasive plants eventually infest an area larger than the established, source population. They also found that control efforts focusing on the large, main infestation rather than the new, small satellites reduced the chances of overall success. The lowest priority is treating large infestations (sometimes monotypic stands) of well-established pests. In this case, initial efforts focus upon containment of the perimeter followed by work to control/eradicate the established infested area. If containment and/or control of a large infestation is not effective, then efforts refocus upon halting pest reproduction or managing source populations. Maxwell et al. (2009) found treating fewer populations that are sources represents an effective long-term strategy to reduce the total number of invasive populations and decrease meta-population growth rates.

Although state-listed noxious weeds are always of high priority for management, other pest species known to cause substantial ecological impact are also considered for priority treatment. For example, cheatgrass may not be listed by a state as noxious, but it can greatly alter fire regimes in shrub steppe habitats (like at Clear Lake NWR), eventually establishing large monotypic stands that displace native bunch grasses, forbs, and shrubs. Pest control requires a multi-year commitment. Essential to the long-term success of pest management is pre- and post-treatment monitoring, assessment of the successes and failures of treatments, and development of new approaches when proposed methods do not achieve desired outcomes.

5.0 Best Management Practices (BMPs)

BMPs can minimize or eliminate potential pesticide effects to non-target species and/or sensitive habitats, as well as degradation of water quality from drift, surface runoff, or leaching. Based upon the Department of Interior Pesticide Use Policy (517 DM 1) and the Service Integrated Pest Management policy (569 FW 1), the use of applicable BMPs help ensure that pesticide uses do not adversely affect federally listed species and/or their critical habitats through determinations made using the consultation process described in Federal regulations (50 C.F.R. part 402).

Following are BMPs for mixing/handling and applying pesticides for all ground-based pesticide treatments of pesticides. Although not listed below, the most important BMP to eliminate/reduce potential impacts to non-target resources is an IPM approach to prevent, control, eradicate, and contain pests.

5.1 Pesticide Handling and Mixing

- As a precaution against spilling, spray tanks shall not be left unattended during filling.
- All pesticide containers shall be triple rinsed and the rinsate would be used as water in the

sprayer tank and applied to treatment areas.

- All pesticide spray equipment shall be properly cleaned. Where possible, rinsate should be used as part of the make-up water in the sprayer tank and applied to treatment areas.
- Pesticide containers shall be triple rinsed and recycled (where feasible).
- All unused pesticides shall be properly discarded at a local “safe send” collection site.
- Pesticides and pesticide containers shall be lawfully stored, handled, and disposed of in accordance with the label and in a manner safeguarding human health, fish, and wildlife, soil and water.
- Where specified on the pesticide label, water quality parameters (e.g., pH and hardness) that are important to ensure greatest efficacy shall be considered.
- All pesticide spills shall be addressed immediately using procedures identified in the refuge spill response plan.

5.2 Applying Pesticides

- Pesticide treatments shall only be conducted by or under the supervision of Service personnel and non-Service applicators with the appropriate state certification to safely and effectively conduct these activities on refuge lands and waters.
- All Federal, state, and local pesticide use laws and regulations as well as Departmental, Service, and NWRS pesticide-related policies shall be complied with. For example, as required under FIFRA, the proper application equipment and rates should be used for the specific pest(s) identified on the pesticide label.
- Before each treatment season and prior to mixing or applying any product for the first time each season, all applicators shall review the labels, MSDSs, and Pesticide Use Proposal (PUPs) for each pesticide, determining the target pest, appropriate mix rate(s), PPE, and other requirements listed on the pesticide label.
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- Low-impact herbicide application techniques (e.g., spot treatment, cut stump, oil basal, and Thinvert system applications) rather than broadcast foliar applications (e.g., boom sprayer and other larger tank wand applications) shall be used, where practical.
- To maximize herbicide effectiveness and ensure correct and uniform application rates, low-volume rather than high-volume foliar applications shall be used where the low-impact methods above are not feasible or practical.
- Applicators shall use and adjust spray equipment to apply the coarsest droplet size spectrum with optimal coverage of the target species while reducing drift.
- Applicators should use the largest droplet size that results in uniform coverage.
- Applicators shall use drift reduction technologies such as low-drift nozzles, unless otherwise authorized by the refuge manager.
- Where possible, spraying shall occur during low (average <7mph and preferably 3 to 5 mph) and consistent direction wind conditions with moderate temperatures (typically <85 ^{o}F).
- Where possible, applicators shall avoid spraying during inversion conditions (often associated with calm and very low wind conditions) that can cause large-scale herbicide drift to non-target areas.
- Equipment shall be calibrated regularly to ensure that the proper rate of pesticide is applied to the target area or species.

- Spray applications shall be made at the lowest height for uniform coverage of target pests to minimize/eliminate potential drift.
- If windy conditions frequently occur during afternoons, spraying (especially boom treatments) shall typically be conducted during early morning hours.
- Spray applications shall not be conducted on days with >30% forecast for rain within 6 hours, except for pesticides that are rapidly rain fast (e.g., glyphosate in 1 hour) to minimize/eliminate potential runoff.
- Where possible, applicators shall use drift retardant adjuvants during spray applications, especially adjacent to sensitive areas.
- Where possible, applicators shall use a non-toxic dye to aid in identifying target area treated as well as potential over spray or drift. A dye can also aid in detecting equipment leaks. If a leak is discovered, the application shall be stopped until repairs can be made to the sprayer.
- For pesticide uses associated with cropland and facilities management, buffers, as required in PUPS, shall be used to protect sensitive habitats, especially wetlands and other aquatic habitats.
- When drift cannot be sufficiently reduced through altering equipment set up and application techniques, buffer zones shall be identified to protect sensitive areas downwind of applications.
- Applicators shall utilize scouting for early detection of pests to eliminate unnecessary pesticide applications.
- The timing of applications shall be considered so native plants are protected (e.g., senescence) while effectively treating invasive plants.
- Rinsate from cleaning spray equipment shall be recaptured and reused or applied to an appropriate pest plant infestation.
- Application equipment (e.g., sprayer, ATV, tractor) shall be thoroughly cleaned and PPE removed/disposed of on-site by applicators after treatments to eliminate the potential spread of pests to un-infested areas.

6.0 Safety

6.1 Personal Protective Equipment

All applicators should wear the specific personal protective equipment (PPE) identified on the pesticide label. The appropriate PPE should be worn at all times during handling, mixing, and applying. PPE can include the following: disposable (e.g., Tyvek) or laundered coveralls; gloves (latex, rubber, or nitrile); rubber boots; and an NIOSH-approved respirator. Because exposure to concentrated product is usually greatest during mixing, extra care should be taken while preparing pesticide solutions. Persons mixing these solutions can be best protected if they wear long gloves, an apron, footwear, and a face shield.

Coveralls and other protective clothing used during an application should be laundered separately from other laundry items. Transporting, storing, handling, mixing, and disposing of pesticide containers should be consistent with label requirements, USEPA and OSHA requirements, and Service policy.

If a respirator is necessary for a pesticide use, then the following requirements must be met in accordance with Service safety policy (242 FW 12): a written Respirator Program, fit testing, physical examination (including pulmonary function and blood work for contaminants), and proper storage of the respirator.

6.2 Notification

The restricted entry interval (REI) is the time period required after the application at which point someone may safely enter a treated area without PPE. Refuge staff, Service authorized agents, volunteers, and members of the public who could be in or near a pesticide treated area within the stated re-entry time period on the label should be notified about treatment areas. Posting shall occur at any site where individuals might inadvertently become exposed to a pesticide during other activities on a refuge. Where required by the label and/or state-specific regulations, sites shall also be posted along their perimeter and at other likely locations of entry. The refuge staff shall also notify appropriate private property owners (e.g., adjacent landowners) of an intended application, including any private individuals who have requested notification. Special efforts shall be made to contact nearby individuals who are beekeepers or who have expressed chemical sensitivities.

6.3 Medical Surveillance

Medical surveillance may be required for Service personnel and approved volunteers who mix, apply, and/or monitor use of pesticides (see 242 FW 7, Pesticide Users and 242 FW 4, Medical Surveillance). Consistent with Service policy (242 FW 7.12A), Service personnel should be medically monitored if one or more of the following criteria is met: exposed or may be exposed to concentrations at or above the published permissible exposure limits or threshold limit values (see 242 FW 4); use pesticides in a manner considered “frequent pesticide use;” or use pesticides in a manner that requires a respirator (see 242 FW 14 for respirator use requirements). In Service policy (242 FW7.7A), “**Frequent Pesticide Use** means when a person applying pesticide handles, mixes, or applies pesticides, with a Health Hazard rating of 3 or higher, for 8 or more hours in any week or 16 or more hours in any 30-day period.” Under some circumstances, individuals may be medically monitored who use pesticides infrequently (see section 7.7), experience an acute exposure (sudden, short term), or use pesticides with a health hazard ranking of 1 or 2. This monitoring decision should consider the individual’s health and fitness level, the pesticide’s specific health risks, and the potential risks from other pesticide-related activities. Refuge cooperators (e.g., cooperative farmers) and other authorized agents (e.g., state and county employees) are responsible for their own medical monitoring needs and costs.

Standard examinations (at Service expense) of appropriate refuge staff are provided by the nearest certified occupational health and safety physician as determined by Federal Occupational Health (a non-appropriated agency within the Program Support Center of the U.S. Department of Health and Human Services).

6.4 Certification and Supervision of Pesticide Applicators

Appropriate refuge staff or approved volunteers handling, mixing, and/or applying or directly supervising others engaged in pesticide use activities can be trained and be state or federally (USBLM) licensed to apply pesticides to refuge lands or waters. In accordance with 242 FW7.18A and 569 FW 1.10B, certification is required to apply restricted use pesticides based upon USEPA regulations. For safety reasons, all individuals participating in pest management activities with general use pesticides also are encouraged to attend appropriate training or acquire pesticide applicator certification. The certification requirement is for a commercial or private applicator depending upon the state. New staff unfamiliar with proper procedures for storing, mixing, handling, applying, and disposing of herbicides and containers shall receive orientation and training before handling or using any products. Documentation of training shall be kept in the files at the refuge office.

6.5 Record Keeping

6.5.1 Labels and material safety data sheets

Pesticide labels and material safety data sheets (MSDSs) shall be maintained at the refuge shop and laminated copies should be kept in the mixing area. These documents also shall be carried by field applicators, where possible. A written reference (e.g., note pad, chalk board, dry erase board) for each tank to be mixed shall be kept in the mixing area for quick reference while mixing is in progress. Approved PUPs stored in the PUPS database typically contain website links (URLs) to pesticide labels and MSDSs.

6.5.2 Pesticide use proposals (PUPs)

A PUP is prepared for each proposed pesticide use associated with annual pest management on refuge lands and waters. A PUP includes specific information about the proposed pesticide use including the common and chemical names of the pesticide(s), target pest species, size and location of treatment site(s), application rate(s) and method(s), and federally listed species determinations, where applicable.

Upon meeting identified criteria, including an approved IPM plan, where necessary and consistent with Service guidelines (see Director's memo, December 12, 2007), refuge staff may receive up to a five-year approval for proposed pesticide uses that had been reviewed/approved by the field and Washington Office (see http://www.fws.gov/contaminants/Issues/IPM.cfm). For a refuge, an IPM plan (requirements described herein) can be completed independently or in association with a CCP or a habitat management plan (HMP) if IPM strategies and potential environmental effects are adequately addressed within appropriate NEPA documentation.

PUPs are created, approved, approved with modification, or disapproved, and stored as records in the Pesticide Use Proposal System (PUPS), which is a centralized database on the Service's intranet (https://systems.fws.gov/pups). Only Service employees can access PUP records in this database.

6.5.3 Pesticide usage

The refuge project leader is required to maintain annual records of all pesticides applied on lands or waters under refuge jurisdiction (569 FW 1). This would encompass pesticides applied by other Federal agencies, state and county governments, and non-governmental applicators, including cooperators and their U.S. Fish and Wildlife Service-approved pest management service providers. For clarification, pesticide means all insecticides, insect and plant growth regulators, desiccants, herbicides, fungicides, rodenticides, acaricides, nematicides, fumigants, avicides, and piscicides.

The following usage information can be reported for approved PUPs in the PUPS database.

- Pesticide trade name(s)
- Active ingredient(s)
- Total acres treated
- Total amount of pesticides used (lbs or gallons)
- Total amount of active ingredient(s) used (lbs)
- Target pest(s)
- Efficacy (% control)

To determine whether treatments are efficacious (eradicating, controlling, or containing the target pest) and achieving resource objectives, habitat and/or wildlife response should be monitored both pre- and post-treatment, where possible. Considering available annual funding and staffing, appropriate monitoring data regarding characteristics (attributes) of pest infestations (e.g., area, perimeter, degree of infestation-density, % cover, and density) as well as habitat and/or wildlife response to treatments may be collected and stored in a relational database (e.g., Refuge Habitat Management Database), preferably a geo-referenced data management system (e.g., Refuge Lands GIS) to facilitate data analyses and subsequent reporting. In accordance with adaptive management, data analysis and interpretation would allow treatments to be modified or changed over time, as necessary, to achieve resource objectives considering site-specific conditions in conjunction with habitat and/or wildlife responses. Monitoring can also identify short- and long-term impacts to natural resources and environmental quality associated with IPM treatments in accordance with adaptive management principles identified in Federal regulations (see 43 C.F.R. 46.145).

7.0 Evaluating Pesticide Use Proposals

Pesticides can only be used on refuge lands for habitat management as well as croplands or facilities maintenance after approval of a PUP. Potential effects to listed and non-listed species are evaluated with quantitative ecological risk assessments and other screening measures. Potential effects to environmental quality are based upon pesticide characteristics of environmental fate (water solubility, soil mobility, soil persistence, and volatilization) and other quantitative screening tools. Ecological risk assessments as well as characteristics of environmental fate and potential to degrade environmental quality for pesticides are documented in Chemical Profiles (see Section 7.5). These profiles include threshold values for quantitative measures of ecological risk assessments and screening tools for environmental fate that represent minimal potential effects to species and environmental quality. In general, only pesticide uses with appropriate BMPs (see Section 4.0) for habitat management and cropland or facilities maintenance on refuge lands that would potentially have minor, temporary, or localized effects on refuge biological resources and environmental quality (threshold values not exceeded) are approved.

7.1 Overview of Ecological Risk Assessment

An ecological risk assessment process is used to evaluate potential adverse effects to biological resources as a result of a pesticide(s) proposed for use on refuge lands. This process is an established quantitative and qualitative method for comparing and prioritizing risks of pesticides and conveying an estimate of the potential risk for an adverse effect. This quantitative methodology provides an efficient mechanism to integrate best available scientific information regarding hazard, patterns of use (exposure), and dose-response relationships in a manner that is useful for ecological risk decision-making. It provides an effective means to evaluate potential effects where there is missing or unavailable scientific information (data gaps) to address reasonable, foreseeable adverse effects in the field as required under Federal regulations (40 C.F.R. Part 1502.22). Protocols for ecological risk assessment of pesticide uses on the refuge were developed through research and established by the US Environmental Protection Agency (2004). Assumptions for these risk assessments are presented in Section 7.2.3.

The toxicological data used in ecological risk assessments are typically results of standardized laboratory studies provided by pesticide registrants to the USEPA to meet regulatory requirements under FIFRA. These studies assess the acute (lethality) and chronic (reproductive) effects associated with short- and long-term exposure to pesticides on representative species of birds, mammals, freshwater fish, aquatic invertebrates, and terrestrial and aquatic plants. Other effects data that are publicly available are also utilized for risk assessment protocols described herein. Toxicity endpoint and environmental fate data are available from a variety of resources. Some of the more useful resources can be found in Section 7.5.

Table 1. Ecotoxicity tests used to evaluate potential effects to birds, fish, and mammals to establish toxicity endpoints for risk quotient calculations.

Species Group	Exposure	Measurement endpoint
Bird	Acute	Median Lethal Concentration (LC_{50})
	Chronic	No Observed Effect Concentration (NOEC) or No Observed Adverse Effect Concentration (NOAEC)[1]
Fish	Acute	Median Lethal Concentration (LC_{50})
	Chronic	No Observed Effect Concentration (NOEC) or No Observed Adverse Effect Concentration (NOAEC)[2]
Mammal	Acute	Oral Lethal Dose (LD_{50})
	Chronic	No Observed Effect Concentration (NOEC) or No Observed Adverse Effect Concentration (NOAEC)[3]

[1]Measurement endpoints typically include a variety of reproductive parameters (e.g., number of eggs, number of offspring, eggshell thickness, and number of cracked eggs).
[2]Measurement endpoints for early life stage/life cycle typically include embryo hatch rates, time to hatch, growth, and time to swim-up.

[3]Measurement endpoints include maternal toxicity, teratogenic effects or developmental anomalies, evidence of mutagenicity or genotoxicity, and interference with cellular mechanisms such as DNA synthesis and DNA repair.

7.2 Determining Ecological Risk to Fish and Wildlife

The potential for pesticides used on a refuge to cause direct adverse effects to fish and wildlife are evaluated using USEPA's Ecological Risk Assessment Process (USEPA, 2004). This deterministic approach, which is based upon a two-phase process involving estimation of environmental concentrations and then characterization of risk, would be used for ecological risk assessments. This method integrates exposure estimates (estimated environmental concentration [EEC] and toxicological endpoints [e.g., LC_{50} and oral LD_{50}]) to evaluate the potential for adverse effects to species groups (birds, mammals, and fish) representative of legal mandates for managing units of the NWRS. This integration is achieved through risk quotients (RQs) calculated by dividing the EEC by acute and chronic toxicity values selected from standardized toxicological endpoints or published effect (Table 1).

$$RQ = EEC/Toxicological\ Endpoint$$

The level of risk associated with direct effects of pesticide use are characterized by comparing calculated RQs to the appropriate Level of Concern (LOC) established by US Environmental Protection Agency (USEPA, 1998 [Table 2]). The LOC represents a quantitative threshold value for screening potential adverse effects to fish and wildlife resources associated with pesticide use. Following are four exposure-species group scenarios that would are used to characterize ecological risk to fish and wildlife on a refuge: acute-listed species, acute-non-listed species, chronic-listed species, and chronic-non-listed species.

Acute risk indicates the potential for mortality associated with short-term dietary exposure to pesticides immediately after an application. For characterization of acute risks, median values from LC_{50} and LD_{50} tests are used as toxicological endpoints for RQ calculations. In contrast, chronic risks indicate the potential for adverse effects associated with long-term dietary exposure to pesticides from a single application or multiple applications over time (within a season and over years). For characterization of chronic risks, no observed adverse effect concentrations (NOAEC) or no observed effect concentrations (NOEC) for reproduction are used as toxicological endpoints for RQ calculations. Where available, the NOAEC is preferred over a NOEC value.

Listed species are those federally designated as threatened, endangered, or proposed in accordance with the Endangered Species Act of 1973 (16 U.S.C. 1531-1544). For listed species, potential adverse effects are assessed at the individual level because loss of individuals from a population can detrimentally impact a species. In contrast, risks to non-listed species are considered at the population level. A $RQ<LOC$ indicates the proposed pesticide use "may affect, not likely to adversely affect" individuals (listed species) and it would not pose an unacceptable risk for adverse effects to populations (non-listed species) for each taxonomic group (Table 2). In contrast, an $RQ>LOC$ would indicate a "may affect, likely to adversely affect" for listed species and it would also pose unacceptable ecological risk for adverse effects to non-listed species.

Table 2. Presumption of unacceptable risk for birds, fish, and mammals (USEPA, 1998).

Risk Presumption		Level of Concern	
		Listed Species	Non-listed Species
Acute	Birds	0.1	0.5
	Fish	0.05	0.5
	Mammals	0.1	0.5
Chronic	Birds	1.0	1.0
	Fish	1.0	1.0
	Mammals	1.0	1.0

7.2.1 Environmental exposure

Following release into the environment through application, pesticides experience several different routes of environmental fate. Pesticides which are sprayed can move through the air (e.g., particle or vapor drift) and may eventually end up in other parts of the environment such as non-target vegetation, soil, or water. Pesticides applied directly to the soil may be washed off the soil into nearby bodies of surface water (e.g., surface runoff) or may percolate through the soil to lower soil layers and groundwater (e.g., leaching) (Baker and Miller 1999, Pope et. al. 1999, Butler et. al. 1998, Ramsay et. al. 1995, EXTOXNET 1993*a*). Pesticides which are injected into the soil may also be subject to the latter two fates. The aforementioned possibilities are by no means comprehensive, but they illustrate that movement of pesticides in the environment is very complex with transfers occurring continually among different environmental compartments. In some cases, these exchanges occur not only between areas that are close together, but also may involve transportation of pesticides over long distances (Barry 2004, Woods 2004).

7.2.1.1 Terrestrial exposure

The ECC for exposure to terrestrial wildlife is quantified using an USEPA screening-level approach (USEPA. 2004). This screening-level approach is not affected by product formulation because it evaluates pesticide active ingredient(s). This approach varies depending upon the proposed pesticide application method (e.g., spray or granular).

7.2.1.1.1 Terrestrial-spray application

For spray applications, exposure is determined using the Kanaga nomogram method (USEPA, 2005*a*, USEPA. 2004, Pfleeger et al. 1996) through the USEPA's Terrestrial Residue Exposure model (T-REX) version 1.2.3 (USEPA. 2005*b*). To estimate the maximum (initial) pesticide residue on short grass (<20 cm tall) as a general food item category for terrestrial vertebrate species, T-REX input variables include the following from the pesticide label: maximum pesticide application rate (pounds active ingredient [acid equivalent]/acre) and pesticide half-life (days) in soil. Although there are other food item categories (tall grasses; broadleaf plants and small insects; and fruits, pods, seeds and large insects), short grass was selected because it yields maximum EECs (240 ppm per lb ai/acre) for worst-case risk assessments. Short grass is not representative of forage for carnivorous species (e.g., raptors), but it characterizes the maximum potential exposure through the diet of avian and mammalian prey items. Consequently, this approach provides a conservative screening tool for pesticides that do not biomagnify.

For RQ calculations in T-REX, the model requires the weight of surrogate species and Mineau scaling factors (Mineau et. al. 1996). Body weights of bobwhite quail and mallard are included in T-REX by default, but body weights of other organisms (Table 3) can be entered manually. The Mineau scaling factor accounts for small-bodied bird species that may be more sensitive to pesticide exposure than would be predicted only by body weight. Mineau scaling factors are entered manually with values ranging from 1 to 1.55 that are unique to a particular pesticide or group of pesticides. If specific information to select a scaling factor is not available, then a value of 1.15 is used as a default. Alternatively, zero is entered if it is known that body weight does not influence toxicity of pesticide(s) being assessed. The upper bound estimate output from the T-REX Kanaga nomogram is used as an EEC for calculation of RQs. This approach yields a conservative estimate of ecological risk.

Table 3. Average body weight of selected terrestrial wildlife species frequently used in research to establish toxicological endpoints (Dunning 1984).

Species	Body Weight (kg)
Mammal (15 g)	0.015
House sparrow	0.0277
Mammal (35 g)	0.035
Starling	0.0823
Red-winged blackbird	0.0526
Common grackle	0.114
Japanese quail	0.178
Bobwhite quail	0.178
Rat	0.200
Rock dove (aka pigeon)	0.542
Mammal (1000 g)	1.000
Mallard	1.082
Ring-necked pheasant	1.135

7.2.1.1.2 Terrestrial – granular application

Granular pesticide formulations and pesticide-treated seed pose a unique route of exposure for avian and mammalian species. The pesticide is applied in discrete units which birds or mammals might ingest accidentally with food items or intentionally as in the case of some bird species actively seeking and picking up gravel or grit to aid digestion or seed as a food source. Granules may also be consumed by wildlife foraging on earthworms, slugs or other soft-bodied soil organisms to which the granules may adhere.

Terrestrial wildlife RQs for granular formulations or seed treatments are calculated by dividing the maximum milligrams of active ingredient (ai) exposed (e.g., EEC) on the surface of an area equal to 1 square foot by the appropriate LD_{50} value multiplied by the surrogate's body weight (Table 3). An adjustment to surface area calculations is made for broadcast, banded, and in-furrow applications. An adjustment is also made for applications with and without incorporation of the granules. Without incorporation, it is assumed that 100% of the granules remain on the soil surface available to foraging birds and mammals. Press wheels push granules flat with the soil surface, but they are not incorporated into the soil. If granules are incorporated in the soil during band or T-band applications or after broadcast applications, it is assumed only 15% of the applied granules remain available to wildlife. It is assumed that only 1% of the granules are available on the soil surface following in-furrow applications.

EECs for pesticides applied in granular form and as seed treatments are determined considering potential ingestion rates of avian or mammalian species (e.g., 10-30% body weight/day). This provides an estimate of maximum exposure that may occur as a result of granule or seed treatment spills such as those that commonly occur at end rows during application and planting. The availability of granules and seed treatments to terrestrial vertebrates is also considered by calculating the loading per unit area (LD_{50}/ft^2) for comparison to USEPA Level of Concerns (US Environmental Protection Agency 1998). The T-REX version 1.2.3 (USEPA, 2005*b*) contains a submodel which automates Kanaga exposure calculations for granular pesticides and treated seed.

The following formulas are used to calculate EECs depending upon the type of granular pesticide application.

- In-furrow applications assume a typical value of 1% granules, bait, or seed remain unincorporated.

$$mg\ a.i./ft.^2 = [(lbs.\ product/acre)(\%\ a.i.)(453{,}580\ mg/lbs)(1\%\ exposed))] / \{[(43{,}560\ ft.^2/acre)/(row\ spacing\ (ft.))] / (row\ spacing\ (ft.)\}$$

or

$$mg\ a.i./ft^2 = [(lbs\ product/1000\ ft.\ row)(\%\ a.i.)(1000\ ft\ row)(453{,}580\ mg/lb.)(1\%\ exposed)$$

$$EEC = [(mg\ a.i./ft.^2)(\%\ of\ pesticide\ biologically\ available)]$$

- Incorporated banded treatments assume that 15% of granules, bait, and seeds are unincorporated.

$$mg\ a.i./ft.^2 = [(lbs.\ product/1000\ row\ ft.)(\%\ a.i.)(453{,}580\ mg/lb.)(1\text{-}\%\ incorporated)] / (1{,}000\ ft.)(band\ width\ (ft.))$$

$$EEC = [(mg\ a.i./ft.^2)(\%\ of\ pesticide\ biologically\ available)]$$

- Broadcast treatment without incorporation assumes 100% of granules, bait, seeds are unincorporated.

$$mg\ a.i./ft.^2 = [(lbs.\ product/acre)(\%\ a.i.)(453{,}590\ mg/lb.)] / (43{,}560\ ft.^2/acre)$$

$$EEC = [(mg\ a.i./ft.^2)(\%\ of\ pesticide\ biologically\ available)]$$

Where:

- *% of pesticide biologically available = 100% without species specific ingestion rates*
- *Conversion for calculating mg a.i./ft.^{2} using ounces: 453,580 mg/lb. /16 = 28,349 mg/oz.*

The following equation is used to calculate an RQ based on the EEC calculated by one of the above equations. The EEC is divided by the surrogate LD_{50} toxicological endpoint multiplied by the body weight (Table 3) of the surrogate.

$$RQ = EEC / [LD_{50} (mg/kg) * body\ weight\ (kg)]$$

As with other risk assessments, an RQ>LOC would be a presumption of unacceptable ecological risk. An RQ<LOC would be a presumption of acceptable risk with only minor, temporary, or localized effects to species.

7.2.1.2 Aquatic exposure

Exposures to aquatic habitats (e.g., wetlands, meadows, ephemeral pools, water delivery ditches) are evaluated separately for ground-based pesticide treatments of habitats managed for fish and wildlife compared with cropland and facilities maintenance. The primary exposure pathway for aquatic organisms from any ground-based treatments is likely particle drift during the pesticide application. However, different exposure scenarios are necessary as a result of contrasting application equipment and techniques as well as pesticides used to control pests on agricultural lands (especially those cultivated by cooperative farmers for economic return from crop yields) and facilities maintenance (e.g., roadsides, parking lots, trails) compared with other managed habitats on a refuge. In addition, pesticide applications may be made <25 feet from the high water mark of aquatic habitats for habitat management treatments; whereas, no-spray buffers (≥25 feet) are used for croplands/facilities maintenance treatments.

7.2.1.2.1 Habitat treatments

For the worst-case exposure scenario to non-target aquatic habitats, EECs (Table 4) are derived from Urban and Cook (1986). They assume an intentional overspray to an entire, non-target water body (1-foot depth) from a treatment <25 feet from the high water mark using the max application rate (acid basis [see above]). However, use of BMPs for applying pesticides (see Section 4.2) likely minimize/eliminate potential drift to non-target aquatic habitats during actual treatments. If there is unacceptable (acute or chronic) risk to fish and wildlife with the simulated 100% overspray (RQ>LOC), then the proposed pesticide use may be disapproved or the PUP may be approved at a lower application rate to minimize/eliminate unacceptable risk to aquatic organisms (RQ=LOC).

Table 4. Estimated Environmental Concentrations (ppb) of pesticides in aquatic habitats (1 foot depth) immediately after direct application (Urban and Cook 1986).

Lbs/acre	EEC (ppb)
0.10	36.7
0.20	73.5
0.25	91.9
0.30	110.2
0.40	147.0
0.50	183.7
0.75	275.6
1.00	367.5
1.25	459.7
1.50	551.6
1.75	643.5
2.00	735.7
2.25	827.6
2.50	919.4
3.00	1103.5
4.00	1471.4
5.00	1839
6.00	2207
7.00	2575
8.00	2943
9.00	3311
10.00	3678

7.2.1.2.2 Cropland/facilities maintenance treatments

Field drift studies conducted by the Spray Drift Task Force, which is a joint project of several agricultural chemical businesses, were used to develop a generic spray drift database (U.S. EPA, https://www.epa.gov/pesticide-registration/prn-90-3-announcing-formation-industry-wide-spray-drift-task-force-notice). The AgDRIFT computer model was created from this database to satisfy

USEPA pesticide registration spray drift data requirements and as a scientific basis to evaluate off-target movement of pesticides from particle drift and assess potential effects of exposure to wildlife. Several versions of the computer model have been developed (i.e., v2.01 through v2.10). The Spray Drift Task Force AgDRIFT® model version 2.01 (SDTF 2003, AgDRIFT 2001) is used to derive EECs resulting from drift of pesticides to refuge aquatic resources from ground-based pesticide applications >25 feet from the high water mark. The Spray Drift Task Force AgDRIFT model is publicly available at http://www.agdrift.com. At this website, click "AgDRIFT 2.0" and then click "Download Now" and follow the instructions to obtain the computer model.

The AgDRIFT model is composed of submodels called tiers. Tier I Ground submodel is used to assess ground-based applications of pesticides. Tier outputs (EECs) are calculated with AgDRIFT using the following input variables: max application rate (acid basis [see above]), low boom (20 inches), fine to medium droplet size, EPA-defined wetland, and a ≥25-foot distance (buffer) from treated area to water.

7.2.2 Use of information on effects of biological control agents, pesticides, degradates, and adjuvants

Consistent with Federal regulations (see 43 CFR 46.135), the Service specifically incorporates through reference ecological risk assessments prepared by the U.S. Forest Service (http://www.fs.fed.us/r6/invasiveplant-eis/Risk-Assessments/Herbicides-Analyzed-InvPlant-EIS.htm) and U.S. Bureau of Land Management (http://www.blm.gov/wo/st/en/prog/more/veg_eis.html). These risk assessments and associated documentation also are available in total with the administrative record for the Final Environmental Impact Statement entitled *Pacific Northwest Region Invasive Plant Program – Preventing and Managing Invasive Plants* (USFS, 2005) and *Vegetation Treatments Using Herbicides on Bureau of Land Management Lands in 17 Western States Programmatic EIS (PEIS)* (USBLM, 2007). Federal regulations also state that use of existing NEPA documents by supplementing, tiering to, incorporating through reference, or adopting previous NEPA environmental analyses avoids redundancy and unnecessary paperwork (see 43 CRF 46.120(d)).

For example, ecological risk assessments for the following herbicide and adjuvant uses prepared by the U.S. Forest Service could be incorporated through reference and provide a basis for completing "Chemical Profiles" to be used for approving or disapproving refuge PUPs.

- 2,4-D
- Chlorosulfuron
- Clopyralid
- Dicamba
- Glyphosate
- Imazapic
- Imazapyr
- Metsulfuron methyl
- Picloram
- Sethoxydim
- Sulfometuron methyl

- Triclopyr
- Nonylphenol polyethoxylate (NPE) based surfactants

Also, ecological risk assessments for the following herbicide uses and evaluations of risks associated with pesticide degradates and adjuvants prepared by the U.S. Bureau of Land Management could be incorporated through reference and provide a basis for completing "Chemical Profiles" to be used for approving or disapproving refuge PUPs.

- Bromacil
- Chlorsulfuron
- Diflufenzopyr
- Diquat
- Diuron
- Fluridone
- Imazapic
- Overdrive (diflufenzopyr and dicamba)
- Sulfometuron methyl
- Tebuthiuron
- Pesticide degradates and adjuvants (*Appendix D – Evaluation of risks from degradates, polyoxyethylene-amine (POEA) and R-11, and endocrine disrupting chemicals*)

7.2.3 Assumptions for ecological risk assessments

There are a number of assumptions involved with the ecological risk assessment process for terrestrial and aquatic organisms associated with utilization of the US Environmental Protection Agency's (2004) process. These assumptions may be risk neutral or may lead to an over- or under-estimation of risk from pesticide exposure depending upon site-specific conditions. The following describes these assumptions, their application to the conditions typically encountered, and whether or not they may lead to recommendations that are risk neutral, underestimate, or overestimate ecological risk from potential pesticide exposure.

- Indirect effects are not be evaluated by ecological risk assessments. These effects include the mechanisms of indirect exposure to pesticides: consuming prey items (fish, birds, or small mammals), reductions in the availability of prey items, and disturbance associated with pesticide application activities.
- Exposure to a pesticide product is assessed based upon the active ingredient. However, exposure to a chemical mixture (pesticide formulation) may result in effects that are similar or substantially different compared to only the active ingredient. Non-target organisms may be exposed directly to the pesticide formulation or only various constituents of the formulation as they dissipate and partition in the environment. If toxicological information for both the active ingredient and formulated product are available, then data representing the greatest potential toxicity is selected for use in the risk assessment process (USEPA, 2004). As a result, this conservative approach may lead to an overestimation of risk characterization from pesticide exposure.
- Because toxicity tests with listed or candidate species or closely related species are not available, data for surrogate species is most often used for risk assessments. Specifically, bobwhite quail and mallard duck are the most frequently used surrogates for evaluating

potential toxicity to federally listed avian species. Bluegill sunfish, rainbow trout, and fathead minnow are the most common surrogates for evaluating toxicity for freshwater fishes; and sheep's head minnow can be an appropriate surrogate marine species for coastal environments. Rats and mice are the most common surrogates for evaluating toxicity for mammals. Interspecies sensitivity is a major source of uncertainty in pesticide assessments. As a result of this uncertainty, data is selected for the most sensitive species tested within a taxonomic group (birds, fish, and mammals) given the quality of the data is acceptable. If additional toxicity data for more species or organisms in a particular group are available, the selected data are not limited to the species previously listed as common surrogates.

- The Kanaga nomogram outputs maximum EEC values that may be used to calculate an average daily concentration over a specified interval of time, which is referred to as a time-weighted-average (TWA). The maximum EEC would be selected as the exposure input for both acute and chronic risk assessments in the screening-level evaluations. The initial or maximum EEC derived from the Kanaga nomogram represents the maximum expected instantaneous or acute exposure to a pesticide. Acute toxicity endpoints are determined using a single exposure to a known pesticide concentration, typically for 48 to 96 hours. This value is assumed to represent ecological risk from acute exposure to a pesticide. On the other hand, chronic risk to pesticide exposure is a function of pesticide concentration and duration of exposure to the pesticide. An organism's response to chronic pesticide exposure may result from either the concentration of the pesticide, length of exposure, or some combination of both factors. Standardized tests for chronic toxicity typically involve exposing an organism to several different pesticide concentrations for a specified length of time (days, weeks, months, years or generations). For example, avian reproduction tests include a 10-week exposure phase. Because a single length of time is used in the test, time response data are usually not available for inclusion into risk assessments. Without time response data it is difficult to determine the concentration which elicited a toxicological response.
- Using maximum EECs for chronic risk estimates may result in an overestimate of risk, particularly for compounds that dissipate rapidly. Conversely, using TWAs for chronic risk estimates may underestimate risk if it is the concentration rather than the duration of exposure that is primarily responsible for the observed adverse effect. The maximum EEC is used for chronic risk assessments although it may result in an overestimate of risk. TWAs may be used for chronic risk assessments, but they will be applied judiciously considering the potential for an underestimate or overestimate of risk. For example, the number of days exposure exceeds a Level of Concern may influence the suitability of a pesticide use. The greater the number of days the EEC exceeds the Level of Concern translates into greater the ecological risk. This is a qualitative assessment, and is subject to reviewer's expertise in ecological risk assessment and tolerance for risk.
- The length of time used to calculate the TWA can have a substantial effect on the exposure estimates and there is no standard method for determining the appropriate duration for this estimate. The T-REX model assumes a 21-week exposure period, which is equivalent to avian reproductive studies designed to establish a steady-state concentration for bioaccumulative compounds. However, this does not necessarily define the true exposure duration needed to elicit a toxicological response. Pesticides, which do not bioaccumulate, may achieve a steady-state concentration earlier than 21 weeks. The duration of time for calculating TWAs will require justification and it will not exceed the duration of exposure in the chronic toxicity test (approximately 70 days for the standard avian reproduction study).

An alternative to using the duration of the chronic toxicity study is to base the TWA on the application interval. In this case, increasing the application interval would suppress both the estimated peak pesticide concentration and the TWA. Another alternative to using TWAs would be to consider the number of days that a chemical is predicted to exceed the LOC.

- Pesticide dissipation is assumed to be first-order in the absence of data suggesting alternative dissipation patterns such as bi-phasic. Field dissipation data would generally be the most pertinent for assessing exposure in terrestrial species that forage on vegetation. However, these data are often not available and they can be misleading particularly if the compound is prone to “wash-off.” Soil half-life are the most common degradation data available. Dissipation or degradation data that would reflect the environmental conditions typical of refuge lands are utilized, if available.
- For species found in the water column, it is assumed that the greatest bioavailable fraction of the pesticide active ingredient in surface waters is freely dissolved in the water column.
- Actual habitat requirements of any particular terrestrial species are not considered, and it is assumed that species exclusively and permanently occupy the treated area, or adjacent areas receiving pesticide at rates commensurate with the treatment rate. This assumption produces a maximum estimate of exposure for risk characterization. This assumption likely overestimates exposure for species that do not permanently and exclusively occupy the treated area (USEPA, 2004).
- Exposure through incidental ingestion of pesticide contaminated soil is not considered in the USEPA risk assessment protocols. Research suggests <15% of the diet can consist of incidentally ingested soil depending upon species and feeding strategy (Beyer et al. 1994). An assessment of pesticide concentrations in soil compared to food item categories in the Kanaga nomogram indicates incidental soil ingestion likely does not increase dietary exposure to pesticides. Inclusion of soil into the diet would effectively reduce the overall dietary concentration compared to the present assumption that the entire diet consists of a contaminated food source (Fletcher et al. 1994). An exception to this may be soil-applied pesticides in which exposure from incidental ingestion of soil may increase. The potential for pesticide exposure under this assumption may be underestimated for soil-applied pesticides and overestimated for foliar-applied pesticides. The concentration of a pesticide in soil would likely be less than predicted on food items.
- Exposure through inhalation of pesticides is not considered in the USEPA risk assessment protocols. Such exposure can occur through three potential sources: spray material in droplet form at time of application, vapor phase with the pesticide volatilizing from treated surfaces, and airborne particulates (soil, vegetative matter, and pesticide dusts). The USEPA (1990) reported exposure from inhaling spray droplets at the time of application is not an appreciable route of exposure for birds. According to research on mallards and bobwhite quail, respirable particle size (particles reaching the lung) in birds is limited to maximum diameter of 2 to 5 microns. The spray droplet spectra covering the majority of pesticide application scenarios indicate that less than 1% of the applied material is within the respirable particle size. This route of exposure is further limited because the permissible spray drop size distribution for ground pesticide applications is restricted to ASAE medium or coarser drop size distribution.
- Inhalation of a pesticide in the vapor phase can be another source of exposure for some pesticides under certain conditions. This mechanism of exposure to pesticides occurs post application, and it pertains to those pesticides with a high vapor pressure. The USEPA is

currently evaluating protocols for modeling inhalation exposure from pesticides including near-field and near-ground air concentrations based upon equilibrium and kinetics-based models. Risk characterization for exposure with this mechanism is unavailable.

- The effect from exposure to dusts contaminated with the pesticide cannot be assessed generically as partitioning issues related to application site soils and chemical properties of the applied pesticides render the exposure potential from this route highly situation specific.
- Dermal exposure can occur through three potential sources: direct application of spray to terrestrial wildlife in the treated area or within the drift footprint, incidental contact with contaminated vegetation, or contact with contaminated water or soil. Interception of spray and incidental contact with treated substrates may pose risk to avian wildlife (Driver et al. 1991). However, available research related to wildlife dermal contact with pesticides is extremely limited, except dermal toxicity values are common for some mammals used as human surrogates (rats and mice). The USEPA is currently evaluating protocols for modeling dermal exposure. Risk characterization may be underestimated for this route of exposure, particularly with high risk pesticides such as some organophosphates or carbamate insecticides. If protocols are established by the USEPA for assessing dermal exposure to pesticides, they will be considered for incorporation into pesticide assessment protocols.
- Exposure to a pesticide can occur from consuming surface water, dew, or other water on treated surfaces. Water-soluble pesticides have the potential to dissolve in surface runoff and puddles in a treated area can contain pesticide residues. Similarly, pesticides with lower organic carbon partitioning characteristics and higher solubility in water have a greater potential to dissolve in dew and other water associated with plant surfaces. Estimating the extent to which such pesticide loadings to drinking water occurs is complex and would depend upon the partitioning characteristics of the active ingredient, soils types in the treatment area, and the meteorology of the treatment area. In addition, the use of various water sources by wildlife is highly species-specific. Currently, risk characterization for this exposure mechanism is not available. The USEPA is actively developing protocols to quantify drinking water exposures from puddles and dew. If and when protocols are formally established by the USEPA for assessing exposure to pesticides through drinking water, these protocols will be incorporated into pesticide risk assessment protocols.
- Risk assessments are based upon the assumption that the entire treatment area is subject to pesticide application at the rates specified on the label. In most cases, there is potential for uneven application of pesticides through such plausible incidents as changes in calibration of application equipment, spillage, and localized releases at specific sites in or near the treated field that are associated with mixing and handling and application equipment as well as applicator skill. Inappropriate use of pesticides and the occurrence of spills represent a potential underestimate of risk. It is likely not an important factor for risk characterization. All pesticide applicators are required to be certified by the state in which they apply pesticides. Certification training includes the safe storage, transport, handling, and mixing of pesticides; equipment calibration; and proper application with annual continuing education.
- The USEPA relies on Fletcher (1994) for setting the assumed pesticide residues in wildlife dietary items. The USEPA (2004) "believes that these residue assumptions reflect a realistic upper-bound residue estimate, although the degree to which this assumption reflects a specific percentile estimate is difficult to quantify." Fletcher's (1994) research suggests that the pesticide active ingredient residue assumptions used by the USEPA represent a 95th percentile estimate. However, research conducted by Pfleeger et al. (1996) indicates USEPA

residue assumptions for short grass were not exceeded. Baehr and Habig (2000) compared USEPA residue assumptions with distributions of measured pesticide residues for the USEPA's UTAB database. Overall residue selection level will tend to overestimate risk characterization. This is particularly evident when wildlife individuals are likely to have selected a variety of food items acquired from multiple locations. Some food items may be contaminated with pesticide residues whereas others are not contaminated. However, it is important to recognize differences in species feeding behavior. Some species may consume whole above-ground plant material, but others will preferentially select different plant structures. Also, species may preferentially select a single food item although multiple food items are present. Without species-specific knowledge regarding foraging behavior, characterizing ecological risk other than in general terms is not possible.

- Acute and chronic risk assessments rely on comparisons of wildlife dietary residues with LC_{50} or NOEC values expressed as concentrations of pesticides in laboratory feed. These comparisons assume that ingestion of food items in the field occurs at rates commensurate with those in the laboratory. Although the screening assessment process adjusts dry-weight estimates of food intake to reflect the increased mass in fresh-weight wildlife food intake estimates, it does not allow for gross energy and assimilative efficiency differences between wildlife food items and laboratory feed. Differences in assimilative efficiency between laboratory and wild diets suggest that current screening assessment methods are not accounting for a potentially important aspect of food requirements.
- There are several other assumptions that can affect non-target species not considered in the risk assessment process. These include possible additive or synergistic effects from applying two or more pesticides or additives in a single application, co-location of pesticides in the environment, cumulative effects from pesticides with the same mode of action, effects of multiple stressors (e.g., combination of pesticide exposure, adverse abiotic and biotic factors) and behavioral changes induced by exposure to a pesticide. These factors may exist at some level contributing to adverse effects to non-target species, but they are usually characterized in the published literature in only a general manner limiting their value in the risk assessment process.
- It is assumed that aquatic species exclusively and permanently occupy the water body being assessed. Actual habitat requirements of aquatic species are not considered. With the possible exception of scenarios where pesticides are directly applied to water, it is assumed that no habitat use considerations specific for any species would place the organisms in closer proximity to pesticide use sites. This assumption produces a maximum estimate of exposure or risk characterization. It would likely be realistic for many aquatic species that may be found in aquatic habitats within or in close proximity to treated terrestrial habitats. However, the spatial distribution of wildlife is usually not random because wildlife distributions are often related to habitat requirements of species. Clumped distributions of wildlife may result in an under- or over-estimation of risk depending upon where the initial pesticide concentration occurs relative to the species or species habitat.
- For species found in the water column, it is assumed that the greatest bioavailable fraction of the pesticide active ingredient in surface waters is freely dissolved in the water column. Additional chemical exposure from materials associated with suspended solids or food items is not considered because partitioning onto sediments likely is minimal. Adsorption and bioconcentration occurs at lower levels for many newer pesticides compared with older more persistent bioaccumulative compounds. Pesticides with RQs close to the listed species level

of concern, the potential for additional exposure from these routes may be a limitation of risk assessments, where potential pesticide exposure or risk may be underestimated.

- Mass transport losses of pesticide from a water body (except for losses by volatilization, degradation and sediment partitioning) are not considered for ecological risk assessment. The water body is assumed to capture all pesticide active ingredients entering as runoff, drift, and adsorbed to eroded soil particles. It's also assumed that a pesticide's active ingredient is not lost from the water body by overtopping or flow-through, nor is concentration reduced by dilution. In total, these assumptions lead to a near maximum possible water-borne concentration. However, this assumption does not account for the potential to concentrate pesticide through the evaporative loss. This limitation may have the greatest impact on water bodies with high surface-to-volume ratios such as ephemeral wetlands, where evaporative losses are accentuated and applied pesticides have low rates of degradation and volatilization.
- For acute risk assessments, there is no averaging time for exposure. An instantaneous peak concentration is assumed, where instantaneous exposure is sufficient in duration to elicit acute effects comparable to those observed over more protracted exposure periods (typically 48 to 96 hours) tested in the laboratory. In the absence of data regarding time-to-toxic event, analyses and latent responses to instantaneous exposure, risk is likely overestimated.
- For chronic exposure risk assessments, the averaging times considered for exposure are commensurate with the duration of invertebrate life-cycle or fish-early life stage tests (e.g., 21-28 days and 56-60 days, respectively). Response profiles (time-to-effect and latency-of-effect) to pesticides likely vary widely with mode of action and species and should be evaluated on a case-by-case basis as available data allow. Nevertheless, because the USEPA relies on chronic exposure toxicity endpoints based on a finding of no observed effect, the potential for any latent toxicity effects or averaging time assumptions to alter the results of an acceptable chronic risk assessment prediction is limited. The extent to which duration of exposure from water-borne concentrations overestimate or underestimate actual exposure depends on several factors. These include the following: localized meteorological conditions, runoff characteristics of the watershed (e.g., soils and topography), the hydrological characteristics of receiving waters, environmental fate of the pesticide active ingredient, and the method of pesticide application. It should also be understood that chronic effects studies are performed using a method that holds water concentration in a steady state. This method is not likely to reflect conditions associated with pesticide runoff. Pesticide concentrations in the field increase and decrease in surface water on a cycle influenced by rainfall, pesticide use patterns, and degradation rates. As a result of the dependency of this assumption on several undefined variables, risk associated with chronic exposure may in some situations underestimate risk and overestimate risk in others.
- There are several other factors that can affect non-target species not considered in the risk assessment process. These include the following: possible additive or synergistic effects from applying two or more pesticides or additives in a single application, co-location of pesticides in the environment, cumulative effects from pesticides with the same mode of action, effects of multiple stressors (e.g., combination of pesticide exposure, adverse abiotic [not pesticides] and biotic factors), and sub-lethal effects such as behavioral changes induced by exposure to a pesticide. These factors may exist at some level contributing to adverse effects to non-target species, but they are not routinely assessed by regulatory agencies. Therefore, information on the factors is not extensive limiting their value for the risk assessment

process. As this type of information becomes available, it is included, either quantitatively or qualitatively, in this risk assessment process.
- USEPA is required by the Food Quality Protection Act to assess the cumulative risks of pesticides that share common mechanisms of toxicity, or act the same within an organism. Currently, USEPA has identified four groups of pesticides that have a common mechanism of toxicity requiring cumulative risk assessments. These four groups are: the organophosphate insecticides, N-methyl carbamate insecticides, triazine herbicides, and chloroacetanilide herbicides.

7.3 Pesticide Mixtures and Degradates

Pesticide products are usually a formulation of several components generally categorized as active ingredients and inert or other ingredients. The term active ingredient is defined by the FIFRA as preventing, destroying, repelling, or mitigating the effects of a pest, or it is a plant regulator, defoliant, desiccant, or nitrogen stabilizer. In accordance with FIFRA, the active ingredient(s) must be identified by name(s) on the pesticide label along with its relative composition expressed in percentage(s) by weight. In contrast, inert ingredient(s) are not intended to affect a target pest. Their role in the pesticide formulation is to act as a solvent (keep the active ingredient is a liquid phase), an emulsifying or suspending agent (keep the active ingredient from separating out of solution), or a carrier (such as clay in which the active ingredient is impregnated on the clay particle in dry formulations). For example, if isopropyl alcohol would be used as a solvent in a pesticide formulation, then it would be considered an inert ingredient. FIFRA only requires that a product label declare the total percentage of all inert ingredients and inert ingredients identified as hazardous and associated percent composition. Inert ingredients that are not classified as hazardous are not required to be identified.

The USEPA (September 1997) issued Pesticide Regulation Notice 97-6, which encouraged manufacturers, formulators, producers, and registrants of pesticide products to voluntarily substitute the term “other ingredients” for “inert ingredients” in the ingredient statement. This change recognized that all components in a pesticide formulation could potentially elicit or contribute to an adverse effect on non-target organisms and, therefore, are not necessarily inert. Whether referred to as “inerts” or “other ingredients,” these constituents within a pesticide product have the potential to affect species or environmental quality. The USEPA categorizes regulated inert ingredients into the following four lists (http://www.epa.gov/opprd001/inerts/index.html):

- List 1 – Inert Ingredients of Toxicological Concern;
- List 2 – Potentially Toxic Inert Ingredients;
- List 3 – Inerts of Unknown Toxicity; and
- List 4 – Inerts of Minimal Toxicity.

Several of the List 4 compounds are naturally-occurring earthen materials (e.g., clay materials, simple salts) that would not elicit toxicological response at applied concentrations. However, some of the inerts (particularly the List 3 compounds and unlisted compounds) may have moderate to high toxicity to aquatic species based on MSDSs or published data.

Comprehensively assessing potential effects of pesticide use to non-target fish, wildlife, plants, and/or their habitats is a complex task. It would be preferable to assess the cumulative effects from exposure to the active ingredient, its degradates, and inert ingredients as well as other active ingredients in the spray mixture. However, it would only be feasible to conduct deterministic risk assessments for each component in the spray mixture singly. Limited scientific information is available regarding ecological effects (additive or synergistic) from chemical mixtures and these assessments typically rely upon broad assumptions. For example, the U.S. Forest Service (2005) found that mixtures of pesticides used in land (forest) management likely would not cause additive or synergistic effects to non-target species based upon a review of scientific literature regarding toxicological effects and interactions of agricultural chemicals (ATSDR, 2004). Moreover, information on inert ingredients, adjuvants, and degradates is often limited by the availability of and access to reliable toxicological data for these constituents.

Toxicological information regarding "other ingredients" may be available from sources such as the following:

- TOMES (a proprietary toxicological database including USEPA's IRIS, the Hazardous Substance Data Bank, and the Registry of Toxic Effects of Chemical Substances [RTECS]).
- USEPA's ECOTOX database, which includes AQUIRE (a database containing scientific papers published on the toxic effects of chemicals to aquatic organisms).
- TOXLINE (a literature searching tool).
- Material Safety Data Sheets (MSDSs) from pesticide suppliers.
- Other sources such as the Farm Chemicals Handbook.

Due to the paucity of specific toxicological data regarding inerts, it is unknown whether they may cause adverse ecological effects. However, inert ingredients typically represent only a small percentage of the pesticide spray mixture and it is expected that their use results in negligible effects.

Although the potential effects of degradates should be considered when selecting a pesticide, it is beyond the scope of this assessment process to consider all possible breakdown chemicals of the various product formulations containing an active ingredient. Degradates may be more or less mobile and more or less hazardous in the environment than their parent pesticides (Battaglin et al., 2003). Differences in environmental behavior (e.g., mobility) and toxicity between parent pesticides and degradates make assessing potential degradate effects extremely difficult. For example, a less toxic and more mobile, bioaccumulative, or persistent degradate may have potentially greater effects on species and/or degrade environmental quality. The lack of data on the toxicity of degradates for many pesticides represents a source of uncertainty for assessing risk.

A USEPA-approved label specifies whether a product can be mixed with one or more pesticides. Without product-specific toxicological data, it is not possible to quantify the potential effects of these mixtures. In addition, a quantitative analysis can only be conducted if reliable scientific information allows a determination of whether the joint action of a mixture is additive, synergistic, or antagonistic. Such information would not likely exist unless the mode of action would be common among the chemicals and receptors. Moreover, the composition of and exposure to mixtures can be highly site- and/or time-specific and, therefore, it is nearly impossible to assess potential effects to species and environmental quality.

Applying pesticides in accordance with labeling requirements minimizes or eliminates potential negative effects associated with applying two or more pesticides as a mixture. Labels for two or more pesticides applied as a mixture should be completely reviewed and products with the least potential for negative effects shall be selected for use on a refuge. This is especially relevant when a mixture is to be applied in a manner that may already have the potential for an effect(s) associated with an individual pesticide (e.g., runoff to ponds in sandy watersheds). Use of a tank mix under these conditions increases the level of uncertainty in terms of risk to species or potential to degrade environmental quality.

Adjuvants generally function to enhance or prolong pesticide activity. For terrestrial herbicides, adjuvants aid in the absorption into plant tissue. Adjuvant is a broad term that generally applies to surfactants, selected oils, anti-foaming agents, buffering compounds, drift control agents, compatibility agents, stickers, and spreaders. Adjuvants are not under the same registration requirements as pesticides and the USEPA does not register or approve the labeling of spray adjuvants. Individual labels identify types of adjuvants approved for use with the particular pesticide. In general, adjuvants compose a relatively small portion of the volume of pesticides applied. To reduce the potential for the adjuvant to influence the toxicity of the pesticide, adjuvants with limited toxicity and low volumes should be selected.

7.4 Determining Effects to Soil and Water Quality

The approval process for pesticide uses considers the potential to degrade water quality on and off refuge lands. A pesticide can only affect water quality through movement away from the treatment site. After application, pesticide mobilization can be characterized by one or more of the following (Kerle et al. 1996):

- Attach (sorb) to soil, vegetation, or other surfaces and remain at or near the treated area;
- Attach to soil and move off-site through erosion from runoff or wind; and
- Dissolve in water that can be subjected to runoff or leaching.

As an initial screening tool, selected chemical characteristics and rating criteria for a pesticide can be evaluated to assess potential to enter ground and/or surface waters. These include persistence, sorption coefficient (K_{oc}), groundwater ubiquity score (GUS), and solubility.

Persistence, which is expressed as half-life ($t_{½}$), represents the length of time required for 50% of the deposited pesticide to degrade (completely or partially). Persistence in the soil can be categorized as the following: non-persistent <30 days, moderately persistent = 30 to 100 days, and persistent >100 days (Kerle et al., 1996). Half-life data are usually available for aquatic and terrestrial environments.

Another measure of pesticide persistence is dissipation time (DT_{50}). It represents the time required for 50% of the deposited pesticide to degrade and move from a treated site; whereas, half-life describes the rate for degradation only. As for half-life, units of dissipation time are usually expressed in days. Field or foliar dissipation time is the preferred measure for estimating pesticide concentrations in the environment. However, soil half-life is the most common persistence measure cited in published literature. If field or foliar dissipation data are not available, soil half-life data may be used. The average or representative half-life value of most important degradation mechanism will be selected for quantitative analysis for both terrestrial and aquatic environments.

Mobility of a pesticide is a function of how strongly it is adsorbed to soil particles and organic matter, its solubility in water, and its persistence in the environment. Pesticides strongly adsorbed to soil particles, relatively insoluble in water, and not environmentally persistent are less likely to move across the soil surface into surface waters or to leach through the soil profile and contaminate groundwater. Conversely, pesticides that are not strongly adsorbed to soil particles, are highly water soluble, and are persistent in the environment have greater potential to move from the application site (off-site movement).

The degree of pesticide adsorption to soil particles and organic matter (Kerle et al., 1996) is expressed as the soil adsorption coefficient (K_{oc}). The soil adsorption coefficient is measured as micrograms of pesticide per gram of soil (µg/g) and can range from near zero to the thousands. Pesticides with higher K_{oc} values are strongly sorbed to soil and, therefore, less subject to movement.

Water solubility describes the degree to which a pesticide will dissolve in a known quantity of water. The water solubility of a pesticide is expressed as milligrams of pesticide dissolved in a liter of water (mg/L or parts per million [ppm]). Pesticide with solubility <0.1 ppm are virtually insoluble in water, 100-1000 ppm are moderately soluble, and >10,000 ppm highly soluble (USGS, 2000). As pesticide solubility increases, there is greater potential for off-site movement through runoff or leaching.

The Groundwater Ubiquity Score (GUS) is a quantitative screening tool to estimate a pesticide's potential to move in the environment. It utilizes soil persistence and adsorption coefficients in the following formula.

$$GUS = \log_{10} (t_{½}) \times [4 - \log_{10} (K_{oc})]$$

The potential pesticide movement rating is based upon its GUS value. Pesticides with a GUS <0.1 are considered to have an extremely low potential to move toward groundwater. Those with values of 1.0-2.0 are low, 2.0-3.0 are moderate, 3.0-4.0 are high, and >4.0 have a very high potential to move toward groundwater.

GUS, water solubility, $t_{½}$, and K_{oc} values are available for selected pesticides from the OSU Extension Pesticide Properties Database at http://npic.orst.edu/ppdmove.htm. Many of the values in this database were derived from the SCS/ARS/CES Pesticide Properties Database for Environmental Decision Making (Wauchope et al., 1992).

Soil properties influence the fate of pesticides in the environment. The following six properties are mostly likely to affect pesticide degradation and the potential for pesticides to move off-site by leaching (vertical movement through the soil) or runoff (lateral movement across the soil surface).

- Permeability is the rate of water movement vertically through the soil. It is affected by soil texture and structure. Coarse textured soils (e.g., those with a high sand content) have a larger pore size and are generally more permeable than fine textured soils (i.e., those with a high clay content). More permeable soils have a greater potential for pesticides to move vertically down through the soil profile. Soil permeability rates (inches/hour) are usually available in county soil survey reports.
- Soil texture describes the relative percentage of sand, silt, and clay. In general, greater clay content with smaller pore size lowers the likelihood and rate water moves through the soil profile. Clay also serves to adsorb (bind) pesticides to soil particles. Soils with high clay content adsorb more pesticide than soils with relatively low clay content. In contrast, sandy soils with coarser texture and lower water holding capacity have a greater potential for water to leach through them.
- Soil structure describes soil aggregation. Soils with a well-developed soil structure have looser, more aggregated, structure that is less likely to be compacted. Both characteristics allow for less restricted flow of water through the soil profile resulting in greater infiltration.
- Organic matter is the single most important factor affecting pesticide adsorption in soils. Many pesticides are adsorbed to organic matter which reduces their rate of downward movement through the soil profile. Also, soils high in organic matter tend to hold more water, which may make less water available for leaching.
- Soil moisture affects how fast water moves through the soil. If soils are already wet or saturated before rainfall or irrigation, excess moisture can run off rather than infiltrate into the soil profile. Soil moisture also influences microbial and chemical activity in soil, which affects pesticide degradation.
- Soil pH influences chemical reactions that occur in the soil which in turn determines whether or not a pesticide degrades, the rate of degradation, and, in some instances, which degradation products are produced.

Based upon the aforementioned properties, soils most vulnerable to groundwater contamination are sandy soils with low organic matter. In contrast, the least vulnerable soils are well-drained clayey soils with high organic matter. Consequently, pesticides with the lowest potential for movement in conjunction with appropriate best management practices (see below) should be used in an IPM framework to treat pests while minimizing effects to non-target biota and protecting environmental quality.

Along with soil properties, site-specific environmental and abiotic conditions (including rainfall, water table conditions, and topography) help determine the potential for a pesticide to affect water quality through runoff and leaching (Huddleston, 1996).

- Water is necessary to separate pesticides from soil. This can occur in two ways. Pesticides that are soluble move easily with runoff water., and pesticide-laden soil particles can be dislodged and transported from the application site in runoff. The concentration of pesticides in surface runoff is greatest for the first runoff event following treatment. The rainfall intensity and route of water infiltration into soil, to a large extent, determine pesticide concentrations and losses in surface runoff. The timing of the rainfall after application also can have an effect. Rainfall interacts with pesticides at a shallow soil depth (¼ to ½ inch), which is called the mixing zone (Baker and Miller 1999). The pesticide/water mixture in the mixing zone tends to leach down into the soil or run off, depending upon how quickly the soil surface becomes saturated and how rapidly water can infiltrate into the soil. Leaching decreases the amount of pesticide available near the soil surface (mixing zone) to run off during the initial and subsequent rainfall events following application.

- Terrain slope affects the potential for surface runoff and the intensity of runoff. Steeper slopes have greater potential for runoff following a rainfall event. In contrast, soils that are relatively flat have little potential for runoff, except during intense rainfall events. In addition, soils in lower areas are more susceptible to leaching as a result of receiving excessive water from surrounding higher elevations.
- Depth to the water table is an important factor affecting the potential for pesticides to leach into groundwater. If the distance from the soil surface to the top of the water table is shallow, pesticides have less distance to travel to reach groundwater. Shallower water tables that persist for longer periods would be more likely to experience groundwater contamination. Soil survey reports are available for individual counties. These reports provide data in tabular format regarding water table depths and the months during which it persists. In some situations, a hard pan exists above the water table that prevents pesticide contamination from leaching.

7.5 Determining Effects to Air Quality

Pesticides may volatilize from soil and plant surfaces and move from the treated area into the atmosphere. The potential for a pesticide to volatilize is determined by the pesticide's vapor pressure which is affected by temperature, sorption, soil moisture, and the pesticide's water solubility. Vapor pressure is often expressed in mm Hg. To make these numbers easier to compare, vapor pressure may be expressed in exponent form (I x 10^{-7}), where I represents a vapor pressure index. In general, pesticides with $I<10$ would have a low potential to volatilize; whereas, pesticides with $I>1,000$ would have a high potential to volatilize (OSU, 1996). Vapor pressure values for pesticides are usually available in the pesticide product MSDS or the USDA Agricultural Research Service (ARS) pesticide database.

7.6 Preparing a Chemical Profile

The following instructions are used by Service personnel to complete Chemical Profiles for pesticides. Specifically, profiles are prepared for pesticide active ingredients (e.g., glyphosate and imazapic) that are contained in one or more trade name products registered and labeled with USEPA. All information fields under each category (e.g., Toxicological Endpoints and Environmental Fate) are included in a Chemical Profile. If no information is available for a specific field, then "No data is available in references" is recorded in the profile. Available scientific information is then used to complete Chemical Profiles. Each entry of scientific information is coupled with applicable references.

Completed Chemical Profiles provide a structured decision-making process utilizing quantitative assessment/screening tools with threshold values (where appropriate) that are used to evaluate potential biological and other environmental effects on refuge resources. For ecological risk assessments presented in these profiles, the "worst-case scenario" is evaluated to determine whether a pesticide could be approved for use considering the maximum single application rate specified on pesticide labels for habitat management and croplands/facilities maintenance treatments pertaining to refuges. Where the “worst-case scenario” likely would only result in minor, temporary, and localized effects to listed and non-listed species with appropriate BMPs (see Section 5.0), the proposed pesticide’s use in a PUP would have a scientific basis for approval under any application rate specified on the label that is at or below rates evaluated in a Chemical Profile. In some cases, the Chemical Profile includes a lower application rate than the maximum labeled rate in order to protect refuge resources. As necessary, Chemical Profiles are periodically updated with new scientific information or as pesticides with the same active ingredient are proposed for use on the refuge in PUPs.

Throughout this section, threshold values (to prevent or minimize potential biological and environmental effects) are clearly identified for specific information presented in a completed Chemical Profile. Comparison with these threshold values provides an explicit scientific basis to approve or disapprove PUPs for habitat management and cropland/facilities maintenance on refuge lands. In general, PUPs are approved for pesticides with Chemical Profiles where there would be no exceedances of threshold values. However, BMPs are identified for some screening tools that would minimize/eliminate potential effects (exceedance of the threshold value) as a basis for approving PUPs.

Date: Service personnel record the date when the Chemical Profile is completed or updated. Chemical Profiles (e.g., currently approved pesticide use patterns) are periodically reviewed and updated, as necessary. The most recent review date id recorded on a profile to document when it was last updated.

Trade Name(s): Service personnel accurately and completely record the trade name(s) from the pesticide label, which includes a suffix that describes the formulation (e.g., WP, DG, EC, L, SP, I, II or 64). The suffix often distinguishes a specific product among several pesticides with the same active ingredient. Service personnel record a trade name for each pesticide product with the same active ingredient.

Common chemical name(s): Service personnel record the common name(s) listed on the pesticide label or material safety data sheet (MSDS) for each active ingredient. The common name of a pesticide is listed as the active ingredient on the title page of the product label immediately following the trade name, and the MSDS, Section 2: Composition/ Information on Ingredients. A Chemical Profile is completed for each active ingredient.

Pesticide Type: Service personnel record the type of pesticide for an active ingredient as one of the following: herbicide, desiccant, fungicide, fumigant, growth regulator, insecticide, piscicide, or rodenticide.

EPA Registration Number(s): This number (EPA Reg. No.) appears on the title page of the label and MSDS, Section 1: Chemical Product and Company Description. It is not the EPA Establishment Number that is usually located near it. Service personnel record the EPA Reg. No. for each trade name product with an active ingredient based upon PUPs.

Pesticide Class: Service personnel list the general chemical class for the pesticide (active ingredient). For example, malathion is an organophosphate and carbaryl is a carbamate.

CAS (Chemical Abstract Service) Number: This number is often located in the second section (Composition/Information on Ingredients) of the MSDS. The MSDS table listing components usually contains this number immediately prior to or following the % composition.

Other Ingredients: From the most recent MSDS for the proposed pesticide product(s), Service personnel include any chemicals in the pesticide formulation not listed as an active ingredient that are described as toxic or hazardous, or regulated under the Superfund Amendments and Reauthorization Act (SARA); Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); Toxic Substances Control Act (TSCA); Occupational Safety and Health Administration (OSHA); State Right-to-Know; or other listed authorities. These are usually found in MSDS sections titled "Hazardous Identifications," "Exposure Control/Personal Protection," and "Regulatory Information." If concentrations of other ingredients are available for any compounds identified as toxic or hazardous, then Service personnel record this information in the Chemical Profile by trade name. MSDS(s) may be obtained from the manufacturer, manufacturer's website, or from an on-line database maintained by Crop Data Management Systems, Inc. (see list below).

Toxicological Endpoints

Toxicological endpoint data are collected for acute and chronic tests with mammals, birds, and fish. Data are recorded for species available in the scientific literature. If no data are found for a particular taxonomic group, then "No data available in references" is recorded as the data entry. Throughout the Chemical Profile, references (including for toxicological endpoint data) are cited using parentheses (#) following the recorded data.

Mammalian LD_{50}: For test species in the scientific literature, Service personnel records available data for oral lethal dose (LD_{50}) in mg/kg-bw (body weight) or ppm-bw. Most common test species in scientific literature are the rat and mouse. The lowest LD_{50} value found for a rat is used as a toxicological endpoint for dose-based RQ calculations to assess acute risk to mammals (see Table 1 in Section 7.1).

Mammalian LC_{50}: For test species in the scientific literature, Service personnel record available data for dietary lethal concentration (LC_{50}) as reported (e.g., mg/kg-diet or ppm-diet). Most common test species in scientific literature are the rat and mouse. The lowest LC_{50} value found for a rat is used as a toxicological endpoint for diet-based RQ calculations to assess acute risk (see Table 1 in Section 7.1).

Mammalian Reproduction: For test species listed in the scientific literature, Service personnel record the test results (e.g., Lowest Observed Effect Concentration [LOEC], Lowest Observed Effect Level [LOEL], No Observed Adverse Effect Level [NOAEL], No Observed Adverse Effect Concentration [NOAEC]) in mg/kg-bw or mg/kg-diet for reproductive test procedure(s) (e.g., generational studies [preferred], fertility, new born weight). Most common test species available in scientific literature are rats and mice. The lowest NOEC, NOAEC, NOEL, or

NOAEL test results found for a rat are used as a toxicological endpoint for RQ calculations to assess chronic risk (see Table 1 in Section 7.1).

Avian LD_{50}: For test species available in the scientific literature, Service personnel record values for oral lethal dose (LD_{50}) in mg/kg-bw or ppm-bw. Most common test species available in scientific literature are the bobwhite quail and mallard. The lowest LD_{50} value found for an avian species is used as a toxicological endpoint for dose-based RQ calculations to assess acute risk (see Table 1 in Section 7.1).

Avian LC_{50}: For test species available in the scientific literature, Service personnel record values for dietary lethal concentration (LC_{50}) as reported (e.g., mg/kg-diet or ppm-diet). Most common test species available in scientific literature are the bobwhite quail and mallard. The lowest LC_{50} value found for an avian species is used as a toxicological endpoint for dietary-based RQ calculations to assess acute risk (see Table 1 in Section 7.1).

Avian Reproduction: For test species available in the scientific literature, Service personnel record test results (e.g., LOEC, LOEL, NOAEC, NOAEL) in mg/kg-bw or mg/kg-diet consumed for reproductive test procedure(s) (e.g., early life cycle, reproductive). Most common test species available in scientific literature are the bobwhite quail and mallard. The lowest NOEC, NOAEC, NOEL, or NOAEL test results found for an avian species is used as a toxicological endpoint for RQ calculations to assess chronic risk (see Table 1 in Section 7.1).

Fish LC_{50}: For test freshwater or marine species listed in the scientific literature, Service personnel record an LC_{50} in ppm or mg/L. Most common test species available in the scientific literature are the bluegill, rainbow trout, and fathead minnow (marine). Test results for many game species may also be available. The lowest LC_{50} value found for a freshwater fish species is used as a toxicological endpoint for RQ calculations to assess acute risk (see Table 1 in Section 7.1).

Fish Early Life Stage (ELS)/Life Cycle: For test freshwater or marine species available in the scientific literature, Service personnel record test results (e.g., LOEC, NOAEL, NOAEC, LOAEC) in ppm for test procedure(s) (e.g., early life cycle, life cycle). Most common test species available in the scientific literature are bluegill, rainbow trout, and fathead minnow. Test results for other game species may also be available. The lowest test value found for a fish species (preferably freshwater) is used as a toxicological endpoint for RQ calculations to assess chronic risk (see Table 1 in Section 7.1).

Other: For test invertebrate as well as non-vascular and vascular plant species available in the scientific literature, Service personnel record $LC_{50,}$ $LD_{50,}$ LOEC, LOEL, NOAEC, NOAEL, or EC_{50} (environmental concentration) values in ppm or mg/L. Most common test invertebrate species available in scientific literature are the honey bee and the water flea (*Daphnia magna*). Green algae (*Selenastrum capricornutum*) and pondweed (*Lemna minor*) are frequently available test species for aquatic non-vascular and vascular plants, respectively.

Ecological Incident Reports: After a site has been treated with pesticide(s), wildlife can be exposed to these chemical(s). When exposure is high relative to the toxicity of the pesticides, wildlife can be killed or visibly harmed (incapacitated). Such events are called ecological incidents. The USEPA maintains a database (Ecological Incident Information System) of ecological incidents. This database stores information extracted from incident reports submitted by various federal and state agencies and non-government organizations. Information included in an incident report is date and location of the incident, type and magnitude of effects observed in various species, use(s) of pesticides known or suspected of contributing to the incident, and results of any chemical residue and cholinesterase activity analyses conducted during the investigation.

Incident reports can play an important role in evaluating the effects of pesticides by supplementing quantitative risk assessments. All incident reports for pesticide(s) with the active ingredient and associated information would be recorded.

Environmental Fate

Water Solubility: Service personnel record values for water solubility (S_w), which describes the amount of pesticide that dissolves in a known quantity of water. S_w is expressed as mg/L (ppm). Pesticide S_w values are categorized as one of the following: insoluble <0.1 ppm, moderately soluble = 100 to 1000 ppm, highly soluble >10,000 ppm (USGS, 2000). As pesticide S_w increases, there is greater potential to degrade water quality through runoff and leaching. Sw is used to evaluate potential for bioaccumulation in aquatic species [see **Octanol-Water Partition Coefficient (K_{ow})** below].

Soil Mobility: Service personnel record available values for soil adsorption coefficient (K_{oc} [μg/g]). This value provides a measure of a chemical's mobility and leaching potential in soil. K_{oc} values are directly proportional to organic content, clay content, and surface area of the soil. K_{oc} data for a pesticide may be available for a variety of soil types (e.g., clay, loam, sand). K_{oc} values are used in evaluating the potential to degrade groundwater by leaching (see **Potential to Move to Groundwater** below).

Soil Persistence: Service personnel record values for soil half-life ($t_{½}$), which represents the length of time (days) required for 50% of the deposited pesticide to degrade (completely or partially) in the soil. Based upon the $t_{½}$ value, soil persistence is categorized as one of the following: non-persistent <30 days, moderately persistent = 30 to 100 days, and persistent >100 days (Kerle et al., 1996).

Threshold for Approving PUPs:
If soil $t_{½} \leq 100$ days, then a PUP can be approved without additional BMPs to protect water quality. If soil $t_{½} > 100$ days, then a PUP can only be approved with additional BMPs specifically to protect water quality. One or more BMPs such as the following are included in the **Specific Best Management Practices (BMPs) section** *to minimize potential surface runoff and leaching that can degrade water quality.*

- *Do not exceed one application per site per year.*
- *Do not use on coarse-textured soils where the ground water table is <10 feet and average annual precipitation >12 inches.*

- *Do not use on steep slopes if substantial rainfall is expected within 24 hours or ground is saturated.*

Along with K_{oc}, soil $t_{½}$ values are used in evaluating the potential to degrade groundwater by leaching (see **Potential to Move to Groundwater** below).

Soil Dissipation: Dissipation time (DT_{50}) represents the time required for 50% of the deposited pesticide to degrade and move from a treated site; whereas, soil $t_{½}$ describes the rate for degradation only. As for $t_{½}$, units of dissipation time are usually expressed in days. Field dissipation times are the preferred data for use to estimate pesticide concentrations in the environment because they are based upon field studies, compared to soil $t_{½}$, which is derived in a laboratory. However, soil $t_{½}$ are the most common persistence data available in the published literature. If field dissipation data are not available, soil half-life data are used in a Chemical Profile. The average or representative half-life value of the most important degradation mechanism is selected for quantitative analysis for both terrestrial and aquatic environments.

Based upon the DT_{50} value, environmental persistence in the soil is categorized as one of the following: non-persistent <30 days, moderately persistent = 30 to 100 days, and persistent >100 days.

Threshold for Approving PUPs:
If soil DT_{50} ≤100 days, then a PUP can be approved without additional BMPs to protect water quality. If soil DT_{50} >100 days, then a PUP can only be approved with additional BMPs specifically to protect water quality. One or more BMPs such as the following are included in the **Specific Best Management Practices (BMPs) section** *to minimize potential surface runoff and leaching that can degrade water quality.*

- *Do not exceed one application per site per year.*
- *Do not use on coarse-textured soils where the ground water table is <10 feet and average annual precipitation >12 inches.*
- *Do not use on steep slopes if substantial rainfall is expected within 24 hours or ground is saturated.*

Along with K_{oc}, soil DT_{50} values (preferred over soil $t_{½}$) are used in evaluating the potential to degrade groundwater by leaching (see **Potential to Move to Groundwater** below), if available.

Aquatic Persistence: Service personnel record values for aquatic $t_{½}$, which represents the length of time required for 50% of the deposited pesticide to degrade (completely or partially) in water. Based upon the $t_{½}$ value, aquatic persistence is categorized as one of the following: non-persistent <30 days, moderately persistent = 30 to 100 days, and persistent >100 days (Kerle et. al. 1996).

Threshold for Approving PUPs:
If aquatic $t_{½}$ ≤100 days, then a PUP can be approved without additional BMPs to protect water quality. If aquatic $t_{½}$ >100 days, then a PUP can only be approved with additional BMPs specifically to protect water quality. One or more BMPs such as the following are included in

the **Specific Best Management Practices (BMPs) section** *to minimize potential surface runoff and leaching that can degrade water quality.*

- *Do not exceed one application per site per year.*
- *Do not use on coarse-textured soils where the ground water table is <10 feet and average annual precipitation >12 inches.*
- *Do not use on steep slopes if substantial rainfall is expected within 24 hours or ground is saturated.*

Aquatic Dissipation: Dissipation time (DT_{50}) represents the time required for 50% of the deposited pesticide to degrade or move (dissipate); whereas, aquatic $t_{½}$ describes the rate for degradation only. As for $t_{½}$, units of dissipation time are usually expressed in days. Based upon the DT_{50} value, environmental persistence in aquatic habitats is categorized as one of the following: non-persistent <30 days, moderately persistent = 30 to 100 days, and persistent >100 days.

Threshold for Approving PUPs:
If aquatic DT_{50} ≤100 days, then a PUP can be approved without additional BMPs to protect water quality. If aquatic DT_{50} >100 days, then a PUP can only be approved with additional BMPs specifically to protect water quality. One or more BMPs such as the following is included in the **Specific Best Management Practices (BMPs) section** *to minimize potential surface runoff and leaching that can degrade water quality.*

- *Do not exceed one application per site per year.*
- *Do not use on coarse-textured soils where the ground water table is <10 feet and average annual precipitation >12 inches.*
- *Do not use on steep slopes if substantial rainfall is expected within 24 hours or ground is saturated.*

Potential to Move to Groundwater: Groundwater Ubiquity Score (GUS) = $\log_{10}$(soil $t_{½}$) x [4 – $\log_{10}(K_{oc})$]. If a DT_{50} value is available, it is used rather than a $t_{½}$ value to calculate a GUS score. Based upon the GUS value, the potential to move toward groundwater is recorded as one of the following categories: extremely low potential<1.0, low - 1.0 to 2.0, moderate - 2.0 to 3.0, high - 3.0 to 4.0, or very high>4.0.

Threshold for Approving PUPs:
If GUS ≤4.0, then a PUP can be approved without additional BMPs to protect water quality. If GUS >4.0, then a PUP can only be approved with additional BMPs specifically to protect water quality. One or more BMPs such as the following is included in the **Specific Best Management Practices (BMPs) section** *to minimize potential surface runoff and leaching that can degrade water quality.*

- *Do not exceed one application per site per year.*
- *Do not use on coarse-textured soils where the ground water table is <10 feet and average annual precipitation >12 inches.*
- *Do not use on steep slopes if substantial rainfall is expected within 24 hours or ground is saturated.*

Volatilization: Pesticides may volatilize (evaporate) from soil and plant surfaces and move off-target into the atmosphere. The potential for a pesticide to volatilize is a function of its vapor pressure that is affected by temperature, sorption, soil moisture, and the pesticide's water solubility. Vapor pressure is often expressed in mm Hg. To make these values easier to compare, vapor pressure is recorded by Service personnel in exponential form ($I \times 10^{-7}$), where I represents a vapor pressure index. In general, pesticides with I<10 have low potential to volatilize; whereas, pesticides with I >1,000 have a high potential to volatilize (OSU, 1996). Vapor pressure values for pesticides are usually available in the pesticide product MSDS or the USDA Agricultural Research Service (ARS) pesticide database (see **References**).

Threshold for Approving PUPs:
If I ≤1,000, then a PUP can be approved without additional BMPs to minimize drift and protect air quality. If I >1,000, then a PUP can only be approved with additional BMPs specifically to minimize drift and protect air quality. One or more BMPs such as the following is included in the **Specific Best Management Practices (BMPs) section** *to reduce volatilization and potential to drift and degrade air quality.*

- *Do not treat when wind velocities are <2 or >10 mph with existing or potential inversion conditions.*
- *Apply the largest-diameter droplets possible for spray treatments.*
- *Avoid spraying when air temperatures >85^{o}F.*
- *Use the lowest spray height possible above target canopy.*
- *Where identified on the pesticide label, soil incorporate pesticide as soon as possible during or after application.*

Octanol-Water Partition Coefficient (K_{ow}): The octanol-water partition coefficient (K_{ow}) is the concentration of a pesticide in octanol and water at equilibrium at a specific temperature. Because octanol is an organic solvent, it is considered a surrogate for natural organic matter. Therefore, K_{ow} is used to assess potential for a pesticide to bioaccumulate in tissues of aquatic species (e.g., fish). If K_{ow} >1,000 or S_w<1 mg/L and soil $t_{½}$>30 days, then there is high potential for a pesticide to bioaccumulate in aquatic species such as fish (USGS, 2000).

Threshold for Approving PUPs:
If there is not a high potential for a pesticide to bioaccumulate in aquatic species, then the PUP can be approved.
If there is a high potential to bioaccumulate in aquatic species (K_{ow}>1,000 or S_w<1 mg/L and soil $t_{½}$>30 days), then the PUP cannot approved, except under unusual circumstances where approval is granted by the Washington Office.

Bioaccumulation/Bioconcentration: The physiological process where pesticide concentrations in tissue would increase in biota because they are taken and stored at a faster rate than they are metabolized or excreted. The potential for bioaccumulation is evaluated through bioaccumulation factors (BAFs) or bioconcentration factors (BCFs). Based upon BAF or BCF values, the potential to bioaccumulate is recorded as one of the following: low – 0 to 300, moderate – 300 to 1,000, or high >1,000 (Calabrese and Baldwin, 1993).

Threshold for Approving PUPs:
If BAF or BCF≤1,000, then a PUP can be approved without additional BMPs.
If BAF or BCF>1,000, then a PUP cannot approved, except under unusual circumstances where approval is granted by the Washington Office.

Worst-Case Ecological Risk Assessment

Max Application Rates (acid equivalent): Service personnel record the highest application rate of an active ingredient (ae basis) for habitat management and cropland/facilities maintenance treatments in this data field of a Chemical Profile. These rates can be found in Table CP.1 under the column heading "Max Product Rate – Single Application (lbs/acre – AI on acid equiv basis)." This table is prepared for a Chemical Profile from information specified in labels for trade name products identified in PUPs. If these data are not available in pesticide labels, then "NS" for "not specified is written on label" in this table.

EECs: An estimated environmental concentration (ECC) represents potential exposure to fish and wildlife (birds and mammals) from using a pesticide. EECs are derived by Service personnel using an USEPA screening-level approach (USEPA, 2004). For each maximum application rate [see description under **Max Application Rates (acid equivalent)**], Service personnel record 2 EEC values in a Chemical Profile; these represent the worst-case terrestrial and aquatic exposures for habitat management and croplands/facilities maintenance treatments. For terrestrial and aquatic EEC calculations, see description for data entry under **Presumption of Unacceptable Risk/Risk Quotients**, which is the next field for a Chemical Profile.

Presumption of Unacceptable Risk/Risk Quotients: Service personnel calculate and record acute and chronic risk quotients (RQs) for birds, mammals, and fish using the provided tabular formats for habitat management and/or cropland/facilities maintenance treatments. RQs recorded in a Chemical Profile would the worst-case assessment for ecological risk. See Section 7.2 for discussion regarding the calculations of RQs.

For aquatic assessments associated with habitat management treatments, RQ calculations are based upon selected acute and chronic toxicological endpoints for fish and the EEC is derived from Urban and Cook (1986) assuming 100% overspray to an entire 1-foot deep water body using the maximum application rate (ae basis [see above]).

For aquatic assessments associated with cropland/facilities maintenance treatments, RQ calculations are done by Service personnel based upon selected acute and chronic toxicological endpoints for fish and an EEC is derived from the aquatic assessment in AgDRIFT® model version 2.01 under Tier I ground-based application with the following input variables: max application rate (acid basis [see above]), low boom (20 inches), fine to medium/coarse droplet size, 20 swaths, EPA-defined wetland, and 25-foot distance (buffer) from treated area to water. See Section 7.2.1.2 for more details regarding the calculation of EECs for aquatic habitats for habitat management and cropland/facilities maintenance treatments.

For terrestrial avian and mammalian assessments, RQ calculations are done by Service personnel based upon dietary exposure, where the "short grass" food item category represents the worst-case scenario. For terrestrial spray applications associated with habitat management and cropland/facilities maintenance treatments, exposure (EECs and RQs) is determined using the Kanaga nomogram method through the USEPA's T-REX version 1.2.3. T-REX input variables include the following: max application rate (acid basis [see above]) and pesticide half-life (days) in soil to estimate the initial, maximum pesticide residue concentration on general food items for terrestrial vertebrate species in short (<20 cm tall) grass. For granular pesticide formulations and pesticide-treated seed with a unique route of exposure for terrestrial avian and mammalian wildlife, see Section 7.2.1.1.2 for the procedure that is used to calculate RQs.

All calculated RQs in both tables are compared with Levels of Concern (LOCs) established by USEPA (see Table 2 in Section 7.2). If a calculated RQ exceeds an established LOC value (in brackets inside the table), then there is a potential for an acute or chronic effect (unacceptable risk) to federally listed (T&E) species and non-listed species. See Section 7.2 for detailed descriptions of acute and chronic RQ calculations and comparison to LOCs to assess risk.

Threshold for approving PUPs:
If RQs≤LOCs, then a PUP can be approved without additional BMPs. If RQs>LOCs, then a PUP can only be approved with additional BMPs specifically to minimize exposure (ecological risk) to bird, mammal, and/or fish species. One or more BMPs such as the following is included in the **Specific Best Management Practices (BMPs) section** *to reduce potential risk to non-listed or listed species.*

- *Lower application rate and/or fewer number of applications so RQs≤LOCs.*
- *For aquatic assessments (fish) associated with cropland/facilities maintenance, increase the buffer distance beyond 25 feet so RQs≤LOCs.*

Justification for Use: Service personnel describe the reason for using the pesticide-based control of specific pests or groups of pests. In most cases, the pesticide label will provide the appropriate information regarding control of pests to describe in the section.

Specific Best Management Practices (BMPs): Service personnel record specific BMPs necessary to minimize or eliminate potential effects to non-target species and/or degradation of environmental quality from drift, surface runoff, or leaching. These BMPs are based upon scientific information documented in previous data fields of a Chemical Profile. Where necessary and feasible, these specific practices are included in PUPs as a basis for approval.

If there are no specific BMPs that are appropriate, then Service personnel describe why the potential effects to refuge resources and/or degradation of environmental quality is outweighed by the overall resource benefit(s) from the proposed pesticide use in the BMP section of the PUP. See Section 4.0 of this document for a complete list of BMPs associated with mixing and applying pesticides appropriate for all PUPs with ground-based treatments that would be additive to any necessary, chemical-specific BMPs.

References: Service personnel record scientific resources used to provide data/information for a chemical profile. Use the number sequence to uniquely reference data in a chemical profile.

The following on-line data resources are readily available for toxicological endpoint and environmental fate data for pesticides.

1. California Product/Label Database. Department of Pesticide Regulation, California Environmental Protection Agency. (http://www.cdpr.ca.gov/docs/label/labelque.htm#regprods)

2. ECOTOX database. Office of Pesticide Programs, US Environmental Protection Agency, Washington, DC. (http://cfpub.epa.gov/ecotox/)

3. Extension Toxicology Network (EXTOXNET) Pesticide Information Profiles. Cooperative effort of University of California-Davis, Oregon State University, Michigan State University, Cornell University and University of Idaho through Oregon State University, Corvallis, Oregon. (http://extoxnet.orst.edu/pips/ghindex.html)

4. FAO specifications and evaluations for plant protection products. Pesticide Management Unit, Plant Protection Services, Food and Agriculture Organization, United Nations. (http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGP/AGPP/Pesticid/)

5. Human health and ecological risk assessments. Pesticide Management and Coordination, Forest Health Protection, US Department of Agriculture, US Forest Service. (http://www.fs.fed.us/foresthealth/pesticide/risk.htm)

6. Pesticide Chemical Fact Sheets. Clemson University Pesticide Information Center. (http://entweb.clemson.edu/pesticid/Document/Labels/factshee.htm)

7. Pesticide Fact Sheets. Published by Information Ventures, Inc. for Bureau of Land Management, Department of Interior; Bonneville Power Administration, U.S. Department of Energy; and Forest Service, US Department of Agriculture. (http://infoventures.com/e-hlth/pesticide/pest-fac.html)

8. Pesticide Fact Sheets. National Pesticide Information Center. (http://npic.orst.edu/npicfact.htm)

9. Pesticide Fate Database. US Environmental Protection Agency, Washington, DC. (http://cfpub.epa.gov/pfate/home.cfm).

10. Pesticide product labels and material safety data sheets. Crop Data Management Systems, Inc. (CDMS) (http://www.cdms.net/pfa/LUpdateMsg.asp) or multiple websites maintained by agrichemical companies.

11. Registered Pesticide Products (Oregon database). Oregon Department of Agriculture. (http://www.oda.state.or.us/dbs/pest_products/search.lasso)

12. Regulatory notes. Pest Management Regulatory Agency, Health Canada, Ontario, Canada. (http://www.hc-sc.gc.ca/pmra-arla/)

13. Reptile and Amphibian Toxicology Literature. Canadian Wildlife Service, Environment Canada, Ontario, Canada. (http://www.cws-scf.ec.gc.ca/nwrc-cnrf/ratl/index_e.cfm)

14. Specific Chemical Fact Sheet – New Active Ingredients, Biopesticide Fact Sheet and Registration Fact Sheet. U.S Environmental Protection Agency, Washington, DC. (http://www.epa.gov/pestidides/factsheets/chemical_fs.htm)

15. Weed Control Methods Handbook: Tools and Techniques for Use in Natural Areas. The Invasive Species Initiative. The Nature Conservancy. (http://tnsweeds.ucdavis.edu/handbook.html)

16. Wildlife Contaminants Online.US Geological Survey, Department of Interior, Washington, D.C. (http://www.pwrc.usgs.gov/contaminants-online/)

17. One-liner database. 2000. US Environmental Protection Agency, Office of Pesticide Programs, Washington, D.C.

Chemical Profile

Date:			
Trade Name(s):		**Common Chemical Name(s):**	
Pesticide Type:		**EPA Registration Number:**	
Pesticide Class:		**CAS Number:**	
Other Ingredients:			

Toxicological Endpoints

Mammalian LD_{50}:	
Mammalian LC_{50}:	
Mammalian Reproduction:	
Avian LD_{50}:	
Avian LC_{50}:	
Avian Reproduction:	
Fish LC_{50}:	
Fish ELS/Life Cycle:	
Other:	

Ecological Incident Reports

Environmental Fate

Water solubility (S_w):	
Soil Mobility (K_{oc}):	
Soil Persistence ($t_{½}$):	
Soil Dissipation (DT_{50}):	
Aquatic Persistence ($t_{½}$):	
Aquatic Dissipation (DT_{50}):	
Potential to Move to Groundwater (GUS score):	
Volatilization (mm Hg):	
Octanol-Water Partition Coefficient (K_{ow}):	
Bioaccumulation/Bioconcentration:	**BAF:`** **BCF:**

Worst Case Ecological Risk Assessment

Max Application Rate (ai lbs/acre – ae basis)	**Habitat Management:** **Croplands/Facilities Maintenance:**
EECs	**Terrestrial (Habitat Management):** **Terrestrial (Croplands/Facilities Maintenance):** **Aquatic (Habitat Management):** **Aquatic (Croplands/Facilities Maintenance):**

Habitat Management Treatments:

Presumption of Unacceptable Risk		Risk Quotient (RQ)	
		Listed (T&E) Species	Non-listed Species
Acute	Birds	[0.1]	[0.5]
	Mammals	[0.1]	[0.5]
	Fish	[0.05]	[0.5]
Chronic	Birds	[1]	[1]
	Mammals	[1]	[1]
	Fish	[1]	[1]

Cropland/Facilities Maintenance Treatments:

Presumption of Unacceptable Risk		Risk Quotient (RQ)	
		Listed (T&E) Species	Non-listed Species
Acute	Birds	[0.1]	[0.5]
	Mammals	[0.1]	[0.5]
	Fish	[0.05]	[0.5]
Chronic	Birds	[1]	[1]
	Mammals	[1]	[1]
	Fish	[1]	[1]

Justification for Use:	
Specific Best Management Practices (BMPs):	
References:	

Table CP.1 Pesticide Name

Trade Name[a]	Treatment Type[b]	Max Product Rate – Single Application (lbs/acre or gal/acre)	Max Product Rate - Single Application (lbs/acre - AI on acid equiv basis)	Max Number of Applications Per Season	Max Product Rate Per Season (lbs/acre/season or gal/acre/season)	Minimum Time Between Applications (Days)

[a]From each label for a pesticide identified in pesticide use proposals (PUPs), Service personnel would record application information associated with possible/known uses on Service lands.
[b]Treatment type: H – habitat management or CF – cropland/facilities maintenance. If a pesticide is labeled for both types of treatments (uses), then record separate data for H and CF applications.

7.0 References

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