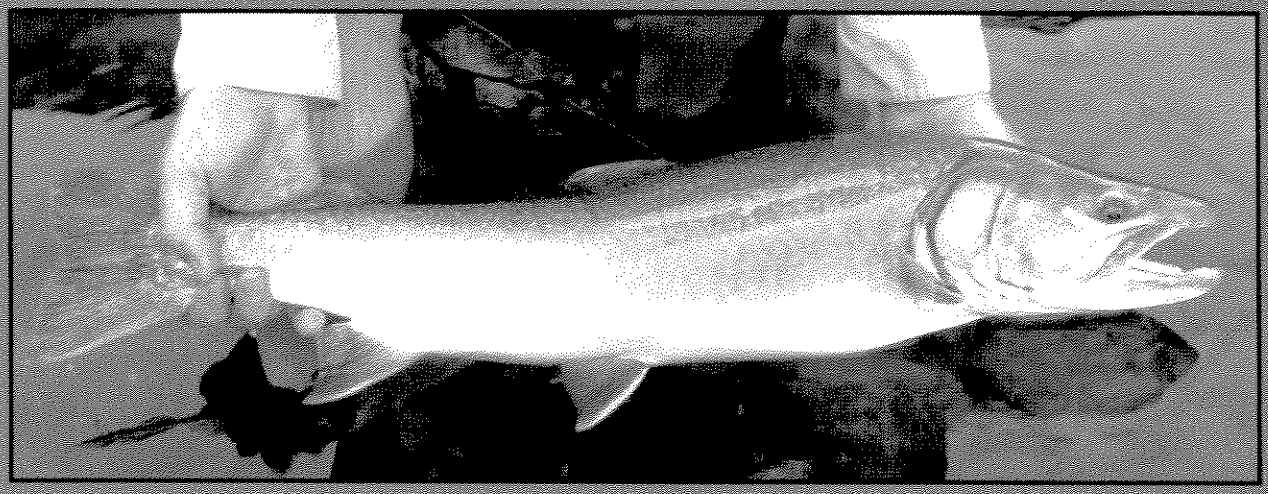
ACTION PLAN TO CONSERVE BULL TROUT IN GLACIER NATIONAL PARK



by
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December 2007

Action Plan to Conserve Bull Trout in Glacier National Park, Montana

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December 2007

EXECUTIVE SUMMARY

In 2003 the U.S. Fish and Wildlife Service, Glacier National Park, and the U.S. Geological Survey Montana Cooperative Fishery Research Unit collaborated to begin a research project that would examine all the bull trout resources in the Flathead River Basin (i.e., west side) portions of the Park in Montana. The first two objectives of the research project were accomplished and the scientific results are reported by Meeuwig and Guy (2007) as well as in condensed form in the research summary supplement to this report (see accompanying compact disk). The primary purpose of this report is fulfilling the third objective of the proposal (i.e., develop a comprehensive action plan for bull trout in Glacier National Park).

Only about 100 lakes in the contiguous United States contain native adfluvial bull trout populations and only about half of those are in naturally functioning, undammed ecosystems. Comprehensive and recent status information for bull trout in Glacier National Park waters was notably lacking. This report describes 17 such waters along the western flanks of the Glacier National Park, representing an important and irreplaceable portion (approximately one-third) of the remaining natural lacustrine habitat supporting the adfluvial life history of bull trout.

This report is organized to facilitate stand-alone use of the action plan by Glacier National Park staff members that may not necessarily be fisheries scientists. Within the action plan we have grouped the 17 lakes that were assessed into three threat categories: 1) secure lakes [Upper Kintla, Trout, Arrow, Isabel, and Upper Isabel, 2) vulnerable lakes [Akokala and Cerulean], and 3) compromised lakes [Kintla, Bowman, Quartz, Middle Quartz, Lower Quartz, Logging, Rogers, Harrison, McDonald, and Lincoln]. Secure lakes are all relatively small backcountry lakes with the documented presence of fish passage barriers in their drainages downstream. As a result, we consider these five lakes to have the most secure populations of bull trout on the west side of the Park. Consequently, the management emphasis for these lakes should be on long-term maintenance of current conditions. Vulnerable lakes are grouped together because we believe there is a high likelihood that they could become compromised from potential invasion by nonnative *Salvelinus* spp. (i.e., lake trout and/or brook trout). Unlike the secure lakes, we did not document the presence of any physical structures that would preclude fish passage in the drainages downstream from these vulnerable lakes. As a result, we consider the vulnerable lakes to be among the most at-risk populations of bull trout in the Park and the management emphasis should be on active evaluation of methods to maintain or improve the status in these vulnerable bull trout waters. Compromised waters are defined as those lakes containing lake trout or brook trout. The status of the lake trout invasion and corresponding status of bull trout populations in each lake is variable. These invasions illustrate there are no physical barriers downstream of these lakes to preclude ongoing lake trout movement or future invasions of other species from other waters in the interconnected Flathead Basin. Management actions for compromised lakes are highly variable and in some instances suppression may be an option. However, suppression will require considerable resources because of logistic constraints.

A common theme in management recommendations for each lake is angler and Park staff awareness of non-native species and their impact on bull trout populations throughout the Park. We highly recommend that Park staff develop interpretive materials to educate backcountry users regarding the impacts of non-native organisms on this native top-level predator (i.e., the bull trout). We suggest that anyone going into the backcountry view a short video that describes the importance of the bull trout populations in the Park and the anatomical features used to differentiate between bull trout and lake trout.

This report presents a somewhat gloomy overall picture of the declining status of bull trout in the pristine headwater drainages of the Park, due primarily to the advancing threat of nonnative lake trout and brook trout. While we emphasize that serious threats are unfolding, it is also apparent that there is still time to attempt corrective actions in some waters. Such actions will require allocation of substantial resources, in some cases to largely experimental approaches, with varying degrees of uncertainty tied to the outcome. Specifically, an expanded commitment of both personnel and financial support is needed to develop an aquatic resource program within the Park.

ACKNOWLEDGMENTS

Major funding for this project was provided by the U.S. Geological Survey and the U.S. Fish and Wildlife Service under the Science Support Partnership (SSP) program. Additional funding and in-kind services were provided by the U.S. National Park Service. We thank J. Potter and J. Tilmant for administrative support. B. Michels provided invaluable logistic support associated with most field-related aspects of this project. Access to remote sampling locations was made possible by the assistance of J. Joubert, C. Hickenbotham, and T. Sullivan. Additional field support and access was provided by R. Altop, S. Emmerich, and G. Moses. Major field assistance was provided by H. Hodges, C. Penne, D. Pewitt, L. Rose, and S. Townsend. Additional field assistance was provided by P. Brown, A. Dux, R. Epley, K. Fredenberg, J. Giersch, P. Polzin, J. Rasmussen, E. Riggs, L. Tennant, and A. Wick. J. Coco, B. Conard, M. Conard, C. Dustin, D. Coco, B. Karschnik, D. Rice, and C. Rice assisted during sampling of Harrison Lake. Attendees of the 2005 meeting of the *Salvelinus confluentus* Curiosity Society assisted during sampling of Lake McDonald.

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INTRODUCTION

The glaciers, snow fields, glacial lakes, and streams tucked along the Continental Divide on the west side of Glacier National Park are an important water source for headwaters of the Flathead River Basin, which converge in Flathead Lake (Figure 1). At approximately 125,000 acres, Flathead Lake is the largest natural freshwater lake in the lower 48 states located west of the Mississippi River. The Flathead River combines with the Clark Fork River downstream of Flathead Lake to form a major source of the headwaters of the Columbia River Drainage. Much of the diversity and evolutionary history of the adfluvial (lake-dwelling) life history form of bull trout can be found within the upper Columbia ecosystem, including the Park and downstream lakes such as Flathead and Pend Oreille. Only about 100 lakes in the contiguous United States contain native adfluvial bull trout populations and only about half of those are in naturally functioning, undammed ecosystems. This report describes 17 such waters along the western flanks of the Park, representing an important and irreplaceable portion (approximately one-third) of the remaining natural habitat supporting the adfluvial life history of bull trout.

It is important to note that Flathead Lake and the Flathead River Basin upstream, with its connected and accessible headwater lakes (i.e., in the Park and the Bob Marshall and Great Bear Wilderness), historically functioned as an interconnected watershed for migratory fish (Figure 1). Native bull trout and westslope cutthroat trout within

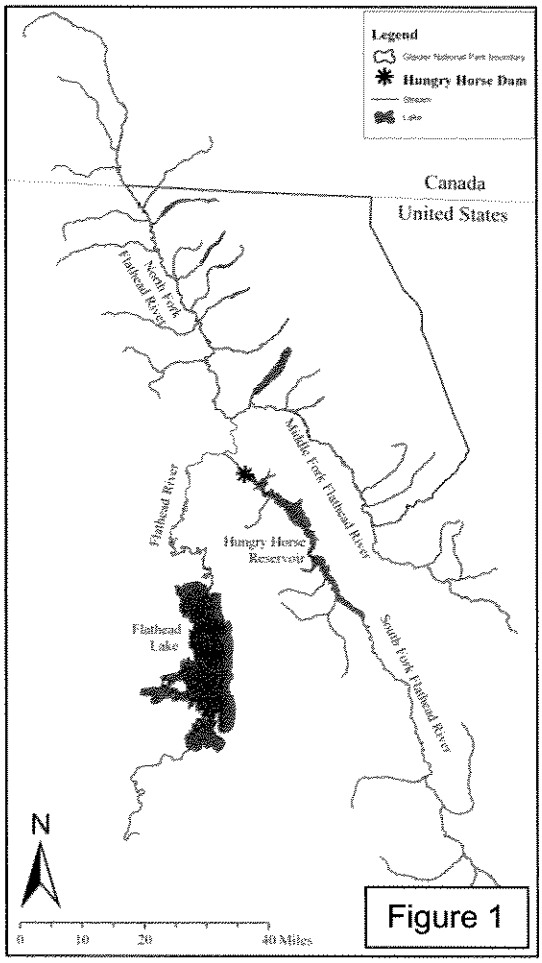
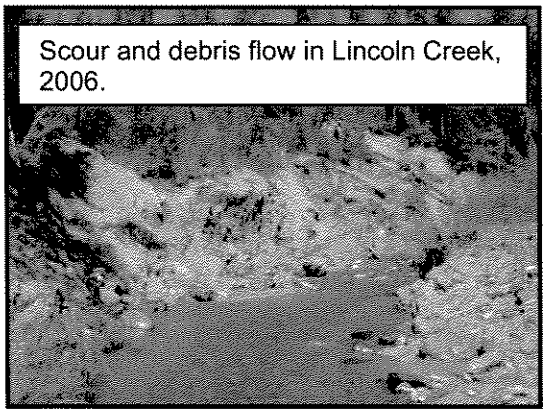


Figure 1

the Flathead Basin were documented to exhibit long spawning migrations, sometimes exceeding 100 miles (Fraley and Shepard 1989). The degree of migration and historic patterns of genetic exchange among lakes are not easily documented and were no doubt variable from lake to lake, but most lakes must have been initially colonized from downstream (i.e., Flathead Lake) following the end of the last ice age.

Glacier National Park is an area where very dynamic natural physical processes occur. Fire, flood, landslides, avalanches, debris flows, and other natural events frequently affect habitat for fish and terrestrial animals. Recently,



Scour and debris flow in Lincoln Creek, 2006.

the potential impacts of climate change in the Park was examined (GAO 2007) and it is believed that bull trout distribution may be one of the more sensitive indicators of changes in water temperatures as a result of climate change (GAO 2007, Rieman et al. 2007). In this report, we highlight concerns related to climate change in certain drainages that are dependent on glacial tributary streams, where loss of late-season snowfield or glacial melt-water (e.g., Upper Kintla Lake, Lake Isabel, Cerulean Lake, and Harrison Lake) could jeopardize bull trout reproduction in the foreseeable future.

We also discuss the dynamic nature of fish passage barriers. For our purposes, barriers were strictly defined as waterfalls or cascades with a vertical drop greater than 6 feet and some are quite large and obvious. However, in many cases a lesser obstacle can act as a temporary or partial barrier, especially at varying discharges. Some examples are described, such as scouring and debris flows (i.e., Bowman Creek, Lincoln Creek, see picture above) or velocity chutes (i.e., Camas Creek between Trout and Arrow lakes). Some barriers can also be temporary in nature, which is why we focus some recommendations on routine re-examination of known barriers.

Early in the 20th century, fishery resources of Glacier National Park (which was designated as America's 10th National Park by President Taft in 1910), were of public interest. Early in the Park's history, much of the interest in the fishery resources related to "improving" the existing fishery. The railroad moguls (who brought the first influx of visitors to future Park locations prior to formal designation) as well as early National Park Service administrators did not generally recognize the low productivity of the streams and lakes, especially west of the Continental Divide.

In 1933-1935, A.S. Hazzard, Associate Aquatic Biologist from the U.S. Bureau of Sport Fisheries who was detailed to write *Management Recommendations for Waters of Glacier National Park*, spent two years surveying and assessing fishery resources in Park waters. Hazzard (1935) concluded that "fishing is unusually good in the lakes of Glacier National Park" and "it is our opinion that the great majority of the waters of Glacier National Park are best adapted to the Native Cutthroat trout." Curiously, Hazzard's report made little mention of the other native trout species, bull trout.

Hazzard (1935) goes on to note that unlike the lake fishery: "Fishing has not been good in the majority of the streams in Glacier National Park in spite of generous stocking." This deficiency was attributed to low and intermittent late summer and winter flows, resulting from the natural hydrologic cycle and depletion of glacial melt with the

"coming of winter." The second factor cited for the lack of productivity was the low summer water temperatures which were believed to inhibit trout growth.

Hazzard (1935) was quite astute in observing that "in many lakes the spawning grounds are restricted to a few hundred yards of stream or even less." He also recommended supplemental stocking of 1-5 inch fingerlings for some waters, apparently believing that the populations were limited mainly by recruitment. He further noted that the larger and deeper lakes (specifically citing Upper St. Mary Lake on the east side and Bowman and McDonald lakes on the west side) had serious limitations in productivity from the deep configuration and lack of shoals and stated "...whether continued plantings in such lakes will prove worth while is highly problematical."

In a foreshadowing of things to come, Hazzard (1935) noted: **"It has been suggested by some that Mackinaw (i.e., lake trout) be introduced into the deep lakes of the west side to improve the fishing. It is true that food and other conditions are apparently suitable for this species and that it might furnish additional fishing. However in view of the tendency of this trout to spread into other waters and its extremely piscivorous habits such an introduction is not recommended in Glacier National Park."**

Fish stocking was a major portion of the fishery management program in the Park, from its earliest inception in 1912 (just two years after the Park was created) to about 1959 (Morton 1968). In this action plan we describe for each lake the major fish stocking activities, which consisted mainly of hatchery plants of nonnative species (brook trout, lake whitefish, rainbow trout, and even Chinook salmon and steelhead). By far the largest share involved over 10 million planted cutthroat trout, the vast majority of which were nonnative Yellowstone cutthroat trout, a different subspecies whose eggs were obtained from Yellowstone National Park. Many of those planted fish did not persist, but others are still viable today.

Of course, the major purpose of fish stocking was to promote recreational angling. In the second half of the 20th century the Park made an effort to track angler use and species composition in the catch. Some of those results provide meaningful insight into changes in the species composition in bull trout waters, due to species introductions. We report on several such transitions in the action plan. Hand in hand with recreational angling is the promulgation of fishing regulations. We note several instances where fishing regulations that may have evolved to fit one set of circumstances, now seem out of character with the objective of promoting bull trout conservation. In some cases, we recommend changes to the existing regulations and in nearly all cases we believe there needs to be greater emphasis on making anglers aware of practices that have the potential to seriously harm the remaining native fish resource.

This is a bull trout conservation plan and we focus much of our concern on the widespread establishment and negative impacts of two related nonnative *Salvelinus* species, the lake trout and brook trout. Because these two species

are closely related to bull trout they share many common attributes (e.g., food habits, behavior, and reproductive traits) and as a result seem to either compete directly with or replace bull trout populations throughout the Intermountain West (Donald and Alger 1993, Fredenberg 2002). While other introduced salmonid species may be widespread in the Park (e.g., kokanee and rainbow trout), their impacts to bull trout are not nearly so pronounced and in some cases they may even provide supplemental food resources.

Morton (1968), who developed the most comprehensive series of fishery management recommendations for Park waters to date, made note of the overall plight of bull trout. "The most notable feature of these streams and lakes is the presence of large Dolly Varden, or western brook charrs." He further notes: "These large spawners are very vulnerable to angler and bear predations as they run up these streams....." and goes on to conclude: "This is one good reason why *Salvelinus malma* is, or should be, on our endangered species list." (Note: *S. malma* was the previous name for bull trout, now *S. confluentus*).

Interestingly, over the nearly three-fourths of a century since Hazzard's 1935 writing and forty years since Morton (1968), we now understand how profoundly and tragically visionary their statements in regard to the potential spread of lake trout in large lakes on the west side of the Park have become. This action plan provides a framework for the management of compromised waters (i.e., those with established populations of lake trout or brook trout) and those waters where lake trout do not currently exist.

PURPOSE

In accordance with the legislation that established Glacier National Park and in keeping with subsequent policies governing natural resource protection and management in the Park, (USDI National Park Service 2001), the purposes of the Park are to:

- **Preserve and protect natural and cultural resources unimpaired for future generations.**

- **Provide opportunities to experience, understand, appreciate, and enjoy Glacier National Park consistent with the preservation of resources "in a state of nature."**

Consistent with that intent is National Park Service Management Policy that natural resources should be managed "to understand natural processes and human-induced effects; mitigate potential and realized effects; monitor ongoing and future trends; protect existing natural organisms, species populations, communities, drainages, and processes; and interpret these organisms, drainages and processes to the park visitor" (USDI National Park Service 2001). National Park Service Policy places high importance on the protection and restoration of native organisms and encourages suppression and removal of exotic species where prudent and feasible.

Approximately 95 percent of the Park was identified in 1974 as suitable for wilderness and, though not formally designated, Park backcountry has been managed consistent with that approach. In the years since Morton (1968) developed fishery management plans

for the Park, surveys of waters with bull trout resources have been conducted infrequently. The U.S. Fish and Wildlife Service, working cooperatively with the Park, conducted status surveys of the fish assemblages for several large lakes on the west side of the Park in 1969 and 1977. Through the development of a status assessment for the Montana Bull Trout Restoration Plan (MBTSG 1995), it became evident that comprehensive and recent status information for bull trout in Park waters was seriously lacking. Bull trout were listed as a threatened species under the U.S. Endangered Species Act in June of 1998 (U.S. Fish and Wildlife Service 1998). In 2000, the U.S. Fish and Wildlife Service resurveyed the major lakes on the west side of the Park, using similar methods to the 1969 and 1977 surveys. Results of the study indicated a broad decline in bull trout in most lakes sampled and a corresponding increase in nonnative lake trout (Fredenberg 2002). The study concluded that four of the five bull trout populations studied in the Park are at high risk of extirpation due primarily to incompatibility with introduced lake trout.

In 2002, the U.S. Fish and Wildlife Service published a Draft Bull Trout Recovery Plan (USFWS 2002). Among the high priority recovery tasks identified for the Flathead subunit and particularly targeted to lakes in the Park were:

- Conduct watershed problem assessments.
- Develop protocols for suppressing nonnative fish.
- Consider installing barriers to hinder spread of nonnative fish.
- Aggressively protect remaining native species complexes.
- Evaluate site-specific conflicts with introduced sport fish (i.e., lake trout).
- Develop standardized monitoring procedures.
- Map spawning habitat.
- Conduct genetic inventory.
- Increase monitoring of adfluvial bull trout in smaller lakes.

With those objectives in mind, in 2003 the U.S. Fish and Wildlife Service, Glacier National Park, and the Montana Cooperative Fishery Research Unit collaborated in developing a research proposal that would examine all the bull trout resources in the Flathead River Basin (i.e., west side) portions of the Park. This proposal was funded under the Science Support Partnership (SSP) program by the U.S. Geological Survey and the U.S. Fish and Wildlife Service. The primary objectives of the SSP proposal, abbreviated here, were to:

1) Evaluate bull trout status, demographics, spawning and recruitment potential in Park lakes west of the Continental Divide. Assess status of known nonnative *Salvelinus* invasions and potential for future invasions.

2) Implement baseline bull trout population inventory in the Quartz Creek drainage (considered unimpaired) and propose and implement a barrier strategy to preclude invasion.

3) With successful completion of the above steps, develop a comprehensive action plan.

The first two objectives were accomplished and scientific results are

reported by Meeuwig and Guy (2007) as well as in condensed form in the supplement to this report.

The primary purpose of this report is fulfilling the third objective of the proposal: ***"develop a comprehensive action plan for the long-term monitoring, management, and eventual recovery of bull trout resources in the lakes of Glacier National Park"***. The expectation is that this action plan will be used by the U.S. Fish and Wildlife Service and the National Park Service to implement bull trout recovery actions in Park waters.

This report is organized to facilitate stand-alone use of the action plan by Park staff members that may not necessarily be fisheries scientists. Within the action plan we have grouped the 17 lakes that were assessed into three **threat categories**:

- **Secure Lakes (5)** – Upper Kintla, Trout, Arrow, Isabel, and Upper Isabel.
- **Vulnerable Lakes (2)** – Akokala, Cerulean.
- **Compromised Lakes (10)** – Kintla, Bowman, Quartz, Middle Quartz, Lower Quartz, Logging, Rogers, Harrison, McDonald, and Lincoln.

Each of the three threat categories is described in greater detail in the action plan portion of the document that follows, along with some common characteristics and management needs for lakes in each category.

Within this action plan each lake is independently profiled within one of the three threat categories and designated with a priority level (high, medium, or low) for management attention. Additional information is provided on lake dimensions and barrier status (in most cases with maps provided in the supplemental appendices). Native and nonnative salmonid species presence, specific resource attributes, site-specific recommendations for management of each body of water and a profile of monitoring, research, and information needs are also presented.

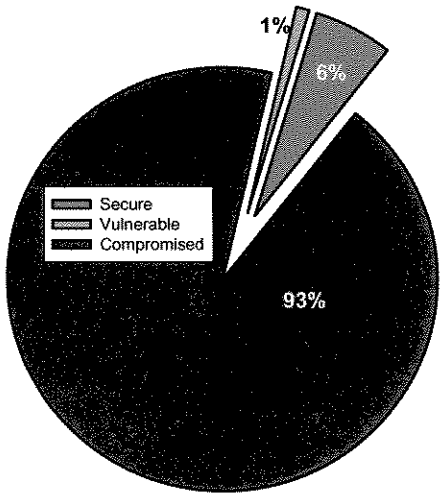


Figure 2. Percent of lake surface area by threat category.

The research summary, on the accompanying compact disk, is a conventional presentation of research results in a scientific report format. It condenses the more complete scientific results reported by Meeuwig and Guy (2007). The scientific support summary in this document is for readers desiring a more thorough analysis of some of the issues and data that may not be fully described in the action plan. The

sampling appendix, on the accompanying compact disk, is provided for scientific personnel and managers who will be implementing monitoring activities or other actions prescribed in the action plan.

It is our intent that this somewhat unconventional, but straight-forward and simplified presentation will facilitate long-term use of this action plan by Park administration and outreach staff, informing scientists and the public about the urgent nature of the protection and restoration of these important aquatic ecosystems. This format also lends itself to regular updates for specific bodies of water.

Some readers may perceive that this report presents a somewhat gloomy overall picture of the declining status of bull trout in the pristine headwater drainages of the Park, due primarily to the advancing threat of nonnative lake trout and brook trout. While we emphasize that serious threats are unfolding, it is also apparent that there is still time to attempt corrective actions in some waters. Such actions will require allocation of substantial resources, in some cases to largely experimental approaches, with varying degrees of uncertainty tied to the outcome. Specifically, an expanded commitment of both personnel and financial support is needed to develop an aquatic resource program within the Park.

It is often repeated in the popular lexicon that Glacier National Park represents the only ecosystem in the lower 48 States where the complete suite of native predators is still intact. The statement may be true for terrestrial animals, yet as this report illustrates, we are dangerously close to losing the top native fish predator from many portions of the Flathead Basin ecosystem in the Park. The authors of this report advocate a much more focused and aggressive approach to dealing with the proliferation of nonnative lake trout and brook trout in the Park.

Former Oregon Governor John Kitzhaber made some strong statements in the late 1990s while discussing the fate of native Pacific salmon in the Columbia River Basin. Kitzhaber's comments remain appropriate and are relevant to the fate of bull trout in the Park:

> ***"Some will say that we have not done enough science. I say that we can always play that card as an excuse for inaction and as a justification for avoiding tough choices."***

LAKE CATEGORIES AND PRIORITIES

Each of the seventeen study lakes are placed into one of three categories (secure, vulnerable, or compromised), based on common attributes we have documented during the three years of our study. Each of the three categories is described and shared attributes among the lakes within each category are discussed. While we treat each of the 17 lakes as an independent unit in the following action plan, the fate of bull trout populations and the course of nonnative species invasions in some drainages are much more closely tied to adjacent lakes than in others. In general, lakes that occur in sequence in the same drainage (e.g.,

Cerulean and the three Quartz Lakes, or Trout and Arrow in the Camas drainage) show a greater degree of genetic similarity (Meeuwig and Guy 2007), an indicator of more frequent historic or contemporary genetic exchange. These data suggest that these water bodies may be managed as a single unit. However, where fish passage barriers occur (e.g., between Kintla and Upper Kintla Lakes) genetic relationships may not be as close, even though the lakes are in close proximity. In the action plan, we identify many such relationships.

Secure Lakes – Upper Kintla, Trout, Arrow, Isabel, Upper Isabel

These five lakes are grouped together because they are all relatively small backcountry lakes with the documented presence of fish passage barriers in their drainages downstream. As a result, we consider these five lakes to have the most secure populations of bull trout on the west side of the Park. Consequently, the management emphasis for these lakes should be on long-term maintenance of current conditions. Collectively, secure lakes represent nearly one-third by number of the 17 adfluvial bull trout core areas in the Flathead Basin drainages of the Park, but due to their small size these five lakes constitute only about 6% of the surface area of lakes on the west side of the Park that are occupied by bull trout (Figure 2). Bull trout in secure lakes exhibit genetic evidence of long-term isolation from downstream waters (Meeuwig and Guy 2007). The available survey data suggest that the five bull trout populations we consider secure are self-sustaining. In our judgment these lakes are unlikely to become compromised by natural invasion of nonnative fishes or any anthropogenic changes within their watersheds in the foreseeable future. These conclusions are partially dependent on the continued integrity of existing barriers to upstream fish migration in these drainages. Their persistence is expected, but partially unpredictable given the unstable geological nature and flashiness of flow events in Park watersheds. The management needs for secure lakes include occasional verification of the integrity of the natural barriers, a low level of population assessment, and possible reevaluation of angling regulations. Secure lakes should be made high priority for ongoing information and education, both internally with Park staff and externally with the public.

Vulnerable Lakes – Cerulean, Akokala

The two lakes we categorized as vulnerable are grouped together because we believe there is a high likelihood that they could become compromised from potential invasion by nonnative *Salvelinus* spp. (i.e., lake trout and/or brook trout). Unlike the secure lakes, we did not document the presence of any physical structures that would preclude fish passage in the drainages downstream from these vulnerable lakes. As a result, we consider the vulnerable lakes to be among the most at-risk populations of bull trout in the Park and the management emphasis should be on active evaluation of methods to maintain or improve the status in these vulnerable bull trout waters. Each of these lakes represents a separate and unique set of circumstances and their management concerns are different. We recommend that site-specific actions be evaluated in each case (partially detailed in the following lake-specific

section) to ensure vulnerable lakes are not compromised in the future. These two lakes represent important resources in the Flathead Basin portion of the Park, but due to their small size these lakes constitute a small fraction (about 1%) of surface area of lakes on the west side of the park that are occupied by bull trout (Figure 2).

Compromised Lakes – Quartz, Logging, Middle Quartz, Lower Quartz, Bowman, Harrison, Lincoln, Kintla, McDonald, Rogers

These ten lakes represent over half of the 17 core area lakes containing adfuvial bull trout and collectively they represent 93% of the surface area of bull trout lakes on the west side of the Park (Figure 2). Nine of the lakes are compromised by lake trout and Lincoln Lake contains brook trout. A timeline, showing the gradual expansion of lake trout into Park lakes west of the Continental Divide at various points since 1959 (when they were first detected in Lake McDonald) illustrates how thoroughly the invasion has progressed (Figure 3). Seven of the ten lakes now compromised are over 100 surface acres. The status of the lake trout invasion and corresponding status of bull trout populations in each lake is variable. These invasions illustrate there are no physical barriers downstream of these lakes to preclude ongoing lake trout movement or future invasions of other species from other waters in the interconnected Flathead Basin. Other species established in Flathead Lake and elsewhere throughout the interconnected basin with the potential to invade these lakes include lake whitefish, rainbow trout, Yellowstone cutthroat trout, kokanee, and northern pike. We consider the ten compromised lakes to be at-risk and the bull trout populations are potentially vulnerable to extirpation. Again, each of the compromised lakes represents a unique set of circumstances so while we group

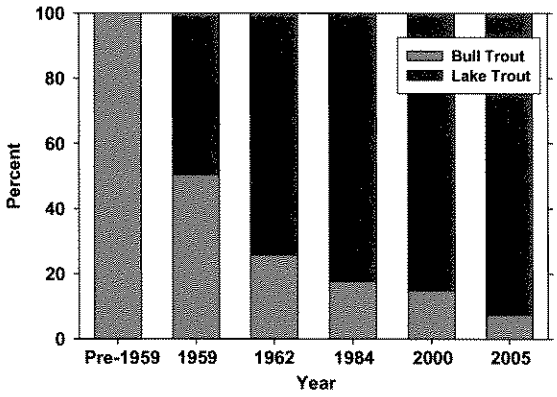


Figure 3. Percent of total surface area of lakes with bull trout occupied by lake trout.

them together in the same "compromised lakes" category their management needs may vary and we recommend that site-specific actions be evaluated in each case (partially detailed in the following lake-specific section). These ten lakes represent an overwhelming majority of the adfluvial bull trout resource in the Flathead Basin portions of the Park. In our judgment Kintla, Bowman, Quartz, Middle Quartz, Lower Quartz, Logging, Rogers, McDonald, Harrison and Lincoln lakes each offer variable opportunities for conservation of native fish resources. In the following action plan we have attempted to prioritize the needs.

Priority Levels Within Categories

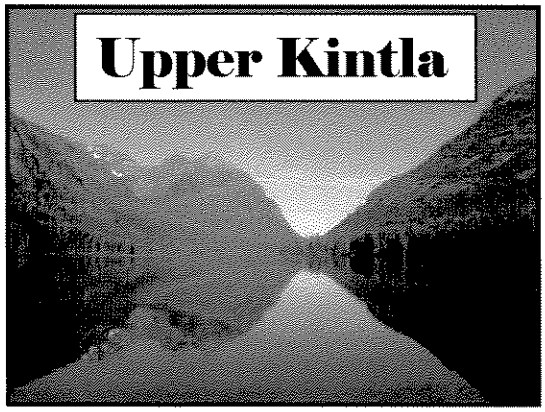
Within each category, each lake is assigned an individual priority level; high, medium, or low. These priority levels are meant to reflect the relative importance that should be placed on maintaining and protecting the bull trout resource in that particular water body. The priorities of these lakes vary according to the relative importance of the remaining bull trout populations and their security, potential resiliency, and genetic and biological status.

The priority levels we assigned provide Park managers with some relative sense of where limited resources should be allocated in the near future.

For example, all five lakes in the "Secure" category are ranked of high importance, as they represent the best protection against future extirpation of bull trout in the Park. However, limited active management is required in those secure lakes. The prioritization is probably most useful for lakes within the "Compromised" category, where we have assigned a relative ranking of "high" for lakes that we believe have the most potential resiliency in order to perpetuate the bull trout resource in those waters.

Matrix illustrating the relationship between lake category and management priority. See text above for definitions.

Management Priority Level	Lake Categories		
	Compromised	Vulnerable	Secure
High	Quartz Logging	Cerulean	Upper Kintla Trout Arrow Isabel Upper Isabel
Medium	Middle Quartz Lower Quartz Bowman Harrison Lincoln	Akokala	
Low	Kintla McDonald Rogers		



CATEGORY: Secure

PRIORITY LEVEL: High
All lakes in the secure category are considered high priority because their long-term protection is the best insurance against future extirpation of bull trout in Glacier National Park.

SURFACE AREA: 467 acres

MAXIMUM DEPTH: 183 feet

BARRIER STATUS:
A series of upstream fish migration barriers (likely impassable), including a 22 foot vertical falls, are located in the drainage downstream of Upper Kintla Lake (Figures 4 and 5). The absence of species other than bull trout in the lake and other genetic evidence reinforce the hypothesis that long-term isolation has occurred.

NATIVE SALMONIDS PRESENT:
Bull trout.

NONNATIVE SALMONIDS PRESENT:
None.

RESOURCE ATTRIBUTES:
Upper Kintla Lake has long been considered a unique refuge for bull trout in the Park and is possibly unique across the entire U.S. range, because no other fish species are known to occur in Upper Kintla Lake. The Park has recognized this uniqueness and fishing is not allowed in Upper Kintla Lake. Bull trout spawning occurs late (October) relative to other lakes in the Park. A portion of the bull trout spawning occurs in the outlet stream, which is also relatively unusual. Bull trout in Upper Kintla Lake do not appear to attain as large sizes as in other waters where mixed species assemblages are found, seldom exceeding 20 inches, perhaps due to prey limitations. The lake is mostly fed by Agassiz Glacier in late summer and fall and future loss of glacial melt could impact late summer streamflow and potentially affect the fall-spawning bull trout. Voluntary angler creel surveys conducted by the Park in 1959-1966 reported 130 bull trout caught in Upper Kintla Lake. Morton (1968) warned about the possibility for this lake to be overfished. In recent years the lake has been closed to fishing, as bull trout are still the only fish species known to be present.

MANAGEMENT RECOMMENDATIONS:
Status quo. Stringent protection of the Upper Kintla Lake fishery resource should be continued. Due to the uniqueness and importance of this drainage, risks associated with allowing angling (i.e., invasive species, overutilization, or other concerns) are probably best not taken and the lake currently provides an excellent model for research on an unexploited bull trout population existing in isolation from other fish species.

Monitoring Needs:

Downstream barriers isolating Upper Kintla Lake should be re-evaluated in 2010 and every five years thereafter, or following any major catastrophic runoff events, to ensure that log jams or other changes have not compromised barrier integrity. The fish population should be resurveyed in 2015 (see Appendix) and every ten years thereafter to collect additional biological data (e.g., age, growth, wild fish health, genetics) and to ensure that the existence of other species has not compromised the drainage. Sampling crews should use extreme caution when sampling to ensure they do not introduce invasive species.

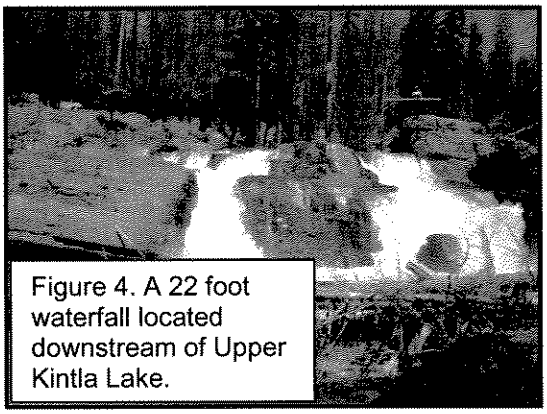


Figure 4. A 22 foot waterfall located downstream of Upper Kintla Lake.

Research Priorities:

More information about population size and reproductive demographics (e.g., timing and numbers, relative use of upstream locations compared to outlet spawning, site fidelity of upstream vs. downstream spawning bull trout) would be useful. Evaluate the contribution of Upper Kintla Lake stock to Kintla Lake stock (i.e., amount of out migration).

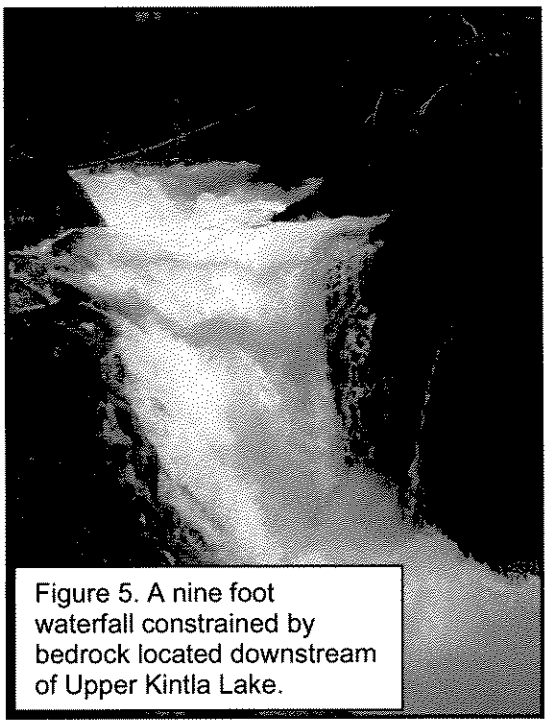
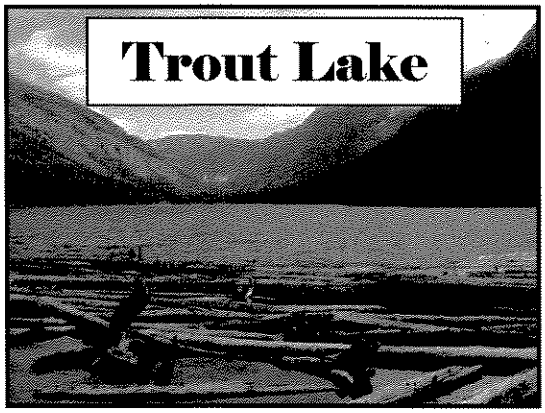


Figure 5. A nine foot waterfall constrained by bedrock located downstream of Upper Kintla Lake.

Information Needs:

The uniqueness of the Upper Kintla Lake bull trout population should be highlighted by the Park. Signs and interpretive displays, describing the unique natural history of these bull trout (e.g., no other fish species present, outlet spawning) and their importance in conserving the species in the Park should be developed. Corresponding outreach materials should also be available.



CATEGORY: Secure

PRIORITY LEVEL: High
All lakes in the secure category are considered high priority because their long-term protection is the best insurance against future extirpation of bull trout in Glacier National Park.

SURFACE AREA: 215 acres

MAXIMUM DEPTH: 163 feet

BARRIER STATUS:
A 24 foot vertical waterfall is located in Camas Creek downstream of Trout Lake (Figure 6). A much wider variety of both native and nonnative fish species was detected in Rogers Lake, immediately downstream of the barrier, providing further evidence of the effectiveness of this barrier and the long-term isolation it has provided. The absence of species other than bull trout, westslope cutthroat trout, and sculpins in Trout Lake (and only bull trout and cutthroat in Arrow), reinforces the determination that isolation of Trout and Arrow Lakes from the downstream drainage has occurred. There are no barriers between Trout and Arrow lakes, as defined in this report, though a very swift chute over flat rock at one location in the stream between the lakes may explain the presence of sculpins in Trout Lake not detected in Arrow. Evidence indicates Trout and Arrow Lake bull trout exhibit a high degree of genetic similarity and frequent genetic exchange between these lakes may occur.

NATIVE SALMONIDS PRESENT:
Bull trout, westslope cutthroat trout.

NONNATIVE SALMONIDS PRESENT:
None. Yellowstone cutthroat trout were stocked upstream in Camas Lake and elsewhere in the drainage, beginning in 1924, and are now common in Camas and Evangeline lakes. Plants of 125,000 cutthroat trout fry and fingerlings that occurred in Trout Lake in 1931-1933 (Morton 1968) were probably Yellowstone cutthroat, but there is little evidence they have persisted. Based on visual identification, Yellowstone cutthroat trout are common in Arrow Lake and upstream lakes, but not in Trout Lake.

RESOURCE ATTRIBUTES:
Trout Lake has been known as a bull trout refuge in the Park and is aptly named, as westslope cutthroat trout and sculpins are the only other native fish species found in Trout Lake. Morton (1968) noted that Schultz (1941) had emphasized cutthroat trout were especially abundant in Trout and Arrow lakes. Morton (1968) reported that voluntary angler creel surveys from Trout Lake in 1959-1966 included 1,140 cutthroat and 138 bull trout caught. Approximately twenty years later, voluntary angler survey results from Trout Lake for the period 1979-1986 (USFWS 1983 and 1987) indicated 568 cutthroat and, surprisingly, only 1 bull trout in the catch. Trout Lake had

among the highest bull trout net catch rates of any lake we sampled in 2000 (unpublished file data) and again in 2005.

Management Recommendations:

Care should be taken to avoid the movement of any fish species above the Camas Creek barrier. Introduction of nonendemic species would compromise the uniquely simple species assemblage now present. Cessation of angling in this drainage would further reduce the risk. If an angling closure is not implemented, we recommend an educational effort and regular angler contact by the Park Rangers and interpretive staff to highlight concerns and emphasize the unique qualities of the resource in Trout and Arrow lakes. The Park should consider developing a HACCP Plan (Hazard Analysis and Critical Control Point) and implement strategies that emerge from that analysis in drainages where anglers are identified to present high risk of invasive species introduction.

Monitoring Needs:

The downstream barrier isolating Trout and Arrow lakes should be reevaluated in 2010 and every five years thereafter, or following any major catastrophic runoff events, to ensure that log jams or other changes have not compromised barrier integrity. The fish population should be resurveyed in 2015 (see Appendix) and every ten years thereafter to collect additional biological data (e.g., age, growth, wild fish health, genetics) and to ensure that the existence of other species has not compromised the drainage.

Research Priorities:

Little is known about the location of spawning reaches in the Camas Creek drainage and the degree to which movement or interchange of bull trout may occur between Trout and Arrow lakes. Identification of bull trout spawning areas and potential follow-up with annual redd counts would be the best mechanism for monitoring bull trout trends in the future.

Information Needs:

Trout and Arrow lakes provide unique bull trout refugia that should be highly valued. Interpretive information at both trailheads (Camas Creek and Lake McDonald) and at both Trout and Arrow lakes, describing the unique qualities of these fisheries and their important role in conserving bull trout in the Park should be developed. Anglers must be advised of the importance of gently releasing any bull trout they catch. Direct warnings to anglers not to pack in or disperse any fish eggs, fish parts, or other foreign materials for bait, or otherwise engage in transfer of any potentially live aquatic matter is also needed. Corresponding outreach materials, such as a card with a picture of a bull trout and specific concerns could also be made available.

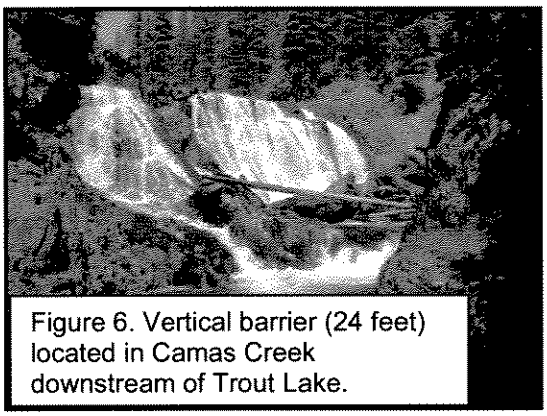
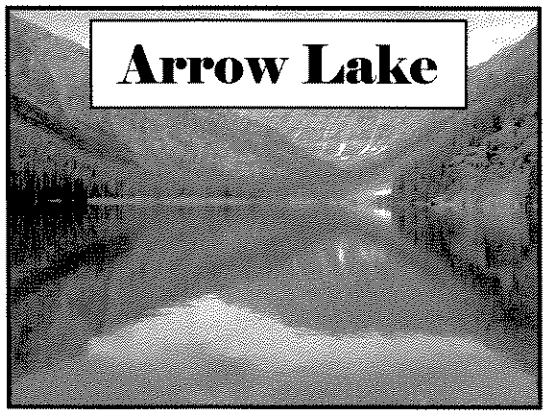


Figure 6. Vertical barrier (24 feet) located in Camas Creek downstream of Trout Lake.



CATEGORY: Secure

PRIORITY LEVEL: High
All lakes in the secure category are considered high priority because their long-term protection is the best insurance against future extirpation of bull trout in Glacier National Park.

SURFACE AREA: 59 acres

MAXIMUM DEPTH: 54 feet

BARRIER STATUS:
A 24 foot vertical waterfall is located in Camas Creek downstream of Trout Lake (Figure 7). A much wider variety of both native and nonnative fish species was detected in Rogers Lake, immediately downstream of the barrier, providing further evidence of the effectiveness of this barrier and the long-term isolation it has provided. The absence of species other than bull trout, westslope cutthroat trout, and Yellowstone cutthroat trout in Arrow Lake, reinforces the determination that isolation of Trout and Arrow Lakes from the downstream drainage has occurred. There are no barriers between Trout and Arrow lakes, as defined in this report, though a very swift chute over flat rock at one location in the stream between the lakes may explain the presence of sculpins in Trout Lake but not detected in Arrow Lake. Evidence indicates that bull trout in Trout and Arrow lakes exhibit a high degree of genetic similarity and frequent genetic exchange between these lakes may occur.

NATIVE SALMONIDS PRESENT:
Bull trout, westslope cutthroat trout.

NONNATIVE SALMONIDS PRESENT:
Yellowstone cutthroat trout were stocked upstream in Camas Lake and elsewhere in the drainage, beginning in 1924, and are now common in Camas and Evangeline lakes. Plants of 112,000 cutthroat trout eggs made into Arrow Lake tributaries in 1924 and 9,720 fry stocked in the lake itself in 1935 (Morton 1968) were probably Yellowstone cutthroat. Based on visual identification, Yellowstone cutthroat trout are common in Arrow Lake and upstream lakes and the rate of hybridization with westslope cutthroat is unknown.

RESOURCE ATTRIBUTES:
Arrow Lake is closely joined to Trout Lake downstream and bull trout genetic information indicates there is strong genetic similarity and potentially frequent genetic interchange. Morton (1968) reported that between 1959 and 1966 voluntary creel surveys at Arrow Lake indicated 668 cutthroat and 11 bull trout caught by anglers. Arrow Lake is less than one-third the size of Trout Lake and fewer bull trout were sampled in Arrow Lake than Trout Lake in 2005. Most of the bull trout sampled in Arrow Lake were adults, but several juveniles were sampled near the shoreline.

Management Recommendations:

The relocation of the campground in this drainage, from Trout Lake to Arrow Lake, following grizzly bear incidents in the late 1960s, has probably had the unintended consequence of increasing fishing pressure on Arrow Lake. Because Arrow Lake is small, the bull trout population is vulnerable and due to their aggressive nature bull trout could easily be overexploited. Introduction of nonendemic species would also compromise the uniquely simple species assemblage now present. Cessation of angling in this drainage would further reduce the risk. If an angling closure is not implemented, we recommend an educational effort and regular angler contact by the Park Rangers and interpretive staff to highlight concerns and emphasize the unique qualities of the resource in Trout and Arrow Lakes. The Park should consider developing a HACCP Plan (Hazard Analysis and Critical Control Point) and implement strategies that emerge from that analysis in drainages where anglers are identified to present high risk of invasive species introduction.

Monitoring Needs:

The downstream barrier isolating Trout and Arrow lakes should be reevaluated in 2010 and every five years thereafter, or following any major catastrophic runoff events, to ensure that log jams or other changes have not compromised barrier integrity. The fish population should be resurveyed about 2015 (see Appendix) and every ten years thereafter to collect additional biological data (e.g., age, growth, wild fish health, genetics) and to ensure that bull trout are not being overexploited by anglers or the introduction of other species has not compromised the status of the drainage.

Research Priorities:

Little is known about the location of spawning reaches in the Camas Creek drainage and the degree to which movement or interchange of bull trout may occur between Trout and Arrow lakes. Identification of bull trout spawning areas and potential follow-up with annual redd counts would be the best mechanism for monitoring bull trout trends in the future.

Information Needs:

Trout and Arrow lakes compose another unique bull trout refuge that should be highly valued. Interpretive information at both trailheads (Camas Creek and Lake McDonald) and at both Trout and Arrow Lakes, describing the unique qualities of these fisheries and their important role in conserving bull trout in the Park should be developed. Anglers must be advised of the importance of gently releasing any bull trout they catch. Direct warnings to anglers not to pack in or disperse any fish eggs, fish parts, or other foreign materials for bait, or otherwise engage in transfer of any potentially live aquatic matter is also needed. Corresponding outreach materials, such as a card with a picture of a bull trout and specific concerns could also be made available.

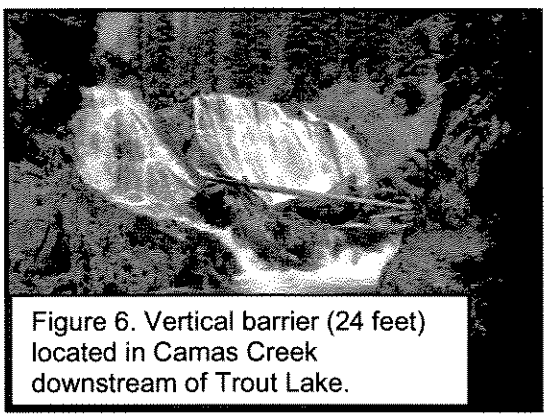
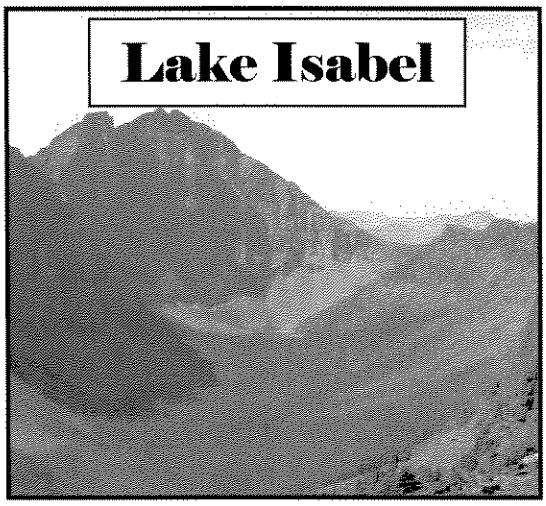


Figure 6. Vertical barrier (24 feet) located in Camas Creek downstream of Trout Lake.



CATEGORY: Secure

PRIORITY LEVEL: High
All lakes in the secure category are considered high priority because their long-term protection is the best insurance against future extirpation of bull trout in Glacier National Park.

SURFACE AREA: 44 acres

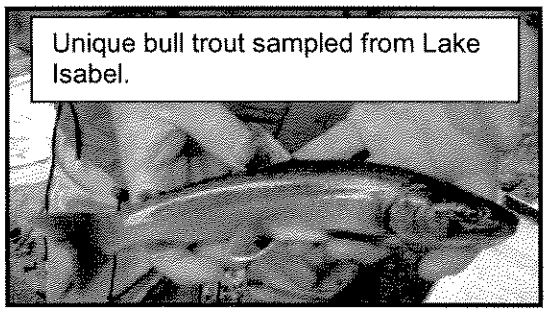
MAXIMUM DEPTH: 52 feet

BARRIER STATUS:
There are no barriers between Lake Isabel and Upper Lake Isabel. Several 6 foot to 9 foot vertical falls were documented in the Park Creek drainage not far downstream of Lake Isabel (Figure 7). The falls in Park Creek are believed to have functioned as long-term barriers to upstream migration. An intermittent barrier also occurs in the lower end of Park Creek. Morton (1968) reported there were barrier falls (which were estimated at 10-15 feet high, from helicopter observations), about one mile upstream from where Park Creek joins the Middle Fork Flathead River. However, Montana Fish, Wildlife & Parks staff conducted periodic bull trout redd counts in the Park Creek drainage and located as many as 87 redds, made by large migratory bull trout in certain years in the 1980s, most of which were upstream of the barrier location identified by Morton (1968). Personal communication with Montana Fish, Wildlife & Parks personnel indicated that in recent years redd counts were much lower and all redds were again downstream of the lowermost barrier site. This example illustrates the dynamic situation that barriers can represent and why regular monitoring and evaluation is needed.

NATIVE SALMONIDS PRESENT:
Bull trout, westslope cutthroat trout.

NONNATIVE SALMONIDS PRESENT:
None.

RESOURCE ATTRIBUTES:
Lake Isabel is the most unique of all bull trout populations in the Park, both genetically and phenotypically. Bull trout in Lake Isabel occur at the highest


Unique bull trout sampled from Lake Isabel.

density of any of the 17 lakes sampled. Of the 57 bull trout captured, none exceeded 12 inches in length. Age information indicated these fish were as old as 12 and most bull trout over 10 inches were mature adults. As early as the 1940s bull trout in Lake Isabel were noted to have unique qualities (Schultz 1941), including maturing at very small

size, typically 10-12 inches (Wasem and McClelland 1965). Lake Isabel had been stocked with 1,800 catchable-sized brook trout (from beaver ponds in Aster Creek on the south shore of Two Medicine Lake) in 1933, in anticipation of a visit by President Hoover (MacDonald 1985). It had been speculated in the past that the fish in Lake Isabel might represent a unique hybrid of bull trout X brook trout; however, there had been no direct evidence of brook trout persistence from the 1933 stocking nor corroboration of the hybridization hypothesis. Genetic analysis of 13 diagnostic microsatellite markers and mitochondrial DNA from 20 bull trout sampled from Lake Isabel in 2004 failed to detect brook trout hybridization (Pat DeHaan, U.S. Fish and Wildlife Service, personal communication).

Management Recommendations:

The connectivity with Upper Lake Isabel immediately upstream of Lake Isabel is not precluded by any barriers and the two lakes should be treated as a connected entity for management purposes. Limited genetic sampling from Upper Isabel did not indicate the strong genetic similarity that close proximity would presuppose, but due to the small sample size those results should be considered preliminary and further analyses are warranted. Much like for Trout and Arrow lakes, care should be taken to ensure that introduced species do not compromise this uniquely simple headwaters species assemblage. The remoteness of Isabel Lakes offers a certain degree of protection. Cessation of angling in this drainage would further reduce the risk. If an angling closure is not implemented, we recommend an educational effort and regular angler contact by the Park Rangers and interpretive staff to highlight concerns and emphasize the unique qualities of the resource in the Isabel lakes. Any recommendations from a HACCP Plan to prevent risk of invasive species introduction should also apply in this drainage. Overutilization by anglers does not presently appear to be a concern, given the high density of bull trout in Lake Isabel and remoteness of the location.

Monitoring Needs:

The downstream barriers isolating the two lakes should be reevaluated in 2010 and every five years thereafter, or following any major catastrophic runoff events, to ensure that log jams or other changes have not compromised barrier integrity. Further documentation of the intermittent barrier near the mouth would also be beneficial. The fish population should be resurveyed in 2015 (see Appendix) and every ten years thereafter to collect additional biological data (e.g., age, growth, wild fish health, genetics) and to ensure that the existence of other species has not compromised the drainage.

Research Priorities:

Further research into the morphology, habits, and natural history of this unique "dwarf" bull trout phenotype would be warranted, as well as a more comprehensive assessment of the degree of genetic similarity between bull trout from Lake Isabel and Upper Lake Isabel.

Information Needs:

The true uniqueness of the Isabel Lakes bull trout populations, perhaps throughout the species range, should be emphasized. Interpretive information at the trailheads on both sides of the divide

and/or at Park Creek Patrol Cabin, describing the unique life history features of Lake Isabel bull trout and their importance in preserving the species in the Park should be developed. Anglers must be advised of the importance of gently releasing any bull trout they catch. Direct warnings to anglers not to pack in or disperse any fish eggs, fish parts, or other foreign materials for bait, or otherwise engage in transfer of any potentially live aquatic matter is also needed. Corresponding outreach materials, such as a card with a picture of a bull trout and specific concerns could also be made available.

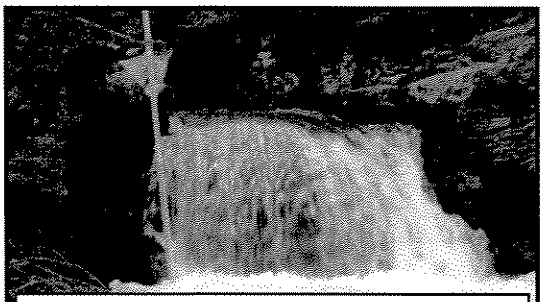
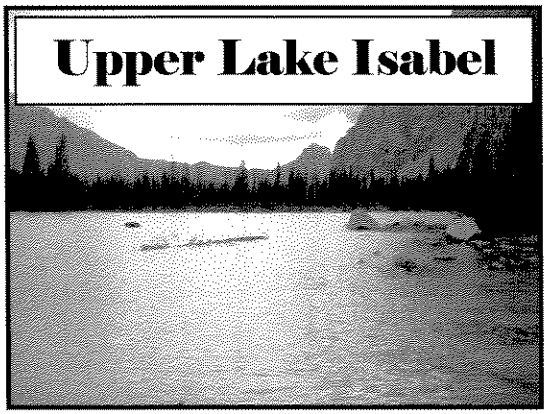


Figure 7. Six foot waterfall downstream of Lake Isabel and Upper Lake Isabel in the Park Creek drainage.



CATEGORY: Secure

PRIORITY LEVEL: High
All lakes in the secure category are considered high priority because their long-term protection is the best insurance against future extirpation of bull trout in Glacier National Park.

SURFACE AREA: 12 acres

MAXIMUM DEPTH: Unknown

BARRIER STATUS:
Several 6 foot to 9 foot vertical falls were documented in the Park Creek drainage not far downstream of Lake Isabel (Figure 8). The falls in Park Creek are believed to have functioned as long-term barriers to upstream migration, isolating these two lakes. Morton (1968) noted outstanding cutthroat trout fishing in Upper Lake Isabel and stated there was probably a natural falls barrier between the two lakes. We surveyed the stream between Lake Isabel and Upper Lake Isabel and found no barriers.

NATIVE SALMONIDS PRESENT:
Bull trout, westslope cutthroat trout.

NONNATIVE SALMONIDS PRESENT:
None.

RESOURCE ATTRIBUTES:
Fish populations in Upper Lake Isabel have not been extensively sampled, either in our survey or previously. Preliminary results from our limited sample of bull trout from Upper Lake Isabel (n = 7) indicates a surprising and relatively high degree of genetic differentiation between the two lakes. Existing records do not indicate that the uniquely small phenotype of bull trout found in Lake Isabel is also present in Upper Lake Isabel. However, based on physical connectivity and close proximity we still recommend that they be managed as a closely related pair, pending further examination. Upper Lake Isabel is the highest elevation lake (5989 feet msl) containing bull trout on the west side of the Park and also the smallest (12 acres). The lake is turbid from fine suspended glacial sediment and portions of the shoreline were impacted by the Rampage Complex fires in the drainage in 2003. Upper Lake Isabel sits in a cirque beneath a snowfield at the head of the Park Creek drainage, with very limited drainage area upstream. Future loss of glacial melt water could impact late summer streamflow and affect the fish assemblage.

MANAGEMENT RECOMMENDATIONS:
More information is needed before definitive conclusions can be made about the status and management needs of bull trout in this lake. Upper Lake Isabel is very small and due to their aggressive nature, bull trout in this lake (which probably number considerably fewer than 100 adult fish) are vulnerable to potential overexploitation by anglers. The

remoteness of the location does provide some protection. Cessation of angling in this drainage would further reduce the risk. If an angling closure is not implemented, we recommend an educational effort and regular angler contact by the Park Rangers and interpretive staff to highlight concerns and emphasize the unique qualities of the resource in the Isabel lakes. Any recommendations from a HACCP Plan to prevent risk of invasive species introduction should also apply in this drainage.

Monitoring Needs:

The downstream barriers isolating the Isabel lakes should be reevaluated every five years, beginning in 2010. The fish population should be resurveyed in 2015 (see Appendix) and every ten years thereafter.

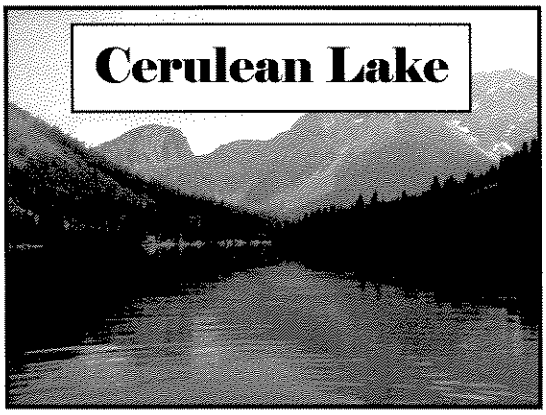
Research Priorities:

More information about the demographics of the Upper Lake Isabel bull trout population, their spawning location, and the degree of interchange with the downstream lake would be useful in setting management priorities. As this is the smallest and highest lake in the Park with a self-sustaining bull trout population, it represents one end of the spectrum for research opportunities.

Information Needs:

The uniqueness of the bull trout populations in both Isabel lakes should be emphasized. Interpretive information describing the unique life history features of bull trout in the Isabel lakes and their importance in preserving the species in the Park should be developed. Anglers must be advised of the importance of gently releasing any bull trout they catch. Direct warnings to anglers not to pack in or disperse any fish eggs, fish parts, or other foreign materials for bait, or otherwise engage in transfer of any potentially live aquatic matter is also needed. Corresponding outreach materials, such as a card with a picture of a bull trout and specific concerns could also be made available.

Figure 8. Six foot waterfall downstream of Lake Isabel and Upper Lake Isabel in the Park Creek drainage.



CATEGORY: Vulnerable

PRIORITY LEVEL: High
Cerulean Lake is of considerable importance, due to its position at the head of the Quartz drainage. Fish assemblages and species interactions that may occur in Cerulean Lake have the potential to influence all three downstream lakes in the Quartz drainage. In the past, the relatively pristine habitat and seldom-fished status have made Cerulean Lake an excellent benchmark to evaluate natural function for similar lakes across the species range, but that status is now at risk due to potential lake trout invasion.

SURFACE AREA: 49 acres

MAXIMUM DEPTH: 118 feet

BARRIER STATUS:
Cerulean Lake is at the head of the Quartz Creek drainage with limited drainage area upstream. Several high gradient cascades occur within stream reaches in the Quartz Creek drainage, especially in a narrow canyon between Lower Quartz and Middle Quartz lakes. However, no impassable fish passage barriers occur between the North Fork Flathead River and Cerulean Lake. The lake appears highly vulnerable to invasion from downstream.

NATIVE SALMONIDS PRESENT:
Bull trout, westslope cutthroat trout, mountain whitefish.

NONNATIVE SALMONIDS PRESENT:
None.

RESOURCE ATTRIBUTES: Cerulean Lake is extremely difficult to access, with no trail beyond the lower end of Quartz Lake. Consequently, it is seldom visited and the fish population is believed to be virtually unexploited. Morton (1968) reported that next to nothing was known about this difficult-to-access lake and that the first report that it even contained fish was not received until two anglers reported going there in 1963. Morton noted: ".....here is another possible precious unspoiled isolated population of native indigenous cutthroats to add to our gene pool of rare trouts." Cerulean Lake continues to be the least impacted by humans of all Glacier National Park lakes containing bull trout. The lake is mostly fed by runoff from Rainbow Glacier in late summer and fall and future loss of glacial melt could impact late summer streamflow, potentially affecting fall-spawning species like bull trout and mountain whitefish. The genetic similarity we documented among bull trout from the four lakes in the Quartz Lake drainage is a probable indication that regular gene flow has occurred and is likely still occurring. For that reason, it is critical that the entire Quartz drainage be evaluated and managed as an interconnected unit.

Management Recommendations:

The density of bull trout in Cerulean is low; perhaps a function of the small size of the lake and limited spawning and rearing habitat upstream of Cerulean Lake. Therefore, concern regarding overutilization by anglers is warranted, but difficulty of access limits visitation to only a few people each year. This lake could be a very high priority candidate for installation of a fish passage barrier; however, there is uncertainty whether lake trout may have already invaded. In preliminary searches we were unable to identify any sites where a barrier could be easily constructed. This lake was placed in the vulnerable category because, unfortunately, Cerulean Lake is possibly the next lake "most likely to be invaded" by lake trout, given the relatively recent population downstream in Quartz Lake and easily negotiable stream corridor. If invaded, Cerulean Lake has suitable attributes (cold and deep) to support establishment of a self-sustaining lake trout population. Angling regulations throughout the Quartz drainage should include catch and kill requirements for lake trout. Anglers who intend to visit Cerulean Lake could be required to check in at the North Fork Ranger Station in Polebridge, so that follow-up documentation of observations from their visit can be gathered by Park authorities.

Monitoring Needs:

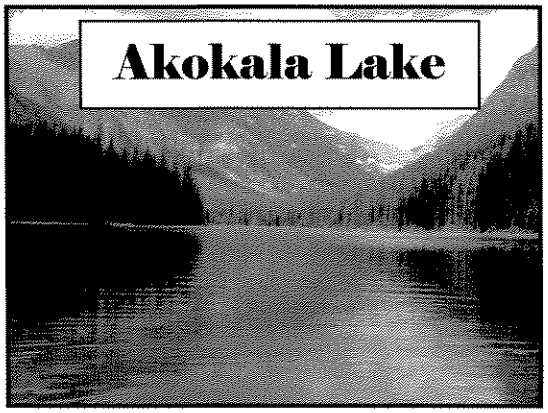
The fish population should be resurveyed in 2015 (see Appendix) and every ten years thereafter to collect additional biological data (e.g., age, growth, wild fish health, genetics) and to ensure that bull trout are not being overexploited by anglers and that invasion of other species has not further compromised the drainage.

Research Priorities:

Cerulean Lake currently presents a good model for further research on intact natural alpine lake fisheries and associated aquatic communities. The Montana Cooperative Fishery Research Unit is currently assessing bull trout spawning and rearing in the stream between Quartz and Cerulean lakes. The information will directly apply to further research questions in the Quartz drainage.

Information Needs:

Because Cerulean Lake is currently highly vulnerable to lake trout invasion, interpretive information at the Quartz Lake campground should notify anglers of this concern and ask anglers to carefully document any lake trout catches in the drainage (preferably photo identification) and to also kill any lake trout caught. The uniqueness and vulnerability of the bull trout population in Cerulean Lake, as it occurs in a small, pristine, isolated headwater cirque, should be emphasized.



CATEGORY: Vulnerable

PRIORITY LEVEL: Medium
The small size, combined with lack of any known unique bull trout population characteristics, make Akokala Lake a somewhat lower priority for bull trout conservation needs. Also, there are doubts about suitability of the habitat for colonization and persistence of lake trout, though brook trout might thrive here.

SURFACE AREA: 22 acres

MAXIMUM DEPTH: 23 feet

BARRIER STATUS:
No identifiable fish barrier was documented in Akokala Creek downstream of the lake; however, the stream is small, highly braided, shallow, with numerous beaver dams and dead-fall. Summer water temperatures in Akokala Creek are also very warm. We speculate these factors may combine to make Akokala Creek less attractive, but not protected from upstream invasion by lake trout.

NATIVE SALMONIDS PRESENT:
Bull trout, westslope cutthroat trout, mountain whitefish.

NONNATIVE SALMONIDS PRESENT:
None. Morton (1968) indicates 32,480 cutthroat trout fingerlings, presumably Yellowstone cutthroat, were stocked in 1937 but there is no evidence they persisted.

RESOURCE ATTRIBUTES:
Akokala Lake is relatively small and one of the shallowest bull trout waters in Glacier National Park. However, bull trout abundance was relatively high in our survey and the largest bull trout sampled in the study (30.7 inches) was sampled from Akokala Lake. The length of the drainage (11.1 miles) and potential difficulty of upstream passage from the North Fork Flathead River may provide some degree of isolation and protection from invasion by lake trout or other nonnative fishes. However, genetic results indicate only moderate differentiation between the Akokala Lake bull trout population and bull trout from adjacent waters, suggesting the potential for natural dispersal. Additionally, the Quartz drainage was similarly isolated and lake trout invasion has recently occurred in that drainage; therefore, the potential for invasion by nonnative species should not be disregarded. Voluntary angler creel reports from Akokala Lake in 1959 through 1966 indicated 210 cutthroat and 13 bull trout were caught by anglers (Morton 1968).

MANAGEMENT RECOMMENDATIONS:
Because Akokala Lake is so small, the bull trout population is limited and vulnerable to overexploitation by

anglers. Further restrictions on angling, such as complete closure, would probably reduce the risk of overexploitation and should be considered. Any recommendations from a HACCP Plan, to prevent risk of invasive species introduction, should also apply in this drainage. Akokala Lake could be considered one of the lakes "most likely to be invaded" by lake trout, brook trout, or rainbow trout should they become established in or obtain access to lower Akokala Creek. We also recommend an educational effort and regular angler contact by Park Rangers and interpretive staff to highlight concerns. This lake would be among the highest priorities for consideration of placement of a fish passage barrier. However, the uncertainty of whether lake trout may have already invaded, the potential unsuitability of lacustrine habitat for lake trout to colonize, and our inability to identify any sites where a barrier could be easily constructed complicate consideration of a barrier.

Monitoring Needs:

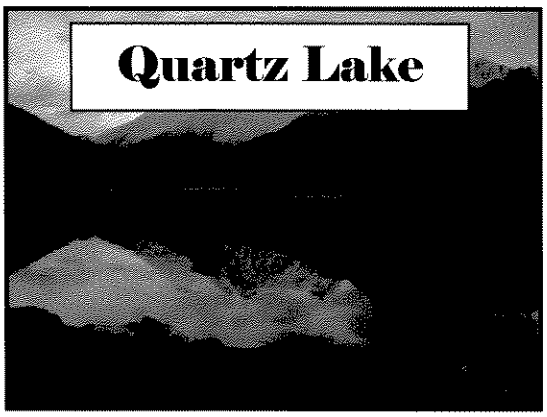
Akokala Creek downstream of the lake should be reevaluated in 2015 and every ten years thereafter or following any major catastrophic runoff events, to reexamine opportunities for reinforcing any natural barriers that may develop. The fish population should be resurveyed in 2015 (see Appendix) and every ten years thereafter to collect additional biological data (e.g., age, growth, wild fish health, genetics) and to ensure that bull trout are not being overexploited by anglers or the invasion of other species has not compromised the drainage.

Research Priorities:

Continued emphasis should occur on evaluating means and efficacy of placing a barrier in Akokala Creek. Evaluation of the likelihood that invasion by lake trout, brook trout, or rainbow trout will occur is also an ongoing need.

Information Needs:

Because Akokala Lake is highly vulnerable to lake trout invasion, interpretive information at the trailheads should notify anglers of invasive species concerns and ask anglers to carefully document any lake trout or brook trout catches in this drainage (preferably accompanied by photo documentation).



CATEGORY: Compromised

PRIORITY LEVEL: High
Quartz Lake currently hosts the most viable and least impacted bull trout population remaining among the larger lakes in Glacier National Park. Protection from near-term decline in the face of lake trout invasion is critically important to the conservation of bull trout in the Park, with implications to the entire Flathead Basin. This lake is the highest priority among waters in the compromised category.

SURFACE AREA: 869 acres

MAXIMUM DEPTH: 273 feet

BARRIER STATUS: Several high gradient cascades occur within stream reaches in the Quartz Creek drainage, especially in a narrow canyon between Lower Quartz and Middle Quartz lakes. However, no impassable fish barriers occur from Cerulean Lake downstream to the North Fork Flathead River. Quartz Lake remains vulnerable to further invasion from downstream.

NATIVE SALMONIDS PRESENT: Bull trout, westslope cutthroat trout, mountain whitefish.

NONNATIVE SALMONIDS PRESENT: Lake trout were first documented in 2005, presumably from upstream migration from the Flathead Basin. Lower Quartz Creek was also stocked with over 80,000 cutthroat trout between 1935 and 1944, Lower Quartz Lake with nearly 250,000 cutthroat between 1934 and 1940, and Quartz Lake with 8,550 cutthroat fry in 1940 (Morton 1968). These were presumably Yellowstone cutthroat trout, but there is no evidence those fish persisted in this drainage.

RESOURCE ATTRIBUTES: Quartz Lake is the largest (and 3rd highest) in a chain of four lakes in the Quartz and Rainbow Creek drainages of the North Fork Flathead River Basin. Morton (1968) indicated that the existing native salmonid species complexes of Quartz Lake and Lower Quartz Lake were first described by O'Brien and Carter in 1927 and that Garlick (1950) wrote: "Quartz Lake, famous for its excellent fishing, has fine spawning area available in the stream at the head of the lake." Voluntary angler creel surveys from Quartz Lake in 1959-1966 (Morton 1968) reported 966 cutthroat and 58 bull trout caught. Subsequent volunteer angler survey results for the period 1979-1986 (about twenty years later, with no attempt to standardize angler effort) indicated a catch of 137 cutthroat and 20 bull trout (USFWS 1983 and 1987). Until the discovery of invasive lake trout in 2005, Quartz Lake was considered to be among the largest natural bull trout lakes in the Columbia River Basin that contained an intact native fish assemblage – one of the "Crown Jewels" of the Crown of the Continent. In 2004, prior to the documentation of lake trout presence,

an attempt to place a fish barrier in Quartz Creek between Lower Quartz Lake and Middle Quartz Lake was started. It was subsequently abandoned, short of completion, upon the discovery of lake trout in Quartz Lake. Bull trout redd counts were initiated in 2003, upstream of Quartz Lake, and have been highly variable, varying from 14 (2007) to 55 (2004). Variation probably reflects annual streamflow conditions, rather than any measurable impact from lake trout to date. Bull trout redds have been well-distributed through the first 0.9 miles of stream upstream of Quartz Lake (see Appendix). Our sampling results in Quartz Lake and Quartz Creek in 2000, 2005, and 2006 showed consistently high bull trout catch rates and indicate a robust native fish community including westslope cutthroat trout, mountain whitefish, longnose sucker, largescale sucker, redside shiner, and sculpin. Bull trout were well-distributed across multiple year classes. The genetic similarity among bull trout from the four lakes in the Quartz Lake chain is a likely indication that fish are highly mobile throughout the drainage.

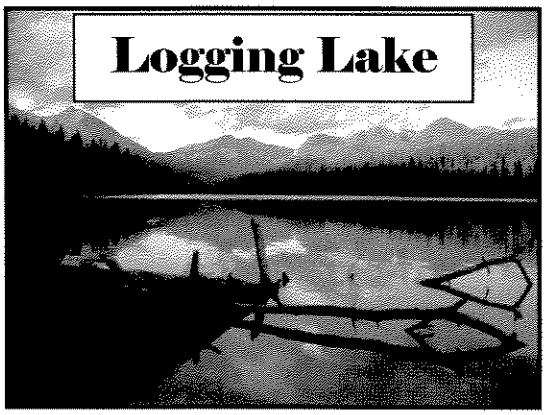
MANAGEMENT RECOMMENDATIONS: It is expected that if lake trout successfully reproduce in Quartz Lake (suspected and anticipated, but not yet confirmed), then the entire Quartz Lake chain will be severely and perhaps permanently compromised for native fish and wildlife (including effects on osprey, otters, eagles, loons, and bears). Based on current knowledge, we recommend an angling regulation be considered that would require all lake trout caught by anglers in the Quartz Creek drainage be killed immediately and either consumed, packed out, or sunk in deep water in the lake. At the early stage of invasion fish removal efforts to eliminate even a few potential reproductive lake trout may be beneficial. Current efforts must be aimed at rapidly gaining as much information as possible about the dynamics of lake trout in the Quartz Lake drainage. Suppression of lake trout in the Quartz Lake drainage is likely to be a more advantageous approach to conserving bull trout in the Park than restoration efforts in other more heavily-compromised waters.

MONITORING NEEDS: Redd counts, initiated in 2004, should be continued indefinitely (see Appendix). Lake-wide gill net survey, re-established on a five-year rotation beginning in 2000 and 2005 should be repeated in 2010 and every fifth year thereafter (see Appendix). Of particular interest is the documentation of any lake trout reproduction in Quartz Lake. If a lake trout suppression effort were to be implemented, then an ongoing monitoring strategy would be needed to measure the response.

RESEARCH PRIORITIES: Beginning in summer 2007, the Montana Cooperative Fishery Research Unit began evaluating bull trout spawning demographics and early life history in Quartz Creek upstream of Quartz Lake. The intent is to determine life history characteristics and population parameters prior to lake trout establishment, to provide a benchmark against which future conservation efforts can be measured. Additional research on movement patterns (especially to Cerulean Lake), spawning locations of lake trout within the Quartz drainage, salmonid genetic relationships and interchange, assessment of the potential value and

consequences of completing the partial barrier downstream of Middle Quartz Lake, and ways to effectively control or suppress lake trout are important research priorities.

INFORMATION NEEDS: Trailhead interpretive information should be developed that informs anglers of special regulations and management concerns, including information on how to reliably differentiate between lake trout and bull trout and the potential impact lake trout may have on aquatic and terrestrial ecosystems. Anglers must be advised of the importance of gently releasing any bull trout they catch. Direct warnings to anglers not to pack in or disperse any fish eggs, fish parts, or other foreign materials for bait, or otherwise engage in transfer of any potentially live aquatic matter is also needed. Corresponding outreach materials, such as a card with a picture of a bull trout and specific concerns could also be made available. Continued planning and implementation of a university field course, to provide cooperative long-term study of various aspects of the Quartz ecosystem, should be pursued with Montana State University or other interested partners.



CATEGORY: Compromised

PRIORITY LEVEL: High
Logging Lake historically supported one of the most productive bull trout populations in the Flathead Basin and the potential for recovery is higher than for most other large lakes (e.g., Kintla, Bowman, and McDonald). High quality upstream spawning and rearing habitat remains available.

SURFACE AREA: 1,114 acres

MAXIMUM DEPTH: 198 feet

BARRIER STATUS: A large 23 foot vertical falls, about 0.7 miles upstream of Logging Lake (Figure 9), stops fish migration upstream of Logging Lake to Grace Lake, which was historically fishless. Morton (1968) noted that downstream of the falls the "quality of the stream for spawning" is very high. Our study concluded there are no fish passage barriers in Logging Creek downstream of Logging Lake to the North Fork Flathead River. A note in Glacier National Park files indicates a Park biologist visually surveyed lower Logging Creek on August 2, 1967, in attempts to learn why kokanee from the Flathead River were not reaching Logging Lake. He reported "There are no appreciable waterfalls evident, though in a number of places there are log jams, probably formed during the 1964 flood." Log jams are still present throughout Logging Creek downstream of Logging Lake to the North Fork Flathead River; however, their structure is similar to log jams observed in other streams in the Park and are not presumed to represent significant impediments to fish movement.

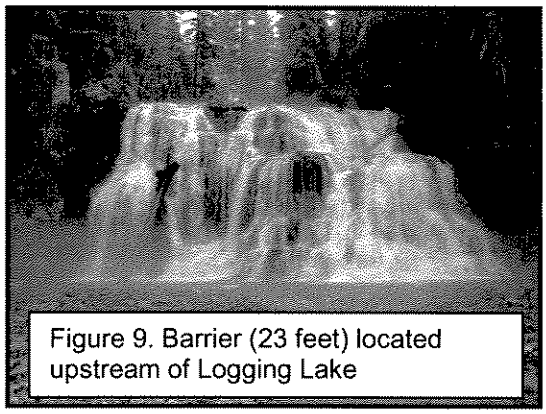


Figure 9. Barrier (23 feet) located upstream of Logging Lake

NATIVE SALMONIDS PRESENT: Bull trout, westslope cutthroat trout, mountain whitefish.

NONNATIVE SALMONIDS PRESENT: Lake trout were first documented in 1984, presumably from upstream migration from the Flathead Basin. Between 1934 and 1944, about 97,000 cutthroat trout fry and fingerlings were stocked in lower Logging Creek and 202,000 in Logging Lake (Morton 1968). These were presumably Yellowstone cutthroat trout, but there is no evidence those fish persisted in this drainage.

RESOURCE ATTRIBUTES: Logging Lake was historically considered an excellent bull trout fishery. Morton (1968) quotes Garlick (1950): "Logging and Quartz provide excellent fishing while McDonald, Bowman, and Kintla are only fair to poor". Prior to 1984, lake

trout were not known to occur in Logging Lake and in the 23 years since then lake trout appear to have steadily replaced bull trout. In 2005 lake trout outnumbered bull trout nearly 4:1 and Logging Lake had the second lowest catch rate for bull trout of any lake sampled. Logging Lake is more productive than other large lakes on the west side of the Park, with large beds of aquatic macrophytes at both ends. Logging Lake is the only lake other than Lake McDonald with an abundant population of northern pikeminnow, a native cyprinid. Genetic evaluation of bull trout from Logging Lake indicated the greatest similarity was with lakes in the adjacent Quartz drainage. Redd counts in Logging Creek upstream of the lake, first initiated in 2004, have provided variable results; however, a maximum of 20 redds were observed in 2005. Bull trout redds have been located as far as 0.7 miles upstream of the lake, near the barrier falls. Morton (1968) reported a summary of voluntary creel census results between 1959 and 1966. Anglers fishing Logging Lake reportedly caught 1,096 cutthroat trout and 245 bull trout. Subsequent volunteer angler survey results (USFWS 1983 and 1987) for the period 1979-1986 (about twenty years later, with no effort to standardize sample sizes) indicated a catch of 571 cutthroat, 226 bull trout, and 7 lake trout (the latter all caught in 1984-1986).

MANAGEMENT RECOMMENDATIONS: We view partial recovery of bull trout in Logging Lake as a feasible prospect because of the relatively high quality and availability of bull trout spawning and rearing habitat in the Logging Creek drainage. Preservation of the bull trout genetic resource in Logging Lake should be a high priority. Lake trout suppression in Logging Lake would be feasible, though logistically difficult, given the unavailability of road access. Such a program would require a long-term commitment, but a natural increase in native bull trout and westslope cutthroat trout populations would likely result. Angling regulations that set no limits or restrictions on lake trout harvest should be instituted in Logging Lake, consistent with Kintla, Bowman, and McDonald, providing an important message to the public that the species is not desired in Park waters west of the Continental Divide.

MONITORING NEEDS: Lake-wide gill net surveys were re-established on a five-year rotation, beginning in 2000 and 2005, and should be repeated in 2010 and every fifth year thereafter (see Appendix). If a lake trout suppression effort is implemented, then an ongoing evaluation strategy should accompany the effort to measure response. It is also imperative that annual bull trout redd counts, initiated in 2004 upstream of Logging Lake be continued indefinitely (see Appendix).

RESEARCH PRIORITIES: Ongoing documentation of the status and demographics of the bull trout resource in Logging Lake is needed. The collapse of bull trout, following lake trout introduction, appears to have occurred more rapidly in Logging Lake (~ 20 years) than in other waters. We consider Quartz, Logging, and Bowman lakes, in that order, as the highest priorities for potential lake trout suppression efforts in the future.

INFORMATION NEEDS: The trailhead and patrol cabins on both ends of the lake should be posted with interpretive information to educate anglers about the current status of the fishery. Staff should be educated about the past and current status of this resource and the potential to implement future recovery actions, so that information is accurately transmitted to interested public.

CATEGORY: Compromised

PRIORITY LEVEL: Medium
Middle Quartz Lake is closely connected to Quartz Lake and nearly all of the same resource attributes, species assemblage, and concerns and recommendations apply. We have rated it a step lower in priority because of its small size and lack of nearby bull trout spawning habitat. It is believed that the fate of bull trout in Middle Quartz is closely tied to Quartz Lake and they may in fact represent the same population.

SURFACE AREA: 47 acres

MAXIMUM DEPTH: 41 feet

BARRIER STATUS: Several high gradient cascades occur within stream reaches in the Quartz Creek drainage, especially in a narrow canyon between Lower Quartz and Middle Quartz lakes. However, no impassable fish passage barriers occur from Cerulean Lake downstream to the North Fork Flathead River. Middle Quartz Lake is separated from upstream Quartz Lake by only 0.25 miles of low gradient and easily passable stream channel. Middle Quartz Lake remains vulnerable to invasion from downstream.

NATIVE SALMONIDS PRESENT: Bull trout, westslope cutthroat trout, mountain whitefish.

NONNATIVE SALMONIDS PRESENT: Lake trout were first documented in Quartz Lake in 2005, presumably from upstream migration from the Flathead Basin (they would have had to pass through Middle Quartz Lake to get there). To date, there are no actual records of lake trout in Middle Quartz Lake. Lower Quartz Creek was also stocked with over 80,000 cutthroat trout between 1935 and 1944; Lower Quartz Lake with nearly 250,000 cutthroat between 1934 and 1940; and Quartz Lake with 8,550 cutthroat fry in 1940 (Morton 1968). These were presumably Yellowstone cutthroat trout, but there is no evidence those fish persisted in this drainage.

RESOURCE ATTRIBUTES: Middle Quartz Lake is relatively small and shallow, though gill net sampling indicates it hosts a relatively high abundance of bull trout. In recent surveys (annually since 2004), no bull trout spawning redds have been identified in Quartz Creek upstream of Middle Quartz Lake, and it is possible and considered likely that both Quartz and Middle Quartz share the same population of fish, with spawning occurring upstream of Quartz Lake. It is highly likely that fish move freely between Quartz and Middle Quartz lakes. Voluntary angler creel survey from Middle Quartz Lake in 1959-1966 (Morton 1968) indicated 304 cutthroat and 12 bull trout were caught in Middle

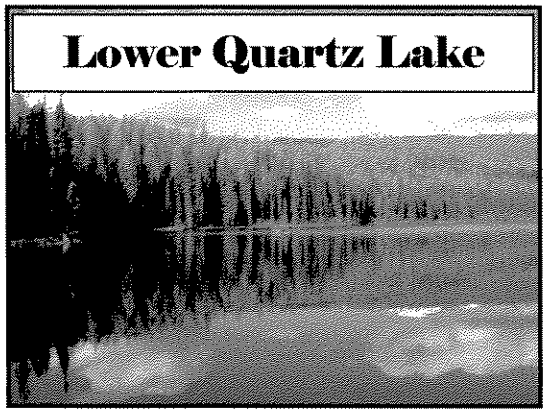
Quartz Lake. Genetic similarity among bull trout from the four lakes in the Quartz Lake chain is an indication of historic and contemporary gene flow. Based on the results of genetic analyses and the close proximity of Middle Quartz and Quartz lakes we suggest that these lakes be managed as a single system. Because the Middle Quartz bull trout population appears to be shared with the much larger Quartz Lake population, the two waters should be managed as a single drainage. A barrier project, consisting of a rock gabion weir located approximately 100 yards downstream of Middle Quartz Lake, was started in 2004. The barrier was abandoned, after partial completion, when lake trout were discovered in Quartz Lake in 2005. Completion of that barrier may still be a viable option. The habitat in Middle Quartz Lake (small, shallow, relatively warm) may be less than suitable for long-term establishment of lake trout. Fish sampling results from Middle Quartz Lake generally paralleled results for Quartz Lake.

MANAGEMENT RECOMMENDATIONS: Similar to Quartz Lake, establishment of lake trout in Middle Quartz Lake will severely and perhaps permanently compromise the aquatic and terrestrial ecosystem. We recommend an angling regulation be adopted that would require all lake trout caught by anglers in the Quartz Creek drainage be killed and properly disposed of. We have made Middle Quartz Lake a lower priority because we believe management efforts aimed at rapidly gaining as much information as possible about the dynamics of lake trout in this drainage should focus on Quartz Lake, with incidental observations in Middle Quartz Lake. Successful suppression of lake trout in Quartz Lake might allow the currently high quality native trout fishery in Middle Quartz Lake to remain relatively unaffected.

MONITORING NEEDS: Lake-wide gill net surveys were re-established on a five-year rotation beginning in 2000 and 2005. They should be repeated in 2010 and every fifth year thereafter (see Appendix).

RESEARCH PRIORITIES: Assess the potential value and consequences of completing the partial barrier downstream of Middle Quartz Lake, and consideration of methods to effectively control or suppress lake trout throughout the drainage. Verification of lake trout occupancy or reproduction in Middle Quartz Lake would also be useful information.

INFORMATION NEEDS: Trailhead interpretive information should be developed that informs anglers of special regulations and management concerns, including information on how to reliably differentiate between lake trout and bull trout and the potential impact lake trout may have on aquatic and terrestrial ecosystems. Anglers must be advised of the importance of gently releasing any bull trout they catch. Direct warnings to anglers not to pack in or disperse any fish eggs, fish parts, or other foreign materials for bait, or otherwise engage in transfer of any potentially live aquatic matter is also needed. Corresponding outreach materials, such as a card with a picture of a bull trout and specific concerns could also be made available.



CATEGORY: Compromised

PRIORITY LEVEL: Medium
Lower Quartz Lake is rated as medium priority, in part because the bull trout population appears to have maintained a lower natural density than upstream lakes; perhaps due to restrictive spawning and rearing or otherwise less suitable habitat (e.g., shallower depth). It is also believed that the fate of bull trout in Lower Quartz Lake may be closely tied to Quartz Lake upstream.

SURFACE AREA: 168 acres

MAXIMUM DEPTH: 62 feet

BARRIER STATUS: Several high gradient cascades occur within stream reaches in the Quartz Creek drainage, especially in a narrow canyon between Lower Quartz and Middle Quartz lakes. However, no impassable fish passage barriers occur from Cerulean Lake downstream to the North Fork Flathead River. The entire Quartz Creek drainage remains vulnerable to invasion from downstream.

NATIVE SALMONIDS PRESENT: Bull trout, westslope cutthroat trout, mountain whitefish.

NONNATIVE SALMONIDS PRESENT: Lake trout were first documented in 2003, presumably from upstream migration from the Flathead Basin. Lower Quartz Creek was also stocked with over 80,000 cutthroat trout between 1935 and 1944; Lower Quartz Lake with nearly 250,000 cutthroat between 1934 and 1940; and Quartz Lake with 8,550 cutthroat fry in 1940 (Morton 1968). These were presumably all Yellowstone cutthroat trout, but there is no evidence those fish persisted or reproduced in this drainage.

RESOURCE ATTRIBUTES: Lower Quartz Lake is the furthest downstream of four lakes in a chain in the Quartz and Rainbow Creek drainages of Glacier National Park. Anecdotal reports of lake trout being caught by anglers in Lower Quartz Lake had occurred in recent years with photo documentation authenticating those reports in 2003. The genetic similarity among bull trout from the four lakes in the Quartz Lake chain is a probable indication that gene flow has regularly occurred. Lower Quartz Lake is relatively shallow for its size and has been regarded by anglers primarily as a productive cutthroat trout fishery. While lake trout are now known to be present, Lower Quartz Lake is not the prototypic cold, deep lake that lake trout typically prefer. Bull trout catch rates in the past were moderate and since redd monitoring began in 2004 a small number of bull trout redds (1-3) were found each year in Quartz Creek, all located immediately upstream (within 0.1 miles) of Lower Quartz Lake. At this time, bull trout appear to still outnumber lake trout in Lower Quartz Lake. Voluntary angler creel survey from Lower Quartz Lake in 1959-1966

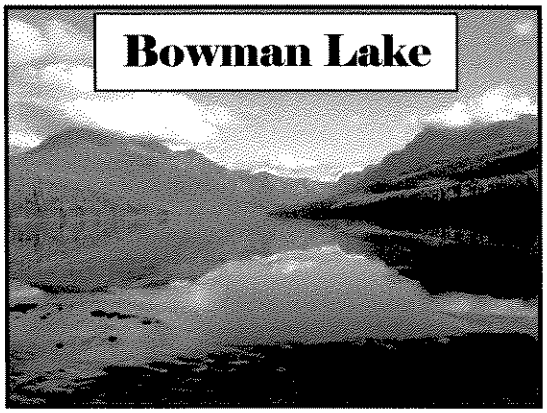
(Morton 1968) reported 665 cutthroat and 13 bull trout caught, though the bull trout were uniformly large, averaging over 18 inches. Subsequent volunteer angler survey results for the period 1979-1986 (about twenty years later, with no attempt to standardize the sample size) indicated a catch of 776 cutthroat and 74 bull trout (USFWS 1983 and 1987).

MANAGEMENT RECOMMENDATIONS: If lake trout successfully reproduce in the Quartz Lake drainage (suspected and anticipated, but not yet confirmed), the entire Quartz Lake chain will be severely and perhaps permanently compromised for native fish and wildlife (including effects on osprey, otters, eagles, loons, and bears). Based on current knowledge, we recommend an angling regulation be considered that would require all lake trout caught by anglers in the Quartz Creek drainage be killed immediately and either consumed, packed out, or sunk in deep water in the lake. At early stages of invasion, efforts to eliminate even a few sexually mature lake trout may be beneficial. Current efforts must be aimed at rapidly gaining as much information as possible about the dynamics of lake trout in the Quartz drainage. Efforts to suppress lake trout expansion in upstream portions of the drainage, if successful, might allow the native fishery to be sustained. Early suppression of lake trout is likely to be more advantageous than later restoration efforts, either here or elsewhere in more heavily compromised drainages.

MONITORING NEEDS: Redd counts, initiated in 2004 at Lower Quartz Lake, should be continued indefinitely (see Appendix). Lake-wide gill net survey, re-established on a five-year rotation beginning in 2000 and 2005 should be repeated in 2010 and every fifth year thereafter (see Appendix). Of particular interest is the documentation of any lake trout reproduction in Lower Quartz Lake.

RESEARCH PRIORITIES: Research on movement patterns of lake trout and bull trout, identification of spawning areas for lake trout, evaluation of salmonid genetic interchange, assessment of the potential value and consequences of completing the partial barrier downstream of Middle Quartz Lake, and continued evaluation of methods to effectively control or suppress lake trout expansion are important research priorities for the drainage. Verification of lake trout reproductive success in Lower Quartz Lake would be useful.

INFORMATION NEEDS: Trailhead interpretive information should be developed that informs anglers of special regulations and management concerns, including information on how to reliably differentiate between lake trout and bull trout and the potential impact lake trout may have on aquatic and terrestrial ecosystems. Anglers must be advised of the importance of gently releasing any bull trout they catch. Direct warnings to anglers not to pack in or disperse any fish eggs, fish parts, or other foreign materials for bait, or otherwise engage in transfer of any potentially live aquatic matter is also needed. Corresponding outreach materials, such as a card with a picture of a bull trout and specific concerns could also be made available.



CATEGORY: Compromised

PRIORITY LEVEL: Medium
The medium priority level assigned to Bowman Lake is related to the seriously compromised nature of the existing bull trout population (i.e., long-term decline in abundance to existing remnant status) and the high abundance of lake trout. This lake is also lowered in priority due to the natural instability of accessible spawning and rearing habitat. However, the long-term recovery potential for bull trout in Bowman Lake could be high, as explained below.

SURFACE AREA: 1,724 acres

MAXIMUM DEPTH: 253 feet

BARRIER STATUS: No fish passage barriers occur in Bowman Creek, from the lake downstream to the North Fork Flathead River. Fish passage upstream of Bowman Lake in Bowman Creek is seasonally limited due to recent natural debris flows, resulting in subsurface stream reaches immediately upstream of the lake during late summer and fall in most recent years.

NATIVE SALMONIDS PRESENT: Bull trout, westslope cutthroat trout, mountain whitefish.

NONNATIVE SALMONIDS PRESENT: Lake trout were first documented in 1962, presumably from upstream migration from the Flathead Basin. Kokanee (presumably from the same source) were abundant in the past, but may have been extirpated. Glacier National Park records indicate a long history of fish stocking in Bowman Lake, with over 2.5 million cutthroat trout stocked between 1915 and 1959 (Morton 1968) in attempts to bolster a reputedly poor cutthroat trout fishery. Most of the earlier plants were Yellowstone cutthroat trout, though there is little evidence they have persisted.

RESOURCE ATTRIBUTES: Bull trout catch rates in recent sampling (2000 and 2005) were low, lake trout catch rates were high, and lake trout dominate the *Salvelinus* species complex. Bull trout in Bowman Lake historically had access to extensive upstream spawning and rearing areas. Morton (1968) noted that upper Bowman Creek (upstream of Bowman Lake) "drops only 500 feet in five miles.....this whole stretch at less than 4,500 feet elevation is believed to be excellent breeding and feeding grounds..." Apparently, following the record snowfall during the winter of 1996-1997, a large debris flow occurred in Bowman Creek, filling the lower stream channel with gravel and large wood. Subsequently, the stream has gone subsurface in the lower reaches after runoff occurs in most recent years. In fall surveys conducted annually between 2001 and 2006 we noted the

channel has gradually been reestablished and two bull trout redds were located in lower Bowman Creek in 2006, the first observed redds since we began redd monitoring in 2001. Voluntary angler creel surveys between 1959 and 1966 in Bowman Lake indicated catch of 1,408 kokanee, 744 cutthroat, 394 bull trout, and 21 lake trout (the latter first recorded in the catch in 1962). Morton (1968) stated Bowman Lake had the highest proportion of bull trout in the catch of any lake in the region. Morton (1968) also noted the kokanee fishery in both Kintla and Bowman Lakes was prospering during the late 1960s, "moving these two lakes to the head of the list of best fishing lakes (in the region) in recent years from their position at the bottom of the list ten years earlier." Subsequent volunteer angler survey results for the period 1979-1986 (about twenty years later, with no attempt to standardize sample sizes) indicated a catch of 1,006 cutthroat trout, 988 kokanee, 412 bull trout, and 86 lake trout (USFWS 1983 and 1987). The presence of juvenile bull trout in net samples from Bowman Lake in recent years (Meeuwig and Guy 2007) also provides evidence of reproduction, despite the paucity of identified redds.

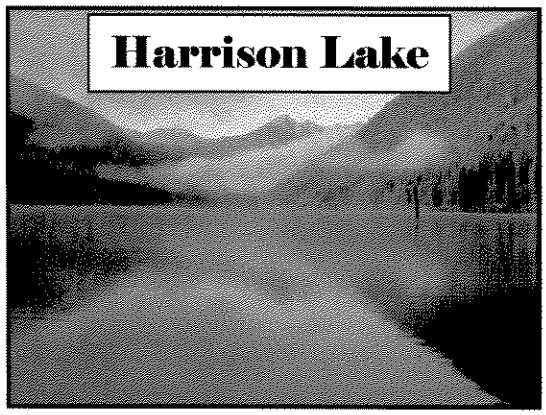
MANAGEMENT RECOMMENDATIONS: The potential for natural fluvial processes to reestablish active surface flow conditions in Bowman Creek upstream of Bowman Lake during most years would result in reconnecting Bowman Lake to a large reach of potential spawning and rearing habitat for bull trout. Therefore, we view long-term conservation of bull trout in Bowman Lake as a better prospect than for some similar large waters (e.g., Kintla Lake or Lake McDonald). Maintenance of the bull trout population at a sufficient level to ensure protection of the bull trout resource in Bowman Lake should be a high priority. Natural expansion and contraction of spawning and rearing habitat due to unstable geology has probably occurred many times over thousands of years in similar systems. Short-term natural events, such as the debris flow that occurred in 1997, would probably not have historically resulted in extirpation of bull trout. However, in the current presence of lake trout there is more concern. Lake trout suppression in Bowman Lake would be feasible, given the available road access. While a suppression program would require a long-term commitment, if successful a natural increase in native bull trout and westslope cutthroat trout populations would be likely to result. However, potential immigration of lake trout into Bowman Lake from elsewhere in the Flathead Basin might also have to be addressed. Current angling regulations that set no limits or restrictions on lake trout harvest should be maintained, consistent with the message to the public that the species is not desired in west-side Park waters.

MONITORING NEEDS: A lake-wide gill net survey, re-established on a five-year rotation beginning in 2000 and 2005, should be repeated in 2010 and every fifth year thereafter (see Appendix). If a lake trout suppression effort is implemented, then an ongoing monitoring strategy is needed to accompany such an effort. It is also imperative that annual bull trout redd counts, initiated in 2001 upstream of Bowman Lake, be continued indefinitely

(see sampling appendix on accompanying compact disk). Additional photo documentation of the status of habitat and availability of access to Bowman Creek within the spawning and rearing reach should also be gathered.

RESEARCH PRIORITIES: Continuing documentation of the status and demographics of the bull trout resource in Bowman Lake is needed. The potential for limited outlet spawning in Bowman Creek during late October should also be evaluated, as we have not examined the outlet stream for redds at that late date. Bowman Lake (along with Logging and Quartz) is a high priority for lake trout suppression experiments, because of the road access. Migration of lake trout in or out of Bowman Lake should be evaluated to better determine the feasibility of a suppression effort.

INFORMATION NEEDS: Bowman Lake campground receives heavy use; thus, there is an opportunity to provide staff with the necessary information to conduct outreach, using Bowman and Kintla Lakes as a "lesson" to illustrate the negative impact nonnative fish introductions can have on native fish communities. Handout materials, campfire talks, and interpretive information could be part of an effort. It is also imperative that anglers not inadvertently harvest bull trout caught in Bowman Lake.



CATEGORY: Compromised

PRIORITY LEVEL: Medium
Harrison Lake is reduced to medium in priority due to the well-established complex of nonnative species, including lake trout and brook trout. However, long-term recovery potential in Harrison Lake could be high given that a relatively large amount of spawning and rearing habitat is available upstream for bull trout.

SURFACE AREA: 403 acres

MAXIMUM DEPTH: 135 feet

BARRIER STATUS: Harrison Creek is unobstructed, both upstream to several miles of spawning and rearing habitat and downstream to the Middle Fork Flathead River.

NATIVE SALMONIDS PRESENT: Bull trout, westslope cutthroat trout, mountain whitefish.

NONNATIVE SALMONIDS PRESENT: Lake trout were first documented in 2000, presumably resulting from upstream migration from the Flathead Basin. Rainbow trout were also documented in 2000. Brook trout and kokanee have been present for many years and were also noted as recently as 2005. Morton (1968) documented a 1935 hatchery plant of some 35,000 cutthroat trout in Harrison Creek. Harrison Lake was also stocked with 7,000 brook trout (1912), 2,000 cutthroat (1915), and about 23,000 cutthroat (1935). The cutthroat trout plants were likely Yellowstone cutthroat, but there is no record they persisted.

RESOURCE ATTRIBUTES: The fishery resource of Harrison Lake has not received a lot of attention in the past. Morton (1968) noted there had been no fishery assessments recorded for Harrison Lake. Voluntary angler creel survey results from 1959 – 1966 for Harrison Lake indicated catch of 361 cutthroat, and 22 bull trout (Morton 1968). Subsequent volunteer angler survey results for the period 1979-1986 (about twenty years later, with no attempt to standardize sample size) indicated a catch of 272 cutthroat trout, 4 kokanee, and 44 bull trout (USFWS 1983 and 1987). Harrison Lake hosts the highest number of nonnative salmonids of any lake we sampled and is the only lake where both nonnative *Salvelinus spp.* (lake trout and brook trout) as well as brook X bull trout hybrids have been detected. Samples collected in 2000 near the inlet indicated a high prevalence of bull trout X brook trout hybrids. Bull trout and lake trout catch were about equal in the 2005 samples, which indicated the highest bull trout catch rate of any lake with an established lake trout population. Bull trout redd counts, conducted beginning in 2004, varied between 0 and 15 (2007). Redds have been located in Harrison Creek as far as 1.4 miles

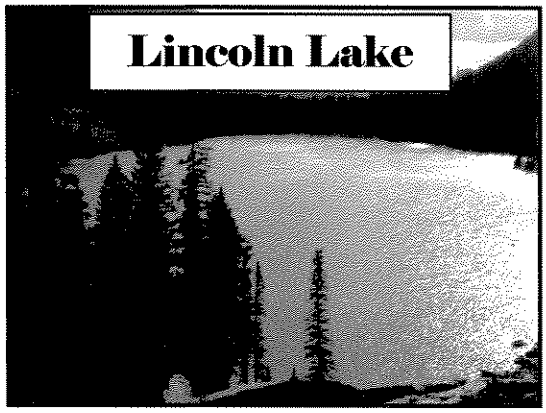
upstream of the lake and the drainage is accessible even further upstream. Genetic analyses indicate that bull trout in Harrison Lake are well differentiated from bull trout sampled in other lakes; an interesting finding considering the lack of migratory impediments between Harrison Lake and the Middle Fork Flathead River. Harrison Lake is partially fed by Harrison Glacier in late summer and fall and future loss of glacial melt could impact late summer streamflow and potentially affect the fish assemblage.

MANAGEMENT RECOMMENDATIONS: We view conservation efforts for bull trout in Harrison Lake as achievable, given the relatively high quality and availability of bull trout spawning and rearing habitat in Harrison Creek. Maintenance of the bull trout population at a sufficient level to ensure protection of the bull trout genetic resource in Harrison Lake should be a high priority. Given its relatively smaller size, lake trout suppression in Harrison Lake might be feasible, though logistically difficult given the unavailability of road access. While a suppression program would require a long-term commitment, a natural increase in native bull trout and westslope cutthroat trout populations would likely result. Angling regulations that set no limits or restrictions on lake trout harvest should be instituted in Harrison Lake, the same as in Kintla, Bowman, and McDonald and consistent with the message to the public that the species is not desired in Glacier National Park waters west of the divide.

MONITORING NEEDS: A lake-wide gill net survey, re-established on a five-year rotation beginning in 2000 and 2005, should be repeated in 2010 and every fifth year thereafter (see Appendix). It is also imperative that annual bull trout redd counts, initiated in 2004 upstream of Harrison Lake, be continued indefinitely (see sampling appendix on accompanying compact disk). Evaluation of potential brook trout removal from the spawning and rearing reach of Harrison Creek might also be considered.

RESEARCH PRIORITIES: Further evaluation of the bull trout demographics in Harrison Lake is needed. The impact of the high incidence of hybridization between brook trout and bull trout on the bull trout population should also be evaluated.

INFORMATION NEEDS: Trailhead interpretive information should be developed that informs anglers of special regulations and management concerns, including information on how to reliably differentiate between lake trout and bull trout and the potential impact lake trout may have on aquatic and terrestrial ecosystems. Anglers must be advised of the importance of gently releasing any bull trout they catch. Direct warnings to anglers not to pack in or disperse any fish eggs, fish parts, or other foreign materials for bait, or otherwise engage in transfer of any potentially live aquatic matter is also needed. Corresponding outreach materials, such as a card with a picture of a bull trout and specific concerns could also be made available.



CATEGORY: Compromised

PRIORITY LEVEL: Medium
Lincoln Lake is classified medium priority because of the long-term presence of brook trout and the source of brook trout upstream. The limited size of the lake, and the minimal spawning and rearing habitat for bull trout are also concerns.

SURFACE AREA: 35 acres

MAXIMUM DEPTH: 74 feet

BARRIER STATUS: Lincoln Lake sits in a cirque near the head of the Lincoln Creek Basin. Beaver Chief Falls is a high barrier located immediately upstream of Lincoln Lake and 195 acre Lake Ellen Wilson lies upstream of the barrier. Our 2006 survey indicated no fish passage barriers from Lincoln Lake downstream to the Middle Fork Flathead River. However, an abundance of log jams and deadfall were present in the active channel and there was evidence of recent scouring event(s) (e.g., channel incision and accumulation of fine sediments downstream of incised channel), which could make fish passage intermittently difficult.

It is rather surprising, given the length (9.9 miles) and gradient (1,326 foot drop) in Lincoln Creek between the outlet of the lake and the Middle Fork Flathead River that no permanent fish passage barriers are present. However, the presence of mountain whitefish, longnose sucker, and sculpin in Lincoln Lake is further evidence of the historical connectivity within the Lincoln Creek drainage.

NATIVE SALMONIDS PRESENT: Bull trout, westslope cutthroat trout, mountain whitefish.

NONNATIVE SALMONIDS PRESENT: There is no history of fish stocking in Lincoln Lake, but Lake Ellen Wilson, a historically fishless water in the Lincoln Creek drainage immediately upstream of Lincoln Lake, was stocked with 21,000 brook trout fingerlings in 1916 (Morton 1968). The Lake Ellen Wilson brook trout population has been self-sustaining ever since. Brook trout likely moved downstream (date unknown) and became established in Lincoln Lake from the Lake Ellen Wilson source.

RESOURCE ATTRIBUTES: Morton (1968) noted that the introduction of brook trout in Glacier National Park waters of the Columbia River drainage has been "a controversial subject ever since the 1920s." Morton (1968) reported that Schultz (1941) surveyed Lincoln Lake in 1934 and found native cutthroat and bull trout. Morton (1968) also reported that voluntary angler creel surveys between 1959 and 1962 indicated a catch of 76 cutthroat, 6 bull trout, and 1 brook trout from Lincoln Lake. Our sampling of Lincoln Lake in 2004 resulted in the lowest catches for

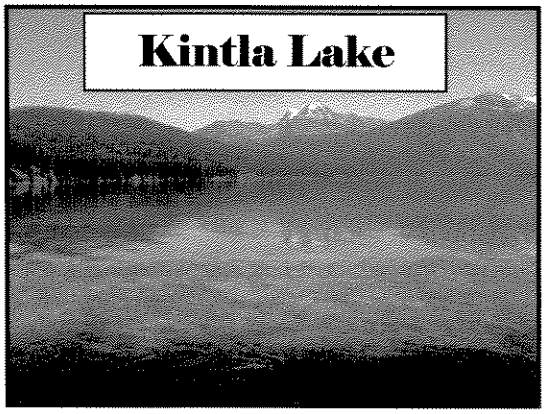
bull trout of any lake where lake trout were absent. This is consistent with the hypothesis that brook trout, another nonnative *Salvelinus* spp., also compete with bull trout. Brook trout were as numerous as bull trout in 2004 samples and small brook trout were abundant along the lake margin. Lincoln Lake is among the smallest Park lakes with a native bull trout population. Morton (1968) concluded Lincoln Creek, downstream of Lincoln Lake was "one of the better Dolly Varden spawning streams," but also indicated that practically nothing was known about the stream. More recent sampling in lower Lincoln Creek, conducted by Montana Fish, Wildlife & Parks, found brook trout and cutthroat but no bull trout. Lincoln Creek is no longer considered a bull trout spawning stream (MBTSG 1995), and likely never was heavily used as summer water temperatures are documented to approach 20°C in lower reaches (Montana Fish, Wildlife & Parks file data).

MANAGEMENT RECOMMENDATIONS: We are concerned that the brook trout population may further impact bull trout through competition and hybridization. An experimental brook trout suppression effort could be conducted in this lake, if sufficient monitoring and evaluation could be maintained to determine its effectiveness, but such an effort is probably a low priority. The lake also remains open to reinvasion from either upstream or downstream (including lake trout). Given the general inability of anglers to differentiate between juvenile bull trout and brook trout, and the remote location and limited fishing pressure Lincoln Lake receives, any type of special angling regulations would likely not be effective in reducing brook trout.

MONITORING NEEDS: The fish population in Lincoln Lake should be resurveyed in 2015 (see Appendix) and every ten years thereafter to collect additional biological data (e.g., age, growth, wild fish health, genetics) and to ensure that bull trout are not being overexploited by anglers or the existence of other species has not further compromised the bull trout population.

RESEARCH PRIORITIES: Due to the uncertainty regarding the rate of immigration of brook trout from upstream or downstream, a full rehabilitation of Lake Ellen Wilson and installation of a downstream fish passage barrier might be necessary before brook trout suppression in Lincoln Lake would be effective. Research on fish migration within the Lincoln Creek drainage would be useful in making future management decisions.

INFORMATION NEEDS: Lincoln Lake provides an excellent opportunity to educate visitors about the negative consequences of brook trout introduction in Park waters and also to educate anglers on how to differentiate between bull trout and brook trout. Sperry Chalet would be a good location to place interpretive information. The uniqueness and vulnerability of the Lincoln Lake bull trout population as it occurs in a small, isolated headwater cirque should be emphasized.



CATEGORY: Compromised

PRIORITY LEVEL: low
Kintla Lake is ranked as one of the lowest priorities for bull trout due to uncertainty whether a viable bull trout population remains and the near absence of suitable and accessible upstream spawning and rearing habitat.

SURFACE AREA: 1,714 acres

MAXIMUM DEPTH: 390 feet

BARRIER STATUS: A series of high gradient cascades and impassable barriers, including a 22-foot vertical falls, occur in the drainage beginning 0.5 miles upstream of Kintla Lake. No fish passage barriers exist in the drainage downstream of Kintla Lake to the North Fork Flathead River.

NATIVE SALMONIDS PRESENT: Bull trout, westslope cutthroat trout, mountain whitefish.

NONNATIVE SALMONIDS PRESENT: Lake trout were first documented in 1962, presumably from upstream migration from the Flathead Basin. Kokanee (presumably from the same source) were abundant in the past, but were not detected in 2000 or 2005 gill net sampling. Similar to Bowman Lake, Glacier National Park records indicate a long history of fish stocking in Kintla Lake. Over 2.4 million cutthroat trout were stocked between 1931 and 1959 (Morton 1968) in attempts to bolster a reputedly poor cutthroat trout fishery. An additional 42,000 cutthroat fry were stocked in lower Kintla Creek between 1935 and 1940. Most of the cutthroat plants were probably Yellowstone cutthroat trout, though there is little evidence they have persisted.

RESOURCE ATTRIBUTES: Kintla Lake is perhaps the most compromised of the large bull trout lakes on the west side of Glacier National Park. Bull trout catch rates from recent sampling in Kintla Lake (2000 and 2005) were low and lake trout have been the dominant piscivore for at least two decades (Fredenberg 2002). Bull trout sampled were typically subadult or small adult size fish (10-20 inches) and there is no direct evidence of reproduction in Kintla Lake (e.g., redds or juveniles). The barrier upstream of Kintla Lake limits potential bull trout spawning and rearing to a short reach of Kintla Creek. Bull trout sampled from Kintla Lake show a high degree of genetic similarity to bull trout sampled from Lake McDonald and Flathead Lake, but they are genetically differentiated from bull trout in Upper Kintla Lake. These results suggest that there is connectivity among at least some of the lakes in Glacier National Park (e.g., Kintla Lake and Lake McDonald) as well as the greater Flathead Basin. Morton (1968) reported that Garlick (1949) "placed Kintla Lake at the bottom of the list of North Fork lakes in quality of fishing, and speculated on the possible reasons for

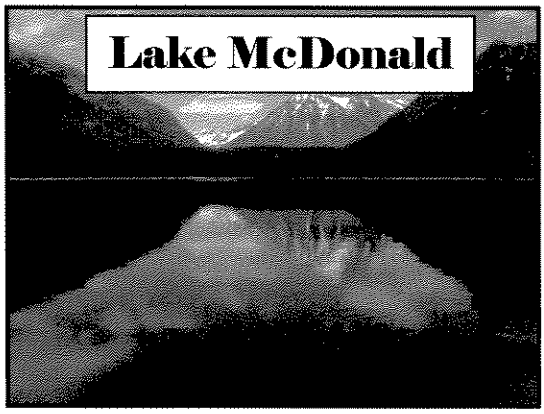
scarcity of game species." Garlick noted (quoted by Morton 1968): "Kintla Lake is extremely deficient in spawning area." Anglers reported catching 5,826 kokanee, 1,290 cutthroat, 501 bull trout, and 35 lake trout between 1959 and 1966 in Kintla Lake (Morton 1968). Subsequent volunteer angler survey results for the period 1979-1986 (approximately 20 years later, with no effort to standardize sample size) indicated a catch of 593 cutthroat, 38 kokanee, 25 bull trout, and 180 lake trout (USFWS 1983 and 1987).

MANAGEMENT RECOMMENDATIONS: We believe there is little that can be done to restore bull trout in Kintla Lake. Lake trout suppression may be feasible, given the available road access, but would require a long-term commitment. Our concern is that bull trout and/or westslope cutthroat trout populations may be unlikely to naturally expand given the paucity of spawning and rearing habitat. Current angling regulations that set a 15 fish limit on lake trout should be modified to remove all limits on lake trout (consistent with regulations in Bowman Lake and Lake McDonald). This is necessary in order to send a consistent message to the public that the species is not desired in Park waters west of the Continental Divide.

MONITORING NEEDS: Continue to conduct a lake-wide gill net survey in 2010 and every fifth year thereafter (see Appendix). This is consistent with sampling that has been repeated on a five-year rotation since 2000.

RESEARCH PRIORITIES: A key question is whether the existing bull trout resource in Kintla Lake represents an endemic population that merits protection of the unique genetic resources. Current indications are otherwise. Additional focus should be placed on locating the source of any remnant bull trout spawning or recruitment within the drainage.

INFORMATION NEEDS: Because the Kintla Lake campground receives heavy visitor use, there is an opportunity to provide staff with the necessary information to conduct outreach, using Kintla and Bowman Lakes as a "lesson" to illustrate the negative impact nonnative fish introductions can have on native fish communities. Handout materials, campfire talks, and interpretive information could all be part of such an effort. Secondarily, the contrast between Kintla and Upper Kintla and the value of protecting resources in Upper Kintla Lake should be emphasized.



CATEGORY: Compromised

PRIORITY LEVEL: Low

Despite the large size of Lake McDonald and its upstream watershed, the streams entering Lake McDonald contain limited habitat suitable for bull trout spawning and rearing (due primarily to natural barriers). Further, the close connectivity of Lake McDonald to the rest of Flathead Basin would make continued invasion by lake trout or other species difficult to control. Finally, with the abundance of lake whitefish, lake trout, and other nonnative species Lake McDonald has the most altered species complex of any lake on the west side of Glacier National Park. Thus, it was assigned a low management priority despite its large size and high visitation profile.

SURFACE AREA: 6,872 acres

MAXIMUM DEPTH: 464 feet

BARRIER STATUS: A series of large cascades and several major barrier falls, beginning about 0.6 miles upstream of Lake McDonald, isolates the extensive McDonald Creek drainage from the lake. Native westslope cutthroat trout occur upstream of the falls, but bull trout do not. Downstream passage from Lake McDonald to the Middle Fork Flathead River through lower McDonald Creek is easy and unobstructed.

NATIVE SALMONIDS PRESENT: Bull trout, westslope cutthroat trout, mountain whitefish, pygmy whitefish.

NONNATIVE SALMONIDS PRESENT: Lake trout were first documented in Lake McDonald in 1959, presumably from upstream migration from the Flathead Basin. Rainbow trout, brook trout, lake whitefish (first documented 1963), and kokanee (first documented 1934) have also been documented in recent sampling. As the most high profile and accessible large lake on the west side of the Park, Lake McDonald was heavily stocked with hatchery fish during the early years of Park management. Park records (Morton 1968) indicate that between 1915 and 1959 over 5.5 million cutthroat trout, mostly Yellowstone cutthroat, were stocked in the lake. More than 780,000 rainbow trout including some referred to as “steelhead” (1919-1929), about 380,500 brook trout (1919-1923), and about 332,000 Chinook salmon (1922-1923) were planted in Lake McDonald. In addition, lower McDonald Creek was planted with more than 2.6 million cutthroat trout between 1925 and 1944 (Morton 1968), an extremely high number given the available habitat. Lower McDonald Creek was also stocked with about 115,000 brook trout (1919-1921), 173,000 rainbow trout (1921-1926) and 100,000 arctic grayling (1924). Rainbow trout and brook trout apparently persisted in the drainage, but Yellowstone cutthroat trout, Arctic grayling, and Chinook salmon did not.

RESOURCE ATTRIBUTES: Lake McDonald, the largest and deepest lake on the west side of the Park, is also among the lakes with the most compromised native fishery resource. At least five nonnative salmonids occur in the lake. Lake whitefish have dominated the biomass and lake trout the piscivore niche in the lake for several decades. Since lake trout were first documented in Lake McDonald in 1959, there has been a steady decline in bull trout and cutthroat trout numbers (Fredenberg 2002). The large size and deep bathymetry of Lake McDonald provide excellent habitat for lake trout. Dux (2005) studied lake trout population dynamics in the lake and documented fish as old as 37 years.

Despite consistently low bull trout catch rates in recent sampling (Fredenberg 2002, Meeuwig and Guy 2007); bull trout continue to exist in Lake McDonald. We have not located bull trout redds in the limited portions of spawning reaches available in direct tributaries to Lake McDonald. Electrofishing of Lake McDonald tributaries in 2004 did not capture a single bull trout (Dux and Guy 2004). Additionally, the genetic similarity between bull trout sampled from Lake McDonald, Kintla Lake, and spawning and rearing tributaries of Flathead Lake in the North Fork Flathead River suggests that bull trout in Lake McDonald may be part of a larger, interconnected bull trout population in the Flathead Basin. Thus, a reproductively isolated Lake McDonald population of adfluvial bull trout may not exist. Rather, Lake McDonald may represent transient habitat for migratory bull trout from elsewhere in the Flathead Basin.

Management investigations of Lake McDonald began as early as 1925 by R.A. Muttkowski from the University of Detroit (Morton 1968). Muttkowski recommended stocking Lake McDonald and Bowman with "food fish" (principally lake whitefish). Muttkowski noted the abundance of suckers in Lake McDonald and believed the suckers should be netted out, along with: "bull trout (the latter not a particularly good trout)".

Morton (1968) reported on voluntary angler survey results for Lake McDonald between 1959 and 1966. A total of 2,173 kokanee, 265 cutthroat trout, 109 lake trout (first reported in the catch in 1961), and 85 bull trout were reported. It is apparent that even in the early 1960s bull trout were not numerous in the angler catch from Lake McDonald. Subsequent volunteer angler survey results for the period 1979-1986 (about twenty years later, with no attempt to standardize the sample size) indicated a catch of 91 kokanee, 519 cutthroat, 478 lake trout, and 137 bull trout (USFWS 1983 and 1987). Morton (1968) noted in his summary recommendations: "Although the Park Service has been rightfully alarmed over the natural invasion of these northern west slope waters by kokanee and mackinaw over the past 2 or 3 decades, wishful thinking will never drive them out. We have to face the fact, shown by the Lake McDonald creel census results, that these exotics are not only here to stay, but they now dominate their respective categories in the Lake McDonald fishery and can be expected to increase their "take-over" as years move on." Morton (1968) goes on to say: "It is this writer's considered opinion therefore, that this lake will eventually have to be managed

for kokanee and lake trout, and we will just have to forget that cutthroat and Dolly Varden originally dominated this great lake."

MANAGEMENT RECOMMENDATIONS: The Lake McDonald fishery has always been considered difficult to manage (Morton 1968). The large size and high profile of Lake McDonald, adjacent to the much-traveled Going-To-The-Sun highway, and accompanying high levels of visitation and visitor use would seem to warrant making restoration of this fishery a high priority. However, we believe restoration of a native fishery is unrealistic given the well-established nonnative species complex already dominated by nonnative lake trout and lake whitefish and the near absence of connected spawning and rearing habitat. Evidence also suggests that historically the Lake McDonald fishery may have been strongly dependent on immigration from Flathead Lake or the Flathead River. Further, the 1990s collapse of bull trout in Flathead Lake limits the potential for a natural influx of migratory bull trout from that source. Additionally, the high density lake trout population now in Flathead Lake has easy access to the migratory corridor into Lake McDonald. Continued movement of nonnative species into Lake McDonald can be anticipated. For all these reasons, we do not view recovery of bull trout in Lake McDonald as a very likely prospect.

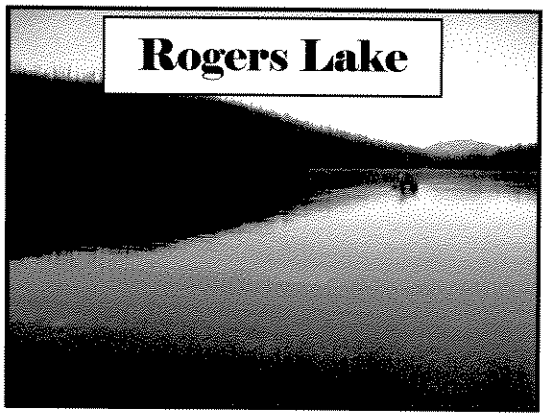
On the other hand, Lake McDonald would be a strong candidate for lake trout suppression, given that the spawning locations have been determined (Dux 2005). Lake trout suppression might increase cutthroat trout survival, which spawn in several tributaries to the lake that are not used by bull trout. At this time, current angling regulations that set no harvest limits on lake trout and lake whitefish should be maintained in order to send a consistent message to the public that these species are not desired in Park waters west of the Continental Divide. Reluctantly, we conclude there is little practical value to conducting lake trout suppression in Lake McDonald and that for the foreseeable future available resources would be better allocated elsewhere, particularly to Quartz, Logging, and possibly Bowman lakes.

MONITORING NEEDS: Lake-wide gill net surveys were re-established on a five-year rotation beginning in 2000 and 2005 and should be repeated in 2010 and every fifth year thereafter (see sampling appendix). If a lake trout suppression effort were implemented, an ongoing evaluation program should accompany such an effort to measure fish assemblage level responses.

RESEARCH PRIORITIES: Identification of sites for any remnant bull trout spawning in the drainage is needed. Further, evaluation of bull trout, lake trout, and other fish movement through the outlet stream (McDonald Creek) would help determine the degree of connectivity and rate of exchange with the Flathead Basin.

INFORMATION NEEDS: The huge amount of visitor traffic along Lake McDonald and the proximity of Apgar and Park headquarters offer major opportunities for public outreach. An interpretive stop on one of the Lake McDonald pullouts, telling the fishery story, would be a beneficial outreach

tool. There is an opportunity to provide both Park and concessions staff with the necessary information to conduct outreach, using the history of Lake McDonald as a "lesson" to illustrate the negative impact nonnative fish introductions can have on native fish assemblages and the associated avian and mammalian predators. Handout materials, campfire talks, and interpretive information could all be part of such an effort.



CATEGORY: Compromised

PRIORITY LEVEL: low
Rogers Lake is small, shallow, and probably never contained a self-sustaining population of bull trout. We believe that bull trout found in Rogers Lake are likely transient fish.

SURFACE AREA: 84 acres

MAXIMUM DEPTH: 14 feet

BARRIER STATUS: A 24 foot vertical falls occurs in Camas Creek immediately upstream of Rogers Lake (Figure 10). There are no barriers downstream of Rogers Lake to the North Fork Flathead River.

NATIVE SALMONIDS PRESENT: Bull trout, westslope cutthroat trout, mountain whitefish.

NONNATIVE SALMONIDS PRESENT: Lake trout were first documented in 2005, presumably from upstream migration from the Flathead Basin. Rainbow trout, presumably from the same source, were also present at that time. Glacier National Park records do not indicate any history of fish stocking in Rogers Lake (Morton 1968), but lower Camas Creek was stocked with 10,000 "steelhead" in 1922, and over 180,000 cutthroat between 1940 and 1958. The latter were probably mostly Yellowstone cutthroat trout.

RESOURCE ATTRIBUTES: Prior to our study, Rogers Lake was not documented to contain bull trout or lake trout. Rogers Lake is shallow (14 feet maximum depth) and it is doubtful bull trout spawn in Camas Creek downstream of Trout Lake, as it is one of the warmer systems in the North Fork Flathead watershed. As early as 1941 Schultz reported Rogers Lake contained an abundance of native suckers and redside shiners (Morton 1968). Schultz noted both Camas Creek and Rogers Lake were "warm and shallow and well suited for suckers and minnows." More recently Camas Creek, downstream of Rogers Lake, has been identified as a hotspot for rainbow trout colonization in the Flathead Basin (Clint Muhlfeld, FWP, personal communication), likely due again to the warmer water temperatures. Great care should be taken to avoid the passage of any fish from Rogers Lake or anywhere downstream of the falls into the upstream drainage. Rogers Lake is seldom visited by anglers.

MANAGEMENT RECOMMENDATIONS: Rogers Lake should be treated as a low priority for bull trout. The Park should consider further evaluation and possible suppression of both lake trout and rainbow trout in Rogers Lake and Camas Creek downstream of the lake, in order to protect the native westslope cutthroat trout resource and reduce the chances of any inadvertent transfer of

nonnative species upstream into Trout or Arrow lakes.

MONITORING NEEDS: Repeat gill net survey at some future date may be warranted, but not necessarily on a scheduled basis.

RESEARCH PRIORITIES: Rogers Lake is a low priority for research related to bull trout.

INFORMATION NEEDS: There is limited need to expand outreach efforts for this resource.

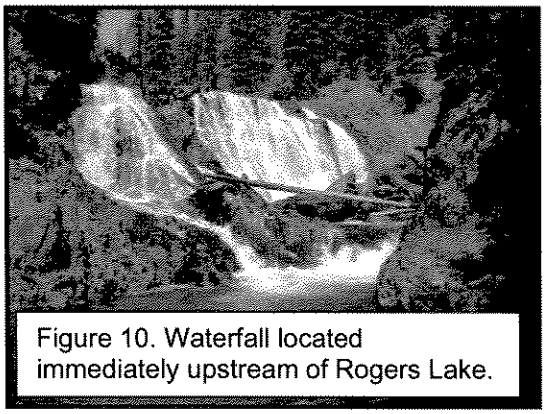


Figure 10. Waterfall located immediately upstream of Rogers Lake.

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