Foth & Van Dyke

Memo

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RE: Flambeau Mining Company - 2005 Annual Report Groundwater and Surface Water Trends

Background

Groundwater and surface water sample results collected for the 2005 monitoring program were added to the analytical monitoring historical database. These results were statistically tested and graphically displayed to determine whether any significant increasing or decreasing trends are occurring in the groundwater or surface water chemistry. Groundwater quality results, trend graphs and statistical test results are included as Attachment 1 for the quarterly monitoring parameters and Attachment 2 for the annual monitoring parameters. Surface water quality results, trend graphs and statistical test results are included as Attachment 3. Hydrographs are included as Attachment 4.

Intervention boundary wells included in the trend analyses are MW-1000P-R, MW-1002, MW-1002G, MW-1004P, MW-1004S, MW-1005, MW-1005P, MW-1005S, and MW-1010P. The in-pit wells included in the trend analyses are MW-1013B, MW-1013C, MW-1014A, MW-1014B and MW-1014C. Wells MW-1015A and MW-1015B (also included in the analyses) were constructed in January 2001 approximately 1000 ft. northwest of the backfilled pit and adjacent to the compliance boundary.

Statistical Methods

October of 1997 was selected as the start date for the trend tests. October of 1997 is the beginning of the post-mining period. (The trend analyses begin in February, 1999 for the in-pit wells MW-1013B, MW-1013C, MW-1014A, MW-1014B and MW-1014C, and April, 2001 for wells MW-1015A and MW-1015B, which is when monitoring began. The trend analyses for the annual monitoring parameters of arsenic, barium, cadmium, calcium, chloride, chromium, lead,

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magnesium, mercury, selenium and silver begin with July 1999 in all wells since this was the recent start date of monitoring for these parameters.)

The non-parametric Mann-Kendall test for trend was used to statistically determine existing trends in the post-mining data. This test indicates whether any general increasing or decreasing trends have occurred during this time frame. The results of the trend tests are best used in conjunction with the trend graphs of Attachments 1, 2 and 3 to properly evaluate trend conditions. It should be noted that a statistically increasing or decreasing trend does not necessarily indicate a substantial increase or decrease in actual parameter concentrations. There are situations where variation in the data is extremely small, allowing very slight consecutive concentration changes to be detected as a statistically significant trend. Although these minor trends may occur, they should not be construed as an indication of a broader impact on water quality.

The statistical trend tests indicate whether a general trend is occurring over the entire time frame of the post-mining period. There are cases where a trend over the entire time frame may be indicated in one direction (either increasing or decreasing), while short term results actually appear to be opposite. Therefore as stated, it is most appropriate to interpret the statistical results in conjunction visually with the trend graphs and in the context of the broader site hydrology.

The procedure for the Mann-Kendall test is given in Gilbert (1987)[1]. The Type I error for each test was set to 0.01. All non-detected values were replaced with a common value below the lowest detected value.

In the trend test results of Attachments 1, 2 and 3, a "+" indicates a statistically increasing trend and a "-" indicates a statistically decreasing trend. If neither a "+" or "-" is given, no statistically significant trend is present.

Trend Results

Similar to past trend results, the annual groundwater parameters of arsenic, barium, cadmium, calcium, chloride, chromium, lead, magnesium, mercury, selenium and silver (Attachment 2) illustrated few statistically significant trends. Since 1999, there are generally smaller decreasing trends of calcium and magnesium in MW-1000PR and MW-1014C, chromium in MW-1013B, cadmium in MW-1014B, and barium in MW-1015A. No statistically significant increasing trends were found for any of these parameters.

No statistically significant trends were observed in either the upstream or downstream surface water monitoring results (Attachment 3). Parameters currently included in the surface water monitoring are copper, hardness, iron, manganese, sulfate, zinc, pH and conductivity.

[1]Gilbert, R.O., 1987. " Statistical Methods for Environmental Pollution Monitoring", Van Nostrand Reinhold, New York.

The majority of observable trends, increasing and/or decreasing, were exhibited in the groundwater results for the quarterly parameters of alkalinity, copper, hardness, iron, manganese, sulfate, TDS, zinc, pH, conductivity and redox (Attachment 1). The pattern of increasing and decreasing trends are not indicative of a broader water quality change but are consistent with historical temporal variation. A number of the observed trends are similar to those noted in the previous annual report. The main conclusions which may be reached from the trend graphs and statistical trend tests for these parameters are as follows:

Intervention Boundary Wells

- MW-1000P-R: Several parameters exhibited an immediate increase in concentrations at the beginning of the post-mining period. These are alkalinity, hardness, iron, manganese, sulfate, TDS and conductivity. While an increasing trend of alkalinity from 1997 through 2005 is indicated in the statistical results, concentrations over the last two years appear to have stabilized. Statistically, general decreasing trends since 1997 have occurred for sulfate, TDS and conductivity. Decreasing trends over the latest six years are also visually evident for hardness, iron and manganese.

- MW-1002: Trends indicated by the statistical results in this well reflect relatively smaller changes in actual concentration. Similar to MW-1000P-R, an overall increasing trend of alkalinity is indicated for post-1997 data, however, over the last two years the trend has reversed. A similar trend can be observed in the historical trend graph for hardness.

- MW-1002G: Statistically increasing trends (during the post-mining period) are indicated for alkalinity and hardness, while decreasing trends are indicated for sulfate and conductivity. However, actual concentration changes in these parameters are relatively small.

- MW-1004P: Statistically decreasing trends were noted for copper, sulfate and conductivity. Copper and sulfate decreased to non-detectable levels during 2001, and have since remained either below detection or very near the detection limit. An increasing trend was noted for manganese, with 2004 concentrations being somewhat elevated over the several years prior. Manganese concentrations in 2005, however, have once again decreased. Iron in this well reflects a similar trend.

- MW-1004S: Increasing trends were noted for hardness and sulfate. Concentrations since 1997 have slowly increased a total of approximately 10 to 20 mg/L. Similarly slow increasing trends can be visually detected in the trend graphs for alkalinity and conductivity. However, levels of alkalinity, hardness and conductivity remain below levels observed historically prior to the onset of mining in 1993.

- MW-1005: Overall statistically decreasing trends of alkalinity and iron continue to be observed for the post-mining period. As can be observed in the trend graphs, hardness, iron, manganese, TDS and conductivity decreased from approximately 1994 through 2003, at which point moderate increases (still below historical levels) occurred. Concentrations have since stabilized or once again decreased.

- MW-1005P: A decreasing trend of sulfate, conductivity and redox continues. Sulfate has not been detected in this well since 1999.

- MW-1005S: A decreasing trend is noted for conductivity and an increasing trend is noted for manganese, however in each case actual concentration changes are relatively small.

- MW-1010P: A decreasing trend of copper and an increasing trend of hardness and manganese were noted for the post-mining period. Similar to MW-1000P-R, copper concentrations were elevated from 1994 through 1999, but have recently decreased to non-detectable levels. Changes in hardness concentrations are only slight, and remain similar to historical concentrations observed prior to mining operations. Manganese increased significantly during October of 2000 (however still below 1991 levels) but has since remained consistent. As can be seen in the trend graphs, iron also increased during this time, but has since decreased, being below detection twice in 2005.

- MW-1015A: Statistically increasing trends were noted for alkalinity and conductivity, however actual changes in concentration are very slight.

- MW-1015B: Statistically increasing trends were noted for iron and manganese. However, after increasing in 2002, manganese has generally been decreasing. Iron has also been generally decreasing after reaching a high during the fourth quarter of 2003. The recent trend in iron is similar to recent trends at the upgradient well MW-1005P.

<u>In-Pit Wells</u>

- MW-1013B: Overall statistically increasing trends (since 1999) were noted for copper and zinc. Copper has illustrated generally increasing concentrations since 2001. The increasing trend of zinc refers to only a slowly increasing trend with small actual concentration increases just above the detection limit. A decreasing trend was noted for TDS.

- MW-1013C: Overall statistically increasing trends were indicated for iron, manganese and conductivity. Iron and manganese concentrations continue to rise, with iron reaching 8.5 mg/L during July of 2005 and manganese reaching 11,000 ug/L during of October 2005. An overall decreasing trend is denoted for zinc.

- MW-1014A: Statistically decreasing trends were noted for iron and manganese. Iron was not detected during 2005. Statistically increasing trends were noted for alkalinity and redox. Redox has increased from below 160 mV during 2001 to above 210 mV during 2005.

- MW-1014B: Overall decreasing trends were noted for manganese and zinc. Manganese, dropped from 23,000 ug/L during 1999 to 15,000 ug/L in 2005, and zinc dropped from 5000 ug/L in 1999 to 2200 ug/L in 2005.

- MW-1014C: Overall decreasing trends continue for hardness, iron, manganese, sulfate, TDS, zinc and conductivity. The most significant relative decreases in concentration occur for iron, dropping from 15 mg/L in 1999 to 7 mg/L in 2005, and for zinc, dropping from 2200 ug/L in 1999 to 550 ug/L in 2005.

As observed in the hydrographs (Attachment 4), all wells illustrating significant drawdown during the production period of 1993 to 1997 now appear to be substantially stabilized. The wells include MW-1000P-R, MW-1001, MW-1001G, MW-1001P, MW-1003, MW-1003P, MW-1004, MW-1004P, MW-1004S, MW-1010P, OW-7, OW-39, OW-42, PZ-1006G, PZ-1006S, PZ-1007S, PZ-1008, PZ-1008G, PZ-1012, PZ-R1, PZ-S1, PZ-S3, ST-9-23 and ST-9-26.

Groundwater elevations increased steadily from 1999 through 2002 for the in-pit wells of MW-1013A, MW-1013B, MW-1013C, MW-1014, MW-1014A, MW-1014B and MW-1014C, but stabilized in 2003. Elevations for MW-1013 rose through 2004, but appear to have stabilized during 2005.

Conclusions

Many of the concentration trends observed during 2004 continued through 2005. Of the trend results listed above, the following are the main conclusions:

Intervention Boundary Wells

- Several parameters in MW-1000P-R (alkalinity, hardness, iron, manganese, sulfate, TDS and conductivity) exhibited concentration increases following the rebounding of water levels after the production period ended. Of these parameters, alkalinity visually appears to have stabilized, while the remainder are now decreasing.

- Iron and manganese in MW-1010P also rose following the production period, but currently have stabilized to levels observed during the pre-mining period.

- Copper in both MW-1000P-R and MW-1010P, after being elevated during the production period, have continued decreasing trends, and are now at non-detectable levels.

- A small rise in iron and manganese concentrations occurred during 2004 in MW-1004P, but decreased again to very low levels in 2005.

- Alkalinity, hardness, sulfate and conductivity continue very slow but consistent concentration increases in MW-1004S. Concentrations of these parameters, however, are still quite low.

- Hardness, iron, manganese, TDS and conductivity in the upgradient well MW-1005 observed decreasing trends through the post-mining period until 2002 and 2003 at which point increases occurred. The increasing trends reversed again during 2004 and stabilized through 2005.

- MW1015B had an increase of iron and manganese during the second half of 2002. Both trends have since reversed.

In-Pit Wells

- With the in-pit wells, increasing trends continue for copper in MW-1013B, iron and manganese in MW-1013C and redox in MW-1014A. Decreasing trends continue for iron and manganese in MW-1014A, zinc in MW-1014B, and hardness, iron, sulfate, TDS, zinc and conductivity in MW-1014C.

Few or no trends were noted for the annual groundwater parameters of arsenic, barium, cadmium, calcium, chloride, chromium, lead, magnesium, mercury, selenium and silver, and the surface water parameters (either upstream or downstream) of copper, hardness, iron, manganese, sulfate, zinc, pH and conductivity.