Steve; November 27, 2006

I address the questions you posed to me relative to our proposed monitoring template for addressing the geomorphological impacts of mining in the northeast. If you have any additional concerns or need for clarification, contact me and I will see what I can do.

1) What is the science behind the 20% and 30% thresholds that would trigger monitoring under your proposal?

Our cutoffs are based largely on logic and professional application of accumulated science. It also follows from established science and recognized protocols, summarized below.

- River systems have five basic, interconnected components: hydrology, geomorphology, connectivity, water quality and biology (Annear et al. 2004).
- Impacts to one component touches and affects the others.
- Hydrology drives stream and river systems (Poff et al. 1997).
- Flow regime is a key variable determining channel form (Hill et al. 1991, Richter et al. 1997, NRC 2005).
- Stream hydrology is best characterized by flow records obtained at gaging stations. Mean annual flow is a common summary statistic for streams and can be fairly accurately derived (e.g., versus daily flow statistics), when working with ungaged systems.
- USGS' standard practice for gaging streams requires additional gaging anytime tributary input exceeds 10%.
- For USGS gages measurement error is typically 10% or less. Measurement error is typically random unless there is malfunctioning equipment. That means that sometimes it (measurement error) will be higher (positive) and add to the stream flow value recorded and sometimes it will be lower (negative) and subtract from the stream flow value recorded.
- If we set a 10% threshold for change and experience a 10% positive measurement error during the assessment period, we are actually setting a 20% limit on change.

Addtionally:

- The increment (10%) for change is an important interval: in statistical science, a 10% or less probability is most commonly selected as the criterion for rejection of the null hypothesis (that two populations are the same).
- In instream flow science, Tennant 's standard setting approach used 10% increments of mean annual flow to characterize the quality of habitat retained (Tennant 1976).
- <u>More recent work by Richter and others (Richter et al. In Review) explicitly ties varying degrees of hydrologic alteration to ecological condition</u>. This Limits of Hydrologic Alteration (LOHA) Method includes some important enhancements to the Tennant Method. *In sum, the LOHA Method is intended to provide a better articulation of the aspects of flow rate and timing thought to be most important to ecological condition, and provide more elaboration on the ecological changes that are associated with increasing degrees of hydrologic alteration.* Table 1 of this article lists 10%, 20%, and greater than 20% flow alteration as setting the

ecological condition of 'natural', 'minimally altered', and 'moderately altered', respectively.

- Recent research findings integrated by the Center for Watershed Protection into a general watershed planning model (impervious cover model - ICM) predict that most stream quality indicators decline when watershed impervious cover exceeds 10%, with severe degradation expected beyond 25% (Schueler 2003). *Recall that our recommendations are based on a change in flow or watershed area.*

2) What is anticipated for ongoing monitoring that would be required under the permit?

- we recommend that Level 2 should be conducted at a minimum of 3 sites for each impacted stream whenever there is a 20% change in watershed area **or** an extraction or addition of flow that exceeds 20% of the mean annual flow (MAF), located,
  1) within 2000 feet of the (each) outflow,
  2) at the endpoint of impact, and,
  3) midway between the two.
- we suspect the >30%mine footprint/total watershed area value is estimated at the discharge point from the mine. Therefore we recommend defining the monitoring reach by extending that point on the stream downstream until the mine footprint becomes 20% of the total watershed. Thus the monitoring reach is from the mine stream outlet to wherever the mine footprint becomes 20% or less. It might be a sudden change in percentage where a large tributary is encountered, so suggested staying above any such tributary.
- within these three general sampling areas, the most sensitive stream types, as indicated by the Level 1 analysis, should be selected.
- do at least two meander wave lengths (or 20 to 40 widths in length) at each site, with permanent (monumented) transects established at 3 riffle and 2 pool cross sections within the reach.
- the threshold for more intense sampling – going to Level 3 geomorphic sampling, i.e., monitoring channel state and condition – is a 30% change in watershed area **or** an extraction or addition of flow that exceeds 30% of the mean annual flow (MAF).
- the Level 3 would include Level 2 work plus: conducting BEHI, Pfankuch ratings on the pool transects, and establishing monumented bank pins.
- if Level 3 is necessary, we recommend a minimum of two control sites of the same stream type as the Level 2 work is necessary (for replication, necessary for statistical validity of comparison(s)).
- after the initial sampling, we recommend repeating sampling at 5 year intervals for the life of the project permit.
- temperature monitoring should begin during Phase I scoping to collect 'before' data, as much as possible. Also, temperature monitoring should be done at the three locations as specified for the Level 2 analysis.
- In addition, a 10% change of watershed area or 10% of the MAF should trigger biological monitoring. Biological monitoring is taken to mean IBI sampling and score derivation following the protocols and metrics established by the Minnesota Pollution Control Agency's IBI sampling program.

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DEPARTMENT: NATURAL RESOURCES STATE OF MINNESOTA

Office Memorandum

DATE: August 7, 2014

TO: Randall Doneen
Environmental Review
Division of Ecological Services

FROM: Ian Chisholm, Luther Aadland
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SUBJECT: Modified Recommendations for Assessing Mining Impacts to the Stream Systems for PolyMet, Minnesota Steel Industries, and Ispat mining proposals

Based on our recent meeting with Division of Waters staff, we are modifying our recommendations for assessing the mining impacts on stream ecosystems.

<u>Geomorphology – Rationale for Current Recommendations</u>
Streams are self-formed and self-maintaining (Leopold 1994). A key variable determining a rivers shape is discharge (Rosgen 1996, Leopold et al. 1964). Fluvial geomorphology then, represents the processes that maintain aquatic habitat in river systems. Habitat is an essential component of healthy river communities, including fish, invertebrates, plants, etc., see Annear et al. 2004). When we assess geomorphology, the resource values that are being targeted are dynamically stable streams, able to transport their water and sediment without adverse change to dimension, pattern, and profile and holding modal aquatic habitat for the various stream types, rather than aggraded or incised channels with degraded habitat.

In terms of public safety, the mine pits can be viewed as similar to the larger power reservoirs where failure to address stream geomorphology at the reservoir outlet (or mine pit outlet) can lead to catastrophic water release (e.g. the Dead River in MI). Finally, we assert that the permitting for the mines should address the road system and culvert and fish passage, as is done elsewhere.

Hydrology – Rationale for Current Recommendations

A primary reason for modifying our previous recommendations relative to geomorphology sampling was the lack of continuous stream flow data. This fact effectively restricts a more refined stepwise approach to monitoring for impacts and emphasizes the need to address this critical deficiency. As a result, we are recommending contracting with the USGS to establish continuous stream gaging on all impacted streams – looking to the long-term, twenty years from now, when such information can lead to better assessments, understanding, and management.

The continuous stream gages and locations will be identified, in conjunction with DOW staff on maps for each of the mining proposals.* There are three lines of reasoning for, or benefits of, establishing continuous steam gages in the impacted river stretches:

1) it provides information necessary for permit requirements related to mine operations. For example, if a requirement is to maintain a certain pool level on a lake affected by the mine, then an accurate real-time relationship between stream inflows and lake stage need to be established.
2) it provides accurate and necessary information to enable assessment of potential ecological impacts. Hydrology is a key driver for river systems. Alteration of the hydrologic regime will disrupt the river ecosystem through changes in geomorphology (e.g., erosion, sediment transport), changes in habitat ((i.e., altering stream aggradation (sediment and wood) and degradation regimes)) and subsequent, associated changes in the aquatic community. Related to hydrologic alteration limits, there are two basic concepts or ideas that are now widely accepted in the scientific community: environmental flow recommendations should support whole ecosystems rather than only specific components such as target fish species (Arthington et al. 1992, Richter et al. 1997, Poff et al. 1997), and ecosystem integrity is best supported by protection of natural flow regime characteristics, and departures from natural flow conditions can be expected to result in ecosystem degradation (Arthington et al. 1992, Poff et al. 1997, Richter et al. 2003, Bunn and Arthington 2003, Annear et al. 2004). Using the data sets generated from the continuous stream gages, the record can be examined for changes to: 1) the magnitude, 2) duration, 3) timing, 4) frequency and 5) rate of change (such as flood rise or fall rates) of flows. This analysis then serves as a basis for assessing the expected impacts on other river components (i.e., geomorphology, water quality, biology and connectivity). The analysis also would be useful in optimally assessing the potential effectiveness of protective or restorative strategies/proposals for attaining environmental goals with minimal extraneous costs.
3) the continuous stream gages can be applied to any mitigation requirements for the mining projects. This fundamental and critical hydrologic information provides the basis for relating the ecosystem components and furthers understanding of the systems; continued investment benefits the agency's information base and management efforts.

Current Recommendations

We base the need for much of the following modifications of our previous template on John Adams (DOW hydrologist) assertion that all of the mining projects were likely to exert a hydrologic change of greater than 30% (based on "back of envelope" estimations of mine footprint/total watershed area) and that hydrologic data does not currently exist to allow more refined assessment based on the degree of likely hydrologic alteration.

Thank you for the opportunity to provide these recommendations. *We look forward to sitting down with DOW staff soon to select the exact location and number of continuous stream gages that should be collecting information for each mining project. If there are questions or concerns that arise as a result of these recommendations please contact us to work through it.

c: John Adams
Steve Colvin
Scott Ek
Mike Peloquin
Jim Japs
Steve Hirsch
Bob Liebfried
Mike Liljegren
Greg Kruse
Chris Kavanaugh
Tim Goeman

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Annear, T., I. Chisholm, H. Beecher, A. Locke, P. Aarestad, N. Burkhart, C. Coomer, C. Estes, J. Hunt, R. Jacobson, G. Jobsis, J. Kauffman, J. Marshall, K. Mayes, C. Stalnaker, and R. Wentworth. 2004. Instream Flows for Riverine Resource Stewardship. Instream Flow Council, Cheyenne, WY.

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We accept this assessment and jump to the need for Level 2 sampling as in our original template. As previously agreed to, Level 1 was being conducted everywhere in the watershed (it is relatively straightforward and accessible data and ensures that we have the information to pick appropriate control sites for Level 3, if it becomes necessary). We provide a stepwise approach based on alteration of watershed area or mean annual flow (MAF) should previous estimations of change not prove accurate or precise enough for decisions.

- Given this new 'information' on the likely occurrence of hydrologic impacts, <u>we recommend that Level 2 should be conducted at a minimum of 3 sites for each impacted stream whenever there is a 20% change in watershed area **or** an extraction or addition of flow that exceeds 20% of the mean annual flow (MAF), located</u>,
  1) within 2000 feet of the (each) outflow,
  2) at the endpoint of impact, and,
  3) midway between the two.

- we suspect the >30%mine footprint/total watershed area value is estimated at the discharge point from the mine. Therefore we recommend defining the monitoring reach by extending that point on the stream downstream until the mine footprint becomes 20% of the total watershed. Thus the monitoring reach is from the mine stream outlet to wherever the mine footprint becomes 20% or less. It might be a sudden change in percentage where a large tributary is encountered, so suggested staying above any such tributary.
- within these three general sampling areas, the <u>most sensitive</u> stream types, as indicated by the Level 1 analysis, should be selected.
- do at least two meander wave lengths (or 20 to 40 widths in length) at each site, with permanent (monumented) transects established at 3 riffle and 2 pool cross sections within the reach.
- the threshold for more intense sampling – going to Level 3 geomorphic sampling, i.e., monitoring channel state and condition – is a 30% change in watershed area **or** an extraction or addition of flow that exceeds 30% of the mean annual flow (MAF).
- the Level 3 would include Level 2 work plus: conducting BEHI, Pfankuch ratings on the pool transects, and establishing monumented bank pins.
- if Level 3 is necessary, we recommend a minimum of two control sites of the same stream type as the Level 2 work is necessary (for replication, necessary for statistical validity of comparison(s)).
- after the initial sampling, we recommend repeating sampling at 5 year intervals for the life of the project permit.
- temperature monitoring should begin during Phase I scoping to collect 'before' data, as much as possible. Also, temperature monitoring should be done at the three locations as specified for the Level 2 analysis.
- In addition, a 10% change of watershed area or 10% of the MAF should trigger biological monitoring. Biological monitoring is taken to mean IBI sampling and score derivation following the protocols and metrics established by the Minnesota Pollution Control Agency's IBI sampling program.

Sandy; Verry (retired)

As it so often goes, we have had to make changes to our original proposal which tied the degree of hydrologic alteration to degree of sampling intensity for geomorphology. What follows is the story of this idea and new proposal, replete with new questions (underlined and numbered) for you to opine on.

The template proposal was highly controversial; DOW staff was not willing or able to model the hydrology to any degree of sophistication, questioned the need for studying geomorphology at all ("what natural resource value are we managing for?"), was uncomfortable with any long-term monitoring provisos tied to the permit, disagreed with the threshold number and concept (but didn't offer an alternative) and on, and on. After months of 'secret' emails complaining about the template proposal, a meeting was arranged and a long, heated discussion with 2 dozen or so people ensued . . . nothing was resolved. With so many administrative types present, a technical work group was formed and charged with addressing the issues that could not be resolved.

Besides frustration, one of the things that eventually came out of the fray was a DOW assertion that all of the mining projects were likely to exert a hydrologic change of greater than 30% for all the projects (based on "back of envelope" estimations of mine footprint/total watershed area . . . .)

So, we accepted this assessment and intellectually jumped immediately to Level 2 sampling in our original template. As previously agreed to, Level 1 was being conducted everywhere in the watershed (it is easy and ensures that we have the information to properly pick control sites for Level 3, if necessary).

Now, with this new 'information' on hydrology, we recommend that Level 2 should be conducted. But where? How extensively? I grabbed your note to Karl and I and suggested your ideas:

At a minimum of 3 sites, located,

1) within 2000 feet of the outflow,
2) at the endpoint of impact, and,
3) midway between the two.

I suspect the >30%mine footprint/total watershed area value is calculated at the discharge point from the mine. In my earlier notes I suggested defining the monitoring reach by extending that point on the stream downstream until the mine footprint became 20% of the total watershed. Thus the monitoring reach is from the mine stream outlet to wherever the mine footprint became 20% or less. It might be a sudden change in percentage where a large tributary is encountered, so suggested staying above the trib.

Within this total reach, then do three sites: beginning, middle, and end. Do at least two meander wave lengths (or 20 to 40 widths in length) at each site.

I did not have a control site in mind to compare to. I would simple use my modal value chart for stream type w/d ratio and consider the condition of the stream modal if it is within 25% of the modal w/d values and degraded if it is more than that. There are some sinuosity guides in that modal value table too that can be used to help interpretation of condition, but I'd rely mostly on the w/d ratio to judge condition.

What about sensitive stream types identified in the Level 1 exercise?

- Here we specify that within the three general sampling areas, the most sensitive stream types, as indicated by the Level 1 analysis, should be selected.

Since we are concerned about the outfall from the mine, I would just do the three sites on the main channel between the mine and the 20% of total watershed cutoff. If there are several stream types in that reach, then I'd leave it to the measurement folks to pick the reaches. I have seen, on the same stream type, where there are bankfull discharge increases, that the first place where a stream dramatically changes its w/d ratio is where there is a significant slope change. Assuming of course the change is not on a bedrock section.

Additionally, I'd collect as many air photos as exist and look at them for beaver dam induced changes, so that overwide or over straight reaches are not automatically assigned a mine outfall cause.

How do we determine the actual impact of the mining (any proposed change in hydrology)?

See my modal w/d table for this.

- We originally suggested Level 3 geomorphic sampling – essentially, monitoring.

Is there a threshold for more intense sampling – going to Level 3? What is it?
Originally, we based this on a threshold for change (10%) and judgement of stream channel sensitivity (from Level 1 and 2 work). It is clear that the data does not exist to detect a 10% change, nor has any other hydrologic alteration threshold been suggested. So we move on . . . .

You originally suggested a cutoff point, over which the permit should be denied ("say 40-50% change in watershed area"). This is problematic, as we have no data to back up actual 'detrimental' impacts from a geomorphological change (recall, ("what natural resource value are we managing for?") and the political will to set such a cutoff limit is doubtful.

- We are recommending going to Level 3 monitoring at the same Level 2 sites at watershed change of 40-50%. The Level 3 would include Level 2 work plus: establishing permanent (monumented) transects at riffle and pool cross sections, conducting BEHI, Pfankuch ratings on the pool transects, establishing monumented bank pins, collecting substrate pebble counts for both the longitudinal section and at the transects.
- For vegetation changes, I used a threshold of 60% change (40% open) as a management guide. I am not sure if the mineland use change would have a similar threshold or not. I did a similar response curve for drained wetland and found that response to be at about 35% of the total basin in intense drainage channels. I suspect the mineland change is somewhere in between, so I'd set it at 40 or 50%. This could be your key for going to level 3. I suspect this would be the first reach away from the mine as this is where the mineland percentage of the total basin would be largest.

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Bear in mind that other things may destabilize the channel (e.g. channel straightening, road prism blowouts from undersized culverts, blowout of the mine pit sill, etc. These would also trigger level 3.

What about control sites?

- If the threshold is reached, and Level 3 is necessary, we recommend a minimum of two control sites is necessary (for replication, necessary for statistical validity of comparison(s)).

I saw no recommendation from you on this - what had you intended?

I had intended to use the modal value chart to evaluate condition. In effect, the modal values for a given stream type are the control.

How often should the sampling be repeated?
The time element is critical. As you know, immediate change in channel shape is unlikely, especially if the stream is stable. If it is unstable, teasing the ongoing change from the new impacts is the issue, and can be difficult/tenuous without proper control sampling (see note above too).

- After the initial sampling, we recommend repeating sampling at 5 year intervals for the life of the project permit. What do you think?

What I see happening (fore instance Silver Creek in Wisconsin) where there are ongoing changes in bankfull discharge (an increase), the channel takes 5 to 10 years to soften up the banks with larger and perhaps more frequent (within a year) bankfull flows. Then you get the 10 to 15 year storm and it blows everything out and the channel adjusts to a new width and depth, but usually near the modal values.

Why not give everybody a little room and say 4 to 7 years where an eyeball assessment at 4 years will decide do it now or wait another 3 years.

Temperature Sampling

From ours and your original memo"

- "On trout streams, temperature monitoring should begin during Phase I scoping to collect 'before' data, as much as possible. Also, temperature monitoring should be done above and below impact site(s) at multiple locations. Collection sites chosen should consider potential impacts occurring through changes in vertical (groundwater to stream bed) connectivity. I agree with this , get those hobos in there as soon as possible. It should just be a requirement of applying for the permit."

Why just trout streams? Temperature changes affect warmwater systems as well and the sampling is relatively cheap.

I agree, could put them on the same 3 reaches as outlined above

Finally and most importantly: a primary reason for moving this way in terms of sampling was the total lack of basic hydrologic data. As a result, we are insisting on establishing continuous stream gaging on all impacted streams – looking to the long-term, twenty years from now, when such information can lead to better assessments and prescriptions.

This is a good idea, but you have to address the same concerns that the USGS does at gaging sites: Pick a relatively stable cross section, multiple stream measurements each year, and shifting rating curves when channels change. Given these complexities, I might opt for the USGS approach and pick a box culvert, bridge, etc. for the site. You really want the discharge data and you can use the 3 channel reaches for channel changes.

Hope this will help. I think the resource values are dynamically stable streams able to transport their water and sediment with out adverse change to dimension, pattern, and profile and holding modal aquatic habitat for the various stream types, rather than aggraded or incised channels with degraded habitat.

In terms of public safety, I see the mine pits similar to the larger power reservoirs where failure to address stream geomorphology at the reservoir outlet (or mine pit outlet) can lead to catastrophic water release (e.g. the Dead River in MI). Finally, the permitting should address the road system and culvert and fish passage just like anywhere else.

Sandy