FINAL PROGRAMMATIC ENVIRONMENTAL ASSESSMENT

for

WDFW Statewide Lake and Stream Rehabilitation Program
As funded by the USFWS Wildlife and Sportfish Restoration Program

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Introduction

The Washington Department of Fish and Wildlife (WDFW) is charged with dual roles of conserving and providing for public use and enjoyment of fish and wildlife under its jurisdiction. WDFW's resident fish management reflects both aspects of the agency mission and is deeply invested in managing inland fishing opportunities. In some cases, achievement of management objectives depends on removal of competing or predaceous species (typically non-native carp, sunfishes, or bullhead catfish) and restocking with trout or warmwater game fishes. In Washington, as in many other states, competing species are most often eradicated by application of rotenone, a piscicide registered with the US Environmental Protection Agency for such use.

WDFW has operated a program of rotenone applications for lake and stream rehabilitation for many years. For the past five years a portion of that program has been funded by a grant of Federal Aid in Sportfish Restoration Program funds administered by the US Fish and Wildlife Service (USFWS). Heretofore, grants have been for projects in arid eastern Washington, primarily in lakes or lake systems with no outflow at time of treatment. Each year's proposals have been individually reviewed relative to the Endangered Species Act (ESA) Section 7 and National Environmental Policy Act responsibilities of the USFWS Wildlife and Sport Fish Restoration Program. However, the Program and WDFW see potential public benefits, with no increase in environmental risk, through a streamlined NEPA approach.

The WDFW's program of rotenone application is potentially broader in scope than is currently supported by grant funds, engaging both native fish conservation and fishing management objectives, and extending statewide. We believe that by defining the circumstances under which significant environmental effects are avoided, most of the projects that can be proposed under WDFW's extensive internal policy constraints can be covered by this assessment. Any that fall outside the conditions evaluated or whose effects would rise to significance as defined here would require individual NEPA review.

This assessment does not attempt to programmatically analyze Endangered Species Act (16 U.S.C. 1531 et seq.) issues or evaluation per Section 106 of the National Historic Preservation Act (NHPA, 16 U.S.C. 470 et seq.). The first step in evaluation of any proposed project is review under ESA Section 7. Any project whose expected effects are likely to adversely affect listed or candidate species or their proposed or designated critical habitats is rejected and never passes to NEPA review. There is little potential to effect historic properties. Access is via developed sites, and use outside those areas is by low ground pressure vehicles or foot traffic, and there is no excavation or other earth moving. The requirements of Section 106 are met for individual projects. As with ESA review, no projects pass to NEPA review until NHPA requirements are satisfied.

This programmatic determination of impacts is expected to reduce state and federal staff time needed for subsequent NEPA determination, and to provide a mechanism not now available for examination of cumulative impacts across the scope of the program and among years. Thus, the preferred alternative is expected to result in both increased administrative efficiency and a means to comprehensively examine cumulative effects.

1.1 Purpose of Action

The purpose of the proposed action and alternatives is to respond to annual applications for federal funding through the Sport Fish Restoration Act, submitted by the Washington Department of Fish and Wildlife to use rotenone to treat lakes and streams in Washington State to control undesirable fish species.

This environmental assessment examines the effects of fish management activities carried out by the Washington Department of Fish and Wildlife with funding provided through the Sport Fish Restoration Act. Under this Act, state fish and wildlife agencies are eligible for grants drawn from funds apportioned to them by the U.S. Fish and Wildlife Service from sources described in the enabling legislation. The Act describes its goals in terms of expected benefits to fish management and a framework for administration of the program by the USFWS Division of Federal Assistance. The Service is given specific responsibility to work with the grantees to accomplish the goals and benefits of the Act:

> "…the Secretary of the Interior is authorized and directed to cooperate with the States through their respective State fish and game departments in fish restoration and management projects as hereinafter set forth… The Secretary of the Interior and the State fish and game department of each State accepting the benefits of this Act shall agree upon the fish restoration and management projects to be aided in such State under the terms of this Act, and all projects shall conform to the standards fixed by the Secretary of the Interior."
> Dingell-Johnson Sport Fish Restoration Act, as amended Through P.L. 106–580, Dec. 29, 2000

The Washington Department of Fish and Wildlife is one of the "state fish and game departments" eligible to apply for federal assistance grants under the Federal Aid in Sport Fish Restoration Program that implements Public Law 106-580. WDFW's purpose in proposing these projects is that the WDFW and its policy-making body, the Washington Fish and Wildlife Commission, are required by Washington statute to manage and improve recreational fishing in Washington (RCW 77.04.012). The same legislation specifically charges the Fish and Wildlife Commission with maximizing game fish angling opportunities for all citizens.

In practice, the Washington Department of Fish and Wildlife achieves part of its mandated fish management objectives with funding administered by the USFWS through grants. Approval of grants, including those for the application of rotenone as a fish management tool, is a federal action that requires review under the National Environmental Policy Act. This environmental assessment is a programmatic treatment of the scope of activities that the WDFW considers likely to be proposed for federal grant funding through the Sport Fish Restoration Program.

When WDFW submits a fish management grant proposal to the FWS Division of Federal Assistance, federal grants managers are obligated to respond by processing the proposal for funding. For the grant proposal to be approved, proposed activities must be in compliance with all applicable federal laws and regulations, as well as being eligible for funding under the intended grant program, and comprising generally accepted management approaches. Key among the federal compliance requirements is consultation under Section 7 of the Federal Endangered Species Act (ESA) with the USFWS and National Marine Fisheries Service (NOAA Fisheries) to ensure that we avoid funding activities that are likely to jeopardize the continued existence of listed species or destroy or adversely modify critical habitats; and review under the National Environmental Policy Act (NEPA) for significant effects to the human environment. Federal staff evaluate the potential effects of every proposed grant to species protected under the ESA and complete the appropriate level of review under NEPA.

1.2 Need(s) for Action

The WDFW is given authority and responsibility for the management of native and introduced fishes, and other wildlife, by Washington statutes. That authority is further defined in statute and by the Washington Fish and Wildlife Commission within its rule-making and policy guidance authorities. Management direction is formalized to include conservation of native species as its foundation, with much discretion in the creation and maintenance of fishing opportunities that are consistent with conservation needs.

The Commission (and WDFW) is authorized by RCW 77.12.420 to rehabilitate lakes and streams by eradicating existing fish communities and re-establishing species that will meet fishery objectives. WDFW staff implements approved projects consistent with policy direction adopted by the Commission as POL-C3010, which was approved in 2002. That policy explicitly recognizes treatment with rotenone as "…a valuable and cost effective management tool for providing quality fishing opportunities and protecting native fishes…" The policy further directs that all lake and stream rehabilitation projects be in accordance with state water quality requirements in WAC 173-201A; the Washington Pesticide Control Act (RCW 15.58); the State Environmental Policy Act (RCW Chapter 43.21C); the federal Clean Water Act; all chemical pesticide labeling restrictions and chemical materials safety data sheet requirements; and will avoid negative impacts to state or federally listed threatened, endangered, candidate, or sensitive species.

Freshwater fish management by the WDFW is funded by a mix of sources, most notably the dedicated state revenues from angling license and tag sales, and fish management grants from the USFWS' Federal Aid in Sport Fish Restoration Program. These federal grants augment state funding (as anticipated by Public Law 106-580), increasing WDFW's flexibility to provide sound management that includes angling opportunities.

A programmatic assessment of the federally funded component of WDFW's chemical rehabilitation program would be advantageous to both WDFW and federal grants managers in streamlining NEPA review of proposed funding of future rotenone application, and would also assure that all projects receive the same uniform, NEPA review.

Background on WDFW's Use of Piscicides in Resident Fish Management

There are 7,938 lakes listed in the State of Washington (Wolcott 1964, 1973), with 4,845 (61%) being classified as "lowland lakes" below 2,500 feet in elevation. The Washington Department of Fish and Wildlife (WDFW) manages lowland lakes throughout the state according to public desires, recreational demands, ecosystem considerations and historic management efforts (Bradbury 1986, WDG 1982; WDFW 1996a). There are 1,777 "high lakes" that support fish in the Cascades, Olympic, Blue, and Selkirk Mountains, with about 800 that are periodically stocked with trout (Pfeifer et al. 2001). The remainder of these high lakes has self-sustaining fish populations, often with stunted exotic species such as eastern brook trout.

The State of Washington licenses 736,000 total anglers, the majority of whom (538,000, or 73%) spend over 7.5 million angler days fishing in freshwater (USFWS 2006). Angler preference surveys (Mongillo and Hahn 1988, WDFW 1996b, Michael 2004) have consistently shown that trout are the most popular of the state's game fish. Some lakes are managed to improve populations of warm water species such as bass, sunfish, crappie, and catfish, the second most popular category of game fish reported (Mongillo and Hahn 1986, WDFW 1996b, Michael 2004). In response to these angler preferences, WDFW manages approximately 400 lowland lakes specifically for trout fisheries. About 1,200 to 1,500 lakes in the State contain warm water game fish species and are managed for a mixture of trout and warmwater species, or are managed solely for the warmwater fisheries.

The WDFW responds in a number of ways to declines and imbalances in preferred game fish populations, changes in species composition that are adverse to management goals, and to degradation of fish habitat and water quality caused by species such as carp. To address angler preferences in restoring fisheries, a series of management options are considered, including modifications in fisheries regulations, changes to fish-stocking strategies, or modification of fish populations.

Modification of fish populations through angling regulation changes, mechanical removal, biological controls, habitat modifications, chemical treatments and other methods are used or considered to maintain viable fisheries. In many cases, the most cost-effective and biologically sound strategy to restore degraded fisheries is determined to be piscicidal treatment of the lake or stream to restore sport fisheries.

The benefits to rehabilitation of degraded sport fisheries is to support viable recreational fisheries as mandated by policy, to maintain an active clientele of license-purchasing anglers, and to take advantage of the natural productivity of the lakes to grow trout to sizes desirable to anglers without additional hatchery or management costs..

Two piscicidal products, rotenone and antimycin, are registered for use by the U.S. Environmental Protection Agency and by the Washington Department of Agriculture. Other piscicidal products are not registered for use in the United States (e.g., the use of chlorine, chloramine, copper sulfate, toxaphene, pentachloraphenol, etc.).

Antimycin-a (Fintrol©) has undergone extensive laboratory testing and field use as a piscicide, and is both a feasible and effective method to kill fish in flowing and standing waters. However, antimycin is not effective in deep lakes or in water with pH values greater than or equal to 8.5. Antimycin is registered for use as a piscicide in Washington, but has not yet been used by the Washington Department of Fish and Wildlife, and is not currently funded through the Federal Aid to Sport Fish Restoration as part of WDFW's lake and stream rehabilitation program. The use of antimycin in fisheries management will not be considered further in this assessment. Therefore, for this environmental assessment, the USFWS is only proposing the use of rotenone piscicide.

Rotenone is a natural, botanical isoflavone chemical ($C_{23}H_{22}O_6$) found in the roots of several tropical plants in the bean family (Fabaceae). It was historically used by indigenous peoples in Asia, South America, and Australia to catch fish for food by extracting rotenone from plants and releasing it into water. The fish then came to the surface, gasping for air, and were easily caught. Its use as a piscicide began in 1934, when fisheries researchers in Michigan began using the powdered formulation for fish population management (Finlayson et al. 2000).

Use of rotenone as a selective piscicide for fisheries management is common in the United States and Canada who represent a considerable proportion of total rotenone consumption. Annual average rotenone use for fisheries management in North America decreased from 12,500 kg for the period 1988 to 1992 to 5,600 kg in the following five-year period, although the data were somewhat skewed by the large-scale (20,600 kg) Strawberry Reservoir treatment in Utah in 1990. Most of this decrease was in the use of liquid formulations although there was a corresponding slight rise in the use of rotenone powders (McClay 2000).

Rotenone has been used in fisheries management projects in Washington since 1940, when Kings Lake in Pend Orielle County was treated to remove competing fish species prior to establishing a brood stock lake for native westslope cutthroat trout. In the years subsequent to this initial treatment, the State of Washington has conducted 1,286 treatments for 521 lakes and streams. In the most recent 5-year period, WDFW has treated an average of 11 lakes and associated waters (1,194 acres) per year using an annual average 95,480 pounds (43,320 kg) of 5% equivalent powdered rotenone and 380 gallons (1,440 liters) of 5% liquid rotenone.

Piscicidal rotenone is manufactutred in several formulations, which are described in Appendix I. The three preparations used in the WDFW lake and stream rehabilitation program are a water-wettable powdered rotenone fish toxicant, emulsifiable 5% liquid formulations, and synergized 2.5% liquid formulations.

Potassium Permanganate

Most use of rotenone by WDFW has been to treat lakes, ponds, and reservoirs, but it has regularly been used to treat tributary stream sections associated with lake treatments (Turner et al. 2007). Generally, the outflow of water from the treatment area is achieved through use of water control structures or treating lakes where outflows are restricted during periods of low discharge. Where stream transport of rotenone away from the intended treatment sites is a concern, potassium permanganate may be used to deactivate the rotenone. For any necessary detoxification of the piscicidal product downstream from a treatment area, WDFW follows the guidelines of the American Fisheries Society (Archer 2001) for application rates, field methods and equipment to safely and effectively neutralize field applications of rotenone.

Potassium permanganate is a strong oxidizing agent used in many industries and laboratories. It is also used as a disinfectant, especially in the treatment process of potable water. In fisheries and aquaculture, potassium permanganate is used as a treatment for some fish parasites. It is and can be used as a neutralizing compound following the addition of rotenone to a body of water (USEPA, 2006; Ling, 2003). Under the National Pollution Discharge Elimination System permit issued to the WDFW for fish management, potassium permanganate is the only chemical permitted to neutralize rotenone treated waters when necessary to prevent damage to non-targeted organisms and maintain water quality outside the area intended for rotenone treatments (Washington Dept. of Ecology Permit No. WA0041009).

Following rotenone application, after a crucial time interval based on the management goal of the fishery, potassium permanganate is added to the water at ratios of between 2 and 4 parts potassium permanganate to each part of rotenone (EPA 2006, Finlayson et al. 2000). Under the Proposed Project (Alternative 2), this concentration may approximate 2 to 16 ppm, depending on the organic load in the receiving water at the time of treatment.

Manganese is the principal element in the permanganate solution with potential toxicity. However, manganese is also an essential nutrient for plants and animals, and specific deficiency signs have been identified with a wide range of symptoms including nervous system disorders, bone fragility, and growth suppression (Browning1961). Manganese comprises about 0.1% of the earth's crust and is ubiquitous in the environment (rock, soil, water). Potassium permanganate is produced by thermal oxidation of manganese dioxide followed by electrolytic oxidation. The environmental chemistry and fate of manganese is controlled largely by pH. At pH values above 5.5 (approximately), colloidal manganese hydroxides generally form in water. Such colloidal forms are not generally absorbed by plants and animals in the water.. As a strong oxidizing agent, permanganate is reduced when it oxidizes other substances (such as rotenone). Thus, in the process of oxidizing rotenone, the potassium permanganate is itself reduced, liberating bioavailable oxygen in the process. Through this mechanism, the respiratory toxicity caused by rotenone is effectively countered. In the process, potassium ions are liberated (an essential electrolyte), and manganese dioxide is formed. Manganese dioxide is insoluble, hence not bioavailable, and chemically similar to the MnO_2 found in the earth's crust (Vella 2006).

In the presence of rotenone (and other organic reducing agents, for that matter), permanganate will be reduced, will not persist in the environment, and poses essentially no human health risk to groundwater quality. Indeed, it is used second only to chlorine as a pre-treatment method for the removal of organic contaminants such as naphthalene and tetrachloroethene (TCE) in potable groundwater wells according to a recent survey by the American Water Works Association (Vella 2006). In groundwater, its use helps to control iron, manganese, sulfides and color, and it can also be used to reduce high concentrations of radionuclides and arsenic (again, by forming insoluble colloids). Potassium permanganate is also used in surface water treatment plants, primarily to control taste and odor problems.

Like rotenone, the aquatic toxicity of potassium permanganate differs among species. Because of the volume of potassium permanganate that may be required for neutralization and its moderate to high toxicity to fishes, this neutralizing compound may itself present a hazard to aquatic vertebrates during application. It has been reported to elicit toxicity at concentrations of 1 to 2 ppm (EPA, 2006). However, this toxicity range also lies within its therapeutic range for fish disease therapy. Indeed, therapeutic doses range from 2 to 25 parts per million (ppm), depending on the time prescribed for treatment (i.e., prolonged bath versus dip treatments). A concentration of 4 ppm is generally recommended for "permanent bath" treatments of external parasites (Noga 2000). In a permanent bath, no flushing is anticipated and degradation is through natural oxidative processes — generally occurring within 1 to 4 days. Marking and Bills (1976) demonstrated that its toxicity was inversely proportional to water temperature for both rainbow trout and channel catfish. It is reported to be more toxic in hard water, due to potential precipitation of manganese dioxide on fish gills.

Potassium permanganate is also considered to be toxic to aquatic invertebrates and zooplankton although, as with vertebrates, there is a wide tolerance range between various freshwater invertebrates. Toxicity of permanganate has been reported in the zooplankton representative, *Daphnia sp*., at concentrations ranging from 84 to 3500 parts per billion (USEPA 2006). By comparison, toxicity of rotenone to *Daphnia sp*. is reported at 25 to 27 parts per billion. Effects of permanganate on other aquatic invertebrates represent a data gap. Daphnia are not special status species.

1.3 Decision(s) to be made

This environmental assessment is expected to result in two decisions by USFWS Assistant Regional Director Chris McKay. First, Mr. McKay will decide for the regional Wildlife and Sport Fish Restoration Program whether to adopt this environmental assessment as fully meeting NEPA requirements for grants to the Washington Department of Fish and Wildlife whose projects fall completely within the criteria presented in the preferred alternative or select a different alternative, making the same determination. Second, he must either issue a finding of no significant impact or recognize the existence of significant effects and require that they be evaluated in an environmental impact statement.

The decision process used by WDFW for determining whether piscicidal treatment is necessary for individual waters is described in detail at Appendix II.

1.4 Related Plans and Processes

1.4.1 National Pollution Discharge Elimination System (NPDES)
We incorporate by reference the National Pollution Discharge Elimination System (NPDES)/Waste Discharge Individual Permit No. WA0041009, issued by the Washington Department of Ecology to the Washington Department of Fish and Wildlife for the application of rotenone, an aquatic pesticide used to manage fish populations in lakes and streams into the waters of the State of Washington, in compliance with the State of Washington Water Pollution Control Law (Chapter 90.48 of the Revised Code of Washington) and the Federal Clean Water Act (Title 33 United States Code, Section 1251 et seq.). The NPDES permit is fundamental in allowing WDFW to use piscicides in fisheries management projects in the State of Washington, and strictly defines the conditions of use, monitoring, and reporting requirements under which WDFW operates. This permit is currently in the process of renewal under a permit extension issued by the Washington Department of Ecology.

1.4.2 State Environmental Policy Act
We incorporate by reference the Environmental Impact Statement (EIS) on lake and stream rehabilitation written by the Washington Department of Game in 1976, and Supplemental Environmental Impact Statements (SEIS) written by the Washington Department of Wildlife in 1992 and the Washington Department of Fish and Wildlife in 2002, which were completed under the Washington State Environmental Policy Act (Chapter 43.21C of the Revised Code of Washington). The EIS and SEIS processes determined that lake and stream rehabilitation for fisheries management was a significant action, documented and analyzed the use of rotenone in fisheries management, alternatives to such use, the affected environment, and environmental consequences. Annual rotenone use plans are reviewed each year through processes mandated by the State Environmental Policy Act. Each has been determined to be non-significant under provisions of the Act.

> Washington Department of Game. 1976. Final Environmental Impact Statement. Proposed Lake and Stream Rehabilitation 1976-77. 18 pp + appendices.
>
> Washington Department of Wildlife (WDW). 1992. Final – Supplemental Environmental Impact Statement: Lake and Stream Rehabilitations – 1992-1993. Rep. 92-14. 137 pp + appendices.
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> Washington Department of Fish and Wildlife (WDFW). 2002. Final Supplemental Environmental Impact Statement Lake and Stream Rehabilitation: Rotenone Use and Health Risks, Prepared by: John S. Hisata, Fish Program Fish Management Division. 120 pp.

1.4.3 We incorporate by reference a literature review completed by the Washington Department of Game relative to the need for chemical lake and stream rehabilitations and the State’s trout stocking program. This document specifically reviews the State of Washington’s lake and stream rehabilitation program relative to the management of lakes for trout fisheries, the effects of rotenone on the environment, and human health effects.

> Bradbury, A. 1986. Rotenone and trout stocking: a literature review with special reference to Washington Department of Game's lake rehabilitation program. Washington Department of Game, Fisheries Management Report 86-2, Seattle, Washington. 181 pp.

1.4.4 We incorporate by reference the sections on the affected environment and Environmental Consequences of the following environmental impact statements and environmental assessment. These sections provide an update to the information presented on environmental and human health in the documents referenced above.

> Diamond Lake Final EIS November 2004, US Forest Service, Umpqua National Forest
> http://www.fs.fed.us/r6/umpqua/projects/projectdocs/diamondlkresto/#feis
>
> Davis Lake Final EIS – January 2007, California Department of Fish and Game
> http://www.dfg.ca.gov/lakedavis/EIR-EIS/
>
> Utah Native Trout Restoration Final Environmental Assessment – August 2007, USFWS
> http://www.fws.gov/mountainprairie/federalassistance/native_trout/UTAH_FINAL_CUTT_EA_807.pdf

1.4.5 We incorporate the impacts on human and environmental health defined in a risk assessment which was written to provide updated information on rotenone and to support decision-making for the Washington Department of Fisheries and Wildlife's application for renewal of the WDFW Fish Management NPDES permit.

> Turner, L., S. Jacobson, and L. Shoemaker. 2007. Risk assessment for piscicidal formulations of rotenone. Prepared by Compliance Services International, Lakewood, Wash. 104 pp.

1.5 Scoping Process

WDFW completed a programmatic Environmental Impact Statement (EIS) for its lake and stream rehabilitation program in 1976, and a Supplemental EIS in 1992 through the State Environmental Policy Act (SEPA) process. In 2002, based on concerns related to human and applicator health, WDFW again completed a Supplemental EIS on Lake and Stream Rehabilitation: Rotenone Use and Health Risks. WDFW contracted with Compliance Services, Incorporated to perform an assessment of risk from the use of rotenone in its lake and stream rehabilitation program (Turner et al. 2007).

All impact statements addressed the proposed action to enhance game fish populations, fisheries, and habitats through the reduction or elimination of competing or predaceous undesirable fish species in selected lakes and streams. Methods of application, justification for treatments, inter- and intra-agency reviews and responsibilities, public participation, and decisional processes are described. Assessments were made regarding human and environmental impacts, and of alternatives for controlling undesirable species.

For the SEPA process, WDFW completes addenda to the original EIS and SEIS on an annual or project basis for lake and stream rehabilitation projects that are conducted subsequent to the 1976 EIS and 1992 and 2002 SEIS. During all of these SEPA processes, the public, other agencies, and tribes are involved and invited to provide comments.

Issues that have been raised during the SEPA process relative to lake and stream rehabilitation:

Fishery Management Alternatives
- No Treatment (manage for reduced or imbalanced populations of game fish)
- Partial Rotenone Treatment
- Use of Alternative Piscicides
- Control of Water Levels
- Mechanical control (netting, trapping, electrofishing)
- Predatory Fish Stocking

Environmental Health
- Soils and Sediments
- Soils
- Groundwater impacts
- Water Quality
- Air Quality
- Non-target Species Impacts
  - Plants
  - Zooplankton
  - Invertebrates
  - Fish
  - Amphibians
  - Reptiles
  - Birds
  - Mammals
  - Threatened, Endangered, and Species of Concern

Aesthetics
- Objectionable Odors and Disposal of dead fish
- Bacteria

Human Health
- Protection for Applicators
- Protection for Bystanders
- Protection for Recreationists
- Surface Water Withdrawals
- Concern for Wildlife, Pets and Livestock
- Rotenone and Parkinson's Disease

Other Issues:
- Inert Ingredients Used with Rotenone
- Metabolites of Rotenone
- Use of Potassium Permanganate as a Neutralizing Agent
- Use of Treated Fish as Food or Feed
- Loss of Fishing Opportunity until Fisheries are Restored
- Administration of WDFW's lake and stream rehabilitation program

WDFW routinely notifies an estensive list of state, federal, and local agencies; tribes; non-governmental organizations; and individuals each year of its intended applications of rotenone under its chemical rehabilitation program The same list of potentially interested parties (see Section 8.0 List of Agencies, Tribes, Organizations and Individuals Consulted) was notified of this environmental assessment of the federal grant-funded portion of

WDFW's program and invited to comment on the assessment and on selection of the proper alternative. From those notifications two responses were received: the Washington Department of Ecology (the agency that issues WDFW's NPDES permit) requested a copy for their files; and one respondent representing a city in western Washington suggested selection of the no action alternative, giving no rationale for that selection. That respondent was offered an opportunity for additional comment but did not do so. Both respondents will be notified of Service's decision through copies of the finding of no significant impact adopted by the Service subsequent to the public comment period. Copies of the finding are also available from the Service at the address on the cover or at r1fa_grants@fws.gov

1.5.1 Consultation and Coordination

When a lake or stream is first considered for chemical treatment by the WDFW Area or District Fish Biologist, the WDFW district and regional fish, wildlife, and habitat biologists and managers are informed, and a review of potential impacts to priority species and habitats, species of concern, and threatened or endangered species is conducted. Proposed lake and stream treatment projects funded by the Federal Aid to Sport Fish Restoration office, or having any other Federal connection, are reviewed under NEPA and subjected to ESA Section 7 and NHPA consultation.

As previously stated, public comment, including comments from Federal, State and local jurisdictions and agencies and Indian Tribes, is solicited on annual project proposals by the publication of project addenda through the State Environmental Policy Act.

2.0 Alternatives

2.1 Actions common to all alternatives

For all alternatives where rotenone use is a component, the general procedure outlined below applies. These actions are necessary for the use of rotenone in Washington State based on state and federal pesticide use rules, WDFW policy, and conditions of the WDFW NPDES fish management permit.

2.1.1. Stream Selection

WDFW Area or District Fish Biologists identify waters in which survival, growth, or catchability of game fish are not performing according to goals established in developed management plans or agency guidelines. In the lakes and streams identified as being managed specifically for trout in the WDFW fisheries program, management action is deemed to be necessary when the survival of stocked fingerling/fry trout declines to the point that a viable fishery can only be provided with introductions of "catchable-sized" fish at approximately 7 to 12 inches in length. Performance of fish populations, other than trout, may likewise decline to the point that management action is necessary to restore a viable fishery. Standard indicators of fingerling growth and survival, fish size and quality, or fishery viability include measurements of catch per unit effort, such as the average catch per hour on opening day, and fish size and abundance data from electrofishing or gillnet surveys. When poor juvenile performance is coupled with gillnet or electrofishing survey data that demonstrate a presence or an increase in undesirable species, or when water quality is being negatively impacted by fish (such as carp) to the level that declines in fish and wildlife populations and habitat is documented, the biologist will consider management alternatives for reducing the abundance and effects of the competing species. If treatment with piscicides is determined to be the preferred alternative, the lake or stream is added to an annual list of proposed rotenone treatments.

2.1.2. Science and Management

When lakes and streams have been identified as candidate waters for rehabilitation, the local fish biologist proposes the projects through the WDFW Regional Fish Program Manager to the WDFW Regional Wildlife, Habitat, and Enforcement Program staff for review. WDFW staff assess potential impacts to the species and habitat in the treatment area, as well as potential conflicts with ongoing fish and wildlife management initiatives.

Candidate species include fish and wildlife species that the Department will review for possible listing as State Endangered, Threatened, or Sensitive. A species will be considered for designation as a State Candidate if sufficient evidence suggests that its status may meet the listing criteria defined for State Endangered, Threatened, or Sensitive. Under WDFW policy POL-C3010, waters will not be treated in ways which would cause significant negative impacts to fish or wildlife which are state or federally listed as Threatened, Endangered, Sensitive or Candidate Species. A determination would be made whether a proposed project would cause "significant negative impacts" to such species, through WDFW internal review, SEPA public review, and decision of the Director of WDFW.

At this time, the fish biologist determines land ownerships and whether surface water withdrawal rights are present for that water body. Letters are mailed to landowners and any water right holders announcing WDFW's intent to treat the water with piscicides. Meeting dates are set to inform Tribes, agencies, landowners, water right holders, and the general public of the lake management plans and proposals for rehabilitation.

2.1.3. Public Outreach and SEPA

WDFW's routine public outreach on proposed projects includes public meetings near the waters being considered for treatment and a public meeting in western Washington, all announced through local and other news releases; individual contacts with all landowners and water right holders on waters selected for treatment; extensive public disclosure and solicitation of comments through the SEPA review process; notification of anglers using waters being considered for treatment; postings on the agency web site; postings at the selected treatment site; and other venues and processes. This level of public engagement and response will continue regardless of the alternative chosen as a result of this assessment.

The general public, interested parties, and affected state, tribal, and federal agencies review proposed rehabilitations through the SEPA process, where each project is included in an annual addendum to the 1976 EIS, and the 1992 and 2002 SEIS determinations, along with lake and stream management plans, and the pre-rehabilitation plans. A 30-day public comment period follows, after which a determination of significance is made after considering comments received.

2.1.4. Agency approval and public notification

Subsequent to a determination of non-significance, the proposals, along with any modifications based on SEPA comments, are reviewed and approved by the WDFW Fish Program Assistant Director and the Director of the WDFW. Bag limits and angling gear restrictions may be waived by the Director for lakes and streams approved for chemical treatment, until the time of actual treatment when they would be closed.

Notification of residents and businesses by mail, email, posting of flyers, and publication in the legal section of local newspapers are carried out by requirement of the NPDES permit. The EPA label for rotenone restricts human consumption of fish, swimming, irrigation, or any other precautions relevant to public or private water use during and subsequent to the treatments: WDFW staff post signs along public property and boat access areas to warn potential water users.

2.1.5. Treatment and monitoring of approved projects

Treatment is conducted according to EPA label restrictions, Washington pesticide use rules, Washington Fish and Wildlife Commission policy, conditions of the NPDES permit, and any provisions mandated by the funding source. Monitoring of water quality parameters, such as pH, temperature, alkalinity, and organic demand is conducted immediately pre-treatment, as required by the NPDES permit. Monitoring for rotenone toxicity, residual inert ingredients from liquid rotenone products, and changes in zooplankton and aquatic macroinvertebrate populations is likewise conducted pre- and post-treatment as required by the permit.

WDFW continually monitors current and emerging information concerning application techniques, human health issues, new products and formulations, ecological consequences, legal requirements, and other pertinent aspects of science and management. Staff responsible for the rehabilitation program actively engage in workshops and seminars, review professional society publications, routinely monitor internet sites, and consult with knowledgeable professionals relative to piscicidal issues and use. WDFW is committed to this active engagement regardless of the alternative selected.

The NPDES/Waste Discharge Individual Permit issued by the Washington Department of Ecology to WDFW for Fish Management is in the renewal process. WDFW applied for a renewal of this permit on 21 December 2006. This permit remains in effect until Ecology issues a renewed permit. The proposed permit is expected to be available for public comment in the fall of 2008. Public hearings will be scheduled for Olympia and in Moses Lake, Washington. Following the close of the public comment period, the reissuance of the permit is expected in Spring 2009.

2.2 Alternative A - No Action Alternative

The no-action alternative continues the current process of NEPA review of proposed projects on a case-by-case basis. WDFW would continue internal and SEPA public review processes, as described in Section 2.1. All proposed projects will be reviewed according to the requirements of ESA section 7 and will be taken to informal or formal consultation with the federal listing agencies (USFWS and NMFS) if required by identified project effects. Similarly, all proposed projects will be evaluated for compliance with Section 106 of the National Historic Preservation Act. Some projects will be categorically excluded from further review if their impact levels warrant; others may require environmental assessments or environmental impact statements of their potential effects. There would be no comprehensive evaluation of cumulative impacts due to the piecemeal annual consideration of projects.

2.3 Alternative B (Preferred) - Proposed Action: Treatments in standing and flowing waters

The preferred alternative is to streamline annual NEPA project-level review and conduct a comprehensive evaluation, including cumulative impacts. WDFW would continue internal and SEPA public review processes, as described in Section 2.1.

The programmatic assessment of the WDFW's federally-funded chemical rehabilitation program presented in this document defines significant impacts; project characteristics that do not lead to significant impacts; project characteristics that are outside the scope of this review; and WDFW commitments for monitoring and public engagement that will be requirements of the federal grant. In application, any proposed work that meets the following criteria, defining projects expected to have no significant impacts, would need no further NEPA review unless required by new information.

This alternative includes the use of both rotenone and potassium permanganate in both standing and flowing waters. Projects meeting the criteria specified here are within the scope of this programmatic environmental assessment. All other projects would require individual review.

- no adverse effects are expected to listed or candidate species or their designated or proposed critical habitats. The ESA Section 7 determination by Federal Assistance must be either "no effect" or "may affect, but not likely to adversely affect" listed or candidate species or designated or proposed critical habitats.

- planned approaches follow all product label restrictions and materials safety data sheet requirements for any rotenone products or potassium permanganate to be used.

- treatment is conducted with powdered rotenone and/or liquid rotenone formulations according to label directions, at concentrations not to exceed the equivalent of 4 ppm of 5% rotenone product (equal to 0.2 mg/L active rotenone), except in pre-impoundment treatments above a dam, where concentrations would not exceed the equivalent of 5 ppm of 5% rotenone product (equal to 0.25 mg/L active rotenone).

- the water being treated would not be used to irrigate crops or released within ½ mile upstream of a potable water or irrigation water intake in a standing body of water such as a lake, pond, or reservoir (this is a label requirement for rotenone). Domestic water sources include all situations in which surface water is withdrawn for human consumption, including private wells. WDFW obtains letters from all surface water right holders prior to treatment to confirm that the water right holder understands the need to cease any water withdrawal from the lake or stream, and agrees "not to withdraw water from the lake for up to 8 weeks or until notified after the treatment is applied."

- there would be no escape of toxic water to waters outside the treatment area.

- under no circumstances would the detoxification of treated, flowing water be solely dependent upon travel time and dilution of the rotenone product. Instead, treated waters would either be confined within the treatment area or detoxified with potassium permanganate.

- application is from shore, boats, drip stations, or aircraft. Aerial applications are conducted under contract with licensed private pesticide applicators, following best management practices described in technical procedures manuals such as Finlayson et al. 2000.

2.4 Alternative C – No live outflow of toxic water from the impact area

This is identical to the previous alternative, excluding use of potassium permanganate to neutralize rotenone that flows beyond the designated treatment area; therefore only projects with no outflow past the area intended to be treated are considered.

2.5 Comparison of the Alternatives

Table 1 displays the comparison of alternatives for the action. Alternative A (No Action) will continue the annual project-by-project evaluation of individual piscicidal treatments proposed by WDFW under NEPA. Review under ESA Section 7 and National Historic Preservation Act review for effects to cultural resources will be unchanged for all alternatives.

Under Alternative B (Preferred Alternative) programmatic approval is provided only for piscicidal treatment projects proposed by WDFW that have no significant impact to human health or the environment and comply with NEPA standards when conducted according to the criteria described in Section 2.3.

Alternative C would provide programmatic NEPA approval of proposed lake and stream treatments, except in cases where the project would include release of treated water either to be detoxified with potassium permanganate or solely through dilution by the receiving waters and breakdown of the rotenone product over time. In such instances, WDFW biologists will have reviewed downstream waters for impacts to the environment and human health, similar to reviews for the specified treatment area of the proposed project. This option would preclude inclusion of such projects under programmatic NEPA coverage. Such projects could still be proposed for federal funding, but they would be individually reviewed for NEPA purposes.

Table 1. Comparison of alternatives.

Alternative	Alternative A – No Action	Alternative B – Programmatic Assessment	Alternative C – Programmatic Assessment, disallowing use of potassium permanganate to neutralize rotenone-treated waters
NEPA Determination	Determination of significance to continue on project-by-project basis	Determination of significance approved on programmatic basis when listed criteria followed	Same as Alternative B, but disallows use of potassium permanganate to neutralize rotenone-treated waters
Number of Lakes Treated	5 to 30 annually	Same as Alternative A	Potentially preclude a small number of proposed projects.
Note that this comparison does not account for actions that are common to all alternatives.			

2.6 Alternatives Considered But Dismissed From Further Consideration

Other alternatives were considered, but were not deemed to be viable options for restoring recreational fisheries in circumstances where treatment would otherwise be proposed as an effective measure; therefore those alternatives could not meet the purpose and need and were dismissed. The alternative of "no federal funding" was also dismissed, because we would not have a basis to reject any proposal for eligible work if all other requirements were met.

2.6.1 No Treatment with Piscicides

WDFW assesses options for managing lakes and streams where game fish populations are compromised with undesirable fish species competing with or predating upon desirable species, or where populations of desirable species are not providing viable sport fisheries due to imbalances in population dynamics. The alternative of not using rotenone as a management tool was dismissed after consideration and analyses of the various options determined them to be ineffective in accomplishing the goals of the sport fisheries management plans on a case-by-case basis. The several management options are described in Appendix II, with reasons given for dismissing individual options.

2.6.2 No Federal Aid Office Funding of WDFW Lake and Stream Rehabilitation Projects

Consideration was given to the alternative that the Federal Aid in Sportfish Restoration Program not approve grants that propose to use rotenone for fish management. This alternative was dismissed after examination of the circumstances under which it could be exercised. Activities eligible for funding through Federal Aid in Sportfish Restoration Program grants are described in 50 CFR 80, both by description of eligible activities and by exclusion, through description of ineligible activities. The use of rotenone consistent with current fish management practices is not excluded. For Wildlife and Sport Fish Restoration Program grants managers to reject grants proposing the use of rotenone, the rotenone usage would have to be outside generally accepted fish management practices and norms, or the grants would have to be otherwise flawed in ways not related to rotenone use. All of the WDFW grants for application of rotenone have presented credible fishery management approaches and have been otherwise scientifically sound, with costs commensurate with expected benefits. In granting parlance, these are criteria of substantiality. Grants managers have no authority to reject proposals that are "substantial in character and design", as these have been.

3.0 Affected Environment

In general, the core area for lake and stream rehabilitation projects funded through the Sport Fish Restoration Program is in eastern Washington. However, the scope of the potential affected environment includes all the inland waters of Washington State that meet the criteria previously defined for the preferred alternative. Although the geographical scope of the rehabilitations may be statewide, there are several reasons western Washington waters have not been rehabilitated in recent years to improve fisheries (WDFW 2002). The first is growth in human population and public sentiment against use of chemicals. Western Washington lake shorelines are becoming more developed with residences, and many of these residents are not anglers and therefore are not interested in maintaining quality trout fisheries. By the late 1980s, WDFW experienced substantial opposition by the public and political pressure against use of rotenone in western Washington.

The second reason is that revised label restrictions prevented use of rotenone in systems with water withdrawals for irrigation or potable use. With extensive shoreline development on west side lakes, most now have some type of water withdrawals effectively eliminating them as possible candidates for rehabilitation.

Finally, many west side lowland lakes have outlets accessible to anadromous fish, many of which contain stocks that are listed under the federal Endangered Species Act (ESA). Obtaining permits for fishery management rehabilitations that might impact threatened or endangered species would be very difficult.

The potential for lake rehabilitations in western Washington is limited to three areas:

1) Removal of harmful species to protect native populations.
2) Isolated lowland lakes: The potential remains for the use of rotenone in waters that do not have substantial adjacent development, and do not have anadromous fish or ESA issues.
3) High lakes: Although this management tool has not been used much in Washington's high lakes, it could provide substantial benefits. Many lakes and their tributaries contain stunted brook trout and cutthroat that over populate the ecosystem and do not reach a size to attract anglers. Removing these populations and replacing them with species that would not reproduce will reduce the density of trout, allowing for better growth of individual fish, provide fish of a size much more acceptable to anglers, and reduce impacts to the ecosystem.

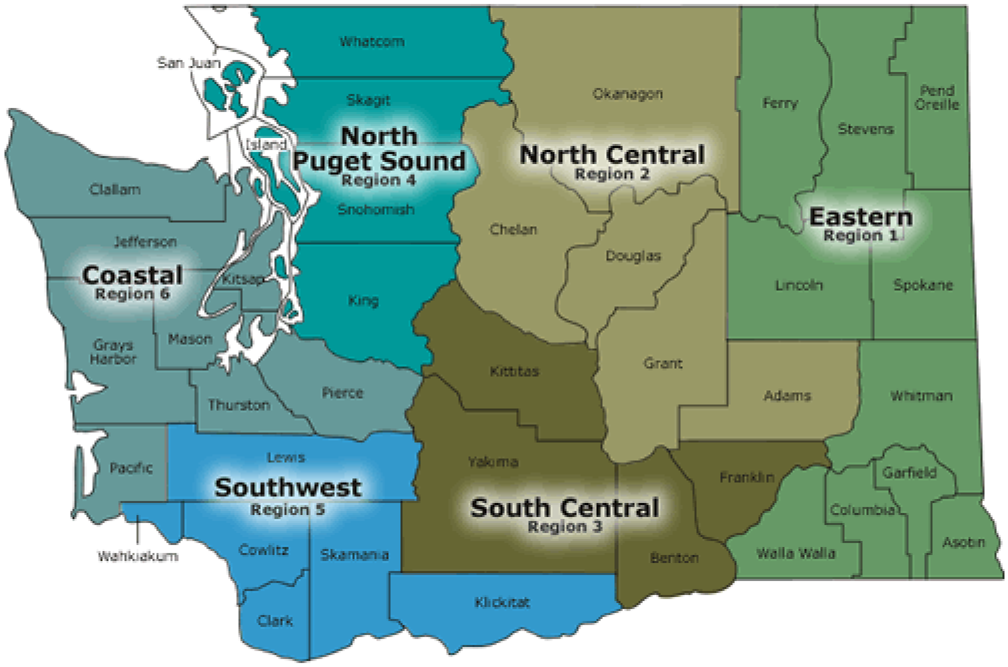
Relative to considerations and issues raised during the scoping processes (Section 1.5), the following components of the environment may be affected when rotenone is used for piscicidal rehabilitation as proposed.

3.1 Floodplains, Wetlands, Lakes, and Streams

Rotenone has been used in fisheries management projects in Washington since 1940, when Kings Lake in Pend Orielle County was treated to remove competing fish species prior to establishing a brood stock lake for westslope cutthroat trout. In the years subsequent to this initial treatment, the State of Washington has conducted 1,186 treatments for 510 lakes and streams. In the most recent 5-year period, WDFW has treated an average of 10.4 lakes (1,173 acres) using 95,480 pounds (43,320 kg) of 5% equivalent powdered rotenone and 377 gallons (1,440 liters) of 5% liquid rotenone annually. The average size of the waters treated was 119 surface acres. Most treatments occur in WDFW Regions 1 and 2 in eastern Washington (Figure 1). Since 1992, rotenone treatments have taken place in nine eastern Washington counties: Adams, Ferry, Grant, Lincoln, Okanogan, Pend Oreille, Spokane, Stevens, and Yakima. One western Washington lake was treated in 1998 (Crocker Lake, Jefferson County) to eliminate illegally planted non-native northern pike as a measure to protect native juvenile coho salmon from unnatural predation.

The treatments may take place within floodplains and wetlands of the project areas of the lakes and streams identified for the removal of undesirable fish. The wetlands, springs, and seeps associated with the various treatment projects are generally confined to small areas adjacent to the lakes and streams.

Figure 1. WDFW Regions.



3.2 Water Quality

Piscicidal treatments have the potential to affect the environment through direct and indirect modifications of water quality. Direct impacts include the addition of rotenone and related products to the water, and potential effects from the carriers in liquid formulations. The NPDES permit issued to WDFW by the Washington Department of Ecology allows WDFW to effect short-term modifications of water quality. Direct impacts of lake and stream treatments to water quality are addressed through the monitoring requirements, to demonstrate effects resulting from the treatments, and ensure that these impacts are consistent with the permit.

Indirect impacts may result from the modification of the zooplankton community, resulting in changes to levels of phytoplankton populations. Further impacts may result from the decomposition of fish carcasses, which have the potential for modification of nutrient loading to the lake or stream systems. These impacts are expected to be of short duration following treatment. In situations where bottom-feeding fish are being controlled, it is expected that water quality parameters will improve subsequent to treatment.

Lake and stream rehabilitation will not result in contamination of groundwater, since rotenone will not transport from surface waters or soils into the groundwater because it is quickly bound by organic material in soils. Waters will not be treated if there is a potential for surface water withdrawals for irrigation or potable water use. There is no label restriction on use of treated water by livestock or wildlife.

3.3 Recreation

Treatments are generally conducted in the autumn, subsequent to the season of heavy recreational use. Rehabilitation projects are occasionally conducted in the springtime, to ensure control of the eggs and fry of several undesirable fish species. According to the label requirements, and for health and safety considerations, WDFW does not apply rotenone if people are swimming in the lake or stream. Signs are posted and lakeside residents are informed by mail when waters are treated, to warn them from entering the water during the period of treatment. There are no restrictions on swimming after the rotenone has mixed into the water, nor are there restrictions on boating or other lakeshore activities.

3.4 Fisheries

Rotenone is applied to waters with degraded fisheries, and degraded fish and wildlife habitats, as a means to remove undesirable species of fish to rehabilitate the lake or stream, to revitalize the subsequent fisheries, and to improve fish and wildlife habitats to maintain viable fisheries. All fish in the treatment areas are killed, and species that will support fisheries are restocked.

3.5 Wildlife

Other than fish, there are negligible direct impacts to wildlife. Birds, mammals, reptiles, and crayfish are not affected by rotenone at piscicidal levels used in lake and stream treatments. Adult forms of amphibians are generally not impacted by rotenone at these levels, although larval and neotenic forms may be killed. Losses of forage for piscivorous birds and mammals following treatment are temporary.. Restocking of the waters with hatchery-origin fish, and the usually rapid recovery of plankton and aquatic insects, mitigate these temporary losses. Timing treatments to avoid critical breeding, rearing, and nesting periods of species of concern mitigate for those impacts.

3.6 Threatened, Endangered, and Proposed Species, State Sensitive Species

If threatened, endangered, or proposed species were in the area affected by rotenone application, they would be affected as described for the various taxa in Section 4.0 (Environmental Consequences). However, prior to consideration of any treatment project under this programmatic environmental assessment, the potential direct and indirect effects on species of concern are assessed by state and federal biologists. Federal law requires review under Endangered Species Act Section 7; a project must pass Section 7 review to be considered for NEPA review and federal grant approval. To proceed, a project must qualify for one of two possible determinations defined in the Endangered Species Act: either a finding of "no effect" to listed species or their designated critical habitats, or a finding that the project "may affect but will not likely adversely affect" listed species or their designated critical habitats. A third determination, "may affect, likely to adversely affect" listed species or their designated critical habitats is also possible under the Endangered Species Act. However, no project receiving a "likely to adversely affect" determination is moved forward for NEPA review and none is approved for federal funding. Hence, any project that may adversely affect listed species is dropped from consideration unless it can be revised to avoid adverse impacts.

3.7 Grazing

Grazing occurs on private and public rangelands, riparian areas, and pastures adjacent to some treated waters. The streams are used as a water source by livestock, and riparian vegetation in parts of the project area is also used for forage by livestock. There are no restrictions or warnings on watering livestock or wildlife in rotenone treated water, because there are no adverse effects when used according to the USEPA label.

3.8 Cultural Resources

Cultural resources are present throughout the inland Pacific Northwest. There is no expected impact to cultural resources resulting from the piscicidal treatment of lakes and streams for fisheries rehabilitation because no earthwork is involved. No species of cultural importance to tribal members are affected by treatment projects..

3.9 Public Health and Safety

The general public uses the treated waters for recreational purposes, especially sport fishing, but only after detoxification of the rotenone, and typically only months after treatment when stocked fish reach catchable size. They may also be used for stock watering or for downstream irrigation. Piscicidal treatments may result in airborne particles of powdered rotenone or volatilized liquid product. The effects area for analysis purposes is the project area. Potential impacts to human health are discussed in Section 4.0.

4.0 Environmental Consequences

The following section details environmental consequences as outlined in Section 1.5, common to all alternatives using rotenone, and measures taken by WDFW to avoid significant adverse impacts.

Environmental Health

Soils and Sediments

Rotenone adsorbs strongly to sediments or particulate matter, including plants, in the water column. Because of these characteristics, rotenone is not persistent and not a concern for environmental safety or human health.

The concentrations of rotenone in sediments are typically higher than in the water column in standing waters; however, rotenone residues are rarely detected in treated streams, based upon experience in California (Finlayson et al., 2001). Where there are large quantities of sediments and plants, rotenone is adsorbed to the extent that the amounts of rotenone applied may have to be higher to achieve the same target concentration in the water (Bradbury, 1986).

Soils

Soil mobility data point out expected behavior of rotenone sprayed over the shoreline and to some extent indicates what may happen if a lake level drops, exposing shoreline sediment to drying, soon after treatment. The data also give at least an indication of rotenone's adsorption potential on sediment. Sediment will usually have a higher organic material content than typical soils except for muck soils, and therefore, soil tests may underestimate the potential for rotenone adsorption to high-organic matter sediments.

Controlled laboratory "batch equilibrium" studies are designed to measure the adsorptive properties of the active ingredient of a pesticidal product. In the case of rotenone, such a study has not been submitted. In the absence of this study, Hansch et al. (1995) used the available chemical characteristics and the EPIWIN program (Estimation Programs Interface for Windows®), a suite of physical/chemical property and environmental fate estimation models developed by the USEPA Office of Pollution Prevention Toxics and the Syracuse Research Corporation, to estimate the adsorption characteristics of rotenone. The sorption parameters indicate how well rotenone is adsorbed and released on that typical soil and hence will give one measure of leaching potential. The K_d values calculated from EPIWIN range from 4.2 to 122 L/kg leading to the conclusion that rotenone is expected to be sorbed to soil and sediment surfaces and not be likely to move through the soil/sediment compartment. Although there is some disagreement as to exact classification values, generally Kd_{ads} values greater than 5 are characteristic of compounds that are not appreciably mobile, values from about 1 to 5 indicate a potential for greater mobility, while values under 1 denote considerable mobility potential. In a similar manner, high Kd_d values indicate that a compound will stay bound to soil and resist being carried downward.

Broadcast sprays, especially aerially broadcast rotenone, may result in some exposure of land adjacent to the treated water as a result of spray drift. Because the amount applied depends upon the quantity of water to be treated, it is necessary to make some assumptions. For the purpose of this analysis, the EPA model of a one-acre pond, six feet deep (Urban and Cook, 1986) is used (In recent times this has been expressed in metric units, but since label calculations for applications are based upon acre-feet, the older English units are used here). To achieve the labeled maximum concentration of 250 ppm, it would require application of 13.5 lb of a 5% product per acre-foot or 81 pounds of product for six acre-feet. The latter would be 4.05 lb (active ingredient) of rotenone, which would then be applied to a surface acre of water. For a direct application to plants, that would amount to plant residues on short grass of 972 ppm, based upon the 95% confidence limits findings of Fletcher et al. (1994). Since EPA models for terrestrial applications estimated 10% drift from the application site to adjacent water, it seems reasonable to assume that 10% of the material applied to water would drift to adjacent land. This would result in a maximum exposure on short grass of 97.2 ppm.

Residues on vegetation would be of short duration, and not a concern to the environment or human health. The photolysis half-life of technical rotenone is 2.9 hours (adjusted for volatilization) on bean leaves. The dust and a powder formulation had photolysis half-lives on lettuce leaves of 2.9 and 3.6 days, respectively. For tomato leaves, the respective half-lives were 2.7 days for the dust and 0.9 days for the powder. In summary, the small amounts of rotenone may be present in soils for a very short duration.

<u>Sediments</u>

There are few studies available that directly assess the behavior of rotenone in aquatic sediments. It is likely that the behavior of rotenone may be inferred from the K_d values obtained by Hansch et al. (1995). This reiterates that high K_d values indicate that rotenone is strongly bound to sediment and vegetation, rendering rotenone unlikely to move through the sediment. Rotenone is likely to be adsorbed to the surface of sediment particles when contacted. Such sorption will limit both the movement of the residue and its availability to the flora and fauna in the water body. In the case of Lake Davis, California, the sediment levels of rotenone peaked at 14 days post treatment and declined to less than detectable levels by 33 days. Similarly, rotenolone (the metabolite of rotenone) declined to non-detectable levels by 33 days post treatment (CDFG, 1999).

After mixing is complete, concentrations of rotenone in the sediments would be expected to be higher than in the water column, due to the tendency of rotenone to adsorb to sediments. Finlayson et al. (2001) found that residues in three lentic water projects were 310, 180, and 522 µg/Kg. In two of these, concentrations dropped below detection limits in 14 days. In the cold Lake Davis, concentrations were not detectable after 60 days. Data from stream applications indicate that sediments are likely to have no or very low rotenone residues (Finlayson, et al., 2001).

Because rotenone is not persistent and is strongly bound to sediments until it breaks down, its use is not considered a concern relative to sediment-dwelling organisms in lakes and streams.

Groundwater withdrawals
From the above data, it is clear that rotenone does not pose a substantial threat to groundwater. Bioavailability of rotenone is reduced as a result of strong adsorption to sediments, plants, and particulate matter in treated waters. As a result, rotenone should not leach into groundwater. No rotenone has ever been detected in groundwater, even in test areas associated with rotenone treatments (Turner et al. 2007). Rotenone is not significantly mobile in most soils and sediments and is readily adsorbed to the high organic content sediments to be expected in lakes. Because rotenone is so readily degraded, with half-lives typically less than 14 days and usually less, it is gone from lake sediments before it can be transported into surrounding soil. Overspray onto lakeshores, or exposure of treated shallow lake sediments is expected to be negligible. Even if those situations occur, rotenone is not significantly mobile in soil to move beyond the immediate surface layers.

Data from the USEPA's Pesticides in Ground Water Database indicate that for the number of wells that have been analyzed for rotenone and related compounds there have been no detections (Barbash and Resek, 1996). Barbash and Resek (1996) reported that there had been 12 random well samples analyzed for rotenone with no detections. Additionally, four (4) wells were analyzed for rotenolone and eight (8) wells for "other rotenone metabolites" with no detections in any of the wells.

The California Department of Fish and Game monitored wells as part of nine rotenone applications projects throughout that state. In fifteen years of monitoring the effects of rotenone application to streams and lakes, the CDFG found that the behavior of rotenone and organic compounds is dictated by the dilution, temperature, and alkalinity of the treated water. The degradation rates for rotenolone and the synergist piperonyl butoxide decrease at lower water temperatures and the chemicals may persist for up to nine months in colder waters. All other components of rotenone application degrade or dissipate within six weeks in water samples. Chemicals were found in the sediments of treated water bodies for up to 180 days following rotenone application, but no evidence was found of rotenone or the associated chemicals in groundwater or wells neighboring the treatment areas (Finlayson et al. 2001). Case studies in Montana have likewise concluded that rotenone movement through ground water is minimal (Clancy 2005).

Because it binds strongly to lake and stream sediments, is not persistent, and has not been observed in groundwater, the use of rotenone is not considered a concern for groundwater resources.

Water Quality
Following the rotenone treatment, the treated lake may be expected to have increased nutrient loads from the decomposition of dead fish (Fisher Wold and Hershey 1999). However, Claeson et al. (2006) found that carcass-derived nutrients

were quickly assimilated by biofilm, benthic insects, and fish. Nutrient intake by insects and fish feeding directly on carcasses peaked about 2 weeks after carcass addition, but indirect uptake of nutrients by insects and biofilm was delayed by approximately 2 months, and was considered a transitory effect. In lakes treated with rotenone, fish feeding on carcasses would not be likely. However, crawfish and amphipods are unaffected at piscicidal treatment levels and would be assumed to contribute to uptake of carcass-derived nutrients post-treatment. The observed consequences of leaving fish to decay are short-term and inconsequential.

Parmenter and Lamarra (1991) reported that although the quantitative importance of carrion-derived elements to ecosystem nutrient budgets is site-specific, studies have shown that in aquatic environments supporting large vertebrate populations, carrion decomposition can contribute important nutrients that ultimately influence the structure and functioning of the aquatic ecosystem.

Because zooplankton populations would be reduced by rotenone, a short-term increase in phytoplankton abundance may be anticipated along with the water quality problems associated with algae proliferation. Once the zooplankton populations increase to graze on the phytoplankton, these short-term interactions may function together to decrease water quality in the treated waters. This short term potential indirect effect is not expected to be a risk within or downstream of treatment areas because WDFW obtains written assurances from persons holding surface water withdrawal permits that they will refrain from any such water withdrawals until rotenone has dispersed from the water.

Carp in particular eliminate vegetation, muddy the water, and release nutrients that accelerate eutrophication. Elimination or substantial reduction of this and similar species, and the removal of reintroduced game fish (and the nutrients bound up in their bodies) through sport angling, result in lower levels of nutrients over the long term, thus lowering rates of within-basin and downstream eutrophication. Chemical treatment of waters containing carp and other species which remove macrophytic vegetation, perturb the substrate, and cause increased suspended sediment levels have the greatest potential to result in indirect long term beneficial effects to downstream water quality and the health of the people who may potentially drink from these downstream waters.

Sanni and Wærvågen (1990) studied oligotrophication as a result of the removal of planktivorous fish with rotenone in the small, eutrophic, Lake Mosvatn, Norway. The first summer after treatment the zooplankton community changed markedly from rotifer dominance and few grazers, to a community with few rotifers and many grazers. Accordingly there was a fivefold increase in the biomass of the water flea, *Daphnia galeata*. Adult females of *D. galeata* approximately doubled in weight. The decrease in rotifer biomass was probably mainly due to a loss of food by competition with the daphnids. The phytoplankton community was also markedly affected. Prior to treatment, the mean summer concentration of total phosphate was $44\mu g\ P\ l^{-1}$ (per liter). This decreased to $29\mu g\ P\ l^{-1}$ in the first summer and $23\mu g\ P\ l^{-1}$ the second summer after the treatment. Total nitrogen decreased from $0.68\ mg\ N\ l^{-1}$ before treatment to $0.32\ mg\ N\ l^{-1}$ the first summer after the treatment. The phosphate loading was not reduced, therefore it was concluded that the fish removal provided a biomanipulation that caused the more oligotrophic conditions.

The impacts to water quality resulting from the use of rotenone have been observed to be of short duration, and are closely monitored as required by conditions of the NPDES permit under which WDFW conducts treatments.

Air Quality

The use of powdered rotenone involves mixing powdered formula into a slurry-type media with water and injecting the mixture into the water body (Finlayson et al. 2000). While the mixing is being conducted, all staff in the vicinity are required by WDFW policy to wear personal protective equipment. Personnel mixing formulations would follow label (Federal Insecticide, Fungicide, and Rodenticide Act [FIFRA]) requirements necessary for protection from exposure to the formulation. If necessary, rotenone powder can be combined with sand and gelatin to form sand-gelatin-rotenone balls to treat large pools, seeps, and springs. When applying these balls, small amounts of powdered rotenone may be released into the air, but only protected pesticide applicators in the immediate vicinity would be exposed. Therefore, no impacts to air quality outside the treatment area are expected.

Some liquid rotenone formulations (i.e., Prenfish or Noxfish) contain 1,3,5-Trimethylbenzene, sec-Butylbenzene, 1-Butylbenzene, Isopropylbenzene, 1-Propylbenzene, 1,3,5-Trimethylbenzene, 1,2,4-Trimethylbenzene, and 1-Butylbenzene; all of which are alkyl benzenes that contain a core benzene ring. These compounds are related to benzene in structure, and differ only by the addition of methyl, butyl, and propyl chains to the benzene ring, which contributes to their toxicological consideration. The addition of alkyl chains to the benzene ring, however, results in these compounds being less toxic than is benzene. Although these liquid rotenone formulations contain alkyl benzenes, the projects would not be a significant source of hazardous air pollutants based on the quantities of alkyl benzenes produced (California Department of Fish and Game and U.S.D.A. Forest Service 2007).

Environmental issues associated with air quality include the following:

- Objectionable odors from rotenone application and decaying fish;
- Elevated levels of air pollutant emissions from motorized equipment required for application;
- Particulate dust from equipment and vehicle use;
- Dust from powdered rotenone application.

The use of the rotenone and the resulting deceased fish may result in objectionable odors for persons in the vicinity of the treatment areas, including agency staff, recreationists, and interested citizens. Odors would be short-term and temporary, and are mitigated by cooler ambient temperatures during treatments in the autumn which reduce the rate of decay. The WDFW generally plans to leave fish carcasses in the water to provide nutrients for growth of phytoplankton and zooplankton subsequent to piscicidal treatment. In response to local concerns, WDFW has offered, upon request, to remove dead fish that have washed onto the shore of lakeside residences.

All of the treatment projects involve transportation/hauling and staging of chemicals and/or equipment. Fugitive dust impacts from driving on unpaved roads are a potential concern for the proposed actions and alternatives. The use of vehicles and equipment would create particulate dust and would impact workers in the vicinity of the treatment areas during operation of vehicles and equipment. Dust emissions would be limited to the operation of the equipment, and would be no greater than normal vehicle traffic in the vicinity of the treatments. The application of rotenone formulations is short-term and temporary in nature. It is expected that the equipment would be categorized as mobile, off-road, non-road, aerial, and temporary.

Significant or measurable chemical emissions from the use of rotenone are not expected based on estimated emissions from the powdered rotenone formulation and the liquid rotenone formulations under consideration. Neither the proposed action nor any of the alternatives would result in a change to any state or Federal air quality attainment designation.

Non-target Species Impacts

Target species are defined as those fish species that are described as being undesirable in the water management plan, and are the object of the treatment. At times, species that are desirable game fish may become undesirable because of stunted size, or because they impact other desirable species through competition or predation. Because rotenone is non-selective, non-target species are those species that may be impacted during a treatment directed at the undesirable species.

Rotenone has the ability to inhibit cellular respiration in fish, mammals, birds, insects, reptiles, amphibians, and even plants. However, at concentrations used in fisheries management, rotenone is only toxic to gill-breathing organisms such as fish, some forms of amphibians and aquatic invertebrates (Bradbury 1986; Finlayson et al. 2000). Studies determined that the reason rotenone is generally toxic to fish, tadpoles, and aquatic invertebrates and not to other animals is that gills provide an efficient mode of entry of the chemical into the cells, while the skin and the stomach do not (Bradbury 1986; Finlayson et al. 2000). Finlayson et al. (2000) describe that all animals (including fish) have natural enzymes in the digestive tract that neutralize rotenone, and that the gastrointestinal absorption of rotenone is inefficient. However, gill-breathing organisms are more susceptible to rotenone because rotenone is readily absorbed directly into their blood through their gills (non-oral route) and thus, digestive enzymes cannot neutralize it.

Plants

Phytoplankton are not directly affected by rotenone and tend to increase initially because of the loss of the zooplankton feeding on them, but then become markedly reduced the following spring, or later in the season following a springtime treatment, when the zooplankton recover. Aquatic macrophytes are not affected directly by rotenone. When imbalanced fish populations have resulted in depressed zooplankter numbers, increased clarity of the water results post-rehabilitation, due to increases in zooplankton feeding on the phytoplankton. Improved water clarity increases the amount of sunlight penetrating the water, allowing macrophytes to flourish and spread (Hanson, et al., 2006).

Zooplankton

Rotenone can be highly toxic to certain aquatic invertebrates. However this toxicity is quite variable (Turner et al. 2007). Ling (2003) reported that zooplankton usually decline substantially following rotenone treatments and a few benthic invertebrates are also affected. Because Daphnia, a zooplanktonic cladoceran sensitive to rotenone, is a standard test species, it is often considered that aquatic arthropods are sensitive in general. However, benthic invertebrates, to a great degree are not sensitive at the labeled rates of rotenone use. In reports (e.g., Bradbury, 1986; Ling, 2003) on various rotenone treatments in lakes, it has generally been found that there is a substantive impact on zooplankton and other invertebrates, but that these recover by the following year, often to a greater degree initially than before rotenone treatment because the predators on the zooplankton have been removed and subsequent stocked fish consume fewer zooplankton.

Zooplankton and littoral macroinvertebrate communities were monitored as part of a 1997 rotenone treatment of Lake Davis, Plumas County, California (CDFG 2006). Samples were taken pre- and post-treatment, starting in July 1997, and ending in August 1999. Changes in zooplankton taxa richness during the study could not be distinguished from natural yearly cycles of increase and decrease. Overall, zooplankton abundance decreased immediately following the treatment, recovered to roughly 300% of the pre-treatment abundance within 1 year after the treatment, and was at approximately 150% of the pretreatment abundance 2 years after the treatment. Littoral macroinvertebrate taxa richness decreased immediately after the treatment, then increased over the next 2 years as additional taxa were found in the reservoir after removal of the fish community. Two sensitive macroinvertebrate taxa that were sampled prior to the treatment were not found in the samples taken over the 2 years after the treatment. Littoral macroinvertebrate abundance decreased to approximately 57% of the pre-treatment abundance immediately after the treatment, increased to 58% of the pre-treatment abundance within 1 year after the treatment, and was at 61% of the pre-treatment abundance by the end of the study, 2 years subsequent to the treatment. Samples taken before and after the rotenone treatment of Lake Davis indicated that the adult population of zooplankton almost entirely died off and the littoral macroinvertebrate abundance decreased to almost half of its pre-treatment level immediately following treatment. Most of the zooplankton and macroinvertebrate community structures remained intact. Zooplankton taxa richness in the post-treatment period remained stable while the abundance increased in the absence of fish. Macroinvertebrate taxa richness increased in the years after the treatment, but abundance remained significantly lower through the end of their study.

During an investigation of long-term effects of rotenone on zooplankton communities, Anderson (1970) found that most variations in composition and abundance after rotenone were likely due to changes in competition and predation pressures rather than to changes in environmental factors or direct effects of rotenone.

The response of zooplankton to the effects of rotenone treatments in Washington State was variable in each of 23 lake rehabilitation projects sampled from 2002 to 2006 (Anderson 2008). In general, the ratio of cladocerans to copepods tended to decline after six months post-treatment, then was found to have returned to near pre-treatment levels at one year post-treatment. The average length of cladocerans showed an inconsistent response at six months post-treatment, and generally was slightly larger at one year post-treatment. Copepod average lengths also showed inconsistent response at six months post-treatment, and tended to increase in size or remain the same at one year post-treatment.

The reaction of the zooplankton community appears to be more dependent upon fish stocking and the development of predatory populations that develop subsequent to treatments, than upon the effects of rotenone itself.

Invertebrates

Aquatic arthropods are often considered more sensitive than mollusks, but a modest number of tested arthropods are not very sensitive, and two of the four bivalve mollusks are as sensitive as many arthropods (Turner et al. 2007). Melaas et al. (2001) suggested that benthic invertebrates can seek refuge from piscicides in organic sediments, whereas nektonic species (organisms in the water column, e.g. zooplankton, damselflies, and diving beetles) cannot. This may explain why, in their study, rotenone seemed to have very little impact on some benthic taxa, such as snails, and had limited, short-lived impacts on aquatic invertebrate communities. The abundances of three taxonomic groups, Ephemeroptera, Trichoptera, and Chironomidae, were found to increase with time after rotenone poisoning of the Green River in Wyoming (Brenneis 2006). In two Norwegian rivers, Arnekleiv et al. (2001) reported a reduction in standing stocks of most mayflies following rotenone treatment, and that all the abundant species recorded pre-treatment occurred again in high numbers within one year.

With their gill-like tracheae, aquatic invertebrates are theoretically as susceptible to the toxic effects of rotenone as fish or amphibian larvae (Bradbury, 1986). After laboratory based tests, Chandler and Marking (1982) concluded that, apart from an Ostracod (*Cypridopsis sp*.), aquatic invertebrates are much more tolerant of rotenone than most fishes and amphibian larval stages. In their study, the most resistant organisms exposed were a snail (*Helisoma sp.*) and the Asiatic clam (*Corbicula manilensis*) for which the LC_{50} 96h concentrations were 50 times greater than those Marking and Bills (1976) reported for the black bullhead (*Ictalurus melas*), one of their most resistant fishes. The LC_{50} of a toxic substance is the concentration required to kill half the members of a tested population in a given amount of time. LC_{50} figures are frequently used as a general indicator of a substance's acute toxicity.

Sanders and Cope (1968) also conducted lab tests examining the effect of rotenone to the nymph or naiad stage of a stonefly (*Pteronarcys californica*) They found that the LC_{50} 24h was 2,900 µg/L and the LC_{50} 96h was 380 µg/L. These values are greater by an order of magnitude to those found by Marking and Bills (1976) for the black bullhead (*Ictalurus melas*), indicating that aquatic invertebrates are much less sensitive to rotenone than fish. Larger, later instar naiads were less susceptible to given concentrations of toxin than were smaller, earlier instars of the same species (Sanders and Cope, 1968).

Field studies examining the effect of rotenone on aquatic macroinvertebrate communities have provided varied results. Whereas some workers noticed dramatic, long-term effects (Mangum and Madrigal, 1999; Binns, 1967), others observed rotenone has a negligible effect on most aquatic macroinvertebrates (Demong, 2001; Melaas, 2001). Most researchers would agree, however, that the effects of rotenone are less pronounced and more variable to macroinvertebrates than the effects of the chemical on zooplankton. Like the range of sensitivities demonstrated by various fish species to rotenone, different species of aquatic macroinvertebrates also exhibit a range of tolerances (Mangum and Madrigal, 1999; Chandler and Marking, 1982; Engstrom-Heg et al., 1978), perhaps based on their oxygen requirements.

WDFW identifies two invertebrate species that may potentially be found in eastern Washington treatment areas as State Candidate species (Columbia clubtail, *Gomphus lynnae*, and California floater *Anodonta californiensis*). The Columbia clubtail has been identified in Washington only in Benton County (Slater Museum 2008). Lakes and streams that have not been previously treated are surveyed for the presence of Anodontids.

Dolmen et al. (1995) investigated the effect of rotenone on the vulnerable freshwater pearl mussel, *Margaritifera margaritifera*, in connection with rotenone treatments of Norwegian rivers against the salmon parasite *Gyrodactylus salaris*. In a field experiment, the mussels survived treatments with 5 ppm rotenone solution for 12 hours. In a laboratory experiment, the mussels survived 30 ppm for 12 hours. At 40 ppm, the mussels survived the treatment, but died less than a week later. The lethal concentration of rotenone for the freshwater mussel, over a 12 hour exposure period in the laboratory, is thus estimated at 30-40 ppm. Compared to fish, the freshwater pearl mussel is highly resistant to rotenone. Rotenone treatments, such as those carried out in Norwegian rivers to get rid of the salmon parasite (< 5 ppm rotenone solution for < 8 h), would not represent a threat to a population of the freshwater pearl mussel. Hart et al. (2001) reported that following a rotenone treatment on Minnesota's Knife River, the mussel species present at the time of treatment were still present and comparatively similar in abundance to other streams throughout the drainage ten years subsequently.

From this information, it can be seen that rotenone toxicity and impacts on invertebrates are highly variable, but are of fairly short duration (less than one year) for most species. Rotenone treatments are not expected to result in the loss of taxa or in reduced productivity of invertebrate communities.

<u>Fish</u>

Fish are variably sensitive to rotenone, depending on tolerance of the species to the piscicide. The efficacy of rotenone on various aquatic organisms has been examined in controlled aquatic toxicity tests. Such tests commonly aim to determine the LC_{50} value (the median water concentration of the active ingredient that kills 50 percent of the animals) over specified periods of time (e.g., 24 hours, 96 hours, etc.). Marking and Bills (1976) summarized such rotenone toxicity data for a variety of fish species. The tests used to establish these values are conducted with laboratory quality water that lacks the colloid and sediment load typical of field settings. These organic loads consistently increase the amount of chemical required to elicit a toxic effect. Thus, laboratory values are conservative estimators of effects that could be seen in field settings.

Rotenone applications of the commercial formulations between 1 and 4 mg formulation/L have generally proven sufficient to eliminate all fish in the treated water body (Ling, 2003). Such formulations result in active ingredient (a.i.) concentrations of rotenone ranging from 50 to 150 µg/L (parts per billion). In such aquatic exposures, the water-borne chemical enters fish by simple diffusion across the gills. Marking and Bills (1976) recorded 24h LC_{50} rotenone concentrations of 1.4 µg/L to 33.3 µg/L, and 96h LC_{50} concentrations of a.i. ranging from 1.1 µg/L to 24.9 µg/L. Some of the most resistant species in field and lab applications have included black bullhead (*Ictalurus melas*), channel catfish (*I. punctatus*), and fathead minnow (*Pimephales promelas*) with 24-hour LC_{50} rotenone concentrations of 33.3 µg/L, 20 µg/L, and 20 µg/L, respectively. Salmonids (i.e., trout, salmon, and char) tended to be among the most sensitive species tested to the active ingredient with LC_{50} concentrations commonly less than 2.5 µg/L. Northern pike (*Esox lucius*) demonstrate slightly less tolerance to rotenone than salmonids, with a 24-hour LC_{50} value of approximately 2.3 µg/L (Marking and Bills, 1976). In Montana, the response of native slimy sculpins (*Cottus cognatus*) to Prenfish was similar to salmonids (Grisak et al. 2006).

Fisheries managers have exploited this considerable range in rotenone sensitivity among fish species to selectively remove populations of unwanted species in mixed-species communities (Bills et al., 1996). Reasons for such marked differences may be a result of differences in tissue distribution, rates of uptake, and rates of detoxification based on differences in the levels of liver enzymes responsible for rotenone breakdown and elimination, or supplemental means for oxygen uptake from air. Another possible explanation is that although rotenone stops cellular respiration at the mitochondrial level, certain species are biochemically more successful in using alternative pathways to generate adenosine triphosphate, which transports chemical energy within cells for metabolism (Rach and Gingerich, 1986), and are therefore still able to function at some concentrations of rotenone that would otherwise kill other fish species.

Omnivorous fish species generally demonstrate higher tolerance levels to rotenone than strict carnivores. One explanation promoted for this elevated tolerance is that bottom-feeding omnivorous fish tend to have much greater concentrations of the mixed function oxidase (MFO) enzymes responsible for metabolizing rotenone than species with strictly carnivorous diets (Moyle and Cech, 1988). The MFO class of enzymes metabolize foreign compounds like rotenone, and accelerate their elimination, thus increasing the tolerance of such species with high rates of MFO induction to withstand otherwise lethal rotenone concentrations.

Consistent with rotenone's intended use as a piscicide, it is not only expected that fish will be killed from labeled use, it is intended that fish will be killed. Fisheries managers carefully plan treatments to use the minimum amount of rotenone necessary to reduce or eliminate the target species.

<u>Amphibians</u>
Rotenone is toxic to amphibians, but generally less toxic than to fish. The toxicity of rotenone to gilled stages of amphibians, e.g., tadpoles and larval or neotenic salamanders, is approximately similar to fish and aquatic invertebrates (Fontenot et al. 1994, Turner et al. 2007). Rotenone may be absorbed into both skin and respiratory membranes, but skin may provide more of a barrier due to a greater distance across which the chemical must diffuse (Fontenot et al., 1994), and a smaller surface area relative to gill structure. Fontenot et al. (1994) reported that amphibian larvae with gills are most sensitive to rotenone. In early 1974, African clawed frogs (*Xenopus*

laevis) were discovered in some ponds located in California's Santa Clara River drainage. An eradication program using rotenone to extirpate the exotic frogs was undertaken in the spring of 1974. Results indicated that all *X. laevis* tadpoles had been killed but adults were unaffected and, thus, able to reproduce again later that spring (McCoid and Bettoli, 1996).

In standard laboratory 24-hour and 96-hour aquatic rotenone toxicity tests, the LC_{50} values for tadpoles and larval amphibians have ranged between 5 µg/L and 580 µg/L in 24-hour tests, and 25 µg/L to 500 µg/L in 96-hour tests (Fontenot et al. 1994, Chandler 1982). The adult Northern Leopard Frog demonstrated a much greater resistance with LC_{50} concentrations ranging from 240 µg/L and 1,580 µg/L (24 hours) and 240 µg/L and 920 µg/L (96 hours) (CDFG and USDA Forest Service 2007). This highlights the fact that tadpoles and other larval forms of amphibians that utilize gills for respiration may be just as sensitive to rotenone as fishes while adult forms, no longer having to utilize gills, have a much lower susceptibility to rotenone. Larval amphibians appear to have resistance roughly equivalent to the most tolerant fish species.

Because rotenone is more toxic to gilled larva than to adult amphibians, treatments have little effect on these populations when conducted in the fall, after larva have morphed into adults, or in the spring, prior to egg-laying and rearing of juvenile frogs, toads, and salamanders.

Young of the non-native bullfrog (*Rana catesbeiana)* may over-winter as juveniles. As adults, bullfrogs are serious predators on native amphibians, fish, and other wildlife. An added benefit to piscicidal rotenone treatments is realized when bullfrog tadpoles are killed, reducing their numbers the following spring.

<u>Reptiles</u>

Detailed studies of rotenone toxicity to reptiles are particularly lacking (Fontenot et al. 1994). Carr (1952) and Dundee and Rossman (1989) suggested that soft-shelled turtles (*Apalone* spp.) may be affected by rotenone applications in fisheries, although neither provided data to support their statements. The adult green anole (*Anolis carolinensis*) is the only reptile species for which pre-registration testing of chemicals, including rotenone compounds, for acute lethal toxicity has been considered (Fontenot et al. 1994). Aquatic turtle species with specialized respiratory mechanisms such as buccopharyngeal respiration (*Apalone spinifera* and *Kinosternon minor*), or modified skin and cloaca to enhance respiration (*Trachemys scripta* and *K. odoratum*), may be more susceptible to the effects of rotenone than other more terrestrial species. Turtle species in the family Kinosternidae generally possess these special respiratory systems (Fontenot et al. 1994).

A fish population study using rotenone on Lake Conroe (Montgomery County, Texas), conducted between 1980 and 1986, indicated that aquatic turtles (*K. subrubrum*) were indeed susceptible to rotenone poisoning. At least 60 dead or dying individuals were observed around the periphery of the lake 24–48 hours after treatment (McCoid and Bettoli, 1996). This is thought to be a very conservative figure however as *K. subrubrum* tends to sink when dead (McCoid and Bettoli, 1996). Freshwater aquatic snakes do not utilize aquatic respiration and absorption of rotenone through the thick skin is considered very unlikely (Fontenot et al., 1994). One study (Haque, 1971), however, reported the death of an aquatic snake in a pond 48 hours after treating with rotenone, but noted a second healthy-looking snake swimming in the same pond at the time. The mechanism of action of uptake and toxicity of rotenone to reptiles requires further study. Turtles, such as *Kinosternon* spp., using buccopharyngeal, cloacal, or dermal aquatic respiration are expected to be more susceptible to rotenone poisoning than species that do not. None of the turtles native to Washington State, all of which are in the family Emydidae, commonly use such aquatic respiration.

Rotenone treatments proposed in Washington State are not expected to adversely impact reptiles.

<u>Birds</u>

Based on the most sensitive species tested, i.e., ring-necked pheasants, rotenone is classified as slightly toxic to birds on a subacute dietary exposure basis (USEPA 2006).

Rotenone has a very low toxicity to wildfowl, and birds are extremely unlikely to be affected by normal usage in fisheries management practices (Ling, 2003). Avian acute toxicity LD_{50} values range from 130 mg/kg for the nestling English song sparrow (Cutcomp 1943) to 2200 mg/kg for an adult mallard duck (USEPA 2006). In general, young birds are about 10 times more sensitive to rotenone poisoning (CDFG and USDA Forest Service 2007) and, like mammals, birds have a much-reduced tolerance to rotenone when it is introduced intravenously. During recent rotenone treatments in California, fish-eating birds and mammals were observed foraging on dying and recently deceased fishes for several days following treatment. There were no reported sightings of dead birds or mammals over the following days and weeks (CDFG and USDA Forest Service 2007). Ling (2003) also examined rotenone poisoning and sublethal toxicity in birds as a result of consuming fish or even fish management baits. Ling concluded that "…rotenone is slightly toxic to wildfowl, and birds are extremely unlikely to be affected by normal fisheries management programmes." For example, baits used to kill carp for management purposes have around 0.01 g of rotenone each. Ling calculated that a duck would need to consume approximately 200 baits to receive a fatal dose. It is very unlikely that birds would consume baits, but they could consume fish killed by rotenone. The concentration of rotenone in poisoned fish is usually 25,000 times lower than that found in baits (CDFG and USDA Forest Service 2007).

Non-target effects of rotenone in shallow lakes and wetlands are carefully considered in lake rehabilitation planning. For example, Sprague Lake supports one of four colonies of breeding western grebes in Washington State, and impacts and benefits to their nesting success prior to the 2007 carp removal treatment were evaluated. Availability of small prey fishes is considered crucial for successful recruitment of western grebes because adults fly infrequently other than during migration. Hanson et al. (2006) report that during 2004, and following the 2003 rotenone treatment, adult western grebes returned to Lake Christina, Minnesota, but quickly abandoned traditional nesting areas and left the lake, presumably due to absence of fishes suitable as prey. By 2005, western grebes returned in large numbers and over 300 nests were identified and monitored.

This may indicate that non-target effects of rotenone on some colonial waterbirds should be expected, but are short-term in that breeding waterbird populations return in response to recruitment of prey-sized young fishes. At the concentrations of rotenone allowed in fish management projects, no effects are expected to birds from swimming in or drinking treated waters, nor by feeding on fish killed by rotenone.

Mammals

Absorption of rotenone in the stomach and intestines in mammals is relatively slow and incomplete. If absorbed, the liver effectively metabolizes rotenone to produce less toxic excretable metabolites, as shown by Ray (1991) in laboratory mammals. Approximately 20 percent of the oral dose, and probably most of the absorbed dose, is excreted within 24 hours as water-soluble products with the remainder as hydroxylated rotenoids (Fukami et al. 1969). Large oral doses (200 mg/kg in pigeons and 10 mg/kg in dogs) usually stimulate vomiting in animals (Haag 1931). Based on a review of results from these papers and others, Ling (2003) concluded that rotenone is not easily absorbed in higher animals and does not accumulate in the body. These results also indicate that rotenone is not anticipated to bioaccumulate in increasing concentrations through food web consumption of exposed animals. Even when fish are available for consumption by mammals scavenging along the shoreline for dead or dying fish, it is not likely that the mammals would be able to consume sufficient quantities of rotenone to result in acute toxicity (USEPA 2006).

Mammalian acute oral toxicity LD_{50} values for rotenone range from 39.5 mg/kg for female rats to 1,500 mg/kg for rabbits (USEPA 2006). For most lab mammals, rotenone is much more toxic when introduced intravenously or inhaled rather than taken orally. For example, the average oral LD_{50} for rats is 60 mg/kg compared with just 0.2 mg/kg for rotenone introduced directly into the bloodstream. Efficient breakdown of rotenone by the liver, oxidation of rotenone in the gut, and slow absorption in the stomach and intestines account for this significant difference in toxicity (Narongchai et al. 2005; Ling 2003). This explanation may also account for the significant difference in rotenone sensitivity between mammals and fishes, and not from a difference in the primary site of action between fishes and mammals (Fukami et al., 1969). The USEPA considers rotenone safe to use in the presence of cattle. The use of rotenone to achieve fishery management purposes, where the compound is applied directly to water, is not likely to represent a means of exposure to wild mammals or livestock relative to consumption of rotenone residues on terrestrial forage items. Additionally, formulated end products of the piscicide are roughly three times less toxic to mammals based on an acute exposure basis (USEPA 2006).

At the concentrations of rotenone allowed in fish management projects, no effects are expected to domestic or wild mammals from swimming in or drinking treated waters, nor by feeding on fish killed by rotenone.

Threatened, Endangered, and Species of Concern

The Washington Fish and Wildlife Commission adopted a policy on lake and stream rehabilitations (POL-C3010), in 2002 that explicitly recognizes treatment with rotenone as "…a valuable and cost effective management tool for providing quality fishing opportunities and protecting native fishes…". The policy further directs that all lake and stream rehabilitation projects be in accordance with state water quality requirements in WAC 173-201A; the Washington Pesticide Control Act (RCW 15.58); the State Environmental Policy Act (RCW Chapter 43.21C); the federal Clean Water Act; all chemical pesticide labeling restrictions and chemical materials safety data sheet requirements; and will avoid negative impacts to state or federally listed threatened, endangered, candidate, or sensitive species. WDFW local and regional fish, wildlife, and habitat program staff review lakes and streams proposed for chemical treatment to ensure that species listed as threatened, endangered, candidate, and species of concern are not adversely impacted. Each project proposal is also considered by the US Fish and Wildlife Service's Wildlife and Sport Fish Restoration Program under ESA Section 7 consultation to ensure compliance with federal law.

Aesthetics

Objectionable Odors and Disposal of Dead Fish

The use of rotenone and the resulting deceased fish may result in objectionable odors for persons in the vicinity of the treated water body, including agency staff and interested citizens. Odors would be short-term and temporary. The WDFW generally determines to leave dead fish in the water to provide nutrients for primary and secondary production of plankton, as this results in optimal growth of desirable fish that are stocked subsequent to chemical treatment. The agency usually offers to pick up fish carcasses from the lakeshore in areas where residents have requested this action.

Bacteria

Concerns have been expressed regarding the increase of harmful bacteria resulting from the decomposition of fish carcasses. Following a rotenone treatment, the decomposition of dead fish could potentially result in elevated bacteria levels in the water, particularly in near-shore areas. It is assumed that the majority of dead fish would sink, resulting in isolated areas of elevated bacterial levels. This impact could occur for a period of up to about three months following the treatment.

Bacterial levels vary from year to year, and may be associated with ongoing contributions from animal wastes, such as livestock and wildfowl, as well as contributions from human development, such as septic and sewerage inputs. The bacteria associated with decomposition of fish are generally not pathogenic, although it is possible that enhanced nutrient loading might temporarily elevate levels of pathogens. The mode of transmission from decay bacteria at the benthic levels of the lake or stream would generally preclude risk to humans, livestock, or pets, as contact with concentrated levels of bacteria are not likely because of the static nature of the decaying fish.

The California Department of Fish and Game found that elevated bacterial levels associated with the decomposition of dead fish are temporary and cause "less than significant adverse impacts" (CDFG and USDA 2007). This has been the experience following rotenone treatments in Washington.

Human Health

The major risks to human health from rotenone come from accidental exposure during application. This is the only time when humans are exposed to concentrations that are greater than that needed to remove fish. To prevent accidental exposure to rotenone, the Washington Departments of Agriculture and Fish and Wildlife require applicators to:

- be trained and certified to apply the pesticides
- be equipped with the proper safety gear which includes a fitted respirator, eye protection, rubberized gloves, and a hazardous material suit
- have product labels and Material Safety Data Sheets with them during use
- store or hold materials only in approved containers that are properly labeled, and
- adhere to the product label requirements for storage, handling, and application

Any threats to human health during application can be greatly reduced with proper use of safety equipment. Recreationists in the treatment areas would likely not be exposed to rotenone products. Proper warning through news releases, posting, and signing at access areas, and administrative personnel in the project area should be adequate to keep recreationists from being exposed to treated waters during application. Recreationists are rarely encountered in the treatment area during rotenone treatments.

The US Environmental Protection Agency conducted a comprehensive risk assessment for the effects of rotenone on human health. The results of all studies support the conclusion that rotenone was not genotoxic (capable of damaging genetic material), and that there was no cytotoxic (toxic to cells) effect or mutagenic (capable of causing mutations) effect to human cells (USEPA 2006a). Rotenone is currently being studied for its anticancer actions (Udeani et al. 1997; Fang and Casida 1998; Lee et al. 2005).

<u>Protection for applicators</u>

WDFW prepared a supplement to their 1992 Final Supplemental Environmental Impact Statement, Lake and Stream Rehabilitation using rotenone (WDW 1992) to review published information new since 1992 on rotenone and its human health risks related to its use in fisheries management (WDFW 2002). The following were discussed: risk of rotenone use to human health; review of safety procedures for applicators; review of an alternative application method that reduces airborne dust and applicator exposure to rotenone, and incorporation of procedural changes to meet the need to address National Pollution Discharge Elimination System permit requirements. New information about rotenone and human health was reviewed, and the document addressed a report (Betarbet et al. 2000) that indicated a possible connection between rotenone and Parkinson's disease. Contemporary information that had been reported on rotenone treatments and inert ingredients found in the liquid rotenone formulations and information on rotenone treatment impacts to groundwater were reviewed.

Review of the information showed no overall risk to human health. However, in keeping with the USEPA's 1993 changes to the rotenone product label, WDFW modified their rotenone application procedures to reduce applicator and public exposure to rotenone. Changes to reduce exposure were that the supervisor of the application project was charged with ensuring that all label requirements are followed and all safety requirements are met. The application procedure for powdered rotenone product was changed to a method pioneered by the Utah Division of Wildlife Resources (Thompson et al. 2001). Additionally, Powered Air Purifying Respirators were adopted for use by the applicator crews and support staff. Procedures were adopted in WDFW's pre-treatment process to meet National Pollution Discharge Elimination System permit requirements.

The product label states:

" . . . do not use dead fish for food or feed, do not use water treated with rotenone to irrigate crops or release within ½ mile upstream of a potable water or irrigation water intake in a standing body of water such as a lake, pond, or reservoir . . . . do not allow swimming in rotenone treated water until the application has been completed and all pesticide has been thoroughly mixed into the water according to the labeling instructions. This product is flammable and should be kept away from heat and open flame . . ."

Accidental exposure during application is the only time when humans are exposed to concentrations that are greater than that needed to remove fish. To prevent accidental exposure to rotenone, the WDFW requires applicators to be:

- trained and certified to apply the pesticide in use,
- equipped with the proper safety gear which includes an approved respirator, eye protection, rubberized gloves, Tyvek suit,
- have product labels with them during use,
- contain materials only in approved containers that are properly labeled,
- adhere to the product label requirements for storage, handling, and application

Any threats to human health during application can be greatly reduced with proper use of safety equipment.

<u>Protection for bystanders</u>
No public exposure via inhalation of either rotenone formulation is expected since the work areas where such dose pathways are possible are restricted to WDFW staff. Airborne drift into adjacent areas was found to be 1,000 times less than the "no observed effect level" of the chemical (Finlayson et al. 2000). Consequences of drift of rotenone dust do not rise to the level where adverse effects can be expected.

<u>Protection for recreationists</u>
Recreationists in the area would likely not be exposed to rotenone during the treatments. Proper warning through news releases, signing at access points, and administrative personnel in the project areas should be adequate to keep recreationists from being exposed to treated waters. Such measures have proven effective in past treatments.

No dermal exposure associated with the public boating, swimming, or wading in the treated waters is expected because the rotenone would not be concentrated enough once it has been mixed in the lake to lead to any concerns regarding dermal exposure (Finlayson et al. 2000). Rotenone product labels state that swimming would be allowed once the product has been mixed into the water (CWE Properties, Ltd. 2003, Foreign Domestic Chemicals Corporation 1997, Prentiss 1998). WDFW posts public access with warnings regarding swimming and wading during treatments, and does not apply rotenone if swimmers or waders are present. Even though diluted rotenone poses no threat to swimmers and bathers, the treated waters are posted with warning signs to inform the public that rotenone has been applied. Moreover, no member of the public is allowed to have access to the concentrated formulations at the project staging site, where there is a potential they might receive a deleterious respiratory or dermal dose.

At treatment, the take of fish is prohibited by emergency rule, news releases are provided to all local media, and access areas are posted with signs noting that the waters are closed to fishing and the removal of fish. No public exposure to contaminated fish is expected because most fish will rapidly sink, and agency biologists and enforcement staff are present to educate the public and prohibit people from removing fish. Post-treatment 'take' of fish will not be a problem because warning signs will be posted and several-day-old decaying fish will not be attractive to the public.

Due to cautionary actions taken by the WDFW in response to USEPA labeling requirements for rotenone, adherence to best management practices for applying rotenone by trained staff, and compliance with Washington pesticide rules and the conditions of the NPDES permit, exposure and risk to the recreating public will be minimal.

Surface water withdrawals

The labels for use of rotenone read: "Do not use water treated with rotenone to irrigate crops or release within 1/2 mile upstream of a potable water or irrigation water intake in a standing body of water such as a lake, pond or reservoir." Because the WDFW does not control water uses on lakes or streams that it may treat, the agency obtains letters from the holders of surface water rights which confirm that the holder of a surface water withdrawal permit agrees to not withdraw water from the water body for up to eight weeks following treatment or until notified by the department that the water is safe for use. If a holder of surface water rights does not agree to cease withdrawals of treated water, treatment with rotenone products will not commence.

Concern for wildlife, pets, and livestock

Mammalian consumption of rotenone-killed fish can be thought of as a potential for bioaccumulation. In a thorough review of the literature, empirical evidence has not been identified to suggest that birds or mammals have died or become ill after eating fish killed by rotenone treatment, or by drinking treated waters. The World Health Organization published a review of rotenone health and safety, where it was noted that pigs seem to be especially sensitive to rotenone by the oral route (Oliver and Roe 1957). A spray of 5% rotenone in water was fatal to a 100-pound pig when exposed to 250 cubic centimeters (mL) of the airborne mixture (Ray 1991). The ability of birds and mammals to effectively neutralize rotenone in the gut by enzymatic action is largely thought to prevent bioaccumulation and adverse reactions from dietary and drinking water exposure. These physiological adaptations, coupled with the minute concentrations of rotenone generally found in dead fish or treated waters, limit the extent that rotenone could be appreciably translocated through this pathway to other ecosystems to a negligible level (CDFG and USDA Forest Service 2007).

When rotenone is applied in accordance with USEPA labeling and the conditions of the NPDES permit, no impacts to wildlife, pets, or livestock are anticipated.

Rotenone and Parkinson's Disease

Parkinson's disease results in a lost function of the brain cells that produce dopamine, used to transmit signals in the brain. Symptoms of the disease usually include limb tremors and occasional rigidity. The causes of Parkinson's disease are diverse and complex. Some cases can be attributed to genetic factors, and several mutations have led to familial Parkinson's disease (Giasson and Lee 2000). Researchers at Emory University in Atlanta, Georgia, conducted a study that demonstrated that rotenone produced Parkinson's-like anatomical, neurochemical, and behavioral symptoms in laboratory rats when administered chronically and intravenously (Betarbet et al. 2000). In this study, 25 rats were continuously exposed for 5 weeks to 2 to 3 mg rotenone dissolved in dimethyl sulfoxide (DMSO) and polyethylene glycol (PEG) per kg body weight per day. The exposure was accomplished by injecting the mixture directly into the right jugular vein of the rats using an osmotic pump. Twelve of the 25 rats developed lesions characteristic of Parkinson's disease. Structures similar to Lewy bodies (microscopic protein deposits) in the neurons of the substantia nigra in the brain (characteristic of Parkinson's disease) were produced in several of the rotenone-exposed rats. Further research implies that mitochondrial dysfunction and oxidative stress could link environmental and genetic forms of the disease (Betarbet et al. 2006), and suggested that further study is warranted into environmental agents that inhibit complex I for their potential role in Parkinson's disease (Sherer et al. 2007).

The Fish Management Chemicals Subcommittee Task Force on Fishery Chemicals of the American Fisheries Society believes that the reported findings of a relationship between Parkinson's disease and rotenone in the Emory University study (Betarbet et al. 2000) do not suggest a need for additional precautions with respect to current uses of rotenone (AFS 2001). Neither studies conducted for the U.S. Environmental Protection Agency, nor the use of rotenone for many decades, have indicated any associations with Parkinson's disease. The AFS stated that Betarbet et al.'s (2000) report generated unfounded fears, caused by the inaccurate and incomplete reporting of the study and its implications. In fact, Betarbet et al. (2000) concluded that their findings do not show that exposure to rotenone has caused Parkinson's disease. They stated further: "rotenone seems to have little toxicity when administered orally".

The manner that rotenone was administered to the laboratory rats was highly artificial. Not only was it administered by continuous jugular vein infusion, it was mixed with dimethyl sulfoxide (DMSO) and polyethylene glycol. DMSO enhances tissue penetration of many chemicals. The normal exposure to rotenone in humans from its use in fisheries management would be ingestion, inhalation or through the skin. Direct injection is the fastest way to deliver chemicals to the body, as evidenced in intravenous application of medicines. Continuous intravenous injection, as done in this study, also leads to continuously high levels of the chemical in the bloodstream. Normal ingestion, inhalation, and dermal exposures substantially slow down the introduction of chemicals into the bloodstream. Administering any chemical directly into living tissues can have grave consequences. For example, sodium chloride (table salt) administered to developing chick embryos causes birth defects (Dr. P. Kurtz, M.D., California Department of Food and Agriculture, personal communication *in* AFS 2001). However, this model has no practical predictive value for humans ingesting salt. Similarly, penicillin injected into the brain of cats induces seizures, but this does not suggest that ingestion will cause similar effects in humans.

Likewise, the method of exposure in the Emory University studies (Betarbet et al. 2000, Greenamyre et al. 2003) cannot be used as a model for any form of rotenone exposure in fisheries management. Rotenone exposure in the environment is extremely limited. Rotenone is very unstable in the environment (half-life measured in days), is oxidized (neutralized) through enzymatic action in the gut of mammals and birds, is metabolized to very polar (water soluble) compounds in the body, and these compounds are excreted by the liver and kidney (Finlayson et al. 2000). Because of the rapid metabolism and clearance in mammals and birds, it is not likely that rotenone could reach the site of action in the substantia nigra in the brain where the dopamine is formed. Rotenone is toxic to fish because it is taken up rapidly across the gills and gets directly into the bloodstream, thus, bypassing the gut. Rotenone is considered safe for the environment because it loses all its toxicity in a few days. In fact, the Emory University investigators could not administer rotenone in any other manner except intravenously with solvents to achieve delivery of rotenone to the brain; otherwise, rotenone would have been neutralized in the gut and liver.

Exposure to applicators applying rotenone in fisheries management is further minimized through the use of protective equipment such as air-purifying respirators, protective clothing (coveralls, gloves), and eye protection (splash goggles or face shields) that are required on the product labels (Finlayson et al. 2000). Specific information on proper handling procedures and protective equipment are found on rotenone labels.

The results from a chronic feeding study with rats using rotenone found no Parkinson's-like anatomical or behavioral symptoms (Marking 1988). In this 24-month chronic feeding study, rotenone was orally administered to 320 rats in doses up to 75 mg/kg per day. All animals were sacrificed and tissues and organs of all test animals were examined macroscopically and microscopically. The brain was sectioned, and microscopic examinations of the basal ganglia, frontal cortex, occipital cortex, thalamus, and cerebellum were completed. No changes were observed in the brain of these rotenone-exposed rats. These rats were exposed to up 30 times more rotenone (2.5 versus 75 mg/kg/day) for 21 times longer (5 versus 104 weeks) than the rats used in the Emory University study. However, these rats were exposed to rotenone by ingestion, a route through which people could be exposed to rotenone.

Several researchers in Parkinson's disease (including J. Langston, Director of the Parkinson's Institute) have stated that the study is not direct evidence that rotenone causes Parkinson's disease. The U.S. Environmental Protection Agency has known for some time of the effects of rotenone on the nervous system when injected directly into animals. In 1993, the U.S. Environmental Protection Agency published the Worker Protection Standard Handbook that listed all the known effects of pesticides and necessary steps for treating pesticide poisoning (Pesticide Regulation Notice 93-7). In the Biologicals section of the handbook the following statement is made, "When rotenone has been injected into animals, tremors, vomiting, incoordination, convulsions, and respiratory arrest have been observed. These effects have not been reported in occupationally exposed humans." Thus, the effects of rotenone injected directly into animals were known before the study done at Emory University. The true value of the study is in developing a model of Parkinson's disease so researchers will have a better method to study the cellular defects associated with Parkinson's disease, not in discovering the cause(s) of Parkinson's disease.

Dr. Joseph Borzelleca of the Virginia Commonwealth University Department of Pharmacology and Toxicology critically reviewed the Emory University study to determine its relevance for humans. Dr. Borzelleca writes in response to Dr. Greenamyre's quoted comment (Adam 2000) that "Marking (1988) administered rotenone in the diet to male and female rats (320) for 24 months (lifetime for rats) at doses up to 75-mg/kg-body weight/day. At the end of the study, all surviving rats were sacrificed and autopsied and all tissues and organs were examined grossly and microscopically. Several dozen tissue sections per animal were examined including all areas of the brain. There were no changes to the brains of the rats that had eaten rotenone daily for two years. This (Marking's) study is relevant for human exposure because entry into the body was with food (simulates the human condition). The doses in this study were about 30 times greater (2.5 versus 75 mg/kg-body weight/day) and the exposure was much longer (5 versus 104 weeks) than in the Greenamyre study. It is also important to note that the rats did not develop any signs of Parkinson's disease during the course of the study" (Borzelleca 2001).

Rojo et al. (2007) found that mice and rats subjected to chronic inhalation of rotenone were asymptomatic for Parkinson's disease, and the amount of rotenone that might reach the brain through the nasal route appears to be insufficient to produce a significant neuron loss. A review of the published data since the initial study by Betarbet et al. (2000) suggests that Rotenone-treated rats model atypical Parkinsonism rather than idiopathic Parkinson's disease, and that such studies are not applicable to the application of piscicidal rotenone (Höglinger et al. 2006).

The WDFW addressed the potential effects of rotenone, relative to Parkinson's Disease and other effects, during exposure by agency staff during mixing, loading, and application of rotenone formulations during lake and stream treatments (WDFW 2002). Detailed review of new information on rotenone use as a piscicide showed that the Parkinson's disease connection was not a concern when applicators used appropriate personal protective equipment, nor was its use a public health concern.

There is no evidence to suggest that rotenone use during piscicidal treatments has an adverse impact to human health, when used according to USEPA label directions.

Other Issues

Inert Ingredients Used with Rotenone

Chemical manufacturers often add other ingredients to their formulations, called inert ingredients, to enhance effectiveness. The powdered formulation that would be applied to the lake or stream has no added inert ingredients; it is composed simply of the ground up plant material. The liquid formulations contain inert emulsifiers, solvents, and/or carriers that are important in ensuring the solubility and dispersion of this liquid formulation.

While CFT Legumine® and the PrenFish® and NoxFish® formulations contain the same concentration of rotenone (5%), the concentrations and types of dispersant and carrier compounds in the two formulations differ substantially.

The two primary inactive carrier components in CFT Legumine® are 1-methyl-2-pyrrolidinone and diethylene glycol monoethyl ether, which comprise approximately 93% of the formulation by weight of the constituents that were identified in the analysis conducted by the CDFG (CDFG and USDA Forest Service 2007). Both of these chemicals are infinitely soluble in water, meaning they will remain in the water column and will not tend to adsorb to sediment particulates (NLM, 2006). These chemicals will not readily volatilize from surface water, and neither chemical is expected to undergo hydrolysis or direct photolysis (NLM, 2006). Aerobic biodegradation is expected to be the most important mechanism for the removal of 1-methyl-2-pyrrolidinone and diethylene glycol monoethyl ether from aquatic systems (NLM 2006). The small amount of these chemicals that may volatilize into ambient air will be readily degraded by reaction with photochemically-produced hydroxyl radicals, with an atmospheric half-life of up to 12 hours (NLM 2006). The remaining carrier chemicals include the polycyclic aromatic hydrocarbons (PAH) naphthalene and methylnaphthalene and a few alkylated benzenes. While these chemicals are more volatile than the primary carriers, they comprise less than one percent of the formulation and are not expected to significantly impact the overall fate and transport of CFT Legumine.

Water treated with Prenfish®, Noxfish®, and similar formulations using volatile and semi-volatile organic compounds as the carrier, was found to contain rotenolone, and volatile organic compounds (trichloroethylene, xylene, toluene, and trimethylbenzene) and semi-volatile organic compounds (naphthalene, 1-methyl naphthalene, and 2-methyl naphthalene). These volatile and semi-volatile organic compounds naturally breakdown and dissipate in treated water before rotenone and rotenolone (Finlayson et al. 2000).

Five California rotenone projects treated with Noxfish® were monitored for the fate of the compounds of powdered and liquid formulations including inerts in sediments (Finlayson et al, 2001). Only the naphthalene and methyl naphthalene (associated with Noxfish®) temporarily accumulated in sediments, but this was for a period of less than 8 weeks. The other inert compounds in Noxfish® did not persist in sediments.

Nine California rotenone projects were monitored for the inert ingredients in Noxfish® in surface water (Finlayson et al, 2001). All ingredients were well below the minimum concentrations allowed under maximum contaminant levels (MCLs) for these ingredients in drinking water standards set by the EPA (Finlayson, 2001). Of the seven organic compounds found in Noxfish, trichloroethylene (TCE) is the only carcinogen; the rest are not considered carcinogenic. However, there are inconsistencies in the scientific literature regarding whether naphthalene is carcinogenic. Naphthalene was reported in one source as causing carcinogenic activity in rat nose tissue in an inhalation study (US National Toxicology Program, 2001). The bulk of the toxicology literature however, indicates that naphthalene is not carcinogenic.

Following application of Noxfish®, samples collected during application into flowing water did not detect TCE (<0.5 µg/L) or xylene (<0.5 µg/L) except for one sample collected immediately below a drip station at 0.76 µg/L TCE and 0.56 µg/L xylene. Naphthalene and 2-methylnaphthalene were detected at concentrations ranges of <0.5 to 57 µg/L and <2 to 50 µg/L.

The USEPA has established drinking water standards for levels of rotenone and associated chemicals. The following table displays the available human health standards set by the EPA for rotenone and other associated chemicals. Based on analysis by the USEPA, and by the Washington Department of Ecology when issuing the NPDES permit to WDFW, we believe that the risk to ecological and human health from inert ingredients in the rotenone formulations is low.

Table 2. Human Health Standards, Risk-based Safe Levels, and Detection Limits for Rotenone and Other Associated Ingredients in Drinking Water. (USDA Forest Service 2004)

Fish Toxicant Ingredients	Maximum Contaminant Level (µg/L)	Maximum Contaminant Level Goal[1] (µg/L)	Preliminary Remediation Goal[2] (µg/L)	Analytical Detection Limit (µg/L)	Analytical Method
Rotenone	Not Available	Not Available	150	50	SDWA EPA Method 553 (HPLC)
Naphthalene	Not Available	Not Available	6.2	0.5	SWDA EPA Method 524.5
Toluene	1,000	1,000	720	0.5	SWDA EPA Method 524.5
Trichloroethylene	5	Zero	0.028	0.006[3]	USEPA 8260 Mod SIM
Trimethylbenzene	Not Available	Not Available	Not Available	0.5	SWDA EPA Method 524.5
Xylene	10,000	10,000	210	0.1	USEPA 8260 Mod SIM

NOTES:
1. USEPA 2002b Based on safe drinking water standards.
2. USEPA 2002a Based on safe risk-based levels for residential tap water use
3. Value provided is the MDL instead of the reporting limit. The reporting limit for TCE is 0.05 µg/L using EPA Method 8260 Mod GCMS-SIM.

MCL – maximum contaminate level. The highest level of a chemical allowed in drinking water. It is an enforceable level under the Safe Drinking Water Act.
PRG - preliminary remedial goal. The level of a chemical in drinking water that is not expected to cause any adverse effects for a lifetime of exposure. Lifetime exposure is based on 30 years of exposure for a child and adult drinking 1 and 2 liters, respectively.
Analytical Detection Limit. The level at which a chemical can be accurately and precisely quantified by a certain method.
SWDA – Safe Drinking Water Act. Gives EPA the authority to set drinking water standards. Used in the context of analytical methods developed under the SWDA program for monitoring water quality.
RCRA - Resource Conservation and Recovery Act. Used in the context of analytical methods developed under the RCRA program for monitoring water quality.

Metabolites of Rotenone

The possible metabolites of rotenone are carbon dioxide and a more water-soluble compound (rotenolone) that, if ingested, is excreted in the urine. Studies indicate that approximately 20 percent of applied oral doses are eliminated from the animals system within 24 hours (Fukami et al. 1969). The potential effects of rotenone metabolites are much lower than from rotenone itself, and do not rise to a level of concern.

Use of potassium permanganate as a neutralizing agent

Potassium permanganate is a neutralizing agent that is transported with rotenone and stored on site as a precautionary measure. It has no deleterious effects at the concentrations normally associated with the neutralizing process (Finlayson et al, 2000). However, in its concentrated form, it is caustic to mucous membranes in the nose and throat. The required protective clothing and breathing apparatus for applicators handling the concentrated powder would minimize human health risks. This neutralizing agent is commonly transported and stored with rotenone as a precautionary measure in case rotenone is spilled or otherwise escapes into non-target water bodies.

Use of potassium permanganate is uncommon with WDFW lake and stream rehabilitation projects, but would be necessary in the event that flow from a treated water body could not be contained within the treatment area, or in case of accidental spills of rotenone. Effects from the use of potassium permanganate would be localized, and mitigated by the use of personal protective equipment by applicators.

Use of treated fish as food or feed

Historically, WDFW allowed members of the public to keep fish that were killed during rotenone treatments. However, current USEPA label restrictions prohibit the use of dead fish for food or animal feed, because no FDA/EPA tolerances for rotenone in the human diet have been established. Because all label directions are followed, there will be no allowed human consumption of treated fish.

Indigenous peoples of Southeast Asia and South America have used ground *Derris* and *Lonchocarpus* root containing rotenone for centuries to harvest fish for human consumption (Ling 2003). This was still commonly practiced as recently as 1990 in Papua New Guinea (Dudgeon 1990). Only about a quarter of the total body burden of rotenone in poisoned fish is found in the filet, with most of the chemical accumulating in the head, bones, skin, and liver (Rach and Gingerich 1986). Concentrations of rotenone in fish filets are generally below 1 ppm, whereas the level considered safe for human consumption has been estimated at 10 ppm (Lehman 1950, Turner et al. 2007).

Because fish that are desired for human consumption , such as trout and salmon, are considerably more susceptible to rotenone than less valued species such as goldfish, carp and catfish, rotenone residues in the former will be relatively low. On the basis of measured concentrations of rotenone in fatally poisoned carp filets, and assuming that all rotenone in the meal were absorbed, an adult human would need to eat approximately 10 tonnes of fish in one sitting to receive a fatal dose. Following fisheries management treatments in North America, poisoned fish had often been given to community groups for human consumption (Bettoli and Maceina 1996). Given that rotenone is thermally labile, any residue is likely to be destroyed during cooking.

The greatest risk for humans and wildlife in eating rotenone-poisoned fish is from bacterial spoilage. WDFW treatment programs provide adequate personnel and equipment to enable effective collection and safe disposal of dead fish as well as providing notice to the public that rotenone-killed fish should not be consumed.

It would be extremely unlikely that members of the public would have access to dead or dying fish to unwittingly consume any contaminated fish and receive a dose of the fish toxicant. This is because the take of fish is prohibited by WDFW emergency rule during the treatment period. Public awareness of the closure would be heightened well in advance of the treatment through news releases and posted signage throughout the area. Since the fish in treated lakes and streams are rapidly killed by the treatment, there would be no lingering danger of anglers ignoring the warnings and potentially angling and consuming fish. The large number of carcasses would be further disincentive for human consumption. No fish would be restocked into treated waters until well after rotenone residues have dissipated.

Current labels prohibit the use of dead fish for food or animal feed. If label directions and agency precautions are followed, there will be no human consumption of treated fish.

<u>Loss of fishing opportunity until fisheries are restored</u>
It is expected that fishing opportunity will be lost in waters treated with rotenone, until populations of desirable game fish have been restored. The management and pre-treatment plans for waters proposed for rehabilitation define the management objectives in terms of fishery type, angler use, stocking objectives, and management strategies. WDFW reintroduces catchable-sized game fish, fingerlings or fry to the treated waters after the rotenone has degraded and lost its toxicity, and after zooplankton populations have recovered to the point where they can support a population of predating fish. Although fishing opportunity may be lost for a short period, the reason that the water was selected for treatment was because of the degradation of the fishery due to imbalanced fish species and populations. Restocking with appropriate sport fish species following lake and stream rehabilitation results in improved recreational angling benefits to local anglers and to those who travel from throughout Washington State to fish in waters improved by rotenone treatments and subsequent fish stocking. No tribal subsistence fisheries are affected by treatment projects.

<u>Administration of WDFW's lake and stream rehabilitation program</u>
WDFW carries out an extensive internal review process of all project proposals and takes any that pass muster to external review through State Environmental Policy Act review (as previously described). In addition, WDFW and federal biologists jointly meet environmental compliance review requirements in federal law (primarily the Endangered Species Act and National Environmental Policy Act). Adoption of one of the action alternatives proposed in this environmental assessment will both strengthen the analyses for compliance with NEPA and save state and federal staff time in making those analyses. Time savings translate directly to cost savings, allowing more of the funds granted by the USFWS to be spent on carrying out projects and less to be spent on administrative tasks.

5.0 Cumulative effects

Cumulative Effects to Human Health with All Alternatives Using Rotenone

On average, WDFW has treated about 10 lakes (range 6-21) per year since inception of their F-125-D federal assistance grant. Eastern Washington contains about 3,000 lakes that provide angling and could be candidates for the application of rotenone. Clearly, both the annual increment and collective total treated during the life of this grant are small in comparison to the universe of waters managed for angling in that area. The cumulative environmental effects, fish management benefits, and human health implications of grant-funded rotenone application reflect the same general relationship.

Potential cumulative environmental effects of rotenone use are limited by the small number of waters treated in any year, and also by the explicit annual administrative safeguards that are built into WDFW's internal screening of candidate waters and comprehensive discussion in the State Environmental Policy Act public disclosure and review process, and in federal review of all projects for Endangered Species Act and NEPA determinations. No projects are taken to the WDFW director for final approval without all of these steps being completed with positive outcomes.

Fisheries and fishery management are dynamic; management is largely reactive to the condition of fisheries and public expectations, bounded by a variety of biological and other constraints. WDFW's use of rotenone is in response to fish community dynamics that result in unmet angling potential: typically overpopulation and stunting, loss of game fish survival and growth due to competition with other species, or other ecological imbalances. While WDFW treats a small number of ponds and lake each year to restore angling quality, fish community changes are constantly in progress in the untreated waters. Some of those develop conditions that warrant rotenone application, as the agency treats others. In the synoptic view, grant-funded rotenone application benefits fish management in the waters treated waters, but most waters are not treated due to available funding, physical constraints, or other reasons. The baseline of recently treated waters, waters under successful management, and potential candidates for treatment changes little from year to year.

Humans apply rotenone, and humans live near some of the treatment sites. As with other potential non-target effects, each treatment presents very small and controlled risk of human exposure. The safeguards for both applicators and persons not associated with treatment reduce the site-specific risk of exposure to almost none. Only the applicators are likely to be in the proximity of more than one treatment project, and they are protected by mandatory training, agency prescribed procedures and mandatory protective apparel and gear. No cumulative human health effects can be expected.

No aspect of these projects releases greenhouse gases or in any other way contributes to global climate change. In the long term climate change that leads to increased temperatures, changes in the timing and amount of precipitation, or increased water temperatures could affect the selection of waters to treat. None of those conditions is predictable in the near term.

WDFW is the sole user of rotenone for fish management in the State of Washington. The Washington Department of Ecology has issued NPDES/Waste Discharge Individual Permit No. WA0041009 to WDFW for the use of rotenone and antimycin in fishery resource management, and does not issue permits to any other individuals for such use. The role of WDFW as the primary manager of fish and wildlife in Washington, and as the sole user of piscicidal chemicals, allows the agency to strictly and carefully review, apply, and monitor the effects and benefits of rotenone treatments in the State. This ensures that no adverse cumulative effects will occur.

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Nature Conservancy
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Washington Environmental Council
1402 Third Avenue, Suite 1400
Seattle, WA 98101

Washington Wildlife Federation
PO Box 1656
Bellevue, WA 98009-1656

WA DEPT OF NATURAL RESOURCES
ATTN: AQUATICS
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9.0 List of All Federal Permits

NPDES/Waste Discharge Individual Permit No. WA0041009 issued by the Washington Department of Ecology in conformance with the state Water Pollution Control Law (Chapter 90.48 of the Revised Code of Washington) and as authorized by the U.S. EPA acting under the federal Clean Water Act. All treatments using rotenone will be conducted under the provisions and conditions of this permit, and any renewed permits from the Washington Department of Ecology.

APPENDIX I
FORMULATIONS OF ROTENONE

Powdered Rotenone

The powdered form of the piscicide rotenone (produced from the dried and ground roots of tropical legumes such as *Derris* spp. and *Lonchocarpus* spp.) is a proven and feasible method for eradicating fish in standing water. Powdered rotenone can have limited effectiveness in moving water such as streams and creeks. Registered for use as a piscicide with the USEPA and the Washington Department of Agriculture, powdered rotenone has undergone extensive laboratory and field-testing and has explicit directions for use. If used according to label instructions, the United States Environmental Protection Agency has determined the product safe for workers and the general public. Powdered rotenone is extremely toxic to organisms that obtain oxygen through the gills. It readily biodegrades in water via oxidation and in light via photolysis.

The inert ingredients in the powdered ('cube root') rotenone product are plant fiber from the root of the plants ground up to produce the product. The plant fiber constitutes approximately 81.5% of the powder form of rotenone while approximately 11.1% is associated with plant resins and approximately 7.4% is active rotenone, depending on the final assay of each lot of product (WDFW 2002). Because of the low application rates required for rotenone used in fisheries management, the entire plant root is ground up and packaged rather than extracting and/or concentrating the active chemical rotenone from the ground up roots.

An aspirator was developed by the Utah Division of Wildlife Resources to mix rotenone slurry used to eradicate undesirable fish species in 1990 (Thompson et al. 2001). The system uses a high-pressure pump that forces water through the aspirator, creating suction used to vacuum powdered rotenone from bulk bags. The powder and water combine inside the aspirator chamber, forming a slurry. The slurry is discharged directly on to the water's surface from the aspirator nozzle. Rotenone loss in the form of dust is significantly reduced compared to other mixing techniques, and there is limited exposure of the chemical to personnel. One person can operate the aspirator efficiently.

Liquid Rotenone

Standard liquid formulations of rotenone (for example, Prenfish®, Noxfish®, CFT Legumine®) are a proven and feasible method for eradicating fish in both standing and flowing water. Registered for use as a piscicide with the USEPA and the Washington Department of Agriculture, the Prenfish® and Noxfish® formulations have undergone extensive laboratory and field-testing and have explicit directions for use. The formulation consists of rotenone extract dissolved into solvents and emulsifiers, which help mix the product into water.

According to the Prenfish® and Noxfish® labels, these product contain aromatic hydrocarbons as part of the solvent system. By definition, aromatic hydrocarbons are volatile and do not remain in water for long. These compounds, particularly naphthalene, have a strong odor.

Some rotenone formulations use a smaller amount of rotenone with a pesticide synergist, piperonyl butoxide. The piperonyl butoxide is far less toxic than rotenone, but makes the rotenone more effective so that less rotenone is needed to get the same effect. During field treatments in California (Lake Davis was treated with Nusyn-Noxfish® in 1997), this compound did not biodegrade as readily as the other compounds. It was detected at the part per billion levels in the deepest sampling station in the lake for about seven months following the treatment. The synergized formulations of rotenone are slightly cheaper, but are infrequently used by WDFW because of inconsistent results experienced in the past.

With the exception of the synergist piperonyl butoxide, rotenone is the most persistent chemical in the synergized liquid formulation. Rotenone itself readily decomposes in water (oxidation) and light (photolysis). Standard formulated rotenone may contain other ingredients that are proprietary information and therefore not listed on the label. All ingredients, however, were disclosed to the USEPA and taken into consideration when the product was registered.

An alternative 5% rotenone formulation, CFT Legumine®, has been recently tested and registered for use as a piscicide by the EPA and the Washington Department of Agriculture. Its safety and effectiveness has been demonstrated in laboratory and in the field. This formulation uses diethylene glycol ethyl ether, 1-methyl-2-pyrollidone and a fatty acid ester to improve the rotenone's ability to dissolve into water. As with the traditional formulations of rotenone, the solvents and emulsifiers break down rapidly. The product has a faint odor. During monitoring of field trials in the United States, rotenone was the most persistent chemical in the formulation.

Carrier Compounds in liquid formulations

The California Department of Fish and Game (CDFG) analyzed CFT Legumine and a standard liquid formulation (Noxfish®) prior to the 2007 treatment of Lake Davis. While the CFT Legumine® and NoxFish® formulations contain the same concentration of rotenone (5%), the concentrations and types of dispersant and carrier compounds in the two formulations differ substantially.

The two primary inactive carrier components in CFT Legumine® are 1-methyl-2-pyrrolidinone and diethylene glycol monoethyl ether, which comprise approximately 93% of the formulation by weight of the constituents that were identified in the analysis conducted by the CDFG (CDFG and USDA Forest Service 2007). Both of these chemicals are infinitely soluble in water and have an estimated organic carbon partition coefficient (i.e., the "Koc") of 12, indicating that they will remain in the water column and will not tend to adsorb to sediment particulates (NLM, 2006). Based on their low Henry's Law constants, these chemicals will not readily volatilize from surface water, and neither chemical is expected to undergo hydrolysis or direct photolysis (NLM, 2006). Aerobic biodegradation is expected to be the most important mechanism for the removal of 1-methyl-2-pyrrolidinone and diethylene glycol monoethyl ether from aquatic systems (NLM 2006). The small amount of these chemicals that may volatilize into ambient air will be readily degraded by reaction with photochemically-produced hydroxyl radicals, with an atmospheric half-life of up to 12 hours (NLM 2006). The remaining carrier chemicals include the polycyclic aromatic hydrocarbons (PAH) naphthalene and methylnaphthalene and a few alkylated benzenes. While these chemicals are more volatile than the primary carriers, they comprise less than one percent of the formulation and are not expected to significantly impact the overall fate and transport of CFT Legumine.

In contrast to CFT Legumine, the inert and carrier chemicals for standard liquid rotenone formulations, such as Prenfish® and Noxfish®, consist of the PAH naphthalene, numerous alkylated benzenes, and trichloroethene. These chemicals are moderately soluble in water, with aqueous solubilities ranging from 14 to 1,100 mg/L (NLM, 2006). Koc values range from 94 to 3,200 L/kg, suggesting that these chemicals may also tend to adsorb to sediment particulates, thus increasing their half-lives in natural water bodies (NLM, 2006). The half-lives for these chemicals in surface water bodies range from several hours to several months, depending on the characteristics of the water body (i.e., temperature, flow velocity, agitation, etc.), as well as the amount of sunlight on the water surface. With Henry's Law constants ranging from 0.00048 to 0.15 atm-m3/mol, the primary removal mechanism from surface water for these carrier chemicals is volatilization, with direct photooxidation, hydrolysis and biodegradation contributing to a much smaller degree. Once in the ambient air, chemical vapors are readily degraded by reaction with photochemically produced hydroxyl radicals. The chemical-specific half-lives for this reaction in air range from a few hours to a few days (NLM, 2006). Of particular note is naphthalene, which comprises slightly less than 50% of the NoxFish formulation by weight of the constituents identified in the analysis provided in CDFG and USDA Forest Service (2007). This PAH, which gives moth balls their distinctive odor, has an odor threshold in air of 0.084 ppm, or 0.44 mg/m3.

Prior to breakdown of these inert ingredients in Prenfish or Noxfish, there is a potential of an effect from these compounds from the liquid rotenone formulation. Finlayson (2000) reported that concentrations of these compounds in water immediately following treatments using Noxfish were low and presented no health risks. The likelihood of additive effects is very low. If they do occur it would last a short time over a few weeks, because trichloroethylene, naphthalene, and xylene all break down within about three weeks time (Table I-1). Those most at risk of an adverse effect would be the application workers involved in dispensing rotenone product; however, risks to the applicators are mitigated through the use of protective equipment and training, as addressed in the SEIS regarding rotenone use and health risks (WDFW 2002).

Table I-1. Persistence of rotenone and other organic compounds in water and sediment impoundments treated with 2 mg/L rotenone formulation (Source: Finlayson et al. 2000, p. 192-193).

Compound	Initial water concentration (µg/L)	Water persistence	Initial sediment concentration (µg/L)	Sediment persistence
Rotenone	50	<8 weeks	522	<8 weeks
Trichloroethylene	1.4	<2 weeks	ND*	
Xylene	3.4	<2 weeks	ND	
Trimethylbenzene	0.68	<2 weeks	ND	
Naphthalene	140	<2 weeks	146	<8 weeks
1-m-naphthalene	150	<3 weeks	150	<4 weeks
2-m-naphthalene	340	<3 weeks	310	<4 weeks
Toluene	1.2	<2 weeks	ND	

*ND = Below detection limit

APPENDIX II
WDFW DECISIONAL PROCESS FOR LAKE AND STREAM REHABILIATION PROJECTS

Where game fish populations are not self-sustaining, the WDFW stocks fry, fingerlings, or catchable-sized fish from hatcheries. In lakes that become unproductive, or that have populations of introduced competing or predaceous species, WDFW stocks “catchable-sized” fish (often, trout greater than 6 inches in length), because fish of that size are not as susceptible to predation by, and the effects of competition with, the other fish species.

A number of lakes are managed specifically for trout fisheries, because they are productive and capable of growing fingerling trout to harvestable size in numbers that provide a satisfactory fishery for the angler. The difference in costs for stocking catchable-sized trout, rather than fingerlings, into “mixed-species” waters is substantial and consequential to WDFW’s fish management. Recent cost per pound for growing trout is approximately $1.80. Therefore, to rear trout to between 3 and 4 fish to the pound costs from 45 to 60 cents each to raise a fish to catchable size. It costs 1 to 3 cents apiece to raise trout to release as fry at a size of 2.5 to 3.5 inches in length. Optimistic estimates of survival of 4-6 inch advanced fry in larger mixed species waters range from 10-20 percent. Spring fry survival in lakes free of competing species ranges from 50-80 percent.

Native species, such as sculpins, shiners, dace, and pikeminnow, are often found in lakes managed for trout. In addition, non-native game fish species, such as bass, perch, sunfish, and catfish, are often illegally introduced by anglers, or invade these waters during high-water events. Other non-native species, such as carp, tench, goldfish, and fathead minnows, may likewise enter these lakes via connected waterways or illegal introductions.

In waters designated for trout, warmwater, or mixed-species management, existing populations of fish may likewise become imbalanced, potentially resulting in stunted individual fish with little value to the angler.

When predation and competition result in diminished fish quality or survival, and in lower harvests, WDFW assesses options for managing the water body. The several management options are:

> <u>Take no action</u>. Fry and fingerlings planted in the lake or stream would fail to survive to harvest, or would have reduced growth rates and survival. Stocking of fry and fingerlings would be discontinued because survival to catchable size would be insufficient to provide a viable fishery. Large populations of warmwater species often result in water bodies with stunted fish that are undesirable to the sport angler. Those populations that have reduced catch rates, due to increasing abundance of warmwater or other undesirable species, likewise do not support viable fisheries.
>
> <u>Stock the lake with catchable-sized fish</u>. This option allows for a viable fishery despite the presence of competing or predaceous species. The cost of producing catchable fish is considerably higher, and the quality of the catchable-sized fish is considered lower than that of a naturally reared, “fry-origin” fish. Due to additional rearing costs, fewer fish would be available to the angler. The capacity of the WDFW hatchery system is finite and could not provide sufficient numbers of catchable fish to maintain the current trout fisheries in the absence of viable fry or fingerling plants.
>
> <u>Manage trout lakes for warm water species</u>. Between 25% and 30% of lowland lakes already contain warmwater species. This option reduces the opportunity for anglers to fish for the preferred trout species, and expands the presence and numbers of these exotic species in the State.
>
> <u>Modify, Eliminate, or Reduce the fish populations</u>. This option allows for favorable survival and growth of the preferred species, and is the favored option for managing the fisheries.

Several methods of changing numbers of fish in lakes and streams are considered when this option is chosen. Fishery biologists may attempt to alter the species numbers and composition through angling regulation changes, through mechanical means, or through chemical treatment.

Modification of angling regulations to address low fish survival and growth in the presence of competing or predatory species. Advantages of this method are that it is low in cost, acceptable to the public, and the fish can be used as food. Limitations are that even successful regulation changes take years to achieve favorable results. Often, because fishing success is poor in compromised waters, the angler effort in a compromised lake is insufficient to effect population changes. Furthermore, many species of undesirable fish cannot readily be caught by angling.

Mechanical removal through netting, trapping or electrofishing. While generally acceptable to the public, these methods require very high exploitation rates to be effective. The effort involved is expensive and labor-intensive. Any benefits are of short duration, as escapement of target fish results in juveniles and other fish filling the niches of the fish that are removed.

Biological control. Although this is a low-cost alternative, it has been found that maintaining the elevated population numbers of predators necessary to control undesirable species will generally result in the unwanted control of desirable species as well. Maintaining predator populations at lower numbers has not resulted in achieving predictable success in controlling fish populations.

Dewatering of reservoirs, lakes or streams. This method can be used in a limited number of instances. In almost all cases, legal rights to use the water (hence, to dewater a basin or stream reach) are held by persons, tribes, or agencies other than WDFW who are unlikely to agree to the loss of their water. Regardless of legal ownership of the water, dewatering often has illegal or otherwise unacceptable environmental consequences. It is the only control method, except for piscicides, with potential to completely eradicate fish populations.

Altering water quality parameters. Methods such as injection of CO_2 to raise water acidity, inhibiting fish growth and reproduction, or the introduction of large amounts of nutrients in the form of sugar and alcohol to dramatically increase the biological oxygen demand of the water, have been suggested as alternative methods to reduce the occurrence of algae blooms resulting from excessive numbers of forage fish. These methodologies lack adequate laboratory testing on their effectiveness, feasibility, or environmental safety. Field trials, or a proven track record of successful use, are not available for the assessment of these methods.

Fish barriers. Well-maintained upstream barriers may have long-term advantages. This method is less effective under flood conditions, is ineffective against downstream migrations of fish and illegal plantings, and is costly to maintain.

Use of explosives. This method may be effective in small areas. However, it is hazardous to humans and non-target organisms, harmful to physical habitats, and is generally not effective at eliminating entire fish populations.

The use of piscicides

Ling (2003) noted that, other than complete and prolonged dewatering, toxicants are the only method that is likely to effectively reduce or completely eliminate undesirable fish in a body of water. Although the persistent application of traditional fishing methods can reduce populations to manageable levels in the short term, continually fishing any commercially undesirable species cannot repay project costs through sale of the fish caught, and is economically unsustainable. Complete elimination of any species by fishing or trapping is unlikely given the exponential increase in effort required as catch-per-unit-effort declines.

The use of rotenone to remove fish from the lake or stream, and subsequent restocking with desirable species has been shown to be a safe, successful, and cost-effective means of restoring fisheries. The elimination of undesirable predaceous and competitive species is accomplished by using rotenone in a small portion of the state's lakes where this is possible. This allows management for optimal populations of trout and selected warm water species that meet the state anglers' preferences and agency management goals. The overall objective of the program is to meet the Department's mandate by addressing public demand and improving public recreational game fishing opportunities.