GREAT LAKES INDIAN FISH & WILDLIFE COMMISSION

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Date: August 13, 2001

TO: Neil Kmiecik, Biological Services Director

FROM: John Coleman, Environmental Section Leader JC/ams

RE: Report on the status of the Flambeau Mine

Each year, the Flambeau Mining Company reports the results of its activities at the Flambeau mine site (Fig. 1) to the Wisconsin DNR. A review of the Flambeau Mine 2000 Annual Report indicates a number of issues that require further analysis and investigation. This memo provides background information on activities at the mine site in 2000, discusses the primary issues, and gives supporting analysis for the issues identified.

The primary issues raised by the environmental data from the mine include:

1) Water Quality in the Reflooded Mine Pit. The reflooded mine pit water contains contaminants 10 to 100 times higher than anticipated during the mine permitting process. The impact of this poor quality water on the Flambeau River depends on the flow rate from the pit to the river. Estimates of flow to the river based on the most recent packer test data from the backfilled pit suggest that flow is likely to be 2 to 3 orders of magnitude greater than that predicted by the mining company's consultants.

2) Elevated metals in the Flambeau River. The data show poorer water quality and elevated metals in sediments and crayfish in the Flambeau River below the mine site. The magnitude of this build-up appears small for some metals but in some cases represents a greater than 100% increase over the up-stream levels. The increase in metals below the mine site is statistically significant but whether it is biologically important is unclear. The cause of the elevated metals is also unclear. The data suggest that it may be due to the mining activity but the data in the year 2000 annual report is inadequate to draw strong conclusions as to the cause of the elevated metals below the mine site.

3) Monitoring of the mine site and Flambeau River. The company is reducing their monitoring of the Flambeau River. They propose to test water samples from the river for only a small number of metals. The company will not collect sediment or fish samples in 2001 and will eliminate crayfish sampling in 2002.

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Background and Supporting Analysis

Activities at the mine site up through December 2000

During the life of the mine, the Flambeau Mining Co. (Kennecott Minerals) removed 181,000 tons of copper, 3.3 million ounces of silver and 334,000 ounces of gold from the open pit mine next to the Flambeau River. In 1997 and 1998 the mining company refilled the mine pit with compacted waste rock and the material was covered with soil and seeded. There now exists grasses and a wetland on top of the mine pit. As planned, since 1997 groundwater has been gradually seeping into the pit filled with waste rock. By the end of 2000 the mine pit had almost completely resaturated with groundwater. The waste rock in the pit contains metals that have dissolved in the groundwater and are slowly moving into the Flambeau River. The company estimates that approximately 408 gallons per day (0.28 gpm) of contaminated water move from the pit into the Flambeau River. It is the company's contention that this is not a threat to water quality in the Flambeau River and would cause an "immeasurable" effect on Flambeau water quality.

In 2000 the mining company focused primarily on revegetation of the site and monitoring the mine pit and the Flambeau River. The company has leased 32 acres of the mine site to the Ladysmith Community Industrial Development Corporation (LCIDC). The LCIDC has then leased various mine site buildings to several businesses, including the WDNR for a regional Service Center.

In 2001 the mining company will submit a notice of completion of reclamation. This will begin the process for the WDNR to return the reclamation bond. In the past, the company has monitored the Flambeau River by collecting water, sediment, fish and crayfish samples each year. The company is now reducing their monitoring of the Flambeau River. They will now test water samples from the river for only a small number of metals. The company plans not to collect sediment or fish samples in 2001 and anticipates eliminating crayfish sampling in 2002.

Water Quality in the Reflooded Mine Pit and Flux to the River

During the permitting process (1989 - 1991) for the Flambeau mine, water quality in the reflooded mine pit was predicted to be slightly contaminated (Flambeau FEIS, 1990). Recent samples collected in 1999 and 2000 from sampling wells in the reflooded pit show that the water quality in the pit is 10 to 100 times worse than anticipated (Table 1). Although the water quality in the pit is significantly worse than anticipated, the company contends that it still does not pose a threat to the Flambeau River. Because of their prediction of low flow rate from the pit to the river, the mining company believes that only a small amount of contaminants are entering the river.

While in the previous annual report (1999) the company stated that the pit water quality would improve within a relatively short period, they no longer contend this. In their 2000 annual report they predict that pit water quality will remain in its current condition for "hundreds of years". The higher than anticipated metals and lower pH in the reflooded pit water are primarily due to a larger than anticipated amount of CO_2 accumulating in the pit water. Data show 5 to 50 fold higher CO_2 in the refilled pit than was anticipated during the mine permitting process. According to the company's current analysis it will take hundreds of years for this CO_2 to dissipate.

Flux to the river.- The company had calculated the flow rate of groundwater from the pit to the river as 0.28 gallons per minute. A recalculation of this same equation, but using 1998 field data on the conductivity of the backfill and the correct depth for the mine pit, estimates 100 to over 1000 times more water moving from the pit to the river. The following calculations are based on page 3 of the Foth & Van Dyke memo to Flambeau Mining Co. of August 4, 1999. The parameters listed below are underlined where they differ from those used by Foth & Van Dyke.

- the permeability (K) of the backfill is 1.324 ft/d (the geometric mean of slug test in Type II backfill measured on Nov. 30, 1998). In contrast to a K of 0.028 ft/d used by Foth & Van Dyke.
- the hydraulic gradient (I) between the western end of the pit and the Flambeau River is 0.04 ft/ft (based on the predicted final head for well MW1013 and the elevation of the river taken from topographic maps in the Mine Permit Application, i.e. (1110ft-1086ft)/600ft). In contrast to a gradient of 0.03 ft/ft used by Foth & Van Dyke.
- the cross sectional area (A) is equal to the approximate pit width (650ft) and the pit depth (200 ft) adjacent to the river (see Fig. 4-2 of Flambeau Mining Co. 2000 report). In contrast to a pit depth of 100 ft used by Foth & Van Dyke.

Using the equation Q=K*I*A, these parameters give a flux to the river of 6885 cf/d. This is 126 times the 54.6 cf/d flux proposed by Foth & Van Dyke. The flux could in fact be much greater since the slug tests indicate a maximum K in the Type II waste material of 44.22 ft/d. Flux calculated using this K is 229,944 cf/d (4200 times that calculated by Foth & Van Dyke for Flambeau Mining Co.). In addition, at times of low river flow the level of the river is less than 1086, thereby increasing the gradient and flux. If, in fact the flux is as high as 200,000 cf/d, the poor water quality in the pit poses a threat to the water quality of the Flambeau River.

Metals Analysis in the Flambeau River

The data presented in the Flambeau Mine 2000 annual report show clear impacts to the Flambeau River due to the mine site. The data show that river water, sediments, and macroinvertebrates are all higher in metals below the mine site than above the mine site. The only data set that shows no statistically significant evidence one way or the other is the walleye data. This is not surprising given the great distance at which the above-mine (3 miles up river) and below-mine (6.5 miles down river) walleye were collected and the large variation one typically finds in metal concentrations in walleye even within a single water body. In general, the environmental monitoring data is plagued by excessively high detection limits for the parameters measured. However, the environmental monitoring data that is available does show a clear effect of the mine site. These data sets are:

Surface Water Samples - An examination of the parameters for which there is adequate data above the detection limit (Chromium, Aluminum, Lead, Copper, Hardness, Conductivity and TDS) all show higher levels in samples collected below the mine site than in samples collected above the mine site. Examining all the above-detection-limit data for these parameters, one finds that in a comparison of the 149 pairs of unequal parameter values recorded above and below the mine from October 1992

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to 2000 for these parameters, 102 parameters are higher below the mine and 47 are lower below the mine. This overall trend in the parameter values is highly significant (Sign test, $P<0.001$; Zar 1984) and suggests that examination of the individual parameters is warranted. The baseline data collected prior to October 1992 shows parameter values to be similar above and below the mine site but is statistically inconclusive. The 1990 FEIS for the project stated there was no difference in water quality above and below the mine site based on 1987 and 1988 water testing. When examining the data collected after the start of significant activity at the mine site (data since October 1992) for individual parameters, one finds that all the parameters show a tendency to have higher values below the mine than above the mine. Most of these tendencies are statistically significant when the paired samples are tested for significance with the Wilcoxon Signed Rank test (Zar 1984). For example, chromium (Fig. 2) showed a statistically significant tendency to be higher below the mine since October 1992.

Chromium.- The pairs of samples collected above and below the mine from Oct. 1992 to 2000 show significantly higher values for chromium below the mine than above (Wilcoxon Signed Rank test, $P=0.005$).

Aluminum.- The pairs of samples collected above and below the mine from Oct. 1992 to 2000 show significantly higher values for aluminum below the mine than above (Wilcoxon Signed Rank test, $P=0.03$).

Lead.- Although the measurements more often showed higher lead readings below the mine than above the mine, the pairs of samples collected above and below the mine from Oct. 1992 to 2000 did not show statistically significantly higher lead below the mine (Wilcoxon Signed Rank test, $P=0.338$).

Copper.- The pairs of samples collected above and below the mine from Oct. 1992 to 2000 show significantly higher values for copper below the mine than above (Wilcoxon Signed Rank test, $P=0.047$).

Conductivity.- The pairs of samples collected above and below the mine from Oct. 1992 to 2000 show significantly higher values for conductivity below the mine than above (Wilcoxon Signed Rank test, $P=0.006$).

Hardness.- The pairs of samples collected above and below the mine from Oct. 1992 to 2000 show significantly higher values for hardness below the mine than above (Wilcoxon Signed Rank test, $P=0.003$).

TDS.- Although the measurements more often showed higher TDS readings below the mine than above the mine, the pairs of samples collected above and below the mine from Oct. 1992 to 2000 did not show statistically significantly higher TDS below the mine (Wilcoxon Signed Rank test, $P=0.406$).

No water quality parameters showed significantly lower values below the mine than above the mine.

Metals in Crayfish - The crayfish samples collected below the mine site after 1992 at Meadowbrook Creek showed significantly (Sign test) higher levels of copper ($P=0.008$) in their

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tissues than the samples collected above the mine site. Although aluminum was also more often higher below the mine site than above the site, this was not found to be significant (P=0.145). Copper and aluminum were the only individual metals that had enough above-detection-limit values to be tested statistically. The other metals had too many below-detection-limit values to be examined individually. However, when all pairs of measurements taken above and below the mine site were examined, one sees that while 25 times metals were higher below the mine site, only 11 times were metals lower below the mine site and 5 times metals were equal in samples taken above and below the mine site. A Sign test on these differences shows that metals are significantly (P<0.015) higher in crayfish below the mine site than above the site. The data collected in 1991 and 1992 showed that metals may have been higher below the mine in this period also. However, there is inadequate data to statistically test any of the metals individually. In addition, the number of non-detect values suggests that the collection methods or lab methods may have changed between 1992 and 1993.

While the samples collected at Port Arthur show similar results, they were not considered in my analysis because the sample site was too far from the mine site to be very meaningful.

River Sediments - Initial sampling of sediments was conducted by Flambeau Mining Co. at Port Arthur Dam. This site is over 2.5 miles from the mine site and therefore, unlikely to produce meaningful data. In 1993 the sediment sampling site was moved to Sister's Farm, approximately 1.5 miles from the mine site. A comparison of the sediments collected yearly (1993 to 2000) above the mine site (Blackberry Lane) to those collected below the site (Sister's farm) show significantly (Sign test, P<0.01) elevated levels of metals in the below-mine site samples. Statistical tests (Wilcoxon Signed Rank test) of several individual metals found them to be elevated below the mine site i.e. aluminum (P<0.004), chromium (P<0.05), copper (P<0.008), lead (P<0.05), and zinc (P<0.035). Only nickel had significantly (P<0.035) lower levels below the mine site.

Data collected at Port Arthur prior to mining showed similar levels of metals in sediments above and below the mine but are statistically inconclusive.

Conclusions –

The water quality in the backfilled and reflooded mine pit is poorer than anticipated during permitting by a factor of 10 to 100. This contaminated pit water is moving toward and discharging into the Flambeau River. The water quality in the pit and the water entering the Flambeau River is predicted to remain at its current contamination level for at least several hundred years. More sophisticated analysis of the flux to the river is required to determine if the pit water poses a serious threat to the river. This analysis should be based on the measured conductivity of the backfilled pit and the conductivity of the surrounding bedrock and residual ore. It should also use more accurate measures of the gradient between the pit and the river, particularly during low river flow.

Monitoring of water quality, sediments, and crayfish show higher levels of metals below the mine site than above the site. The baseline data collected in 1991-92 for these indicators is inconclusive. Data collected since mid-1992 indicates poorer water quality below the mine site than above the mine site. The cause(s) of the increases in metals in the river water is unknown but may be

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due to discharge of waste water during mining, surface runoff from the mine site to local creeks or the river, leakage of holding ponds or ore storage areas, discharge of contaminated groundwater into the river. All of these events have been repeatedly documented in the mining company's annual reports. On the other hand, the elevated metals may be due to the presence of the metal-enriched ore zone under the Flambeau River. However, pre-mining data do not suggest that this is the case. The WDNR should respond to the indicators of metals release by initiating an investigation to determine the cause, the current magnitude of the increased metals below the mine site, and determine if metals release from the mine site is an ongoing problem.

The baseline data collected appears to be inadequate to establish river conditions prior to mining. There should be a review and statistical analysis of the adequacy of current baseline data requirements. Standards for baseline data collection should be based on the ability to detect changes due to a mine project.

The Flambeau Mining Company is anticipating reducing monitoring and reclamation activities at the mine site. Within the next 12 months, they may be asking for certification of completion of reclamation from the WDNR. The company anticipates eliminating some monitoring and reducing other monitoring in the Flambeau River. Because of indications of metals release to the river, all monitoring of the mine pit and the Flambeau River should be continued on a quarterly basis and additional water and biological monitoring should be initiated to determine the source and fate of the elevated metals.

Literature Cited

Zar, J. H. 1984. Biostatistical Analysis. Prentice-Hall Inc. Englewood Cliffs. 718 pp.

cc: Kory Groetsch, Environmental Biologist
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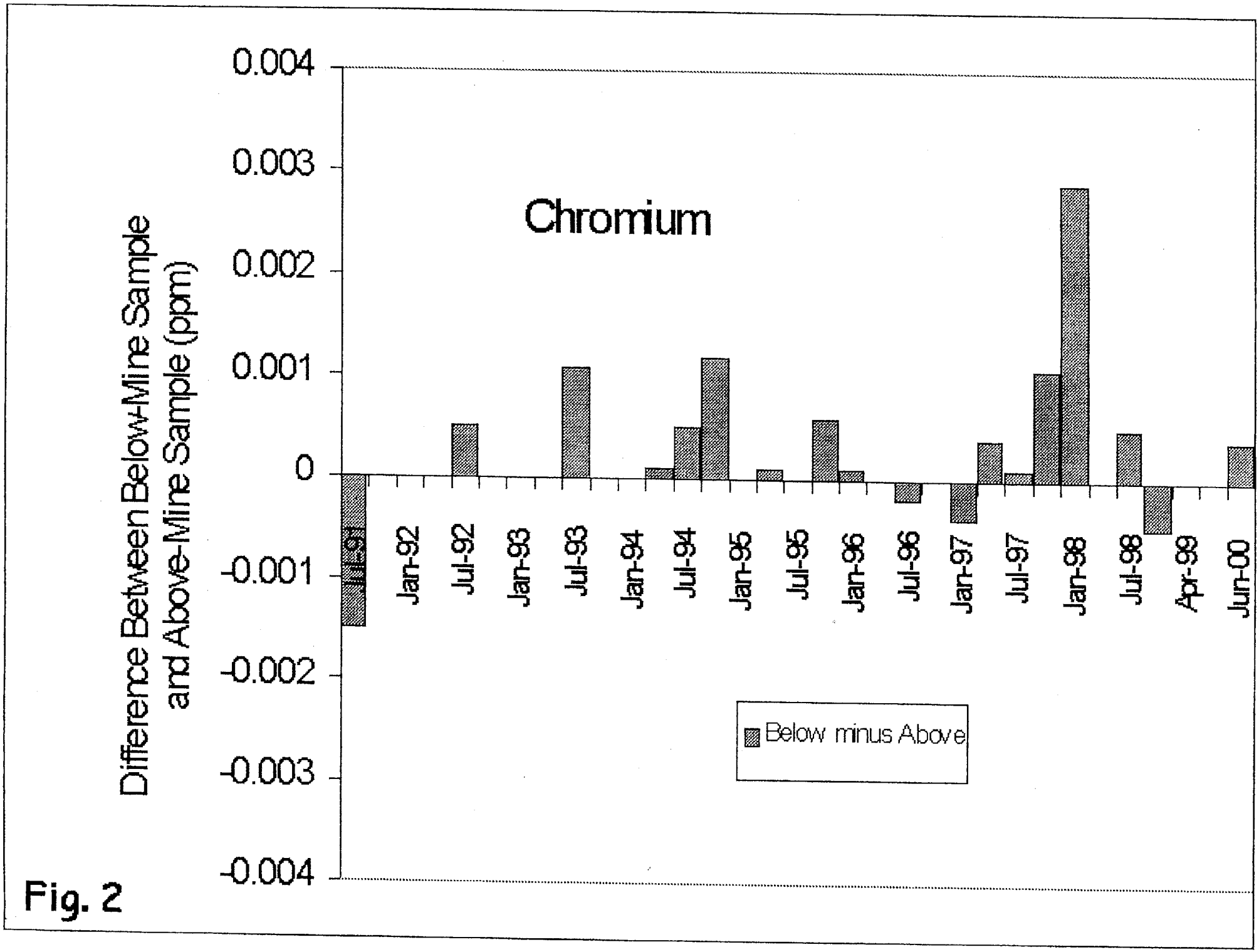
Chromium
Difference Between Below-Mine Sample and Above-Mine Sample (ppm)
0.004
0.003
0.002
0.001
0
-0.001
-0.002
-0.003
-0.004
Jul-91
Jan-92
Jul-92
Jan-93
Jul-93
Jan-94
Jul-94
Jan-95
Jul-95
Jan-96
Jul-96
Jan-97
Jul-97
Jan-98
Jul-98
Apr-99
Jun-00
Below minus Above

Fig. 2

Table 1. Predicted and Current Ground Water Quality (**mg/L**) at the Flambeau Mine.

	Predicted Concentrations			Observed Concentrations								Wisconsin Ground Water Standards	
				In reflooded mine pit filled with waste rock (4 wells)				Between river and pit (1 well)				Enforce-ment Standard	Preventive Action Limit
Compound	**1989**[1]	1996	1997	1/00	4/00	7/00	10/00	1/00	4/00	7/00	10/00		
Copper	**0.014**	<0.01	0.18 - 0.56	<0.005 - 0.50	<0.006 – 0.52	<0.012 – 0.33	<0.012 - 0.43	0.002	0.019	0.007	0.003	1.3	0.13
Manganese	**0.522**	<1.7	1.9 - 2.3	3 - 30	3.6 – 32	3.5 – 34	3.2 – 35	4.1	3.8	5.0	4.2	0.05	0.025
Iron	**0.32**	<1.5	1.6 - 1.9	0.05 - 11.5	<0.15 – 13	<0.36 – 13	<0.36 – 12	4.4	3.4	2.3	6.6	0.30	0.15
Sulfate	**1360**	1000	1043 - 1158	550 - 1700	440 – 1700	480 – 1600	450 – 1600	610	560	550	460	250	125
pH (field)	**>6.5**	7.5	>6.6 to >7.1	6.4 – 6.6	6.4 – 6.9	6.3 - 6.6	6.3 - 6.7	6.3	6.9	6.3	6.2		
TDS				1250 - 3300	1000 – 3600	1400 – 3300	1300 - 3200	1000	960	930	1100		
Source	**Pg. 30, App.L FMC Mine Permit Applic.**	Table 5-3 "Fall 1996 Backfill Plan…" 10/1996	Table 4-23 "1997 Backfill Plan…" 3/1997	Flambeau Mining Co. quarterly environmental monitoring reports for 2000, and 2000 Annual Report, FMC 1/2001								Wisc. Chapter NR140	

[1] **The permit conditions for the mine are in bold.**

Compiled July 2001 by John Coleman, GLIFWC

Year 2000 samples that exceed permit conditions or WI groundwater preventive action limits

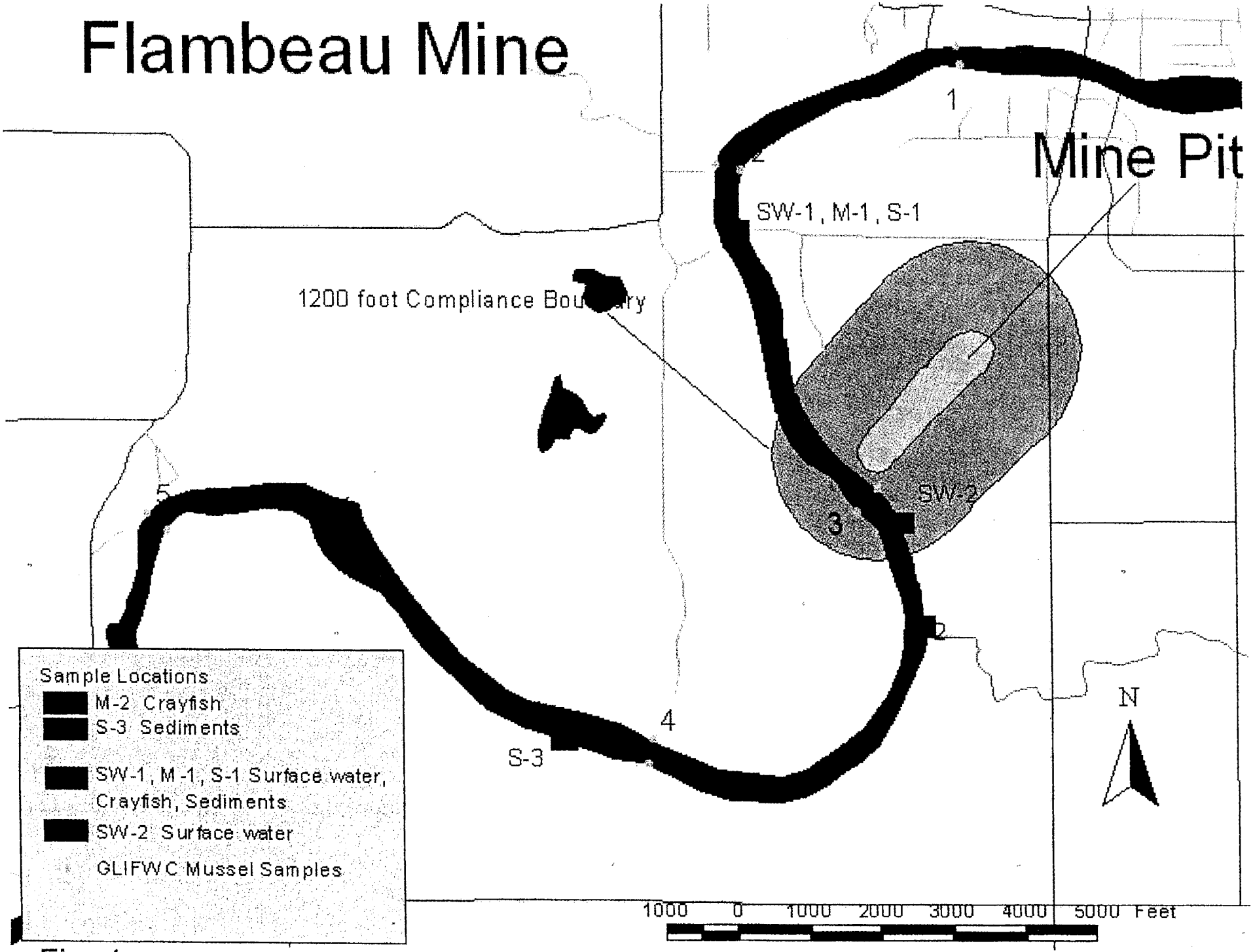
Flambeau Mine
Mine Pit
SW-1, M-1, S-1
1200 foot Compliance Boundary
SW-2
S-3
1
2
3
4
5
N
Sample Locations
M-2 Crayfish
S-3 Sediments
SW-1, M-1, S-1 Surface water, Crayfish, Sediments
SW-2 Surface water
GLIFWC Mussel Samples
1000 0 1000 2000 3000 4000 5000 Feet

Fig. 1