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# MEMORANDUM

| | | |
|---|---|---|
| TO: | MaryBeth Marks, On-Scene Coordinator, USFS | cc: |
| FROM: | Shane Matolyak, Environmental Scientist, Tetra Tech | Allan Kirk, Project Manager, Tetra Tech |
| DATE: | April 13, 2009 | |
| RE: | Non-Degradation Analysis for McLaren Adit Infiltration Basin. | |

Tetra Tech has prepared non-degradation calculations for a potential infiltration gallery to treat seepage water from the McLaren adit as part of the New World Mine District Response and Restoration Project.

These calculations (included in Attachment A) follow the procedures described in the Administrative Rules of Montana (ARM) 17.30.517 and are intended to determine if the site is eligible for a standard mixing zone. Data and assumptions used to complete the calculations are summarized below.

## Existing Groundwater Flux and Load

The volume of water moving beneath the proposed infiltration gallery site was calculated using Darcy's Law:

$$Q = (K)*(i)*(A)$$

Where: Q = volume of flow per unit time
K = hydraulic conductivity
i = hydraulic gradient
A = aquifer cross section

For this analysis, it was assumed that mixing below the infiltration gallery would occur in colluvium between the base of the infiltration gallery and the top of fractured bedrock. Hydraulic conductivity (K) data are available from URS (1998) who calculated K from falling head tests conducted for 11 wells completed in bedrock or waste within and near the McLaren pit. Because K data are not available specifically for colluvial wells, non-degradation calculations were based on three different scenarios of K. Scenario 1 assumes colluvial K is represented by the average K of all wells reported by URS (1998), 0.13 ft/day. Scenario 2 uses the average K of the three

waste rock wells (0.07 ft/day) while Scenario 3 uses the average K of the eight bedrock wells (0.16 ft/day).

The hydraulic gradient (i) was determined based on the difference in average groundwater elevations measured from 2003 through 2008 at monitoring wells DCGW-131 and DCGW-107, both located downhill of the McLaren adit in the area where an infiltration gallery would likely be located. The resulting hydraulic gradient is 0.54 ft/ft.

The vertical depth of the aquifer cross section was determined based on the average saturated thickness of colluvium at monitoring wells DCGW-131, -106, and 107 (23 feet) plus 15 feet per ARM 17.30.517(d)(iii)(A). The resulting depth of 38 feet was then multiplied by the width of the mixing zone as calculated per the procedure described in 17.30.517(d)(iii)(B) assuming a 30 foot wide infiltration basin and a 500-foot mixing zone length. It should be noted that the standard non-residential mixing zone of 500 feet is adequate for this calculation as long as the infiltration basin is located no further downhill than the location of monitoring well DCGW-106. Otherwise, it may be necessary to revise the non-degradation calculations to account for the fact that Daisy Creek would be within 500 feet of the infiltration basin.

Based on the assumptions described above, the flux rate of water beneath the infiltration basin is 325 $ft^3$/day (0.0038 cfs) for Scenario 1, 169 $ft^3$/day (0.0020 cfs) for Scenario 2, and 384 $ft^3$/day (0.0040 cfs) for Scenario 3.

Metal loads in groundwater were determined by multiplying groundwater flux by the average dissolved concentrations measured in wells DCGW-131, -106, and 107 between 2002 and 2008. As was the case for calculating the hydraulic gradient, the chemistry of these wells was chosen to represent conditions beneath the infiltration basin because these wells are located in the area where the basin would likely be constructed. Compared to other monitoring wells in the vicinity, water monitored by DCGW-131, -106, and -107 is of generally good quality with low metals concentrations. In particular, aluminum, copper, and zinc were frequently present in concentrations below their respective analytical detection limits.

## Adit Seepage Rate and Load

Metal loads in McLaren adit seepage were calculated using flow rates measured between 2003 and 2008. This is the entire period of record for adit seepage measurements collected after plugging a drill hole inside the adit thus reducing total adit flow. Water quality data are the average of three sampling events in 2007 and 2008 as these are the only times when dissolved metals analyses were conducted.

## Calculated Metals Concentrations After Mixing

Calculated metals concentrations in groundwater after mixing are reported in Table 1 along with DEQ-7 trigger values for each metal. According to ARM 715.30.715, discharges are “not significant” if the resulting ***change*** in concentration does not exceed the trigger value. Review of the data in Table 1 shows that only the trigger value for zinc would be exceeded in groundwater beneath the infiltration gallery but no applicable DEQ-7 ground or surface water quality standards for zinc would be exceeded. Some portion of the zinc load in McLaren adit seepage may originate from zinc plated galvanized steel culvert and grates previously installed in the adit.

Dilution of aluminum, copper, and manganese concentrations in groundwater would occur upon mixing with adit seepage. This is true for all three assumed K scenarios and, while the data are

not reported in Table 1 or Attachment A, this is also true if the width of the infiltration gallery was assumed to be either one or 300 feet.

Data based on the assumptions described above show that discharges from the proposed infiltration gallery will result in "non-significant" changes in water quality for all but zinc.

**Table 1. Calculated Dissolved Metals Concentrations in Groundwater**

| Metal | Initial Concentration (mg/L) | Final Concentration (mg/L) | Change in Concentration (mg/L) | Trigger Value (mg/L) | Exceeded (Yes or No) |
|---|---|---|---|---|---|
| **Scenario 1:** Average K 0.13 ft/day (based on all wells[1]) | | | | | |
| Aluminum | 0.158 | 0.057 | -0.10 | 0.03 | NO |
| Copper | 0.003 | 0.003 | -0.0001 | 0.0005 | NO |
| Iron | 2.747 | 19.25 | 16.51 | N/A | NO |
| Manganese | 1.53 | 1.23 | -0.30 | N/A | NO |
| Zinc | 0.006 | 0.057 | 0.05 | 0.005 | YES |
| **Scenario 2:** Average K 0.07 ft/day (based on waste rock wells[1]) | | | | | |
| Aluminum | 0.158 | 0.044 | -0.11 | 0.03 | NO |
| Copper | 0.003 | 0.003 | -0.0001 | 0.0005 | NO |
| Iron | 2.747 | 21.38 | 18.63 | N/A | NO |
| Manganese | 1.53 | 1.19 | -0.34 | N/A | NO |
| Zinc | 0.006 | 0.064 | 0.06 | 0.005 | YES |
| **Scenario 3:** Average K 0.16 ft/day (based on bedrock wells[1]) | | | | | |
| Aluminum | 0.158 | 0.061 | -0.10 | 0.03 | NO |
| Copper | 0.003 | 0.003 | -0.0001 | 0.0005 | NO |
| Iron | 2.747 | 18.58 | 15.83 | N/A | NO |
| Manganese | 1.53 | 1.24 | -0.29 | N/A | NO |
| Zinc | 0.006 | 0.055 | 0.05 | 0.005 | YES |

[1] As reported by URS (1998).

## References

**URS 1998.** "START" Report. Site Assessment Summary and Sampling Activities Report. New World Mine. Prepared for EPA. TDD No. 9607-0024.

# Attachment A

**Supporting Data and Non-Degradation Calculations**

**Table A1. Chemistry data.**

| McLaren Adit | | | | | | | |
|---|---|---|---|---|---|---|---|
| Date | Flow (gpm) | Flow (cfs) | Al DIS | Cu DIS | Fe DIS | Mn DIS | Zn DIS |
| 10/1/2003 | 3.59 | 0.008 | | | | | |
| 7/29/2004 | 7.3 | 0.016 | | | | | |
| 8/10/2004 | 7.63 | 0.017 | | | | | |
| 9/23/2004 | 4.7 | 0.010 | | | | | |
| 9/23/2005 | 4.9 | 0.011 | | | | | |
| 8/20/2007 | 4.49 | 0.01 | 0.025 | 0.002 | 25.3 | 1.09 | 0.07 |
| 9/18/2007 | 4.80 | 0.0107 | 0.025 | 0.002 | 23.1 | 1.14 | 0.07 |
| 9/23/2008 | 5.97 | 0.0133 | 0.025 | 0.005 | 24.8 | 1.18 | 0.08 |
| | | | | | | | |
| Average | | 0.012 | 0.025 | 0.003 | 24.400 | 1.137 | 0.073 |
| | | | | | | | |
| **DCGW-106** | | | | | | | |
| Date | Completion | | Al DIS | Cu DIS | Fe DIS | Mn DIS | Zn DIS |
| 10-Jul-03 | Colluvial | | 0.025 | 0.0005 | 2.25 | 0.19 | 0.005 |
| 19-Aug-02 | Colluvial | | 0.05 | 0.0005 | 2.5 | 0.253 | 0.005 |
| **DCGW-107** | | | | | | | |
| 10-Jul-03 | Colluvial | | 0.025 | 0.001 | 0.02 | 0.62 | 0.005 |
| 19-Aug-02 | Colluvial | | 0.05 | 0.0005 | 0.85 | 0.767 | 0.005 |
| 11-Jul-06 | Colluvial | | 0.025 | 0.0005 | 0.62 | 0.83 | 0.005 |
| 18-Jul-07 | Colluvial | | 0.025 | 0.001 | 0.67 | 0.94 | 0.005 |
| 12-Aug-08 | Colluvial | | 0.025 | 0.0005 | 1.3 | 1.43 | 0.005 |
| **DCGW-131** | | | | | | | |
| 09-Jul-03 | Colluvial | | 1.15 | 0.021 | 11.5 | 5.22 | 0.01 |
| 23-Aug-02 | Colluvial | | 0.05 | 0.003 | 5.01 | 3.52 | 0.005 |
| | | | | | | | |
| Average | | | 0.158 | 0.003 | 2.747 | 1.53 | 0.006 |

Shading indicates values that have been divided by 2 to account for values below detection limits.

**Table A2. Hydraulic Conductivity Data***

| Well | Completion | Velocity ((K (ft/day)) |
|---|---|---|
| EPA-5 | FMI | 0.3 |
| EPA-6 | FMI | 0.19 |
| EPA-2 | FMI/Wolsey | 0.17 |
| EPA-1 | Wolsey | 0.1 |
| EPA-9 | Wolsey | 0.1 |
| MW-2 | Wolsey | 0.14 |
| EPA-8 | Meagher | 0.15 |
| EPA-10 | Meagher | 0.12 |
| EPA-3 | Waste Rock | 0.03 |
| EPA-4 | Waste Rock | 0.09 |
| EPA-7 | Waste Rock | 0.09 |

* as reported in Table D of URS 1998. "START" Report. Site Assessment Summary and Sampling Activities Report. New World Mine. Prepared for EPA. TDD No. 9607-0024.

**Table A3. Hydraulic Gradient (i) Calculation.**

| DCGW-131 | | DCGW-107 | |
|---|---|---|---|
| DTW (ft) | Date | DTW (ft) | Date |
| 0 | 20-Jul-04 | 15.94 | 10-Jul-03 |
| 0.07 | 09-Jul-03 | 10.79 | 19-Aug-02 |
| 20.69 | 23-Aug-02 | 9.2 | 26-Aug-02 |
| 17.89 | 26-Aug-02 | 15.27 | 05-Sep-02 |
| 6.58 | 05-Sep-02 | 15.79 | 18-Sep-02 |
| 6.36 | 17-Sep-02 | 15.81 | 07-Oct-02 |
| 4.81 | 07-Oct-02 | 18.29 | 01-Oct-03 |
| 4.85 | 01-Oct-03 | 17.78 | 09-Sep-03 |
| 4.38 | 09-Sep-03 | 17.62 | 27-Aug-03 |
| 3.83 | 27-Aug-03 | 17.34 | 13-Aug-03 |
| 2.4 | 12-Aug-03 | 16.83 | 31-Jul-03 |
| 1.09 | 31-Jul-03 | 15.91 | 11-Jul-05 |
| 0 | 11-Jul-05 | 16.2 | 11-Jul-06 |
| 0.01 | 11-Aug-08 | 16.92 | 18-Jul-07 |
| 2.42 | 17-Sep-08 | 16.8 | 12-Aug-08 |
| | | | |
| 5.025 | Average Depth to Water (ft) | 15.77 | Average Depth to Water (ft) |
| 9589.35 | Well Elevation (ft) | 9458.17 | Well Elevation (ft) |
| 9584.33 | Average Groundwater Elevation (ft) | 9442.41 | Average Groundwater Elevation (ft) |
| | | 141.92 | Difference in Head (ft) |
| | | 262.47 | Distance Between Wells (ft) |
| | | **0.54** | **Hydraulic Gradient (i, ft/ft)** |

**Table A4. Aquifer Cross Section (A) Calculation**

| Mixing Zone Depth | | | |
|---|---|---|---|
| | DCGW-131 | DCGW-107 | DCGW-106** |
| Average Depth to Water (ft) | 5.0 | 15.8 | 0 |
| Auger Refusal (ft)* | 20 | 25 | 45 |
| Aquifer Thickness (ft) | 15.0 | 9.2 | 45 |

| | |
|---|---|
| Average Thickness (ft) | 23.1 |
| plus 15 ft | 38.1 |
| **Mixing Zone Depth (ft)** | **38.1** |

* Auger refusal at bedrock at DCGW-131 and -107. Refusal at dense clay at DCGW-106.
** DCGW-106 is artestian.

| Mixing Zone Width | |
|---|---|
| Width of infiltration basin (assumed) (ft) | 30 |
| 5 degrees converted to radians | 0.087 |
| Tangent of 5 degrees (x2 for each side) | 0.175 |
| Length of mix zone (ft) | 500 |
| **Mixing Zone Width** | **117.5** |

| | |
|---|---|
| **Mixing Zone Cross Section (A) (ft)** | **4472.7** |

NOTES:

A=(Depth of Mixing Zone )*(width)

Depth = Thickness of aquifer + 15 ft per ARM 17-30-517(d)(iii)(A)

Width = width of source plus the distance determined by the tangent of 5º times the length of the mixing zone on both sides of the source per ARM 17-30-517(d)(iii)(B). Degrees were converted to radians so that tangent could be calculated using Microsoft Excel.

Mixing zone length for non-septic water = 500ft per ARM 17-30-517(d)(viii)(D)

**Table A5. Hydraulic Flux (Q) Calculation.**

| | Hydraulic Conductivity (K) (ft/day) | Q (ft^3/day) | Q (CFS) |
|---|---|---|---|
| Average of all wells* | 0.13 | 325.4 | 0.0038 |
| Average of waste rock wells* | 0.07 | 169.3 | 0.0020 |
| Average of bedrock wells* | 0.16 | 383.9 | 0.0044 |

| | |
|---|---|
| i (from Table A3) (ft/ft) | 0.54 |
| A (from Table A4) (ft^2) | 4472.7 |

NOTES:
Q=(K)*(i)*(A)

* as reported in Table D of URS 1998. "START" Report. Site Assessment Summary and Sampling Activities Report. New World Mine. Prepared for EPA. TDD No. 9607-0024.

**Table A6. Concentration Change Under Scenario 1 (assumes Q is avg of all wells).**

| | Initial Concentration | | Initial Load | Source Concentration | | Source Load | Resulting load | Resulting Concentration | |
|---|---|---|---|---|---|---|---|---|---|
| | mg/L | mg/cf | mg/sec | mg/L | mg/cf | mg/sec | mg/sec | mg/cf | mg/L |
| Aluminum | 0.158 | 4.48 | 0.0169 | 0.03 | 0.71 | 0.01 | 0.025 | 1.61 | 0.057 |
| Copper | 0.003 | 0.09 | 0.0003 | 0.003 | 0.08 | 0.00 | 0.001 | 0.09 | 0.003 |
| Iron | 2.747 | 77.78 | 0.2929 | 24.40 | 690.93 | 8.35 | 8.64 | 545.22 | 19.25 |
| Manganese | 1.530 | 43.32 | 0.1632 | 1.14 | 32.19 | 0.39 | 0.552 | 34.83 | 1.23 |
| Zinc | 0.006 | 0.16 | 0.0006 | 0.07 | 2.08 | 0.03 | 0.026 | 1.62 | 0.057 |

| | Change | Trigger Value | |
|---|---|---|---|
| | mg/L | mg/L | Exceed Trigger? |
| Aluminum | -0.10 | 0.03 | NO |
| Copper | -0.0001 | 0.0005 | NO |
| Iron | 16.51 | N/A | NO |
| Manganese | -0.30 | N/A | NO |
| Zinc | 0.05 | 0.005 | Yes |

**Table A7. Concentration Change Under Scenario 2 (assumes Q is avg of waste rock wells).**

| | Initial Concentration | | Initial Load | Source Concentration | | Source Load | Resulting load | Resulting Concentration | |
|---|---|---|---|---|---|---|---|---|---|
| | mg/L | mg/cf | mg/sec | mg/L | mg/cf | mg/sec | mg/sec | mg/cf | mg/L |
| Aluminum | 0.158 | 4.48 | 0.0088 | 0.03 | 0.71 | 0.01 | 0.0173 | 1.23 | 0.044 |
| Copper | 0.003 | 0.09 | 0.0002 | 0.003 | 0.08 | 0.00 | 0.0012 | 0.09 | 0.003 |
| Iron | 2.747 | 77.78 | 0.1524 | 24.40 | 690.93 | 8.35 | 8.50 | 605.37 | 21.38 |
| Manganese | 1.530 | 43.32 | 0.0849 | 1.14 | 32.19 | 0.39 | 0.4738 | 33.74 | 1.19 |
| Zinc | 0.006 | 0.16 | 0.0003 | 0.07 | 2.08 | 0.03 | 0.0254 | 1.81 | 0.064 |

| | Change | Trigger Value | Exceed Trigger? |
|---|---|---|---|
| | mg/L | mg/L | |
| Aluminum | -0.11 | 0.03 | NO |
| Copper | -0.0001 | 0.0005 | NO |
| Iron | 18.63 | N/A | NO |
| Manganese | -0.34 | N/A | NO |
| Zinc | 0.06 | 0.005 | YES |

**Table A8. Concentration Change Under Scenario 3 (assumes Q is avg of bedrock wells).**

| | Initial Concentration | | Initial Load | Source Concentration | | Source Load | Resulting load | Resulting Concentration | |
|---|---|---|---|---|---|---|---|---|---|
| | mg/L | mg/cf | mg/sec | mg/L | mg/cf | mg/sec | mg/sec | mg/cf | mg/L |
| Aluminum | 0.158 | 4.48 | 0.0199 | 0.03 | 0.71 | 0.01 | 0.028 | 1.72 | 0.061 |
| Copper | 0.003 | 0.09 | 0.0004 | 0.003 | 0.08 | 0.00 | 0.001 | 0.09 | 0.003 |
| Iron | 2.747 | 77.78 | 0.3456 | 24.40 | 690.93 | 8.35 | 8.69 | 526.06 | 18.58 |
| Manganese | 1.530 | 43.32 | 0.1925 | 1.14 | 32.19 | 0.39 | 0.581 | 35.18 | 1.24 |
| Zinc | 0.006 | 0.16 | 0.0007 | 0.07 | 2.08 | 0.03 | 0.026 | 1.56 | 0.055 |

| | Change | Trigger Value | |
|---|---|---|---|
| | mg/L | mg/L | Exceed Trigger? |
| Aluminum | -0.10 | 0.03 | NO |
| Copper | -0.0001 | 0.0005 | NO |
| Iron | 15.83 | N/A | NO |
| Manganese | -0.29 | N/A | NO |
| Zinc | 0.05 | 0.005 | YES |