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Arctic Grayling and Burbot Studies at the Fort Knox Mine, 2006

by Alvin G. Ott
and William A. Morris

Last Chance Creek, May 2006
Photograph by William A. Morris

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Acknowledgements

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Executive Summary

Water Quality

- dissolved oxygen (DO) concentrations continue to be low in the Water Supply Reservoir (WSR) and decrease with depth in both summer and winter (pages 11 and 12)
- in August 2006 when surface water temperatures were high (>17°C), Arctic grayling (*Thymallus arcticus*) adults were concentrated at the mouths of Solo and Last Chance creeks (page 13)
- conductivity and pH show no definite trends in the WSR (pages13 and 14)

Arctic Grayling

- Arctic grayling successfully spawned in the wetland complex in spring 2006 with peak spawning activity occurring from May 24 to 26 when water temperatures exceeded 10°C (page 19)
- Arctic grayling did not spawn successfully in Last Chance Creek due to cold water temperatures caused by massive aufeis in spring 2006 (page 20)
- the estimated Arctic grayling population in spring 2006 was 7,926, a substantial increase in numbers of fish >200 mm in the WSR (page 22)
- growth rates of Arctic grayling >200 mm based on marked and recaptured fish indicated better growth in summer 2005 than has been seen in previous years (page 24)

Burbot

- the estimated burbot (*Lota lota*) population for fish >200 mm in spring 2005 was 944 (page 25)
- the estimated burbot population for fish >400 mm in spring 2005 was 143, an increase in numbers over previous years (page 25)
- successful spawning of burbot in the WSR and developed wetlands continues based on catches of small (i.e., age 0) burbot (page 24)

Introduction

Fairbanks Gold Mining Inc. (FGMI) began construction of the Fort Knox hard-rock gold mine in March 1995. The mine is located in the headwaters of the Fish Creek drainage about 25 km northeast of Fairbanks (Figure 1). The project includes an open-pit mine, mill, tailing impoundment, water supply reservoir (WSR), and related facilities. Construction of the WSR dam and spillway was complete by July 1996.

Rehabilitation, to the extent practicable, has been concurrent with mining activities and natural revegetation of disturbed habitats has been rapid. Wetland construction between the tailing dam and WSR began in summer 1998. A channel connecting wetlands along the south side of the valley was built in spring 1999. Civil work to mitigate aufeis in Last Chance Creek was done in fall 2001. Repair work on dikes separating Ponds D and E and the channel connecting the ponds was completed in summer 2002. Buell and Moody (2005) provided recommendations for additional work to enhance fish and wildlife habitats between the tailing dam and WSR.

Fish research prior to construction of the Fort Knox mine and related facilities began in 1992 (Weber Scannell and Ott 1993, Weber Scannell and Ott 1994, Ott et al. 1995). Arctic grayling (*Thymallus arcticus*) and burbot (*Lota lota*) population estimates were made to determine numbers of fish available to colonize the WSR. Following completion of the freshwater dam, we have continued to monitor Arctic grayling and burbot populations in the WSR (Ott and Weber Scannell 1996, Ott and Townsend 1997, Ott and Weber Scannell 1998, Ott and Morris 1999, Ott and Morris 2000, Ott and Morris 2001, Ott and Morris 2002a, Ott and Morris 2002b, Ott and Morris 2003, Ott and Morris 2005a, Ott and Morris 2005b). Water quality sampling in the WSR was started in summer 1997 and has continued annually. Our report summarizes fish and water quality data collected during 2006 and discusses these findings in relation to previous work.

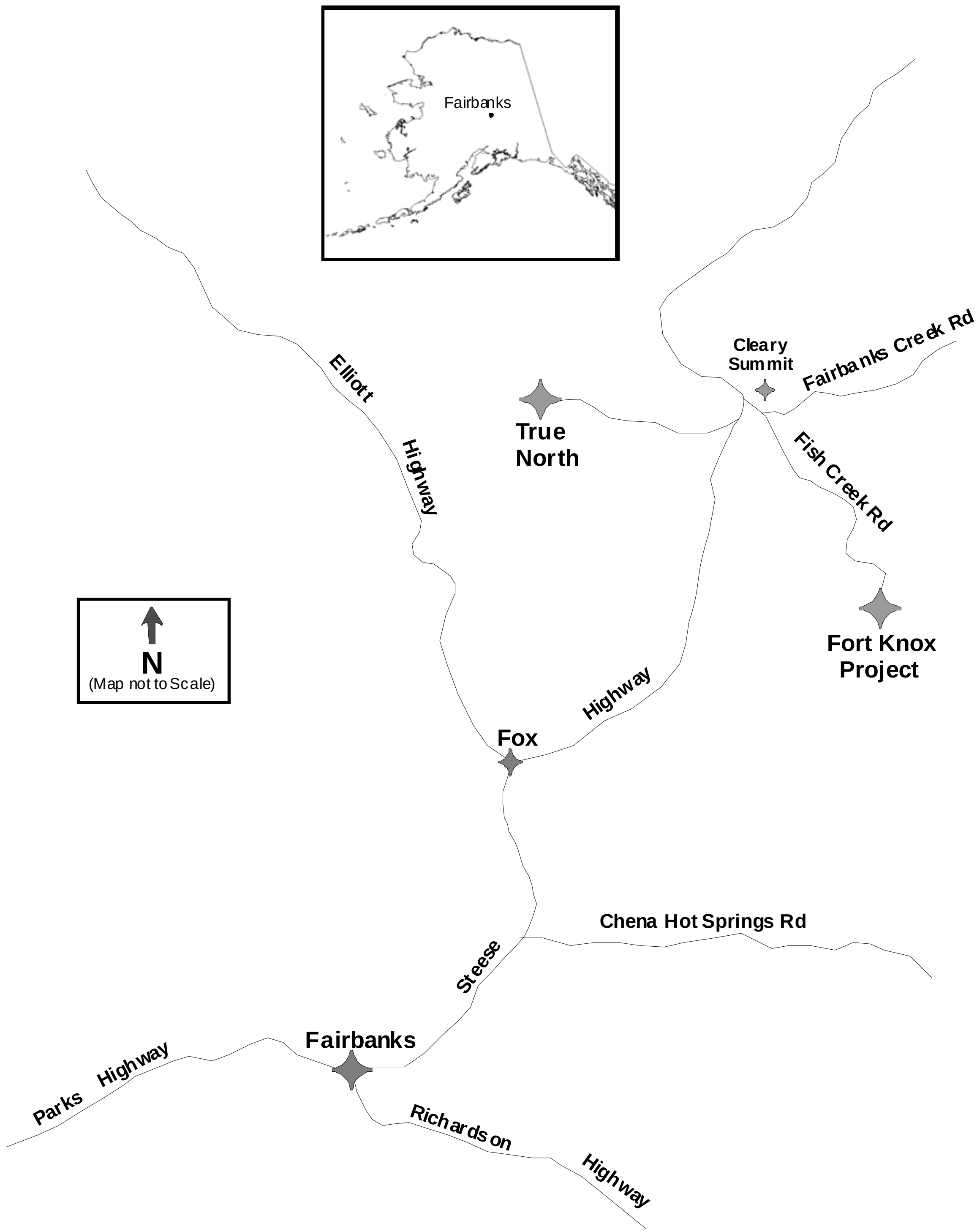

Figure 1. Fort Knox project location.

Methods

Sampling Sites

Multiple fyke net sampling sites have been used (Figures 2 and 3) to capture Arctic grayling. Changes in fyke net locations have been made to optimize catches and to account for water surface elevation changes in the WSR. In spring 2006, fyke nets were fished at four stations (#11, #12, #16, and #18). Hoop traps targeting burbot were set throughout the WSR. Seines were used in the connection channel between Ponds D and E in fall 2006 to capture Arctic grayling fry.

Water Quality

Temperature (°C), dissolved oxygen (DO) concentration (mg/L), DO percent saturation (barometrically corrected), pH, specific conductance (*u* S/cm), and depth (m) were measured with a Hydrolab® Minisonde5® water quality microprobe connected to a Surveyor® 4 digital display unit. The meter was calibrated to suggested specifications prior to use. The DO concentration was calibrated using the open-air method. Conductivity and pH were calibrated with standard solutions. Water quality measurements were made at the surface, at 1 m depth intervals, and near the bottom.

Fish

Fish sampling methods and gear included visual observations, fyke nets, seines, and hoop traps (Figure 4). Prior to setting burbot hoop traps, DO profiles were run at selected sites in the WSR to ensure adequate DO concentrations were present. In spring 2006, DO profiles were not run, but all traps were set in water with depths less than 4 m. Burbot and Arctic grayling >200 mm were marked with a numbered Floy® T-bar internal anchor tag.

Arctic grayling and burbot abundance were estimated using Chapman's modification of the Lincoln-Petersen two-sample mark-recapture model (Chapman 1951). Variance was calculated as given by Seber (1982).

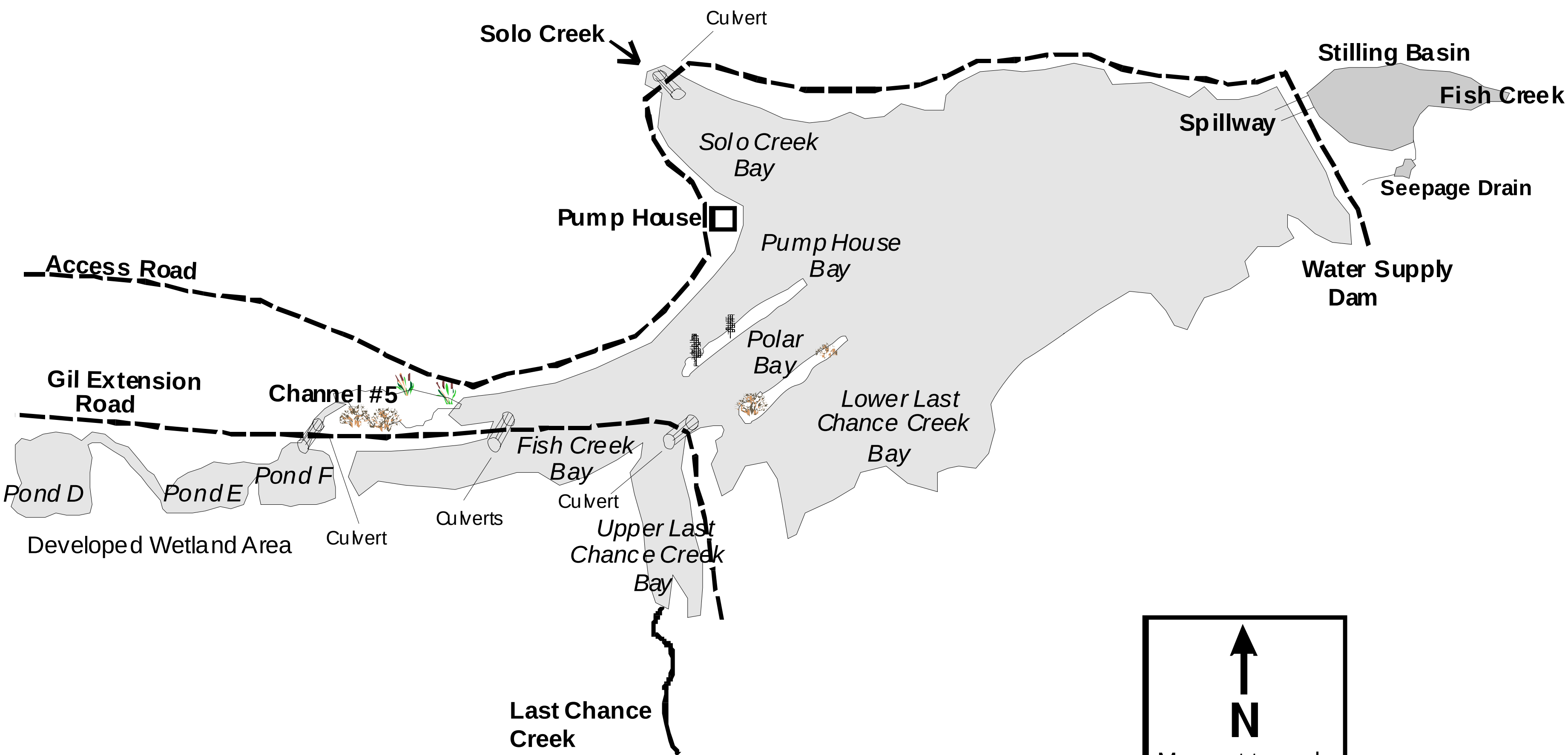

Figure 2. Sample areas in the Fort Knox WSR, stilling basin, and developed wetlands.

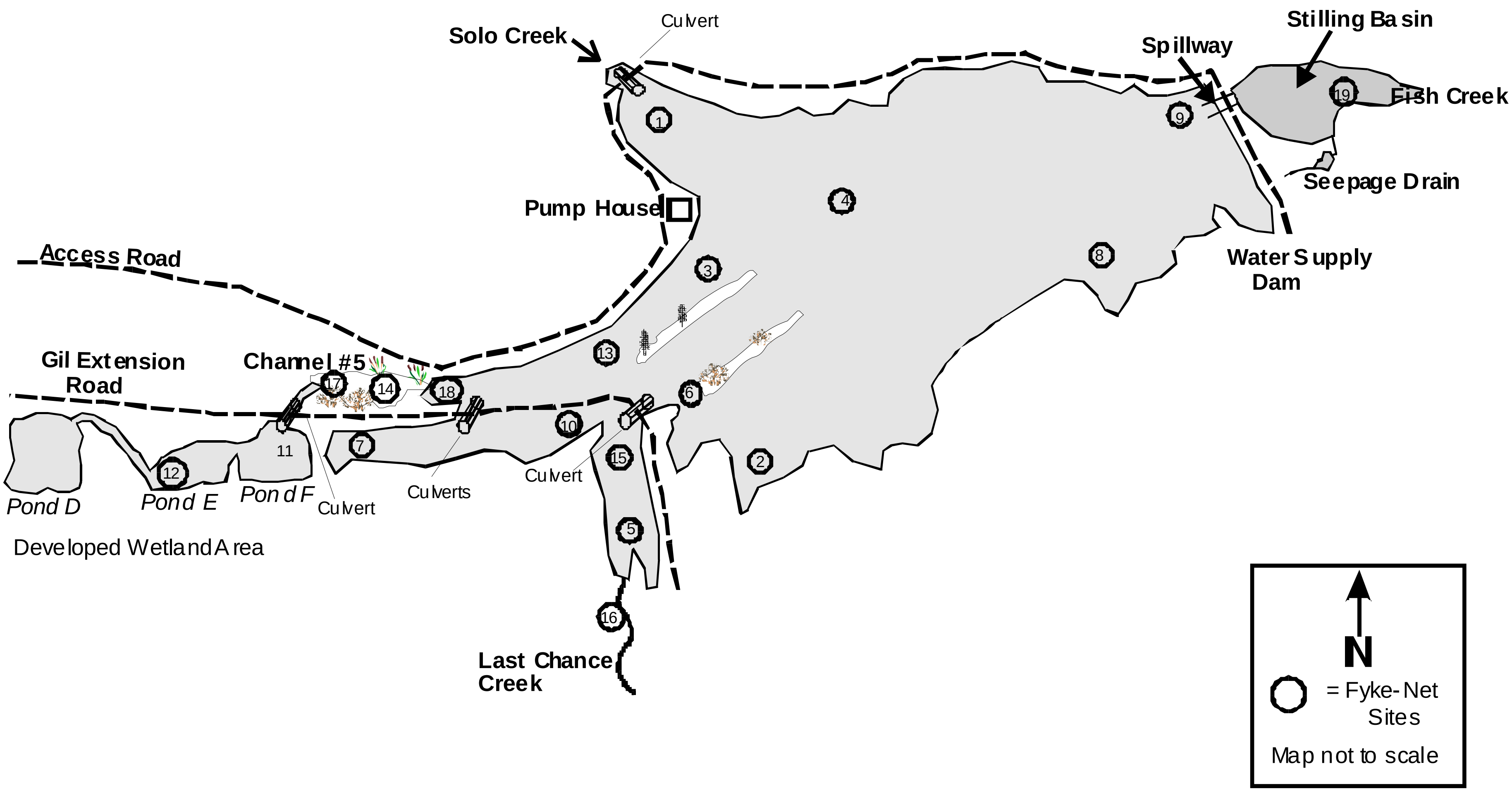

Figure 3. Fyke net sample sites in the Fort Knox WSR, stilling basin, and developed wetlands.

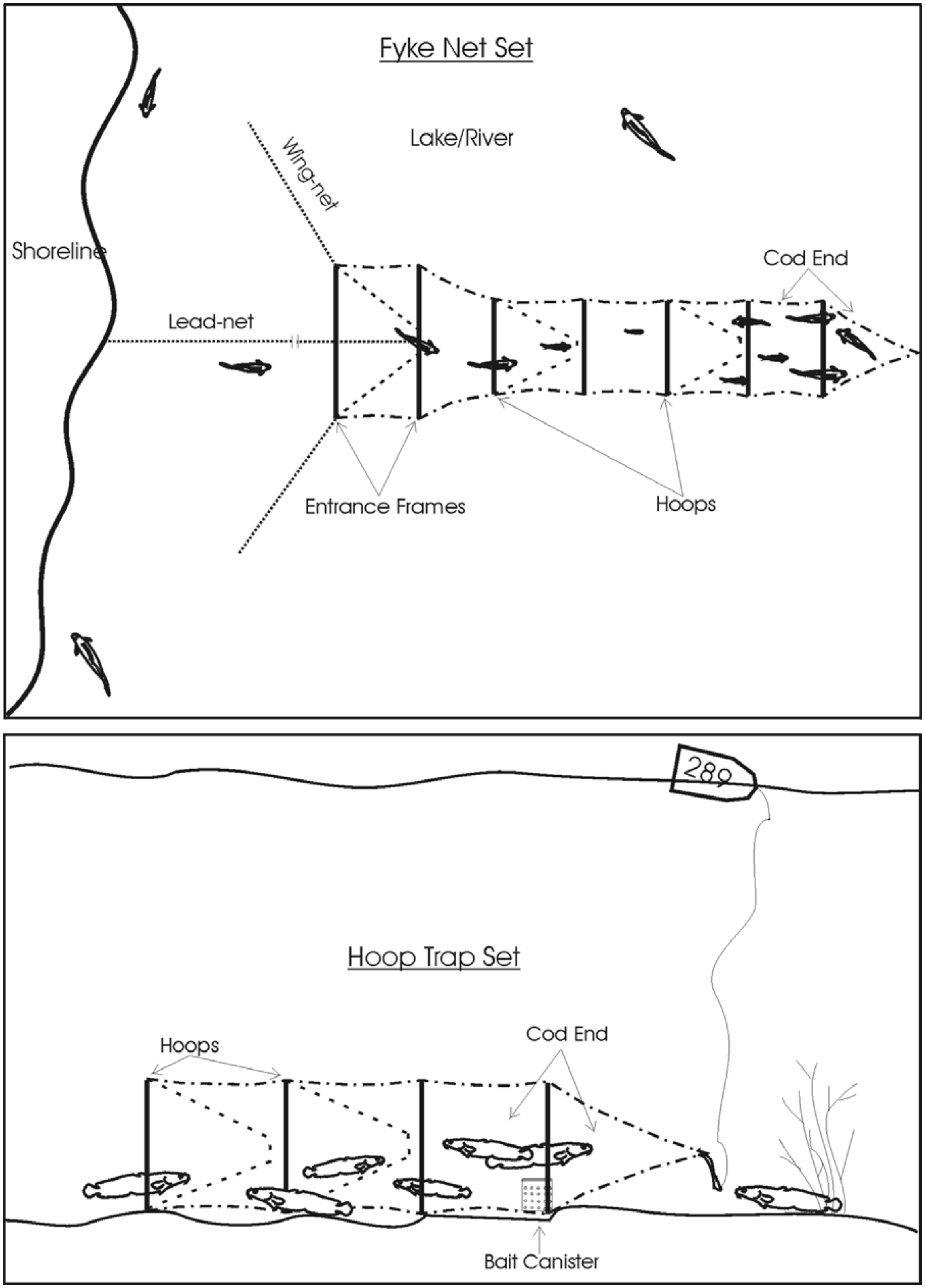

Figure 4. Diagram of fyke net and hoop trap sets.

Results and Discussion

Water Supply Reservoir, Water Quality

Five water quality sites located in the main portion of the WSR have been sampled annually since 1997 (Figure 5). Ponding of water in the WSR began in November 1995. Water surface elevations varied in 1996 and 1997 due to water use and winter seepage below the freshwater dam. The WSR reached the projected maximum surface elevation of 1,021 feet on September 29, 1998, following a major rainfall event. When full, the WSR contains about 3,363 acre-feet (1.096 billion gallons) of water.

Water levels have remained fairly constant since 1998, except in winter 2000/2001 when about 1,464 acre-feet (477 million gallons) of water was removed and transferred to the tailing impoundment (Table 1). In 2001, it took until mid-summer before the WSR recharged and water flowed over the spillway. Generally, there is a discharge from the WSR over the spillway throughout the year, including most of the winter.

Table 1. Winter water use from the WSR, 1997 through 2006.

Year	Acre-Feet of Water Removed
1997/1998	660
1998/1999	605
1999/2000	577
2000/2001	1,464
2001/2002	320
2002/2003	337
2003/2004	279
2004/2005	716
2005/2006	659

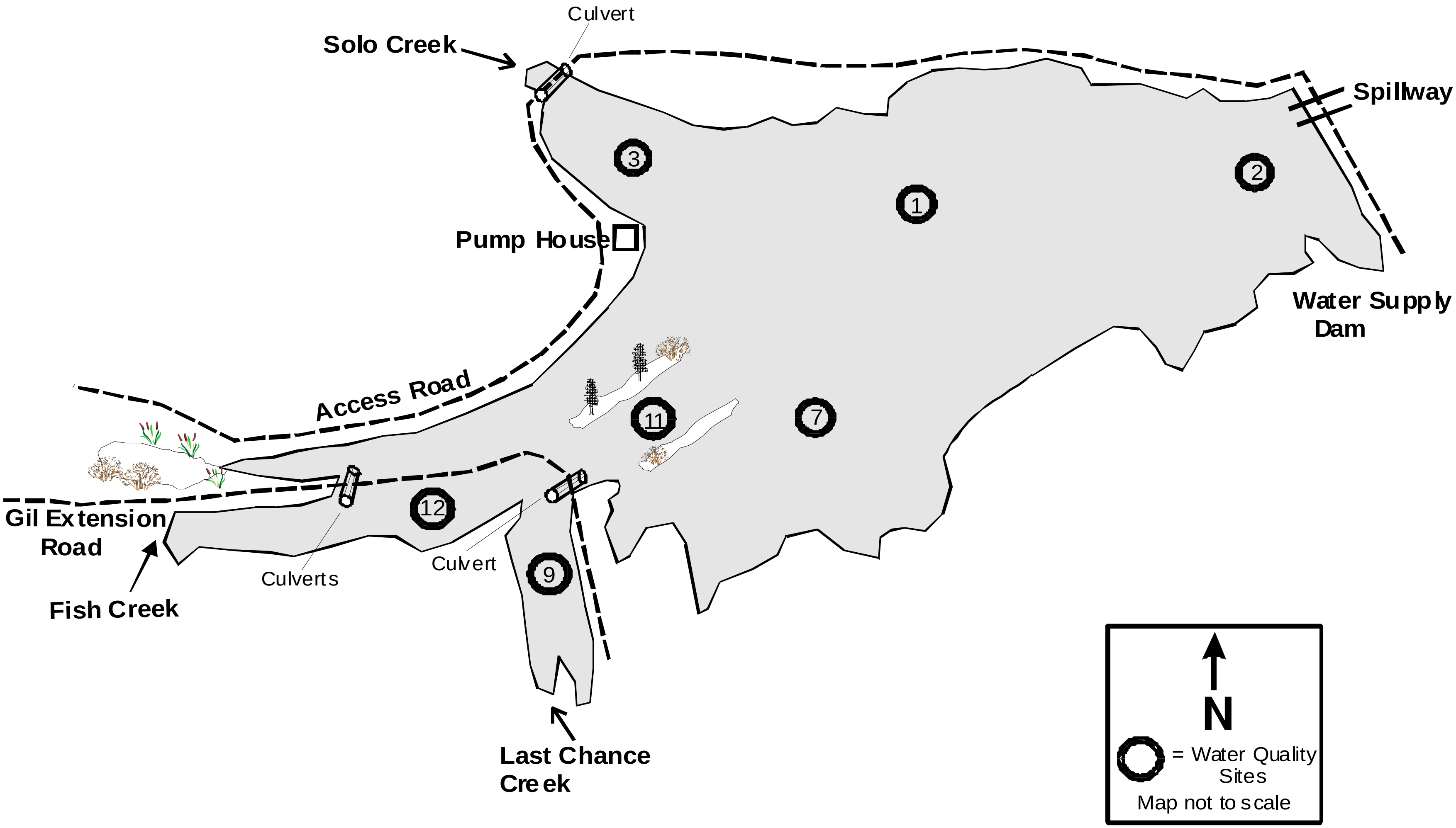

Figure 5. Water quality sample sites in the Fort Knox WSR.

Seepage flow downstream of the WSR is monitored by FGMI. Seepage flow has remained fairly constant for the last eight years (Table 2).

Table 2. Seepage flow rates below the WSR dam.

Year	Rate of Flow (cfs)	Geometric Mean (cfs)
1999	1.16 to 1.82	1.47
2000	1.03 to 1.86	1.38
2001	1.03 to 1.78	1.31
2002	1.13 to 1.78	1.41
2003	1.13 to 1.78	1.36
2004	1.00 to 1.69	1.28
2005	0.97 to 2.35	1.49
2006	1.30 to 2.35	1.44

In April 2006, winter water quality data were collected. The dissolved oxygen (DO) concentration was highest at the surface and decreased with depth (Figure 6). At Site #1 (i.e., in the middle of the WSR), higher DO concentrations in the upper water column are seen, but DO reaches less than 1 mg/L in deep water, except in 2001 when 477 million gallons of low DO water were removed from the WSR.

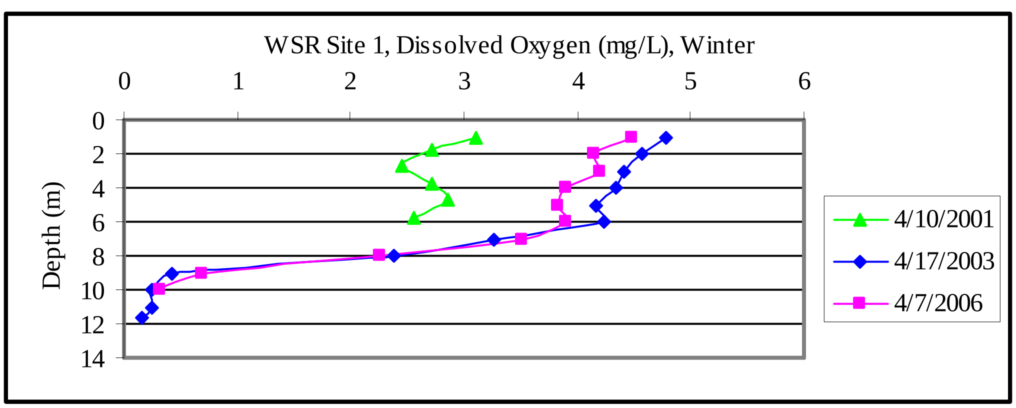

Figure 6. Winter dissolved oxygen concentrations at Site #1 (middle of WSR).

In spring 2006, aufeis in Last Chance Creek and in the wetland complex upstream of Pond E was extensive. Since 1996, only in spring 2004 and 2005 has aufeis been minimal in these areas. Minimal aufeis in Last Chance Creek and the wetland complex probably allows a higher discharge of oxygenated water during winter to the WSR. In April 2004, DO concentrations in Polar Bay Site #11 were highest (Figure 7), where Last Chance Creek enters the WSR.

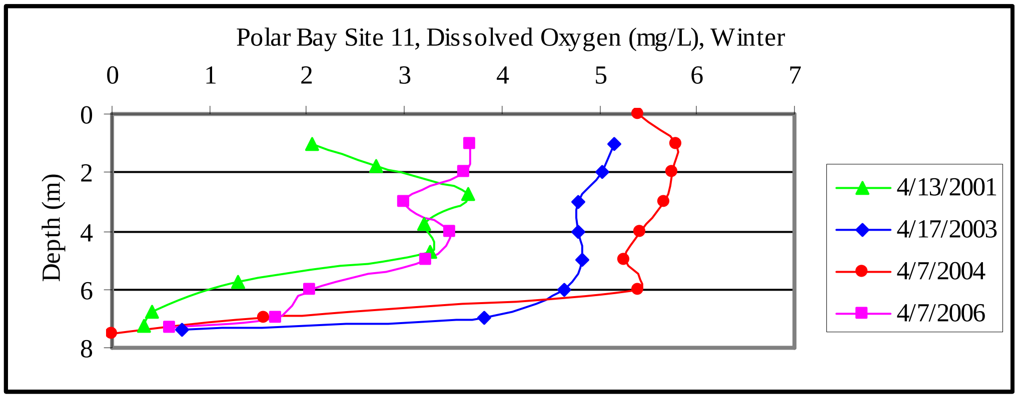

Figure 7. Winter dissolved oxygen concentrations at Site #11 (Polar Bay).

In August 2006, DO concentrations were high and near saturation in the upper 3 m of water, but fell dramatically between the 3 and 4 m depths (Figure 8). Decreased DO with depth has been observed consistently in the WSR during the ice-free season.

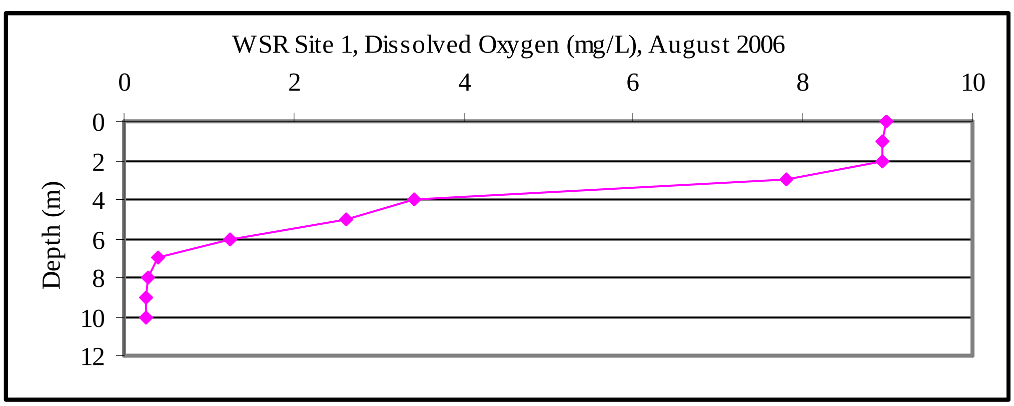

Figure 8. Dissolved oxygen concentrations at Site #1 in the WSR.

Surface water temperatures were warm (>17°C) at all sample sites with temperatures decreasing to about 6°C in deeper waters (Figure 9) in August 2006. Adult Arctic grayling were concentrated at the mouths of Solo and Last Chance creeks. Whereas water temperatures were high in the WSR, water from Solo and Last Chance creeks was much cooler. Water temperatures in Last Chance Creek where it enters the WSR were about 7°C. Visibility was limited in the Solo Creek area, but fish were actively surface feeding. At the mouth of Last Chance Creek, the entire bottom of the creek was covered with an estimated school of over 1,000 Arctic grayling that extended out into the WSR. Adult Arctic grayling were using the cool water inputs for thermal relief.

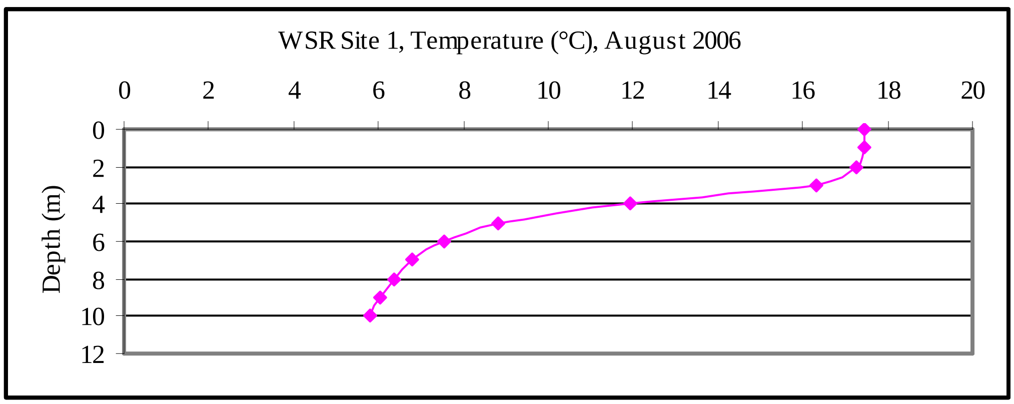

Figure 9. Water temperature at Site #1 in the WSR.

High surface water temperatures and DO concentrations near saturation in the upper 3 m of the water column were found at all five sample sites in the WSR, including Solo, Polar, and Lower Last Chance bays.

Conductivity and pH in the WSR have varied, but no definitive trends have been seen. Conductivity and pH at Site #1, located in the middle of the WSR are presented in Figures 10 and 11. Data were collected at different times, but all were obtained under ice-free conditions.

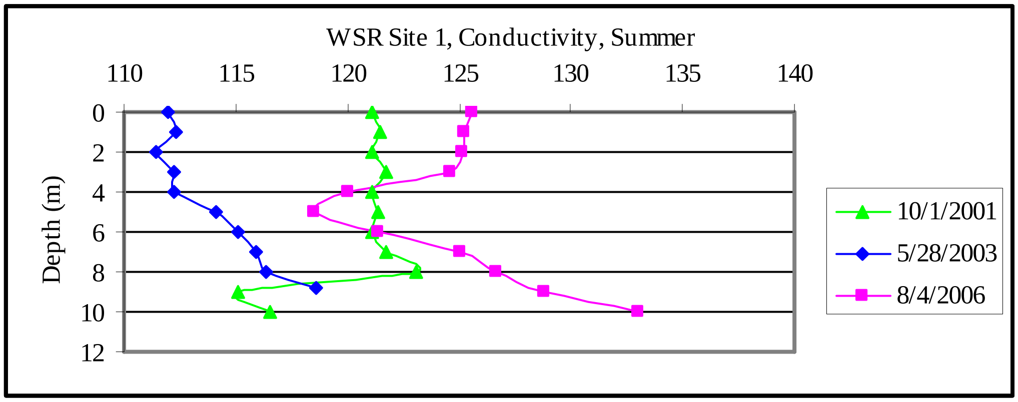

Figure 10. Conductivity at Site #1 in the WSR.

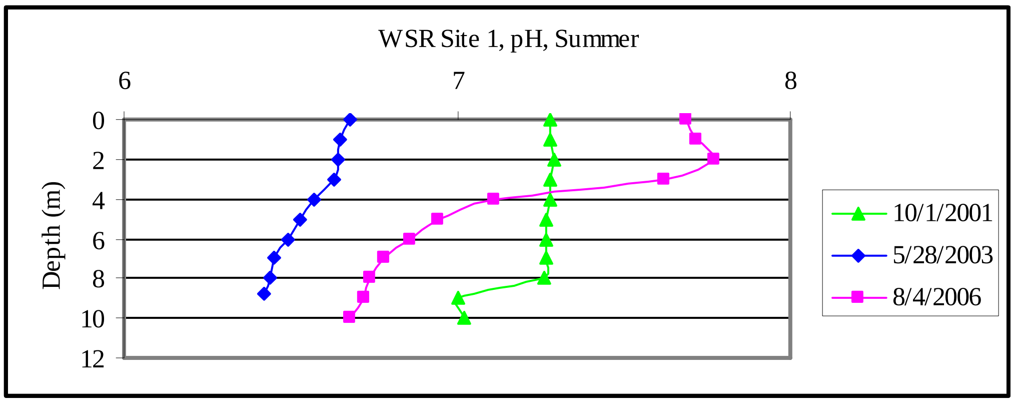

Figure 11. pH at Site #1 in the WSR.

Arctic Grayling and Burbot, Stilling Basin

The stilling basin, located immediately downstream of the WSR spillway, is fed by groundwater, seepage flow, and surface flow (Figures 2 and 3). In spring 2005 and 2006, we did not sample the stilling basin due to time constraints, an increased water level in the basin from beaver dams, and the high likelihood of having fyke nets damaged by beavers. Visual observations in spring and in early August documented the continued use of this area by Arctic grayling. In early August, Arctic grayling were concentrated where the seepage water drainage from the freshwater dam enters the stilling basin.

Arctic Grayling, Last Chance Creek and Developed Wetlands

Arctic grayling were found throughout the Fish Creek drainage prior to construction of the WSR. Fish were concentrated in ponds located in Last Chance Creek and overwintered in these flooded placer mine cuts. Arctic grayling were characterized as stunted: fish larger than 220 mm were rare; annual growth rate was 9 mm; and size at maturity was small (148 mm for males, 165 mm for females). Successful spawning occurred in outlets and inlets to the ponds with minimal fry survival in Last Chance Creek. Flooding of the WSR eliminated all pond inlets and outlets.

Fish sampling from 1996 through 1998 in the WSR and Last Chance Creek found very few fry. In spring 1999, FGMI constructed an outlet channel to connect the wetland complex with the WSR (Channel #5, Figure 2). Channel #5 bypassed water from the wetland complex that previously had flowed through a perched culvert. Channel #5 was built to provide access to spawning habitat in the wetland complex.

Successful spawning by Arctic grayling in the wetland complex has occurred every year since spring 1999. Arctic grayling have used most of the wetland complex each year, except in 2002 when spawning was limited to the lower portion (i.e., Channel #5 and Ponds E and F) by massive aufeis. Extensive aufeis in Last Chance Creek has limited spawning to only spring 2004 and 2005. In both 2004 and 2005, aufeis was minimal, water temperatures warmed quickly, Arctic grayling adults entered the creek, and numerous fry were observed later in the summer.

Arctic Grayling Spawning (Timing – Temperature)

In 2006, fyke nets were fished in Last Chance Creek and in the wetland complex. We only fished a fyke net in Last Chance Creek for one day due to extensive aufeis that physically prohibited installation of a net. Arctic grayling spawning in the wetland complex occurred only in Ponds E and F and in Channel #5 due to massive aufeis upstream and an impassable beaver dam at the outlet of Pond D. A chronology of observations of Arctic grayling spawning activity in the wetland complex and Last Chance Creek are presented in Tables 3 and 4.

Table 3. Chronology of Arctic grayling spawning in the wetland complex in spring 2006 at the Fort Knox Mine.

Date	Observations
May 2	Discharge about 2 cfs, slightly turbid, two small open water areas in stream below Pond F, aufeis 1 m thick below Pond F in wetlands, no fyke net sites available, temperature probes not placed due to ice
May 11	Discharge about 3 cfs, stained but clear, some open water in Pond F just upstream of CMP, water temperature 0.9°C in Pond F outlet and 0.5°C in Pond D Channel, temperature probe placed in channel below Pond F, wetlands areas covered in aufeis but water flow is under ice
May 15	Discharge about 5 cfs, slightly turbid and stained, some open water in Pond F just upstream of CMP, water temperature 1.1°C, set fyke net at wetland outlet to WSR, temperature probe placed in channel below D, temperature in channel below D Pond 0.2°C, all of Channel C still ice except top 100 m
May 19	Discharge about 4 cfs, stained but clear, open water still limited to just upstream of CMP and in portions of wetland complex below CMP, Arctic grayling moving into wetland complex, about 300 fish handled, most females are ripe, no evidence of any spawning activity
May 22	Discharge about 3 cfs, stained but clear, open water now present below Pond F and about 50% of Ponds E and F are ice free, water temperature 4°C, Arctic grayling numerous in channel below Pond F, some spawning observed, handled 145 Arctic grayling with most females ripe in wetland complex and evidence of spawning below the CMP, a few partially spent females present in catches
	Channel below Pond D contained about 150 Arctic grayling, Pond D still 100% ice (aufeis), water temperature in channel 2°C, fish blocked from moving into Pond D by beaver dams
May 24	Arctic grayling actively spawning in outlet channel from Pond F, water temperature 8.0°C, about 100 spawners in late afternoon in channel

Table 3. Chronology of Arctic grayling spawning (concluded).

May 24	Arctic grayling not present in channel below Pond D, Pond D still covered with aufeis
May 25	Arctic grayling actively spawning in outlet from Pond F, 100's of spawning fish, still no fish in channel below Pond D (water temperature 4.5°C)
May 26	Arctic grayling actively spawning in outlet from Pond F, still no fish in channel below Pond D, Pond D still ice covered (water temperature 4.8°C in channel below D Pond)
May 30	Only a few Arctic grayling still spawning in outlet from Pond F, still no fish in channel below Pond D
June 2	No Arctic grayling in outlet channel from Pond F, no Arctic grayling in channel below Pond D, Arctic grayling observed feeding in both Ponds E and F, Pond D still partially ice covered

Table 4. Chronology of Arctic grayling spawning in Last Chance Creek in spring 2006 at the Fort Knox Mine.

Date	Observations
May 11	Discharge about 5 cfs, stained, aufeis extensive throughout lower 2 km of creek, aufeis up to 3 m thick, water temperature 0.1°C, flow on top of aufeis in some reaches
May 19	Discharge about 8 cfs, stained, aufeis extensive, water temperature 0.2°, bottom founded ice still present, no indication of any Arctic grayling entering creek
May 22	Discharge about 5 cfs, stained, aufeis extensive, water temperature 0.2°C, bottom founded ice still present, flow still not in channel due to aufeis, no indication of any Arctic grayling entering creek, no suitable fyke net site available due to ice
May 24	Discharge about 3 cfs, stained, still no indication of any Arctic grayling entering creek, bottom founded ice present
May 25	Dischage about 5 cfs, stained, still full of ice including bottom founded ice, finally able to set fyke net in channel, water temperature 0.6°C, still no evidence of any Arctic grayling entering Last Chance Creek
May 26	Caught about 75 Arctic grayling in fyke net in Last Chance Creek, water temperature 1.1°C, pulled net
May 30	Aufeis still present in channel, no Arctic grayling observed
June 2	Aufeis still present in channel, no Arctic grayling observed

Water temperatures in the wetland complex in spring 2006 were influenced by massive aufeis in Pond D and in Channel C upstream of Pond D (Figure 12). Movement of Arctic grayling into Pond D was completely blocked by a beaver dam (Figure 12).

Figure 12. Massive aufeis upstream and downstream of Pond D (May 2006).

In early May, water temperatures in the Pond F outlet stream were influenced by aufeis in the upper part of the drainage and ice in Ponds E and F. A fyke net was set on May 15 in the Pond F outlet stream just upstream of the WSR. Arctic grayling already were present in Ponds E and F and fish were caught in the fyke net on May 16. On May 19, Ponds E and F were still ice covered with open water only at the outlet of Pond F. Ponds E and F were about 50% ice free by May 22.

The fyke net set at the outlet of the wetland complex effectively blocked the entire stream to upstream moving fish. Highest catches per day of fish >200 mm occurred on May 17 (84), May 19 (101), and May 25 (120). Peak spawning activity as observed in the Pond F outlet channel occurred from May 24 to 26. Peak water temperatures in the Pond F outlet during the major spawning activity ranged from 14.2 to 18.0°C (Figure 13). Peak spawning coincided with a substantial increase in water temperatures. Catches of Arctic grayling <200 mm entering the wetland complex were low (<2/day) until May 26 when 59 juvenile fish were captured.

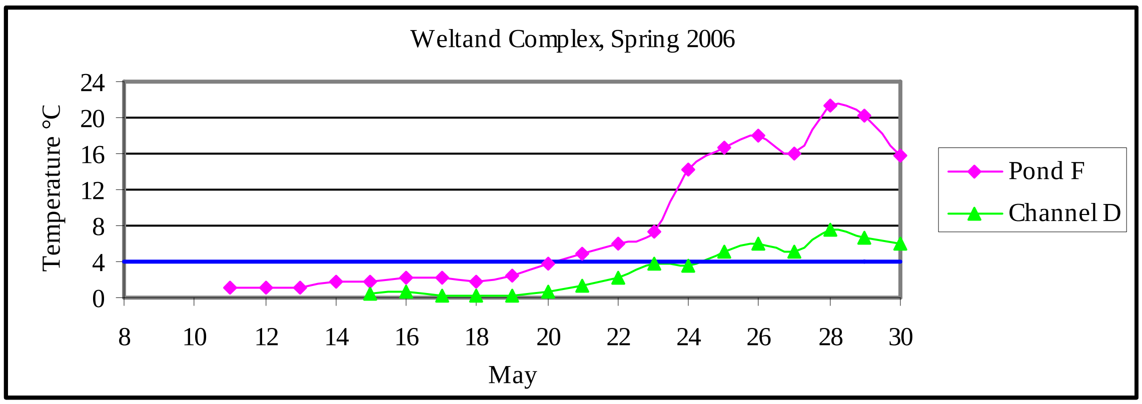

Figure 13. Peak daily water temperatures in the Pond F outlet in spring 2006.

On May 22, about 150 adult Arctic grayling were seen in Channel D immediately downstream of Pond D. Water temperatures in Channel D on May 22 peaked at 2.2°C, but did not reach 4°C or higher until May 25 (Figure 13). Adult Arctic grayling were not present in Channel D on May 24 and were not seen during subsequent fieldwork. Conditions suitable for spawning, specifically warm water temperatures in the Pond F outlet, were present and adults left Channel D to spawn in Ponds E and F or in the Pond F outlet stream. High quality spawning habitat was available in Channel D, but was not used in spring 2006 due to cold water temperatures associated with the aufeis upstream.

Water temperatures in Last Chance Creek never exceeded 4°C during our field sampling effort in 2006 (Figure 14). Only in spring 2004 and 2005 have water temperatures warmed enough to allow Arctic grayling to spawn (Figure 14) in Last Chance Creek. In each year, including 2006, adult Arctic grayling returned to the creek. Successful spawning in spring 2006 did not occur and was confirmed in early August when no fry were found in the lower 200 m of the creek.

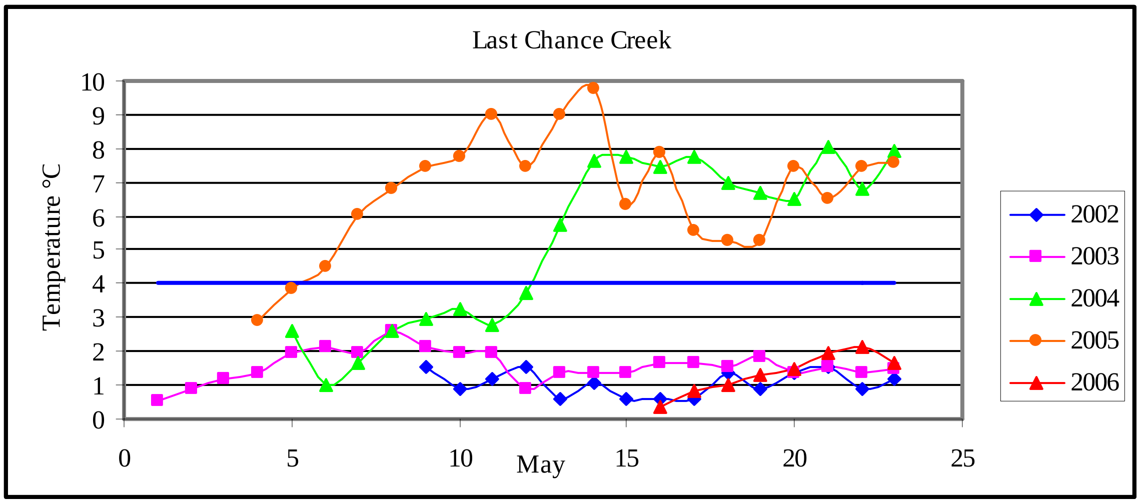

Figure 14. Peak daily water temperatures in Last Chance Creek (2002 to 2006).

In early August 2006, we checked Last Chance Creek, Channel C in the wetland complex, and Ponds E and F for the presence of Arctic grayling fry. Fry were only seen in the wetland complex below Pond D. The size of fry caught in August 2006 was similar to previous years, but substantially smaller than the length of fry caught in August 2005 (Table 5).

Table 5. Arctic grayling fry caught in the wetland complex and Last Chance Creek.

Sample Location	Date	Number of Fish	Average Length (mm)	Range (mm)	Standard Deviation
Wetlands	9/1/99	21	91	76-97	5.4
Wetlands	7/19/02	41	44	32-57	4.8
Wetlands	8/22/02	113	84	66-102	7.2
Wetlands	9/3/02	145	88	60-114	9.5
Wetlands	6/25/03	20	28	21-46	7.3
Wetlands	7/28/03	50	59	33-75	8.4
Wetlands	8/9/03	65	72	58-113	11.1
Wetlands	8/10/04	19	68	50-82	9.7
Last Chance	8/8/05	72	46	37-67	6.2
Wetlands	8/8/05	41	80	63-97	8.2
Channel C	8/8/05	70	56	44-68	4.3
Wetlands	8/2/06	74	58	45-76	6.4

Arctic Grayling (Mark/Recapture, Population Estimate, and Growth)

We estimated the abundance of Arctic grayling in the WSR using spring 2005 as the mark event and spring 2006 as the recapture event. In spring 2006, we caught 948 Arctic grayling >225 mm, with 132 recaptures. Our spring 2005 estimated Arctic grayling population in the WSR for fish >200 mm long was 7,926 (95% CI 6,759 to 9,094). The Arctic grayling population for fish >200 mm long increased from 1999 through 2002, remained stable from 2002 through 2004, and then increased substantially in spring 2005 (Figure 15, Appendix 1).

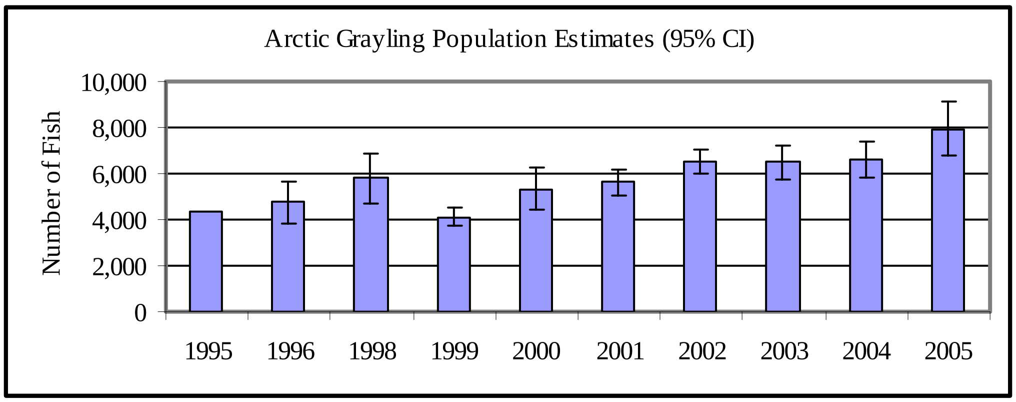

Figure 15. Estimates of the Arctic grayling population in the WSR (1995 to 2005).

For our 2005 estimated Arctic grayling population, we did not include fish that had been marked prior to 2005 unless that individual fish was seen in spring 2005. We also compared length frequency distributions for fish marked in spring 2005 with those recaptured in spring 2006 to eliminate those fish handled in 2006 that would have been too small (<200 mm) to mark in spring 2005 (Figures 16 and 17). Our comparisons of length frequency diagrams indicated that fish <225 mm in spring 2006 should not be included in the population estimate (i.e., they would have been too small in 2005 to mark). Using this approach, we reduced the number of fish seen in 2006 by 198 individuals.

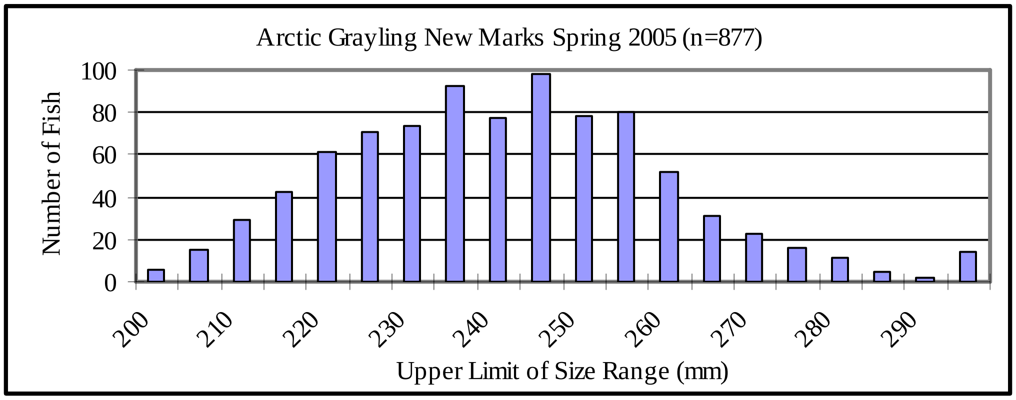

Figure 16. Length frequency distribution of Arctic grayling marked in spring 2005.

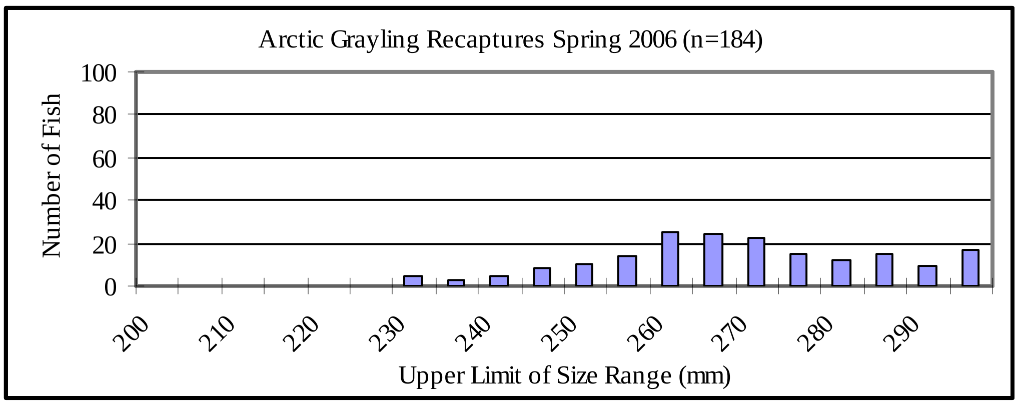

Figure 17. Length frequency distribution of Arctic grayling recaptures in spring 2006.

Average growth prior to the WSR was 9 mm per year. Once the WSR was flooded, annual growth rates for all marked fish increased dramatically. Annual growth rates of marked fish by size class reached its peak in 2001, and then decreased each year through 2004. In 2005, annual growth rates were higher than in 2003 (Figure 18). Data presented in Figure 18 were selected to show the variable growth rates by year. Growth rates by size class for marked fish in 2002 and 2004 also were lower than those seen in 2005.

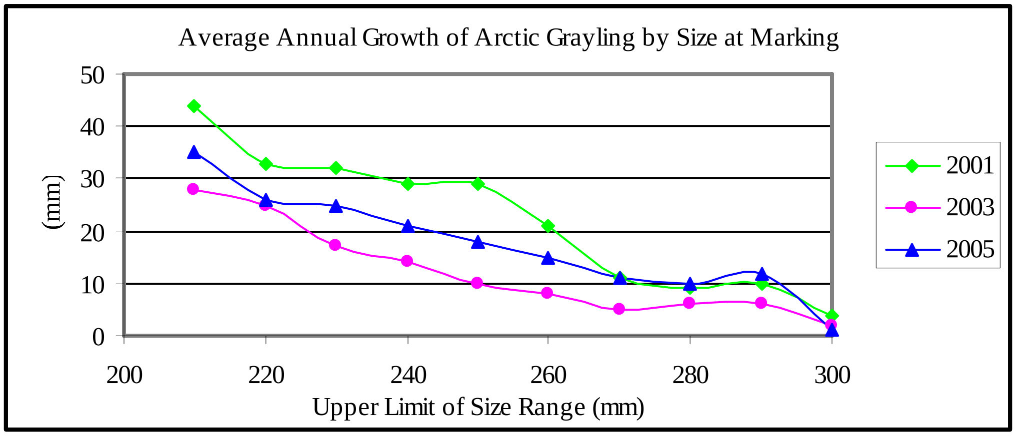

Figure 18. Average growth (mm) for recaptured Arctic grayling in 2001, 2003, and 2005.

The length frequency distribution for Arctic grayling collected in spring 2006 is presented in Figure 19. Most of the small fish present were just beginning to move into the sampling area and were caught on the last day that fyke nets were fished; juveniles are likely underrepresented in the length frequency distribution. All age classes are present in the catches and there is evidence that recruitment to the population remains strong.

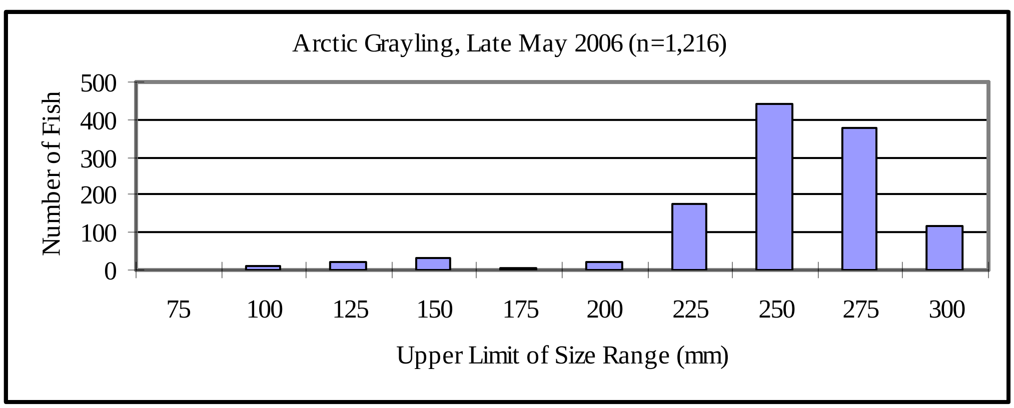

Figure 19. Length frequency distribution for Arctic grayling captured in spring 2006 with fyke nets and by angling.

Burbot, Water Supply Reservoir and Developed Wetlands

Burbot were found in Lower Last Chance Creek pond and in Polar Ponds #1 and #2 prior to flooding of the WSR (Ott and Weber Scannell 1996). In May 1995, we conducted a mark/recapture effort and estimated the abundance of burbot (150 to 331 mm long) to be 825 (Ott and Weber Scannell 1996).

Flooding of the WSR inundated areas where burbot had been caught. Estimates of the burbot population in the WSR continued following creation of the WSR (Figure 20). The population steadily increased and peaked in 1999. Since 1999, numbers of burbot have steadily decreased with the exception of a slight increase in summer 2004 (Figure 20, Appendix 2). The estimated burbot population for fish >200 mm in spring 2005 was 944 (95% CI 572 to 1,316). Burbot use of the wetland complex continues with smaller fish (<300 mm) caught in fyke nets during the spring Arctic grayling sampling event. Age 0 burbot also were caught in the WSR and in the developed wetlands.

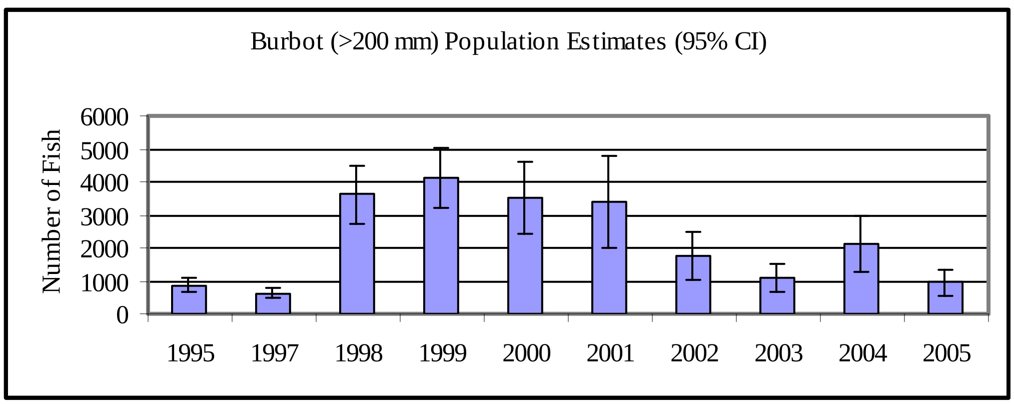

Figure 20. Estimates of the burbot population (>200 mm) in the WSR (1995 to 2004).

We also estimated the number of large burbot (>400 mm) in the population from 2001 through 2005. The number of burbot >400 mm appeared to be stable or slowly decreasing from 2001 to 2004, but in 2005 our estimate of large burbot increased to 143 fish (Figure 21, Appendix 2).

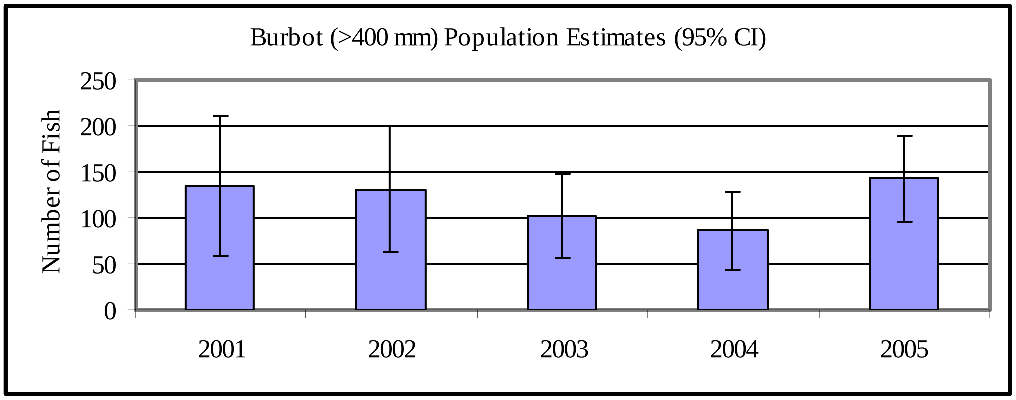

Figure 21. Estimates of the burbot population (>400 mm) in the WSR (2001 to 2005).

Conclusion

Self-sustaining populations of Arctic grayling and burbot have been established in the Fort Knox WSR. Our goal for the Arctic grayling population in the WSR was set at 800 to 1,600 fish >200 mm prior to construction of the freshwater dam. Our spring 2005 estimated population for Arctic grayling >200 mm in the WSR was 7,926. A goal for the burbot population was not set prior to construction, but a self-sustaining population exists. Burbot numbers increased substantially in the first four years, but then declined. Data collected through spring 2006 strongly suggest that a small population of large burbot has become established.

We plan to continue to work cooperatively with FGMI to gather data on fish resources in the WSR. Development of a second wetland complex located along the north side of the Fish Creek valley between the tailing dam and freshwater reservoir would substantially increase fish and aquatic habitat values (Ott and Morris 2005b). One of our long-term objectives is to facilitate incorporation of the second wetland complex into the final reclamation of the Fort Knox Mine.

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Appendix 1. Arctic Grayling Population Estimates in the WSR

Year	Minimum Size of Fish in Estimate (mm)	Estimated Size of Population	95% Confidence Interval
1995[1]	150	4,358	
1996[2]	150	4,748	3,824-5,672
1996[3]	150	3,475	2,552-4,398
1998[4]	200	5,800	4,705-6,895
1999[4]	200	4,123	3,698-4,548
2000[4]	200	5,326	4,400-6,253
2001[4]	200	5,623	5,030-6,217
2002[4]	200	6,503	6,001-7,005
2003[4]	200	6,495	5,760-7,231
2004[4]	200	6,614	5,808-7,420
2005[4]	200	7,926	6,759-9,094

[1]We used estimates from the ponds and creeks for the Arctic grayling population; a confidence interval was not applicable to the data set.
[2]The 1996 estimate was made with a capture and recapture event in summer 1996.
[3]Gear type for the population estimate was a boat-mounted electroshocker with both capture and recapture events in fall 1996.
[4]The 1998 through 2005 population estimates were made using a mark event in spring of the year of the estimate, but the recapture event was in spring of the following year.

Appendix 2. Burbot Population Estimates in the WSR

Year	Minimum Size of Fish in Estimate (mm)	Estimated Size of Population	95% Confidence Interval
1995[1]	150	876	666-1,087
1997[2]	250	622	462-782
1998[2]	300	703	499-907
1998[3]	200	3,609	2,731-4,485
1999[3]	200	4,136	3,215-5,057
2000[3]	200	3,536	2,444-4,629
2001[4]	200	3,391	2,017-4,764
2001	400	134	58-210
2002[4]	200	1,763	1,045-2,480
2002	400	131	62-199
2003[4]	200	1,103	671-1,535
2003	400	102	57-147
2004[5]	200	2,100	1,242-2,957
2004	400	86	44-128
2005[5]	200	944	572-1,316
2005	400	143	96-191

[1]We used fyke nets in the Polar Pond complex to make the 1995 population estimate.
[2]The 1997 and 1998 estimates were made with a capture and recapture event in May of the same year.
[3]The 1998, 1999, and 2000 population estimates were made using a mark event in spring with the recapture event occurring one year later in the spring.
[4]The 2001, 2002, and 2003 population estimates were made with capture and recapture events in the same year.
[5]The 2004 and 2005 population estimates were made using the previous year as the mark event with the recapture event occurring the following spring.