LEM

BP Minerals America
10 East South Temple
P.O. Box 11248
Salt Lake City, Utah 84147
(801) 322-7000
FAX (801) 359-8405

BP MINERALS AMERICA

June 10, 1988

Mr. Alan B. Christianson
City of Ladysmith
120 Miner Avenue
Ladysmith, WI 54848

Dear Al:

In accordance with your suggestion Boyd Possin of Foth and VanDyke has prepared the attached two (2) reports which have been specifically developed for use by non-technical personnel. One report explains why the groundwater on the side of the Flambeau River opposite from the mine cannot be effected by the mining operation. The other report explains the groundwater flow through the reclaimed mine and why the groundwater will not be degraded.

Significant statements extracted from the Foth and VanDyke's report on the wells on the opposite side of the river are as follows:

- Mining impacts on such wells (opposite side of Flambeau River from Mine) would actually be theoretically impossible.
- For the same reasons, water quality impacts across the river are also impossible.
- It is clearly impossible, then, for any activities at the mine, on one side of the river, to affect any water wells on the other side of the river.

Significant statements concerning the reclamation of the open pit include:

- Based on what has been learned from the geologic studies done at the site, (groundwater moving through the Type II waste rock in the reclaimed pit will not degrade groundwater in aquifers that are down gradient of the mine site).

- The Type I waste rock fill going into the pit will be more permeable than the outwash, and much more permeable than the sandstone. Therefore, the flow coming out of the sandstone into the pit and into the Type I waste rock fill will not spread out and go into the deeper parts (Type II waste rock) of the pit. LEM note: The placement of the clay like material like saprolite (ML material) above the Type II waste rock, not discussed in the report, will further assure that the permeability of material below the Type I waste rock will be less than the permeability of the Type I waste rock.

- The very low permeabilities in both the upgradient and downgradient bedrock will create a situation where the amount of groundwater movement into and out of the pit will be insignificant compared to, and completely removed from, that moving above in the aquifers.

Please advise me if you should need any additional information or further clarification of the information presented.

Sincerely,

L. E. Mercando

L. E. Mercando

LEM/st

cc: B. N. Possin
G. D. Schurtz
G. W. Sevick
LEM File 11.8.1.3
LEM File 11.8.31.8

Foth & Van Dyke

2737 S. Ridge Road
P. O. Box 19012
Green Bay, WI 54307-9012
414/497-2500

The Effect of the Flambeau River as a Hydraulic Barrier to Groundwater Underflow

Prepared by Boyd N. Possin

Foth & Van Dyke and Associates, Inc.

June 7, 1988

Concerns have been expressed locally that the proposed mining operation might adversely impact private wells on the other side of the Flambeau River. Kennecott does not believe that its operations will adversely impact any groundwater or any wells, regardless of location. Nowhere is this more evident than in the case of wells located across the Flambeau River from the mine site. Mining impacts on such wells would actually be theoretically impossible, for the following reasons.

Figure No. 1 is a generalized cross-sectional diagram showing the way in which groundwater flows into a river. A cross section is a look at a vertical slice through the earth, in this case, perpendicular to the flow of the river. Think of the river in Figure No. 1 as flowing out of the page, toward the viewer.

The cross section shows the relative position of the water table surface and the river surface. The water table is a surface beneath which all the pores and crevices in the soil and rock are filled with water. Figure No. 1 shows that the water table slopes upward, away from the river. This happens for two reasons. First, the land surface rises away from the river. Second, annual snow melt and rainfall continuously seeps downward through the ground until it reaches the water table.

On an annual average basis, approximately 30 inches of rain falls on Rusk County. Most of this evaporates immediately. Some runs directly off into creeks and rivers. But something on the order of three to five inches annually seeps into the ground, and reaches the water table. That may not sound like very much water, but three to five inches soaking in over a

period of a year on, for example, just one square mile of land is equivalent to a stream of water flowing continuously, 24 hours per day for one year, at the rate of 100 to 200 gallons per minute.

Yet with all this water seeping to the water table year after year, the water table remains more or less in the same position. Why? Where is the water going? The answer to that question is simple. It is flowing, as groundwater, into the rivers. The reason rivers flow, even during prolonged dry periods, is because the water table, as shown on Figure No. 1, is higher than the streams it surrounds. This being the case, gravity causes groundwater to flow from the high ground to the low ground - where the rivers are. In essence, the entire bottom of most rivers is one enormous spring.

Figure No. 1 is conceptually identical with the groundwater situation at the mine site. It is clear from the diagram that groundwater is flowing toward the river from both sides. Because each of its many hundreds of square miles of watershed area is contributing seeped-in groundwater, the flow in the Flambeau river seldom is less than 500,000 gallons per minute!

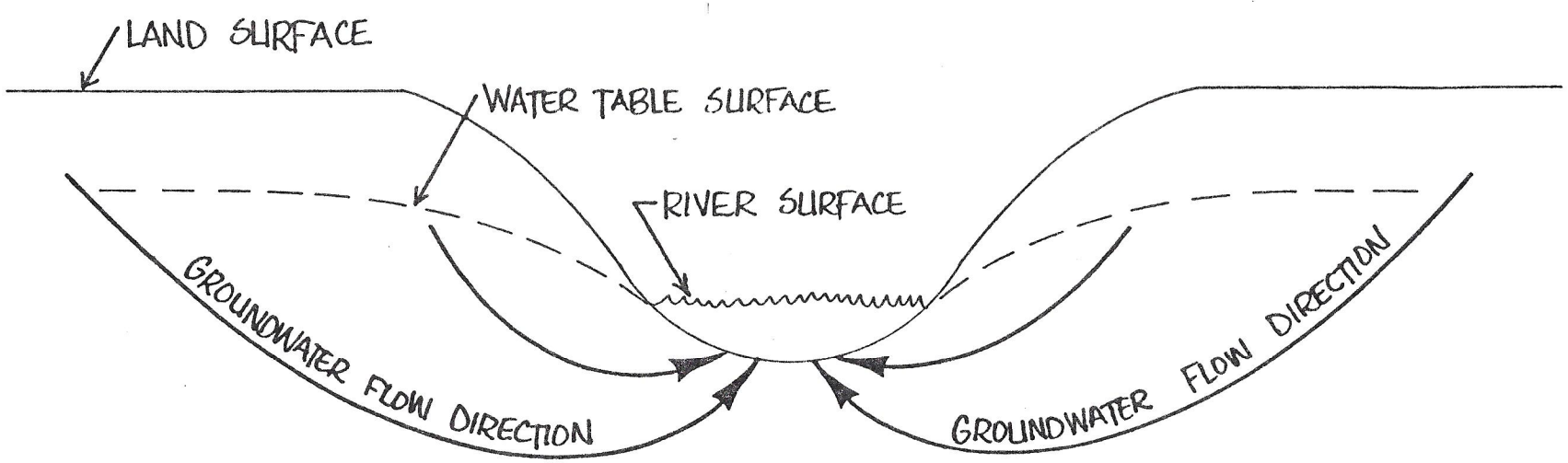
In order to cause any well drawdown problems on the other side of the river, water removed from the Kennecott mine pit would have to be so large as to intercept all the flow in the Flambeau River, clearly an impossibility. Preliminary studies show that the actual groundwater flow into the pit will probably be in an amount that is much less than 1% of the total average flow of the river. And by no means all of this relatively insignificant groundwater flow will come into the pit from the west, from seepage down through the bed of the river. Much of it will come from groundwater sources to the north, east, and south of the site. Thus, the pumping effects of the pit cannot possibly reach beneath the river. The flow in the river is far too great, and dwarfs any impacts the pit could possibly have.

For the same reasons, water quality impacts across the river are also impossible. As Figure No. 1 shows, groundwater moves toward a river. The groundwater supply to a well across the river is moving toward the river from the well, and thus toward the mine site from the well. Groundwater is not moving from the site toward the well. The river is in the way.

It is clearly impossible, then, for any activities at the mine, on one side of the river, to affect any water wells on the other side of the river. In effect, the way in which groundwater flows into the Flambeau River and maintains its stream flow, causes the river to serve as a hydraulic barrier between activities occurring on opposite sides of the river.

Mr. Possin, a professional hydrogeologist for 15 years, received M.S. degrees in Geology and in Water Resources Management from the University of Wisconsin - Madison. He is presently the manager of Foth & Van Dyke's Environmental Investigations Section.

Figure No. 1 Relationship of groundwater movement to river flow



Foth & Van Dyke

2737 S. Ridge Road
P. O. Box 19012
Green Bay, WI 54307-9012
414/497-2500

Groundwater Flow through the Reclaimed Flambeau Mine Pit

Prepared by Boyd N. Possin

Foth & Van Dyke and Associates, Inc.

June 7, 1988

Concerns have been raised as to whether the placement of Type II waste rock in the reclaimed pit could possibly affect groundwater quality. Specifically, the concern is that groundwater moving through the Type II waste rock in the reclaimed pit will degrade groundwater in aquifers that are downgradient (downstream in the groundwater) of the mine site. Based on what has been learned from the geologic studies done at the site, this will not be the case.

Figure No. 1 is a cross-sectional view (a vertical slice) through the earth showing the relationships between the reclaimed mine pit, the various layers of soil and rock, and the groundwater. The first layer on the upgradient (upstream in the groundwater) side of the pit is a glacial till. This material is not an aquifer because it is not very permeable, i.e., it does not allow groundwater to easily flow through it and it does not therefore yield much water to wells. On the other side of the pit the surface layer is glacial outwash - mostly sand and gravel. This material is very permeable and could serve as an aquifer. Underneath the surface layers on both sides of the pit is a sandstone layer. Although this layer is not quite as permeable as the outwash, it is still permeable enough to be considered an aquifer. Underneath the sandstone layer is the crystalline bedrock, in which the ore body is located. The bedrock has a few cracks and crevices here and there, especially near the bedrock surface, but on the whole it, like the glacial till, is not very permeable and is not considered an aquifer.

Figure No. 1 shows how the pit will be backfilled. The Type II waste rock will be placed at the bottom of the pit. The Type I waste rock will be placed next and, atop everything, will be the originally excavated earth fill (till, outwash, and sandstone).

50 years

It is important to understand that no groundwater will flow out of the pit until all the pore spaces between these rock and soil particles are filled with groundwater. The water table in the reclaimed pit must rise to the level shown on Figure No. 1 be fore any outflow can occur. The pit has to fill like a bathtub. Just as a bathtub has a faucet supplying water and an emergency overflow drain to take the water away, so the upgradient side of the pit is the "faucet" and the "downgradient" side of the pit is the drain.

On the upgradient side of the pit, the great majority of groundwater flowing in will come from the sandstone layer. Little will come from either the till or the bedrock. On the downstream side of the pit, the groundwater flowing out will leave through both the outwash and the sandstone, with almost nothing leaving through the crystalline bedrock.

Given all this information then, the question is why the groundwater flowing in from the sandstone and flowing out through the sandstone and outwash, will not somehow circulate through the waste rock in the backfilled pit - at least partially coming into contact with the Type II waste rock. The answer lies in the way in which groundwater flow behaves as it passes through materials of differing permeabilities.

Figure No. 2 is a diagram of what happens when groundwater flows from a less permeable material into a more permeable material, and out again. As the flow lines show, the flow in the more permeable material appears to be constricted through a smaller area than in the less permeable material. This happens because, along the direction of flow, the pathway through the more permeable material is the path of least resistance. Thus, the same amount of water moves more quickly through the more permeable material than it does through the less permeable material. And, because the water is moving more quickly, it needs less space in which to do the moving, much in the way water in a river flows more rapidly through its narrow channels than it does through its wide channels.

This very same phenomenon will occur in the reclaimed pit after it fills with groundwater back up to the initial water table level. The Type I waste rock fill going into the pit will be more permeable than the outwash, and much more permeable than the sandstone. Therefore, the flow coming out of the sandstone into the pit and into the Type I waste rock fill will not spread out and go into the deeper parts of the pit.

Instead, the flow will actually constrict itself, speeding up and moving relatively quickly straight across the pit. When the flow reaches the downgradient outwash and sandstone on the other side of the pit, it will spread out and slow down again.

Down where the Type II rock will be, none of this will be happening. The very low permeabilities in both the upgradient and downgradient bedrock will create a situation where the amount of groundwater movement into and out of the pit will be insignificant compared to, and completely removed from, that moving above in the aquifers.

Mr. Possin, a professional hydrogeologist for 15 years, received M.S. degrees in Geology and in Water Resources Management from the University of Wisconsin - Madison. He is presently the manager of Foth & Van Dyke's Environmental Investigations Section.

Figure No. 1 Relationship of geology and groundwater of the proposed Flambeau Mine Site

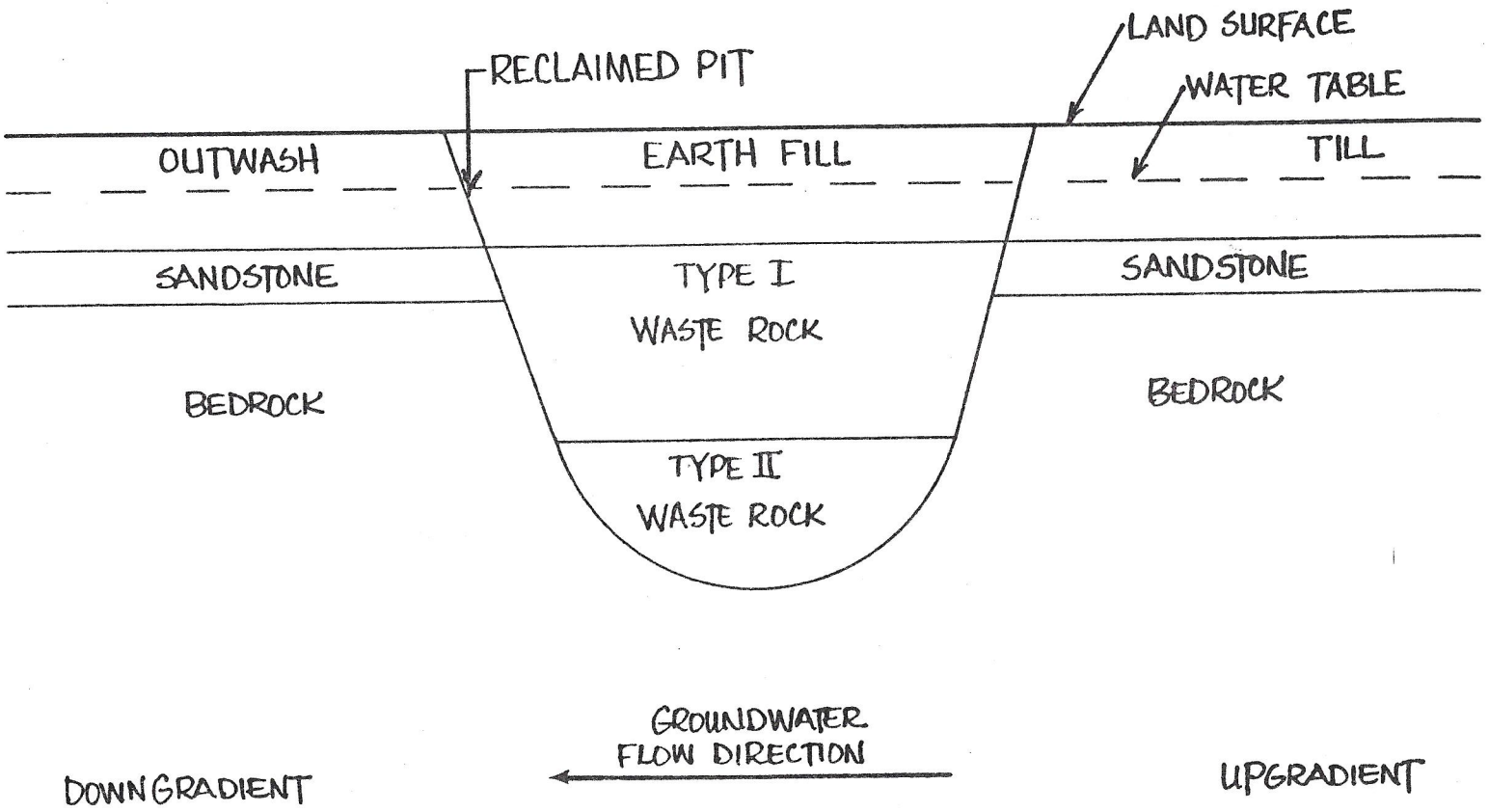
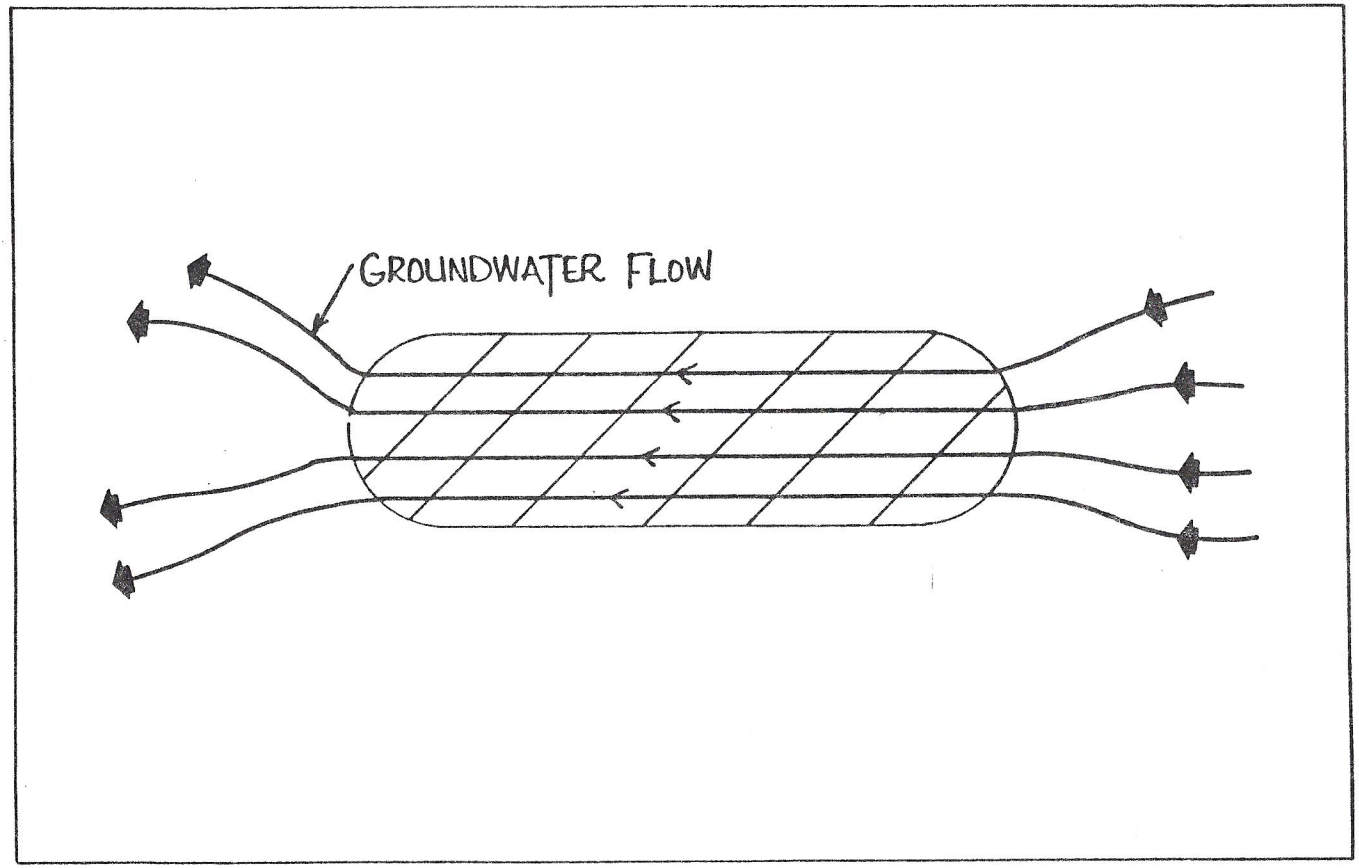


Figure No. 2 Groundwater flow between materials of different permeability



Note: Hatchured area is zone of higher permeability