Meeting Notes from July 17-18, 2007 Technical Sessions on Water Issues

EA0607-002: Tamerlane Ventures Inc's

Pine Point Pilot Project

September 19, 2007

Table of Contents

Introduction

Technical Sessions on water issues were held for the environmental assessment of the Pine Point Pilot Project (PPPP) proposed by Tamerlane Ventures Inc. on July 17-18, 2007, at the Ptarmigan Inn in Hay River. In addition, over lunch on July 17, attendees conducted a site visit at the PPPP site.

This document is a summary of the proceedings from those sessions, compiled by Review Board staff and assessed for accuracy by attendees before being publicly released. Audio CDs of the entire proceedings have also been forwarded to all Parties to the EA, and are available upon request from the Review Board. *NOTE: Quotes that appear in the text are not direct transcriptions: they are paraphrased from meeting notes.*

The four Topics identified for discussion during the Technical Sessions were:

1. Water quantity issues (estimated inflows to the mine and impacts of discharge)
2. Water quality issues (confidence in predicting water quality discharge characteristics)
3. Impacts of discharge water on the receiving environment
4. Discharge water management planning

Topics 1 and 2 were discussed on Day 1 – July 17. Topics 3 and 4 were discussed on Day 2 – July 18. In addition to the four Topics identified prior to the Technical Sessions, there was a fifth Topic added at the end of Day 2 of the Technical Sessions, and that addressed the pros and cons of replacing the proposed infiltration basin with a deep injection well system for mine and process water discharge. In addition, some time was spent on Day 2 by the developer introducing the potential "froth flotation circuit" they were considering adding to their ore beneficiation circuit. Following the Executive Summary of the Technical Sessions, each Topic and individual question addressed at these meetings are examined in turn.

The Technical Sessions were very effective in developing follow-up questions, which were identified as "undertakings", all of which are listed in Appendix 2. Where dialogue on a specific Topic created an undertaking, this is identified in the text herein.

It should be noted, and is throughout the text where applicable, that the subsequent elimination of the infiltration basin from the development by the developer, in favour of a deep well injection system, renders some Undertakings and discussion points outdated and unnecessary for the developer to follow up on. In addition, Parties should consult material placed on the public record for this EA since these meetings to assess the quality of assessment on the Undertakings identified here.

If you have any questions about this document, contact Alistair MacDonald at the Review Board – amacdonald@mveirb.nt.ca; fax (867) 766-7074; phone (867) 766-7052.

Executive Summary

NOTE: See Appendix 2 for a list of Undertakings coming out of the Technical Sessions.

Under Topic 1, Analysis of Different Scenarios of Water Inflow to the Mine, the following issues were focused on:

- The area below the mine works is unfrozen, and the developer had used the assumption that the underlying strata is almost impermeable to estimate that the inflows to the mine would likely be along the order of 55 cubic meters per hour (m3/hr). The developer was unable however to provide the technical experts with a sound rationale (basis) for the inflow estimate.
- Technical experts felt that more information was needed on the underlying rock below the mine workings, pointing out that the Brown, Erdman (1981) report identified this underlying rock not as impermeable, but actually as having characteristics of high groundwater permeability.
- The developer was thus challenged on their estimates of groundwater inflows at the base of the mine. It was established that the 55 m3/hr estimated by the developer could be exceeded by an order of magnitude or greater.
- It was demonstrated by the technical experts that the large head on the groundwater system outside the frozen ring around the mine workings (about 160-180 metres), combined with the surface area of low pressure created by dewatering the mine workings, will promote inflows through the underlying rock that are at least an order of magnitude higher, and perhaps significantly more. Estimates varied from 440 m^3/hr as the base case, to a worst case scenario of over 4000 m^3/hr if there are large fractures in the underlying rock (this is effectively impossible to determine ahead of time). And these estimates were based on earlier studies that the developer had access to.
- The developer came over time to accept inflows of 440-550 m3/hr as a reasonable estimate. However, it was also agreed that the inflow calculations need to be redone by the developers own experts, and different inflow scenarios and implications/contingency plans considered.
- It was noted that higher groundwater inflows to the mine would have little effect on the integrity of the freezewall, which all parties agreed was unlikely to fail given prior experiences.
- The developer identified that their contingency planning for outflow management focused on their confidence that the infiltration basin would be able to handle the water being pumped out of the mine. Experts disagreed with this confidence, noting that the developer estimated the infiltration basin could handle 100 m3/hr when the actual outflows might

be much higher, and that contingencies such as using wet drains and removing any clogging sediment, as well as expanding the boundaries of the infiltration basin, might not be adequate or environmentally acceptable. Greater contingency planning, as well as more accurate delineation of how much outflows the infiltration basin could handle (through additional geotechnical analysis of the infiltration basin lithology and water table) was called for.

- In terms of mining itself, while some safety and cost implications were identified from additional water, it was generally agreed that the mine could technically operate even if there is a large amount of water (e.g., 550m3/hr)flowing into its base. However, if the Infiltration Basin is the chosen option for the location where all this inflow is eventually pumped, a serious reconsideration of the ability of the receiving environment to infiltrate this amount of water below surface, rather than having it spill out into the surrounding surface environment, was called for. Both calculations (inflows at the mine and ability to exfiltrate at the "end-of-pipe") needed to be recalculated before this assessment can occur.

Under Topic 2: Confidence in predicted "end of pipe" water quality, the following issues were focused on:

- Current predictions of "end of pipe", or "discharge", water quality rely on a variety of assumptions, and some information was not examined. For example, tap water rather than deep groundwater was used in process testing with R190 ore in the metallurgical test work.
- In addition, it was established that the Brown et al (1981) pump test water results are a better sample to use as the estimate of current deep groundwater than that used by the developer in the DAR, and that the constituents identified therein would be the ones of interest to further fate analyses. High levels of sulfides, iron, sulphates and TDS merit further consideration.
- In addition, the developer for the first time at the Technical Sessions identified that a "froth flotation" circuit was potentially going to be proposed to further beneficiate, and also separate, the lead and zinc ores. Experts called for more information on reagents used in the process, and for the developer, if they did commit to adding this process to their system, to reassess the likely water quality at the end-of-pipe for all constituents of interest.
- Concerns were expressed that the high level of sulfides in the deep groundwater weren't taken into consideration in the current environmental impact assessment. High sulfides create safety issues (due to H_2S) in the mine workings, and have been associated with issues at the surface as well if they don't oxidize. Sulfide levels had not been considered by the developer; additional work in the form of a fate analysis of sulfides was required in the opinion of experts.

- Current analyses of metals in the discharge water are based on estimates only of soluble metals, which constitute only a small proportion of total metals. While the soluble portion is the most important environmentally (as metals associated with particulate matter would presumably be removed in the infiltration bed and thus not enter the groundwater system flowing away from the release area), totals still should be measured, as they can create environmental liabilities. Concerns were also expressed that the laboratory tests were not set up to reflect the likely loading of metals during water recycling through the system several times before discharge. Experts called for an assessment of total metals in the end of pipe water, as well as updated testing if the froth flotation circuit is going to be used.
- Ammonia was identified by experts as being perhaps the most important water constituent for consideration by the developer. Current estimates need to be re-worked, giving greater likely water inflows and the commitment to use only emulsion explosives. It was noted by the developer that the use of an emulsion for all blasting work will substantially reduce ammonium nitrate losses and thus result in lower ammonia and nitrate levels in the mine water. It is thought likely that ammonia concentrations will go down under this scenario, but accurate estimation is essential for a range of possible mine water flow conditions, because current estimates indicate higher levels of ammonia than typically allowed by water licenses. Reference was made to recent experience at Diavik where ANFO emulsion is now being used in an attempt to reduce the ammonia level in mine water, and the developer agreed to refer to information about the Diavik experience in its reconsideration.

Under Topic 3, Potential Impacts of Discharge Water on the Receiving Environment, the following issues were focused on:

- Two main issues - the ability of the proposed infiltration basin to exfiltrate all the process and mine water (i.e., potential for flooding), and what impact that water would have on the surrounding environment (particularly vegetation).
- In the DAR, the estimate made by the developer is that the infiltration basin can exfiltrate 100m3/hr of water. There was uncertainty about the assumptions and methods used to arrive at this estimate (experts can't replicate it), but it became apparent during the meeting that these estimates did not include analysis of the recharge capacity of the underlying (shallow) aquifer; no geotechnical work had been done to identify the hydraulic properties (stratigraphy, hydraulic conductivity, porosity, depth to water table) of the underlying (shallow) aquifer.
- Three factors were identified that might lead to major problems in the infiltration basin even if the assumed infiltration rates are correct. First of all, if the combined mine water and process water discharge contains high

levels of suspended solids the water may be impeded from draining vertically as the area clogs with fines resulting in reduced infiltration rates. Secondly, given that the discharge flow is likely to be much higher than presented in the DAR, the stated ability of the infiltration capacity of the basin to send water back may be exceeded very quickly (one estimate has the infiltration basin filling within 17 days). Thirdly, continued seepage from the infiltration capacity may result in mounding of the local groundwater table reducing the infiltration rate from the basin and/or discharge of impacted groundwater to near-by wetlands and/or small creeks potentially negatively influencing the surroundings.

- Experts felt that ammoniun-nitrate losses underground and metals leaching in the DMS circuit were the major potential contaminants in the discharge water.
- One point in the developer's favour is the increased dilution of ammonia and nitrates from explosive losses, given the predicted increase in water flows. This would reduce impacts on the receiving environment.
- The developer committed to doing additional geotechnical work in the infiltration basin, to confirm stratigraphy and water table. *NOTE: This work is no longer required because an injection well for water discharge has been proposed, although additional analysis of the potential impacts on the environment of discharge water is still required for the deep injection plan.*

Under Topic 4, Water Quality Management Planning and Closure Issues, the following issues were focused on:

- There is no inclusion in any of the material put forward by the developer, even if only by way of contingency planning, for any secondary holding area for water. This type of containment capacity is something that some experts identified as essential, in case exceedences are identified during testing of discharge waters. Given the inflow speeds, the current (at the time) mine plan would see the developer very quickly having to decide whether to dump bad water into the infiltration basin (clearly unacceptable), or abandon mining until the water problem is dealt with. Neither option is a good one; secondary containment for settling (and potentially treatment), in the opinion of the experts, needed to be considered under contingencies.
- Currently proposed lime treatment would not be effective for ammonia or suspended solids, if they are too high. In addition, the effluent quality is expected to change should a flotation circuit be added to the ore beneficiation plant. Test work being undertaken by the developer was to provide insight into the effects of the additional circuit on metals and other contaminants in the plant effluent.

Under the Added Discussion Topic 5, Pros and Cons of an Injection Well Water Discharge System, the following issues were discussed:

- The developer was interested, given the amount of additional work required because of the perceived high risks associated with the infiltration basin option, to know experts' opinions about the viability of a deep injection well option. *NOTE: The developer did subsequently choose to commit to a deep well injection system rather than the infiltration basin.*
- Experts generally felt that a deep well injection system would be more effective and safe than the proposed infiltration system. Reasons included:
    - Re-injection back into the same aquifer of high TDS and high sulfide water, rather than expose a shallow aquifer to this different water
    - Footprint minimization at the surface
    - Reduction in potential for surface and near sub-surface contamination, minimizing impacts on plants and animals
    - Maintenance of a high pH environment where metals are not soluble
    - Reduce concerns of the landholder – the GNWT Department of Transportation
    - Greater infiltration capacity and dilution capacity before the contaminants of interest migrate toward surface plants or water bodies
- A couple of concerns were raised, associated with the ability for injections wells to clog up with sediments, and the fact that the technology is not well known, especially among lay people. Experts called for the developer to explain properly how the system would work if implemented, developer a water management contingency plan, and properly assess the "contaminant plume's" fate at depth.
- In addition, there were unanswered questions about the acceptability of co-mingling the sewage water with the process and mine water into the injection well, if chosen.

Topic 1: Water Inflows to the Mine

Topic 1 involved analysis of different scenarios of water inflows to the mine, and what potential increases in water quantity might mean for impacts on the environment

GENERAL CONSIDERATIONS: Although the developer had expressed a high degree of confidence in its ability to minimize water inflows to the mine through freezewall technology, specific discussions of the groundwater conditions in the R-190 area by experts were required before previously stated concerns of a variety of parties could be put to rest. Going into the Technical Sessions, there were outstanding questions of whether the conditions had been adequately characterized.

In addition, one of the goals of Environmental Assessment is to consider "worst case" scenarios and have contingency planning in place for such situations, even if they are considered unlikely. In particular, the potential for significant inflows from the base of the frozen wall merited more consideration in the Technical Sessions.

NOTE: In several cases, issues were raised by either the developer or experts as they came to mind, rather than in relation to the specific question being discussed. Where possible, these Meeting Minutes attempt to move those issues back into the Topic they address. The result is two things:

1. **In some places, an issue will be discussed more than once in different sections of the text; and**
2. **Not all discussion points are noted in the chronological order in which they came up.**

3. SPECIFIC QUESTIONS POSED ON TOPIC 1:

a) ***There appears to be lack of information provided to date by Tamerlane regarding the potential for upwelling of water from below the base of the mine workings into the mine. Given the properties of the lithology at the base of the workings, it seems very plausible that this rock formation could be an aquifer. Can Tamerlane, given its limited data, confidently assert that water inflow into the bottom of the workings is to be manageable and not significant?***

NOTE: This discussion contains overlap with Topic 1c; they should be read together.

Developer's comments:

The developer identified that the freezewall is expected to go 600' below the surface. Some 97% of water inflow was estimated to occur within the Presquile layer around the 450' zone, with water flow estimated to drop off exponentially after 510'. The developer felt that they had a minimum 50' buffer zone between the bottom of the mine (550') and the bottom of the freezewall (600'). This 550'-600' zone was described as being basically impermeable, leading to the estimate of mine inflows of 55 cubic metres per hour. The developer did not think it necessary to "re-characterize" the hydraulic conductivity below 600' (described by the developer as the "E-facies"), given that water intrusion was perceived to only be an issue in the higher up sedimentary-dolomite zone, given historic data.

Experts' comments:

Debate ensued between the developer and the technical experts over the permeability of the base of the mine works, the likely amount of inflow in cubic metres per hour (and the range of likely inflows), and the source and calculations used to determine the estimate of 55 cubic metres per hour used by the developer. Relevant points:

- ☐ The base is not being sealed so it is important to have a reasonably accurate estimate of water inflow from the base (and different scenarios of potential inflow), and this had not been looked at by the developer.
- ☐ Experts provided their own estimates of potential inflows. These ranged from 435 to 4320 cubic metres per hour, with one expert using information provided by Stevenson International (1983), as well as initial hydraulic calculations, to come up with this range.
- ☐ The implications of additional inflow to the mine were argued by experts to include mine safety concerns, operability in a high inflow scenario, as well as problems with the proposed infiltration basin being able to absorb higher than expected outflows from the mine. For example, in the Developer' Assessment Report, it was estimated that the infiltration basin could "exfiltrate" 100 cubic metres of discharge water per hour. Any mine inflows above this level could lead to mounding and eventual overflow of the walls of the infiltration basin.

- It was determined through dialogue that the developer's original estimate of 55 cubic metres of inflow per hour would be acceptable only as a low end estimate. The developer committed to providing a re-calculation of estimated mine water inflows and outflows to the receiving environment, and to develop water discharge management contingencies based on "most likely case" and "worst case" scenarios (see Undertaking #1).
- The area characterized by the developer as a low permeability E-facies below the mine works was considered to be the B-facies by historic analysts. This potential mis-characterization also led to questions about whether the perceived impermeability was accurate as well. Work by Brown, Erdmann et al.(1981) done for Western Mines in the early 1980s indicated that the area below 585' in the R-190 area was the poorly characterized B-facies of the Pine Point geological layer, and was considered a potential aquifer (i.e., an area of relatively high water permeability).
- Given this uncertainty, the lack of characterization of groundwater flow below 600' was considered a flaw by the experts. It was stated that recalculated estimates for inflow rates at the open base of the freezewall curtain are important to determine an accurate dewatering rate, thus the lack of this value creates uncertainty in the developer's overall dewatering strategy.
- One expert called for hydraulic testing to be done in order to determine conductivity in the B-facies underneath the proposed mine workings. However, it was also noted that even additional testing would likely measure the permeability of the rock itself, and may not give information about discrete faults and fractures potentially occurring in this underlying rock layer. In fact, it was stated that it is impossible to know for sure ahead of time how much additional water such faults and fractures might add to water inflows. In response, the developer argued that the karst geology only occurs in the ore body itself, not in the surroundings. The developer argued that the presence of a large amount of faults and fractures below the mine works would therefore be very unlikely. In response one expert argued that this would not eliminate the possibility of discrete faults and fractures of higher permeability in the underlying limestone units. .
- In the end, the developer committed to providing all the available drill logs from exploration work in the area to help establish the geological material present at the base of the R190 deposit and the permeability of these rocks below the mine works (see Undertaking #2). More importantly, the uncertainty about the likely water inflows led the developer to commit to re-examining inflow estimates and properly conduct the hydrological calculations (Undertaking #1).

b) ***Can Tamerlane justify its use of the Beak 1981 study as the main input for its desk-top inflow study? This study was apparently conducted for the purpose of a pump-out mining system, not a freezewall system as is currently proposed.***

Developer's comments:

The developer and its main contractor for freezewall, the Layne Christensen Company, re-iterated that they feel they have enough information from seven different hydrological reports to determine that groundwater characteristics are amenable to freeze wall application. They stated that they have taken a conservative approach in all of their calculations, and that freezewall technology success has been proven across a broad spectrum of applications and ground conditions. At present, the developer is proposing 1.6 metre spacing between freeze pipes. A frozen wall thickness of about 3 metres was expected.

The Layne Christensen representative also noted there are a variety of built in systems that will continually monitor ground conditions during construction and operation of the freezewall system, and that mitigation measures for any signs of failure are readily available. Ground freezing adaptations may be required for things like

1. greater than expected ground temperature;
2. greater than expected groundwater flows; and
3. thermal erosion at the base (bottom) of the freezewall.

The amount of salts in the groundwater system was argued by the developer not to likely have a major effect on the functioning of the freezewall. Salt levels do impact upon the temperature at which the ground water freezes, but the developer noted that this technology is used even near saltwater ocean environments. No major questions ensued about salts.

The Layne Christensen representative talked about the different monitoring systems that will be used, as well as protections built in to the above ground brine circulation system (to avoid breakage and accompanying leaking of brine on the ground).
Mitigations include:

1. adjusting the spacing of the pipes (the closer they are together, the greater the strength of the barrier);
2. adjusting the temperature of the brine (the colder, the stronger the barrier);
3. Constant monitoring of pipe, brine and ground temperatures to look for anomalies; and
4. If problems are found, grouting and/or additional pipes will be utilized.

The developer confirmed that brine will be the freezing agent; liquid nitrogen, being hard to deliver below 300 feet, liquid nitrogen will not be used in this case.

The developer also confirmed that no lateral development will occur until the freeze perimeter is established, and undertook (see Undertaking #3) to confirm that with a Gantt Chart of the proposed underground infrastructure timing.

Expert's comments:

The focus around this question was on the viability and technical aspects of the freezewall technology itself. There was a general consensus that the freezewall technology can be made effective through a variety of means that will be adapted to site conditions as the development unfolds. The discussion focused on getting a better understanding of what issues could impede the development of the wall, and what mitigation would deal with those contingencies. The developers answers (summarized above) seemed to assuage concerns about whether the freezewall could be successfully developed and sustained.

One expert wanted more information on surface protections and contingency plans in case of massive brine loss. He wanted to know, given that +/-40 tonnes of calcium chloride will be circulating in the brine solution, what the contingency plans for operational failure and leaking pipes are?

The developer's team responded that along the perimeter of the brine distribution piping system, sensors and solenoid valves are installed so that isolation valves automatically turn off to prevent drainage of the whole system. However, a contingency plan incorporating security against environmental impact by brine pipe leakage (for both small and large amounts) was argued for by the expert. The developer consequently undertook to provide for the public record a revised description of the safety measures in place around the brine distribution system for the freezewall system, including discussion of protections for the main line at the manifold (i.e. the manifold piping will be buried in a lined trench to isolate it from traffic on the site), and a contingency plan and environmental impact worst case assessment of a massive loss of brine from the manifold (Undertaking #4).

c) ***Tamerlane estimated an inflow to the underground workings (main sump in shaft at 165m depth) of 55 m^3/hr (DAR, p. 148). Which method was used and which assumptions were made to arrive at this estimate? Is this a steady-state estimate of basal inflow (below the freezewall) or an average pumping rate over the period of progressive dewatering over the period of the PPPP? What is the estimated range of uncertainty in this estimate?***

Developer's comments:

Following up on earlier discussion under Topic 1a, groundwater velocity at the base of the freezewall was not formally calculated by the developer since they assumed that the base was effectively impermeable and that the horizontal stratigraphy would see groundwater flow rates that are very small at the base of the freezewall.

The developer's estimate of 55 m^3/hr was stated to be based on estimates from Stevenson International (1983) and Brown, Erdman & Associates (1981) studies, of flows at 450-500 feet below the surface. The developer initially expressed certainty that this estimate was reasonably accurate, if not conservative.

When asked directly how the 55 m^3/hr rate of inflow was calculated and what range of uncertainty was identified, the developer responses was that the estimate was based on studies at 510 ft below the surface on an individual pumping well and extrapolated upwards. No formal "K" calculations were undertaken by the developer. Uncertainty was not considered, but it was stated that tests would be performed as drilling is occurring after the mine is permitted. The developer indicated willingness to put piezometers down once the shaft is bored, to measure the response of the groundwater levels in response to trial pumping and/or mine dewatering.

The developer reiterated Tamerlane's belief that the 50 foot "impermeable" barrier between the bottom of the freezewall and the mine workings are likely to keep inflows very low. The developer later accepted the argument that this might not be the case, and subsequently promised to provide updated estimates of water inflows as per Undertaking #1.

Expert's comments:

Concerns were raised that the developer's inflow assumptions might be in error. None of the experts were able to find the information that supported the estimated flow in the source material. One expert noted that the base of the mine still has to be dewatered since it is not sealed, and that any mine has basal inflow and this amount needs to be quantified to determine mine dewatering and process water disposal rates.

It was noted that determining the likely water inflows once the project is already permitted (as required under the developer's piezometer plan) is problematic, given that the time to identify potential significant adverse impact with appropriate evidence is pre-project, during EA.

Experts argued that, while it is possible that the flows could be as low as 55 m^3/hr, it was also necessary to look at other scenarios, given uncertainty associated with not having in situ hydraulic conductivity testing by the developer. The relevant questions is – if inflows increase by an order of magnitude (i.e., from 55 m^3/hr to 550 m^3/hr) or more - what are the impacts to dewatering strategies in the mine *and* the ability of the infiltration basin to handle outflows? It was argued that an order of magnitude increase in water inflows might be significant.

Experts noted that the Stevenson report actually uses a much higher inflow magnitude estimate than the 55 m^3/hr of the developer. One expert put the actual Stevenson test estimate at 432 m^3/hr, with a high end estimate of an order of magnitude higher (i.e. 4320 m^3/hr). Another expert felt that it was unlikely that the inflow would be 10 times higher than the upper end estimate 550 m^3/hr. However, it was noted that there will be a large head forcing water down when it meets the freezewall, and it will be looking for the path of least resistance.

The lack of information on the hydraulic characteristics of the bedrock (the "B" facies that had been mis-labeled the "E" facies in earlier analysis by the developer) below the mine, along with these conflicting estimates of inflows based on what some experts labeled as a misreading of the available historic data, created a high level of general uncertainty and discomfort about inflows to the mine. This was deemed relevant by experts for several reasons, including:

1. mine safety issues (flooding effects)
2. mine operability issues (feasibility of mining in a high water zone and pumping capacity)
3. impacts on the "end-of-pipe" outflow area – the proposed infiltration basin might not be able to handle these increased outflows (see Topic 3d and 3e for further discussion)

As mentioned above, given this uncertainty and its relevance, subsequently the developer undertook to reconsider its estimates of likely inflows (Undertaking #1). Despite the agreement that the initial inflow/outflow data had to be reworked, there was no consensus as to whether additional outflows to the receiving environment would create additional adverse impacts on the environment.

Follow-up discussion from Morning of Day 2:

The developer was asked by one of the experts to revisit Section 5.2 of Brown *et al* (1981) and pages 17 and 18 of the Stevenson report overnight. The next day, the expert was able to show convincingly that the hydraulic testing data presented in Brown *et al* is a much better estimate of vertical permeability of bedrock at the bottom of the mine (585 feet). The use of data from the X-25 site is problematic because this was merely a monitoring station set up to see if the water table was being affected by R-190 dewatering.

The developer initially disagreed and then accepted the argument put forward, at least on the "best estimate" of water inflows (disagreement continued as to the high end values). The expert leading the discussion noted the following:

- During active mining the pressure head in the shaft and mine workings will be zero (atmospheric pressure), while the surrounding bedrock aquifer (outside and beneath the freeze curtain) still has a pressure head of almost 180m This creates a high differential pressure (180m head) which forces groundwater beneath the freeze curtain and into the dewatered mine workings and shafts
- According to Stevenson (1981) the geological unit at the base of the R-190 deposit is the B facies, rather than the E facies, at 585 feet, Brown et al. (1983) later tested three core samples from that approximate depth from the R190 deposit in the laboratory to determine porosity and vertical permeability of this geological unit
- It is highly likely that the core samples used actually under-represent the permeability of the entire base of the underground mine , because small samples do not account for large fractures likely to be present in the bedrock layer. The expert stated that "It is almost impossible to get a higher value of permeability from a small core sample compared to the large-scale permeability in bedrock"
- Assuming a hydraulic conductivity of 6.6 x10-7 m/s (obtained in the lab testing of one core sample from the 585 foot level), Brown et al estimated a basal inflow ranging between 460 and 4000 m^3/hr, and this was based on geometry very similar to the currently proposed mine. The upper end estimate from Stevenson was based on this very concern that the small core samples were not representative of likely fracturing/faulting across the site.

This expert felt that the evidence indicated that the flow rate of 55 m3/hr assumed by the developer did not take into account scale effects and were therefore not representative of actual likely inflow rates. Subsequently, one of the other experts agreed with this assessment. Experts called upon the developer to review the hydraulic testing and flow analyses provided in Stevenson's report and adjust all calculations involving water inflow analysis to reflect Stevenson's results, develop new contingency plans in consideration of these higher inflow rates, and identify expected effects and loading on the environment of the increased water. This became Undertaking #1 by the developer.

d) ***Tamerlane proposes to use a pumping system with a maximum capacity of 2,273 m^3/hr. This capacity is significantly (about 40 times) higher than the estimated inflow to the underground workings. What is the basis for selecting this capacity? In the DAR, it states that this capacity is sized for any unforeseen inflows of water. If such high inflows were to occur the infiltration basin would be at capacity within about 17 days. Has Tamerlane developed any contingency plans for discharge of these large quantities of deep groundwater pumped to surface in the event of an unforeseen inflow of this magnitude?***

Developer's Comments:

For this project the shaft of the mine will act as a sump where all water entering the underground mine will be collected, and then a series of pumps will send water to the surface. Some of this water will be used in the processing, but the bulk of it was intended to be directly sent to the infiltration basin.

It was stated in the DAR and re-iterated at the Technical Sessions that the infiltration capacity of the basin was expected to be around 100 m^3/hr for the entire part of the basin being used. The maximum pump capacity value of over 2,200 m^3/hr was given as an over-design feature to deal with operational failure and excess water inflow and not as an expected contingency value.

The developer stated that if the water inflow rate is higher than expected and the infiltration basin starts flooding, it could be expanded to increase storage and infiltration capacity. The developer also noted that excess inflows to the infiltration basin could be handled by equipping the ground at the release point with perforated culverts (pipes) to further facilitate infiltration of excess water.

Experts' Comments:

Experts saved their questions on how the infiltration capacity of the infiltration basin was determined for Topic #3d. However, using Stevenson's (1983) estimate of 432 m^3/hr inflow to the mine and the 100m^3/hr infiltration capacity stated by the developer, one expert suggested that the infiltration basin could start flooding its banks in only 17 days. The same expert stated that, given the range established by Stevenson's analysis, the 2273 m^3/hr pumping capacity proposed by Tamerlane could actually be a feasible worst case inflow at this site.

The lack of a contingency plan for greater than expected water inflows (worst case scenarios) was noted as a major flaw in the impact assessment to this point. Conceptual plans about how the infiltration basin would be expanded to accommodate greater than expected flows, it was argued, needed to be done in writing.

e) ***What is the relationship between an operational failing (not failure) of the freezewall and water inflow? For example, if the wall proves 5%-10% percent less effective than predicted, how much water will have to report to the surface? What are the implications of this? Is there a margin of error for the effectiveness of such freezewall systems? What has the margin of error been in other locales?***

NOTE: The majority of issues related to this question were discussed earlier around Topic 1b.

Developer's Comments:

In general, the developer's expert advisors from Layne Christensen noted that they have only ever seen one catastrophic failure of a freezewall, and that was a situation where the freezepipe holes were being drilled way out of vertical, creating large gaps in the freeze curtain. *NOTE: This possibility would be avoided through methods discussed further by the developer in Topic 1g.* Once the freezewall is properly established, no operational failing can occur.

At the beginning of Day 2, the developer noted that they are looking at different solutions in the freeze system to decrease the number of holes and have a quicker freeze time. They stated that a backup contingency plan in the case of leaking pipes is to use anhydrous ammonia that allows cooling to -50C as an alternative to minimize the number of holes drilled and have a faster freeze time. They will be rerunning test models based on economic parameters. Tamerlane committed to provide a note for the public record on the possible different solutions and operation parameters to deal with non-freezing zones around the perimeter freezewall, including identifying all the materials to be used.

Experts' Comments:

No experts questioned the overall likelihood of freezewall success, given the explanations of the process and adaptive management options given by Layne Christensen.

Experts, and Review Board staff, focused on the timing of any field testing as key. If all of the testing to determine a reasonable estimate of water inflows doesn't occur until the development has been permitted, there is no way that the environmental assessors can properly do their job, which is to gauge not only the likely inflows, but what significant adverse impacts (if any) that water would have. Getting the developer to accept that 550 m^3/hr inflow is more reasonable expectation, without doing further fieldwork, was a reasonable start but did not address the issue of contingency planning for reasonable worst-case scenarios on mine water inflow.

Some experts, however, argued forcefully for the aforementioned fieldwork (e.g., a Packer test at R-190 and more geotechnical drilling at the infiltration basin site), before the development could proceed further. One reason for this is that while the freezewall itself can be protected from erosion at the base by closer spacing of holes and/or reducing the brine temperature, the fact that erosion would be occurring at all would be linked to a more important factor – high water inflows around the bottom of the freeze pipes and into the mine workings. While this might not compromise the strength of the freezewall, it would cause problems with mine water management (dewatering and disposal). Again, experts expressed concerns about the lack of "worst case scenario" analysis and contingency planning.

NOTE: These concerns were in part addressed by the developer subsequently dropping the infiltration basin release point in favour of a deep injection well, an option that started to be considered on Day 2 of the Technical Sessions.

The following four additional questions were addressed in regards to the freezewall.

> *f) Poor water quality can depress the freezing temperature. What is the freezing temperature that was used for the design of the ground freezing system? What is the justification for the adopted freezing temperature?*

Developer's Comments:

The developer noted that the coolant temperature, through numerical modeling, was determined to be feasible at a brine temperature of -25 degrees Celsius. Water salinity was of no concern as has been demonstrated at applications bordering the marine environment.

Experts' Comments:

Experts expressed the general opinion that any operational issues surrounding the initial development of a freeze wall would have to be resolved before the mine could go into production. Hence it was in the best interest of the developer to ensure that the freeze wall was effective and that there was little risk that such start-up problems would result in environmental concerns or even risks.

> *g) What are the conditions that need to be achieved before the freeze wall is considered fully developed (i.e. ground temperature distribution, freeze wall thickness and depth, heat extraction, etc.)? Was a tolerance for drilling accuracy adopted for the freeze pipes? What is the corrective measure for drilling deviation that exceeds the allowable tolerance?*

Developer's Comments:

The developer will monitor the creation of the freezewall through an advanced downhole monitoring system linked to a central computer and alarm system. Temperature parameters are set ahead of time, and no lateral work on mining stopes and other infrastructure will occur until the freeze ring is fully established.

In terms of drilling tolerances, gyroscopic surveys are used to confirm that all holes are vertical within a tolerance of a 2 metre cylinder for each freeze pipe (i.e., no more than a one metre radius of deflection over a 550 foot drill hole). Where more than this deflection occurs, additional infill drilling will be conducted to assure the freeze pipes are close enough to create an impermeable barrier.

Experts' Comments:

No significant comments on this issue.

h) The construction of the shaft is apparently scheduled to begin before the completion of the freeze wall. Dewatering will likely be required for the construction of the shaft, which would induce groundwater movement that could impact the development of the freeze wall. Does the design of the ground freezing system address this potential groundwater movement?

Developer's Comments:

The developer noted that the shaft will contain a separate frozen barrier that will not intrude upon the progress of the main outside freeze wall. This early freezing of the shaft is to allow construction to take place while the larger frozen barrier is being established, but before any lateral development takes place.

Experts' Comments:

Undertaking #3 by the developer (to establish the exact timing of shaft vs. outside freezewall development), handles questions about timing concerns.

i) Groundwater movement will be induced at the base of the freezewall during dewatering for mine operation. Thermal erosion could occur at the base of the freezewall if the groundwater velocities are too high. Did the design establish a maximum allowable groundwater flow velocity to prevent thermal erosion along the freezewall? And how was it calculated?

Developer's Comments:

Computer programs TEMP-W and SEEP-W were used to model the frozen barriers against moving groundwater. The findings and experience indicate that there is not enough groundwater flow to erode the frozen barrier. The developer did note that the thermal erosion question could be remodeled based on pump test data gathered after the establishment of the curtain. The developer thinks that once a value can be agreed on for basal hydraulic-conductivity, then thermal erosion rates can be looked at and any required changes built into the freezewall adaptive management system.

Experts' Comments:

Given that the initial groundwater flow estimates used in the TEMP-W and SEEP-W modeling were called into question, experts requested that the freeze wall design and the potential for thermal erosion be re-assessed for a range of possible inflow rates. In addition, one expert called for the developer to submit a workplan detailing how the thermal erosion monitoring will be carried out. No formal undertaking on this workplan for thermal erosion monitoring or including the Undertaking #1 re-calculations in a re-assessment of basal freezewall erosion was committed to by the developer at this time.

Topic 2: Confidence in Predicted "End of Pipe" Water Quality

GENERAL CONSIDERATIONS: Prior to the technical sessions, concerns were identified about the limited amount of on-site baseline data in the DAR. In particular, there was a lack of information about the likely characteristics of deep groundwater versus that used in preliminary desktop studies, or in shallow well samples.

In addition, the developer had stated in its Information Request responses that it cannot make predictions of likely amounts of nutrients, sediment, and metals that will be deposited in the infiltration basin. Experts at the Technical Sessions were asked to provide evidence and opinion both on likely discharge characteristics, and what would be the prudent course of action if discharge characteristics cannot be identified with an acceptable level of confidence (e.g., whether additional work needs to be done, either prior to the completion of the Environmental Assessment or in a follow-up water monitoring and management program).

The main issue seemed to be that a realistic estimate of effluent quality had not been prepared/confirmed, and some form of contaminant transport fate and effects analysis of this discharge on ground and/or surface water quality needed to be considered.

SPECIFIC QUESTIONS ON TOPIC 2:

a) ***The Brown, Erdman & Associates Ltd report from 1981 contains data concerning a well test study at R190. The parameters reported upon appear more extensive than those provided in the 2006 study conducted by Tamerlane. Is there any reason why this data was not included in the DAR and considered? Is Tamerlane aware of this data, is the depth at which the water quality sample was taken known?***

Developer's Comments:

The developer stated that it was an oversight the Brown *et. al.* data was not included in the DAR. However, they felt upon review of the data, which they did have access to previously, that the background water quality results from Brown at the R-190 site were similar to those reported in the DAR (which relied on data from the X-25 site east of R-190). The following table compared the two sets of results:

Parameter	X 25	Brown R190
pH	7.1 - 8.1	7.85
Conductivity	3048 - 3122	3400
Ca	407 - 457	520 -602
Mg	167 - 177	159-178
Total Hardness	1706-1784	1950 highest recorded
Depth	Presquile layer	Presquile layer
Alk	306 - 420	382
Na	106 - 122	79-92
SO4	145-205	1780
Fe	Higher	Lower

Note: All values reported in mg/L with exception of pH (pH units), conductivity (μmho/cm), and Fe (iron)

The developer did note that there were differences in the amounts of sulphates, sulfides and iron that might need to be taken into consideration. No information was collected at X-25 on sulfides, but the Brown *et al* R190 report listed sulfides at a relatively high 66 mg/L as S.

Experts' Comments:

Discussion ensued about several water quality constituents, but focused on sulfides in this session. Experts asked the developer what they made of the previously unmentioned high levels of sulfides in the deep groundwater at R-190, noting that sulfides form in anoxic environments and are unstable in the presence of oxygen. It was mentioned that hydrogen sulphide gas can pose very dangerous situations underground. The developer believes that the ventilation system they have designed for the mine will take care of that safety concern. It was noted that the old Pine Point Mine had similarly high levels of sulfides, but the problems were limited because of the open pit mining methods. However, there were concerns created by the lining of ditches with sulfide precipitates, two experts mentioned that was a common occurrence at the Pine Point mine. Nevertheless, historical evidence was presented that indicated that the sulfides in the Pine Point area had not broken down as rapidly as would be expected upon being exposed to oxygen in air, with the result that iron sulphide precipitates lined the drainage ditches at the site. This meant that water was not infiltrating the ground as quickly as might be expected. Concerns arose about whether high levels of sulfides could add to the blocking of exfiltration and mounding at the infiltration basin. The developer stated that the water will be oxidized to get rid of the sulfides, and if this process does not happen naturally (as the developer expects when it reaches open air), the developer will oxidize the water themselves to remove the sulfides. One expert noted that sulfides that don't form chemical complexes or oxidize are toxic. *NOTE: The subsequent adoption of the injection well system renders concerns about lining of the surface area moot.*

In terms of general chemistry, it was noted that there is very differing chemistry between this deep groundwater and the shallow groundwater in a perched aquifer. The developer was asked to quantify the effects of the effluent discharge on the chemistry of the shallow groundwater aquifer in the infiltration basin. *Note: With the subsequent adoption of an injection well system, this work is no longer required, as long as the developer will case off the upper (shallow) aquifer in the injection wells.*

One expert asked why no current samples of water from the deep groundwater were collected, since there is variation in the chemistry at the 600 ft level that we do not know about. One expert felt that a depth sampler should be used to get an accurate, deep groundwater sample. The developer stated that they do have one existing well housing that extends down , but that it would be unlikely to give a very useful, representative water sample because of the rust in the pipe and other contaminants. They countered that once the development starts, representative samples can be taken from depth and the findings built into their water management systems. It was noted that this is not helpful to the required determinations of significance of likely water quality required by the environmental assessment process.

The question was then posed to the experts: How would we benefit if we sample at depth? Is sulfide an issue that needs to be taken to another level? One expert responded that uncomplexed sulfides exist in chemical equilibrium with hydrogen sulphide which is toxicant. It was also noted that it is not always a bad thing if sulfides are present as metal ions complex with sulphides forming insoluble metal sulfides that are highly insoluble from an environmental protection standpoint. However, in the interest of due diligence, the same expert stated he felt the developer should at least provide a literature review on the effects of sulfides, and some form of fate assessment on the likely sulfides in both the mine and process waters.

Another expert recommended that the developer demonstrate what the steady state equilibrium concentration is for sulfides in the near-surface water table at the infiltration basin, and compare that value to the projected amounts in the deep groundwater to setup a standard of comparison.

The developer countered that they should just make sure the water is aerated in the infiltration basin. The developer stated that the groundwater in the area is well known through traditional and scientific knowledge to be of poor quality, and there are many sulphurous springs in the area – why would this be a new problem?

Effectively, what it came down to for experts was that the environmental effects of discharge of sulphide-rich groundwater into an infiltration basin and subsequently into the shallow groundwater system and/or surface water environment had not been assessed by the developer and that such discharge could be an issue. Further it was noted that the deep groundwater chemistry is potentially quite different from the surface, perched water table, so more information is needed on their differences before a full fate analysis of their interactions can be completed. One expert cited the reasons for required additional work and/or analysis as "you should convince yourself that when it makes it to the infiltration basin, the concentration is low enough to cause no harm to the animals and plants". The developer holds that no standing water will ever occur, so sulfides are unlikely to impact on animals. However, the assertion of no standing water was viewed with skepticism by the experts assembled considering the prospect of potentially high mine water discharge rates and the uncertainty around the infiltration capacity of the proposed infiltration basin. ..

In terms of action items on the sulfide issue, one expert stated that the developer should provide numbers on the amount of sulfides left in the water after degassing or residence time in the basin and compare it to known toxic levels of sulfides. Another was adamant that the developer should go down and sample the water at depth in R-190 through the existing hole, and check the levels down there. Yet another expert felt there is no particular need to do additional sampling, and instead suggests doing equilibrium calculations using the existing sample data. The developer was non-committal on this issue at the time, stating only that it is an issue that needs to be recognized and dealt with as they plan for the mine.

In closing off the dialogue on the deep groundwater testing requirements and results, one expert made the following statement: "With respect for the sampling there is no way to get a better sample of deep water then to pump at 3000 Gallons Per Minute for a month (as done in the testing reported on by Brown *et al*). I think it is ideal and no newer samples are needed." There was general consensus in the end that the Brown *et. al.* water sample was a sufficiently representative characterization of the R-190 deep groundwater, and need not be repeated. In fact, the MVEIRB staff undertook (Undertaking #5) to put the Brown *et. al.* results on the public record for all parties to see.

b) ***In the DAR, Tamerlane has developed its annual ammonia loading from the estimate of using 240 m^3/hr of excess ground water. It does not however consider the other 585 m^3/hr that will be sent through the DMS circuit. What is the fate of ammonia passing through the DMS? Should its contribution be included in an overall loading estimation?***

c) ***Is it possible that ammonia concentrations reporting to the surface may be higher in the PPPP than in the Giant Mine, given the predicted smaller amount of water passing through the mine workings?***

Note: These two questions focused on ammonia in the system and were effectively treated at the same time. In addition, some discussion ensued on the related issue of how much ammonia in the system would be acceptable – an issue that corresponds with Topic 4b.

Developer's Comments:

The developer indicated that ammonia will be stripped from solution by the pressurized water spray used in the DMS circuit. Further as a result of recycling 60% of the water in the DMS plant, new water added to the plant would be diluted with the recycle water that would pass through the plant 2 or 3 times. These two processes (active stripping and dilution through use of recycled water), the developer claimed, would effectively eliminate most of the ammonia in the discharge water. Therefore, the developer considered the contribution from the DMS to be insignificant, and did not include it in the ammonia load estimate.

In addition, the developer committed to using 100% emulsion rather than ANFO explosives for underground blasting, which is expected to reduce the amount of ammonia entering the mine water to begin with, due to its lower solubility and the fact it is loaded into the hole like a foam so there is much less loss and more complete utilization of explosive. The way in which the explosives are set up is also geared toward minimizing losses: stopes will not be loaded and left sitting for a long time; they will only be loaded when getting ready to be shot. The use of down hole loading as opposed to up hole loading was also cited as a way to reduce losses.

The developer argued that contamination by ammonium-nitrate is not an issue since excess water inflow is discharged back to groundwater and the nearest stream is a large distance away. In addition, they noted that if, as experts predicted, greater than expect water inflows occur at the bottom of the mine, this will dilute the amount of ammonia and nitrate in the mine water. Furthermore, the developer stated that any ammonia infiltrates into the ground will be assimilated by the natural environment.

In terms of whether the ammonia concentrations could be higher than those at the Giant Mine, three factors led the developer to believe that this was not possible. First of all, the Giant Mine used cyanide, which when it breaks down produces ammonia, adding to the total amount in the system. The developer committed to not use cyanide in this development. Secondly, the use of emulsion rather than ANFO will reduce the amount of ammonia, as mentioned above. Third, and this was an issue that was raised because of the discussion around water inflows in the morning, the developer noted that it was perhaps possible that additional water inflows than previously predicted would occur, diluting the amount of ammonia in the system.

Experts' Comments:

Experts wanted more information on the following:

1. **The use of emulsion vs. ANFO:** One of the experts had done extensive work with the Diavik Ammonia Management Plan, and noted that their research indicated that the developer was accurate in its assessment that using emulsion explosives only would likely reduce the amount of ammonia in mine water. He noted that ammonium nitrate in the emulsion has a solubility rate of about 1% by weight per day. He also stated that it was likely the developer could keep overall ammonia losses from the emulsion explosives below 2%, which is good. He also committed to provide more information on the Diavik Ammonia Management Plan for the Public Record, specifically information on ammonia, including methods for estimating remaining concentrations after blasting and in discharge (Undertaking #7).

2. **The absolute amount of, and relative concentrations of, ammonia and nitrates that will be in the mine and process water discharge**: The developer committed to communicate with the expert in question (Adrian Brown, working on behalf of Indian and Northern Affairs Canada), using this information to help them re-calculate their absolute and relative (concentrations) ammonia and nitrate levels in their mine, process and mixed discharge waters. This re-calculation is required for a variety of reasons, including:

   - ☐ Consideration of the above mentioned data from Diavik with hard numbers on emulsion ammonia loss rates;
   - ☐ Better data on how much of the ammonia in the process water (that reports to the DMS circuit) would be removed before the water is sent to the "end-of-pipe" release point;
   - ☐ Analysis of whether any new step in the ore beneficiation circuit[1] (the two-stage froth flotation system for separate lead and zinc concentrates), would change the ammonia level in the water being discharged from the processing plant; and
   - ☐ Consideration of the relative *concentrations* of ammonia likely in different water inflow scenarios (e.g., the developer's initial prediction of 55 m^3/hr water from underground, versus other estimates anywhere upwards of that amount).

[1] Note: the additional froth flotation system being considered by the developer was not discussed until Day 2, at which point experts noted that any "Lock Cycle Test" that assesses ammonia removal from discharge water needs to include these additional proposed steps.

The developer undertook to provide, given altered estimates of amounts of water being pumped out of the mine, and the commitment to the use of emulsion rather than ANFO, a new estimate of the total amount of ammonia and nitrates left over after blasting, and estimated ammonia and nitrate concentrations in water discharged back to the receiving environment, and if necessary, treatment plant (Undertaking #6). One team of experts suggested that the total ammonia from all processes should be assessed individually from mining process and recycled water, water shipped off with product, water used in backfill and leftover water in infiltration basin and not added together as an overall loading estimation. No commitment was made by the developer to separate the analysis at this time.

It was noted by the developer and experts that the relative concentration of ammonia from explosives would decrease as water being pumped from the mine increased. In this sense, additional inflows could be seen as a benefit ("solution by dilution") rather than a problem.

3. **Whether or not ammonia would actually oxidize out of the DMS process:** One expert challenged the developer's assessment that ammonia would "vaporize into thin air" at the proposed operating pH of 8-8.5 in the DMS circuit, stating "you have to drive up the pH of the water being used to spray the material to around 11 to 12 in order to strip the ammonia from solution". The developer countered that experience at Nanisivik mine was that ammonia was oxidized at the 8-8.5 pH. No resolution was reached on which scenario was accurate. Experts held that the proponent should be required to test their water processing systems and then they can give an idea of what the levels of ammonia are going to be in the discharged water. The developer stated that these findings would be forthcoming in their "Lock Cycle Test" that was being undertaken congruently with the Technical Sessions, and committed to reporting these findings as per Undertaking #6.

4. **Estimates of what levels of ammonia should be considered acceptable if the infiltration basin is the release point:** At this point, MVEIRB staff noted that all of the discussion about the likely concentrations of ammonia needed to be linked to assessments by experts of what levels of ammonia might actually represent a significant adverse impact on the receiving environment. MVEIRB staff also noted that it was particularly important for experts to weigh in on this issue for this development, given the relative lack of experience in determining impacts of direct release of mine and process water to a shallow surface impoundment.

One expert identified the likely expectation from the regulators for ammonia effluent limits of "2:4 " (maximum average of 2 mg/L total ammonia over a 30 day period, and a maximum of 4 mg/L in any one day). One stated that this standard is applied because it is seen to be the best available technology and not just in waters frequented by fish. It was also noted that if those levels are applied it would be necessary to provide treatment facilities at this facility.

The expert with the most experience in dealing with ammonia issues stated that while Diavik tests show that emulsion dissolution rates are much lower, by his calculation the developer would still have a lot of trouble meeting the ammonia levels that are mentioned in the DAR. He stated the developer needs to recognize the possibility of a problem up front and deal with numbers before they get stuck with unrealistic goals for this project.

The developer holds that such a standard as 2:4 is not required for this development, given that there is no nearby water bodies, and that it would take a great deal of time for any ammonia that gets into the water table to move into surface water bodies, by which time the ammonia would be either completely gone through oxidation or be so diluted that no impacts could possibly occur on plants or wildlife. The developer asked people to keep in mind that this is a small mining project that should not be held to the same standards as a larger mining project like Diavik.

Experts generally disagreed with the idea that there was no level at which ammonia could create an environmental impact, thus no treatment necessary regardless of ammonia levels. One expert stated that they disagreed with this line of thinking because it was consistent with the principle of "polluting to the maximum" rather than using Best Available Technologies. Experts felt that the developer needed to demonstrate what the likely range of concentrations would be without treatment, and what the potential effects of these concentrations are on terrestrial and aquatic ecosystems. No commitments were identified, or additional mitigation requiring the treatment for ammonia agreed upon at this time.

5. **An update on nitrates as well as ammonia** (***Note: this is discussed further in Topic 3a)***: Experts asked the developer to also update the predicted amounts of nitrates reporting to the discharge point, and the developer committed to getting that information as part of Undertaking #6.

NOTE: Topics 2 d, e and f all deal with laboratory test results on likely process water discharge characteristics, cited in the DAR and IR responses that have since become outdated. They are outdated because the developer has proposed adding a dual froth flotation circuit to the previously proposed DMS ore beneficiation circuit. This means that any previous estimation of process water discharge characteristics needed to be re-evaluated. .

> ***d) Concerning the metal leach testing; is a single test statistically sufficient to estimate the degree of leaching expected from the ore? Is the use of Ontario tap water acceptable as a proxy for deep minewater from this specific location?***

Developer's Comments:

The developer described the two laboratory tests that have been undertaken to try and determine what the quality will be of process water when it leaves the ore beneficiation circuit. Leaching metals tests were done by crushing R190 ore samples mixed with ferrosilicon and tap water and passed through a 0.45 micron filter. The resulting samples were then analyzed and found to have negligible concentrations of soluble metals.

Leaching tests were performed both with old and fresh ferrosilicon. The first test was determined to have contaminated ferrosilicon, which contaminated the sample chemistry. The second test with fresh ferrosilicon showed much lower levels of metals leaching into the water.

The developer considered tap water to be acceptable because it is only being utilized as a baseline and to check for metals solubility.

Note: the developer did identify on Day 2 that all of the preceding tests now have questionable numbers, given that they were considering adding a froth flotation circuit to the existing DMS circuit. At the time of the Technical Sessions, the developer was still waiting for data from a "Lock Cycle Test", which incorporates the new froth flotation elements of the beneficiation circuit into the analysis of likely discharge water. The developer undertook to provide for the public record all pertinent water discharge characteristic information from the "Lock Cycle Test", and include this information in estimates of total (soluble and insoluble) metals likely to report in discharge water (Undertaking #8). This Undertaking also noted that the information in Table 4.6-1 on page 173 of the DAR needs to be replaced by the information from the "Lock Cycle Test", once reported by the developer.

Experts' Comments:

It was quickly established, and the developer freely admitted, that additional information from the forthcoming "Lock Cycle Test" was required before any full assessment of the accuracy of end of process and end of pipe discharge water quality would be possible. In the current absence of this information, experts generally confined themselves to asking questions about the tests that had been conducted so far, in efforts to make sure the forthcoming tests were as rigorous as possible.

Most of these questions related to the following issues:

1. the appropriateness of using Ontario tap water in the test

Experts did not all agree on the appropriateness of using Ontario tap water for the test. One expert felt that the only difference would be in the major cations. The metals levels in the different water sources, upon his reading of Brown *et al* versus the laboratory results, seemed reasonable. Another expert felt that to get a full picture of the issue, the ability of Toronto tap water to dissolve solids is irrelevant. The only relevant issue is the ability of deep water to do it. He stated... "The best test would be to take the water you are going to use and the stuff your going to mill and shake it up and let it sit that is the most direct test short of setting up the mill." Nonetheless, even this expert felt there was not likely to be a big effect of the different water types on the metals loading outcome, so the issue was effectively dropped.

2. the appropriateness of using extended leach times on one sample instead of recycled water and fresh ore in a series of circuits *(discussed in Topic 2e below)*

3. the focus only on dissolved and not total metals in the results *(discussed in Topic 2f below)*

4. elevated levels of certain metals in the test and whether this was due to realistic conditions or experimental design issues.

Concerning this last issue, experts noted that the high sulfides in the ore sample might have created a highly reducing environment, causing high iron levels in the results. The developer identified that a number of sources of error could have caused these issues.

e) Will recycling of water in the DMS lead to concentration of leached metals? What is the fate of such metals if the concentration do indeed occur? Will they report to the infiltration basin, or will they be sorbed onto separated concentrates?

Developer's Comments:

The developer stated that the DMS process is in an alkaline medium with an elevated pH, which will cause the precipitation of soluble metals which will be adsorbed onto the surface of the solids. Because of this fact, these solids will not be reporting to the infiltration basin; they will instead either be captured in the ore being shipped off site, or returned to the underground as waste product filler.

Upon questioning from experts, the developer felt that several elements of the laboratory tests make for an adequate proxy for actual working mine conditions (particularly the Nanisivik mine that the DMS circuit team had the most experience with). This included:

- ☐ Ore to water ratio
- ☐ Agitation levels
- ☐ Suspension time (longer in this case to deal with the fact the water was not recycled)

Experts' Comments:

There was some question as to whether the recycling that will be used in the water system was adequately replicated by the laboratory tests. One expert asked the developer: "How representative do you feel this test is given agitation time and suspension time?" The developer replied that the test sample was agitated for 6-hours when 1-hour is normal for this type of test, and the water to sample ratio was also representative of the actual process. The length of the leach test was meant to deal with concerns about the amount of water being recycled from the DMS plant and reused, and whether metals loading of the water would occur as fresh ore is added to this water that may have already ceded some metals. The 6-hour leach test (the developer used this extra long leaching to replicate multiple leaches and therefore get "worst case results") did not find any significant loading of metals. The developer was asked if there would be a difference with multiple exposures of water to fresh ore; they didn't think there would be any difference.

In the end, there was no consensus on whether the agitation and suspension methods used were an adequate proxy of the real life system, and the results of the "Lock Cycle Test" were looked forward to by participants.

f) ***What percentage of metal content moving through the DMS circuit is lost to the receiving environment rather than captured in the concentrate? Of these metals lost, what proportion would likely be in solution and what portion would be in suspension?***

Developer's Comments:

The developer stated that effectively zero percent of the metals are lost during the DMS circuit; virtually all of it is adsorbed onto the concentrate. Therefore, they argued that concentrations of metals leaving the DMS circuit via discharge water will be similar to concentrations found in the natural groundwater.

In terms of the small amount of metals that will be lost to the discharge water, the developer estimated half will be in solution (dissolved) and half will be suspended solids.

The developer also went into detail about how the "Lock Cycle Test" was going to provide a better proxy of real life mine process situations: "The best analysis will be in the lock cycle results and we will provide those. A "Lock Cycle Test" is when you take a process and try to duplicate a mill operation and has the dynamics of a build up a reagents and solids and solutes. The water is actually recycled. It's not an exact replication but it does try to create a worst case scenario."

Experts' Comments:

Some of the experts questioned these findings, especially whether or not the laboratory tests were a reasonable proxy of what might happen in real life, and also because the laboratory tests ignored total solids in favour of only analyzing dissolved solids and dissolved metals. A point of concern from the experts was that the filters used in the existing laboratory test only allowed the developer to analyse the amounts of dissolved metals, rather than dissolved plus colloidal materials (i.e., total metals). The developer acknowledged a limitation in that total metals amounts being lost in the DMS circuit were not taken into consideration, only dissolved metals amounts were reported.

A couple of different experts considered this a substantial deficiency in the desktop study, since in their opinion *most* (rather than half) of the metals discharged from the DMS process will likely be colloidal or suspended particles. It was asserted that a value needs to be figured out to calculate the concentration of total metals in the end-of-pipe water discharged back into the environment.

The developer challenged this line of reasoning that most of the metals discharged from the DMS would likely be colloidal, stating that the crushing plant does not produce many fines and the process does not produce colloidals so there shouldn't be many suspended particles. They also warned against reading too much into the "Lock Cycle Test" as it is from a milling process and is ground much finer than will be done at R-190 – "the lock cycle is more of a worst case scenario than a realistic assessment of total metals loss in the DMS circuit on this site".

The developer inquired into how exactly to measure suspended particle levels in a static lab test. Response from one expert: "you could do continuous sub-sampling of a larger sample every hour. If there are colloidals, they will be there after ten hours and you can give the levels of suspended solids." Other experts supported doing an additional laboratory test of this nature that could at least show due diligence on total metals levels, and then to model what the fate of those suspended metals might be.

The developer was reluctant to do that at this time, having never been required to do it on any project before. The developer did, however, state they would try to provide total insoluble metals values w/n the next 10 days from test results from some other operating plants. In addition, the "Lock Cycle Test" results were on a representative ore sample, and forthcoming in short order. Together, these commitments would assist in answer the "Total Metals" question behind Undertaking #8.

In terms of what the ferrosilicon in the DMS circuit might add in terms of contaminants, one expert observed that it contributes phosphorus to the system (which functions as a nutrient), and also elevated strontium levels as indicated by the test results presented in the DAR. . It is worth noting, however, that one of the experts did state that "none of the metals levels in the lab results on discharge water are near typical regulatory limits".

Discussion turned to what the suspended solids might do to the environment and how they might be dealt with if high levels are found in the receiving environment (e.g. it is expected that TSS would be removed in the infiltration pond and could plug the surface over time). Experts felt that ammoniun-nitrate losses underground and metals leaching in the DMS circuit were the major potential contaminants in the discharge water. The developer stated that they would excavate any areas contaminated in the infiltration basin and move it underground with the waste rock at closure. One expert felt this was an appropriate solution and that the metals might not be bio-available and thus present little environmental risk.

Discussion from some of the responsible authorities then centred on whether there would be any mechanism (e.g., a lined settling pond) by which these colloidal metals and other contaminants could be taken out of the system before the water was mixed with the other deep mine water into the infiltration basin discharge system. Concerns were raised that under the present mine plan, there is no way for the system to deal with exceedences except to shut down operations or to dump contaminated water into the infiltration basin. The company stated that it would have no problem setting up ground water monitoring wells to monitor the ground water health, but no specifics were forthcoming on a settling pond or other "final point of control", and the issue was deferred to Topic 4 the next day.

In the end, experts felt that additional study was required, and that the results of the "Lock Cycle Test", along with any information on total metals (either from additional laboratory tests or from existing DMS projects) would have to be used in a more advanced analysis of metals fates in the environment.

g) ***What is the principle aquifer at depth that is being intercepted by underground workings? Is it the sulfate-bicarbonate containing aquifer, or is it the aquifer that contains sodium chloride brines? Are highly saline waters expected to be discharged to surface? If so, what chemical properties are they likely to possess? i.e conductivity, chloride content, TDS content***

Developer's Comments:

The developer had no comments on this issue, because one of the experts stepped in just as the issue was being introduced and stated what had become obvious over the course of the day – that the principle aquifer that was being intercepted was the sulfate-bicarbonate containing aquifer. Attendees all agreed with the notion that this question is a non issue, or was dealt with by the fact that the Brown *et al* report contains sufficient information to characterize the chemistry of the water that will be brought to the surface.

NOTE: Just before the discussion closed at the end of Day 1, an expert identified that there were materials he wanted the developer to consider overnight to see if they impacted upon the developer's estimates of likely inflows to the mine. The expert was still concerned that greater inflow scenarios needed to be considered and contingency plans developed, given that they were in fact likely given data from the following sources, which the developer undertook to analyze overnight:

- ☐ *Pages 17 and 18 of the Stevenson (1983) report.*
- ☐ *Section 5.2 concerns with the B facies and de-watering at 180 metres, from Brown et al (1981)*

Notes on discussion of this material, which occurred first thing on Day 2, are included in Topic 1c above.

At some points during the proceedings of Day 1, the discussions turned quite adversarial. At one point an expert made the following statement to the developer that bears repeating, because it reflects both the general positive feeling among the assembled experts that the development is unlikely to have a huge impact on the environment, but also that "the devil is in the details", and details on the technical side are what is missing from the evidentiary record thus far:

"Almost all potentially serious environmental impacts are absent from this project. What we are dealing with is the residual and that is not major but it has been screwed up before. We are just trying to make sure that you get credit for that, but you have not carried the burden to prove that to us and prove that is true."

End of Day 1.

Discussion Topic 3: Potential Impacts on the Receiving Environment

Topic 3: Potential impacts of different water components on the immediate (gravel pit) and surrounding receiving environment, with an emphasis on potential impacts of salts, ammonia, nitrates, and metals

GENERAL CONSIDERATIONS: At its core, an Environmental Assessment is focused on developing confidence that we understand likely changes to the environment from proposed developments. The developer had stated in IR responses that if any impacts occur from process water inflows, they will be "*extremely localized and likely non-detectable within 10-20 metres downgradient of the infiltration basin*". The developer also stated, in relation to discharge of nutrients, "*nutrients that exfiltrate into the shallow groundwater table would be rapidly assimilated by the natural biological processes operating in the surface and shallow subsurface overburden of the area.*"

Technical experts were invited to provide comments on the veracity of such predictions at the Technical Sessions. Participants were encouraged to consider whether and how specific chemical constituents in the discharge water might impact on the environment and if any of these constituents should be the focus of water monitoring and management programs. The Review Board recognizes that what was being proposed was a dryland infiltration basin rather than a waterbody receiving environment – expert technical input on probable impacts in this type of environment is valuable to the Review Board's decision making process.

In addition, the concerns of the GNWT, particularly those of its Department of Transportation, regarding the potential spiking of metals and other potential contaminants in the infiltration basin merited further discussion by experts.

NOTE: Much of the following information on Topic #3 is outdated, given that the developer on July 20 committed to utilizing a deep well injection system rather than the surface water release involved with the infiltration basin. Other elements, such as the analysis of ammonia and nitrate contaminants, is still relevant, but needs to be considered in light of the fact that all process water is now proposed to be injected into the Presquile aquifer approximately 500 feet underground.

SPECIFIC QUESTIONS ON TOPIC 3:

a) ***Nitrites and Nitrates are not discussed in pg 271 of the DAR. Are they also byproduct of ANFO blasting? Are there any implications regarding such compounds entering the surrounding environment?***

Developer's Comments:

It was acknowledged on page 271 of the DAR that nitrates are a byproduct of blasting. However, the developer expressed little concern about nitrate levels because they feel that nitrates, as beneficial nutrients, will simply be assimilated by the groundwater environment. In addition, the nitrate and ammonia levels were less likely to have an impact, the developer argued, given the amounts of water now being considered likely to inflow in the mine would dilute them by an order of magnitude. The developer also stated that the speed of flow of the groundwater from the release point is very slow, estimating that it could take +/- 100 years for waters to reach a surface water body.

Experts' Comments:

It was requested that the developer should incorporate nitrates as well as ammonia into Undertaking # 7. Experts wanted to know if the developer was actually counting on underground bacteria and fungus to deal with the excess nutrients, i.e., was this the only proposed treatment for these nutrients (ammonia and nitrates). The developer responded that "We don't see a problem with introducing nutrients into the ground water, period. We aren't saying we are relying on it; we don't feel there is any harmful effect and that it shouldn't be a problem. We expect them to be assimilated before they surface." Experts felt that there was not enough evidence from the developer to show that water won't surface closer to the release point.

b) ***What are the implications of discharging highly saline waters to surface on surrounding vegetation, if such waters are expected to be discharged?***

c) ***Are waters discharged to surface likely to be within the rooting zone of vegetation adjacent to the infiltration basin?***

These two issues were dealt with effectively at the same time.

Developer's Comments:

Impacts on vegetation were not a major concern, according to the developer, for several reasons:

1. The expectation that the water reporting to the infiltration basin will flow almost vertically downwards, and not be available to surface vegetation
2. They did not feel that any water infiltrating into shallow zones and available to rooting vegetation in the vicinity of the infiltration basin would create an environmental impact. In fact, they felt it would be of benefit, especially the nutrients
3. The already poor water quality in the area would not likely be impacted by the introduction of deep minewater to the shallow sub-surface; i.e., characteristics of this water would be roughly similar to the shallow (perched) aquifer water

Experts' Comments:

Experts challenged all three of the reasons the developer had for not considering this to be a concern, and they are considered in turn here. It should be noted that no experts affirmed that adverse impact outcomes on vegetation were likely, but rather stated they didn't feel they had enough information to make this determination at this time. It was really a focus on asking for more information about fates analysis of specific water constituents in this receiving environment, even if it was based on literature review.

1. **Vertical permeability:** The discussion of whether the discharge water would be available to the rooting zone of vegetation is linked closely to the discussion in Topic 3d, of whether the infiltration basin will indeed facilitate vertical exfiltration of water, or instead be subject to mounding and overflow. Refer to that discussion.

2. **Potential Environmental Impacts:** The expert from Environment Canada undertook to provide MVEIRB with a copy of a report from the early 1980s at Pine Point that looked at the effects of waters pumped out of the historic mine resurfacing nearby. At a concentration of 18 mg/L, H_2S was found not to be liberated using traditional degassing techniques. In addition, this report found that

precipitates were deposited along the drainage channels and blocked the infiltration capacity. In that instance, water was flowing effectively all the way from Pine Point into the Great Slave Lake. He felt the developer should familiarize themselves with this report (Weyer: 1983), and undertook to provide it for the Public Record (Undertaking #10).

A resident from Fort Resolution added to this discussion of previous effects of mine water pumped to the surface at the Pine Point Mine. He noted flooding from saline mine water and associated vegetation die off. Elders do not feel the mine water is good for vegetation.

While it was not shown that this die off was solely linked to the mine, it was noted by experts that both salts and TDS are deleterious at high concentrations, and the Brown *et al* report identifies relatively high levels of TDS at R-190. That, plus "significantly higher" loading from the DMS circuit of TDS in particular, was cause for concern.

The developer noted that the Brown *et al* report does not indicate high levels of salinity in the deep groundwater. An expert countered that it was the TDS (a weight measure of salinity) that is of concern to plants, and those levels were high in the deep groundwater sample.

The developer stated that there was a high level of uncertainty about what had caused dieoff in the Pine Point area and we shouldn't be speculating. The representative from Environment Canada did note (and promise to put on the Public Record) another study from the Forestry Service (Hocking: 1975) that looked into forest dieoff in the Pine Point area. To his recollection, it concluded that it was largely natural conditions rather than mining that led to this dieoff. An expert stated he felt it was incumbent upon the developer to look into such events, because they are the ones that create public concerns, concerns that it is the developer's job to alleviate.

The developer re-iterated that they felt there were no major problems in the discharge water, stating that "this kind of water is used on farming all over the place". They did however commit to providing additional information on suspended solids when they provide the "Lock Cycle Test" results. They also noted again that it was likely their estimates of contaminant loading would actually go down, now that they are looking at additional mine water flow entering the mine from the deep groundwater, which would dilute any added loading from the DMS circuit.

Concerns were expressed that the developer had not shown convincingly that water would not resurface near the infiltration basin. MVEIRB staff also committed to assessing whether the current information about water flow directions around the infiltration basin on the Public Record was adequate (Undertaking #12).

3. **Similarity of Deep and Perched Groundwater**: Experts also questioned the assertion by the developer that the water quality from the combined mine and process discharge stream would mirror that of the shallow aquifer in the

infiltration basin area. They noted that the 3000-4000 mg/L TDS expected simply from the mine dewatering could be an issue. Also, it was noted that higher levels of sulfides and carbonates could create issues for the receiving environment due to formation of precipitates that could affect the ability of the infiltration basin to drain properly, and that the DMS circuit would increase almost all levels of contaminants in the process release water because of continual recycling.

In the end, experts indicated they were eager for the developer to look at some of the additional historical studies and provide additional evidence that actually show whether the likely levels of sulphur compounds and TDS would effect vegetation or drainage, even from a desktop study.

d) ***Tamerlane states that the infiltration basin has an infiltration rate of 100 m^3/hr (DAR, p. 165). What method was used to estimate the infiltration rate and what assumptions were made? Did the calculation take into account that groundwater may mound beneath the infiltration basin over time?***

e) ***What information is available about the soil profile (and their hydraulic properties) below and adjacent to the infiltration basin and the depth to the water table in this area? Can Tamerlane better explain how the subsurface composition of the infiltration basin will affect the rate of infiltration as it seems plausible that the clay content within the till material could restrict infiltration rates in the overburden profile?***

NOTE: Both these topics on calculations and assumptions behind the developer's estimates of infiltration basin exfiltration capacity were dealt with in one discussion.

Developer's Comments:

The developer identified several formulas they had used to generate the infiltration rate estimate: e.g., Hazen Formula, Moulton Equation, Moretrench American Corp. Nomographs. The developer stated that the $100m^3/hr$ estimate is very conservative. The developer based their estimate of the depth to groundwater in the infiltration basin site on its similarity to the R-190 site, arguing that the gravel and glacial till zones are a consistent depth between the two closely linked locations.

The soil profile would be confirmed prior to the construction of the infiltration basin by excavating the area where the inverted culverts are proposed to be placed. They also noted that if they encountered problems with drainage, there were a variety of options for dealing with that, including additional culverts (aka wet drains), continual removal of solids (dredging), re-routing of overflow through trenches, or even expansion from the Primary Infiltration Basin to the Secondary Infiltration Basin: "We will deal with problems during normal operating. We aren't going to be just allow floods and stuff. We will make changes and mitigate what problems come up. We could make a mitigation or contingency plan now but we are going to be getting the needed information early on in construction and then make plans from there. But we won't know until then."

However, the developer did state they were willing to reconsider how altered inflow rates might impact upon the ability of the infiltration basin to deal with the newly identified higher flow rates (e.g., 450 -550 m^3/hr).

Experts' Comments:

Again concerns were raised about both a lack of information behind assumptions and estimates and the proposed timing of actual on-the-ground studies. It was emphasized that waiting until normal operating started before determining potential impacts and appropriate mitigation was unacceptable during the EA process. It is worth noting that these technical criticisms did not necessarily mean that the developer's estimates were wrong – just that it was impossible to properly ascertain their accuracy. For example, one expert estimated that the infiltration capacity is likely much higher than estimated by the developer, perhaps by as much as an order of magnitude, but without information on the depth of the water table and the lithology (the composition of different layers of ground from the surface to bedrock), this couldn't be confirmed.

Specific concerns about the location, infrastructure, and potential impacts of the infiltration basin had been consistently voiced by the GNWT's Department of Transportation (DoT) coming in to the Technical Sessions. The infiltration basin is located on land controlled by the GNWT (although owned by the federal crown), consisting of a large, shallow gravel pit. The northern end of the gravel pit has a still viable granular resource, while the southern end is mined out. The DoT was concerned on several fronts, including:

1. Their ability to access the remaining granular resource at the north end of the site.
2. Contamination of either the northern end of the site (which would render the economic resource unusable and potentially create liability and cleanup issues for the landholder, along with environmental impacts) or the southern end of the site (the latter concern only).

Questions about the design of the infiltration basin included its:

- ☐ **Location:** (previously, the northern end was mis-identified as having no economic resources and was the proposed infiltration basin location – the developer subsequently committed to locating the infiltration basin at the mined-out southern end), and preserve the ability of DoT to access the northern part of the site with gravel trucks
- ☐ **Infrastructure:** the footprint, height of berms, where material for berms would come from, whether the berms would be permeable or impermeable and how leaks would be dealt with, of the infiltration basin were are issues raised
- ☐ **Contingency planning:** for greater than expected water inflows, greater than expected contaminants in the "end-of-pipe" water, freezing in winter, standing water, seepage through berms
- ☐ **Monitoring and Long-**range management planning
- ☐ **Vertical permeability:** this was a key question. Many experts felt there was a lack of information about the height of the water table, as well as the stratigraphy below the proposed release point, especially the amount and location of clay layers underlying the gravel that would reduce exfiltration capacity.

The representative of the DoT, while willing to come to some accommodation with the developer over use of the non-economic portion of the gravel bed, expressed a high level of discomfort with the use of the area for water release.

Undertaking # 13 called for the developer and the DoT to "provide and both confirm an agreed-upon revised map indicating the boundaries of the primary and secondary infiltration basins (with the focus on separating the primary basin from the remaining aggregate source in the northeast of the areas, an indication of required infrastructure both for the basins and for access by the DoT to the aggregate source, and a plan for diverting any process water that seeps through berms around the infiltration basin".

NOTE: While the subsequent removal of the infiltration basin as the primary water release strategy reduces many of these concerns, the developer has proposed to use part of the southern part of the infiltration basin as a bermed, lined water discharge and settling pond ***as a contingency plan only.*** *The developer and the DoT will be expected to continue dialogue and present to the Review Board any agreement they have about the use of this area, or a list of outstanding concerns in the way of any agreement.*

Experts expressed technical concerns about the following issues in regards to vertical permeability (and by extension, the ability of the infiltration basin to filter all the "end-of-pipe" water):

1. Knowledge of the depth below surface of the water table and the location and depth of the relatively impermeable clay pans known to be in the infiltration basin area, and indeed better information on the entire stratigraphic profile

The developer stated that they didn't look closely at the potential for mounding because they assumed that the material underlying the infiltration basin is loose gravels down to the water table. Others noted that clay pans are common in the area. Experts felt the developers were taking too much on faith and needed geotechnical drilling, sampling and testing to determine what underlies this area. The developer also stated that information on the lithology and water table are in the Brown *et al* and Stevenson reports, but all experts agreed that the information in those reports was not generally applicable to the infiltration basin site. The developer agreed also to contribute their drill log information, as per Undertaking #2, to see if it could assist in characterizing the lithology.

2. The just introduced evidence that at the historic Pine Point mine, precipitates had lined the receiving environment, creating problems with exfiltration

This new evidence contributed to concerns that the bottom of the infiltration basin might become clogged or lined, limiting exfiltration capacity. This in turned was linked to:

3. The lack of consideration of mounding potential in the original analysis.

The developer felt that mounding would not be a problem. One expert stated they don't have information to back up that confidence: "The problem is that there is insufficient information to decide whether or not the infiltration basin will work. The information we need now is lithology, sedimentation consistency, and water table depth as a minimum to see if the basin will work." If that information is not to be collected, experts demanded "top loading" of contingency planning – i.e., committing to a variety of aggressive mitigation and backup contingency measures up front to make sure the infiltration basin does not overflow.

NOTE: As we reached the end of Topic 3, MVEIRB staff asked for any comments in general that experts had about the likely significant adverse impacts they foresaw, given the evidence at hand, at the "end-of-pipe" water discharge release point or in the surrounding environs.

One expert stated: "From material in the DAR the surface water has TDS of 1000 mg/L and will have water added to it with 3000 mg/L TDS and this has the possibility of affecting plants. If the groundwater surfaces it could potentially cause eutrophication in a surface water body. However, if the water percolates largely vertically into the ground, then minimal effects except for minimal discharge of nutrients into surrounding area would be expected. Terrestrial plant effects have not been ruled out as an effect but it has been agreed that the groundwater effects are not likely to be noticeable in scale."

The expert was quick to qualify this statement by saying "I was not speaking to whether the levels would be allowable under conditions in the water license. There would have to be testing of discharge water from containment to know that the water quality is allowable. I want to make a distinction between likely impacts and allowable discharge."

Other experts generally agreed that the environmental impacts were quite possibly not likely to be severe, but that additional information was still required. One of them pointed out that flooding problems could kill plants, and that more information was needed on the infiltration basin's site lithology to assess its feasibility as a release point.

In the end, because experts were adamant about minimum requirements for additional fieldwork, the developer did commit to doing this geotechnical work (although they expressed concerns that this might delay the EA process and that it might be hard to find a drill rig to do the work). This work involves drilling a few holes in the ground to get information on the makeup of the substrata and depth of the water table, so the developer can recalculate with some certainty infiltration qualities. The GNWT DoT and INAC stated they were willing to let them do this work on site. Land use permits are not required for this work. This became Undertaking #11.

Note: Undertaking #11 was never followed up on as it became moot with the abandonment of the infiltration basin concept in the days following the Technical Sessions.

New Development Components: Froth Flotation Circuit

After discussion of Topic 3 was completed, the developer took the time to introduce some new potential development components that had not been included in the DAR. The Review Board staff had encouraged the developer to identify the new components to get an expert audience to talk about what information about them would be expected from reviewers.

Developer Comments:

The developer identified that it was considering adding two froth flotation circuits to further beneficiate the ore from about 40% combined lead-zinc, to separate lead and zinc concentrates about 50-55% pure. Analysis was preliminary at the time, and the developer committed in Undertaking #9 to provide additional information on the structure, process and reagents proposed for use in the flotation circuits, and any potential changes to the discharge water and what those changes might mean environmentally.

Upon questioning about any changes in the materials balance at the mine, the developer noted that by filtering off 40% more coarse material and using it as backfill, the project will not need any other backfill sources, as previously planned.

Experts' Comments:

Experts wanted to get more information on how water discharge qualities change as further concentration occurs and additional reagents are put in the process. They also asked for and received assurances that cyanide would not be used as a reagent. Other than these two issues, the experts adopted a "wait and see" attitude toward this new development. Most importantly, they made it clear that when the developer has a final plan of what components to use in their processing system, they need to make a reasonable estimate of end-of-pipe quality for all constituents of interest, using laboratory testing of site derived ore samples with water that reasonably approximated the water that will actually be used in the system, the deep groundwater from R190.

Topic 4: Water quality management planning

GENERAL CONSIDERATIONS: Before the Technical Sessions, it was determined that the level of detail on monitoring, management and contingency plans in the developer's submissions merited further investigation. Water quality management and monitoring needed to include discussion of Best Available Technologies for treatment, containment and monitoring, and how they apply to direct release into an infiltration basin. Experts in the Technical Sessions were invited to identify whether the monitoring and management systems the developer proposed corresponded appropriately to the level of confidence in the prediction of potential impacts.

In addition, parties identified longer-term water management issues that needed to be addressed in the reclamation and closure planning as a sub-topic. In their DAR submission, the developer provided limited information on water related closure issues, including re-flooding of the underground workings and associated water quality issues, and monitoring/mitigation of a potential seepage plume that might develop beneath the infiltration basin. The developer was asked to identify specific reclamation measures for the underground workings and its influence on groundwater or potentially surface water quantity and quality.

SPECIFIC QUESTIONS ON TOPIC 4:

a) ***Is Tamerlane planning to implement the BIODISK system at the mine site? What is the background context to the sewage treatment plant data provided in the IR responses given no information appeared to be available regarding at what capacity the RBC was operating at, or other factors that might be of consideration?***

Developer's Comments:

The developer confirmed they are planning to implement the BIODISK sewage plant. The data provided for the IR response on sewage plant "output" was supplied by the manufacturer and came from a Toronto Port Authority facility designed to treat effluent for 200 people daily, which is larger than the +/- 100 people proposed for the PPPP. Similar systems have been used at Snap Lake and Ekati, among many other locations.

Experts' Comments:

Experts identified that they didn't see the actual water quality expectations of the sewage effluent in the DAR. The developer stated that their expectations for water quality are included in pages 67-70 of their 1st Round IR Responses, and that because they were only expecting to use about half the capacity the Toronto Port Authority team was using, water quality should be better than those reported results. No additional questions from experts ensued.

b) ***Has Tamerlane given consideration to what conditions would lead to the implementation of adaptive management procedures for discharge of mine and process water? Notwithstanding any water quality/quantity criteria required by the MVLWB in a licence, what would Tamerlane consider to be unacceptable in terms of discharge water characteristics? In other words, what are the cutoff lines?***

Developer's Comments:

The developer re-iterated that they would meet the expectations of all water license parameters. They also stated that appropriate adaptive management procedures will be implemented if they find that the license requirements are exceeded.

The developer did not identify any "unacceptable" levels of discharge by parameter, but did state they don't expect to exceed the following end-of-pipe parameters at any time during operations:

- pH – 6.0 to 9.5
- Cu (copper) – 0.30 mg/L
- Pb (lead) – 0.20 mg/L
- Zn (zinc) – 0.50 mg/L

They also stated that these predictions are for better water quality than required in the current water license of Cominco at Pine Point. In addition, the developer noted that they are waiting for the updated numbers from the "Lock Cycle Test" and other elements of their undertakings on water quality, and have undertaken to reconsider any treatment options - "we will do whatever techniques are required to meet the standards" - if there are potential water quality parameters higher than expected previously.

Experts' Comments:

Experts initially focused on a couple of parameters not considered by the developer in their discussion. It was pointed out that, for example, the current Pine Point tailings pond water license held by Cominco has combined discharge limits of 25 mg/L Total Suspended Solids (TSS) and 2 mg/L of ammonia, It was suggested that the developer consider their mine's ability to meet those standards.

The question was posed as to whether lime treatment was the only proposed form of mitigation for mine water. The developer stated that it was at this time, but that might change if there are added concerns about the amount of TSS in the system, pending laboratory results.

Discussion turned to the fact that experts' concerns lay not so much with the process water being tested in the lab, but with the amount of sediment (suspended solids) in the mine water being pumped basically directly from the mine into the infiltration basin.

Questions were posed about how much time TSS had to settle out in the sump at the bottom of the mine. The developer felt that with a 100 m^3 "sump" at the bottom of the mine, they had about 2 hours settling time for solids, with the liquid surge at the top being the only part pumped off. Of course, one expert pointed out, if we accept the new median estimate of 460-550 m^3/hr of water coming into the base of the mine, this settling time reduces to about 10-15 minutes. Experts argued that suspended sediments in the mine water should be settled out before the water is released and questioned the current proposal's ability to do this.

Discussion started narrowing in on a major issue in the eyes of the experts – the lack of adequate contingency planning for what to do if exceedences are found. Key to this was the fact that no secondary containment facility, below ground or above, has been identified for water, in case treatment is necessary. Despite the developer's stated confidence that no exceedences would occur, experts stated that they would only accept no contingency planning (and here it seemed the focus was on the aforementioned containment facility) if the developer's data showed convincingly and beyond a reasonable doubt that no exceedences could ever occur. In other words, contingency planning needs to be included in the development description unless the developer can show that discharge water is going to be way below effluent parameters in the license.

The developer stated that they do have lime treatment in their contingency plans. Experts stated that this worked for elevating pH and keeping metals insoluble, but does not deal with either TSS or ammonia and nitrates. The developer stated that they don't know of any water license in the NWT that deals with nitrate amounts. Experts noted that EA focuses on acceptability of release parameters, not the specifics of water licenses.

The ability to actually implement lime treatment was also called into question by experts. It was noted that the current storage capacity for mine water is very short term, so how would the lime treatment occur, in what location, and would it be effective for dealing with water given the inflow rates?

Experts identified that the most likely water problem meriting secondary containment might actually be elevated suspended solids in the final discharge, which could potentially plug the immediate receiving environment, minimizing exfiltration capacity. To avoid this potential problem the developer would need adequate holding time in a tank or pond on surface to settle out the solids and test the effluent before discharge. The experts felt that the developer should reconsider its plan not to have a secondary containment facility for water, in light of the greater inflow rates identified as possible during these Technical Sessions, and identify how long they would have before the mine starts flooding if discharge has to be halted for treatment to take place. The developer stated it would do this as part of its Undertaking #1.

Experts pointed out that the alternatives are not very palatable if unforeseen exceedences do occur and no secondary containment for water is available. It was shown that the mine would either have to continue to pump out and discharge unacceptable water (clearly not acceptable to regulators and the public), or shut down the mine until some treatment systems were put in place. As one expert put it "If we are going along and then all of a sudden the water quality does not meet standards....what are you going to do? You have a relatively short time before you are over capacity. Are you going to discharge dirty water or abandon the mine? I haven't seen anything in your proposal that mitigates this possible problem. There is nothing in the plan that gives you more time". To the experts, some sort of treatment plant or a backup adequate storage facility where water can be stored for enough time to figure out how to solve the problem were the only prudent courses of action.

The developer felt that if water quality problems were identified by their remote sampling system, the sump at the bottom of the mine has a holding capacity of about 8000 m^3. This would not be a preferable option for experts, given that there would be concerns about mine flooding and safety. And, considering inflows, this might only buy the developer another 20 hours to deal with the issue.

In the end, experts stated real concerns about the ability of the developer to prove that their water quality will be high enough that these contingency plans are not necessary. This seemed to be a point of fundamental disagreement between the developer and experts at this time. There was argument on different focal points – the developer wanted to be shown that the project *will* exceed acceptable water quality parameters before committing to additional storage/treatment contingencies, while the experts felt the only knowledge necessary to require this contingency planning was the possibility that the development *could* exceed acceptable limits.

The developer committed to do more water quality testing to try to find the expected parameters from the system and when they have this information to identify any more things we need to build into the project such as revisions of water treatment.

c) ***Discussion is required, at least conceptually, on installation of site specific water quality and baseline data and monitoring points for long term monitoring of the basin area.***

NOTE: The elements of this discussion that focus on the infiltration basin are no longer relevant, given the commitment of the developer to eliminate this component in favour of deep well injection. The discussion around the purpose of and need for monitoring remains relevant.

Developer's Comments:

The developer committed to both upgradient and downgradient monitoring wells, although locations and depths have yet to be determined and will likely be handled at the permitting stage. The purpose of these monitoring wells will be to assess any changes in the water tables, as well as changes in the constituents of the water.

When pressed on how deep the wells would go, the developer stated that they would go to the bottom of the overburden layer or the top of the water table, whichever comes first. Approximately 20-30 metres deep.

Experts' Comments:

One expert recommended that more than one downgradient monitoring well was necessary, given that we don't know exactly where the "plume" of water entering the infiltration basin will migrate to. Three downgradient monitoring wells were recommended. Another expert recommended that the upgradient monitoring well should be sufficiently far away to check for any mounding occurring in the infiltration basin.

In terms of what was being monitored for, one expert stated that TSS needs to be included in the slate of constituents. More broadly, one expert asked what the purpose of the monitoring system was. Was it

1. To be a part of regulation of the downstream groundwater? Or
2. As "proof of concept" to see if the infiltration basin plan works.

The developer replied that the purpose of monitoring downgradient is to confirm the effects on groundwater regime and the infiltration basin zone. Results will be recorded to follow the effects on water quality and to be able to confirm at what depths the water is infiltrating to and to determine if mounding is occurring or not. More "proof of concept" than regulatory, because the developer feels the last point of control or release – the "end-of-pipe" should be where water quality is monitored, and if necessary, treatment occur.

The expert team was asked whether they felt there was any possibility that water, once it is added to the infiltration basin, will create any negative changes in the groundwater conditions that need to be monitored or even regulated. The only possible changed mentioned was that changing the oxidation state of the existing groundwater could mobilize minerals not in the water at discharge. The developer felt this phenomenon had never been seen in the north - water doesn't typically get worse in quality as it moves through sediments to the watershed. The Cantung mine, which has an infiltration basin system, was pointed to as an example. To this, the expert stated that uncertainty remains: "That is a nice hope but you have no idea of what might happen with highly reducing water in this situation". So this lent to the argument that monitoring is also required to track changes and movement of infiltrating water.

d) ***What is the estimated time for complete reflooding of the underground workings? What is the expected water quality of the mine water pool after end of reflooding? What is the estimated fate of any potential contaminants of concern in the mine water pool, i.e. where and when could this water discharge to surface? What is the estimated impact of this mine water pool on nearby aquatic resources (aquifers and/or streams) in the long-term?***

Developer's Comments:

The underground workings will be filled with cemented backfill. Therefore, no flooding of the underground workings will take place. There will be no water pool and therefore no water to discharge, and no long term impact on aquatic resources.

Experts' Comments:

Experts generally agreed that contamination would be a non-issue during re-flooding. One expert went as far as to thank the developer for the backfilling plan – "it is a wonderful process and very environmentally friendly". This was determined to be a non-issue from the experts' perspectives.

One question posed was what happens if the development proceeds to another phase – will the shaft be used again and with the same freeze wall? The developer indicated that while this was contingent upon success at R190 and conjecture at this time, yes the shaft would be reused, the existing freezewall kept in place, and other freezewalls set up as necessary to reach other ore bodies.

e) ***The mine water pumped to surface and discharged into the infiltration basin may have elevated concentrations of TDS and potentially other contaminants of concern. Infiltration of this mine water into the shallow subsurface may result in the development of a "salinity plume" beneath the infiltration basin. What monitoring is planned by Tamerlane for this mine water plume in the shallow aquifer post-closure? What contingency plans has Tamerlane developed to mitigate any potential environmental impacts of this mine water plume after closure?***

NOTE: The specifics relating to post-closure monitoring and mitigation at the infiltration basin discussed below are no longer relevant.

Developer's Comments:

The developer stated that upgradient and downgradient monitoring wells (locations of which have yet to be determined) will continue to be in operation as long as they are required by the regulators. The developer will undertake testing of residual fines in the surface area of the infiltration basin, particularly for metals. A risk assessment and/or removal of any fines that are deemed contaminated soils will occur during reclamation.

In terms of what the infiltration basin will look like post closure, the developer noted that there are a series of pictures in the DAR of what it will likely look like. The gravel pit area would not be re-seeded with jack pine like the rest of the development area, but the berms would be contoured, sloped, and leveled off. It will look like a gravel pit again.

Experts' Comments:

One expert wanted clarification on the standing water shown in the DAR picture of the infiltration basin. Was this likely to occur? The developer stated that they expect no standing water, but they wouldn't know for sure until they do additional geotechnical work.

When asked if the same "infiltration basin" concept would likely be used if the development proceeds to a larger operation if the PPPP is successful, the developer noted that an injection well system would likely be preferable to handle the higher water inflows from an expanded operation. At this point, a couple of experts asked why injection wells are not being reconsidered for this development, given all the stated concerns about the infiltration basin – missing evidence, likelihood of success at exfiltration, and uncertainty about impacts. The developer answered that an injection well might alleviate many of the concerns being expressed at these meetings, but that they feared the additional review process might delay the development. Cost was a consideration but not a deal breaker. *This issue would be revisited later as Topic 5.*

f) ***What are the best practices and reclamation techniques for a pilot project of this nature and the freeze curtain system, as noted on page 414 of the DAR?***

g) ***How will the freeze pipe brine be removed, what measures will be in place to prevent spillage/seepage and what are the disposal options that Tamerlane is considering?***

h) ***How will refilling freeze pipes with grout affect long term groundwater flow in the area?***

NOTE: These three issues were generally dealt with as a group.

Developer's Comments:

Best Practices: These were outlined in the DAR, committed to, and have not changed in the interim. Tamerlane is committed to employing progressive reclamation and following INAC's January 2007 Mine Site Reclamation Guidelines. The PPPP site will be relatively simple to reclaim because of its small footprint, limited infrastructure, lack of aboveground waste piles or tailings pond, and the nature of the terrain.

Freeze Pipe Brine: This is a marketable and valuable commodity, one of the reasons the developer would not leave it in the ground. This will be removed from the system and possibly sold to another group which, ironically, is allowed to use this material as a dust suppressant, another indication that this product is relatively environmentally benign. If they don't sell it, the developer will return it to the supplier for reuse or storage.

Effects of Refilling Freeze Pipes with Grout: As both the developer's expert and some of the experts in the sessions indicated, the groundwater will simply flow around the casings left in the ground and continue its downgradient flow. No effects expected. Freezing the ground was pointed out to be the least intrusive process to groundwater flows. The developer even questioned whether re-grouting of the freeze pipe holes would be necessary.

Experts' Comments:

Experts used this discussion on reclamation to ask some questions not related to water issues. A question was asked about where the power line was likely to go and were there any issues with that. The developer pointed out the approximate location of the power lines on a map and undertook to provide a detailed routing image for the Public Record (Undertaking #14). Discussions with Northland Utilities, the GNWT and Environment Canada about minimizing environmental impacts of the power lines have suggested that all power lines should not be in low lying fen area (to avoid impacts on birds' take off and landing zones) and height of power lines need to be considered for wildlife disruption. The project is close to an existing power line and can connect to this line thus not very many new poles to be added. Those added will mostly be below the tree line and those above will be marked so that birds will avoid them.

In regards to the freeze pipe brine, discussion focused first on the distribution system. Experts asked whether the manifold system and/or distribution system would be lined to prevent leakage. The developer stated their plan is to line the area where most of construction will occur with concrete, and elsewhere build a ditch in which to bury the distribution pipes to protect them, especially during construction. The developer had not planned to line the ditch to prevent brine escape in case of a rupture, given that there are shut off valves to each well that would be used if a leak was found. One expert asked them to consider whether HDP (high density polymer) liners should line the whole trench to prevent leakage of brine. The developer stated that their expert was working on a plan and would take that suggestion under consideration.

No substantive discussion occurred around the grouting issue.

Added Discussion Topic 5: Injection Well Scenario for Water Discharge

At the beginning of the Technical Sessions, the option of using a deep well injection system to release the mine/process water mixture back into the same groundwater system it had originally come out of was not being considered by the developer. When the issue was initially raised, the developer stated that a deep well injection system was rejected because it was too costly.

However, the deep well injection system became a much more viable option for the developer when they started to hear the breadth and depth of concerns experts had about the following, along with additional field work that would likely be required:

ISSUE	ADDITIONAL WORK POTENTIALLY REQUIRED
Uncertainty about likely water inflows to the mine	☐ Proper calculation of hydraulic conductivity in the B-facies underlying the mine ☐ Packer tests at depth in R-190 ☐ Proper inflow analysis to mine for different scenarios to bracket the likely range of mine water discharge
Uncertainty about the amounts of ammonia, nitrates, sulfides and total metals in process and "end-of-pipe" water	☐ Additional laboratory studies ☐ Fate analysis of a variety of all constituents ☐ Contingency planning – identification of either additional treatment or a secondary containment facility
Uncertainty about the ability of the infiltration basin to handle greater than estimated amounts of water at "end-of-pipe"	☐ Geotechnical drilling at infiltration basin to determine the presence/depth of any clay layers, depth to the water table, and the overall composition (stratigraphy) of the overburden
Uncertainty about the potential for re-surfacing of impacted shallow groundwater	☐ Assess potential for mounding and groundwater discharge in near-by depressions (wetlands, creeks)
Lack of a settled agreement with the landholder – GNWT's Department of Transportation	☐ Continued discussion with the DoT toward an agreement on use of the area

It was agreed on the second day that after the official Topics had been dealt with, a discussion would ensue between the developer and the gathered experts about the pros and cons of an injection well system versus the proposed infiltration basin.

Notes of this discussion identify pros and cons noted by experts, and questions and answers that followed, including questions from the developer to the experts.

Note: Within two days of the Technical Sessions, the developer committed to using a Deep Well Injection System. The developer has since done additional work identifying how the injection well system will look, work, where it will be situated, contingency planning, and environmental impact assessment. Parties are invited to analyze and critique this work, which is on the Public Record for the EA.

Pros and Cons of Injection Wells

A deep injection well consists of a wide diameter well (perhaps 13") drilled down, in this case, to somewhere between the 450-500 foot level in an area outside of the freezewall perimeter (although it doesn't have to be very far outside this perimeter, just enough so that the water movement doesn't erode the freezewall). One expert identified the "hinge line" north of the freeze line as a good prospect, since it has been identified as having higher hydraulic conductivity so could act to make discharging more productive. Water discharged from the mine and from the processing plant (and potentially from other parts of the operation such as the sewage treatment plant) would then be pumped deep into the underground via this well. The theory is that the water will join with groundwater in the geological strata between 450-500 feet. This is the extremely high conductivity aquifer, the Presquile layer. This injected water should then migrate horizontally into this Presquile layer at depth. Minimal mounding would be expected to occur and no water would migrate back to the surface, at least for a long distance from the mine.

Pros

Most, if not all, of the assembled experts felt that the injection well system would be a better option for this development than the proposed infiltration basin. This included experts for the Review Board, INAC, Environment Canada, and the representatives from the GNWT's Department of Transportation. The infiltration basin concept was succinctly labeled as one where "water is undiluted and discharged to surface creating many environmental impacts." One expert felt that the use of an injection well would effectively be the icing on a very environmentally benign mine plan, stating that "At this pH level none of the metals of concern are mobile. Because of the backfilling process there is really limited oxidization of the removed rock and this excess water is the last problem and just putting it back where it came from is the best solution." He also cited the small footprint of the underground mine and the fact that the injection well further reduced this footprint.

Reasons to support this option included:

☐ Injection of what is essentially groundwater (with a small percentage of process water) back into the aquifer layer of ground it originally came out of – this means that there would be no mixing of deep groundwater with the very different perched groundwater aquifer, as previously proposed;

☐ Footprint minimization – the injection well takes up much less space than the infiltration basin;

☐ No surface contamination by metals or other water constituents – the infiltration basin was a direct to surface release that raised a lot of questions about impacts on animals and the rooting zones of plants. It is highly unlikely that water injected deep underground will surface for a long time, or without diluting out major contaminants below the level of significance;

☐ The pH of the Presquile aquifer is high enough so that none of the metal species that might be of concern such as, lead, arsenic, and cadmium are soluble and mobile. The ground is a limestone host (that is incredibly porous host) and functions as a chemical neutralizer.

☐ It eliminates concerns about contamination of a potentially economic resource in the DoT's granular resource (i.e. the gravel pit);

☐ Less surface disturbance in the infiltration basin and less reclamation work required post-closure;

☐ Greater infiltration capacity: the potential for discharge of mine water into an injection well (in the highly permeable Presquile) is far greater than the most optimistic value for infiltration basin. A lot of the test work has already been done showing the Presquile layer has a very high transmissive capacity and a very high (almost unlimited) storage capacity;

☐ Raises the likelihood of less restrictive water discharge parameters: experts felt the end-of-pipe water quality standards could be less restrictive if the water is pumped back below ground into this very transmissive aquifer for dilution. As one expert stated "It would be very unlikely that there would be any unacceptable concentration." When a community member asked if the water was being injected without treatment, the developer noted that "we don't need to treat it because the water quality will be very similar to where it is being injected back to and the water has no ability to do damage in that [deep underground] area." *NOTE: With the addition of a froth flotation circuit, the assertion that it would be unlikely that any unacceptable concentrations of contaminants could be in the end-of-pipe water that might impact significantly on the environment needs to be reconsidered by the developer.*

☐ No additional geotechnical work would be required on the infiltration basin;

☐ It is a very short pipe length and is more reliable than the longer pipe to the infiltration basin.

☐ Downhole monitoring systems will allow for a lot of lead time if there is any clogging, so that contingencies do not have to be developed at the spur of the moment. Experts identified that at least two deep injections wells – a primary and a backup – would likely be necessary. The backup could act as a monitoring well when not in active use.

Cons

There were very few downsides that experts identified with the injection well system. Most of the issues of concern related to the need for additional study and presentation of findings by the developer to the Review Board. Two main issues reared up:

☐ Potential for clogging of the well via suspended solids (see below for suggested research requirements).

☐ Concerns from communities about this technology, related both to the fact it has not been explained in the past, and also to the fact that experts considered that water that might seem contaminated could just be pumped back into the ground without treatment. Those concerns need to be addressed publicly by the developer.

To assist in addressing these logistical and public concerns, additional work required to assess the injection well option included:

☐ Carry out an assessment of the feasibility of deep well injection for a range of mine water discharge rates using the results of the R-190 pump test data

☐ Assess the environmental impact of deep well injection, with respect to changes in groundwater quality and groundwater levels on the mine lease and further downgradient

☐ Some discussion on how the developer would remove fine particles (TSS) so there is no plugging of the well.

☐ Answer the question "What you would do in case it plugged?" through contingency planning. As one expert put it: "You might want to have mitigation for the failure of an injection well....just as a back up pump so you can alternate pumps or storage ponds for short term holding rather than shutting down the mine. Suspended solids might be a problem but it is a low concern for me, and if you can keep an open hole pumping without a screen, I don't expect it to be a problem. I think you should ask people who are experts on wells to help you design the best system to avoid clogging. But you must provide a contingency plan so we know there is a back up."

☐ Evidence that it would in fact work from case studies and analysis of potential mounding would be useful.

☐ Tracking of the discharge water below ground; where it is going, some sort of fate analysis. Experts did not foresee it resurfacing, but required evidence to this effect.

☐ Confirming an area of high aquifer activity (a "hinge line") to locate the injection well(s)

☐ Determine whether some form of intermediate settling facility to reduce the amount of TSS in the water is necessary, to reduce clogging and potentially to treat the water if it exceeds license parameters.

A couple of points of contention the developer was going to need to address remained. One expert recommended that the developer not add their sewage to that water due to the chemical and biochemical issues that are easier to deal with using standard methods such as a septic field. Other experts were confident in the injection well option's ability to dilute any contaminants and saw no problem with discharging treated sanitary wastewater with co-mingled mine and process water into the injection well. No consensus was found on this point at the time.

Secondly, the willingness of the DoT to let the developer still use the southern portion of the "infiltration basin" as a lined settling pond was far from certain. The developer asked the DoT representative how they would feel about this, and he responded that while he would feel better if the old quarry was not part of the mine at all, the two groups agreed to further discussions toward some agreement.

In the end, experts generally agreed that the injection well basically took care of inflow problems, infiltration problems, and vastly reduced water quality and environmental receptor concerns. One expert labeled it "a perfect solution". Nonetheless, a variety of questions about the technical layout, potential for mounding and clogging, fate analysis (both in direction of flow and potential for impacts on the receiving environment), contingency planning, and likely water quality if a froth flotation circuit is employed, all need to be fully addressed by the developer.

The developer thanked the experts for their points and committed to identifying whether they would pursue an injection well water discharge system very quickly after the Technical Sessions. *The Technical Sessions were adjourned.*

Appendix 1 – Technical Session Attendees

PLEASE SIGN IN

NOTE: IF YOU SIGNED IN ON TUESDAY, YOU DON'T HAVE TO SIGN IN AGAIN.

		Name	Organization/Community
1	1	Al MacDonald	MVEIRB
2	2	Lionel Marcinkoski	INAC - RDC
	3	ADRIAN BROWN	ABC / INAC CONS.
3	4	Rick Hoos	EBA Engineering
	5	David Swisher	Tamerlane Ventures
	6	JOSEPH SOPKO	LAYNE CHRISTENSEN
	7	Catherine Lewis	Layne Christensen Company
	8	Godfrey McDonald	Confidential Metallurgical Servi
	9	Wayne Starling	DIAND Fort Smith
4	10	Art Barnes	DOT - GNWT
5	11	Tom Unka	DKFN - Ft Resolution
	12	[illegible]	Fort Resolution IMA
	13	Bruce Halbert	SENES Consultants
	14	Christoph Wels	Robertson Geoconsultants / SRK
6	15	Jesse Jasper	Environment Canada
	16	NORMAN McCOWAN	INAC

	17	JAYDA ROBILLARD	INAC
	18	ROB WALKER	INAC / HAY RIVER
	19	JOEL HOLDER	ENR / GNWT
	20	LORRAINE SEALE	INAC / Yellowknife
	21	Mike Palmer	INAC / Yellowknife
	22	Lindsey Cymbalisty	INAC / Yellowknife
	23	ROSY BJORNSON	DENINU KUE FIRST NATION
7	24	PAUL HARRINGTON	NWTMN HAYRIVER
	25	Terri Bugg	MVEIRB
	26	Harry O'Keefe	″ ″
	27	Rhonda Batchelor	Dept of Transportation
9	28	Ronald McKay	FRMN / Fort Resolution, NT
	29	[illegible]	IMA Fort Res
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Appendix 2 – List of Undertakings from the Technical Sessions

The following undertakings were committed to during the course of the Technical Sessions.

#	PARTY	UNDERTAKING	NEEDED IF INJECTION WELL CHOSEN?
1	Tamerlane Ventures	Provide recalculation of estimated mine water inflows and outflows to the receiving environment, and develop water discharge management contingencies based on "most likely case" and "worst case" scenarios	Yes
2	Tamerlane Ventures	Provide all applicable drill logs from the PPPP area for the public record, in order to allow technical experts to assess for evidence on permeability of B-facies underlying R190 works, and potentially infiltration basin stratigraphy	Yes, required for public record; No, regarding the infiltration basin
3	Tamerlane Ventures	Re-examine explanation in the DAR of how the installation of the freezewall corresponds with timing of shaft sinking and any necessary de-watering. Clarification notice to be placed on the public record.	Yes
4	Tamerlane Ventures	Provide a revised description of the safety measures in place around the brine distribution system for the freezewall system, including discussion of protections for the main line at the manifold, and a contingency plan and environmental impact worst case for massive losses of brine from the manifold	Yes
5	MVEIRB	Add Appendix 3 from Brown, Erdman (1981) specifically to the public record, and identify it is an acceptable estimate of deep groundwater characteristics at R190	Yes
6	Tamerlane Ventures	Provide, given altered estimates of amounts of water being pumped out of the mine, and the commitment to the use of emulsion rather than ANFO, a new estimate of the total amount of ammonia and nitrates left over after blasting, and estimated ammonia and nitrate concentrations in water discharged back to the receiving environment, and if necessary, treatment plans.	Yes

#	PARTY	UNDERTAKING	NEEDED IF INJECTION WELL CHOSEN?
7	Adrian Brown, courtesy of INAC	Provide for the public record and the developer's consideration, information from the Diavik work on ammonia, including methods for estimating remaining concentrations after blasting and in discharge	Yes
8	Tamerlane Ventures	Provide water discharge characteristic information from the "Lock Cycle Test", and include this information in estimates of total (soluble and insoluble) metals likely to report in water discharge. Information should be provided for the public record, with the identifier of what information already on the public record is to be replaced by this new information (e.g., Table 4.6-1 in DAR)	Yes
9	Tamerlane Ventures	If additional components are going to be included in the DMS process, identify them in detail and conduct appropriate environmental impact assessment, particularly on reagents and their impact on water discharge quality	Yes
10	Environment Canada	Provide Weyer (1983) report for the Public Record	Yes
11	Tamerlane Ventures	Provide a reconsideration of the probable infiltration rate in the infiltration basin (previously estimated at 100 m^3/hr). This will include appropriate geotechnical work on site.	No
12	MVEIRB, may request additional info from Tamerlane	Identify whether existing topographic and hydrological flow direction images are acceptable for solid analysis of local drainage patterns; if not, ask for more information from developer	No
13	Tamerlane Ventures and GNWT Dept of Transportation	Provide and both confirm an agreed-upon revised map indicating the boundaries of the primary and secondary infiltration basins (with the focus on separating the primary basin) from the remaining aggregate source in the northeast of the areas, an indication of required infrastructure both for the basins and for access by the DoT to the aggregate source, and a plan for diverting any process water that seeps through berms around the infiltration basin	No
14	Tamerlane Ventures	Provide more information on the proposed routing of powerlines into the R190 site	Yes

Bibliography

NOTE: All citations referred to here and in the text are available on the MVEIRB website public registry for this EA.

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