MONTANA FISH, WILDLIFE & PARKS
FISHERIES DIVISION

Environmental Assessment of the Rotenone Treatment of Martin Lakes for the purpose of removing northern pike and restocking with cutthroat trout.

PART I: PROPOSED ACTION DESCRIPTION

A. Type of Proposed Action: Improve angling quality of Martin Lakes through removal of northern pike, and pumpkinseed sunfish and yellow perch, by means of rotenone piscicide (fish pesticide) and restocking with westslope cutthroat trout.

B. Agency Authority for the Proposed Action: Montana Fish, Wildlife & Parks (MFWP) "…is hereby authorized to perform such acts as may be necessary to the establishment and conduct of fish restoration and management projects…" under statute 87-1-702, Montana Codes Annotated.

C. Estimated Commencement Date: October 2005

D. Name and Location of the Project: Rotenone treatment of Martin Lakes for the purpose of removing northern pike, and pumpkinseed sunfish and yellow perch, and restocking with westslope cutthroat trout. The project site is located in Flathead County approximately 3 miles due west of the town site of Olney, Montana; T32N, R24W, Sections10, 11and 14 (Figure 1).

E. Project Size (acres affected):

1. Developed/residential – 0 acres
2. Industrial – 0 acres
3. Open space/Woodlands/Recreation – 0 acres
4. Wetlands/Riparian – The upper lake is 14.1 acres in size, has a maximum depth of 62.4 feet, and is 326.6 acre feet in volume (Figure 2). The lower lake is 6.1 acres in size, has a maximum depth of 34.3 feet, and is 94.6 acre feet in volume (Figure 3). The stream that flows out of the lakes was gauged at two sites in 2005. One half mile below the lakes it was 0.74 cfs, and it was 1.94 cfs near its confluence with Martin Creek. The major tributary to Martin Lakes outlet stream is a spring located approximately ½ mile downstream of the lakes, and it was gauged at 1.66 cfs in July of 2005. The entire reach of stream between the lower lake and confluence with Martin Creek is approximately 1.3 miles long.
5. Floodplain – 0 acres
6. Irrigated Cropland – 0 acres
7. Dry Cropland – 0 acres
8. Forestry – 0 acres
9. Rangeland – 0 acres

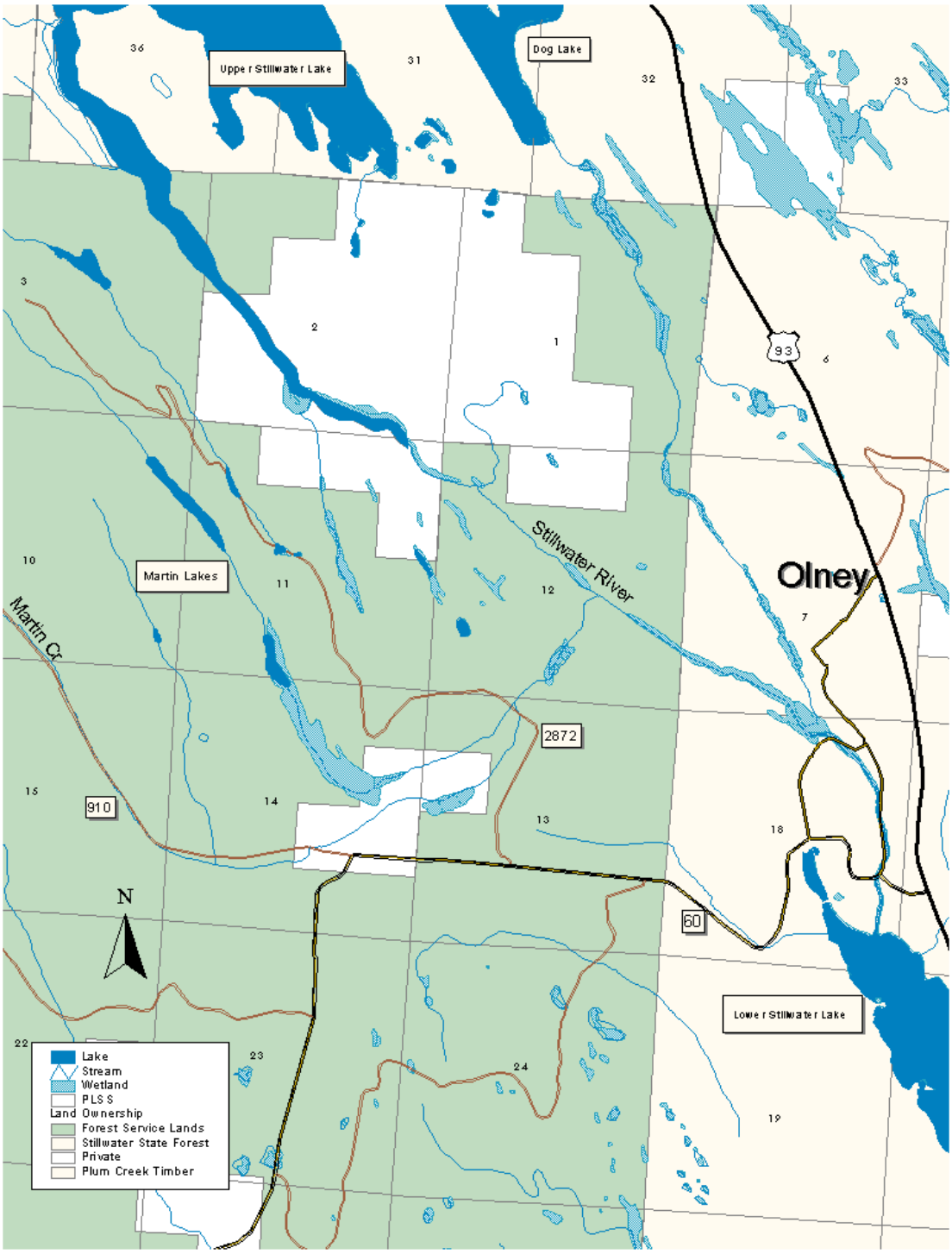

Figure 1. Map of the project site.

Figure 2. Bathymetric map of upper Martin Lake.

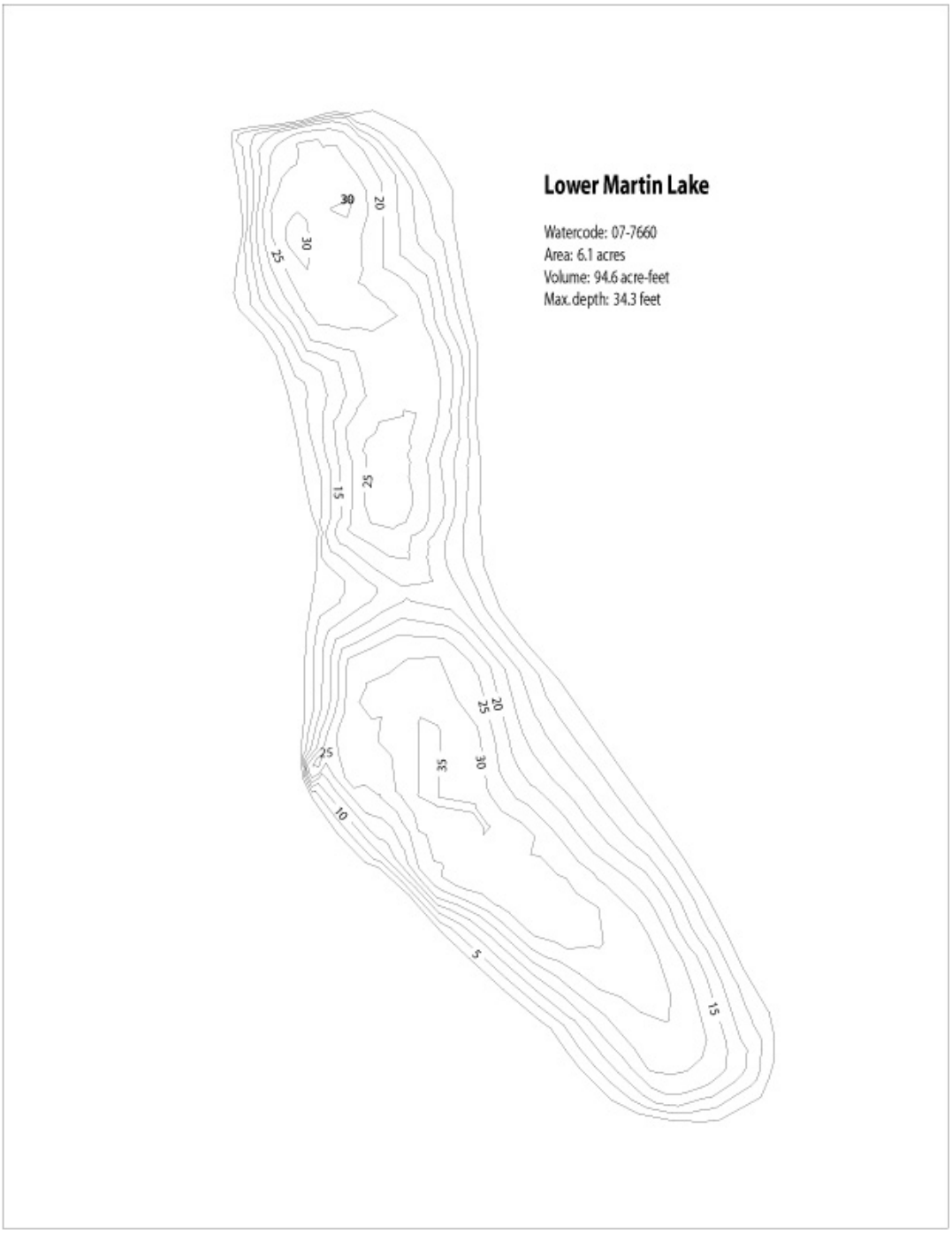

Figure 3. Bathymetric map of lower Martin Lake.

F. Narrative Summary of the Proposed Action and Purpose of the Proposed Action:

Northern pike were introduced to Martin Lakes by unauthorized parties. Surveys conducted between 1984 and 2004 confirm that the lakes contain a low number of northern pike that are small, typically ranging between 13 and 17 inches long. The largest pike sampled over the past 20 years was 25 inches long. During this time frame, a single pumpkinseed sunfish was collected, and numerous small fish presumed to be redside shiners have been observed, but never captured. Local residents have reported brook trout in the stream below the lakes. Surveys in July 2005 found numerous small yellow perch in the lower lake. Reports by anglers and residents in the Olney area indicate that angling quality in recent history has been low, which is likely due to the lack of suitable spawning habitat and low forage base for northern pike. In 1998 MFWP considered treating the lakes with rotenone to remove pike and create a trout fishery, but did not pursue the project beyond the conceptual phase. In an effort to improve angling quality MFWP is at this time proposing to remove the northern pike and other fish species from Martin Lakes using the fish toxicant rotenone and restocking them with a fish species that can 1) provide a quality fishery, 2) thrive in the habitat present at Martin Lakes, and 3) be compatible with other species in the Stillwater River drainage. The species that best meets these three criteria is the westslope cutthroat trout. This is not considered a species conservation project.

MFWP has a long history of using rotenone to manage fish populations in northwestern Montana. From 1948 through 2002, the department has administered 127 rotenone projects for a variety of reasons, but principally to improve angling quality and less so for native fish conservation.

Rotenone is a naturally occurring substance derived from the roots of tropical plants in the bean family, including jewel vine (*Derris* spp.) and lacepod (*Lonchocarpus* spp.), that are found in Australia, Oceania, southern Asia, and South America. Rotenone has been used by native people for centuries to capture fish for food in areas where these plants are naturally found. It has been used in fisheries management in North America since the 1930s. Rotenone has also been used as a natural insecticide for gardening and to control parasites such as lice on domestic livestock.

Rotenone acts by inhibiting oxygen transfer at the cellular level. It is especially effective at low concentrations with fish because it is readily absorbed into the bloodstream through the thin cell layer of the gills. Mammals and other nongill-breathing organisms do not have this rapid absorption route into the bloodstream and thus can tolerate exposure to concentrations much higher than that used to kill fish. In essence, most nontarget organisms are not affected at fish-killing concentrations.

The boundaries for this treatment span from the upper lake downstream to the mouth of the outflow stream from the lower lake where it meets Martin Creek. The waters between these two points would be treated with Prenfish brand 5% rotenone and contained within these boundaries. We would follow the Prenfish label recommendations for concentrations for normal pond use when treating the ponds and connecting waters. On-site bioassays using caged fish would determine the appropriate concentrations needed, estimated to be near 1 mg per 1 liter of water. The Prenfish label states that the persistence would be one week to a month depending on water temperatures, sunlight intensity, alkalinity, etc.

The rotenone would be dispensed in the lakes by boat. Drip stations would be used to dispense the rotenone in the inlet channels, and the marshy areas around the lakes would be treated with backpack sprayers and pumps. The materials and equipment would be transported to the site by helicopter. A single-engine air tanker (SEAT) airplane may be used to transport and dispense a portion of the estimated 140 gallons of rotenone to the lakes. If aerial application occurs, boats would be used to mix the rotenone throughout the lakes. A small amount of powdered rotenone may be used to treat springs to prevent fish from seeking them as freshwater refuges during the application. Rotenone would be applied to the stream using backpack sprayers and drip stations. Pike typically do not use streams for habitat, and the risk of reinvasion would be low. A survey of the stream in July 2005 confirms that the stream is not likely pike habitat, and a barrier to pike exists near the lower reach of the stream. Also, during this survey there was no surface water flowing in the channel between the lakes, and information gathered indicates that water flow between the lakes is seasonal and likely only occurs in the spring.

Depending on the amount of detoxification that occurs naturally in the creek downstream of the lakes, we would rely on potassium permanganate to detoxify the water in the stream so that it would no longer be toxic at the lower project boundary. According to the Prenfish label, potassium permanganate should be applied to water at the appropriate concentration to compensate for organic demand of the stream and/or lake bottom so that enough remains to neutralize the rotenone. The discharge of the stream would be measured prior to treatment, and the potassium permanganate would be applied at the rate specified on the Prenfish label. On-site assays would be conducted in this stream prior to the treatment to determine the appropriate amount of permanganate necessary to neutralize the rotenone. As a precautionary measure the water from Martin Creek would serve to dilute the treated water below levels toxic to fish. Stream discharge measurements conducted in July 2005 indicate that Martin Creek enters the stream and would dilute this water by one half.

The treatment period would occur for an estimated 8 hours. Natural detoxification and/or detoxification with potassium permanganate would occur until a point at which caged fish survive in treated waters for 24 hours. Caged fish would be used to measure the toxicity of the water and neutralized water during the treatment and detoxification processes, respectively. The rotenone label specifies that once caged fish survive 24 hours in treated water, it is safe for restocking. The lakes would be restocked shortly after this time or the following spring.

Dead fish that surface would be left on-site in the water or disposed of properly. Studies in Washington State indicate that approximately 70% of rotenone-killed fish sink to the bottom (Bradbury 1986). Dead fish stimulate plankton growth and aid in plankton recovery.

If unforeseen circumstances confound the success of this project, it may be necessary to implement a second treatment to achieve the desired objectives.

PART II. ENVIRONMENTAL REVIEW

A. PHYSICAL ENVIRONMENT

1. LAND RESOURCES **Will the proposed action result in:**	**Impact Unknown**	**None**	**Minor**	**Potentially Significant**	**Can Impact Be Mitigated**	**Comment Index**
a. Soil instability or changes in geologic substructure?		X				
b. Disruption, displacement, erosion, compaction, moisture loss, or over-covering of soil, which would reduce productivity or fertility?		X				
c. Destruction, covering, or modification of any unique geologic or physical features?		X				
d. Changes in siltation, deposition, or erosion patterns that may modify the channel of a river or stream or the bed or shore of a lake?		X				
e. Exposure of people or property to earthquakes, landslides, ground failure, or other natural hazard?		X				

2. WATER Will the proposed action result in:	Impact Unknown	None	Minor	Potentially Significant	Can Impact Be Mitigated	Comment Index
a. Discharge into surface water or any alteration of surface water quality, including but not limited to temperature, dissolved oxygen, or turbidity?			X		Yes	2a
b. Changes in drainage patterns or the rate and amount of surface runoff?		X				
c. Alteration of the course or magnitude of floodwater or other flows?		X				
d. Changes in the amount of surface water in any water body or creation of a new water body?		X				
e. Exposure of people or property to water-related hazards such as flooding?		X				
f. Changes in the quality of groundwater?		X				2f
g. Changes in the quantity of groundwater?		X				
h. Increase in risk of contamination of surface or groundwater?			X		Yes	See 2a & 2f
i. Effects on any existing water right or reservation?		X				
j. Effects on other water users as a result of any alteration in surface or groundwater quality?		X				
k. Effects on other users as a result of any alteration in surface or groundwater quantity?		X				
l. Will the project affect a designated floodplain?		X				
m. Will the project result in any discharge that will affect federal or state water quality regulations? (Also see 2a)			X		Yes	2m

Comment 2a. This project is designed to intentionally introduce a piscicide (fish pesticide) to surface water to remove unwanted fish. The impacts would be short term and minor. Prenfish rotenone is an EPA-registered compound and is safe to use for removal of unwanted species of fish when handled properly. The concentration of Prenfish rotenone proposed is 1 mg per 1 liter of water, but may be adjusted based upon the results of on-site assays.

There are three ways in which rotenone can be detoxified once applied. The most common method is to allow natural breakdown to occur. Rotenone is a highly unstable compound, and a variety of factors influence natural breakdown including water chemistry, water temperature, exposure to organic substances, exposure to oxygen, and sunlight intensity (Ware 2002; ODFW 2002; Loeb and Engsrtom-

Heg 1970; Engstrom-Heg 1972; Gilderhus et al. 1986). Rotenone persistence studies by Gilderhus et al. (1986) and Dawson et al. (1991) found that in cool water temperatures of 32° to 46°F the half-life ranged from 3.5 to 5.2 days. Gilderhus et al. (1986) reported that 30% mortality was experienced in rainbow trout exposed to degrading concentrations of actual rotenone (0.004 ppm) in 46°F pond water 14 days after a treatment. By day 18 the concentrations were sublethal to trout. The second method for detoxification involves basic dilution by fresh water. This may be accomplished by fresh ground water or surface water flowing into a lake or stream. The final method of detoxification involves the application of an oxidizing agent like potassium permanganate. This dry crystalline substance is mixed with stream or lake water to produce a concentration of liquid sufficient to detoxify the concentration of Prenfish applied. Detoxification is accomplished after about 20-30 minutes of mixing between the two compounds (Prentiss Inc. 1998). Potassium permanganate (KMnO4) quickly detoxifies rotenone, and it may be used to detoxify water leaving the lakes. Potassium permanganate is routinely added to municipal water supplies for the control of compounds causing taste and odors. When all three of these detoxification methods are employed together, rotenone can be neutralized relatively quickly, from hours to a few days.

There is a private fishpond located approximately ½ mile downstream of the lakes. This pond receives its water from a spring source and discharges into the stream that is part of this treatment. There is no danger of this pond being exposed to rotenone-treated water.

Dead fish would result from this project. Bradbury (1986) reported that approximately 70% of rotenone-killed fish in Washington lakes never surface. Although no trout were involved with his study, Parker (1970) reported that at water temperatures of 40°F and less, dead fish required 20-41 days to surface. The most important factors inhibiting fish from ever surfacing are cooler water (<50°F) and deep water (>15 feet). Martin Lakes would undoubtedly meet these criteria during an October treatment. Bradbury (1986) reported that 9 of 11 water bodies in Washington treated with rotenone experienced an algae bloom shortly after treatment. This is attributed to the input of phosphorus to the water as a result of decaying fish. Bradbury further notes that approximately 70% of the phosphorus content of the fish stock would be released into the lake through bacterial decay. This action stimulates phytoplankton production, then zooplankton production, and starts the lake toward production of food for fish. This change in water chemistry is viewed as a benefit to stimulate plankton growth. Any changes or impacts to water quality resulting from decaying fish would be short term and minor.

In July 2005 the creek downstream of the lakes was surveyed. The lake outflow was gauged at 0.74 cfs. This stream runs through a small channel for ½ mile where it meets with a spring creek. This spring creek was gauged at 1.6 cfs and constitutes the majority of contributing water flow into the creek. The stream runs for approximately 1 mile before it crosses the Martin Lakes Road. At this site the stream was gauged at 1.94 cfs, which is 18% less than the combined input from the upstream sources. From this site the stream runs for another 0.15 mile before it flows into Martin Creek. Martin Creek was gauged in July at the Martin Lakes Road crossing and was 1.78 cfs. The freshwater inputs from Martin Creek would serve to dilute treated water below fish-killing concentrations.

Comment 2f: No contamination of groundwater is anticipated to result from this project. Rotenone binds readily to sediments and is broken down by soil and in water (Skaar 2001; Engstrom-Heg 1971, 1976; Ware 2002). Rotenone moves only one inch in most soil types; the only exception would be sandy soils where movement is about three inches (Hisata 2002). In California, studies where wells were

placed in aquifers adjacent to and downstream of rotenone applications have never detected rotenone, rotenolone, or any of the other organic compounds in the formulated products (CDFG 1994). Case studies in Montana have concluded that rotenone movement through groundwater does not occur. For example, at Tetrault Lake, Montana, rotenone was not detected in a nearby domestic well, which was sampled two and four weeks after applying 90 ppb rotenone to the lake. This well was chosen because it was down-gradient from the lake and also drew water from the same aquifer that fed and drained the lake. In 1998, a Kalispell-area pond was treated with Prenfish. Water from a well located 65 feet from the pond was analyzed, and no sign of rotenone was detected. In 2001, another Kalispell-area pond was treated with Prenfish. Water from a well located 200 feet from that pond was tested four times over a 21-day period and showed no sign of contamination.

There is one domestic well located about ½ mile downstream of the site. This well is 400 feet deep, and discussions with the owner indicate that there should be no problems or concern with contamination of this well.

Comment 2m: MFWP would apply for an exemption of surface water quality standards from Montana DEQ under Section 308 of the Montana Water Quality Act.

3. AIR **Will the proposed action result in:**	**Impact Unknown**	**None**	**Minor**	**Potentially Significant**	**Can Impact Be Mitigated**	**Comment Index**
a. Emission of air pollutants or deterioration of ambient air quality? (Also see 13c)			X			3a
b. Creation of objectionable odors?			X			3b
c. Alteration of air movement, moisture, or temperature patterns, or any change in climate, either locally or regionally?		X				
d. Adverse effects on vegetation, including crops, due to increased emissions of pollutants?		X				
e. Will the project result in any discharge that will conflict with federal or state air quality regs?		X				

Comment 3a: Emissions from outboard motors and helicopter turbine exhaust would be created, but are expected to dissipate rapidly. Any impacts from these odors would be short term and minor.

Comment 3b: Liquid-formulated rotenone does contain aromatic solvents that make it soluble in water. This smell of these solvents may last for several hours to several days, depending on air and water temperatures and wind direction. These relatively “heavy” organic compounds tend to sink (remain close to the ground) and move downwind. The California Department of Pesticide Regulation (CDPR 1998, cited in Finlayson et al. 2000) found no health effects from this smell. Applicators would have the greatest contact with these odors, but would be protected because they would be wearing respirators as the product label recommends. Any impacts caused by objectionable odors would be short term and minor.

Dead fish would result from this project and may cause objectionable odors. This condition is greatly reduced during fall applications. We would expect odors from dead fish to be short term and minor.

4. VEGETATION **Will the proposed action result in:**	**Impact Unknown**	**None**	**Minor**	**Potentially Significant**	**Can Impact Be Mitigated**	**Comment Index**
a. Changes in the diversity, productivity, or abundance of plant species (including trees, shrubs, grass, crops, and aquatic plants)?			X			4a
b. Alteration of a plant community?		X				
c. Adverse effects on any unique, rare, threatened, or endangered species?		X				
d. Reduction in acreage or productivity of any agricultural land?		X				
e. Establishment or spread of noxious weeds?		X				
f. Will the project affect wetlands, or prime and unique farmland?		X				

Comment 4a: Martin Lakes are located in a deep canyon area with limited staging sites to conduct this treatment. This would require staging all activities from a single area or a few areas, which may cause trampling of shoreline vegetation. Rotenone does not have an effect on plants at concentrations used to kill fish. Impacts from trampling vegetation are expected to be short term and minor.

5. FISH/WILDLIFE Will the proposed action result in:	Impact Unknown	None	Minor	Potentially Significant	Can Impact Be Mitigated	Comment Index
a. Deterioration of critical fish or wildlife habitat?		X				
b. Changes in the diversity or abundance of game animals or bird species?			X		Yes	5b
c. Changes in the diversity or abundance of nongame species?			X		Yes	5c
d. Introduction of new species into an area?			X			5d
e. Creation of a barrier to the migration or movement of animals?		X				
f. Adverse effects on any unique, rare, threatened, or endangered species?	X					5f
g. Increase in conditions that stress wildlife populations or limit abundance (including harassment, legal or illegal harvest, or other human activity)?		X				
h. Will the project be performed in any area in which T&E species are present, and will the project affect any T&E species or their habitat? (Also see 5f)		X				
i. Will the project introduce or export any species not presently or historically occurring in the receiving location? (Also see 5d)			X			See 5d

Comment 5b: This project is designed to kill unwanted fish. Northern pike are a game species that would be eliminated from Martin Lakes. A local resident has indicated that brook trout occur in the stream downstream of the lakes. A survey in July 2005 confirmed the presence of small northern pike at the lower lake outlet, several small trout presumed to be brook trout in the stream below the lakes, and small perch in the lower lake. These fish would also be removed by the rotenone treatment. Other species that would be killed incidental to this project include pumpkinseed sunfish, redside shiners, and sucker species. These impacts would be short term and minor because the lakes would be restocked with westslope cutthroat trout, and they would also pioneer sections of the stream.

Comment 5c: Nongame (nontarget) species that would be impacted include zooplankton, some aquatic insects, and possibly some amphibians. Numerous studies indicate that rotenone has temporary or minimal effects on aquatic insects and plankton. Anderson (1970) reported that comparisons between samples of zooplankton taken before and after a rotenone treatment did not change a great deal. Despite the inherent natural fluctuations in zooplankton communities, the application of rotenone had little effect on the zooplankton community. Cook and Moore (1969) reported that the application of rotenone has little lasting effect on the nontarget insect community of a stream. Kiser et al. (1963) reported that 20 of 22 zooplankton species reestablished themselves to pretreatment levels within about 4 months of a rotenone application. Cushing and Olive (1956) reported that the insects in a lake treated with rotenone

exhibited only short-lived effects. Hughey (1975) concluded that three Missouri ponds treated with rotenone showed little short-term and no long-term effect on population levels of zooplankton. The effects of rotenone on plankton were consistent with the natural variability that is characteristic of plankton populations, and recolonization was rapid and reached near pretreatment levels within eight months.

Both Anderson (1970) and Kiser et al. (1963) reported that most zooplankton species survive a rotenone treatment via their highly resilient egg structures. In addition, parthenogenesis of some female plankton occurs, causing sexual dimorphism, which greatly increases plankton density in times of population distress. Among the aforementioned studies, variation in climate, physical environment, and water chemistry would likely cause subtle differences in results in other areas.

Case studies conducted on Devine Lake in the Bob Marshall Wilderness from 1994-1996 indicate that invertebrates actually increased in number and very slightly increased in diversity following a rotenone treatment (Rumsey et al. 1996). This is supported by observations made by Cushing and Olive (1956), who reported that oligochaetes (worms) increased in number after a rotenone treatment, then became stable. *Gammarus* species (fresh water shrimp), a common fish food item, were detected in Devine Lake only when fish were present. Neighboring Ross Lake, in the Bob Marshall Wilderness, is fishless and was used to measure natural insect and plankton variation during the Devine Lake treatment and evaluation. *Gammarus* species were never detected in Ross Lake, although it is fishless. Invertebrate numbers in Ross Lake were reported to be relatively stable, but the diversity of insects fluctuated considerably over time. The impacts to these nontarget organisms would be short term and minor.

The effect of rotenone on nontarget organisms has been studied extensively. Mammals in general are not affected because they neutralize rotenone by enzymatic action in their stomach and intestines (AFS 2002). In laboratory tests, forms of rotenone were fed to rats and dogs as part of their diet for periods of six months to two years (Marking 1988). Researchers observed effects such as diarrhea, decreased food consumption, and weight loss, and reported that despite unusually high treatment concentrations of rotenone in rats and dogs, it did not cause tumors or reproductive problems in mammals. CDFG (1994) studies of risk for terrestrial animals found that a 22-pound dog would have to drink 7,915 gallons of lake water within 24 hours, or eat 660,000 pounds of rotenone-killed fish, to receive a lethal dose. The state of Washington reported that a half-pound mammal would need to consume 12.5 mg of pure rotenone to receive a lethal dose (Bradbury 1986). Considering the only conceivable way an animal can consume the compound under field conditions is by drinking lake or stream water, a half-pound animal would need to drink 33 gallons of water treated at 2 ppm. Brooks (1961) reported that this amount is more on the order of 49 gallons. Similar results determined that birds required levels of rotenone at least 1,000-to-10,000 times greater than is required for lethality in fish (Skaar 2001). Cutkomp (1943) reported that chickens, pheasants, and members of lower orders of *Galliformes* were quite resistant to rotenone, and four-day-old chicks were more resistant than adults. Ware (2002) reports that swine are uniquely sensitive to rotenone, and it is slightly toxic to wild fowl, but to kill Japanese quail required 4,500-to-7,000 times more than is used to kill fish. One study, in which rats were injected with rotenone for a period of weeks, reported finding lesions characteristic of Parkinson's disease (Betarbet et al. 2000). However, the results have been challenged on the basis of methodology: (1) that the continuous intravenous injection method used leads to "continuously high levels of the compound in the blood," and (2) that dimethyl sulfoxide (DMSO) was used to enhance tissue penetration (normal routes of exposure actually slow introduction of chemicals into the bloodstream). Finally, injecting rotenone into the body

is not a normal way of assimilating the compound. Similar studies (Marking 1988) have found no Parkinson-like results. Extensive research has demonstrated that rotenone does not cause birth defects (HRI 1982), gene mutations (Van Geothem et al. 1981; BRL 1982), or cancer (Marking 1988). Spencer and Sing (1982) reported that rats that were fed diets laced with 10-1,000 ppm rotenone over a 10-day period did not suffer any reproductive dysfunction. Rotenone was found to have no direct role in fetal development of rats that were fed excruciatingly high concentrations of rotenone. Typical concentrations of actual rotenone used in fishery management range from 0.025 to 0.50 ppm and are far below that administered during most toxicology studies.

Chandler and Marking (1982) found that clams and snails were between 50 and 150 times more tolerant than fish to Noxfish (5% rotenone formulation), and southern leopard frog tadpoles were between 3 and 10 times more tolerant than fish. Grisak et al. (in prep) conducted laboratory studies on long-toed salamanders, tailed frogs, and Columbia spotted frogs and concluded that the adult life stages of these species would not suffer an acute response to rotenone, but the larval and tadpole stages could be affected by rotenone at fish-killing concentrations. These authors recommended implementing rotenone treatments at times when the larvae and tadpoles are not present, such as the fall, to reduce potential for impacts.

It is important to note that nearly all of these examples involved subjecting laboratory specimens to unusually high concentrations of rotenone or conducting tests on animals that would not be exposed to rotenone during normal use in fisheries management.

Based on this information we would expect the impacts to nontarget organisms to range from nonexistent to short term and minor. A survey in July 2005 confirmed a small number of Columbia spotted frogs at the site.

Comment 5d: This project is designed to introduce westslope cutthroat trout into Martin Lakes following the rotenone treatment specifically for the purpose of improving angling quality. The westslope cutthroat has not been detected in Martin Lakes, but this species is native to the Stillwater River drainage and occurs in the private pond approximately ½ mile downstream of the lower lake. If westslope cutthroat trout become established in Martin Lakes and escape, there would be no impact to existing fish populations in this area. A survey of the stream in July 2005 confirmed the presence of a cascading waterfall near its confluence with Martin Creek. This serves as a migration barrier to upstream-migrating fish.

Comment 5f: Dead fish would result from this project. It is possible that osprey or eagles would use rotenone-killed fish. There are two bald eagle nests located within 3 miles of the project site (Figure 4). Eagles using these nests have had varying success with nesting attempts and fledgling young over the past five years. The upper Stillwater Lake nest produced young one time during the past five years, and the last time the lower Stillwater nest produced young was 1999. Conducting this project in the fall would not impact bald eagle nesting, and there would be no impacts to bald eagles that consume rotenone-killed fish. See comment 5c for impacts to birds.

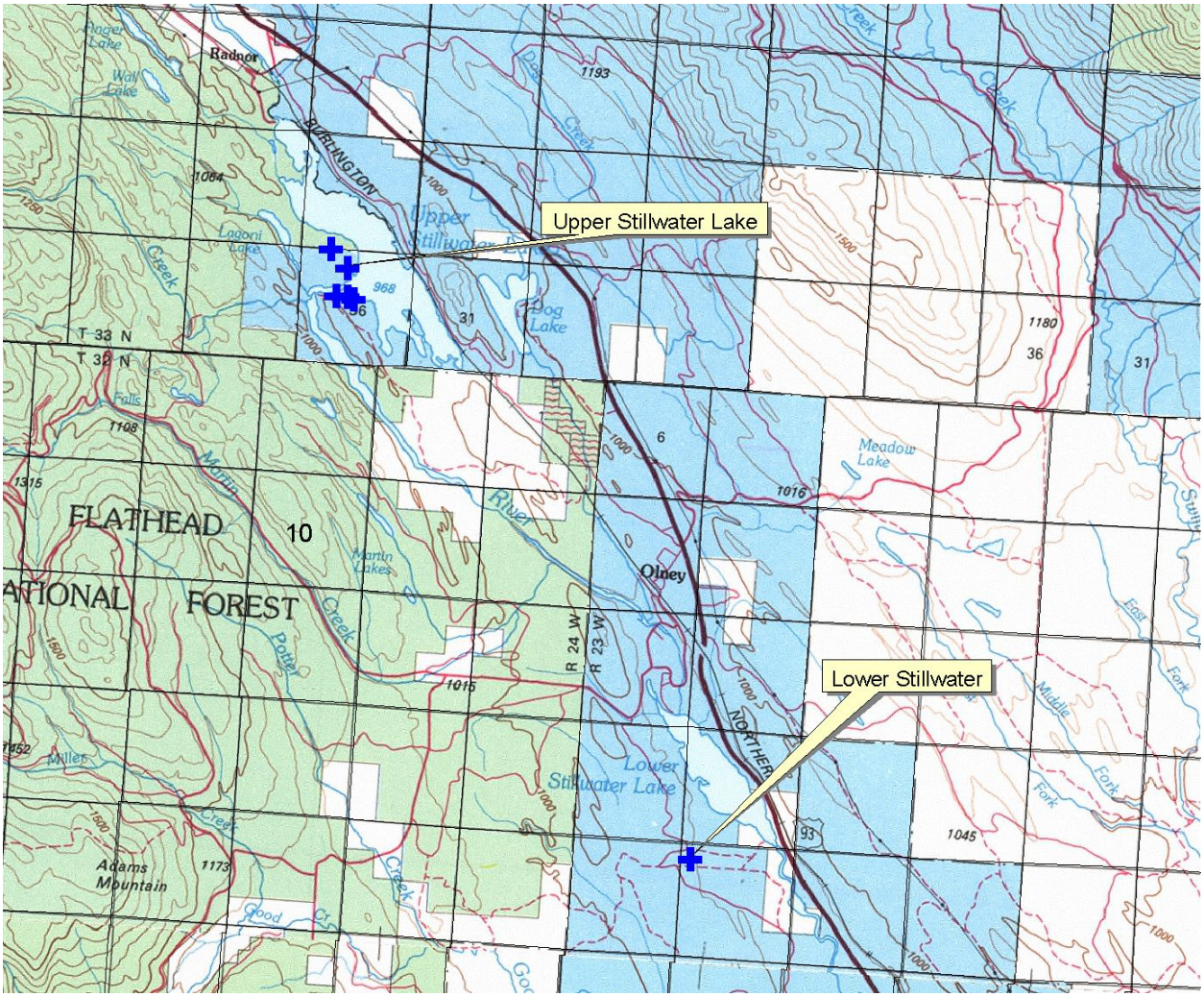

Figure 4. Bald eagle nesting sites in the Stillwater River area.

Grizzly bears are known to be in this area, but are not dependant on the lakes or fish in the lakes for food. The infrequent sighting of grizzly bears, steep side of the lake shore, increased human activity in the area, and cleaning dead fish from the site would contribute to reducing potential for this species to consume rotenone-killed fish. See comment 5c for impacts to mammals. The project itself would not have an impact on grizzly bears.

The project site is within the range of the gray wolf. The Lazy Creek pack ranges through this area, and dispersers from the Murphy Lake pack may use this area at times. The impacts to this species would be nonexistent to minor and short term for the same reasons as the grizzly bear. See comment 5c for impacts to mammals.

B.HUMAN ENVIRONMENT

6. NOISE/ELECTRICAL EFFECTS Will the proposed action result in:	Impact Unknown	None	Minor	Potentially Significant	Can Impact Be Mitigated	Comment Index
a. Increases in existing noise levels?			X			6a
b. Exposure of people to severe or nuisance noise levels?		X				
c. Creation of electrostatic or electromagnetic effects that could be detrimental to human health or property?		X				
d. Interference with radio or television reception and operation?		X				

Comment 6a: Martin Lakes are located in a canyon with steep sides. No boat access is available. This project would involve the use of a boat with outboard motor and a helicopter/fixed wing aircraft. The noise generated from these two would be short term and minor.

7. LAND USE Will the proposed action result in:	Impact Unknown	None	Minor	Potentially Significant	Can Impact Be Mitigated	Comment Index
a. Alteration of or interference with the productivity or profitability of the existing land use of an area?		X				
b. Conflicted with a designated natural area or area of unusual scientific or educational importance?		X				
c. Conflict with any existing land use that would constrain or potentially prohibit the proposed action?		X				
d. Adverse effects on or relocation of residences?	X					7d

Comment 7d: There is one 117-acre parcel of private land with a residence located approximately ½ mile downstream of the lower lake. The lake outlet stream flows through this parcel of land for 0.49 mile. The landowner has been contacted and has been an involved during the planning and ground surveys for this project. Implementing this project would not have an impact on the residence located on this private land.

8. RISK/HEALTH HAZARDS Will the proposed action result in:	Impact Unknown	None	Minor	Potentially Significant	Can Impact Be Mitigated	Comment Index
a. Risk of an explosion or release of hazardous substances (including, but not limited to oil, pesticides, chemicals, or radiation) in the event of an accident or other forms of disruption?			X		Yes	8a
b. Affect of an existing emergency response or emergency evacuation plan or create a need for a new plan?			X		Yes	8b
c. Creation of any human health hazard or potential hazard?			X		Yes	See 8a & c
d. Will any chemical toxicants be used?			X		Yes	See 8a

Comment 8a: The principal risk of human exposure to hazardous materials from this project would be limited to the applicators. All applicators would wear safety equipment listed on the product labels, such as respirator, goggles, rubber boots, Tyvek overalls, and nitrile gloves. All applicators would be trained on the safe handling and application of the piscicide. At least one, and most likely several, Montana Department of Agriculture-certified pesticide applicator(s) would supervise and administer the project. Rotenone and potassium permanganate would be transported, handled, applied, and stored according to the label specifications to reduce the probability of human exposure or spill.

Comment 8b: MFWP has a treatment plan for rotenone projects. This plan addresses many aspects of safety for people who are on the implementation team, such as establishing a clear chain of command, training, delegation and assignment of responsibility, clear lines of communication between members, spill contingency plan, first aid, emergency responder information, personal protective equipment, and monitoring and quality control, among others. Implementing this project should not have any impact on existing emergency plans. Because an implementation plan has been developed by MFWP, the need for emergency response is minimal, and any effects to existing emergency responders would be short term and minor.

Comment 8c (cited from BPA 2004)**:** Although pesticides are used widely to control unwanted species, legitimate public concerns have been raised regarding the safety and health effects to humans. As with any pesticide, direct exposure to, or consumption of, piscicides at full strength can have harmful or sometimes fatal effects on humans. Rotenone is an EPA-registered pesticide under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). There are no federal or Montana numeric water quality standards for rotenone; however, MDEQ (2001) used the EPA method of calculating human health criteria based on noncarcinogenic effects to estimate a safe level for lifelong exposure to water and the consumption of fish exposed to water containing rotenone: 40µg/L water plus fish. The calculation is based on several assumptions:

- Long-term (70 years) exposure.
- Average body mass of 70 kg (BW).
- A person consumes 2 L of water per day (DI).
- A person consumes 0.0065 kg of fish per day (FI).

• Reference dose (RfD) for rotenone = 0.004 mg/kg-day (from EPA, Integrated Risk Information System, IRIS).
• Some chemicals tend to increase in fish tissue over the concentration in the water or bio-concentrate. The amount the chemical increases in the fish relative to the ambient concentration is the bio-concentration factor (BCF). The BCF does not include possible food chain effects.

The calculation of the rotenone criteria is as follows:

0.004 mg/kg-day (RfD) * 70 kg (BW)
2 L/day (DI) + (0.0065 kg/day (FI) * 770 L/kg (BCF))

The rotenone formulation that would be used contains five percent active ingredient. When the formulation is applied to achieve 1 mg/L in the water body, the active ingredient concentration is 0.05 mg/L or 50 µg/L. The target concentration would be 10µg/L above the calculated long-term safe level. But the long-term safe level was determined using the standard assumption that fish would be exposed to rotenone and be able to bio-concentrate rotenone. This assumption is extremely protective. Rotenone is a natural chemical, but is not naturally found in Montana and is not a chemical likely to be found in fish that are commercially available for consumption. Fish exposed to rotenone at the target concentration would die within two-to-three hours, thus bio-concentration is very unlikely. Most of the dead fish in the treated lakes would sink to the bottom of the lake. Fish that wash up during the crew's presence at the lake would be collected for disposal. The potential, long-term risk to humans, with water as their only source of rotenone exposure, yields 140µg/L as a safe, long-term concentration.

Since tissue and water concentrations of rotenone decline quickly after a treatment, and people would not likely be exposed to treatments on a continual basis, hazardous, lifelong exposure to rotenone is extremely unlikely. Public health issues surrounding the use of rotenone have been studied extensively. In general, the EPA through FIFRA certification process has concluded that the use of rotenone for fish control does not present a risk of unreasonable, adverse effects to humans and the environment (Finlayson, et al. 2000) as long as the label instructions are followed.

In their description of how South American Indians prepare and apply *Timbó*, a rotenone parent plant, Teixeira, et al. (1984) reported that the Indians extensively handled the plants during a mastication process, and then swam in lagoons with the plant pulp on their backs for distribution. No harmful effects were reported.

Finlayson, et al. (2000) reported that the EPA "has concluded that the use of rotenone for fish control does not present a risk of unreasonable adverse effects to humans and the environment." In relation to air quality, they further note that "No public health effects from rotenone use as a piscicide have been reported." No waiting period is specified for swimming in rotenone-treated water.

Aside from the rotenone itself, liquid formulations also consist of petroleum emulsifiers. Finlayson (2000) wrote regarding the health risks of these constituent elements:

> " . . . the EPA has concluded that the use of rotenone for fish control does not present a risk of unreasonable, adverse effects to humans and the environment. The California Environmental Protection Agency found that adverse impacts from properly conducted, legal uses of liquid rotenone formulations in prescribed fish management projects were nonexistent or within acceptable levels (memorandum from J. Wells, California Department of Pesticide Regulation, to Finlayson, 3 August 1993). Liquid rotenone contains the carcinogen trichloroethylene (TCE).

> However, the TCE concentration in water immediately following treatment (less than 0.005 mg TCE per liter of water [5 ppb]) is within the level permissible in drinking water (0.005 mg TCE per liter of water, EPA 1980b). None of the other materials, including xylenes, naphthalene, piperonyl butoxide, and methylnaphthalenes, exceed any water quality criteria guidelines (based on lifetime exposure) set by the EPA (1980a, 1981a, 1993). Many of these materials in the liquid rotenone formulations (trichloroethylene, naphthalene, and xylene) are the same as those found in fuel oil and are present in waters everywhere because of the frequent use of outboard motors . . ."

California Department of Fish and Game (CDFG, 1994) calculated that the maximum expected level of these contaminants following a treatment level of 2 ppm formulation are TCE 1.1 ppb, toluene 84 ppb, xylenes 3.4 ppb, and naphthalene 140 ppb. 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 . . ."

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 liquid-formulated rotenone, the Montana Department of Agriculture requires applicators to:

- Be trained and certified to apply the pesticide in use.
- Be equipped with the proper safety gear, which, in this case, includes fitted respirator, eye protection, rubberized gloves, and hazardous material 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 could be greatly reduced with proper use of safety equipment. Recreationists in the area would likely not be exposed to the treatments because temporary trail closures would preclude many from being in the area. Proper warning through news releases, signing at trailheads, trail closures, and administrative personnel in the project area should be adequate to keep unintended recreationists from being exposed to any treated waters. Dead fish would be collected and sunk in the lakes or removed from the site. Administering application in the fall of the year would further reduce exposure due to the relatively low number of users in this remote area.

Aerial application of rotenone on lakes has been successful and is commonly used today (Spielman 2003; Finlayson, et al. 2000). Due to the potential for rotenone to become aerosolized temporarily during this type of application, there is an inhalation risk to ground applicators. To guard against this, ground applicators would be equipped with protective clothing, and eye and breathing equipment.

9. COMMUNITY IMPACT Will the proposed action result in:	Impact Unknown	None	Minor	Potentially Significant	Can Impact Be Mitigated	Comment Index
a. Alteration of the location, distribution, density, or growth rate of the human population of an area?		X				
b. Alteration of the social structure of a community?		X				
c. Alteration of the level or distribution of employment or community or personal income?		X				
d. Changes in industrial or commercial activity?		X				
e. Increased traffic hazards or effects on existing transportation facilities or patterns of movement of people and goods?		X				

10. PUBLIC SERVICES/TAXES/UTILITIES Will the proposed action result in:	Impact Unknown	None	Minor	Potentially Significant	Can Impact Be Mitigated	Comment Index
a. Will the proposed action have an effect upon or result in a need for new or altered governmental services in any of the following areas: fire or police protection, schools, parks/recreational facilities, roads or other public maintenance, water supply, sewer or septic systems, solid waste disposal, health, or other governmental services? If any, specify: _____		X				
b. Will the proposed action have an effect upon the local or state tax base and revenues?		X				
c. Will the proposed action result in a need for new facilities or substantial alterations of any of the following utilities: electric power, natural gas, other fuel supply or distribution systems, or communications?		X				
d. Will the proposed action result in increased used of any energy source?		X				
e. Define projected revenue sources		X				
f. Define projected maintenance costs		X				

11. AESTHETICS/RECREATION Will the proposed action result in:	Impact Unknown	None	Minor	Potentially Significant	Can Impact Be Mitigated	Comment Index
a. Alteration of any scenic vista or creation of an aesthetically offensive site or effect that is open to public view?		X				
b. Alteration of the aesthetic character of a community or neighborhood?		X				
c. Alteration of the quality or quantity of recreational/tourism opportunities and settings? (Attach Tourism Report)			X			See 11c
d. Will any designated or proposed wild or scenic rivers, trails, or wilderness areas be impacted? (Also see 11a, 11c)		X				

Comment 11c: This project is specifically intended to improve angling quality at Martin Lakes, which may result in increased use by recreationists. The benefits of increased recreational use would outweigh any impacts associated with the actual treatment. Any impacts to aesthetics would be short term and minor and be directly associated with the actual rotenone treatment and immediate aftermath, including dead fish in the project area. No tourism report is necessary to quantify these impacts.

12. CULTURAL/HISTORICAL RESOURCES Will the proposed action result in:	Impact Unknown	None	Minor	Potentially Significant	Can Impact Be Mitigated	Comment Index
a. Destruction or alteration of any site, structure, or object of prehistoric, historic, or paleontological importance?		X				
b. Physical change that would affect unique cultural values?		X				
c. Effects on existing religious or sacred uses of a site or area?		X				
d. Will the project affect historic or cultural resources?		X				

13. SUMMARY EVALUATION OF SIGNIFICANCE Will the proposed action, considered as a whole:	Impact Unknown	None	Minor	Potentially Significant	Can Impact Be Mitigated	Comment Index
a. Have impacts that are individually limited, but cumulatively considerable? (A project or program may result in impacts on two or more separate resources which create a significant effect when considered together or in total.)		X				
b. Involve potential risks or adverse effects which are uncertain but extremely hazardous if they were to occur?		X				
c. Potentially conflict with the substantive requirements of any local, state, or federal law, regulation, standard, or formal plan?		X				
d. Establish a precedent or likelihood that future actions with significant environmental impacts will be proposed?		X				
e. Generate substantial debate or controversy about the nature of the impacts that would be created?	X	X			Yes	13e
f. Is the project expected to have organized opposition or generate substantial public controversy? (Also see 13e)	X	X				13f
g. List any federal or state permits required.						13g

Comments 13e and f: The use of pesticides can generate controversy from some people. Public outreach and information programs can inform the public on the use of pesticides. There is one private landowner who lives approximately ½ mile downstream of lower Martin Lake and was consulted regarding the possibility of a rotenone treatment to Martin Lakes and the downstream areas that flow through his property. This landowner was also involved during the surveys of the stream and provided access to his property for these surveys. No specific issues, concerns, or opposing viewpoints were identified or expressed during those discussions, and the landowner provided anecdotal information regarding domestic wells, private fish ponds, access to the lower lake through his property, and general stream flow information. MFWP has a long history of using rotenone for fisheries management in NW Montana, which includes application to nearly 130 streams and lakes from 1948 through present. It is not known if this project would have organized opposition. One reason that MFWP is considering this course of action is based on public reports that angling quality in Martin Lakes is low. This project

would serve to reverse that condition. There is also public support for enhancing fishing opportunities in that area.

Comment 13g: The following permit would be required:

DEQ 308 - Department of Environmental Quality (authorization for short-term exemption of surface water quality standards for the purpose of applying a fish toxicant).

PART III. ALTERNATIVES

Alternative 1 – No Action

The no-action alternative would allow status quo management to continue, which would maintain the low quality angling in the Martin Lakes.

Alternative 2 – Rotenone Treatment and Restocking with Westslope Cutthroat Trout (Proposed Action)

The proposed action involves removing northern pike (and the aforementioned species) from the two lakes and downstream segment of stream using the fish toxicant rotenone. Afterwards the lakes would be stocked with westslope cutthroat trout. Based on the depth of these lakes, westslope cutthroat would be expected to thrive in this type of lake environment.
This alternative offers the highest probability of achieving the goals of improving and maintaining the fishery in Martin Lakes.

Alternative 3 – Mechanical Removal

This alternative would involve using gill nets and/or trap nets to remove northern pike, then stocking westslope cutthroat trout to improve angling quality.

Gillnetting has been used successfully to remove unwanted fish from lakes. Bighorn Lake, a 5.2-acre lake located in Banff National Park in Alberta, Canada, was gillnetted from 1997 to 2000 to remove an unwanted population of brook trout (Parker et al. 2001). Over 10,000 net nights (1 net night = 1 net set overnight for at least 12 hours) were conducted over a four-year period in Bighorn Lake to remove the population, which totaled 261 fish. The researchers concluded that the removal of nonnative trout using gill nets was impractical for larger lakes (> 5 acres). In clear lakes, trout have the ability to become acclimated to the presence of gill nets and to avoid them. These researchers reported observing brook trout avoiding gill nets within about 2 hours of being set. It is not known how pike would respond to gillnetting intended for complete removal, but pike are known to be more territorial than trout.

Knapp and Matthews (1998) reported that Maul Lake, a 3.9-acre lake in the Inyo National Forest in California, was gillnetted from 1992 to 1994 to remove a population of brook trout. The population, which totaled 97 fish, was successfully removed with an effort of 108 net days. The researchers reported that following the removal of brook trout from Maul Lake, it was mistakenly restocked with rainbow trout. Efforts to remove them using gill nets were implemented immediately. From 1994 through 1997, 4,562 net days were required to remove the 477 rainbow trout from the lake. These researchers reported that gill nets could be used as a viable alternative to chemical treatment. They acknowledged that the small size and shallow depth of Maul Lake leant itself to a successful fish eradication using gill nets. Their criteria for successful fish removal using gill nets include lakes less than 3.9 surface acres, less than 19 feet deep, with little or no inflow or outflow to perpetuate reinvasion, and no natural reproduction. Although not tested, the maximum size of a lake that they felt could be depopulated using gill nets was 7.4 surface acres and 32 feet deep.

No information was found that described the probability of success with using gill nets or trap nets to completely remove northern pike from a lake. In any event, upper Martin Lake exceeds both the depth and surface area criteria, and the lower lake exceeds the depth criteria, making the successful removal by nets seem unlikely.

Deploying gill nets and traps requires the use of a motorboat and frequent presence at the site to check and reset nets. Based on the steep banks and the absence of a boat access, this alternative seems impractical and would require overcoming many logistical constraints. In addition, there would be an incredible time commitment required to attempt this method of pike removal. Due to these considerations and expected incomplete results, this alternative has a low probability of meeting the objectives.

Alternative 4 – Stocking the Lake with Westslope Cutthroat Trout

This alternative involves stocking the lakes with westslope cutthroat trout in the presence of northern pike. Northern pike are an extremely efficient top-level predator that would benefit from the addition of a forage base such as trout. However, poor spawning habitat would limit pike numbers in the lakes, just as it does now. MFWP expects this alternative to result in an increase in pike size, but not an increase in pike numbers. Although this alternative may temporarily improve angling quality for both trout and pike, it would require a long-term stocking commitment to maintain the trout population as anglers and pike crop them off. Increasing the quality of the pike fishery in Martin Lakes is not one of the objectives of this project. Based on these considerations, this alternative has a low probability of meeting the objectives.

Prepared by : Brian Marotz Date: July 28, 2005

Submit written comments to: Montana Fish, Wildlife & Parks
c/o Martin Lakes Rotenone Treatment EA Comments
490 North Meridian Road
Kalispell, MT 59901

Comment period is 30 days. Comments must be received by 5:00 p.m. on Wednesday, September 7, 2005.

References

AFS (American Fisheries Society). 2002. Rotenone stewardship program, fish management chemicals subcommittee. www.fisheries.org/rotenone/.

Anderson, R.S. 1970. Effects of rotenone on zooplankton communities and a study of their recovery patterns in two mountain lakes in Alberta. Journal of the Fisheries Research Board of Canada. Vol 27, no. 8, 1335-1355.

Betarbet, R., T.B. Sherer, G. MacKenzie, M. Garcia-Osuna, A.V. Panov, and T. Greenamyre. 2000. Chronic systemic pesticide exposure reproduces features of Parkinson's disease. *Nature Neuroscience* 3 (12): 1301-1306.

BPA (Bonneville Power Administration) 2004. South Fork Flathead watershed westslope cutthroat trout conservation project. Draft environmental impact statement. DOE/EIS 0353. Portland, OR.

Bradbury, A. 1986. Rotenone and trout stocking: a literature review with special reference to Washington Department of Game's lake rehabilitation program. Fisheries management report 86-2. Washington Department of Game.

BRL (Biotech Research Laboratories). 1982. Analytical studies for detection of chromosomal aberrations in fruit flies, rats, mice, and horse bean. Report to U.S. Fish and Wildlife Service (USFWS Study 14-16-0009-80-54). National Fishery Research Laboratory, La Crosse, Wisconsin.

CDFG (California Department of Fish and Game), 1994. Rotenone use for fisheries management, July 1994, final programmatic environmental impact report. State of California Department of Fish and Game.

Chandler, J.H. and L.L. Marking. 1982. Toxicity of rotenone to selected aquatic invertebrates and frog larvae. The progressive fish culturist 44(2) 78-80.

Cook, S.F. and R.L. Moore. 1969. The effects of a rotenone treatment on the insect fauna of a California stream. Transactions of the American Fisheries Society 83 (3):539-544.

Cushing, C.E. and J.R. Olive. 1956. Effects of toxaphene and rotenone upon the macroscopic bottom fauna of two northern Colorado reservoirs. Transactions of the American Fisheries Society 86:294-301.

Cutkomp, L.K. 1943. Toxicity of rotenone to animals: a review and comparison of responses shown by various species of insects, fishes, birds, mammals, etc. Soap and Sanitary Chemicals 19(10): 107-123.

Dawson, V.K., W.H. Gingerich, R.A. Davis, and P.A. Gilderhus. 1991. Rotenone persistence in freshwater ponds: effects of temperature and sediment absorption. North American Journal of Fisheries Management 11:226-231.

Engstrom-Heg, R. 1971. Direct measure of potassium permanganate demand and residual potassium permanganate. New York Fish and Game Journal vol. 18 no. 2:117-122.

Engstrom-Heg, R. 1972. Kinetics of rotenone-potassium permanganate reactions as applied to the protection of trout streams. New York Fish and Game Journal vol. 19 no. 1:47-58.

Engstrom-Heg, R. 1976. Potassium permanganate demand of a stream bottom. New York Fish and Game Journal vol. 23 no. 2:155-159.

Finlayson, B.J., R.A. Schnick, R.L. Caiteux, L. DeMong, W.D. Horton, W. McClay, C.W. Thompson, and G.J. Tichacek. 2000. Rotenone Use in Fisheries Management: Administrative and Technical Guidelines Manual. American Fisheries Society, Bethesda, Maryland.

Gilderhus, P.A., J.L. Allen, and V.K. Dawson. 1986. Persistence of rotenone in ponds at different temperatures. North American Journal of Fisheries Management. 6: 129-130.

Grisak, G.G., D. R. Skaar, G. L. Michael, M.E. Schnee, B.L. Marotz, and M. Maskill. (in prep) Laboratory investigations on the toxicity of antimycin and rotenone to the westslope cutthroat trout, Columbia spotted frog, long-toed salamander, and Rocky Mountain tailed frog. Intermountain Journal of Science, Bozeman, Montana.

Hisata, J.S. 2002. Lake and stream rehabilitation: rotenone use and health risks. Final supplemental environmental impact statement. Washington Department of Fish and Wildlife, Olympia.

HRI (Hazelton Raltech Laboratories). 1982. Teratology studies with rotenone in rats. Report to U.S. Geological Survey. Upper Midwest Environmental Sciences Center (USFWS Study 81-178). La Crosse, Wisconsin.

Hughey, R.E. 1975. The effects of fish toxicant antimycin A and rotenone on zooplankton communities in ponds. Masters thesis. University of Missouri. Columbia.

Kiser, R.W., J.R. Donaldson, and P.R. Olson. 1963. The effect of rotenone on zooplankton populations in freshwater lakes. Transactions of the American Fisheries Society 92(1):17-24.

Knapp, R.A. and K.R. Matthews. 1998. Eradication of nonnative fish by gillnetting from a small mountain lake in California. Restoration Ecology, vol. 6, 2:207-213.

Loeb, H.A. and R. Engstrom-Heg. 1970. Time-dependant changes in toxicity of rotenone dispersions to trout. Toxicology and applied pharmacology 17, 605-614.

Marking, L.L. 1988. Oral toxicity of rotenone to mammals. Investigations in fish control, technical report 94. U.S. Fish and Wildlife Service, National Fisheries Research Center, La Crosse, Wisconsin.

ODFW, 2002. Questions and answers about rotenone. *From* Oregon Department of Fish and Wildlife web page, Diamond Lake rotenone treatment, www.dfw.state.or/ODFWhtml/InfoCntrFish/DiamondLake.Rotenone.html.

Parker, B.R., D.W. Schindler, D.B. Donald, and R.S. Anderson. 2001. The effects of stocking and removal of a nonnative salmonid on the plankton of an alpine lake. Ecosystems (2001) 4:334-345.

Parker, R.O. 1970. Surfacing of dead fish following application of rotenone. Transactions of the American Fisheries Society. 99 4:805-807.

Prentiss Incorporated. 1998. Product label for Prentox-Prenfish toxicant, 5% liquid formulation of rotenone. Sandersville, Georgia.

Rumsey, S., J. Fraley, and J. Cavigli. 1996. Ross and Devine lakes invertebrate results – 1994-1996. File report. Montana Fish, Wildlife & Parks, Kalispell.

Skaar, D. 2001. A brief summary of the persistence and toxic effects of rotenone. Montana Fish, Wildlife & Parks, Helena.

Spencer, F. and L.T. Sing. 1982. Reproductive responses to rotenone during decidualized pseudogestation and gestation in rats. *Bulletin of Environmental Contamination and Toxicology*. 228: 360-368.

Spielman, T. 2003. Aftermath on Lake Christina. *In* Outdoor News, the sportsman weekly, New Hope, Minnesota.

Teixeira, J.R.M., A.J. Lapa, C. Souccar, and J.R. Valle. 1984. Timbós: ichthyotoxic plants used by Brazilian Indians. Journal of Ethnopharmacology, 10:311-318

Van Goethem, D, B. Barnhart, and S. Fotopoulos. 1981. Mutagenicity studies on rotenone. Report to U.S. Geological Survey. Upper Midwest Environmental Sciences Center (USFWS Study 14-16-009-80-076), La Crosse, Wisconsin

Ware, G.W. 2002. An introduction to insecticides 3rd edition. University of Arizona, Department of Entomology, Tuscon. *On* EXTOXNET. Extension Toxicology Network. Oregon State University web page.