Faro Mine Closure Planning

Technical Workshop

Whitehorse

June 23/24, 2004

Minutes and Discussion Notes

Faro Mine Technical Closure Planning Workshop No. 4
June 23rd & 24th, 2004
Whitehorse, Yukon

The fourth Faro Mine Technical Closure Planning Workshop was held on June 23rd and 24th, 2003 at Yukon College in Whitehorse. A complete list of workshop attendees along with their contact information is provided in Attachment 1.

Day 1 - June 23, 2004

Workshop Overview (Attachment 2)

The goal of this workshop was to bring stakeholder groups up to date on the closure planning process for the Faro Mine including an update of the ongoing closure related studies. Presentation is provided in Attachment 2. Key items covered in this presentation included:

- Status of the site
- Process set out in DTA for management of the Faro Mine
- Structure of Joint Canada/Yukon Type II Office
- Faro Closure Planning Structure including Faro Closure Planning Office
- Overview of closure planning and approval process

The Faro Closure Planning Office is responsible for overseeing the overall development of the closure plan. It will be based out of Whitehorse with an office created in Ross River, representing the Kaska, with Kathleen Suza as the coordinator. There is also a resource person in Pelly Crossing, presently Darin Isaac, and a liaison position in Faro filled by Ted Baker. Presently Tony Keen is the Interim Manager of the Faro Closure Planning Office. The focus of this office's activities is on closure, not care and maintenance and legal issues related to the site. The latter remains the responsibility of the Interim Receiver (IR), Deloitte & Touche. As the office gets further established, it will begin the gradual taking over of the technical studies from the IR.

Since fall 2003, DIAND, GY, Kaska and Selkirk First nation have been working on the development of an over-arching strategy for closure planning for the Faro Mine. An agreement was reached by all parties in January 2004 to form a partnership, with a three party Oversight Committee to "oversee" the process.

Overview of the Closure Planning Process

- Extremely tight timeline to have the plan completed and ready to submit by December, 2006 as required by the Water Licence. Based on this timeline it is required to select preferred alternatives for closure by early 2005.
- To enable this, it is necessary to have an open process where all parties involved can have access to the relevant information and take part in the closure planning process
- Along with ongoing technical studies and closure related research, the development of closure objectives is required. This process has now been initiated.
- Once developed, the goal is to mesh the objectives with the technical studies to enable the development of alternatives and preferred alternatives. (See Slide 16 in attached presentation).
- Prior to submitting the plan for the required environmental assessment and regulatory approval, funding approval must be secured from the federal government. As such the plan will not be submitted to the Environmental Assessment Process until the governments have approved the plan. Sufficient time (up to one year) for this approval has been provided for in the closure planning timelines.
- Once approval has been received, the project will move into the EA (YESSA) and regulatory process. Two years have been set aside for the EA and all regulatory approvals
- The next step after EA and regulatory processes is implementation of the closure plan. This will be an iterative process, making changes and modifications as required during plan implementation.
- Post closure activities will continue after closure plan implementation. The duration of these will be varied depending on the level of ongoing care and maintenance required at the site. Some areas of the site may be walk away others may require further work and monitoring.

As outlined in Slide 17, there are two streams to the closure planning process: the technical side and the government process side. Where these two streams come together critically is through the identification of closure objectives. This is a primary focus of the upcoming work this summer. Community meetings have already been held in Ross River, Pelly Crossing and Faro. There will be ongoing community meetings and discussions as the planning process continues, as well as meetings with other stakeholder groups including regulatory agencies, government expert agencies and NGO's.

Issues/concerns/questions

- *Yukon Salmon Committee and Renewable Resource Councils are identified as stakeholders but they have statutory obligations under the UFA which would elevated them to a status level above stakeholders. There is a concern from some groups about UFA obligations and how will they be fulfilled in this process.*
- *Government, through this closure planning process, is going to fulfill any UFA obligations.*
- *Question raised as to who will be the proponent for the closure plan. It was identified that the two governments, GY and DIAND, will be the project proponent.*
- *Government of Yukon needs to be aware of its obligations under the Environment Act (Yukon) with respect to the Faro Mine Closure Plan.*
- *Of concern to Yukon Salmon Committee, and possibly other UFA bodies, is the ability to properly participate in the closure planning process without securing more resources. If a higher level of participation is required, sufficient advance warning is required to put the appropriate funding process in place.*

Summary of Technical Program to Date (Attachment 2)

Previous closure planning activities for the Faro Mine were done by the mining company primarily to meet regulatory requirements. When the IR was looking at re-licensing the site, they looked through previous studies and closure plans to identify what, if any, components could be carried forward to the present site conditions. The environmental problems associated with the site are a lot more complex than were originally anticipated and there are significant data gaps that need to be filled prior to selecting a final closure planning option. Through the ongoing investigations at the site, we are now finding things we did not see before, due to advances in technology.

Many of the existing proposed options for closure have a wide range of price tags associated with them. Whether they are still realistic, valid and viable will be based primarily on the present site conditions and available reclamation technology.

Key Technical Gaps – to ensure sufficient information is available to pick the most robust and viable method:

- Water quality predictions for seepage from waste rock dumps and open pits
- Groundwater contamination below the tailings
- Required surface water diversion closure measures
- Understanding of surface and groundwater flow paths, treatment requirements and options
- Alternative tailings, waste dump and pit closure methods

Overview of Faro Mine Technical Investigation Program (Attachment 2)

Initiated in April 2002 through a workshop held in Vancouver to deal with the various data gaps previously identified. Participants included DIAND, Deloitte & Touche Inc., Faro and Vangorda engineers and external technical specialists. The purpose of this workshop was the development of technical task list and schedule for closure planning. Through brainstorming a variety of closure planning methods were put forward along with information requirements/data gaps. Also considered was the applicability of any previous closure plans and it was determined that in general many components from those plans could not be implemented at the site as it exists now. The results of this workshop flowed into a series of investigation plans for 2002 to start filling in the data gaps identified. Investigations were initiated in the fall of 2002. Studies carried out in 2002 include

- Scoping studies
- Risk-based engineering criteria
- ARD studies
- Borrow sources
- Tailings groundwater
- Faro Creek diversion options
- Vangorda flume options.

The results of the 2002 investigations were pulled together and presented at the January 2003 Technical Advisory Committee meeting held in Whitehorse. It was determined that there was sufficient information to get more people involved in the process.

In June 2003, another workshop was held in Whitehorse with broader participation including representatives from DIAND, GY, Kaska, Selkirk First Nations, Town of Faro, Environment Canada, Department of Fisheries and Oceans, and external technical experts. This workshop utilized the same process as the 2002 workshop. This workshop identified required studies not just for 2003 year but all the way through the closure planning process with a focus primarily on what is technically possible not on what the various communities or regulators might require. It is also recognized the need to initiate work on closure objectives.

In February 2004, the results of 2003 work were presented at a workshop held in Vancouver along with focused discussion of key technical issues: tailings relocation, tailing stabilization and mine area closure. The February 2004 workshop resulted in the identification of outstanding information requirements and 2004 study plans. Presently proposals are being submitted for the 2004 study programs. It is anticipated that the proposals will be reviewed by mid-July and initiated immediately after approval.

It is anticipated that the technical studies will be completed by the end of 2004 with a technical synthesis of all the studies taking place in early 2005. At that time it will be possible to present some clear closure options. In the second quarter of 2005, the two parallel processes need to be brought together: technical and closure objectives. This is a key step in which all the work being carried out comes together. This will result in the selection of preferred alternatives for the site: both technically feasible and meeting the final closure objectives for the site. In the fall of 2005, the draft Faro Mine Closure Plan will be prepared for submission for internal approvals. The FMCP will be finalized during 2006 while internal approvals are being sought.

Questions / Issues / Concerns

- *Who will be involved in finalizing the closure plans: FN, YSC, DFO etc. Another workshop is being planned for the end of 2004 and maybe one in early 2005. First Nations, Government regulators, government expert agencies, NGO's (YSC, YCS, etc.) will be included in these and also have input into the development of the closure objectives.*
- *In terms of the timelines, it is intended to have closure objectives by early 2005 and at the same time all the technical studies will also be complete.* ***What happens if we get to that point and we are not on the same page with the two processes?*** *From a technical perspective, it is not the specific objectives that are key at this point but the issues and concerns that may feed into the objectives. The real danger is that the technical studies go along without an adequate understanding of what the issues and concerns are. That is the goal of these workshops, to ensure that the closure planning team is getting this input and hearing the concerns / issues of the various organizations, communities and stakeholders.*
- *Must ensure, that given the development of closure objectives is now just being initiated, that the technical process does not get too far ahead and miss key issues / concerns.*
- *There is always the possibility that there may be gaps in this kind of process but the reality is that the plan must be submitted on December 31, 2006 as per the Water Licence. At the point of submission, some things may be definitive but some may not. The environmental process is an iterative process and there may need to be modifications made to the originally submitted plan at this point. The development of the closure plan will also be an iterative process.*

- *With respect to closure objectives, at this time we are essentially starting off with a clean slate.*

Development of Closure Objectives (Attachment 2)

It is important to understand that there are some differences between the terms closure, reclamation, remediation, rehabilitation and restoration. Definitions are provided in the attached presentation. It is very common to get these terms mixed up which can result in them being used inappropriately.

When dealing with closure objectives, these are much broader that the technical studies that have been talked about previously. The goal is to establish closure objectives for the Faro Mine that can be used as a basis for selecting preferred closure methods and in the end to measure the performance of the closure plan. The establishment of closure objectives needs to be done early so they can be incorporated in planning process early to ensure that the planning process does not get off track.

It is important to separate closure objectives, methods and alternatives:

- Closure objectives are the broader overall objectives for closure
- Methods are the individual steps required to meet the objective.
- Alternatives are combinations of methods required to meet the objective. A site like Faro will have a lot of alternatives.

It is also important to recognize the difference between closure objectives versus standards / criteria. Standards / criteria are used to determine the performance of various components of the plan and provide quantitative ways of determining if closure objectives have been achieved i.e. CCME Freshwater Aquatic Life Receiving Water Guidelines and Engineering Design Criteria for Dams – Maximum Credible Earthquake (MCE).

All those involved with the closure process will have an idea of what they think some of the closure objectives should be depending on their relationship with the mine site area and surrounding land. It is important to note that the selection of final closure objectives often weighs the balance between the input received from the various stakeholders. It will not be possible to have total and consensus agreement on everything. It is a way to ensure that we do get balance.

The Faro Mine Closure Office is working on a continuous process leading to development of closure objectives. The goal is to get acceptance to closure objectives in the fall so that they can feed into the technical studies and closure plan development.

Issues / Concerns

- *Based on this timeline, there is only four to five months for the development of closure objectives. This may be made difficult with many people being out on the land during the summer. But it is important to acknowledge that we have a December 2006 deadline and this is what everyone needs to work towards.*

Closure Objectives Examples (Attachment 2)

The list of some typical closure related issues were provided (Slide 51) some of which are outlined below. There is a wide variety of issues that need to be considered when looking at closure objectives and closure in general.

- Risk of failure – need to recognize and understand the potential consequences of failure as part of the closure plan.
- Physical stability – earthquake, floods, erosion, degradation of structures must all be considered. A primary goal of the closure plan must be to ensure that components remain stable and do not degrade with time.
- Chemical stability – ensure that chemical degradation of the site does not result in environmental degradation.

- Land use productivity – incorporates non-technical factors such as traditional knowledge, local issues and knowledge.
- Post-closure activity level - target for level of site use post closure. These can range from a walk away scenario to ongoing care and maintenance of the site.
- Duration of implementation – short duration closure plan implementation has a different impact on local economies versus a long drawn out process.
- Leadership/perception – need to look at suitability of using non-conventional treatment systems
- Socio economic – institutional risk, local acceptability to government agencies

A brief summary of closure objectives for four mines was provided and are summarized below.

<u>Polaris (Slide 52)</u>
Closure objectives for the Polaris mine were outlined in the closure plan document approved by Nunavut Water Board. It is important to note that the Polaris Mine is very different than the Faro site, specifically there is no acid rock drainage (ARD) and closure could be designed for a walk away scenario.

<u>Wismut (Slide 53)</u>
Wismut was a uranium mining district in Germany. As part of the closure planning process a very good list of closure objectives were developed: very quantitative in nature. The closure planning process for this site differs significantly than that being used for Faro. For example, institutional risk was a very important consideration in the closure objectives for this site. In Germany, there have been two world wars in the last century and the collapse of government twice in the last 50 years. This is a reality for this site but not here with respect to Faro. The main difference is that public consultation was not a major part of the Wismut process.

<u>Giant Mine (Slide 54)</u>
The primary problem at Giant Mine is 230,000 tonnes of arsenic stored underground. The first step in the closure planning process for Giant was to come up with technical options first. Then it was narrowed down to three options that were then taken to a series of community meetings. Through this process, it is thought, that all the technical issues are identified prior to going to the communities.

<u>Colomac (Slide 55)</u>
The closure planning process for Colomac is somewhat similar to Faro. Community consultation occurred up front to develop the closure objectives. This resulted in the development of both quantitative objectives, which were easy for the technical team to work with, and some other more holistic objectives, which were challenging for the technical team but probably more important for the project.

Questions/Issues/concerns:

- *Has anyone developed a handout on mistakes made or lessons learned from these mines? Answer -Nothing has been specifically generated from these mines, some of which are still in the closure process. There are examples from the US though. The hard part is how to get to all the people and parties who are to be involved in the process for a very technical project. There are a couple models from down south such as the Brenda Mine and the Sullivan Mine. Each of these has taken a unique approach. There is no single template that works universally.*
- *It will be important to document the lessons learned from this process as this information can be used for future mine development planning in the Yukon. This will be the key to successful future mine development in the Yukon.*
- *In the definition of closure objectives there is a purposeful separation of the objective from standards/regulatory guidelines such as CCME. Concerns were raised with the "de-linking" of these two: need to have quantifiable criteria as part of our objectives. The intent of doing this "de-linking" is that at this point, we are looking at things from a much broader perspective, from which we will ultimately work down to determining the guidelines or standards that will be used to measure if our objective has been met and where will these need to be met.*
- *DFO stated that they have their own legislation and policies that must be followed. They are pleased to provide advice but it is without prejudice for the application of their Act etc.*

- *It was clarified that the closure objectives being established through this process will take into the consideration the benchmarks that must be met for regulatory approval. As well at the funding approval stage there will also be input from other government departments such as DFO and EC.*
- *Clarification was sought regarding existing closure objectives that are present in the existing site licence. Specifically will these be used for the development of the closure plan?*

Group Exercise Number 1

Series of questions to draw out areas of interest
Group discussion of areas of interest
Collate list of areas of interests

Exercise 1:

Q1 What are the past, current or future uses of the site?
- By people?
- By wildlife?

Q2 What are the uses that you think should be protected?

Q3 What are the downstream risks that concern you most?
- How is the downstream environment used?
- How can downstream effects impact people, wildlife, fish?

Q4 What elements of the downstream environment do you think should be protected?

Q5 What are the risks?
- If you picture the property 100 years from now, what concerns you most?
- Again thinking 100 years from now, what are the things that can go wrong?

Q6 What are the possible positive effects from the closure projects?
- In the planning and approvals phase?
- In the implementation phase?
- In the pos-closure phase?

Q7 Is there anything else?
- What will you be looking for when you first open the draft of the Final Closure and Remediation Plan?
- What questions will other people ask you about the plan?
- Are there any other concerns or questions that people don't even want to ask?

Each table gave one 'area of interest"
- Maintaining hunting and fishing access
- Environmental protection/enhancement - water quality-fisheries resources/habitat, wildlife and habitat, safe access to healthy country food, long-term risk of resources
- 100 years risk issues:
  - long term physical and chemical stability of what remains,
  - management of the growing volume of sludge,
  - funding and political will (will there be $$ for ongoing activities),
  - consequences of erosion and degradation, and
  - consequences of design based on unknowns and flawed assumptions.
- What are the international implications of the closure plan – implication of downstream risks to Yukon River and Yukon River Salmon Agreement with the US.
- Community and economical benefits
- Cost effectiveness – with respect to other sites and other objectives
- Traditional use after closure in terms of hunting, fishing and harvesting of plants
- More general recreational use after closure
- Protection of human health – workers and public
- Economic benefit
  - Long term economic opportunities for present closure and future opportunities
  - Capacity building and skill development/training
- Technical:

    - Standards and performance criteria: alternate technologies,
    - tailings removal versus control/mitigation of impact of leaving them in place,
    - long term site stability (physical/chemical).
- Water quality – downstream risk: inundation of valley and river
- land lost associated with water treatment sludge
- restoration of productive fish habitat equal to or greater than pre-mine levels
- assurance of funding – are cost requirements of plan going to be precedent setting for government, industry or nationally/internationally.
- Develop a better understanding of what the long term intended land use will be recognizing our regulatory obligations versus people values and expectations
- Participation and collaboration in the closure planning process
- Is the final plan practical, credible and integrate
- Maximum reduction or elimination of Federal Liability
- Eliminate the opportunity for catastrophic failure
- Promotion of biodiversity for the long-term
- Long term maintenance requirements
- Aesthetics
- Climate change – incorporation in closure planning process
- Rehabilitation of the site to the maximum possible
- Historic interest
- Public perception – negative or positive – versus the reality
- Staff stability

Additional after tailings presentation

- *Precautionary principle – we wont ever have all the answer – mineral policy of Canada*
- *Acceptable time frame for closure*

Basic Technical (Science and Engineering) Studies (Attachment 3)

An overview of Basic Technical Studies (2002 – 2004) was provided to the group. Copies of the presentation can be found in Attachment 3. The following is a brief summary of the studies and any issues/comment/questions (in *italics*) raised during the presentations.

Aerial Photos and Mapping

- Flights flown in July 2003.
- Black and white at 1:10,000 and 1:20,000 and colour at 1:40,000
- Ortho-rectified
- Topographic maps generated at 2 metre contours.

Seismic Evaluation (Gail Atkinson, Engineering Seismologist, Carlton University)

- How big is the biggest earthquake? This is very important information need for structure design at the site.
- This question has been plaguing this site for years.
- 1:10000 event – 0.2 g (acceleration of gravity) – this comes from GSC based on all the earthquakes in the entire area.
- G. Atkinson thought it may be more appropriate to focus on the area of the Tintina Trench. These local conditions may be more representative of the mine site.
- Derived a different set of probability curves
    - 1:10000 now a 0.45g possibly up to 0.6g
- During the process of this work they also went back to geologic evidence for her analysis. She is confident that we have a good handle on this.

Hydrology and Flood Estimates (Barry Evans, Northwest Hydraulics Consulting Inc.)

- Review of all flow data for Rose Creek and Vangorda Creek.
- Updated flood estimates for mine site sub basins up to the 1000-year event.
- Review probable maximum flood estimate for Rose Creek. This is the theoretical largest maximum flood event probable at the site.
- The results of this analysis are presently being reviewed. There is a discrepancy between two stations on Vangorda creek.
- Of major concern is the time to peak estimates. There needs to be better data to improve PMF estimates. To facilitate this short duration rainfall and flow data will be collected at the site
- *Is there a tipping bucket rain gauge at the site? There are rain gauges at the two new climate stations installed at the site in December 2003.*

Borrow Sources (SRK Consulting)

- The objectives of this study was to develop an inventory of potential borrow source material.
- Need different types of material depending on the ultimate use. For example cohesive material for low permeability, vegetative covers and coarse granular soil for channel riprap.
- Faro area needs 2 – 8 million cubic metres of borrow material.
- Vangorda/Grum area needs .5 to 2.5 million cubic metres of borrow material
- This inventory was restricted to readily accessible sites only.
- In the Vangorda area there are abundant sources of fine grained till.
- At the Faro site there is mainly granular material.
- Refer to Slide 28 for a summary of the quantities available.
- In general there is an abundance of granular material available at the Faro site but not at Vangorda.
- Organic soil is available in limited quantities at the site in a very thin layer. A significant area of disturbance would be required to access it.
- Presently there are not any more studies on this until it is identified later that additional material is required. At that point the study may look at less accessible areas if required.

Scoping Studies (SRK Consulting, Gartner Lee Ltd and BGC Engineering Ltd.)

- Collect report and prepare bibliography
- Review previous closure plans

- Series of supporting memos on following issues were developed, many of which have now been improved.
  - Summary of previous closure plans
  - Water balance and load estimates
  - Pit wall Stability
  - Feasibility of flow-through open pits
  - Water treatment and pumping costs
  - Surface Water Management Upgrades and Costs.
  - Waste Rock Dump Re-Sloping Costs
  - Tailings Relocation and Costs
  - Waste Rock Backfilling and Costs
- This is the format intended for the reporting on closure alternatives.
- *Who were these tools/memos made available to? Government agencies and regulatory agencies. They were not circulated widely to the former Technical Advisory Committee.*

Water Treatment Cost Estimates (SRK and CEMI)

- Update the water treatment performance and cost estimates developed in 2002 using 2003 data including estimates of sludge generation based on the use of HDS treatment.
- This type of information can then be used when looking at the various closure options for the site. Then for each option put forward an evaluation of the impacts of the various options on water treatment costs can be carried out.
- Cost estimates were developed based on the replacement of each of the three existing treatment systems with a HDS plant: capital and operation/maintenance.
- Once built the HDS systems would be an improvement to existing systems with the exception of Faro Mill, the O&M cost are comparable for this system.
- *Were other costs associated with keeping the Faro Mill plant taken into consideration, given age of building etc? No. The goal of this study was not to say definitively that these new systems should be built but to develop a tool that could be used when looking at the various closure alternatives.*

Terrestrial Effects Study Plan (GLL)

- The objective of the Terrestrial Effects Study is to investigate effects on the terrestrial environment related to the mine: soil, vegetation and wildlife.
- The need for this study stems from the both the development of the closure plan as well as short term impacts due to the ongoing care and maintenance activities.
- A lot of work has been done to develop the study with input from Ross River Dena Council, Selkirk First Nation, Town of Faro, Government of Yukon Department of Environment, Environment Canada and mine personnel.
- Field work will be carried out during the summer/fall including collection of vegetation wildlife and soil samples.

Site Specific Water Quality Objectives (GLL)

- The goal of this project is to develop site-specific water quality objectives for Rose Creek and Vangorda Creek.
- The methodology being used has been developed according to the procedures and protocols have been developed by CCME.
- The Water Effect Ratio (WER) method has been selected for the development of site-specific objectives at the site.
- Seasonal water quality samples are required for toxicity testing: base flow and peak flow conditions.
- Initial test results now being received for the base flow (high hardness) condition.
- Further sampling and testing planned in 2004 to test peak flow conditions and possible whole effluent toxicity testing.
- *It was highlighted that the UFA speaks to water unaffected by quality, quantity and rate of flow and should be taken into consideration for this study.*

Rose Creek Tailings Facility
A brief overview of the tailings facility was provided to group outlining the main components and features.

- Series of three impoundments – Original, Secondary and Intermediate.
- 54.5 million tonnes/ 28.6 million cubic meters of tailings stored in the facility.
- The polishing pond formed by the Cross Valley Dam holds treatment sediments and water.
- Underlying the tailings facility is the Rose Creek Valley Aquifer.

Tailings Area Technical Studies (Attachment 4)

An overview of the Tailings Area Technical Studies was provided to the group by SRK Consulting and Gartner Lee Limited (GLL). Copies of the presentation can be found in Attachment 4. The following is a brief summary of the studies and any issues/comment/questions (in *italics*) raised during the presentations.

Tailings Characterization (John Cunning, Golder Associates Ltd.)

- The objective of this study is to define the representative geotechnical properties of tailings. This information is required for the Tailing Relocation Study and the Tailings Seismic Stability Assessment.
- The properties of the tailings varies throughout the facility depending on how they were deposited. The coarse material is close to source of deposition and finer farther away. – depends on how deposited
- The scope of the study included data review, field investigation (Cone Penetration Test (CPT) probes), and a laboratory program.
- Air photo review was carried out in conjunction with a review of historical records on tailings area.
- The field program consisted of 36 CPT probes at different locations throughout the tailings. The probe is pushed into the ground and measures the geotechnical properties of soil.
- The laboratory testing program utilized 15 samples from the 2003 drill program which were tested for a range of properties such as specific gravity. Two bulk samples were also prepared representing “fine” and “coarse” tailings.
- Depositional history is well documented and matches the results of the CPT program.
- The information generated by this study can then used in subsequent closure studies.

Foundation Soils Seismic Stability Analysis (Dr. Peter Byrne and Mahmood Seid-Karbasi, University of British Columbia)

- The objective of this study is to evaluate the possibility of triggering liquefaction in the foundation soils beneath the Intermediate Dam in the even of an earthquake.
- Seismic activity such as earthquakes can decrease the stability of saturated soils. The soil becomes a viscous fluid creating problems with any structure. This phenomenon of liquefaction develops from repeated disturbances of saturated cohesionless soil and can cause excessive displacements of the ground.
- There are three levels of analysis:
  - Will liquefaction be triggered by a design earthquake in the foundation below the dam?
  - If so, could a flow slide occur?
  - If not, what displacements will occur?
- A preliminary analysis was carried out for the Intermediate Dam. This is the primary element of concern as it holds the tailings. Most of the data on soil conditions coincides with the Cross Valley Dam.
- Preliminary results indicate that liquefaction is marginal at the deep valley section of the dam but widespread near the side of the dam.
- Additional data is required to provide more confidence in the results.

Dam Deformation Analysis (John Cunning, Golder Associates Ltd.)

- The goal of this study is to determine the amount of deformation of the Intermediate Dam that might occur in response to the design earthquake.
- Analysis is based on dam at its maximum height and assumes no liquefaction.

- Under earthquake conditions you get modest horizontal (0.2 – 0.5 m) deformation.
- More analysis is required and the issue of liquefaction remains unresolved.

Tailing Liquefaction Analysis (John Cunning, Golder Associates Ltd.)

- The goal of this study is to determine what happens to the tailings material during an earthquake. What is the earthquake level to get the tailings to liquefy?
- Analysis was done based on the results of the tailings characterization study and considered both the fine and coarse tailings.
- Results indicate that substantial zones of fine tailings are likely to liquefy under a moderate seismic event, in some locations peak ground accelerations of 0.05 to 0.1 would be sufficient. These are less then the accelerations associated with the large earthquakes evaluated by the MCE work discuss previously.
- The fact that the tailings could potentially liquefy has implications on cover design.
- *Has the effect of tailings liquefaction on the stability of the intermediate dam been investigated? No not yet, but there is acknowledgement that under certain seismic activity there is a conversion of solid tailings to a high density medium.*

2003 Groundwater Studies (GLL)

- This program is largely a continuation of sampling of groundwater from existing wells and a drill program to install new multi-level wells.
- Sonic drilling was used which provided for detailed stratigraphy through the aquifer. The soil layers come up and were put in plastic sleeves. This provides a good opportunity to look at the various layers.
- These additional groundwater monitoring wells focused on areas of coarser tailings.
- There are 7 to 9 sampling points in each well from various depths in the aquifer and tailings.
- Based on the data generated during this drill program we have been able to piece together a picture of what the valley looks like under the ground. Two long sections of the valley have been delineated north and south.
- The new monitoring wells are providing data as of 2004. Generally you don't usually want to rely on quality immediately post installation as installation may contaminate wells.

Tailings Area Closure Methods (Attachment 5)

An overview of the Tailings Area Closure Methods Investigations was provided to the group by SRK Consulting and Gartner Lee Limited. Copies of the presentation can be found in Attachment 5. The following is a brief summary of the studies. Any issues/comment/questions raised during the presentations are also presented (in *italics*).

There are three basic tailings closure options being investigated along with the various supporting closure methods:

1. Tailings stay in place:
   - Rose Creek Diversion channel upgrade;
   - Covers;
   - Ground water collection and treatment; and
   - Upgrades to dams and spillways.
2. Relocation of tailings:
   - Methodology of tailings relocation (dredge, hydraulic monitor and mechanical) and
   - Faro Pit requirements.
3. Combination of 1 and 2 – partial relocation.

Assessment of Rose Creek Diversion Canal Upgrades (Barry Evans, Northwest Hydraulics Consulting Ltd. and Jim Cassie, BGC Engineering Ltd.)

- The objective of this study is to determine what upgrades are required to safely pass extreme flood flows around or over the tailings impoundment and into Rose Creek downstream of the Cross Valley Dam.

- This was a desktop study to develop preliminary designs and costs estimates for passing extreme floods up to the PMF round the tailings impoundment.
- Three options were assessed:
  - Option 1 – increase the size of the Rose Creek diversion channel along the south side of the tailings impoundments to convey the PMF;
  - Option 2 – Abandon the Rose Creek diversion channel downstream of the plug and from the plug, convey the PMF over the tailings to a new spillway by-passing the Intermediate and Cross Valley Dams; and
  - Option 3 – Remove the tailings from the original, second and intermediate impoundments to elevation 1042 m then allow Rose Creek to enter the impoundment area. The attenuated PMF passes over a spillway located at the Intermediate Dam.
- Option 1- Enlarge existing diversion channel
  - Essentially have to step out onto the tailings to have the capacity at the lower end of the diversion.
  - Raise the right bank dike.
  - Concrete spillway at lower end downstream of Cross Valley Dam.
  - Accommodate fish passage through a fish by-pass around the spillway.
  - Total Estimated Cost = $32.1 million.
  - Issues
    - Discontinuous permafrost on left bank.
    - Performance of the right bank dike including construction issues such as stability and settlement.
    - Impact of large earthquake – liquefaction.
    - Concrete spillway – longevity
  - *You don't need a large earthquake to have a problem with a big dike on built on tailings. Given the stability issues is this option not a no-go (per previous discussions in Jan. 2004 on stability of the tailings)?*
  - *What is needed for closure is the assessment of the risk due to dam stability if we leave the tailings in place? There is a requirement for more definitive information on the Intermediate Dam and portions of the diversions. We will be doing Becker Density Investigations. If that work concludes that Intermediate Dam would be unstable during an earthquake there are options that can be done to strengthen it. This then introduces new issues that need to be dealt with.*

- Option 2 – Enlarge upper end of existing diversion and run across tailings on and engineered cover.
  - Route PMF over engineered cover on Intermediate Impoundment.
  - Right bank raised down to plug
  - PMF diverted to channel over the tailings to Intermediate Dam
  - Flow passes into spillway approach channel and at Cross Valley Dam enters a concrete spillway.
  - Fish passage provide for using a by-pass around spillway.
  - Total Estimated Cost = $59.9 million.
  - Issues
    - Constructability
    - Performance of the over-tailings channel in an earthquake
    - Concrete spillway – longevity.
    - Cost.

- Option 3 – Partial removal of tailings in upper end and run attenuated PMF over a spillway at the Intermediate Dam
  - PMF enters the dredged impoundment ponds at the Pumphouse Pond.
  - Attenuated flow exits impoundment ponds at the north abutment of the Intermediate Dam at spillway

- Presupposes the removal of a substantial amount of tailings from the upper end of the facility.
- Fish passage is provided in the existing Rose Creek Diversion Channel.
- Total Estimated Cost = $32.6 million
- Issues
  - Requires relocation of 75% of the tailings and a wet cover.
  - Costs do not take into account tailings relocation
  - Concrete spillway – longevity.
- *Is this only in peak flow events? If the water in the pond is not acceptable, can you release bad water in a flood flow? This option implicit in the fact that the water in the pond would be clean water.*
- *It was clarified by DFO that if fish enter the water body, this then becomes the point of compliance.*
- *One of the weaknesses of this is that the Intermediate Spillway is sized to take the peak event of both rose creeks at the same time. It is possible that the size of flood could be attenuated by haul road. This is being looked at.*
- *Care and maintenance associated with this option have not been addressed.*

Cover Options (Maritz Rykaart, SRK Consulting)

- There are a variety of objectives for covering the tailings including:
  - Isolate to prevent dusting and contact with wildlife
  - Revegetation
  - Minimize leachate and shed clean run-off. Particularly important if flow is being diverted over top.
  - Minimize oxidation, but given age of the tailings any attempt to use covers for this purpose is may not be useful.
- This study included the following components:
  - Review of cover related literature;
  - Characterization of potential cover materials
  - Document constructability issues
  - Scoping level numerical modeling.
- Issues/uncertainties
  - Volume of cover material available. Till is essential to building these complex covers.
  - Tailings trafficability including access for construction and settlement of the long term. Two test pads were built in the spring and surveyed to indicate potential settlement.
  - Frost penetration depth is important. Over the years will degrade effectiveness of covers.
  - Formation of evaporates. These can be attractive to animals as a salt lick and hard on and successful re-vegetation. At the Venus mine gravel was place on top of tailings to avoid vegetation bringing up contamination.
  - The overall objective of tailings cover :
    - prevent contact only – constructability is only problem
    - reduce infiltration – constructability (compaction etc) and cost vs. effectiveness. It may be more cost effective to pump and treat aquifer than to cover.
- *What material are pads built out of? Inert waste rock.*
- *Was it compacted? No, it was placed in 1m lifts.*
- *Essentially the test pads are really looking at settlement of placed material not constuctability? This is one concern, will the rock just settle. In fall we will evaluate the degree at which rock settles in tailings.*
- *Will you be addressing the question of the monitoring and maintenance phase of the cover over time? Yes, that would be included in final cost estimate (approximate idea) planning for post implementation and costing is usually done once you have the whole plan in place.*
- *Then there is a concern that you have a cost effective measure up front but possible high costs in the long run and a legacy left for others.*
- *Perhaps we need to look at institutional risk to ensure that there is the money in place to deal with the costs associated with long term care and maintenance.*

- *You say that you will be getting some costing for other cover, infiltration for example. Although in the tests, these types of covers were not looked at. Will they be? It is our feeling that low infiltration covers would be most effective on waste rock and cover tests are going on there.*
- *It was highlighted that the tailings must be loaded gradually and that in only 1 year only primary settlement may be measured in these tests. In the long term there may be ongoing secondary settlement to what level we will not know.*
- *There is lots of experience in covering tailings and there are definitely problems. Ice and water pressure can cause the tailings to pup up. From the point of view of permanent tailings covering, caution must be taken. Also the planning must count on ongoing maintenance of the tailing cover.*
- *It was noted that the test pads are in the Intermediate Impoundment very close to the worst case area –fine grained material. It is thought that construction would be easier in the dryer coarse tailings. Although there would still be settlement.*

Rose Creek Tailings Facility Groundwater Interception (Gartner Lee Limited)

- The premise for this study is that some portion on the groundwater flow in the Rose Creek Valley Aquifer requires interception for treatment.
- This was a desktop exercise that used a hydrogeological model to simulate various pumping scenarios for a comparative analysis.
- The model was refined focusing on new information and updated calibration
- The results from the 2003 multi-level wells indicate downward gradients through the tailings and low gradients in the aquifer. Base on this, the groundwater capture can focus on the upper aquifer.
- Pumping location is at the crest of the Intermediate Dam with 8 pumping scenarios varying the number of wells, pumping depth and pumping rate.
- The capture rate efficiency increases with the greater number of wells at a relatively low pumping rate compared to fewer wells at a higher pumping rate.
- Capture efficiency in increased for wells installed in upper aquifer as opposed to deeper.
- Conceptual costs were determined for well installation, piping and pumping of water, power to pumping location, and treatment costs (using SRK treatment cost information).
- The costs associated with the installation of power would be significant.
- Assumed that there was a treatment system there that can handle the water close to the pumping location.
- *Can you provide comments on real world experience with groundwater pump and treat systems? The numbers do look to be on the low side. This is a desktop based on the data that is available and the current model calibration.*
- *Did you determine that there was not need for a practical test? A next step would be to determine the appropriateness of an actual pumping test to further refine model.*

Tailings Relocation Studies (John Brodie, SRK Consulting and Contractors)

- The premise behind these studies is that the tailings as a whole or part are to be relocated to the Faro Pit.
- A literature search was carried out looking at international scientific and engineering data bases.
- There were very few examples of hydraulic monitoring and dredging. Mechanical methods such as truck and shovel were the most commonly used methods used in arid settings, for small unconfined deposits.
- Case histories were also looked at. The majority of this type of work has been done in S. Africa where the tailings are relocated primarily for reprocessing purposes
- Three Relocation Methods were studied for the two relocation options (total or partial):
  - Dredge, monitor and mechanical.
- The objectives of this study are to develop conceptual designs and preliminary costs for various systems to relocate all or a portion of the tailings. Water management and water treatment issues were also considered.
- Total relocation
  - 57 million tones would go to pit
  - Breach remaining structures
- Partial relocation

  - Relocate tailings above 1042
  - Close with a water cover that would cover the remaining tailings with 3 m free board based on height of existing intermediate dam
- Dredge
  - Tailings sucked into pump system and pumped by a floating pipeline to a boaster pump then up to pit. The dredge floats in water.
  - Need to excavate a starter pit in the original impoundment and pump in water to float the dredge.
  - As the pit grows end up with more and more water in the area.
  - Mechanical clean up of the floor will be required.
  - There is a concern with respect to the secondary dam and it stability. At some point it may have to retain a very large pond.
  - Timeframe - 5 years
  - Cost/tonne - $2.01 - $2.27 (total) and $2.38 - $2.52 (partial)
- Hydraulic Monitor
  - System utilizes a water cannon system.
  - The cannon is directed at tailings to get them moving.
  - The mobilized tailings would be collected in a sump and subsequently pumped to the pit.
  - Timeframe – 12 years for total and 9 years for partial.
  - Cost/tonne - $2.00 (total) and greater than $2.00 (partial)
- Mechanical
  - The entire plan for mechanical tailings relocation is based on the assumption of equipment being able to traffic on tailings and that the tailings can be pushed by a dozer.
  - Tailings pushed to a belt loader and then loaded to trucks for delivery to the pit.
  - Timeframe – 7 years for total and 5.4 for partial.
  - Cost/tonne - $1.61 (total) and $1.63 (partial)
- Comparison of Risks
  - Dredge
    - Large pond that may increase seepage losses and risk of failure of secondary dam.
    - Still require mechanical methods for valley floor.
  - Hydraulic
    - Technically feasible
    - Seepage losses expected to be less than dredging.
    - Internal slope failure within tailings possible.
    - Less risk to secondary dam
    - Still require mechanical methods for valley floor.
  - Mechanical
    - Needs trafficability
    - There are other mechanical methods available but very expensive (drag line).
    - Less expensive than other options, but only under favourable conditions, which may not apply over much of the tailings.
- The cost estimates presented are only for moving the tailings. Engineering and supervision, lime addition, excavation of old dams, stream rehabilitation, groundwater treatment and any costs associated with the pit are not included.
- There are technical risks for all methods with dredging the having the highest environmental risk and most severe water management issues.
- All methods have the same water treatment issues.
- *Is the cost of raising the dam, the big dam to flood the valley included? The goal is not to build any new dams but improve existing or remove.*
- *With respect to the time frame for hydraulic monitoring, is there a way for them to do it faster by putting on more manpower? When looking at the valley, it does make sense to add more guns.*

June 24, 2004 – Day 2

List of Area's of Interest developed during the group exercise on June 23rd was distributed to the group (See Attachment 6). The groups went through the list to see if there are other interests that need to be added. The following comments were received during this exercise:

- The traditional use aspect is not a clear as it could be i.e. trails, hunting, use of water, plants etc.
- Air borne contaminants.
- Separate workers and public into separate items (Item 8.3).
- Clarification was required on what is meant by economic benefits including meaning, definition and indicators.
- There was a discussion on whether benefiting the local economy should be added to long term economic benefits (item 5.1). This needs to be expanded to include benefiting local communities.
- Item 2.4 needs clarification, it should read long term risk to resources such as fish, water, wildlife etc.
- In relation to restoring habitat, how is this measured? Added to this should be monitoring and measuring improvements.
- Clarification was provided on item 17, Eliminate opportunity for catastrophic failure, specifically what kind of failure. The intent was mainly the dams.
- Barriers to animal migration.
- Need to add the human use of wildlife, along with traditional, and expand item 8.2 to include fish, wildlife and water.

Mine Area Studies (Attachment 7)

As an introduction to the Mine Area Studies, Tony Keen presented an overview of the key mine area components including pits, dumps, diversion, access road, haul road, mill area, treatment plants and water retention structures. A summary of the 2002 to 2004 mine area studies was then presented by SRK Consulting. Refer to Attachment 7 for the full presentation. The key areas of study include[DH1]:

- Review of physical risks;
- Waste rock geochemistry;
- Waste rock dump water balances;
- Waste rock dump water quality predictions; and
- Pit lake water quality predictions.

Review of Physical Risks (SRK Consulting)

- The objective of this study was to examine the failure risks associated with the major mine site components:
  - Pits
  - Diversions (those not associated with tailings)
  - Waste Rock Dumps
- Components associated with the tailings facility are being considered as part of other study programs.
- Failure mode and effects analysis was used which looks at the probability of various failure modes i.e. static failure, earthquake, extreme precipitation, weakened foundation, high phreatic level
- This analysis produces a total probability of failure.
- These numbers can then be compared to what would be expected from other projects based on risk of engineering structures.
- For pit walls, the Faro Pit east wall has the highest risk of failure.
- But mine pits are designed for a high risk of failure. They tend to have steep walls as the goal of pit is to get to the ore as quickly as possible and are generally as steep as possible to near failure.
- The key issue is the consequence of a pit wall failure. If there is a failure of the Faro Pit east wall, the entire Faro Diversion fails and flows into the pit. Generally for pit walls there are small consequences except when there is a diversion involved.
- With respect to waste rock piles, they have a much lower probability of failure. But again the key is the consequence. For example, the Faro North East Dumps compared to the North West

Dumps. Generally a low probability of failure with minor consequence except where perched above receiving water or above Little Creek Dam.

- The methods used to date do not tell how bad the failure might be. The failures predicted by these methods can be only a small movement of the waste pile.
- *With respect to risk of physical failure, is this a failure of any given magnitude? Did you look at whether the risk of a dump moving 50 meter or just the risk of the dump moving at all? The analysis done only tells you that a failure will occur, not the size. If there are serious concerns more analysis can be done to evaluate how big the failure could be. Also with some of the rock dumps, there may be re-sloping, this changes the risk.*

Waste Rock Dump Geochemistry (SRK Consulting)

- The objective of this study was to evaluate the current sources of contaminants and predict future changes in contaminant concentrations.
- Tasks included:
    - Review of existing information;
    - Seep surveys;
    - Surface waste rock mapping;
    - Test pits;
    - Waste rock drilling; and
    - Laboratory tests (static and column).
- The effect of waste rock management practices during mining can make it better or worse. On the Faro side pre 1970's there was none. After 1970's there was an "attempt" to build sulfide cells.
- At Vangorda, a sulfide cell was constructed in the Grum Dump and in the Vangorda Dump sulfide rocks were segregated and place in upland portion.
- The effects of geology were considered. The closer the source of waste rock was to the ore body, the more likely it will release contaminants. Certain types of rock release more metals than others.
- Effects of time - there are 4 stages of contaminant evolution details of which are presented in Slide 17. This is a concern as there is rock we know will eventually go acidic but now it is still neutral and not at its peak of contaminant generation. There is not much evidence of Stage 4 drainage on site.
- A waste rock classification system was been developed for both the Faro site and the Vangorda Plateau – Acid Generating (AG), Potentially Acid Generating (PAG), Acid Consuming and Non-Acid Generating (NAG).
- There is now a very good understanding of waste rock on the site. All the previous work done has been compiled and additional sampling has been done to fill in the database.
- Wells were drilled in the waste rock. In some of the holes there were elevated temperature indicative of the chemical reactions occurring. The reactions generate heat which sucks air into the pile and actually accelerates the reaction.
- All this information is then used to characterize the seepage types from the dumps and quantify contaminant loadings for each type. (See Attachment 7 Slide 24).
- There are still some scientific uncertainties but very little can be done to resolve them but continue to monitor seepage over time.

Waste Rock Dump Water Balances (R. Janowicz, Government of Yukon and Northern Hydrology Research Institute)

- The objective of this study is to develop an improved estimate of the amount of water infiltrating into the waste rock dumps.
- In 2003 installed meteorological stations and developed preliminary water balance estimates.
- The Cold Regions Hydrological Model, based and developed on Wolfe Creek research station near Whitehorse, was used to provide the preliminary estimates.
- The model still has some deficiencies, primarily the lack of calibration data. Only had December to February data to work with.
- The area has been divided into hydrological response units:
    - Flat surfaces – flattened; and
    - Bubble dumps – dumped but not flattened (2 m high piles).

- Also divided by north-facing, south-facing etc.
- Based on the preliminary predictions by month, the most important element is infiltration with none predicted over winter. Once thaw occurs you get significant in late June - July period.
- In 2004 weir were installed to measure run off. The meteorological data is being collected and the model will be refined based on the new data in December 2004.

Waste Rock Dump Water Quality Estimates (SRK Consulting)

- The objective of this study is to estimate the concentrations and loadings of contaminants in water draining from the waste rock dumps.
- This study pulls together all above to predict dump water quality coming out of the dumps.
- Empirical estimation method is being used based on rock type, mixing of rock in dumps and dump age.
- Water balance will provide the amount of water going into dumps and a spreadsheet model will be used to predict chemistry coming out.
- Faro results:
    - Current zinc load is 111 tonnes/year with 87% coming from ore stockpiles. A small area of the dumps causes a lot of loading (~1% of rock mass).
    - Future zinc load is not really expected to go up significantly.
- Vangorda results:
    - Current zinc load is 2tonnes/year.
    - Future zinc loading will be much worse - 91 tonnes/year.
- Grum results:
    - Current loading is 0.2 tonnes/year.
    - Future loading is estimated to be 61 tonnes/year.
- Sill working on worst case future predictions, which will be even higher than the above.
- The priority for closure is what can be done to ensure that the dumps don't get up to the future or worst case future loading – covers etc.
- *Where is the Zone 2 pit factored in? It is now treated as a dump (seepage) for the purposes of these calculations.*
- *Are the predicted future loads with in the Vangorda and Grum dumps due to sulfide loads? Yes for Grum. On the Vangorda side the sulfide cell is already acidic. The predicted loads are based on the possibility that the whole dump could go acid.*

Pit Lake Water Quality Estimates (SRK Consulting)

- The objective of this study is to establish intermediate and long term water quality estimates for the three pit lakes.
- Zinc concentrations in the pits:
    - Faro Pit – 1.5 – 11 mg/l
    - Vangorda Pit - 100 mg/l
    - Grum Pit – 4 – 12 mg/l
- If the pit water quality is going to get worse, then treatment costs would be effected as well as the approach for closure.
- A key question is whether we can allow the diversions to run through the pit? How long to fill up and what will be the water quality?
- Does the water flow in clean on surface and then flow out or does the lake mix due to the flow in? Is it stable? For these purposes it was assumed that it will mix.
- Predicted future water quality based on current water quality, creek inflow and other contaminant sources (pit walls etc.).
- All pits are predicted to have a zinc concentration of 1-2 mg/L, if the creek water is allowed to flow through them.
- These concentrations may be amenable to biological treatment.
- *The numbers given for pit presented are only due to dilution with no treatment. It also include some removal of cont. sources from dumps etc.*
- *If the Faro Pit filled up it would flow through the Zone 2 pit. Do these calculations include loading from Zone 2 Pit? No they assume flow out a spillway – plug dam.*

Mine Area Closure Methods (Attachment 8)

A summary of the 2003 to 2004 mine area closure method studies were presented by SRK Consulting. Refer to Attachment 6 for the full presentation. The key methods studied include:

- Waste rock covers
- Seepage collection
- Clean water diversions
- Pit lake treatment

The methods studied are the ones for which there was not sufficient information, they are not the only ones that may be considered.

Waste Rock Covers (SRK Consulting)

- Have the same objectives as those for tailings covers plus the enhancement of long term stability of surfaces and reduction of volume of ARD.
- The components of this study include:
    - Review of site literature;
    - Characterization of potential cover material;
    - Document site specific constructability issues;
    - Conduct scooping level modeling; and
    - Initiate large scale testing program.
- There are some existing examples of covers at the site:
    - Vangorda cover – It is being eroded, rill and sheet erosion, with fine material getting washed away leaving coarse material. There was not an attempt to re-vegetate this cover. The only vegetation seems to be growing at the bottom of the rills.
    - Grum till vegetation plots – There is good growth with an active seeding/revegetation program.
- The key source of potential cover material is till. It has a very low saturated hydraulic conductivity at 95 % proctor density. The in-situ density is lower but still good.
- Using a numerical model, the modeled infiltration is lower than that predicted by the preliminary water balance.
- It is not possible to stop all water from getting in dumps, but it can reduced which will result in a subsequent reduction in water treatment costs. It is a balance of costs.
- Re-sloping would be required for covering. The dumps are steep, typically at the angle of repose, and can't be worked on unless re-sloped.
- Of key importance is the area required to achieve the re-sloping. The Faro North East dumps, for example, would require significant area and encroach on the North Fork Rose Creek.
- The next requirement is to have a field test to evaluate how well covers will work. The test covers should be built with large scale construction equipment. The test covers will need to be instrumented.
- *With respect to the Vangorda cover, it is approximately 1 m thick and was packed with a Cat. It is not 95 % proctor*[DH2]*. This needs to be considered when you look at how much swell there is from frost, and impact of desiccation and precipitation. You must be cautious as to what you can achieve with this material.*
- *Is the requirement to source this material being looked at as part of this study? We are looking at till from the Vangorda area. If we want to use covers at the Faro side it will need to source from Vangorda or other sources.*
- *Given that the dumps are not intended to control oxidation, is there a critical timing element as to when a cover should be place on a dump, a trigger? If we have an adequate monitoring program there may be some dumps that don't need a cover immediately but later based on the trigger. Good idea.*

Grum Seepage Collection (SRK Consulting)

- The objective of seepage collection is to collect contaminated surface seepage and groundwater before it reaches the receiving environment.

- A good example is the Grum Seepage Collection Study. How do we protect Vangorda Creek in the long term?
- Information about the soil conditions has been looked at to reconstruct what is going on there. The bed rock is highly fractured under the dump providing a potential pathway for contaminants.
- With respect to water quality the Grum seeps are currently neutral, zinc is low (2 to 5 mg/l), sulfate greater than 500 mg/l with a trend of increasing sulfate concentrations.
- Conclusions – There are many good options available to collect surface water. It may also be possible to collect some of the groundwater using trenches. The amount that could be collected is unknown. A system of wells would be needed to collect all the groundwater.
- 2004 work:
  - Investigate trends in well at toe of dumps, identify trends and future collection requirements.
  - Determine if collection systems can be designed and subsequently costed.
  - Recommend additional field work where needed.
- *Are we assuming that we are collecting this water and treating at the treatment plant or are we looking at alternative treatment methods such as a biological treatment cell? Some of the results indicate we may have to collect sooner than later. For these ones you would want to go for a collection and treatment systems. For others with a low level problem perhaps use other options like a forced reactive barrier.*
- *It does seem that we are focusing on traditional methods – it would be good to expand to other alternative options.*

Vangorda Creek Diversion Options (SRK Consulting)

- The objective of this study is identify alternative preliminary designs and costs for the long-term closure of Vangorda Creek.
- The existing diversion was established when the pit was built. It reports to a drop box and then to Vangorda Creek. Vangorda Creek flooded on June 8th, 2004.
- First question is what is the stability of the pit wall next to the diversion. The entire diversion is presently in rock. There is also the issue of the rock slope above the flume.
- The stability of the pit wall can be influenced by faults – potential wedge failure. Due to the geometry of pit the walls this is not likely.
- The pit wall stability can also be influenced by the sloughing and raveling of the pit walls. This is significant above the flume. Below the flume the walls are currently stable but over the long term the probability of failure that could breach the diversion is 1:400.
- Given this stability issue, can't rely on stability of the diversion in the long term.
- The study investigated three potential options:
  - Upgrading existing alignment;
    - Issues – pit wall stability and potential for breach.
    - Costs - $3.4 million.
  - Partial backfill of pit and realignment of creek into constructed causeway; and
    - Issues – significant cost of backfilling.
    - Cost - $9.8 million.
  - Relocate to Dixon Creek.
    - Issues – changes to flow regime of Dixon and Shrimp Creeks.
    - Cost – $1.4 million.
- Other diversion methods – Faro Creek
  - Similar issues with pit stability.
  - 2 Options short listed:
    - Relocation higher up and divert to the west into Guardhouse Creek.
    - Relocation higher up and divert to the east.
- *With respect to the Dixon Creek option, would it enter upstream or downstream of Shrimp lake? Pretty sure upstream of that lake.*
- *For Option 2 for Vangorda Creek, is the causeway across the middle of the pit? Yes.*
- *For costing what size was used for flood event? On the Faro side 1:500 PMF and for Vangorda sized for the PMF but not sure.*

Pit Lake Treatment (Dr. G. Lawrence (UBC), Canmet and SRK)

- The objective of this study is to determine is there are treatment options for the pit lakes to clean the water. The study investigated both physical (stratification) and chemical (treatment) considerations.
- Physical considerations – stratification
  - Assess whether the layers that form in pit will be permanently stable
    - The physical stability depends on whether the creeks flow through pit lakes.
    - If the diversions remain in place it may be possible to achieve permanent stratification.
    - If the creeks are allowed to run through, the flow energy will cause mixing and disrupt layer stability.
- Chemical considerations – treatment
  - A literature search was carried out focusing on what treatment methods work and what doesn't:
    - application to in-situ treatment
    - status of technology
    - effectiveness
    - capital and operating costs
    - sustainability of systems
- Conclusions from 2003
  - Lime treatment has proven performance
  - Biological treatment is a promising technology where conditions are right
- Pit lake treatment 2004
  - Biological treatment tests:
    - Laboratory tests under way
  - Field test in Grum Pit scheduled for July
  - Physical stability will be investigated if treatment works.
- *In terms of context of having a closure plan and making decisions in first quarter of 2005 and given uncertainties for pit lake treatment, is the objective of this to make this a closure objective itself? We do have management studies on the effectiveness of pit lake treatment. Will we have enough information to do this? Should have the best information available to us this fall.*
- *Given the variability of the each pit are there not even more uncertainties? The design will be out for review. Testing pit as a whole and also building limnocorrals (3) it may be possible to test different types of water to test the ranges.*
- *Water temperature of water and other site conditions such as the impact of the heat wave on a short term study could be significant. It is not thought that this would have much of an effect. The zooplankton are very adaptable and should be able to deal with the various conditions.*

Group Exercise Number 3 (Tony Keen)

Each group was instructed to discuss the Area's of Interest and prioritize the top three. From this a new list was compiled (Attachment 9)

- Long Term protection of environment and human health
- Short and long term physical and chemical stability
- Need for integrated closure plan
- Community and economic benefits
- Cost effectiveness
- End land use to support maximum beneficial use of the site
- Standards and performance criteria
- Environmental mitigation (off-site), restoration (on-site) and enhancement
- Biodiversity
- Long term requirement for maintenance
- Restoration of productive fish habitats to levels equal or exceeding pre-mine levels

We now have a list of broad areas of interest. These are not objectives. This list will be used as a basis for discussion with the various groups.

Workshop Wrap Up and Next Steps (Tony Keen)

Tony Keen provided the following summary of next steps in the planning process:

- We are not at the point where we have the two streams (technical/community) coming together and working towards closure objectives
- The technical studies will continue with the goal of getting results in a timely fashion so that we can carry on with the planning process.
- A meeting is scheduled the week of June 28th in Ross River with Kaska. We also need to meet with other communities and government agencies.
- The development of closure objectives will not be an easy process but we need to move forward to keep the process going. We will need feedback, review and agreement.
- There are two more closure workshops planned: fall 2004 and early 2005.
- We have now gathered together the people who are likely to be involved in the process and we can now move forward with a common understanding of what we have done and where we are going.

Questions/comments:

- *What is the status of the study to develop a site water quality model? This is key to evaluate the methods with respect to impact on the receiving environment and the ability to achieve water quality objectives. Answer:A preliminary model has been developed. What is missing is the inputs. The development of the water balance for this can be based on the ongoing work. It has been on an hiatus while the studies are done then it will be resurrected.*
- *This should be issued for a review of the water balance and should be done right away.*
- *The YSC wanted clarification on the process and timing of providing feedback on closure objectives. Their next meeting not until august and there is a resource issue if you want to get worthwhile input from them. They do not have the resources available to devote any more time to this project this fiscal year, including workshops. It seems that the YSC is the only organization that has not been involved at the same level since 2003 and it is now being asked to come in piece meal and comment. This is difficult. There is an assumption that there is a constant level of information to all parties during the presentation. They do not see any of this information and this is problematic for them to participate.*
  DIAND responded - We can't assume that everyone is at the same level. One objective of these workshops was to bring everyone up to speed regarding what do they need to do within their mandate to feed the process. DIAND can't comment on access to funding. The individual organizations will need to talk to their funding agencies. There is the reality that we have a timeline and we have to meet this. There are some people who are not here who should be.

Faro Mine Closure Planning Technical Workshop – June 23/24, 2004

List of Attachments

Attachment 1	List of Attendees
Attachment 2	Workshop Overview, Summary of Technical Program and Development of Closure Objectives
Attachment 3	Basic Science and Engineering Technical Studies
Attachment 4	Tailings Technical Studies
Attachment 5	Tailings Closure Methods
Attachment 6	Area's of Interest from Group Exercise
Attachment 7	Mine Area Studies
Attachment 8	Mine Area Closure Methods
Attachment 9	Revised List of Areas of Interest from Group Exercise #3
Attachment 10	Summary of Presentation on Hydraulic Mining of Tailings by David Jansson from South Africa

Attachment 1 – List of Attendees

Faro Mines Technical Workshop No. 4
List of Attendees

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Faro Mine Closure Planning

Technical Workshop
Whitehorse
June 23/24, 2004

Workshop Overview

- Where are we now and what are we trying to accomplish in this workshop?
  - Workshop Objectives
  - Workshop Agenda

Workshop Objectives

To provide all stakeholders involved in the Faro closure planning process with a status update on the project and the plans to proceed:

- **Closure Planning**
  - Update participants on the status of the Faro Closure Planning project, structure and process
  - Review the process for development of Closure Objectives and provide workshop participants the opportunity to discuss areas of interest
- **Technical Studies**
  - Provide an overview of the Technical program to date
  - Provide an overview of the key issues relating to the tailings and mine areas, including ongoing and proposed technical studies and examples of closure methods

Workshop Agenda

- Wednesday Morning
  - Review of project status
  - Review of technical program to date
  - Development of closure objectives
  - Group exercise
- Wednesday Afternoon
  - Background technical studies
  - Rose Creek tailings
    - Overview
    - Technical studies, recent and planned
    - Examples of closure methods identified to date
    - Group discussion

Workshop Agenda

- Thursday Morning
  - Mine area issues and options
    - Overview
    - Technical studies, recent or planned
    - Examples of closure methods identified to date
    - Group discussion
- Thursday Afternoon (Optional)
  - Hydraulic monitoring presentation
  - June 8 storm event
  - Other technical questions


Questions?

Status Update

Background

- On April 1, 2003, administrative control of lands and resources was transferred from the Northern Affairs Program, DIAND to YG
- DIAND and the Government of Yukon have agreed to a co-operative approach to the environmental management of Type II Mine Sites that are under government care
- Type II Mines Project Office established to oversee interim care and maintenance through closure planning and final reclamation of these sites

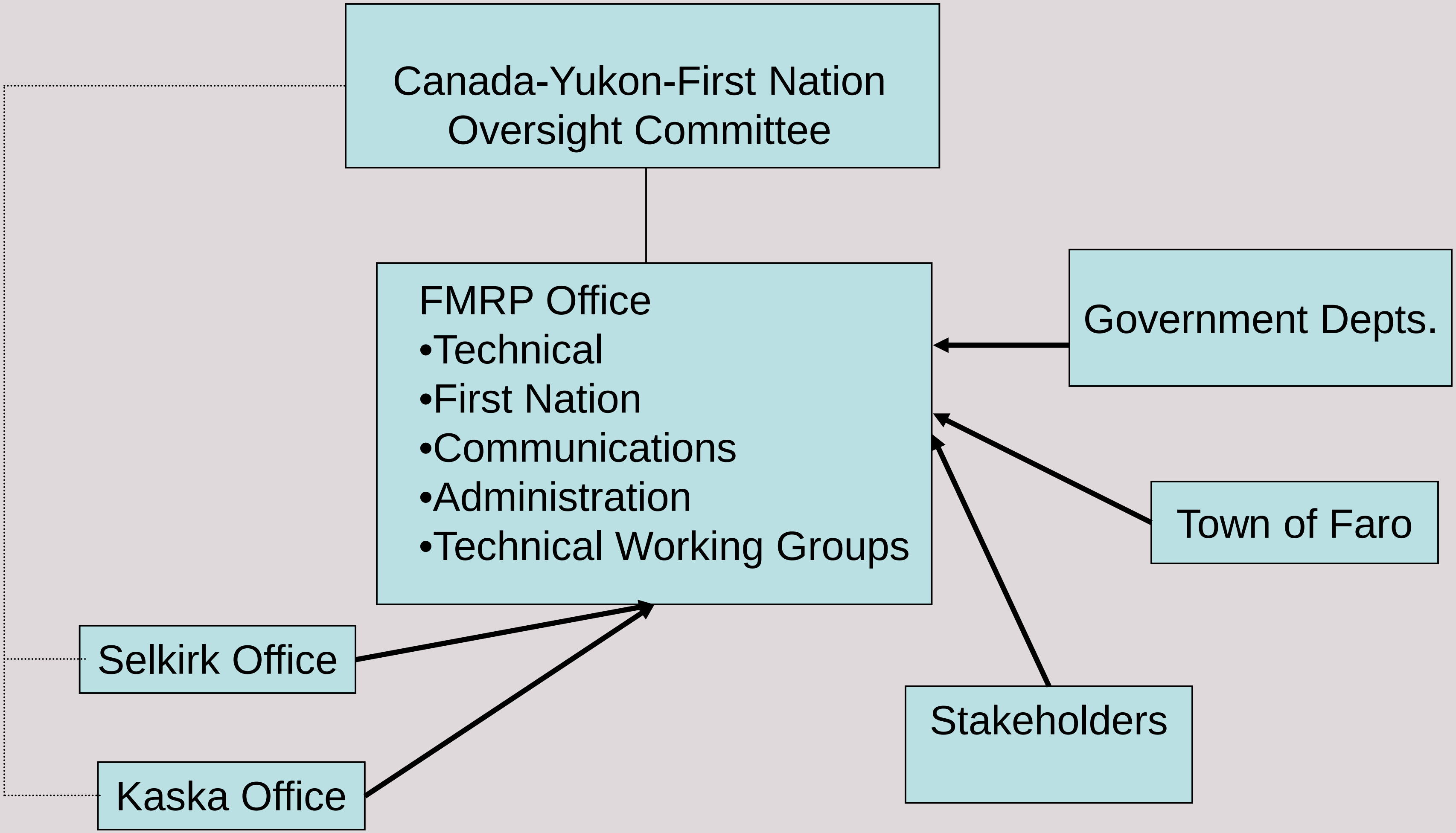
Faro Site

- DIAND and GY acknowledged in January 2003 that the Faro Anvil Range mine would not reopen
- DIAND and YG worked with the Kaska and the Selkirk First Nation, identified in the DTA as Affected First Nations, on partnership process to prepare a Faro Mine Closure Plan
- Agreement reached on process in January 04

Planning/Management Structure

- Senior Level Oversight Committee
- Whitehorse based Faro Mine Closure Planning office
- Community based First Nation offices
  - Ross River based Kaska office
  - Pelly Crossing resource person/office (half time)
- Town of Faro
  - liaison person (part-time)
- Stakeholder advisory group

Closure Planning Structure



Closure Planning Management

- Faro Closure Planning Office to have responsibility for:
  - Overseeing mine remediation planning at the Faro Anvil Range site
  - Assuming the management of ongoing technical studies relating to closure
- Interim Receiver will focus on the legal and care and maintenance issues

Principles

- Open and transparent process
- Sharing of information
- Support community understanding and involvement
- Respectful decision making process

Steps in Closure

- Closure Plan development
  - Studies/research
  - Closure objectives
  - Development of alternatives
  - Selection of preferred alternative
  - Final plan development
- Funding approval

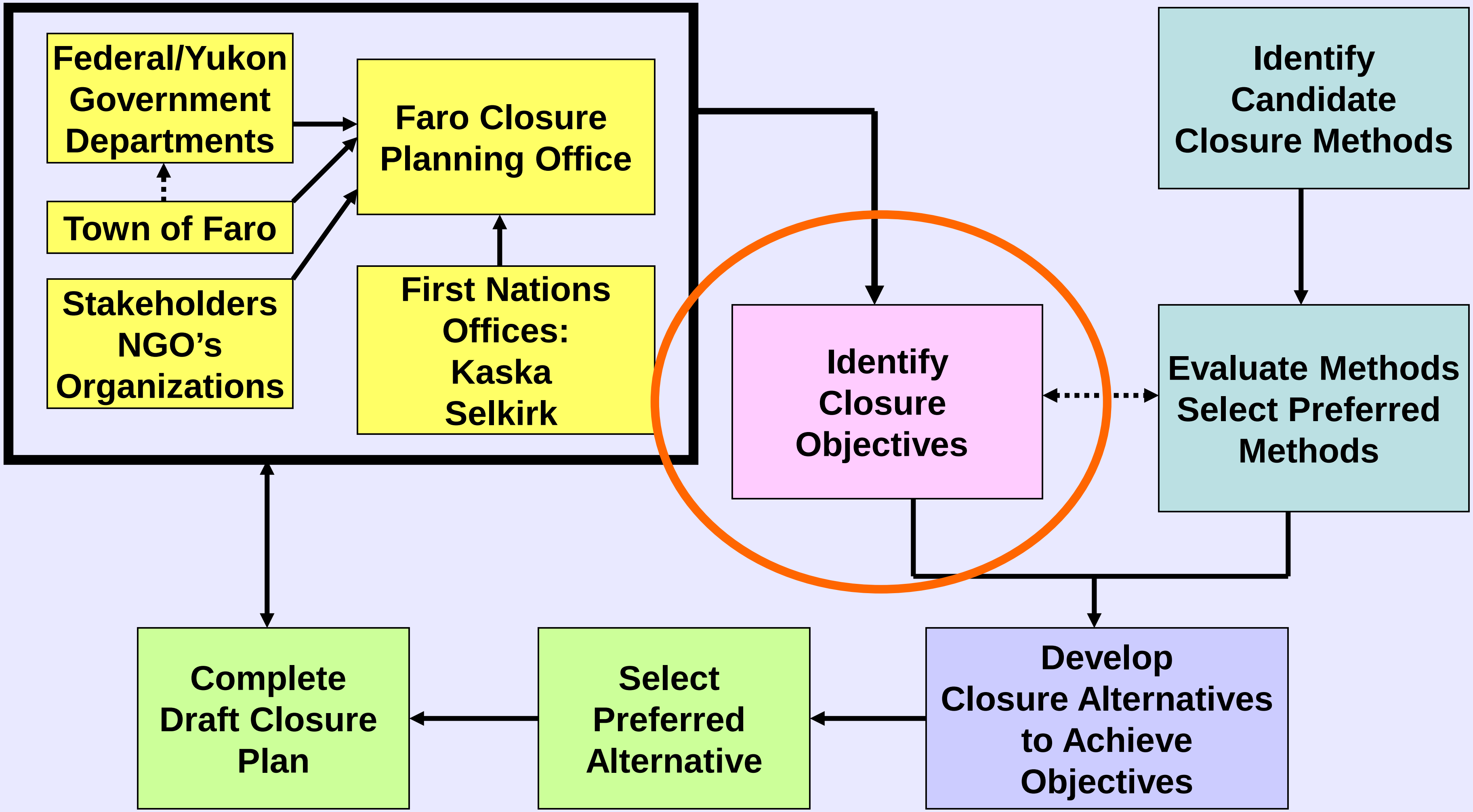
Steps in Closure (cont'd)

- Closure Plan approval
  - Environmental assessment
  - Regulatory approvals
- Implementation of Closure Plan
  - Issue contracts
  - Monitoring of work
  - Revisions as required
- Post Closure
  - Monitoring
  - Maintenance
  - Water treatment

Next Steps

- Continuation of technical studies to fill data gaps
- Community meetings/discussions to identify areas of interest for closure
- Development of overall closure objectives based on input from all
- Evaluation of candidate closure methods using closure objectives to select preferred methods
- Development of closure alternatives
- Select preferred alternative

Faro Closure Planning Process



Closure Plan Development– Overall Timeline

2004 ← **Closure Plan Dev.** → **Dec. 2006** ← **Closure Plan Approval** → **2008**

Closure Plan Dev.

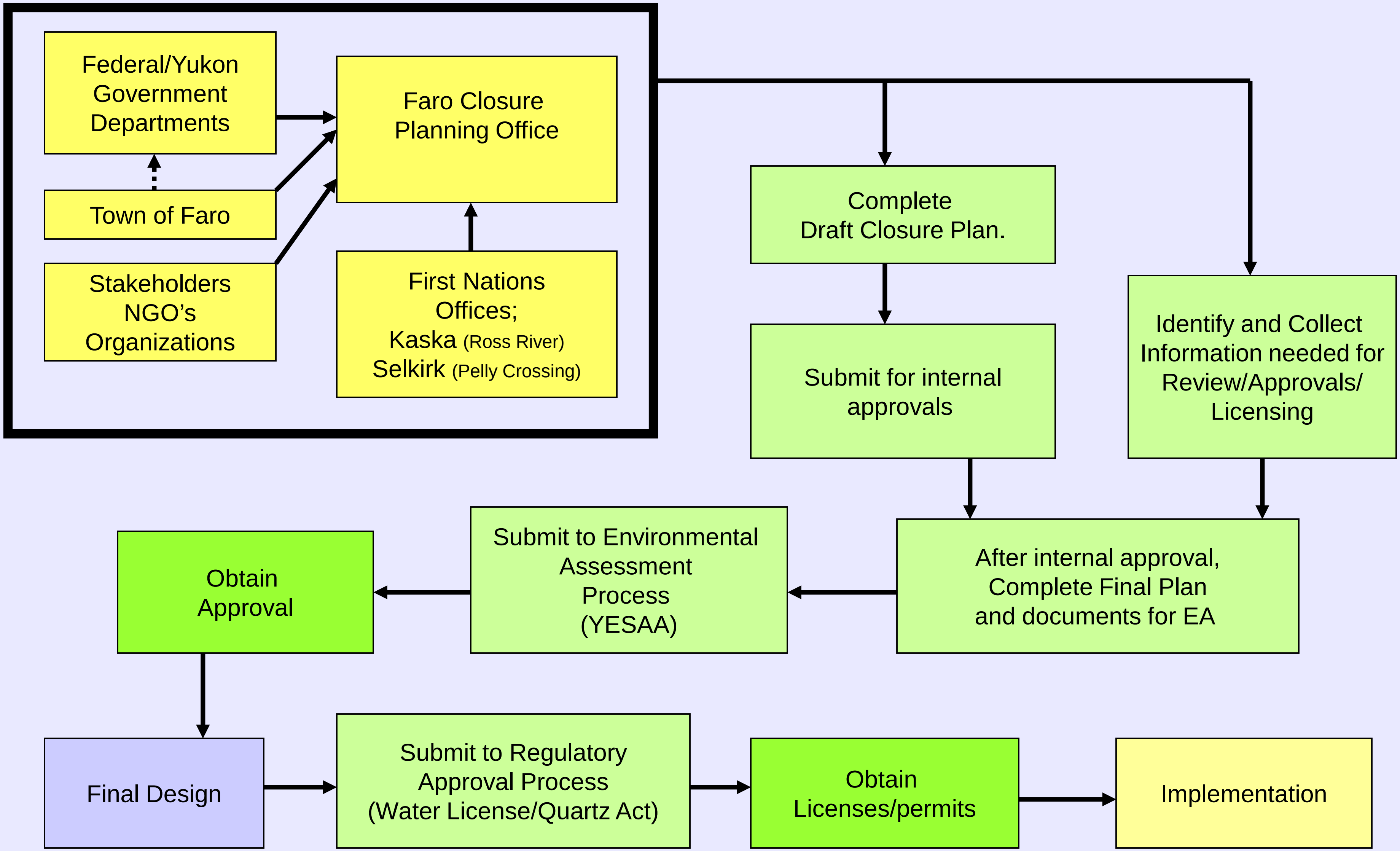
- **Studies/Research**
- **Closure Objectives**
- **Development of Alternatives**
- **Selection of preferred Alternative (Early 2005)**
- **Final Plan Development**
- **Internal approvals**

Closure Plan Approval

- **Environmental Assessment**
- **Regulatory Approvals**

2004 ← **Faro Closure Planning Office** → **2008**

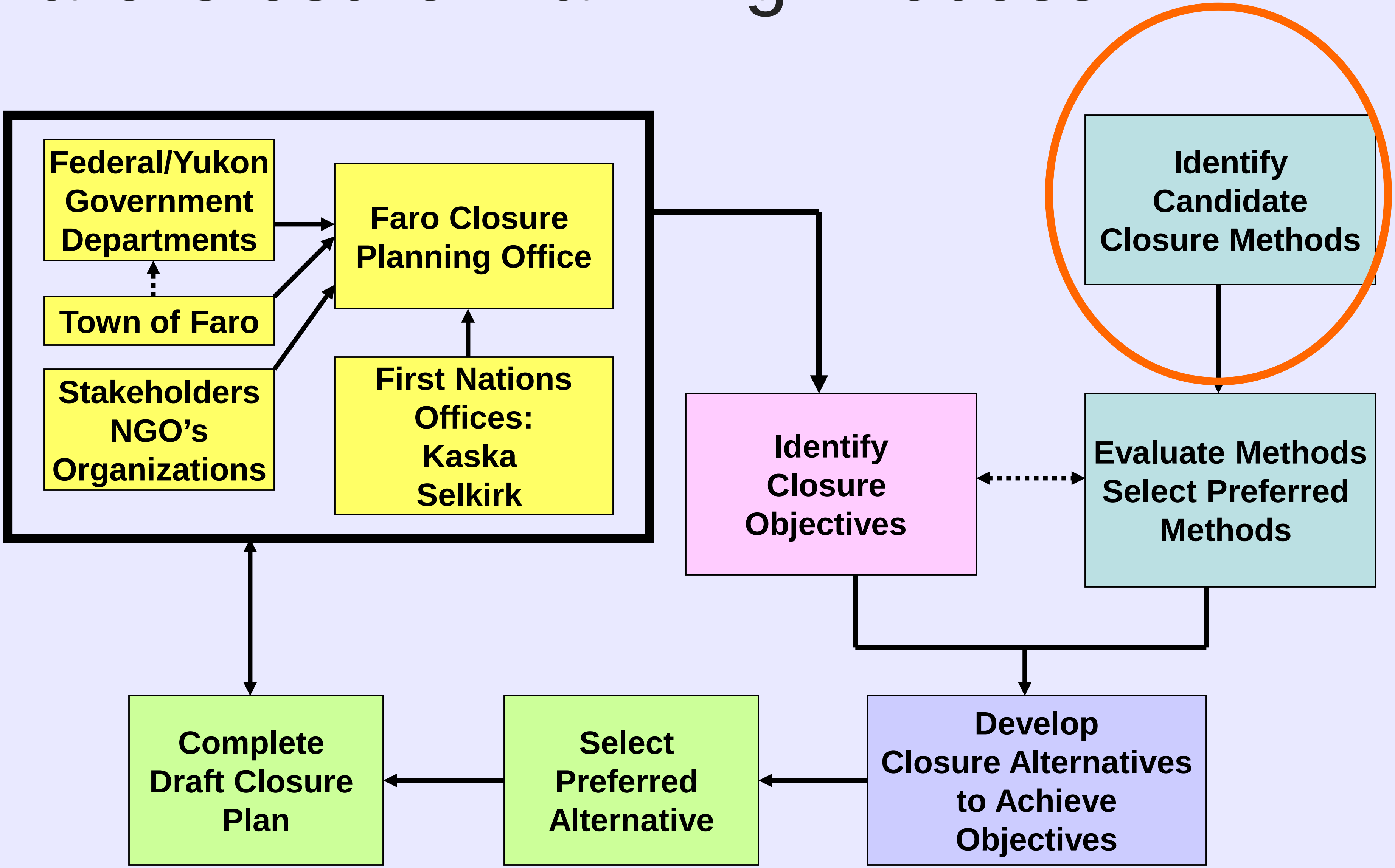
Faro Closure Plan Approval Process




Questions?

Technical Program To Date

Faro Closure Planning Process



Previous Closure Planning

- Four closure planning documents prepared to date for Faro site
  - Faro Mine Tailings Abandonment Plan, 1981
  - Abandonment Submission, 1988
  - Down Valley Tailings Abandonment Plan, 1991
  - Integrated Comprehensive Abandonment Plan, 1996
- Initial closure plans for Vangorda/Grum; 1989 Initial Environmental Evaluation and water license application

Re-evaluation of Previous Work

- Information gaps/unknowns in earlier plans
- Advances in mine reclamation technology
- Complex nature of environmental issues
- Wide range of closure options and costs presented to date
- Previous closure measures no longer possible
- Need to ensure environmental protection is maximized and options are cost-effective

Key Technical Gaps

- Water quality predictions for seepage from waste rock dumps and open pits
- Groundwater contamination below the tailings
- Required surface water diversion closure measures
- Understanding of surface and groundwater flow paths, treatment requirements and options
- Alternative tailings, waste dump and pit closure measures

Technical Program

- April 2002 – Initial workshop
- Aug-Dec 2002 - Field studies
- Jan 2003 - TAC meeting
- June 2003 –Whitehorse workshop
- Aug-Dec 2003 – Field studies
- Feb 2004 – Vancouver workshop
- Future technical program

April 2002 Initial Workshop

- Purpose:
  - Development of technical task list and schedule for closure planning
- Participants:
  - DIAND
  - Deloitte & Touche
  - Faro/Vangorda engineers
  - External specialists

2002 Workshop Highlights

- Brainstorming of closure “methods”:
  - Pits - 12 methods
  - Waste rock dumps – 15 methods
  - Water management – 11 methods
- Not possible to implement existing ICAP:
  - Development of “example alternatives”
  - Need to have new dates in Water License
- Information needs and investigation plans

2002 Technical Studies

- Scoping studies
- Risk-based design criteria
- ARD studies
- Borrow sources
- Tailings groundwater
- Faro Creek diversion option
- Vangorda flume options

January 2003 TAC Meeting

- Presentation of results from April 2002 Initial Technical Workshop and results of 2002 studies
- Decision to include broader group in planning of 2003 technical studies

June 2003 Workshop

- Whitehorse
- Participation
  - DIAND, YTG
  - Kaska
  - Selkirk
  - Town of Faro
  - EC, DFO
  - Experts

June 2003 Workshop

- Technical focus
  - Reviewed methods, example alternatives, information needs, investigations
  - Developed task list, cost estimates for 2003 technical studies
  - Subsequent development of detailed plan
- Recognized need to initiate work on closure objectives

2003 Technical Studies

- Water Quality
  - ARD monitoring and lab studies
  - Dump water balances
  - Dump water quality predictions
  - Pit lake water quality
- Hydrology Studies
  - Faro & Vangorda Creek Hydrology
  - Tailings groundwater
  - Requirement for groundwater collection
  - Requirement for Grum seepage collection
- Geotechnical Studies
- Closure Method Studies

2003 Technical Studies

- Geotechnical Studies
  - Earthquake hazard studies
  - Tailings physical properties
  - Seismic stability assessment
  - Rose Creek Diversion Options
- Closure Method Studies
  - Tailings relocation methods & Plug Dam studies
  - Tailings cover methods
  - Waste rock cover methods
  - Pit lake treatment methods

February 2004 Technical Workshop

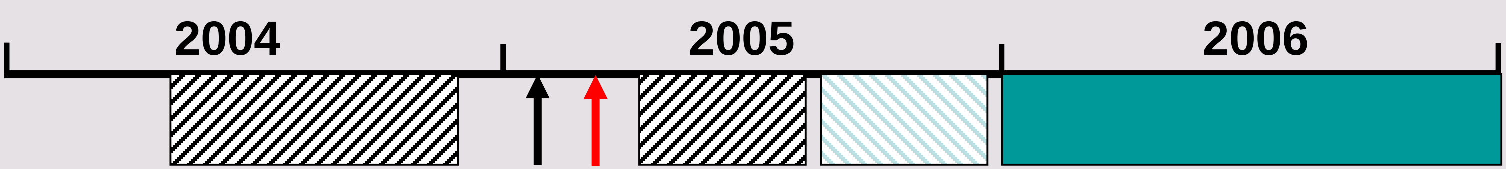
- Presentation and review of 2003 studies
- Discussion of key technical concerns
  - Tailings relocation
  - Tailings stabilization
  - Mine area closure
- Information needs and 2004 study plans

2004 Technical Studies

- Detailed proposals
  - Collecting proposals for all projects
- Review of proposals – next 2 weeks
- Initiation of projects in June and July

Implications for Schedule

- June-Dec 2004 – Complete investigations
- Q1 2005 – Technical synthesis
- Q2 2005 – Select preferred methods
- June-Sep 2005 – Final def'n of methods
- Sep-Dec 2005 – Prepare draft FCRP
- Jan-Dec 2006 – Internal approvals and finalization of FCRP



Questions?

Development of Closure Objectives

Introduction

- Example definitions
- Process for development of closure objectives
- Examples of closure objectives at other mines

Example Definitions

- **Closure:** the whole process of carrying out a number of activities, based on clear objectives, to leave the site safe, stable and with minimum ongoing environmental impacts
- **Reclamation**: the return of a disturbed site to some agreed land use
- **Remediation**: the clean up or mitigation of pollution or of contamination of soil or water by various methods

Example Definitions (cont'd)

- **Rehabilitation**: the return of disturbed land to a stable, productive, and self sustaining condition, after taking into account beneficial uses of the site and surrounding land
- **Restoration**: recreating the original topography and re-establishing the previous land use in a self sustaining condition

Closure Objectives

- What are Closure Objectives?
  - Broader overall objectives for mine closure in relation to social, environmental, financial and safety aspects
- Why do we need them?
  - To provide a basis for selecting preferred closure methods
- Must be defined early in the development of a mine closure plan

Important Questions

- What are the long-term environmental, socio-economic and safety concerns?
- What are the feasible end use options for the mine site?
- Is it possible to reach a “walk away” status considering residual risk and associated costs?

Objectives vs Methods vs Alternatives

- **Closure Objectives** – broader overall objectives for closure in relation to social, environmental, financial and safety aspects
  - e.g. prevent contamination of water
- **Methods** – These are the individual steps that may be required to achieve objective
  - e.g. cover waste rock piles
- **Alternatives** – These are a combination of methods required to achieve the objective
  - e.g. cover waste rock piles + collect and treat dump seepage

Closure Objectives vs Standards/Criteria

- **Closure Objectives** – broader overall objectives for closure in relation to social, environmental, financial and safety aspects

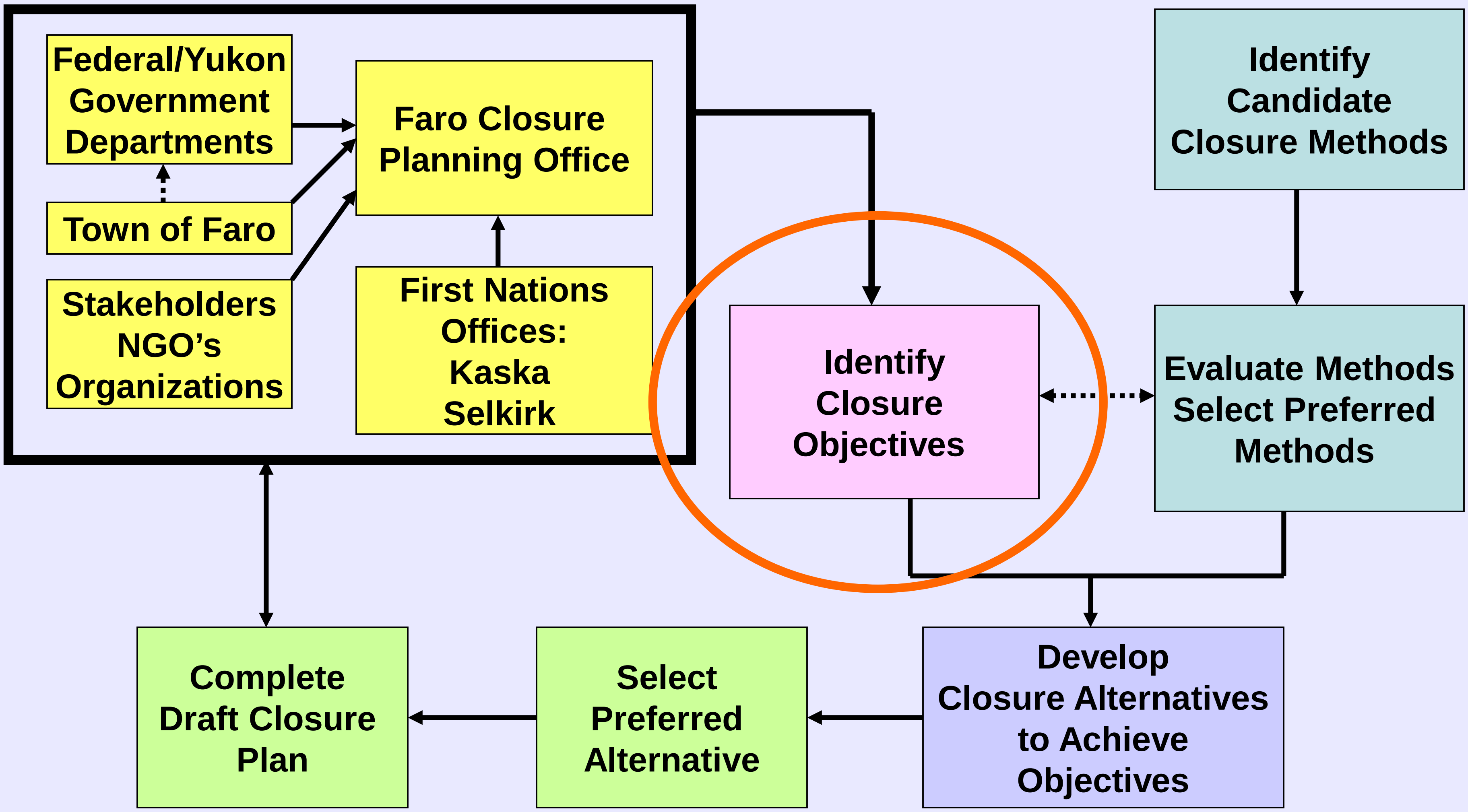
- **Standards/Criteria** – baseline to determine the performance of various components of the plan. For example Receiving Water Criteria for the Protection of Aquatic Life (CCME) and Engineering Design Criteria for Dams (Maximum Credible Earthquake (MCE))

Development of Closure Objectives

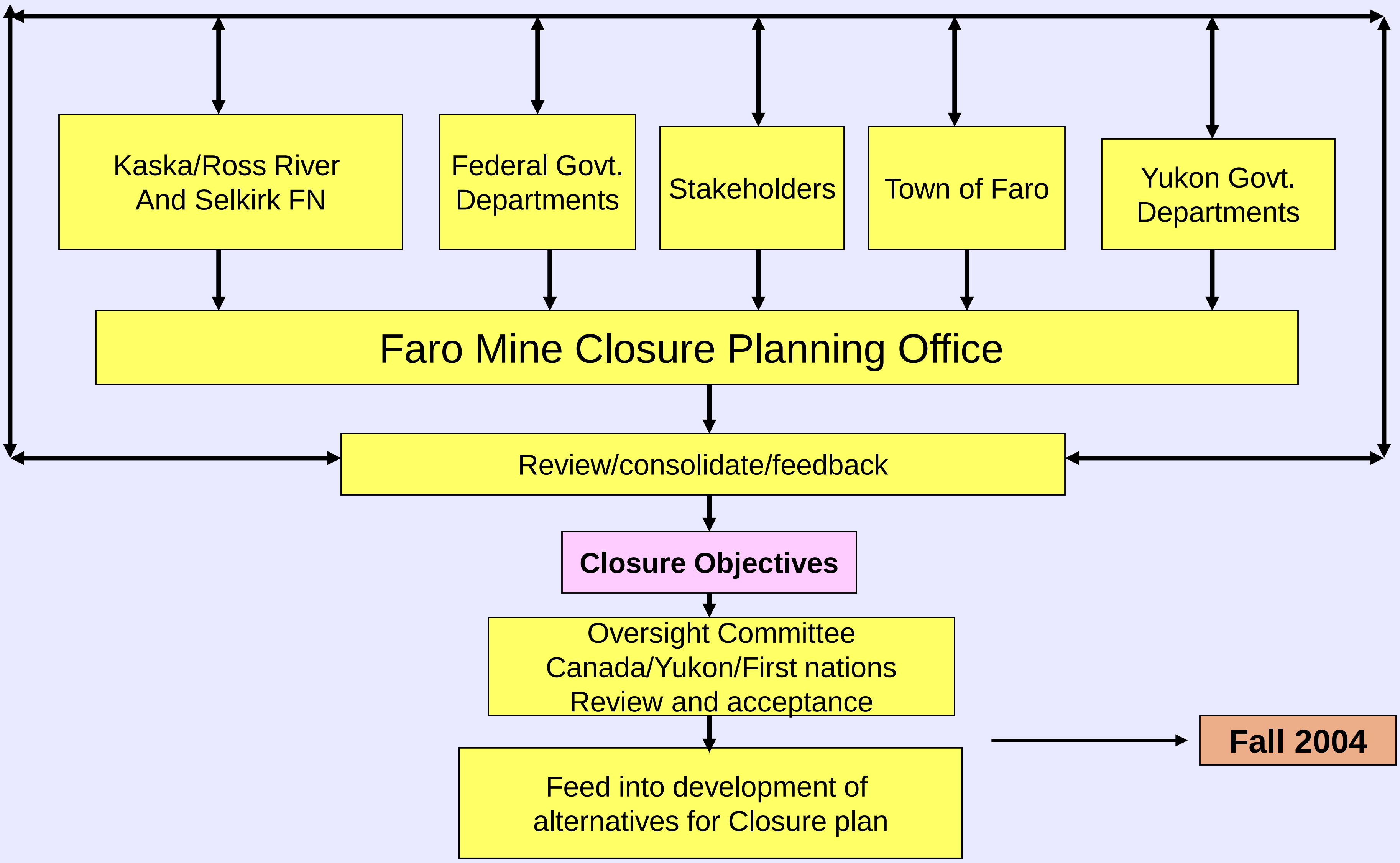
- Each stakeholder can start with different objectives, depending upon their relationship with the mine site area
  - End land use
  - Water quality
  - Cost effectiveness

- The selection of final closure objectives often weighs the balance between various stakeholder inputs

Faro Closure Planning Process



Process for Development of Faro Closure Objectives



Closure Objective Examples

Typical Closure Issues

- Technical Issues
  - Risk of failure
  - Physical stability
  - Chemical stability
  - Land Use
  - Protection of Water Resources
- Social Issues
  - Post-closure activity
  - Duration of mine closure work
  - Leadership/perception
  - Socio-economic
- Economic Issues
  - Cost
  - Timing of work

Closure Objectives – Polaris Mine

- To ensure that the site returns to a condition such that public health and safety, and the environment are protected.
- To provide a working document in which to address the concerns and requirements of all stakeholders during the consultation and implementation stages.
- To ensure that the planned activities during decommissioning are such that the requirements for long term care and maintenance are eliminated or minimized.
- To identify those activities required to return the site to an aesthetically acceptable condition.

WISMUT Project, Germany

- Cost
  - Alternative costs
  - Water Treatment Costs
  - Land Value
- Risk
  - Human Health
  - Worker Health
  - Institutional Risk
- Acceptance
  - Local Public
  - Regulatory Agencies
  - Funding Agency

Giant Mine, NWT

- Short-term risk of arsenic release
- Long-term risk of arsenic release
- Worker health and safety risks
- Cost
- Community acceptance

Colomac Mine, NWT

- Environmental protection
- Human health and safety
- Dogrib acceptance
- Other public acceptance
- Cost
- Long-term effectiveness
- Permitting schedule
- Implementation schedule
- Technical certainty
- Corporate (DIAND) objectives

Questions?

Group Exercise

Development of Closure Objectives

- First Step
  - What do people really care about?
    - e.g. water quality, health and safety, land use
- Second Step
  - What are the broad goals?
- Third Step
  - Specific objectives
- Fourth Step
  - Agreement on objectives

Basic Technical Studies

Overview of Projects
2002 - 2004

List of Studies

- Aerial photos and mapping
- Seismic evaluation
- Hydrology and flood estimates
- Borrow sources
- Scoping studies
- Water treatment cost estimates
- Terrestrial effects
- Site specific water quality objectives

Aerial Photos and Mapping

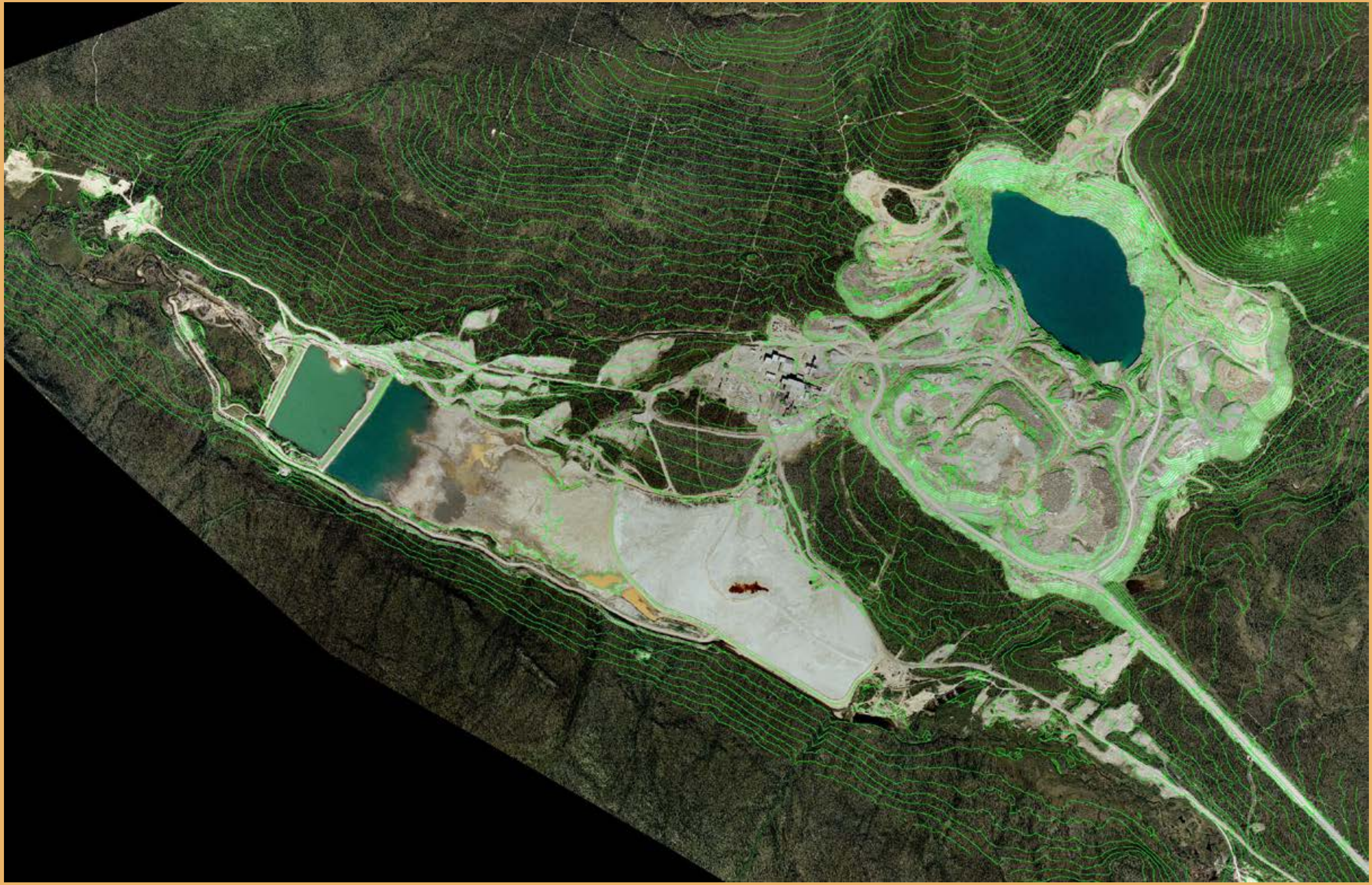
- Flights in July 2003
- Black & white at 1:10,000 and 1:20,000
- Ortho-rectified
- Topographic maps
  - 2m contours
- Colour at 1:40,000

Aerial Photos and Mapping

- Faro Mine and Tailings Areas

Aerial Photos and Mapping

- Faro Mine and Tailings Areas



Aerial Photos and Mapping

- Vangorda/Grum Mine Areas

Aerial Photos and Mapping

- Vangorda/Grum Mine Areas

Seismic Evaluation

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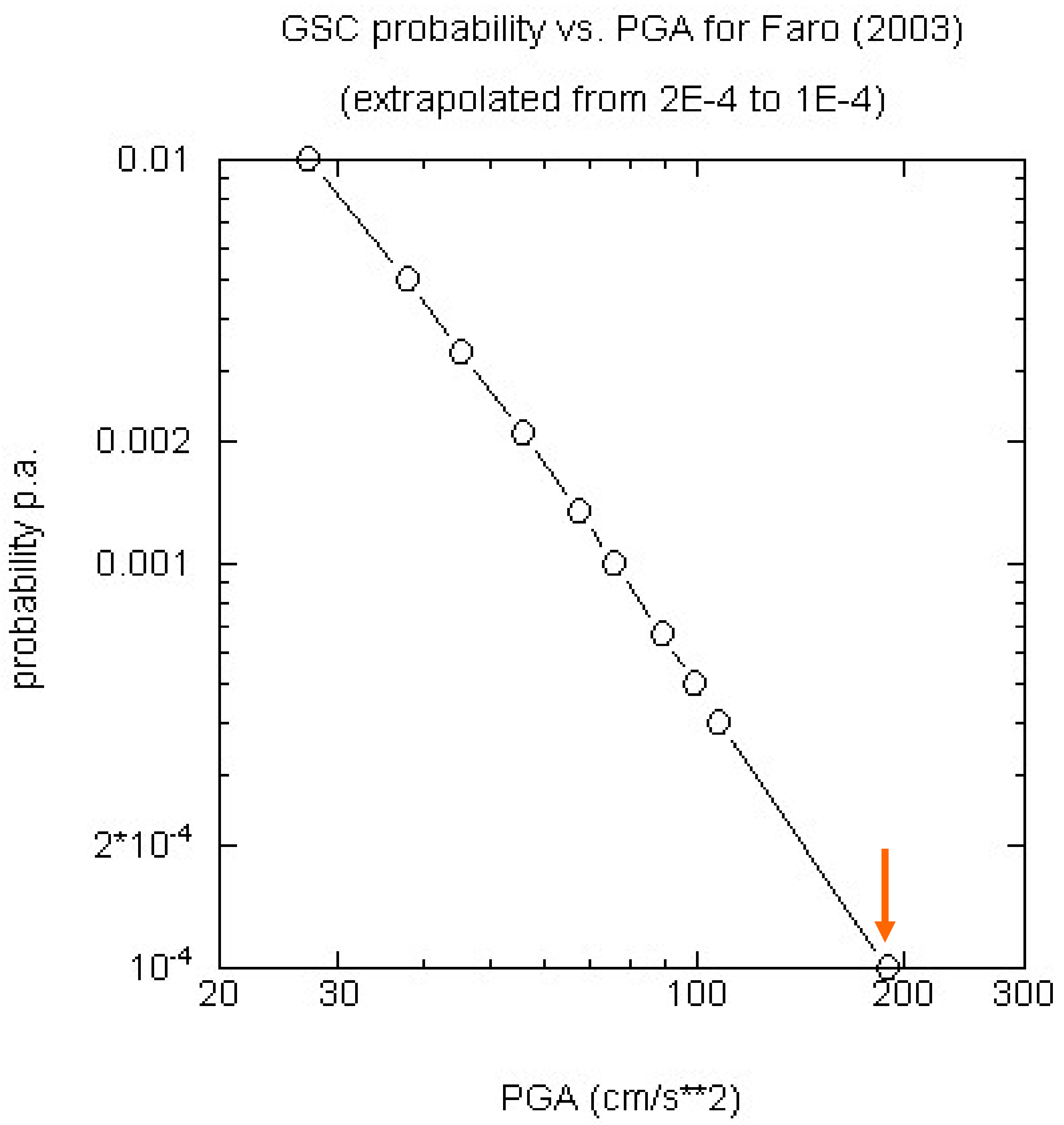
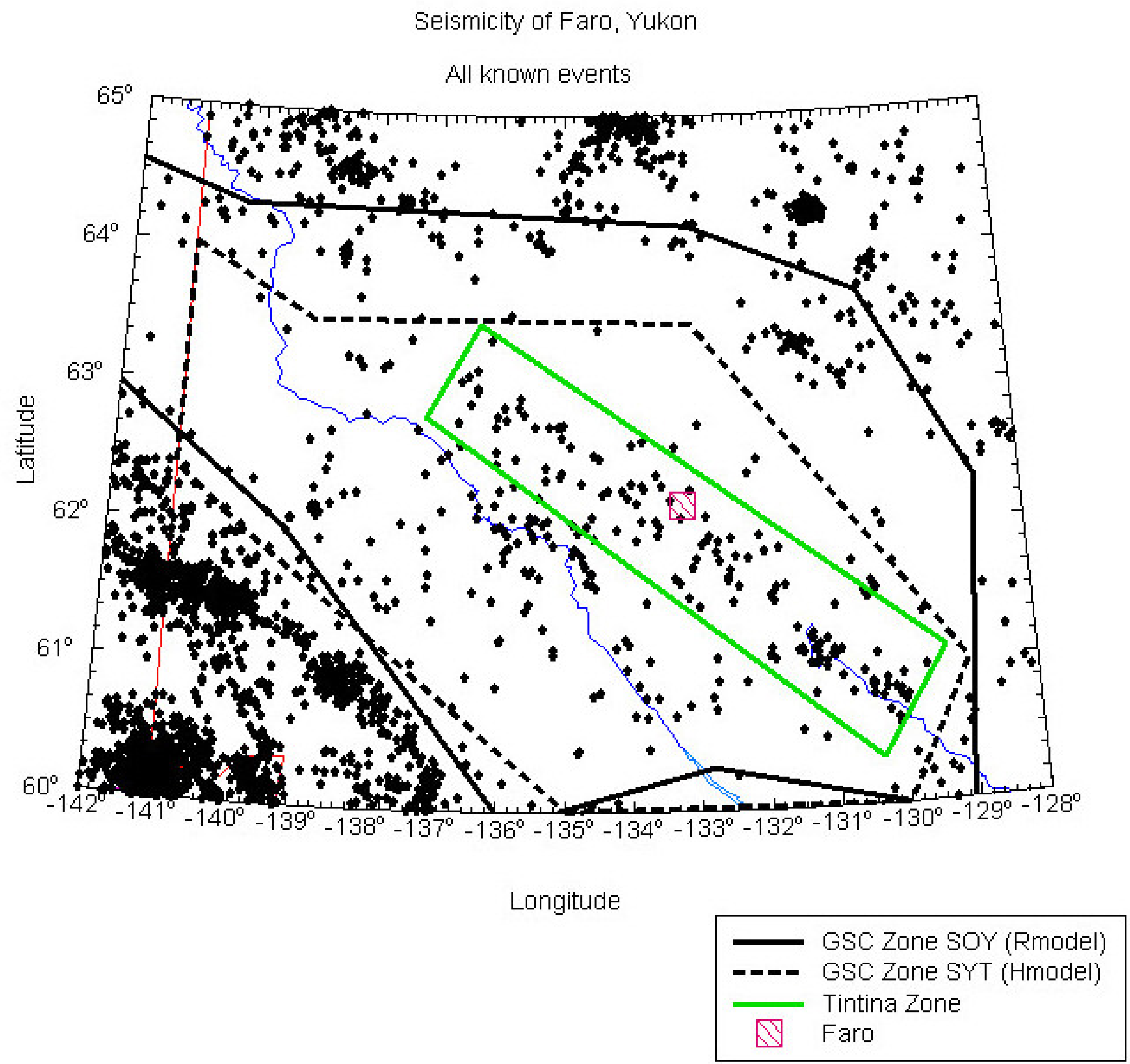


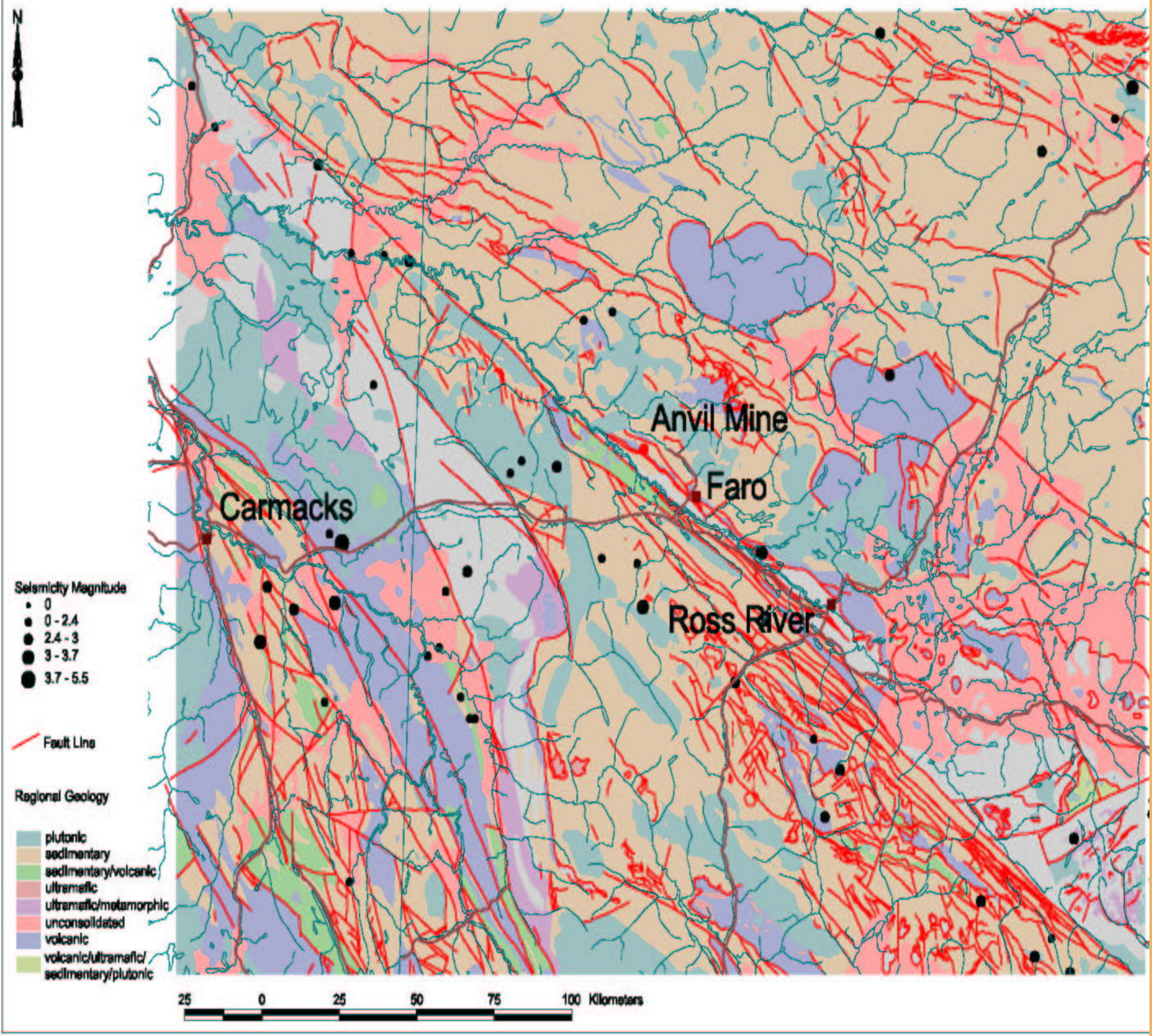
GSC PGA calculation for Faro.

Firm ground NEHRP C site conditions



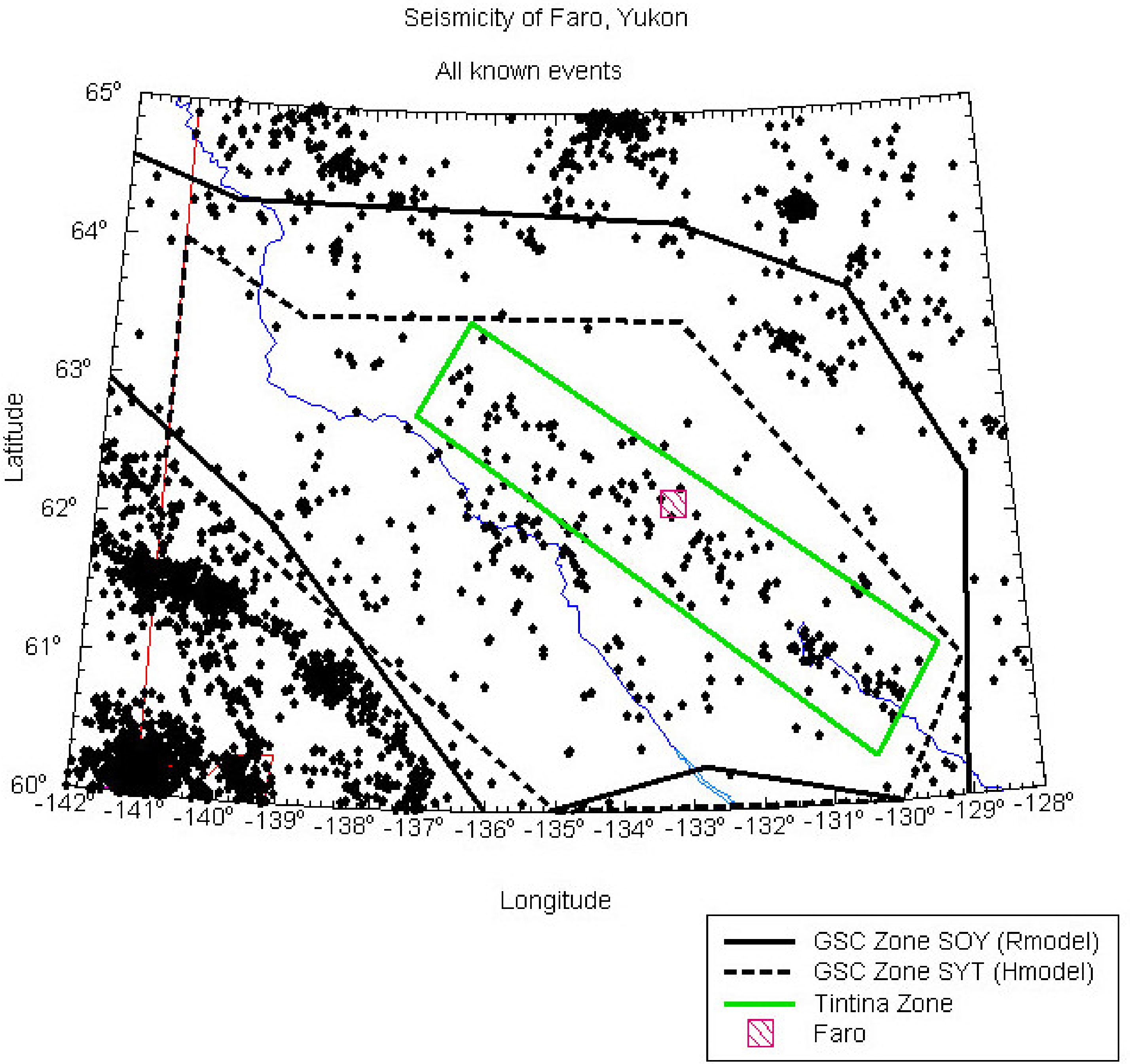
Seismicity of Faro region – all known events.

Green box outlines apparent linear seismicity trend along Tintina Trench



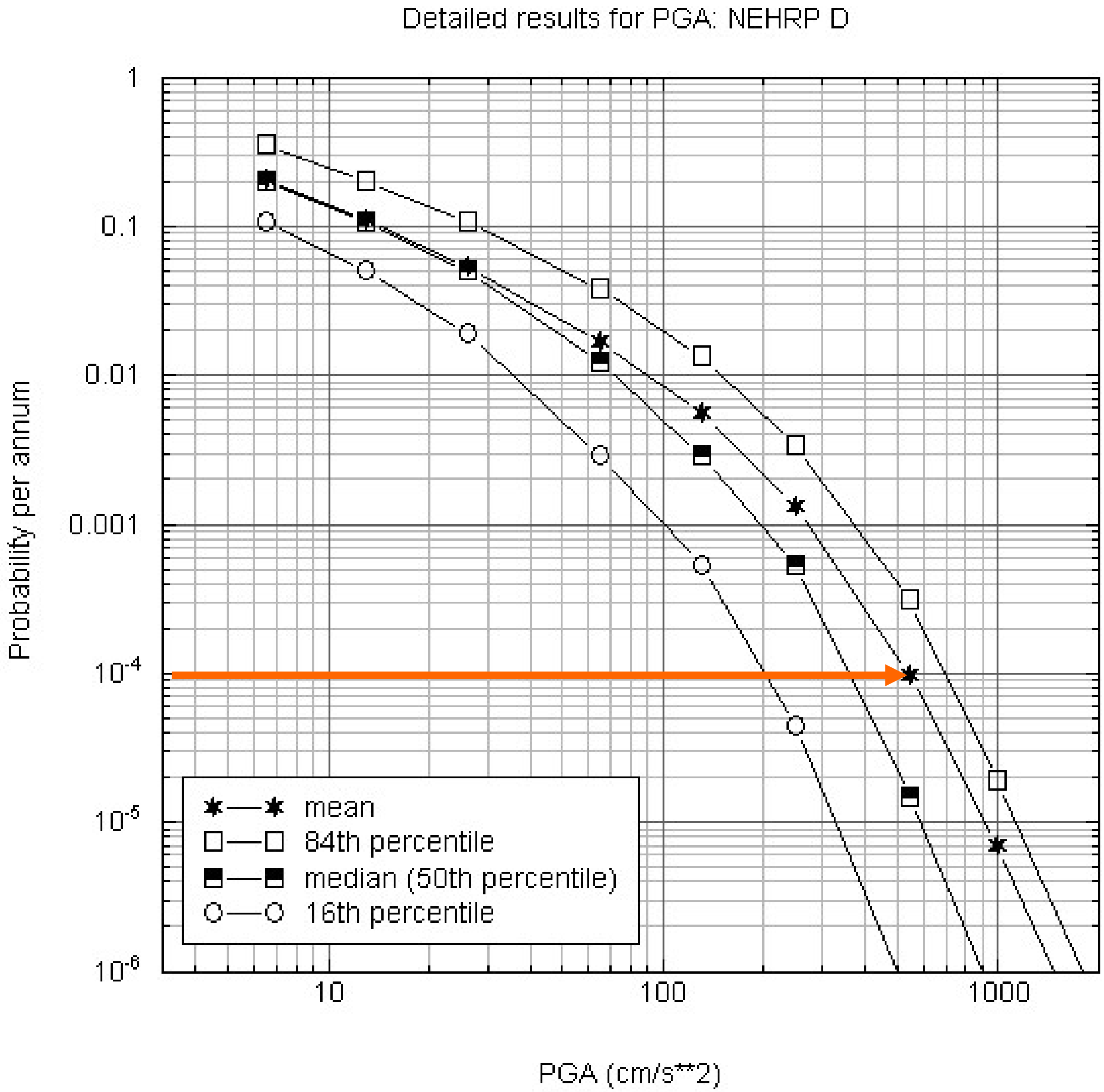
Bedrock faults from Smith (2003) report.

Note the linear fault alignment near Faro that marks the Tintina Trench system.



Weights given to various zone models in hazard analysis:

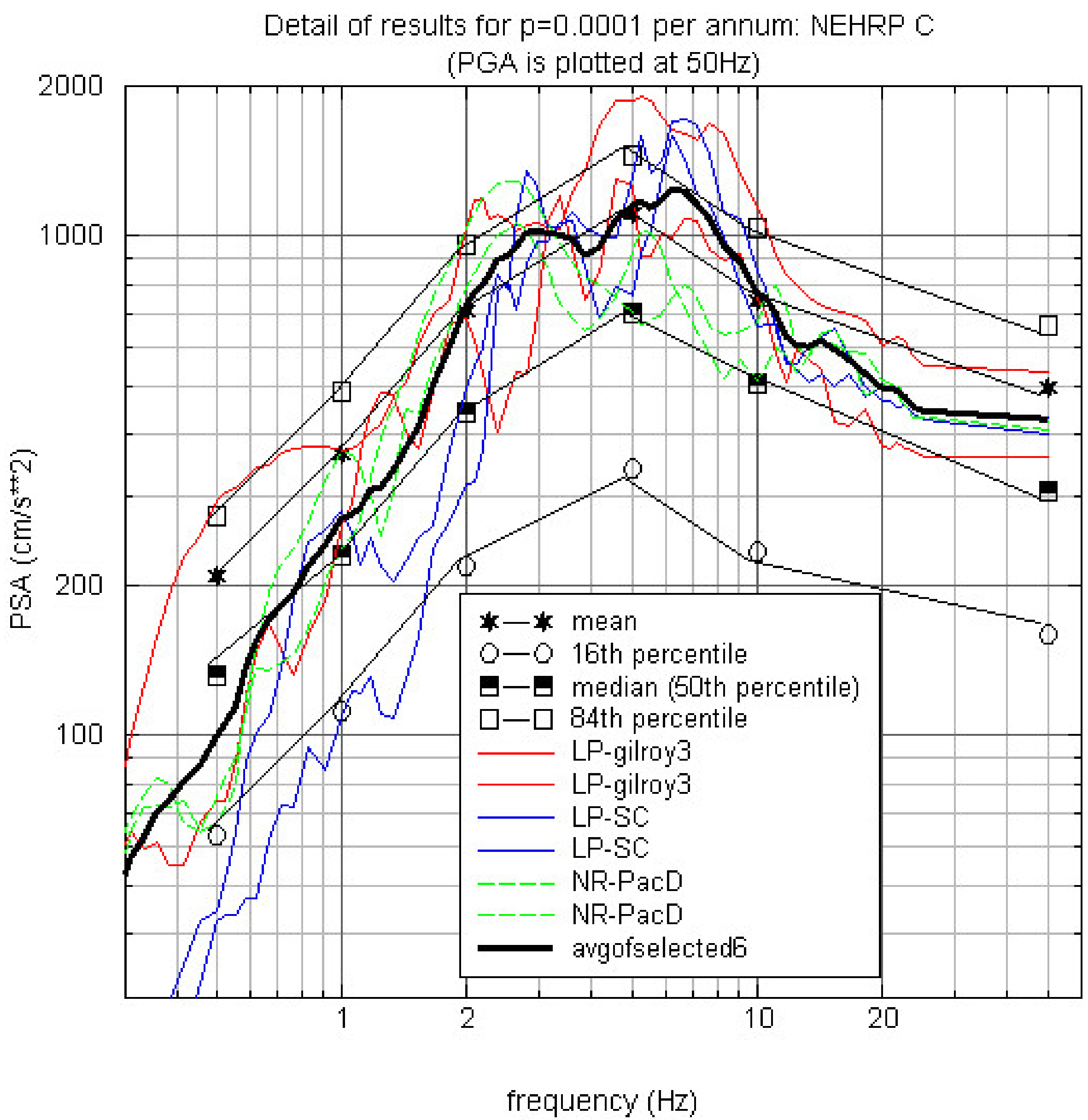
0.33 SYT
0.34 Tintina area source
0.33 Tintina fault source (3 dips considered)



Detailed view of PGA versus probability at Faro, for NEHRP D conditions

Geologic Support for Evaluation

- Geologic slip of 500 to 1000 km in last 65 million yrs →8 mm/yr
- Other evidence (including GPS) suggests 1 to 5 mm/yr
- Seismicity rates consistent with about 4 mm/yr (ranging from 1 to 10 mm/yr)
- Conclude that adopted recurrence relations are consistent with long-term slip rates on Tintina



Spectra for p=0.0001 per annum at Faro, for NEHRP C conditions, in comparison to the spectra of selected time histories.

Records denoted LP are from the Loma Prieta earthquake (Gilroy3 and Lick Observatory); records denoted NR are from the Northridge earthquake (downstream record of Pacoima Dam).

Hydrology and Flood Flows

Barry Evans,

nhc consulting inc.

Scope of Work

- Review all flow data for Faro and Vangorda Creeks
- Update flood estimates for mine site sub-basins up to the 1000-year flood
- Review probable maximum flood estimates for Rose Creek

Flood Estimates

Mine Site Sub-basins	Area (km^2)	Flood Discharge (Instantaneous)					
		Mean	50-year	100-year	200-year	500-year	1000-year
North Fork Rose Cr. above Faro Creek Div. (Stn. R7)	95	9.2	37	45	54	67	77
Faro Creek Diversion above North Fork Rose Cr.	16	1.9	7.7	9.4	11	14	16
North Fork Rose Cr. at Flow-through Rock Drain	118	11	44	54	65	81	93
Fresh Water Supply Dam (FWSD) catchment	67	6.8	27	33	40	49	57
Rose Creek above Rose Creek Diversion	203	18	71	86	103	130	150
Rose Creek downstream of Rose Creek Div. (Stn. X 14)	230	20	79	96	115	145	167

PMF Estimates

Mine Site Sub-basins	Drainage Area (km^2)	PMF Peak Discharge (m^3/s)
North Fork Rose Creek at Flow-through Rock Drain	118	504
Fresh Water Supply Dam (FWSD) Catchment	67	354
Rose Creek above Rose Creek Diversion	203	690
Rose Creek downstream of Rose Creek Diversion (Station X 14)	230	783

Key Uncertainties

- Resolve discrepancy between the data of the two Vangorda Creek gauging stations
- Improve PMF estimates by measuring
  - time to peak estimates
  - collect short duration rainfall and flow data

Borrow Source Surveys

Borrow Source Survey

- Purpose
  - To develop an inventory of borrow sources and associated costs
- Scope
  - Define possible material requirements
  - Complete two phase borrow source survey
    - Document review and air photo interpretation
    - Field testing of accessible sources

Borrow Material Types

Soil Type	Potential Use
Cohesive soil	Low permeability covers, vegetative covers, stabilizing fill, general fill
Granular soil	Filter or drain material, stabilizing fill, general fill, road fill, protective covers for geosynthetic materials, erosion protection and concrete aggregate
Coarse granular soil	Erosion protection in channels (riprap) and road ballast
Organic soils	Vegetative covers

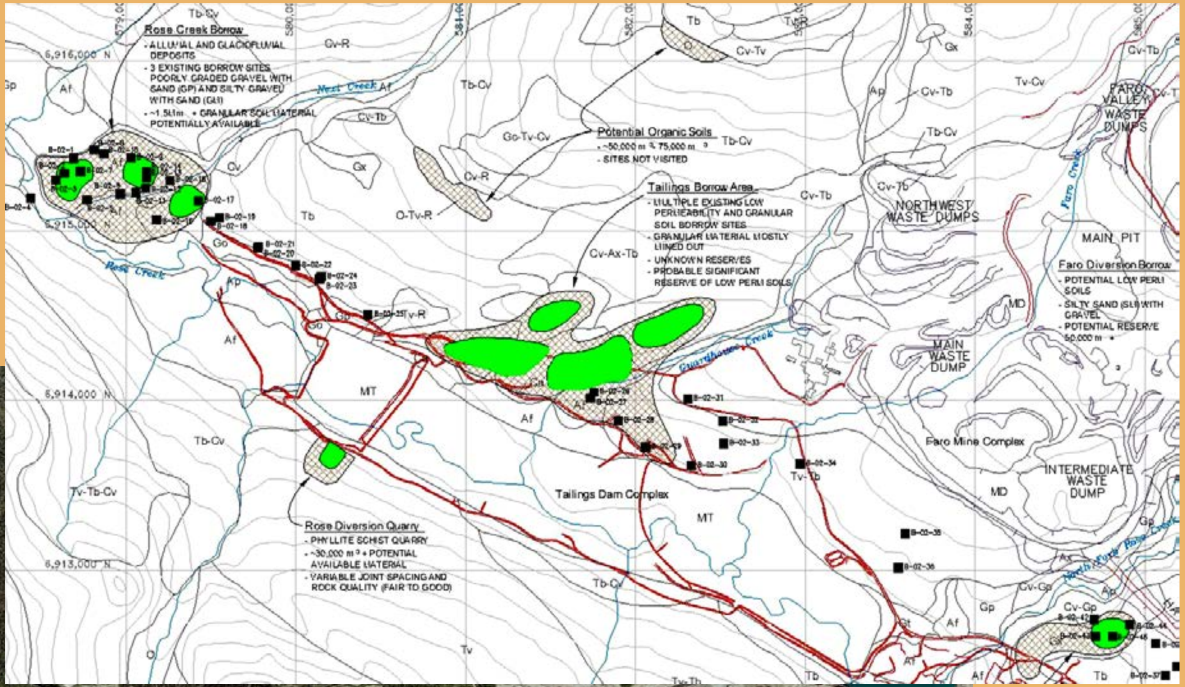
Borrow Material Requirements

Location	Area (ha)	Volume Range
Rose Creek Tailings	196	0.6 to 2.9 Mm^3
Faro Waste Dumps	334	1.0 to 5.0 Mm^3
Vangorda Dumps	43	0.1 to 0.6 Mm^3
Grum Waste Dumps	128	0.4 to 1.9 Mm^3

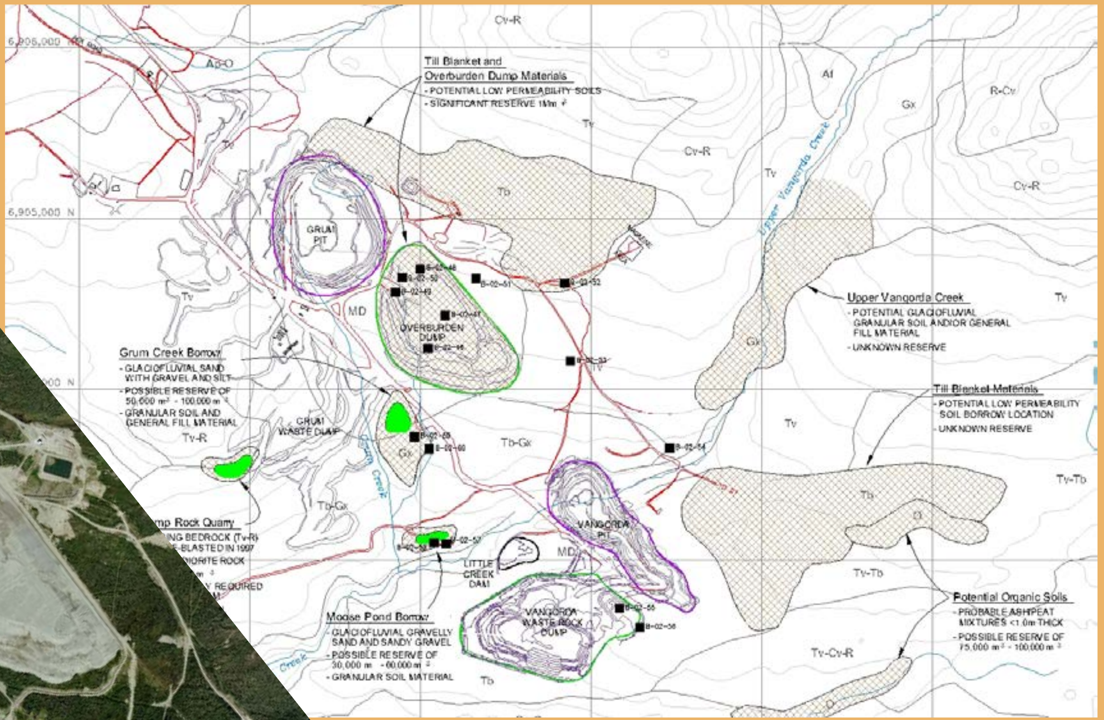
Faro Area: 1,600,000 to 7,900,000 m^3

Vangorda/Grum Area: 500,000 to 2,500,000 Mm^3

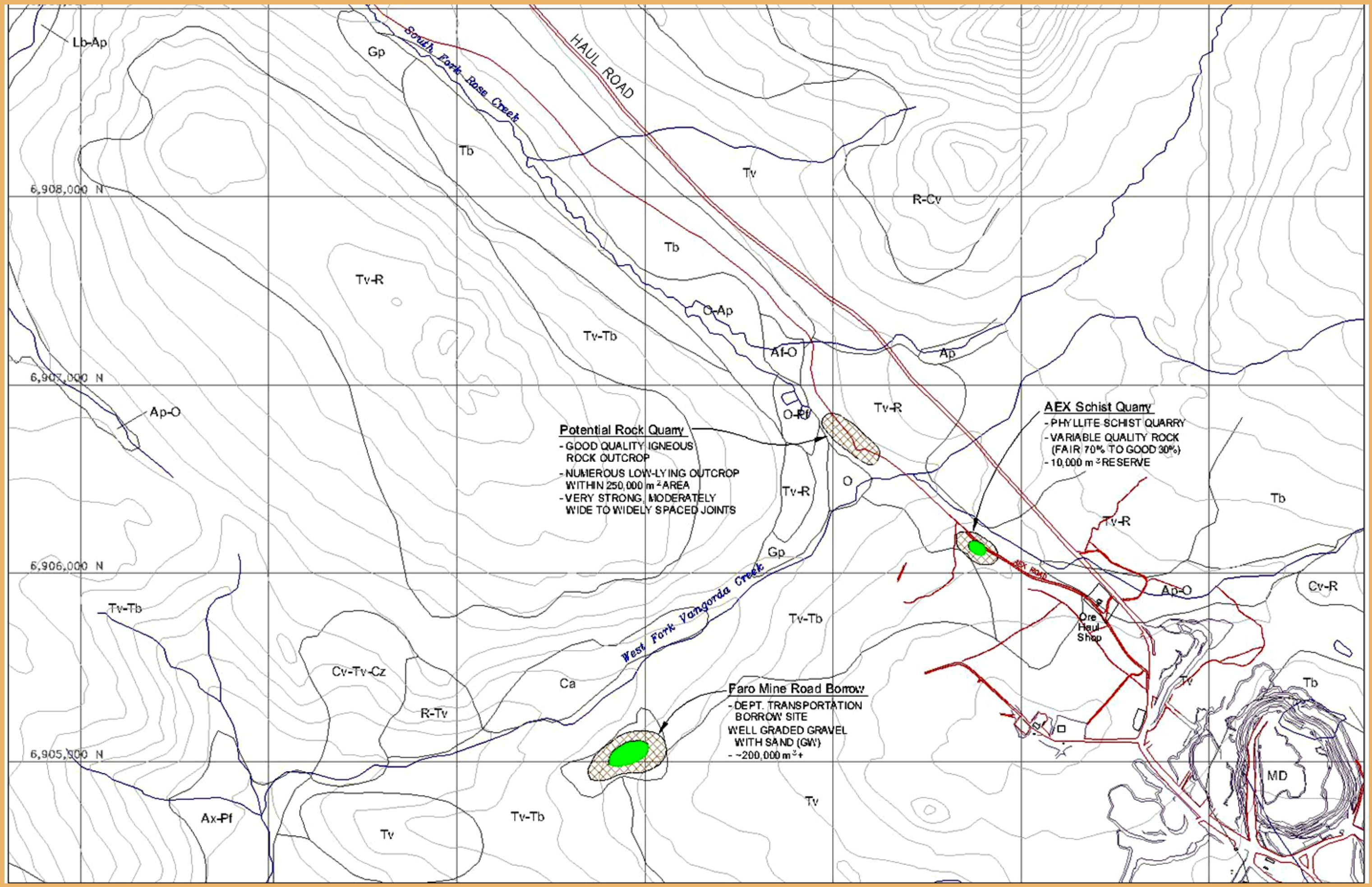
Faro Mine and Tailings Areas



Vangorda/Grum Area



Haul Road



HAUL ROAD
South Fork Rose Creek
West Fork Vangorda Creek
6,908,000 N
6,907,000 N
6,906,000 N
6,905,000 N
Lb-Ap
Gp
Tb
Tv
R-Cv
Tv-R
Tv-Tb
O-Ap
Af-O
Ap
Ap-O
O-Pf
O
Ca
Cv-Tv-Cz
R-Tv
Ax-Pf
Cv-R
MD
Potential Rock Quarry
- GOOD QUALITY IGNEOUS ROCK OUTCROP
- NUMEROUS LOW-LYING OUTCROP WITHIN 250,000 m² AREA
- VERY STRONG, MODERATELY WIDE TO WIDELY SPACED JOINTS
AEX Schist Quarry
- PHYLLITE SCHIST QUARRY
- VARIABLE QUALITY ROCK (FAIR 70% TO GOOD 30%)
- 10,000 m³ RESERVE
Faro Mine Road Borrow
- DEPT. TRANSPORTATION BORROW SITE
WELL GRADED GRAVEL WITH SAND (GW)
- ~200,000 m³ +
Ore Haul Shop

Results

Material	Faro Mine & Tailings	Vangorda/Grum
Cohesive soils	About 2.6 Mm^3 on north side of tailings impoundment and along haul road	Ample supply in overburden dumps
Granular soils	About 1.6 Mm^3 but generally fine granular (sandy)	Very limited, but potentially more at Vangorda Ck.
Coarse granular soils	Perhaps 30,000 m^3 plus calc-silicate at waste rock dump	Perhaps 40,000 m^3
Organic soils	Limited quantities; difficult to develop	Limited quantities; difficult to develop

Scoping Studies

SRK, BGC, GLL

2002

Scoping Studies

- Collect reports and prepare bibliography
- Review previous closure plans
- July meeting at site - SRK, BGC, GLL
- Complete trade-off studies
- Develop cost estimate database

Supporting Memoranda

1. Summary of Previous Closure Plans
2. Water Balance and Load Estimates
3. Pit Wall Stability
   – Faro and Vangorda
   – Grum
4. Feasibility of Flow-through Open Pits
5. Water Treatment Costs
6. Water Treatment Pumping Costs
7. Surface Water Management Upgrades and Costs
   – Faro and Rose Creek Diversions
   – Vangorda Creek Diversion

Supporting Memoranda

8. Surface Water Management Upgrades and Costs
   - Rose Creek Rock Drain
   - Seepage Collection Ditches
9. Waste Rock Dump Re-Sloping Costs
10. Cover Costs
11. Tailings Relocation and Costs
12. Waste Rock Backfilling and Costs

Conclusions

- New tools available to project
  - Report library and bibliography
  - AutoCAD map collage
  - Concise summary of previous closure plans
  - Contaminant and water quality spreadsheet
  - Cost model for water collection, pumping & treatment
  - Cost estimates for major earthworks
    - Covers
    - Relocation
    - Dam upgrades

Revise Water Treatment Costs

SRK and CEMI

Objectives of Task

- ❑ Update water treatment performance and cost estimates using 2003 data
- ❑ Estimate sludge generation

Tasks

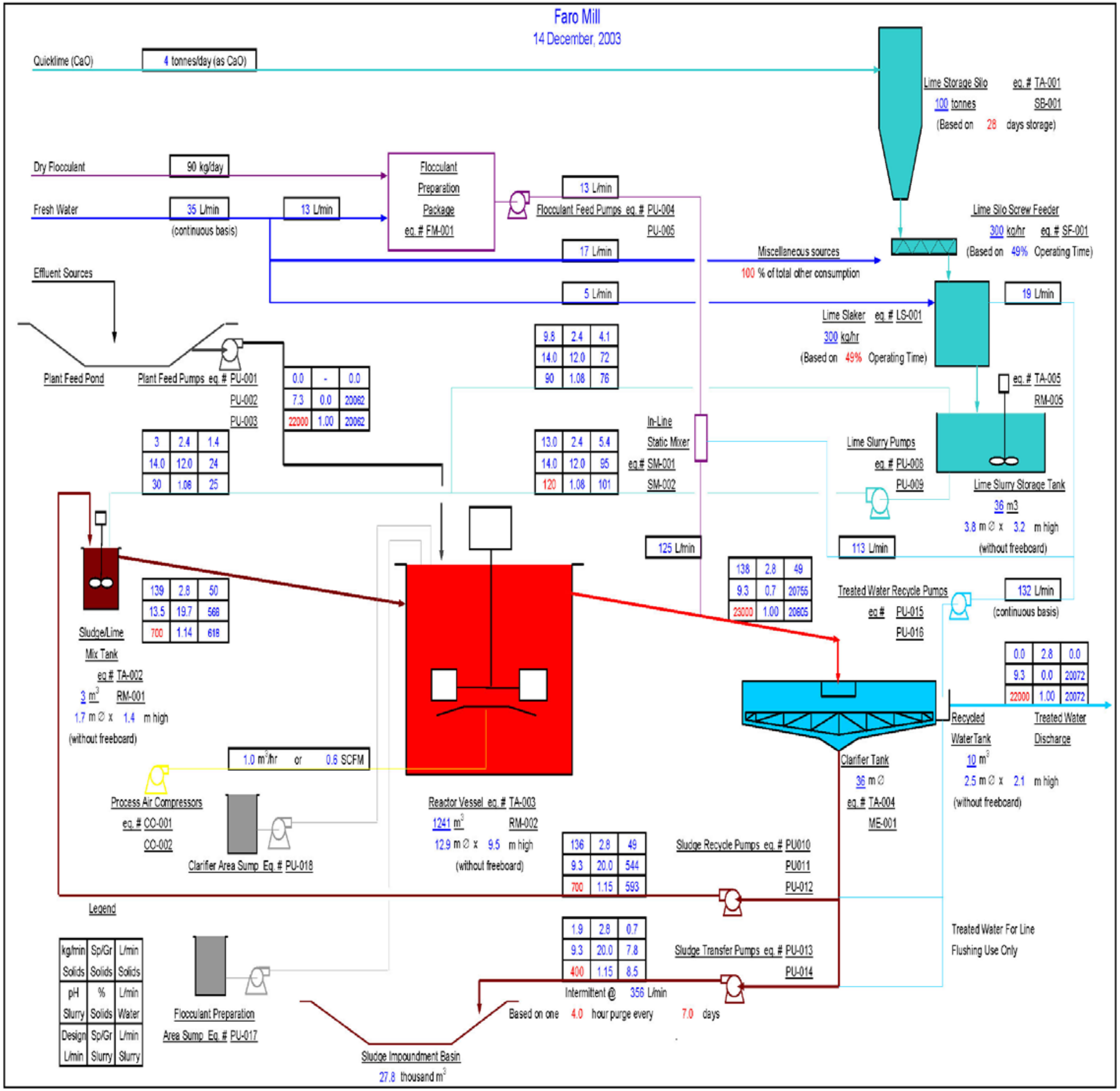
- Review water quality data for water treated in 2003
- Calculate chemical consumption rates and unit water treatment costs
- Model High Density Sludge (HDS) treatment
  - Capital costs
  - Operating costs

Water Treatment Systems

- ❑ Vangorda/Grum
  - – purpose designed and built water treatment system
- ❑ Faro Mill
  - – mill equipment converted water treatment system
- ❑ Down Valley
  - – located at the Intermediate Impoundment Spillway
  - – low mixing / short contact

Water Treatment Systems

- ❑ Gathered inputs with help from site staff
  - – Water quality
  - – Operating conditions
  - – Lime utilization
  - – Operating costs
- ❑ Developed calculations for estimating treatment costs
  - – Current water quality
  - – Future water quality



High Density Sludge treatment system for Faro Pit Water

Conclusions

	Vangorda Grum	Faro Mill	Down Valley
Existing System			
Operating ($/m^{3})	0.53	0.16	0.35
HDS System			
Capital Cost	$4.67M	$8.79M	$3.87M
Operating ($/m^{3})	0.21	0.14	0.21

Terrestrial Effects Study Plan

Gartner Lee Ltd.

Project objectives

- A study that would investigate effects on the terrestrial environment related to the mine

Study Layout

- What to study?
  - soil, vegetation, wildlife
  - selected species should be representative, available, meaningful

- Where to study?
  - reference locations
  - repeatable locations, extend existing transects
  - special or unique forage/growth areas
  - special human use/gathering areas

Input

- Input from Ross River Dena, Selkirk First Nation, YTG Environment, Environment Canada, YTG, Town of Faro, mine personnel.
- Compilation by Technical Team.

Status

- Initiating the field work for 2004 according to the plan developed over the past winter.

Site Specific Water Quality Criteria

Gartner Lee Ltd.

Objectives

- What would site-specific water quality criteria be (for Rose Creek and Vangorda Creek) as derived according to the federal guidelines?

Steps

- Select a methodology within the CCME framework
- Design a plan for collection of field information, as appropriate
- Derive preliminary numerical values

Test Procedures

- Test water from Rose Creek and Vangorda Creek collected in to test seasonal conditions.
- Also test lime treated discharge water.

Status

- The “Water Effects Ratio” method method has been selected from the four options provided by CCME.
- Initial test results now being received.
- Further sampling and testing planned in 2004 to test seasonal conditions.

Tailings Area Technical Studies

Presented by:
SRK Consulting and Gartner Lee Ltd.

List of Tailings Area Technical Studies

- Tailings Characterization
- Foundation Soils Seismic Stability Analysis
- Dam Deformation Analysis
- Tailings Liquefaction Analysis
- Tailings Groundwater

Tailings Characterization

John Cunning
Golder Associates Ltd.

Study Objectives

- Define representative geotechnical properties of the Rose Creek Tailings for:
  - Tailings Relocation Study and
  - Seismic Stability Assessment

Tailings Characterization

Scope

- Data review
- Field program (CPT probes)
- Laboratory program

Tailings Characterization

Data Review

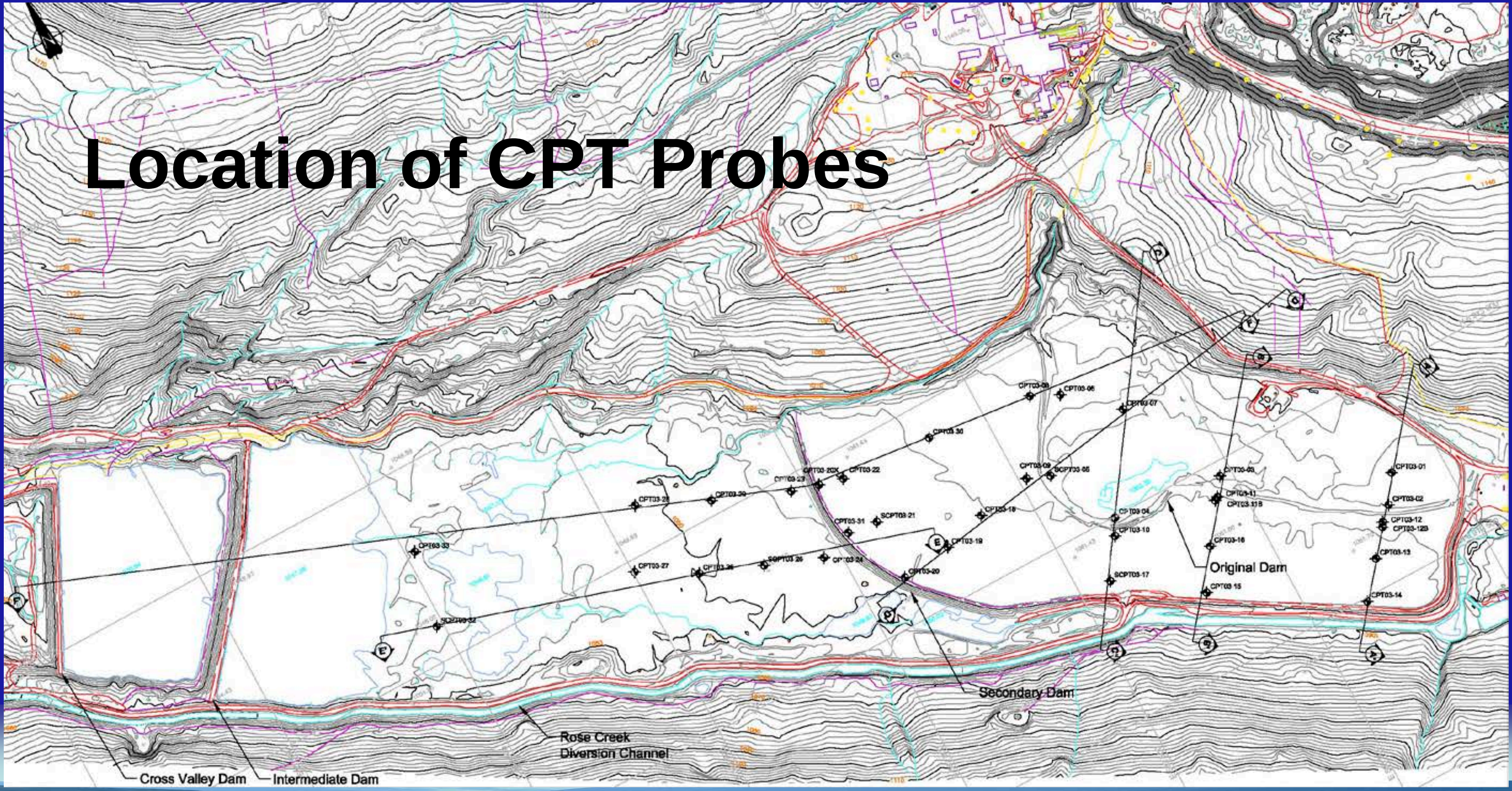
- Tailings Impoundment Aerial Photos reviewed to investigation historical tailings deposition patterns:
  - 1972,
  - 1975,
  - 1979, and
  - 1997

Tailings Characterization

Field Investigation

- 36 CPT probes
  - Almost 500 m of probes
  - Ranging in depth from 1 to 26 m from surface of tailings
  - Shear wave velocity measurements vs depth in 5 holes
    - shear modulus
  - Pore pressure dissipation measurements at 36 locations

Tailings Characterization



Tailings Characterization

Laboratory Testing

- 15 samples obtained from 2003 drill program related to groundwater
- Two bulk samples prepared with gradations representing FINE and COARSE tailings zones
- Various laboratory tests
  - Index testing: gradation, specific gravity and max/min void ratio
  - Triaxial tests

Conclusions

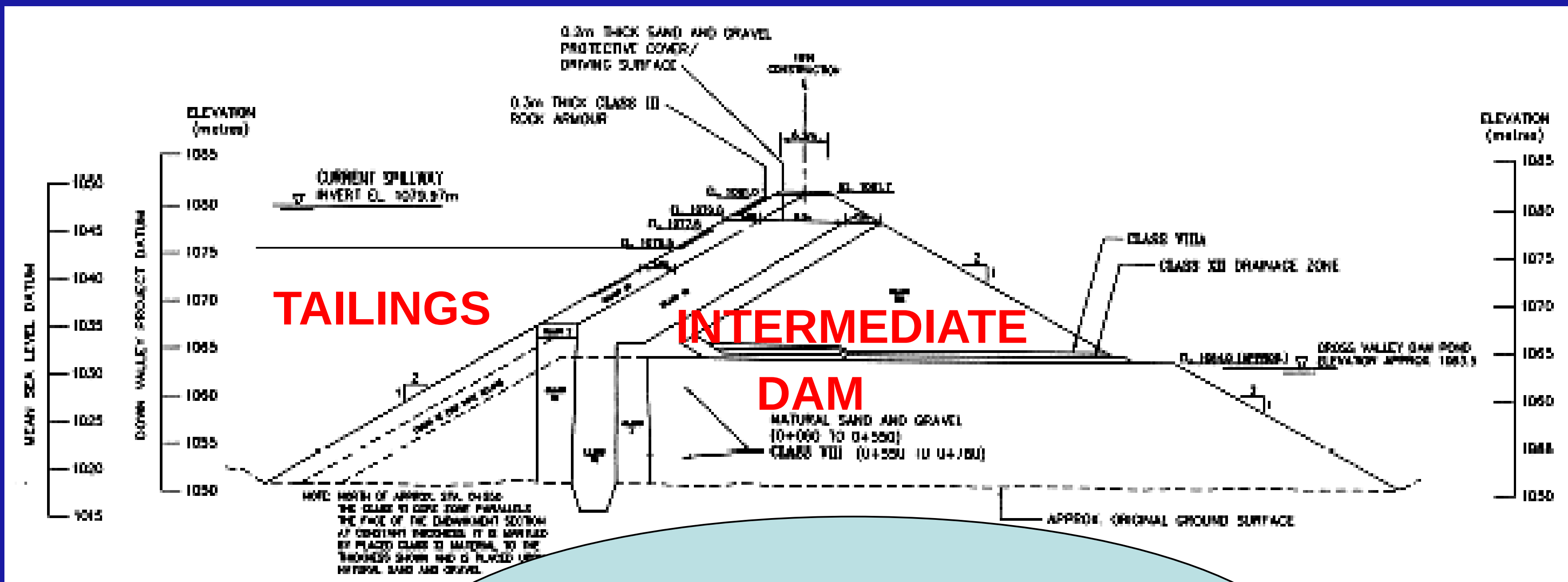
- **Depositional history is relatively well documented**
- **CPT data provides classifications that match the known depositional history**
- **Recently collected field and laboratory data define the tailings properties needed for use in subsequent closure studies**

Foundation Soils Seismic Stability

Dr. Peter Byrne and
Mahmood Seid-Karbasi,
University of British Columbia

Foundation Soils Seismic Stability Analysis

Cross Section through the Intermediate Dam



1. Embankment geometry and internal zoning as shown in Golder Associates Drawing 912-2402-3, Int. Dam Raising & C.V. Dam Toe Drain. Cross Section and Detailed Plan. Rev. 1. Aug 8. 1991.

2. All elevations are referenced to Down Valley Project Datum. Subtract 32.3m from elevations shown to convert to mean sea level (NAD27) datum.

3. Refer to Golder Associates as built reports for detailed descriptions of material classes. General descriptions as follows :

CLASS VI	Dam Core (glacial till)
CLASS VII	Upstream Shell (silty sand and gravel)
CLASS VIII	Downstream Shell (sand and gravel)
CLASS VIIIA	Drainage Filter (sand and gravel)
CLASS IX	Upstream Filter (silty sand)
CLASS X	Downstream Filter (sand and gravel)
CLASS XI	Tailings Sand (fine to medium sand)
CLASS XII	Drainage Zone (gravel)

STUDY FOCUS WAS ON DAM FOUNDATION SOILS

Foundation Soils Seismic Stability Analysis

Objective

- **Evaluate the possibility of triggering LIQUEFACTION in the foundation soils beneath the Intermediate Dam in the event of the design earthquake.**

Foundation Soils Seismic Stability Analysis

What is LIQUEFACTION?

- **Liquefaction involves a large drop in stiffness and strength that can lead to large displacements and severe damage to structures.**
- **Liquefaction is caused by high pore water pressures resulting from the tendency of granular soils to compact under cyclic loading.**

Foundation Soils Seismic Stability Analysis

In dealing with liquefaction, 3 levels of analysis:

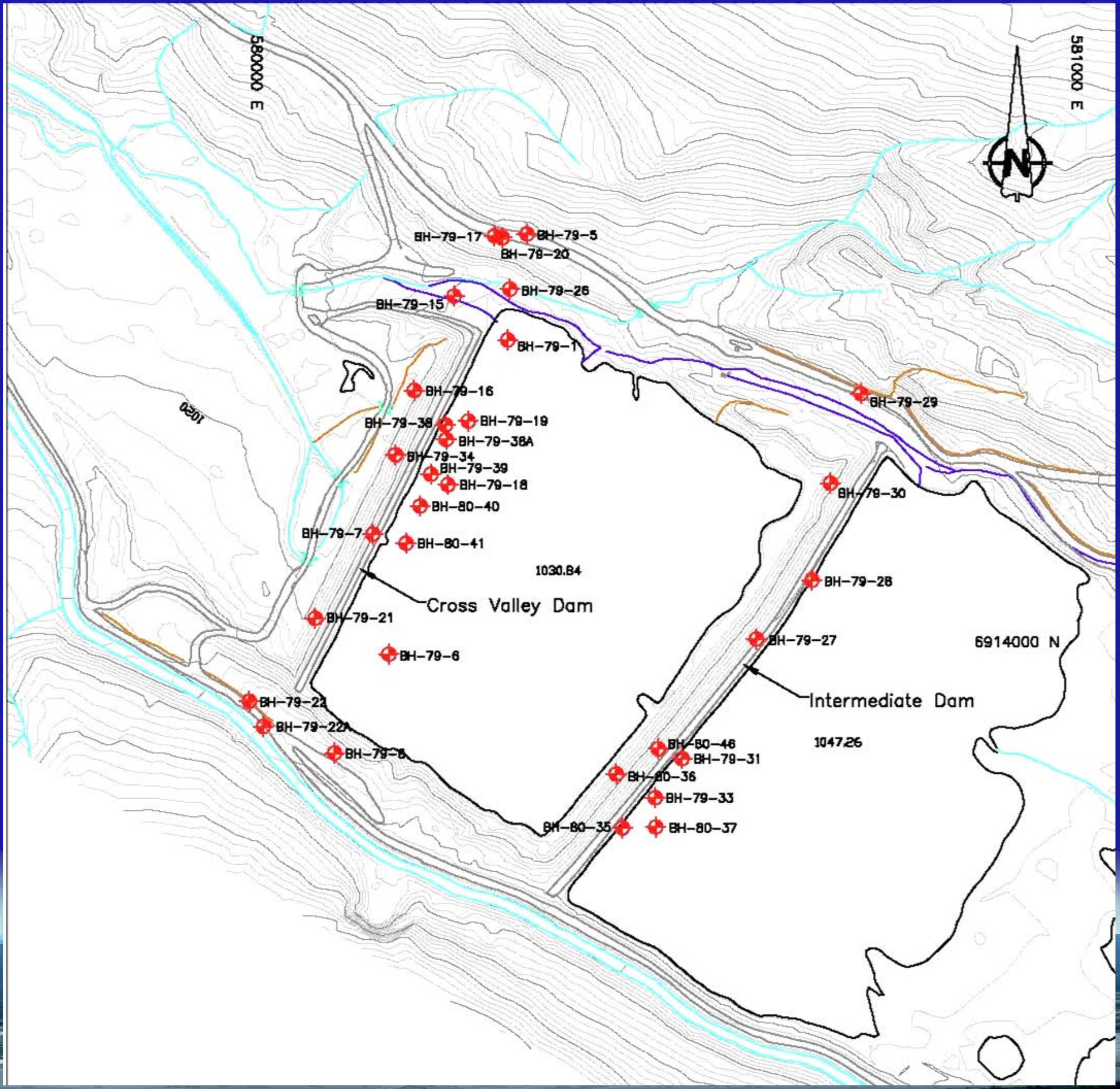
- Will liquefaction be triggered in significant zones by the design earthquake ?, if so,
- Could a flow slide occur? If not,
- What displacements will occur?

Foundation Soils Seismic Stability Analysis

Analysis

- **Foundation soil conditions based on previous drilling programs & SPTs**
- **Earthquake “shake” provided as six typical events based on recent earthquake assessment by Atkinson**
- **Computer program used to assess performance of the foundation soils**

Foundation Soils Seismic Stability Analysis



Foundation Soils Seismic Stability Analysis

Conclusions

- Most of the SPT data coincides with the Cross Valley Dam
- A preliminary liquefaction assessment has been carried out for the Intermediate dam.
- Predicted liquefaction is marginal at the deep valley section.
- Predicted liquefaction is widespread near the side of the dam
- Additional data collection is needed to provide results with a significantly higher level of confidence

Dam Deformation Analysis

John Cunning
Golder Associates Ltd.

Dam Deformation Analysis

Objective

- **To determine the amount of deformation of the Intermediate Dam that might occur in response to the design earthquake**

Dam Deformation Analysis

Analysis

- Based on the dam at its maximum height
- Assumes that the foundation soils do not liquefy
- Earthquake input is based on the use of the 6 earthquake records that Atkinson produced
- The deformation analysis is relatively simple assessment of likely deformations

Dam Deformation Analysis

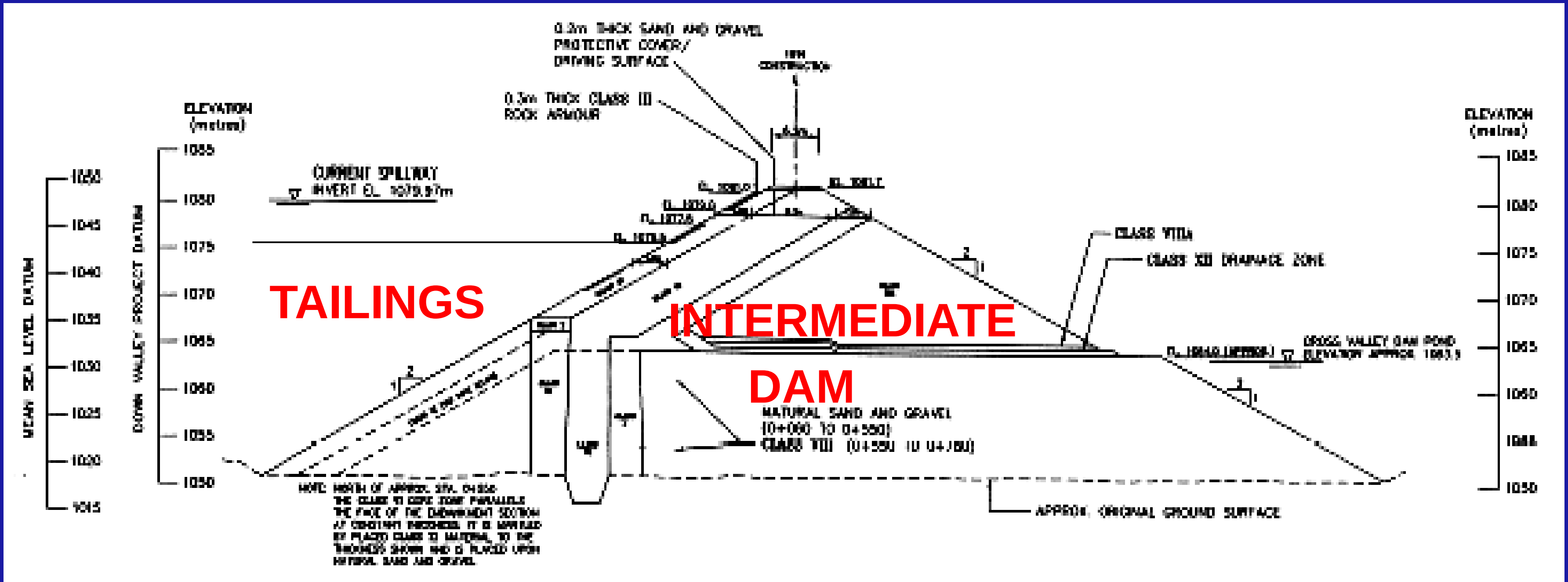
Conclusions

- Horizontal deformations are between 0.2 and 0.5 m
- Vertical deformations are estimated to be about half the horizontal deformations
- Deformations of this magnitude are tolerable but the issue of liquefaction of the foundation soils remains unresolved (to be addressed in 2004)

Tailings Liquefaction Analysis

John Cunning
Golder Associates Ltd.

Cross Section through the Intermediate Dam



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CLASS VI	Dam Core (glacial till)
CLASS VII	Upstream Shell (silty sand and gravel)
CLASS VIII	Downstream Shell (sand and gravel)
CLASS VIIIA	Drainage Filter (sand and gravel)
CLASS IX	Upstream Filter (silty sand)
CLASS X	Downstream Filter (sand and gravel)
CLASS XI	Tailings Sand (fine to medium sand)
CLASS XII	Drainage Zone (gravel)

Tailings Liquefaction Analysis

Objective

- **To determine the trigger level (acceleration) at which the tailings are likely to liquefy in response to an earthquake**

Tailings Liquefaction Analysis

Analysis

- Based on the results of the tailings characterization study
- Considered both the fine and coarse tailings

Tailings Liquefaction Analysis

Conclusions

- **Substantial zones of fine tailings are likely to be triggered into liquefaction at moderate seismic loading**
- **At specific locations, a peak ground acceleration of 0.05g to 0.1g could be sufficient**
- **These accelerations are less then the accelerations associated with the large earthquakes evaluated by Atkinson**

2003 Groundwater Studies

Rose Creek Tailings Facility

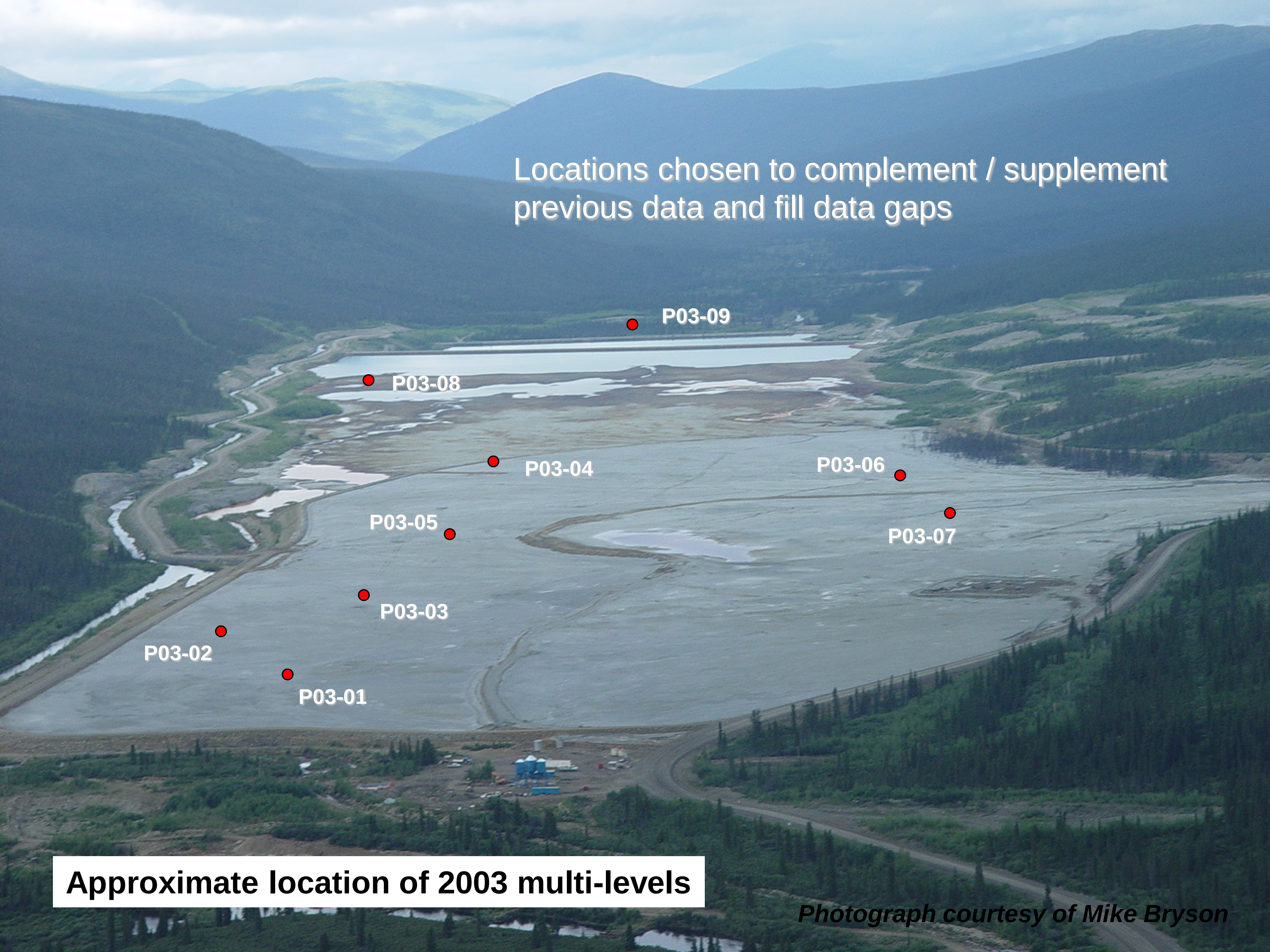
Primary Objectives for 2003

- **detailed stratigraphy through the aquifer**

- **additional groundwater monitoring wells**

(focus on areas of "coarser" tailings)

- **"*increased understanding*"**


Locations chosen to complement / supplement
previous data and fill data gaps
P03-09
P03-08
P03-04
P03-06
P03-05
P03-07
P03-03
P03-02
P03-01
Approximate location of 2003 multi-levels
Photograph courtesy of Mike Bryson

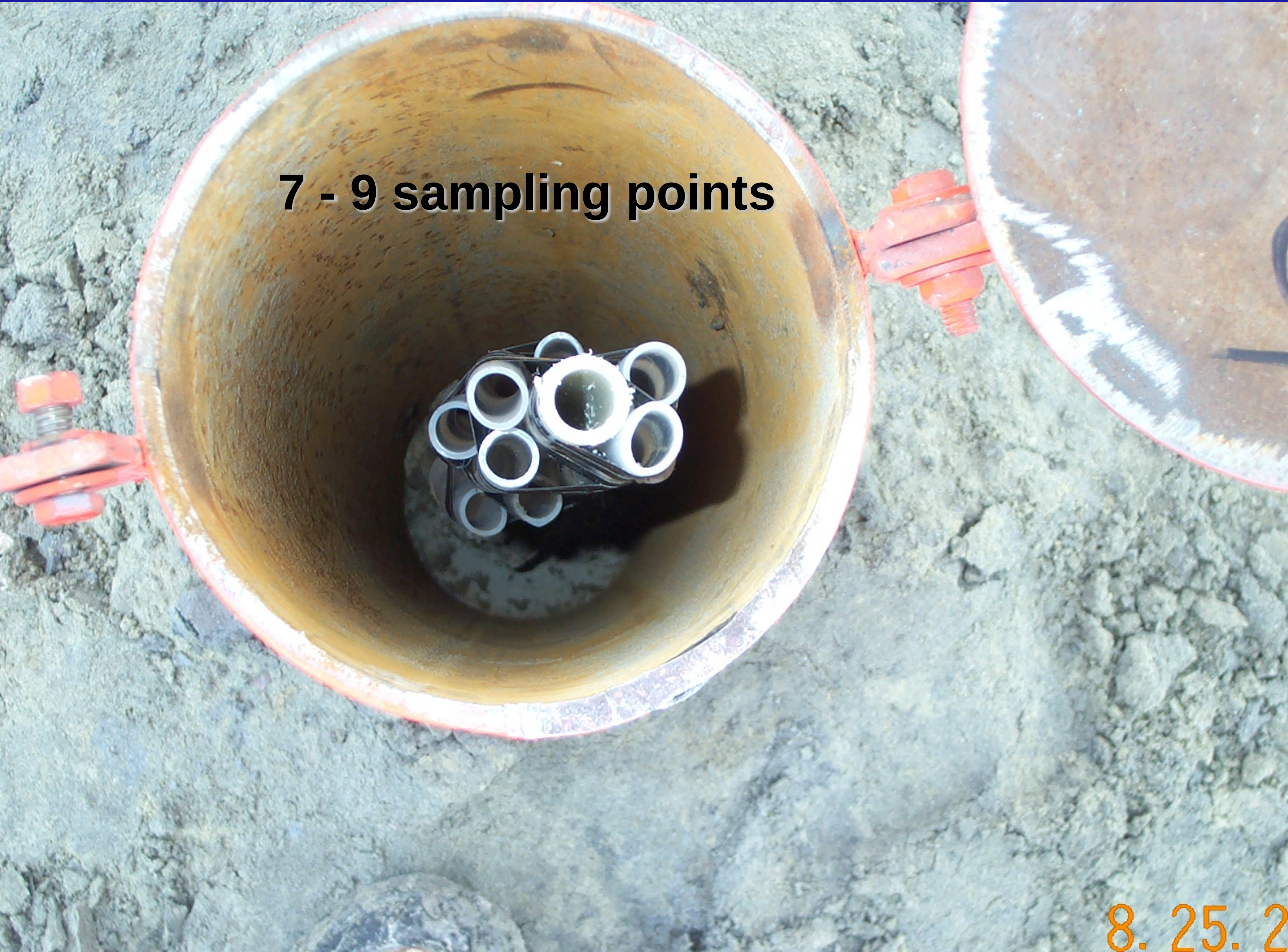
Soil Cores

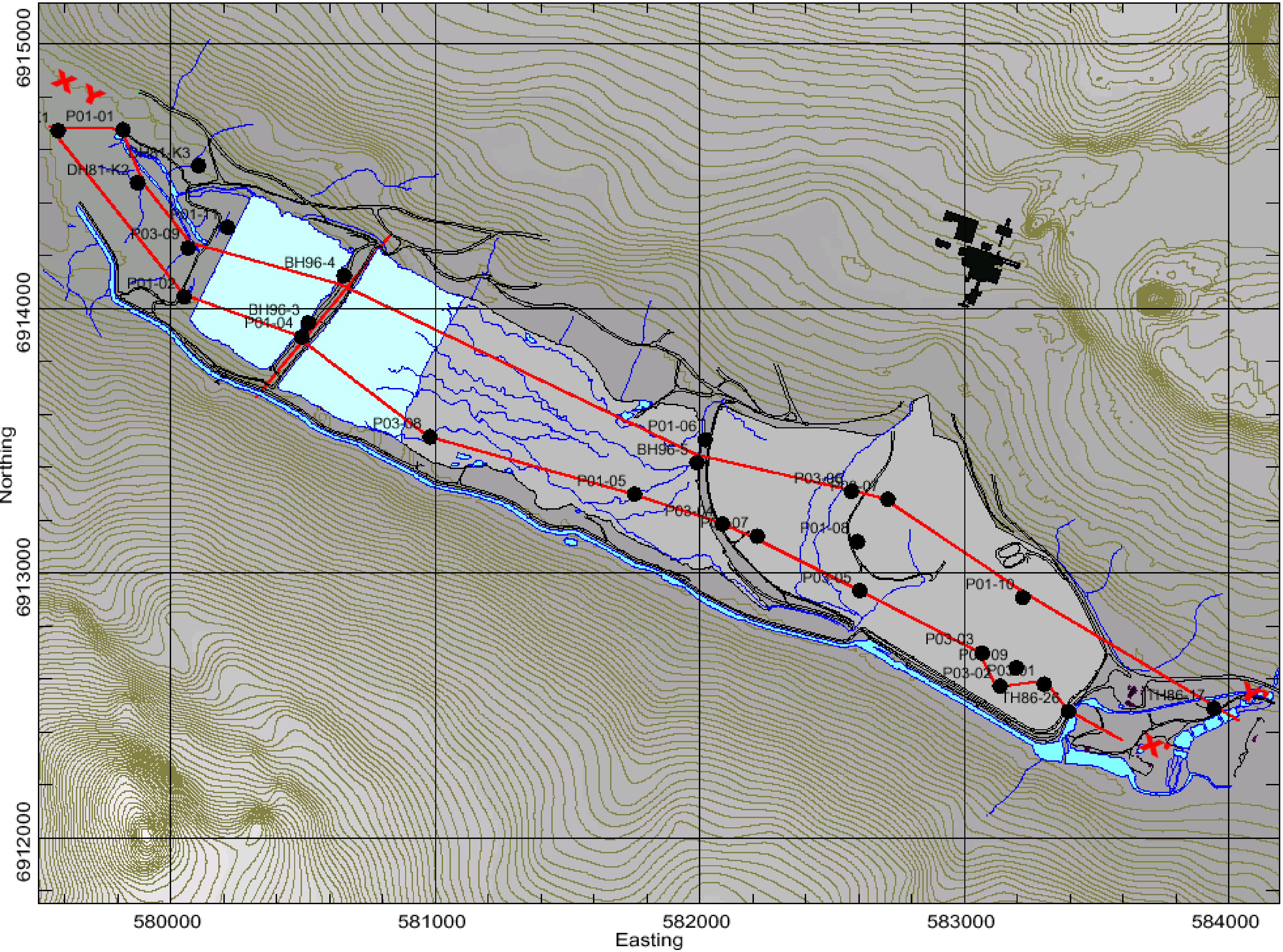
Interface Characteristics

Tailings

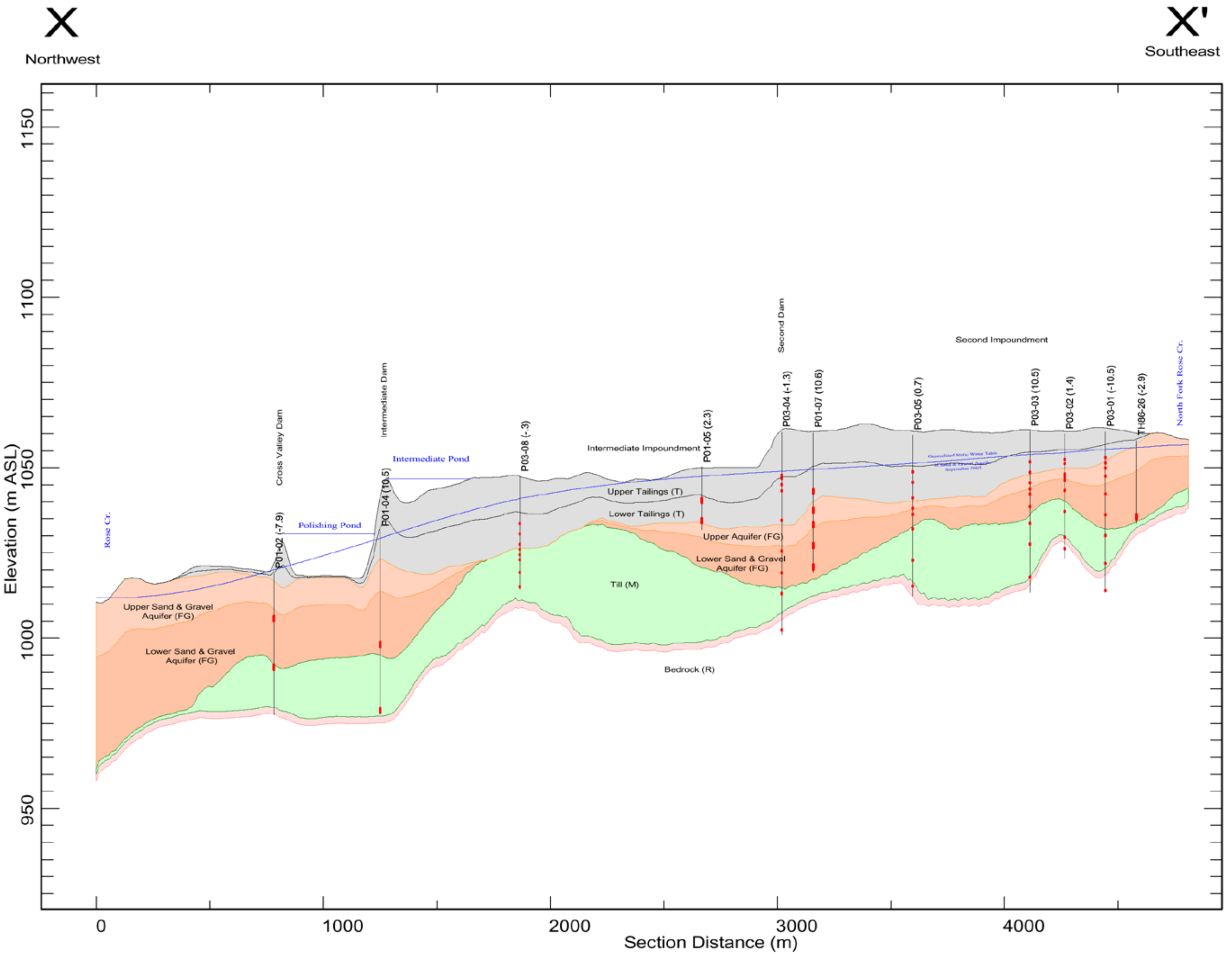
Organics

Native Sediments

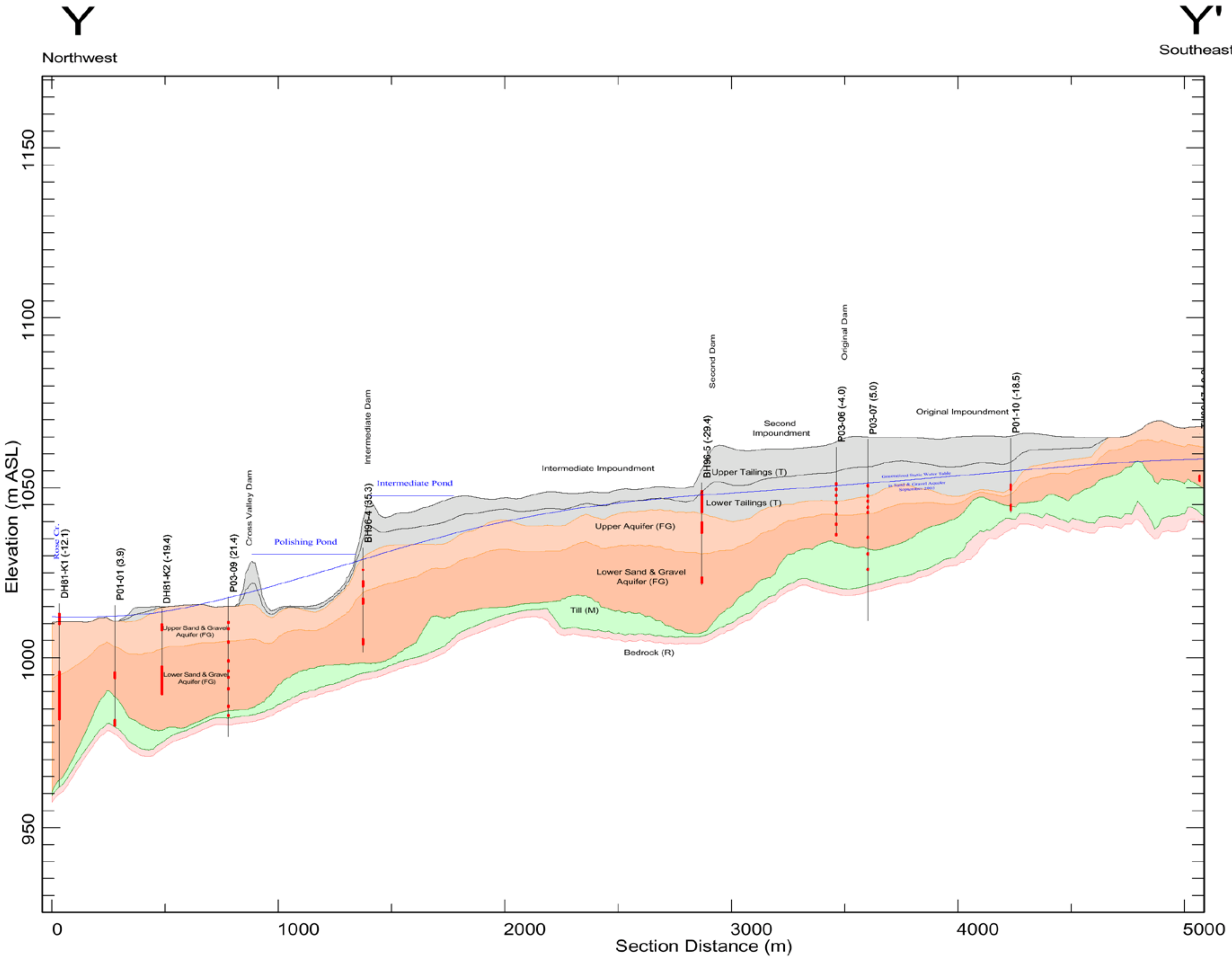

7 - 9 sampling points
8. 25. 2



X
Y
P01-01
DH81-K2
P03-09
P01-02
BH96-4
BH96-3
P01-04
P03-08
P01-06
BH96-5
P01-05
P01-08
P01-10
P03-03
P03-02
TH86-26
TH86-17
6915000
6914000
6913000
6912000
Northing
580000
581000
582000
583000
584000
Easting



X
Northwest
X'
Southeast
Elevation (m ASL)
1150
1100
1050
1000
950
0
1000
2000
3000
4000
Section Distance (m)
Rose Cr.
Cross Valley Dam
P01-02 (-7.9)
Polishing Pond
Intermediate Dam
P01-04 (10.5)
Intermediate Pond
P03-08 (-3)
Intermediate Impoundment
P01-05 (2.3)
Second Dam
P03-04 (-1.3)
P01-07 (10.6)
P03-05 (0.7)
Second Impoundment
P03-03 (10.5)
P03-02 (1.4)
P03-01 (-10.5)
TH86-26 (-2.9)
North Fork Rose Cr.
Upper Tailings (T)
Lower Tailings (T)
Upper Aquifer (FG)
Lower Sand & Gravel
Aquifer (FG)
Till (M)
Upper Sand & Gravel
Aquifer (FG)
Lower Sand & Gravel
Aquifer (FG)
Bedrock (R)



Y
Northwest
Y'
Southeast
Elevation (m ASL)
1150
1100
1050
1000
950
Section Distance (m)
0
1000
2000
3000
4000
5000
Rose Cr.
DH81-K1 (-12.1)
P01-01 (3.9)
DH81-K2 (-19.4)
P03-09 (21.4)
Cross Valley Dam
Polishing Pond
Intermediate Dam
BH96-4 (35.3)
Intermediate Pond
Intermediate Impoundment
BH96-5 (-29.4)
Second Dam
Second Impoundment
Original Dam
P03-06 (-4.0)
P03-07 (5.0)
Original Impoundment
P01-10 (-18.5)
Upper Tailings (T)
Lower Tailings (T)
Upper Aquifer (FG)
Lower Sand & Gravel Aquifer (FG)
Upper Sand & Gravel Aquifer (FG)
Lower Sand & Gravel Aquifer (FG)
Till (M)
Bedrock (R)

Status

- Detailed stratigraphic logs completed
- Aquifer samples available for other project testing
- New detailed groundwater quality information
- Spring 2004 groundwater samples collected


Tailings Area Closure Methods
Presented by SRK Consulting and Gartner Lee Ltd.
1

Basic Tailings Closure Options

- Tailings stay in place
  - Rose Creek Diversion Canal Upgrade
  - Tailings Covers
  - Tailings Groundwater Collection
  - Upgrades to Dams and Spillways
- Tailings are relocated
  - Methodology
  - Pit Requirements
- Combination of the two (partial relocation)

Closure Method Presentations

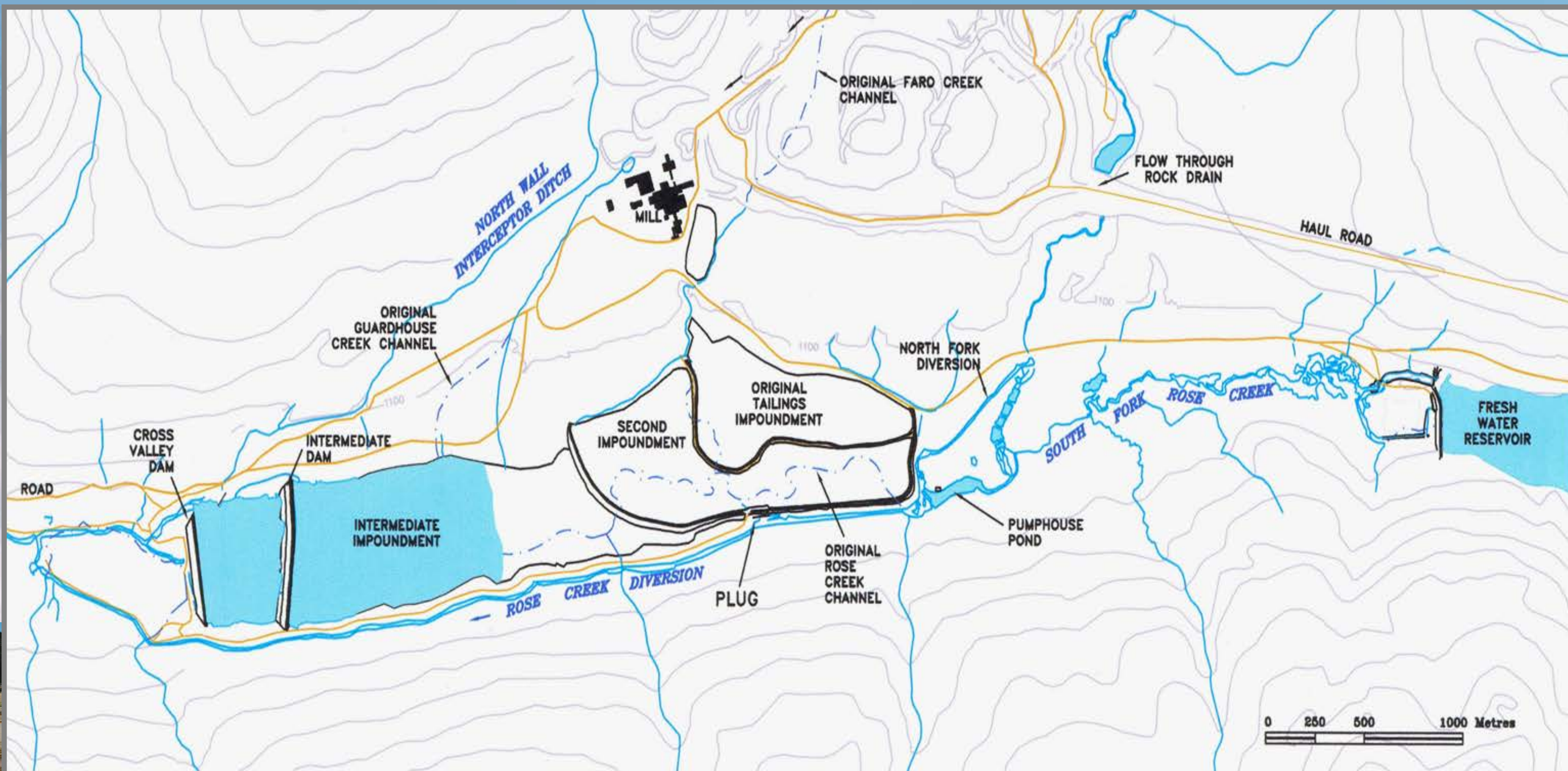
- ❑ Assessment of Rose Creek Diversion Canal Upgrades
- ❑ Tailings Covers
- ❑ Tailings Groundwater Collection
- ❑ Tailings Relocation

Assessment of Rose Creek Diversion Canal Upgrades

Barry Evans
Northwest Hydraulics Ltd.
and
Jim Cassie
BGC Engineering Ltd.

Study Objective

To safely pass extreme flood flows around or over the tailings impoundment and into Rose Creek downstream of the Cross Valley Dam.

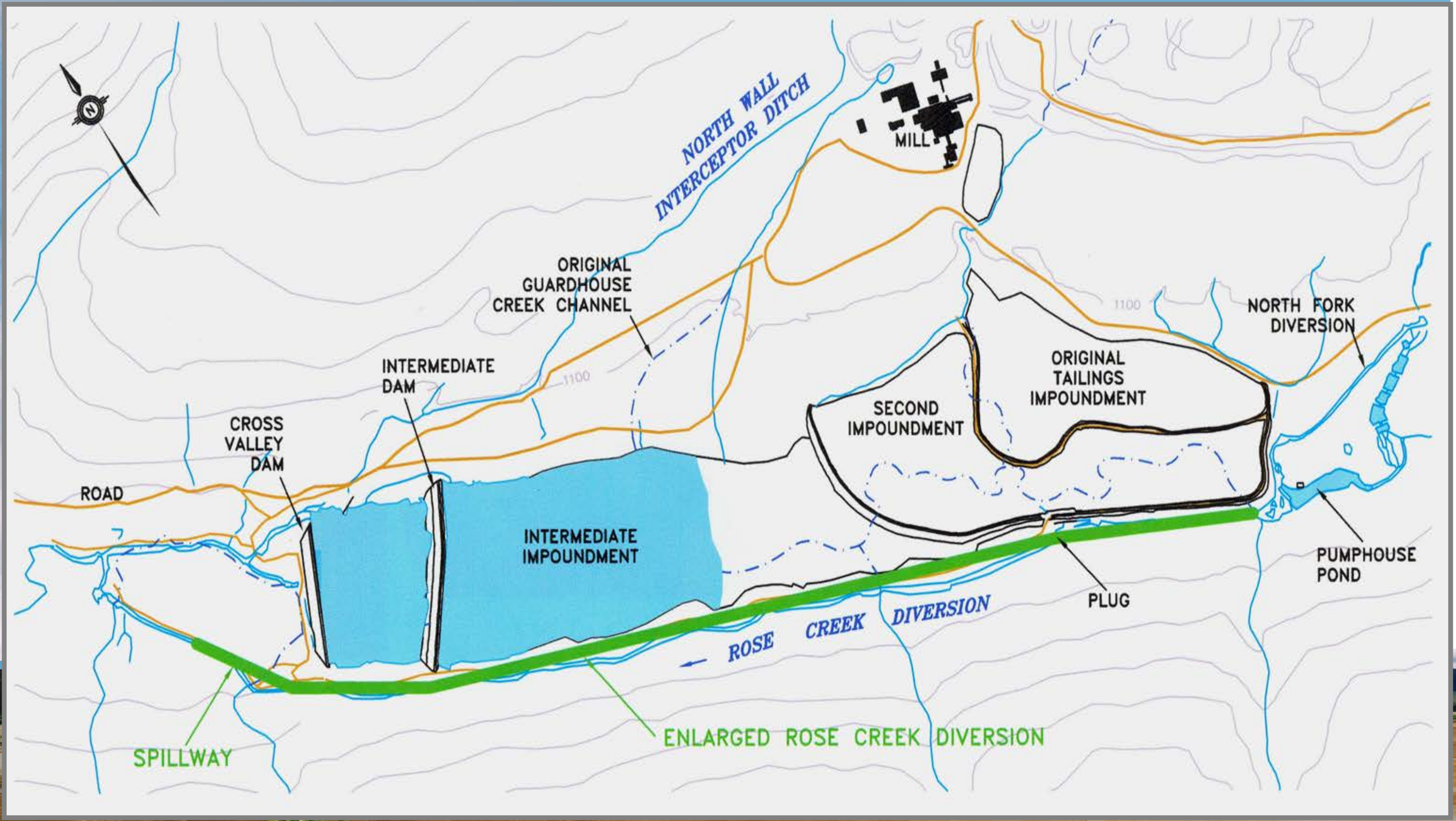


Scope

- Desktop study to develop preliminary designs and costs estimates for passing extreme floods up to the PMF round the tailings impoundment.
- Three options were assessed.

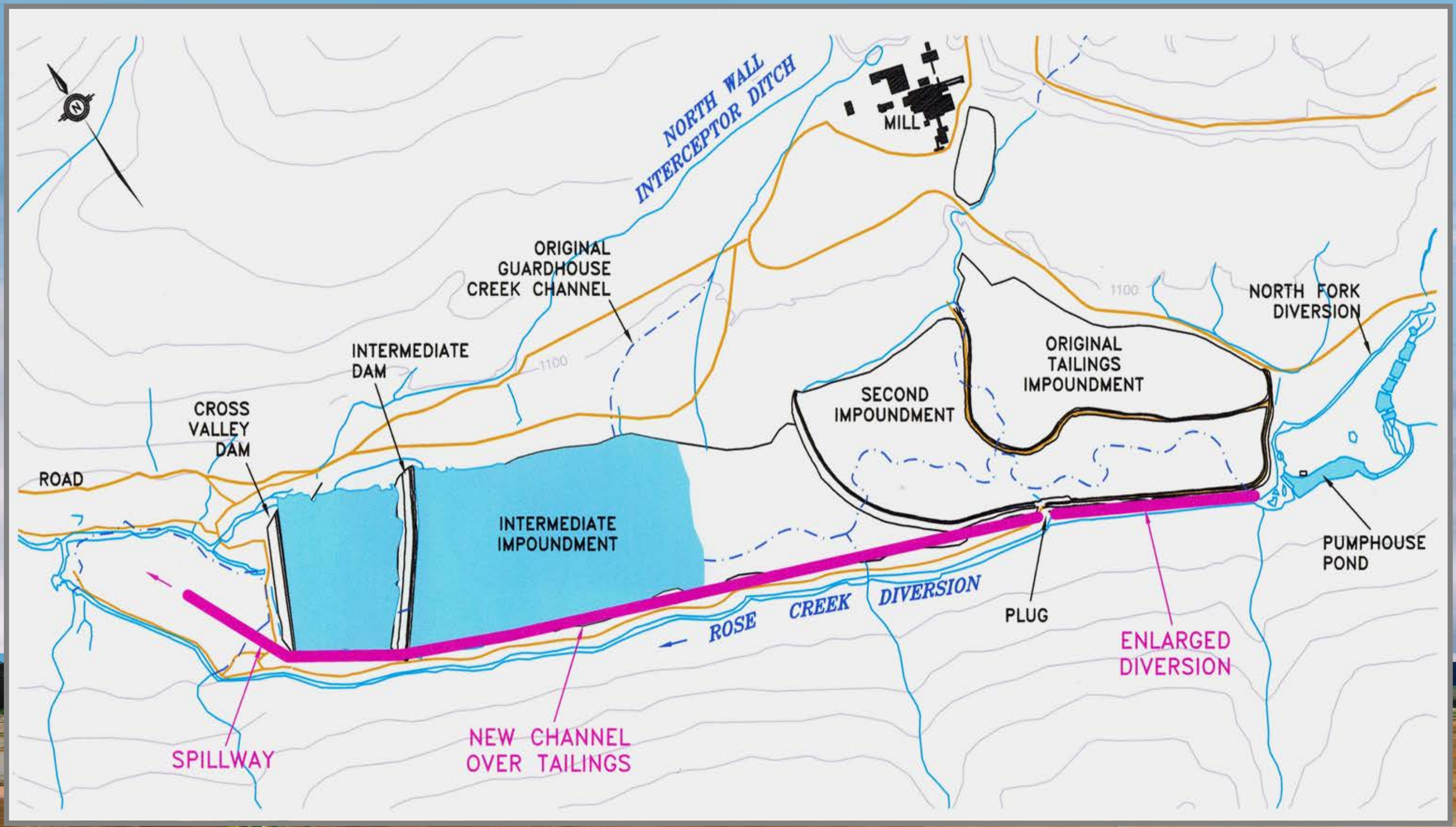
Option 1

- **Increase the size of the Rose Creek diversion channel along the south side of the tailings impoundments to convey the PMF.**



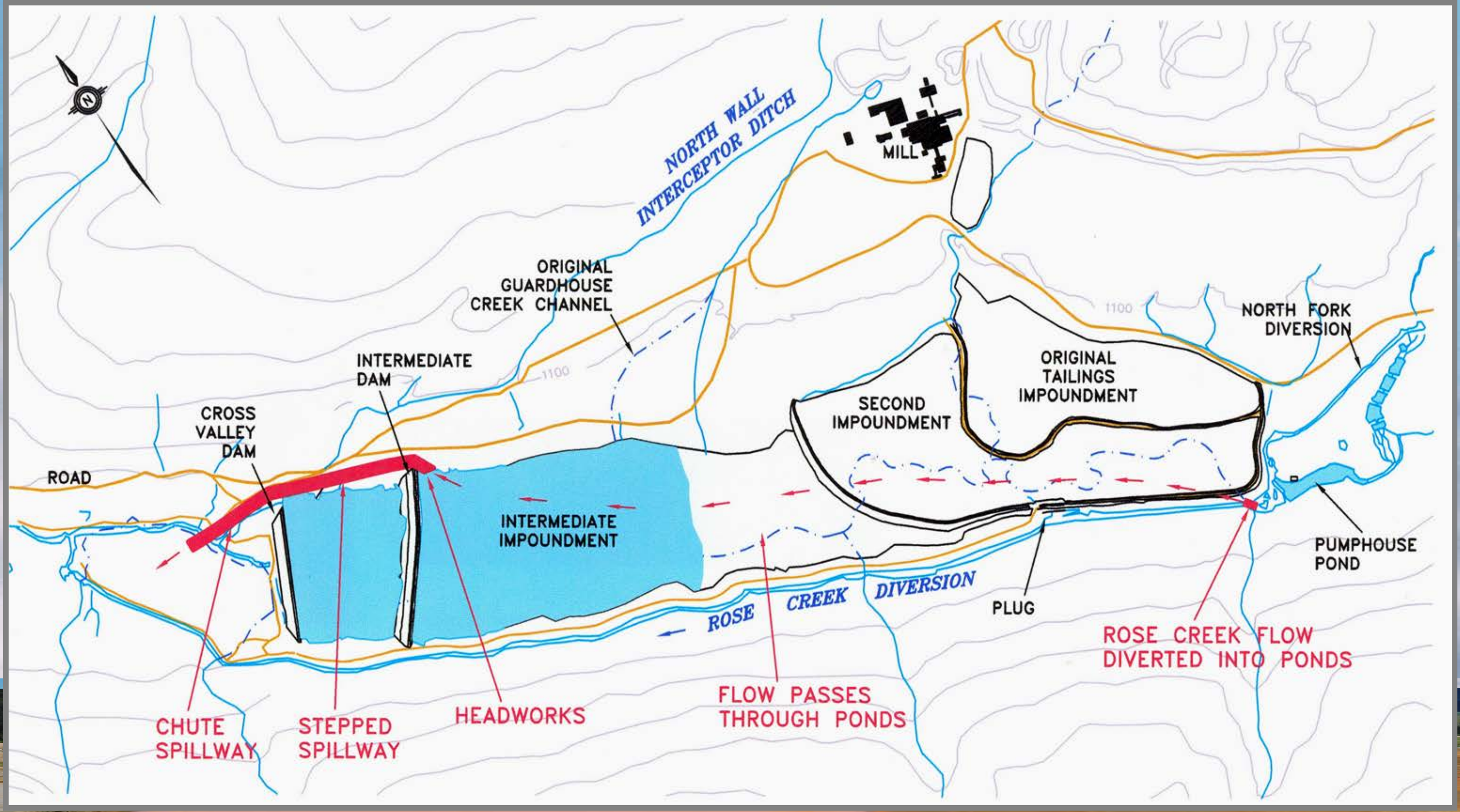
Option 2

- **Abandon the Rose Creek diversion channel downstream of the plug.**
- **From the plug, convey the PMF over the tailings to a new spillway by-passing the Intermediate and Cross Valley Dams.**



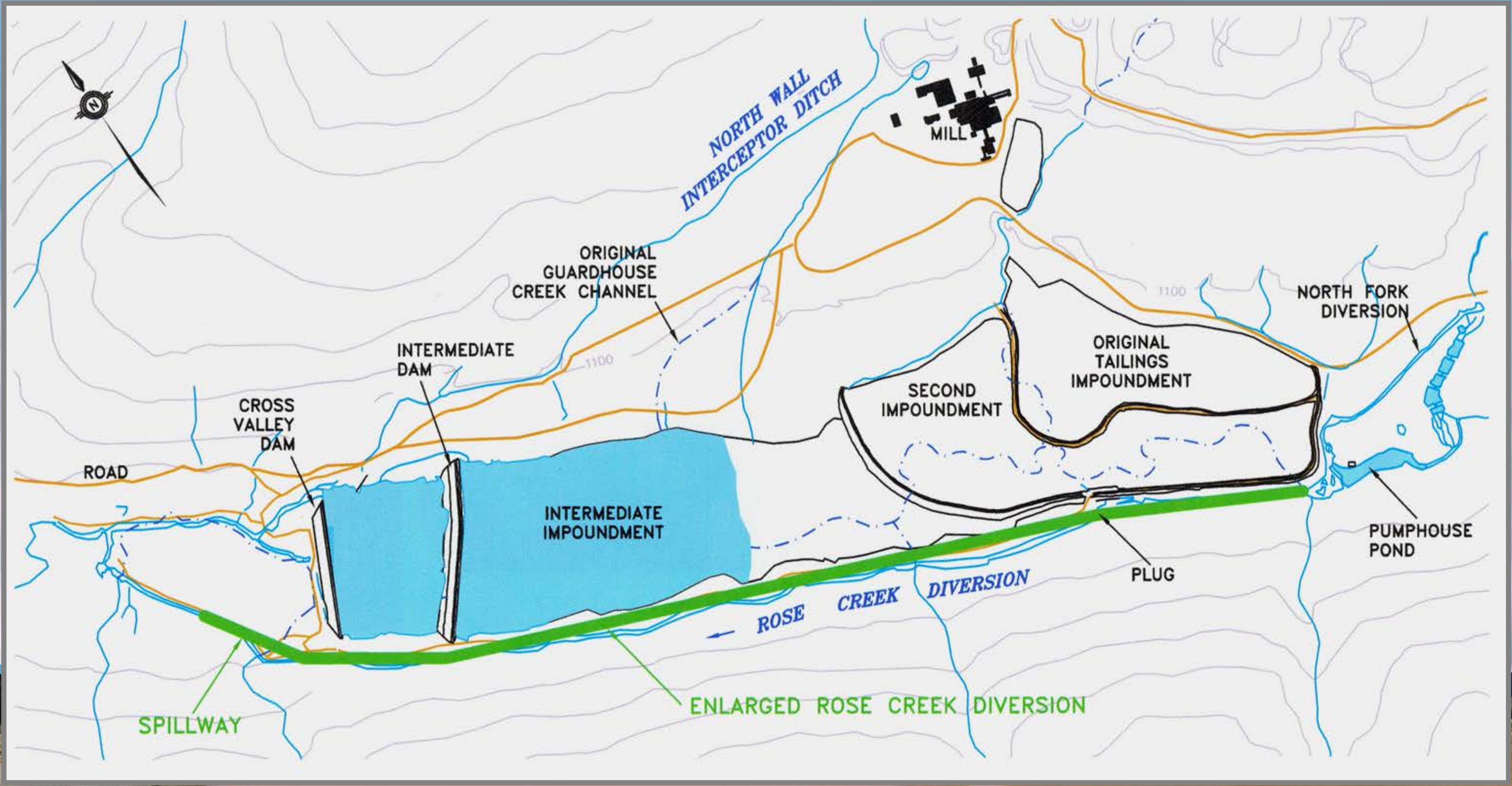
Option 3

- Remove tailings from the original, second and intermediate impoundments to el. 1042 m.
- Rose Creek flow to enter the impoundment area.
- Attenuated PMF to pass over a spillway located at the Intermediate Dam.

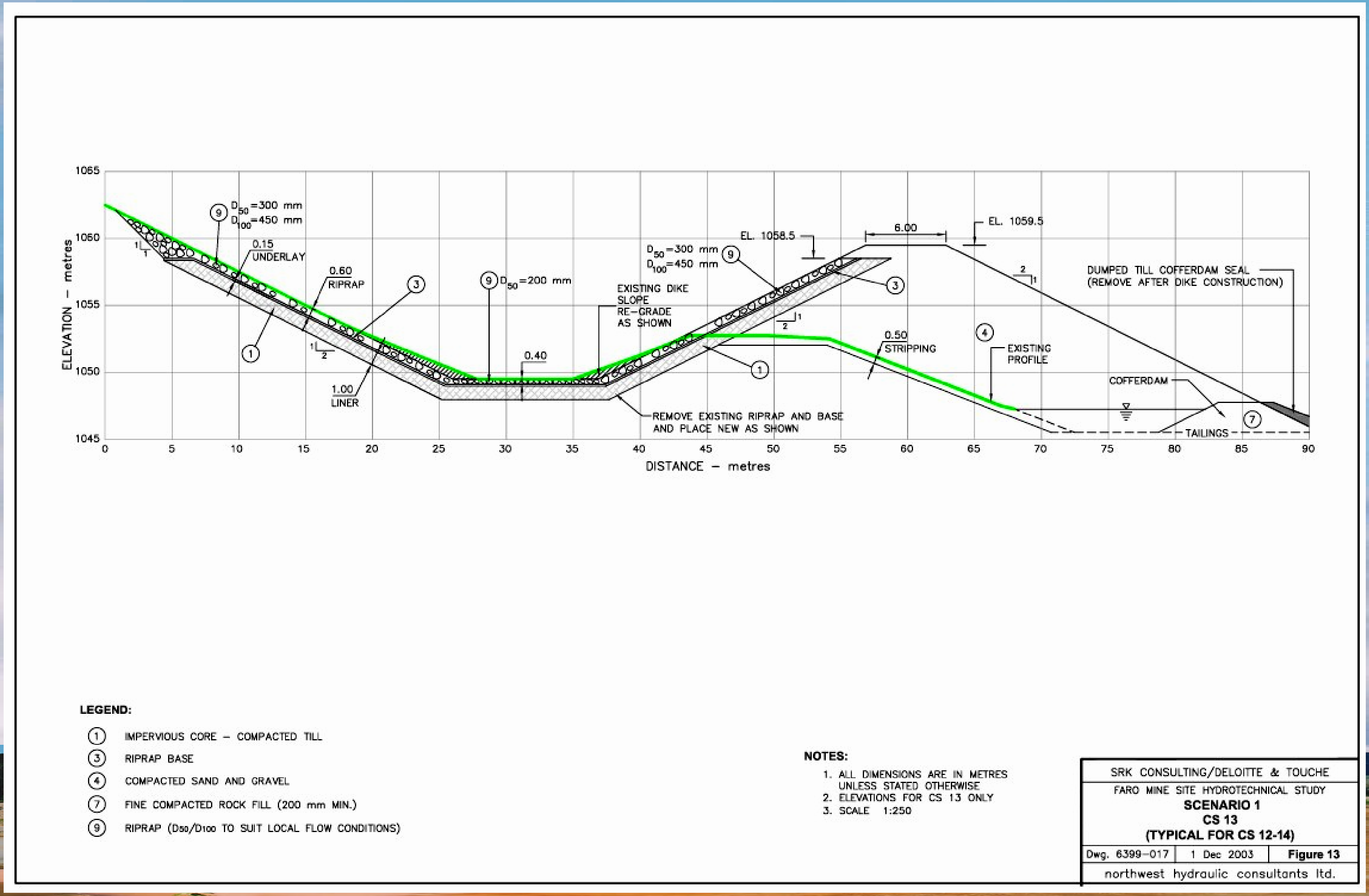


Assessment of Rose Creek Diversion Canal Upgrades Option 1

- Increase the size of the Rose Creek diversion channel along the south side of the tailings impoundments to convey the PMF.



Option 1: Increase existing capacity of canal by raising dike.



Assessment of Rose Creek Diversion Canal Upgrades

Design Summary - Option 1:

- right bank dike raised to accommodate PMF.
- channel boundary protected with rock riprap.
- flow conveyed in a concrete spillway down the steeply sloped section downstream of the Cross Valley Dam.
- 550 m long fish by-pass provided around the spillway.

Option 1- Cost Estimate

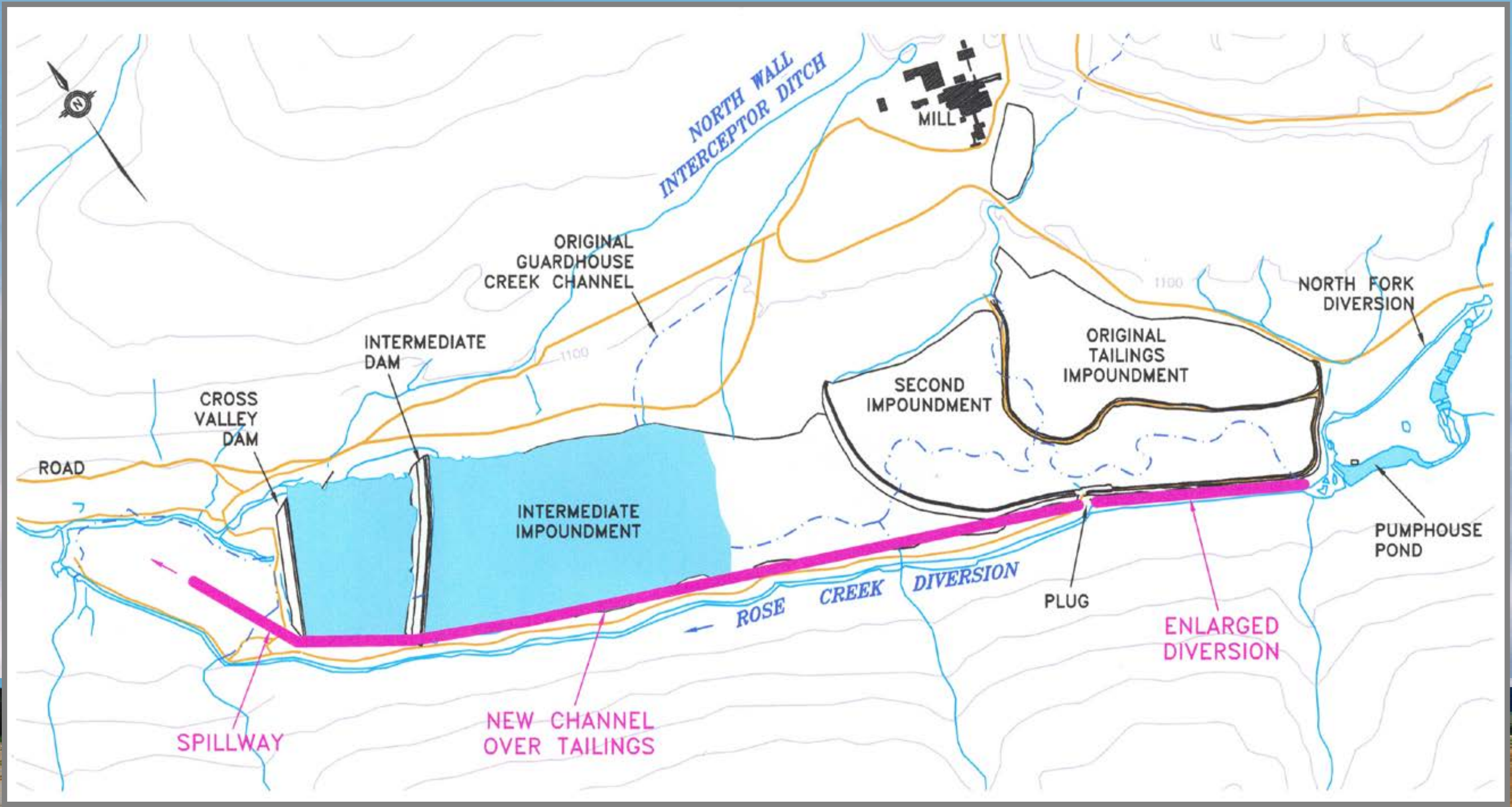
- Earthworks component: $ 13.4 million.
- Spillway structure: $ 17.4 million.
- Outlet channel: $ 0.4 million
- Fish by-pass: $ 0.9 million
- **Total: $32.1 million**
  - All estimates exclude: mob./demob., escalation, extra work allowances, final engineering & construction supervision.

Issues

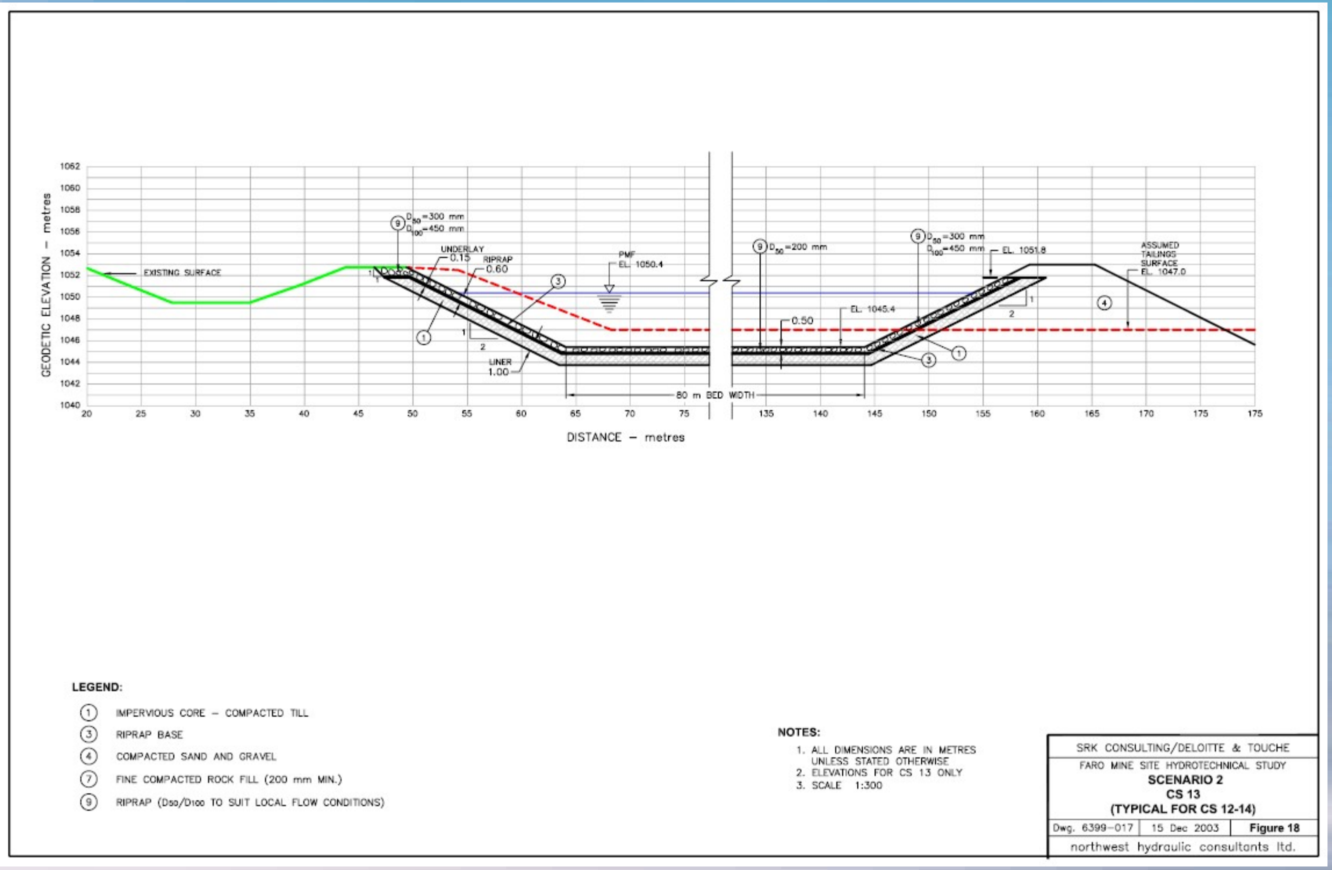
- Discontinuous permafrost in the left bank
- Performance of the right bank dike
  - Construction issues (stability, settlement)
- Impact of a large earthquake
  - Liquefaction
- Concrete spillway
  - Longevity
  - Other alignment options?

Assessment of Rose Creek Diversion Canal Upgrades Option 2

- **Abandon the Rose Creek diversion channel downstream of the plug.**
- **From the plug, convey the PMF over the tailings to a new spillway by-passing the Intermediate and Cross Valley Dams.**



Option 2- Route PMF over engineered cover on Intermediate Impoundment



Assessment of Rose Creek Diversion Canal Upgrade

Design Summary - Option 2:

- right bank dike raised down to the plug to accommodate PMF.
- from plug, PMF diverted into a channel over the tailings to the Intermediate Dam.
- flow passes into spillway approach channel.
- at the Cross Valley Dam flow enters concrete spillway.
- basin outflow into downstream Rose Creek valley.
- 900 m long fish by-pass provided around the spillway.

Option 2- Cost Estimate

- Earthworks component: $29.5 million.
- Spillway structure: $28.7 million.
- Outlet Channel: $0.4 million.
- Fish by-pass: $1.4 million.
- **Total: $59.9 million**

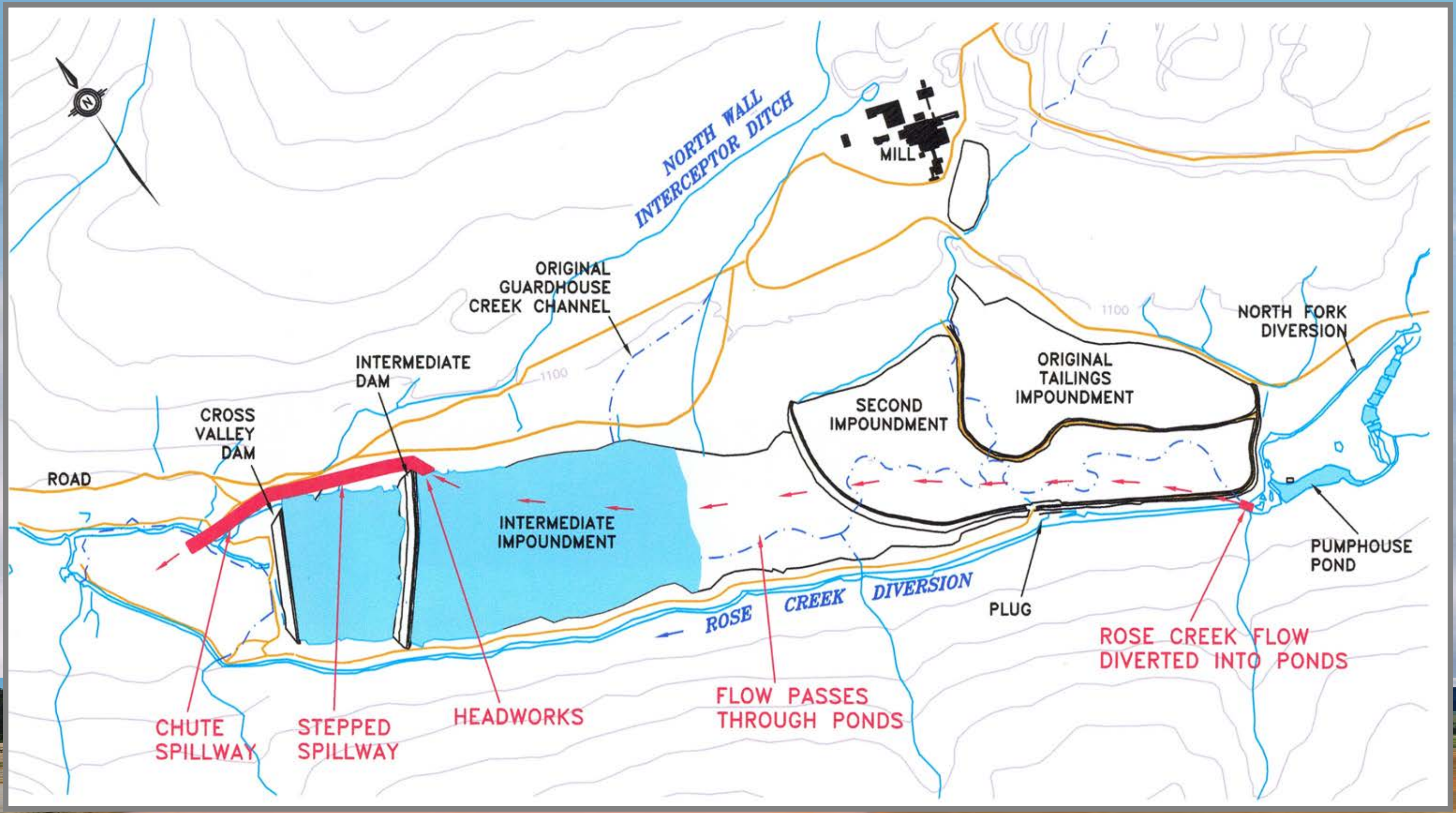
Issues

- Constructability
- Performance of the over-tailings channel in a earthquake
- Concrete spillway
  - Longevity
- Cost

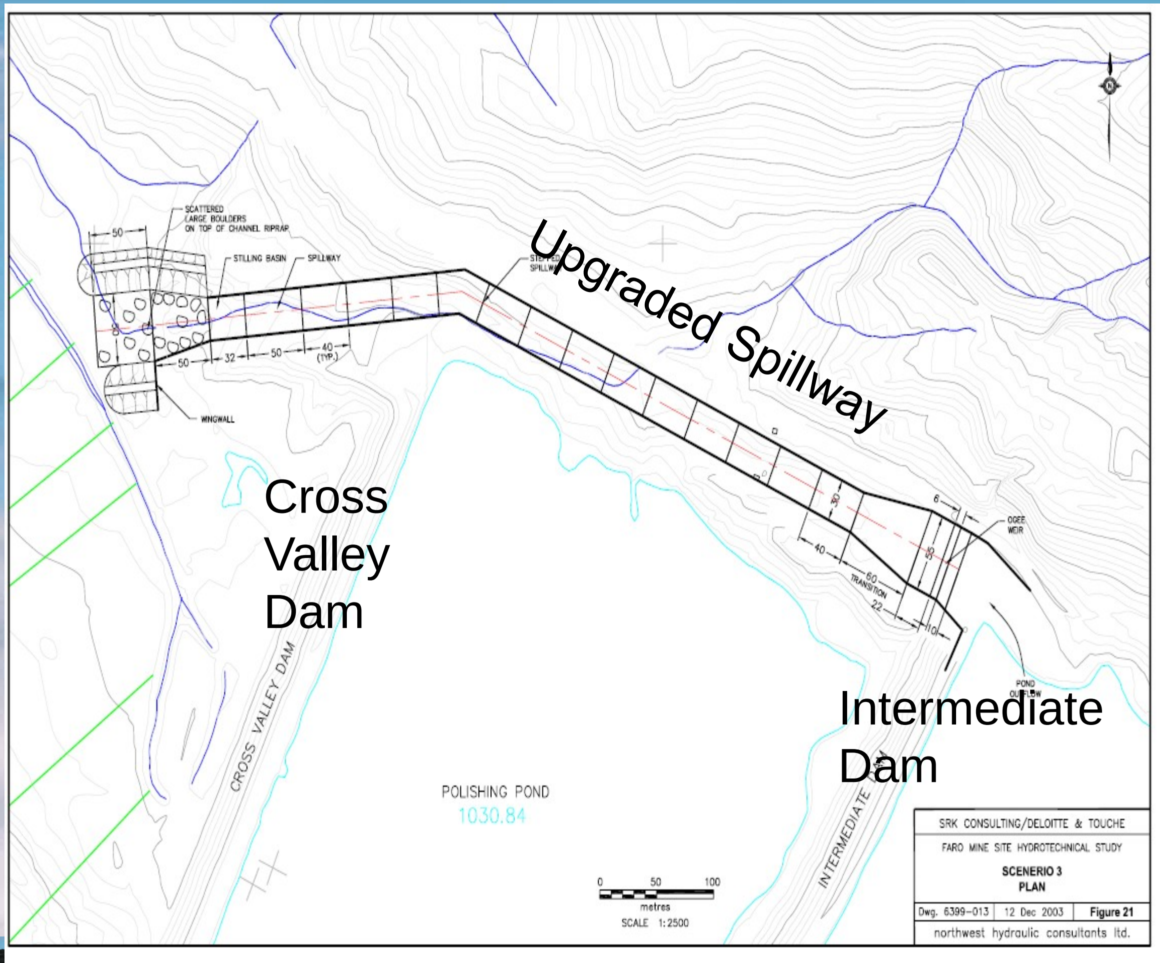
Assessment of Rose Creek Diversion Canal Upgrades

Option 3

- Remove tailings from the original, second and intermediate impoundments to el. 1042 m.
- Rose Creek flow to enter the impoundment area.
- Attenuated PMF to pass over a spillway located at the Intermediate Dam.



Option 3


Upgraded Spillway
Cross Valley Dam
Intermediate Dam
SCATTERED LARGE BOULDERS ON TOP OF CHANNEL RIPRAP
STILLING BASIN
SPILLWAY
WINGWALL
OGEE WEIR
POND OUTFLOW
CROSS VALLEY DAM
INTERMEDIATE DAM
POLISHING POND
1030.84
0 50 100
metres
SCALE 1:2500
SRK CONSULTING/DELOITTE & TOUCHE
FARO MINE SITE HYDROTECHNICAL STUDY
SCENERIO 3
PLAN
Dwg. 6399-013
12 Dec 2003
Figure 21
northwest hydraulic consultants ltd.

Design Summary - Option 3:

- Rose Creek PMF flow enters the dredged impoundment ponds at the Pumphouse Pond.
- Attenuated flow exits impoundment ponds at the north abutment of the Intermediate Dam at spillway headworks.
- basin outflow into downstream Rose Creek valley.
- 900 m long fish by-pass provided by the RCDC downstream of fuse plug dam.

Scenario 3- *Cost estimate*

- No earthworks component.
- Upstream headwall: $ 0.2 million
- Spillway structure: $31.1 million
- Outlet channel: $0.4 million
- Fish by-pass: $0.9 million
- **Total: $32.6 million**

Issues

- Requires relocation of about 75% of the tailings and a wet cover
- Concrete spillway
  - Longevity

Cost Estimate Summary

- ❑ **Option 1- $32.1 million**
- ❑ **Option 2- $59.9 million**
- ❑ **Option 3- $32.6 million**

Questions on RCDC Upgrades?


Soil Covers for Tailings
Maritz Rykaart
SRK Consulting
27

Sample ARMC Cover Objectives

- Isolate waste to prevent dust and direct contact with wildlife
- Re-vegetate
- Minimize leachate and shed clean runoff
- It may not be useful to try and limit or even minimize further oxidation

Project Components

- Reviewed cover related site literature
- Characterized the potential cover materials
- Documented site specific constructability issues that would affect any cover design decision
- Conducted scoping level numerical modeling to estimate cover performance

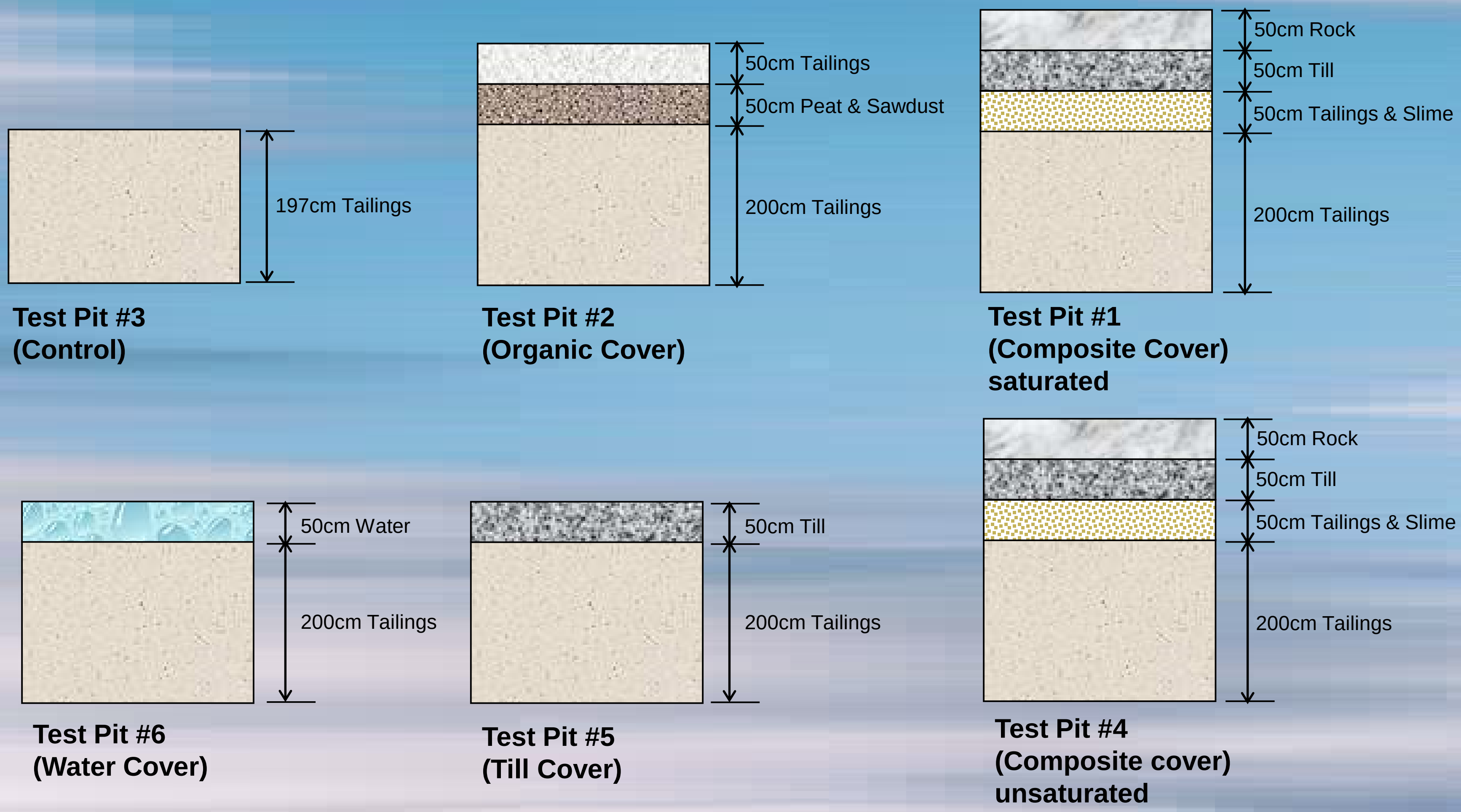
Historic Cover Research

- ARMC tailings test covers
- Partial Vangorda waste rock pile cover
- Vangorda waste rock pile starter berm
- Overburden dump re-sloping & vegetation trial

ARMC Tailings Test Cover Trial

- Constructed 1997 – operated 5 years
- 6 cells and 1 in-situ tailings area
- Located in Original Impoundment
- Results somewhat inconclusive

ARMC Tailings Test Cover Trial



Cover Materials

- What is available?
  - Till – abundant at Vangorda
  - Glaciofluvial – 2.8 million m^3 in Rose Creek valley area
  - Organics – 0.2 million m^3

Test Program

- Laboratory Testing
  - Limits
  - Specific gravity
  - Particle size distribution
  - Compaction
  - Consolidation
  - Saturated hydraulic conductivity
  - SWCC

Test Program

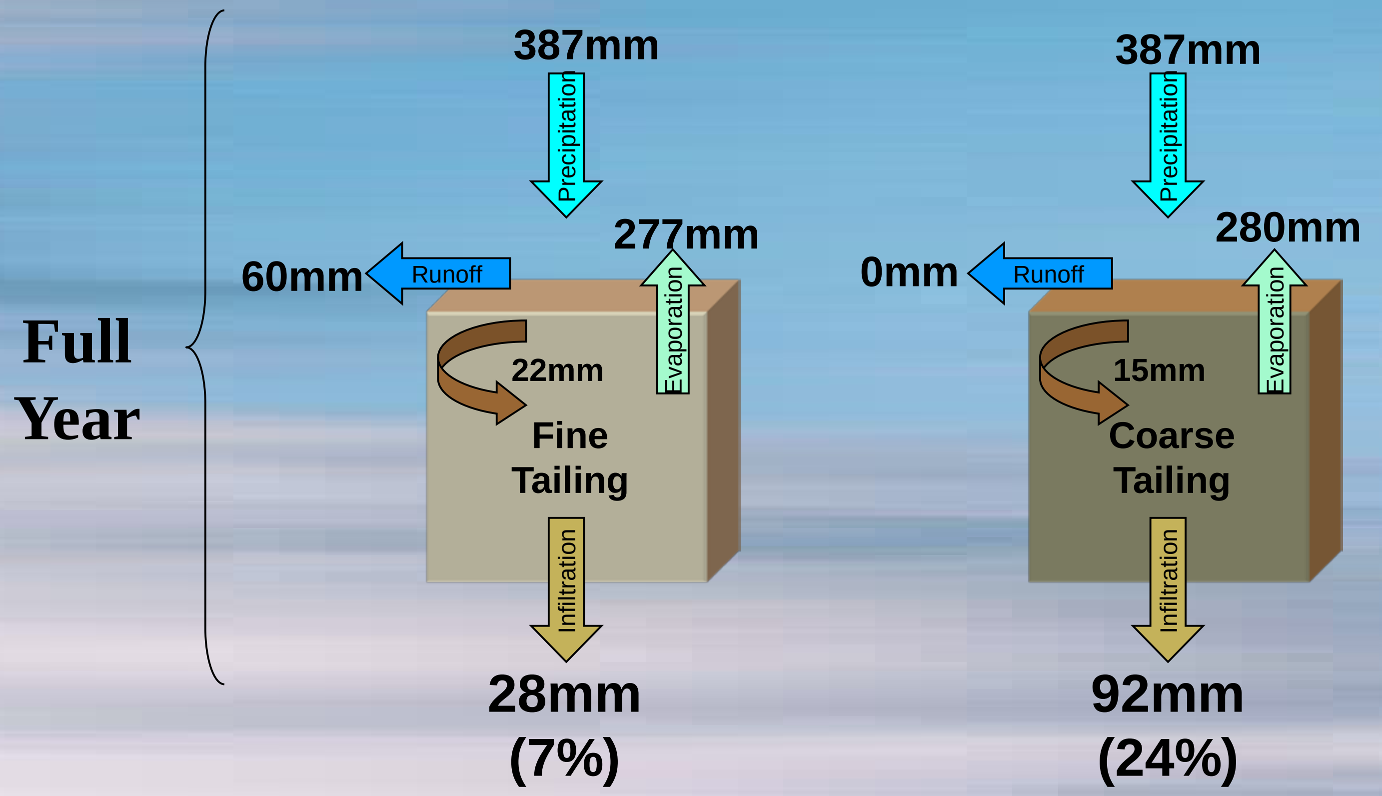
- *In situ* Testing
  - – Saturated hydraulic conductivity
  - – Density
  - – Conductivity & pH
  - – Moisture content
  - – Thermistors

Tailings

Scoping Level Numerical Modeling

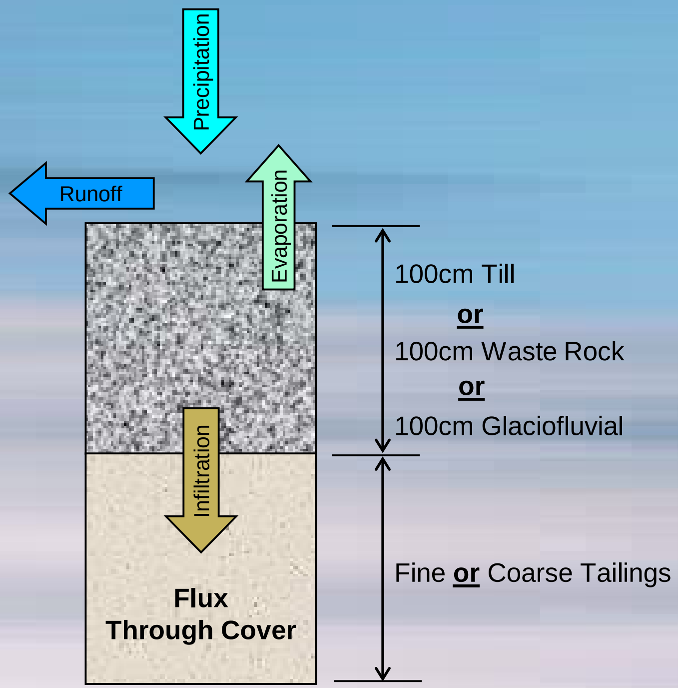
- Mathematical model predicts movement of moisture in soil
  - Un-calibrated predictions
  - Average climatic year
  - Material properties from field and in-situ tests
  - Not refined for slope, aspect etc.

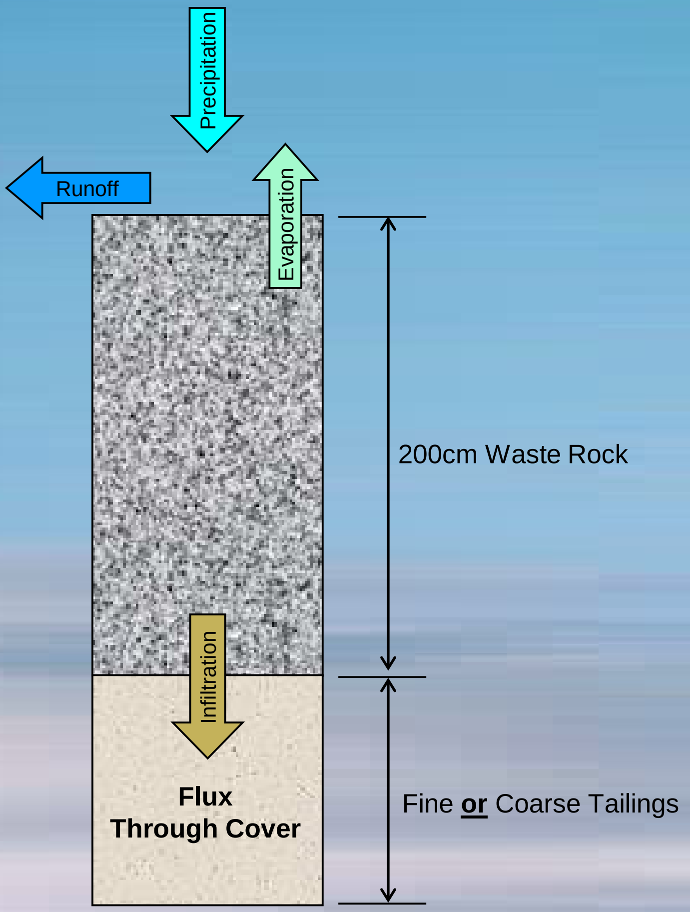
Numerical Modeling – Uncovered Tailings



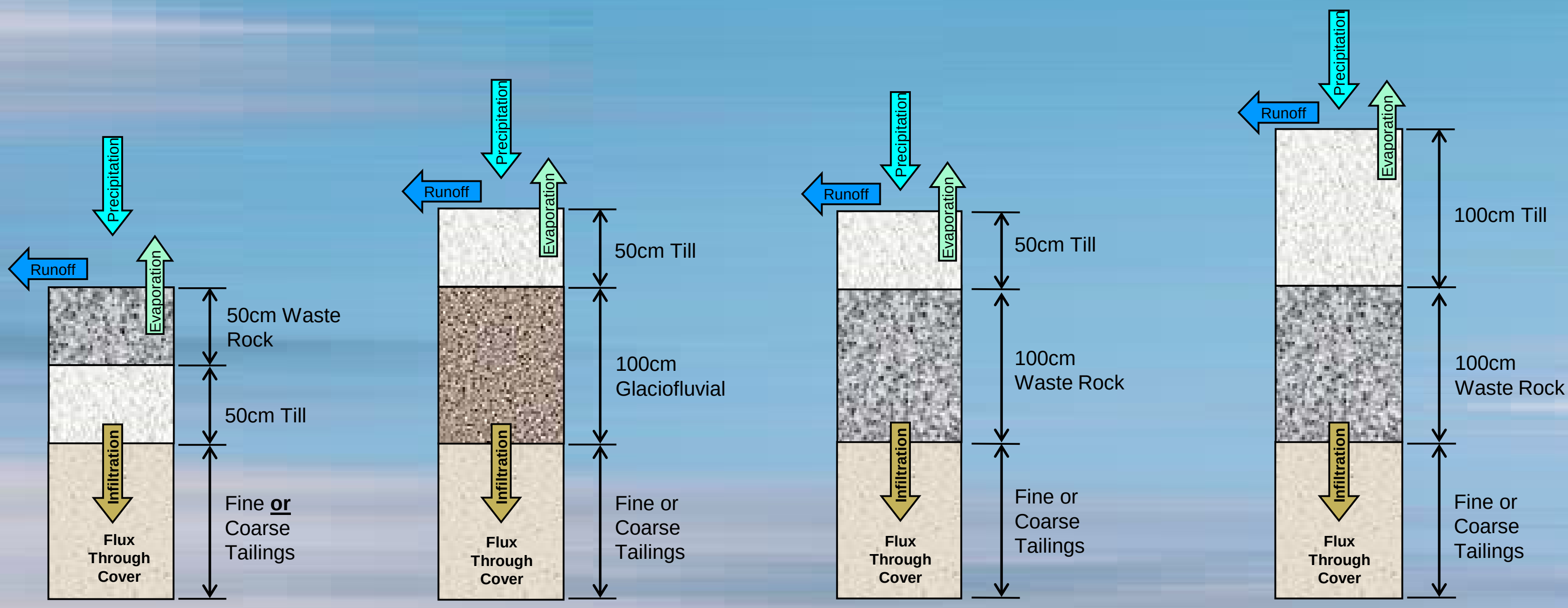
Tailings Profiles - Single-layer Covers

Thicker is better





Tailings Profiles - Two-layer Covers

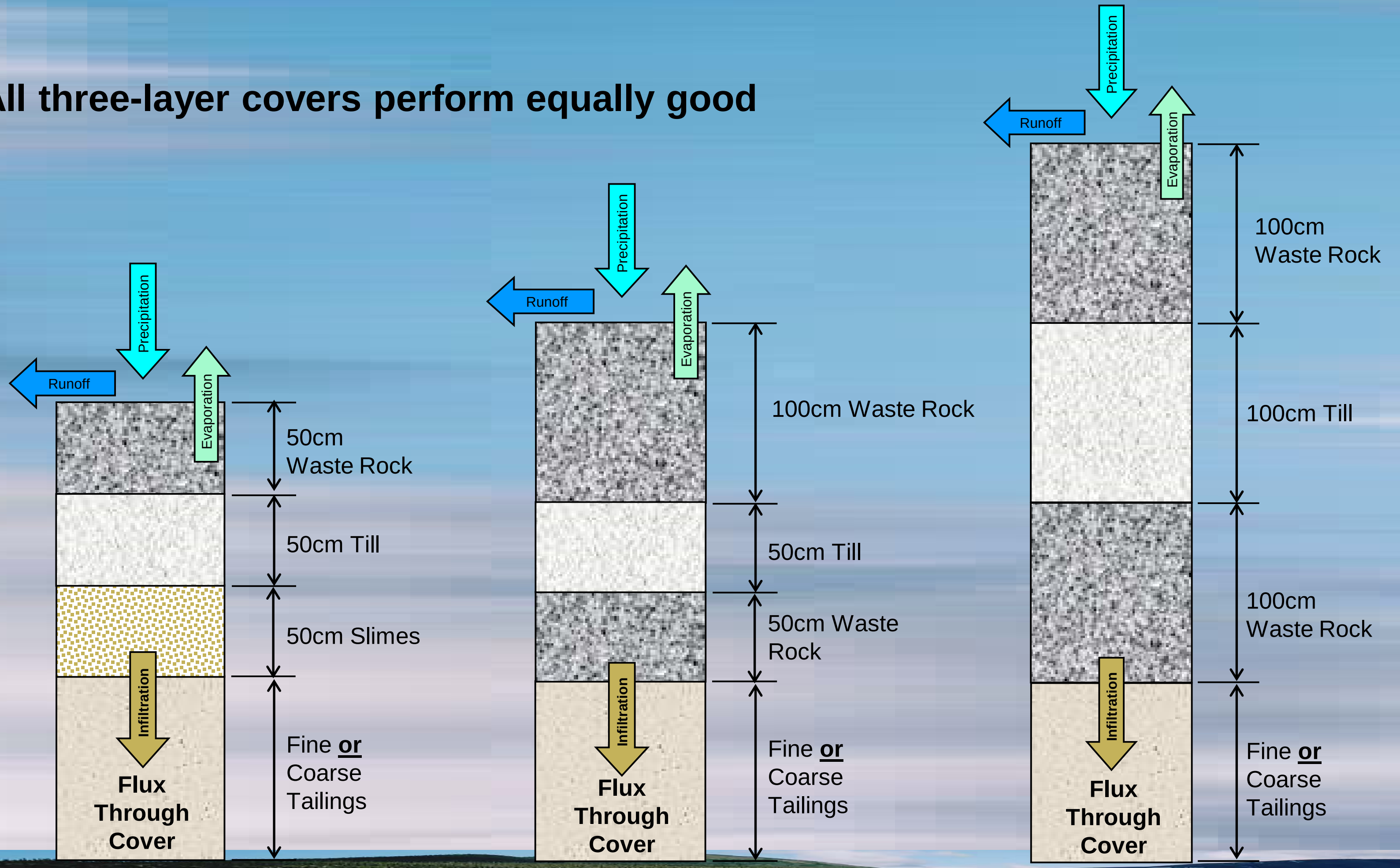


10% Flux

Till over waste rock or glaciofluvial results in low flux

Tailings Profiles - Three-layer Covers

All three-layer covers perform equally good

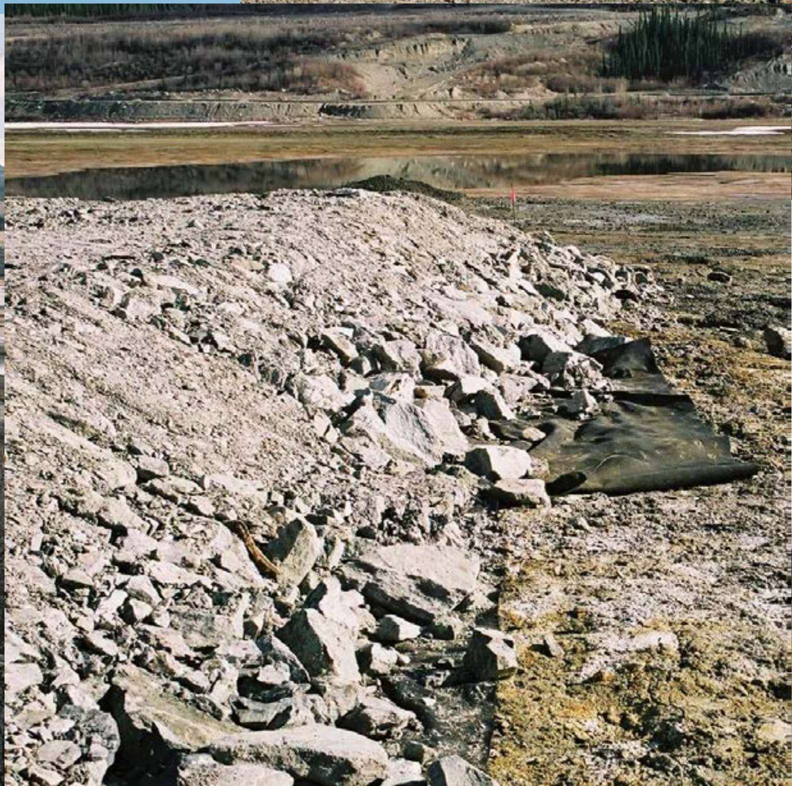


Other Important Issues

- Volume of cover material
- Tailings trafficability
  - Access for construction
  - Settlement over long term
- Frost penetration depth
- Evaporites
  - Can be attractive to animals
  - Problem for vegetation

Key Uncertainties

- Constructability
  - Conduct tailings settlement test
    - two test pads
    - constructed March 2004



Key Uncertainties

- Objective of tailings cover
  - Prevent contact only
    - Constructability is only problem
  - Reduce infiltration
    - Constructability
    - Cost vs. effectiveness

Questions on Tailings Covers

Rose Creek Tailings Facility Groundwater Interception

Premise

- some portion of groundwater flow in the Rose Creek valley aquifer requires interception for treatment

Photograph courtesy of Mike Bryson

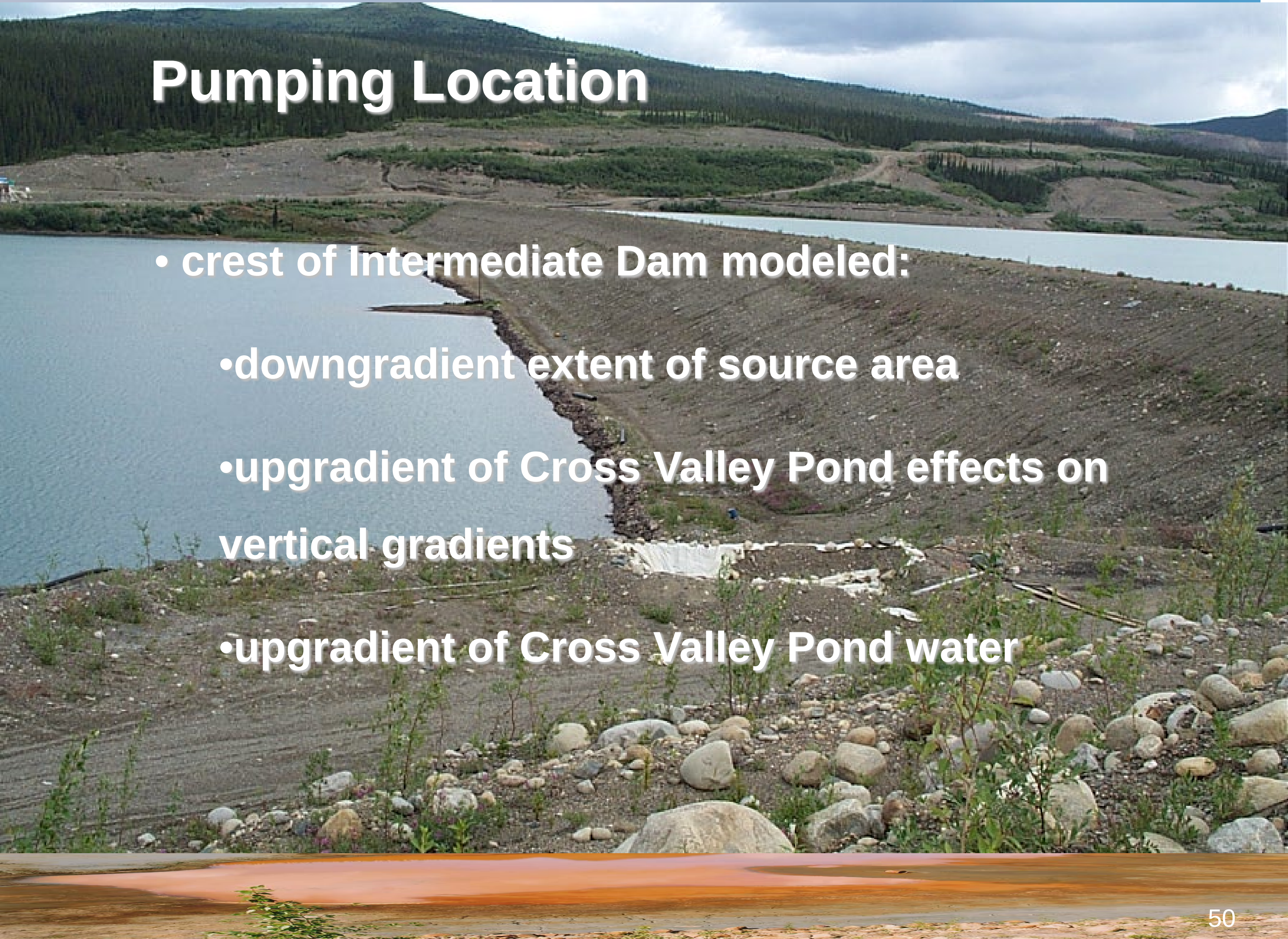
Approach

- **refine the hydrogeological model and use it to simulate pumping scenarios for comparative evaluation**

Model Refinement

- focussed on new information collection and updated calibration in the Cross Valley Pond area where groundwater discharges to surface

- 2003 multilevel wells indicate downward gradients through the tailings and very low gradients in the aquifer (suggesting that groundwater capture can focus on the upper aquifer)



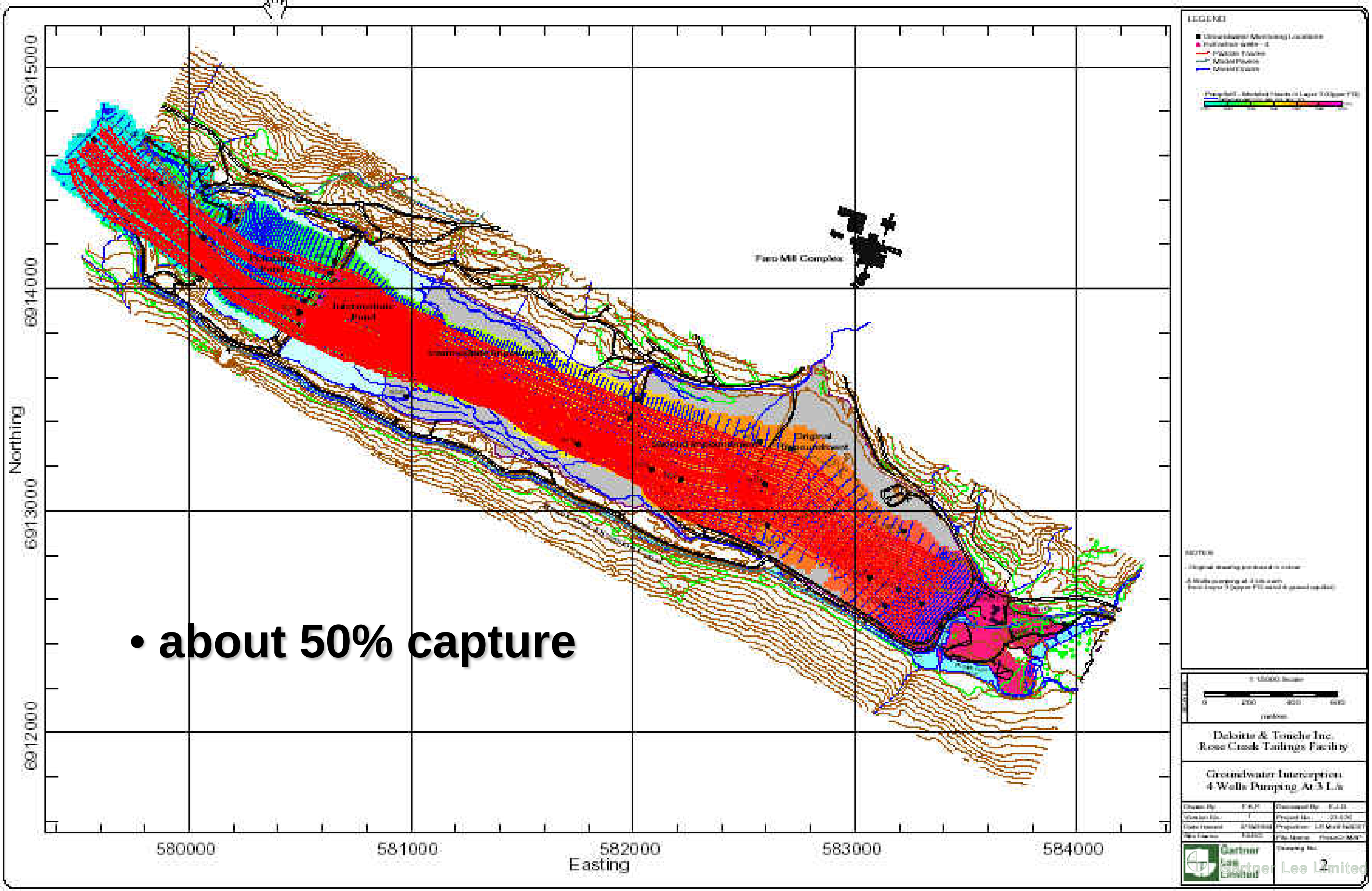
Pumping Location

- crest of Intermediate Dam modeled:
  - downgradient extent of source area
  - upgradient of Cross Valley Pond effects on vertical gradients
  - upgradient of Cross Valley Pond water

Pumping Scenarios

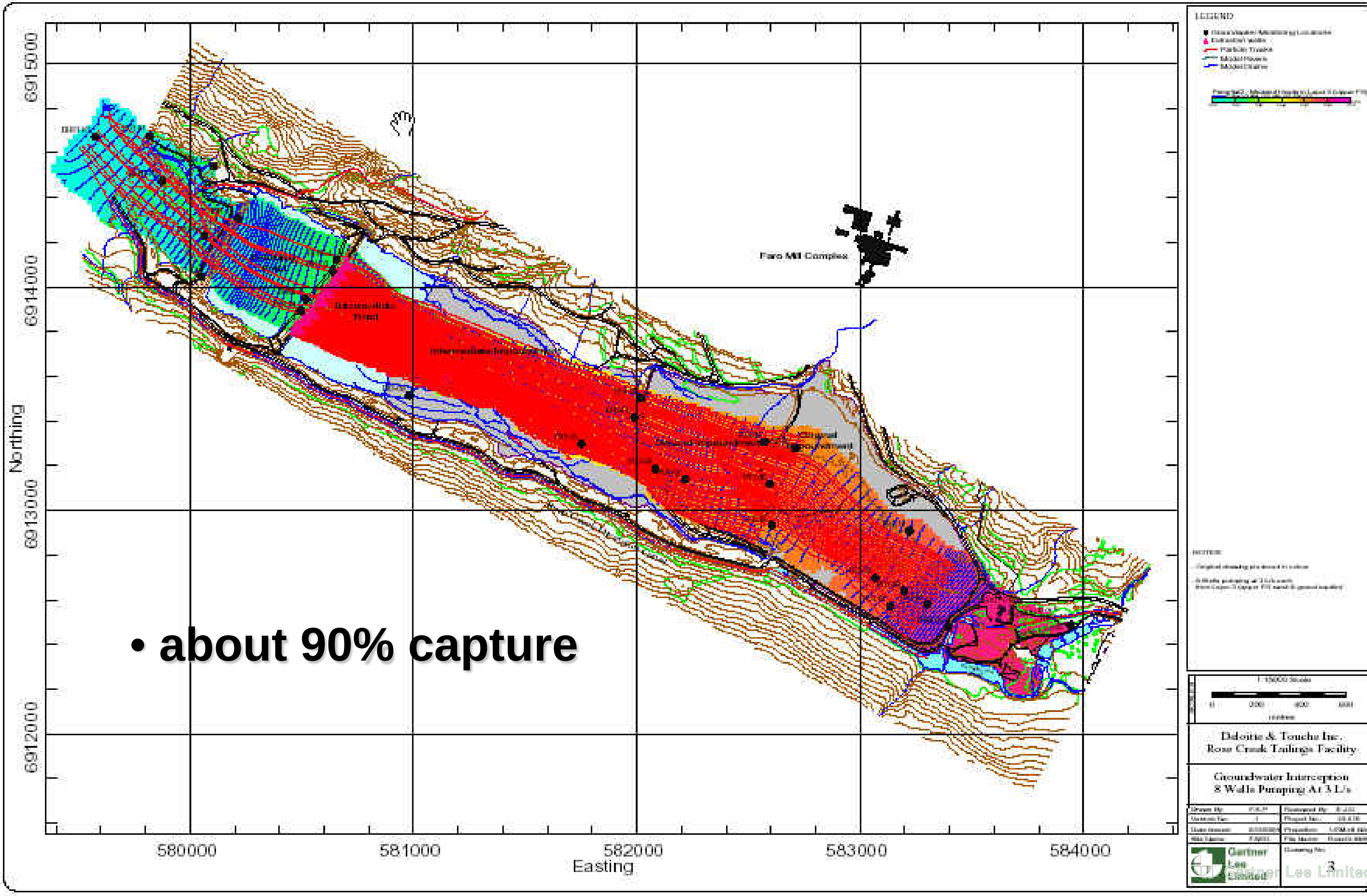
- 8 scenarios modeled:
    - vary the number of pumping wells (4 and 8)
    - vary the pumping rate (1.5 to 5 Lps per well)
    - vary the depth of well intake (upper or lower)

4 Wells at 3 Lps Each



- about 50% capture

8 Wells at 3 Lps Each



• about 90% capture

Observations

- particle capture efficiency increased with a greater number of wells at a relatively low pumping rate as opposed to fewer wells at a higher pumping rate

- particle capture efficiency is increased for wells installed in the upper aquifer as opposed to deeper

Conceptual Costs

- install 4 wells about $600K; 8 wells about $700K
- install pipeline to mill for treatment about $1.1M
- install 3-phase power to Down Valley about $??M
- treatment in Down Valley about $0.351 @ 750,000 m3 = $265K/yr
- treatment in mill about $0.161 @ 750,000 m3 = $120K/yr
- $145K/yr @ 8 years = $1.2M (cost of pipeline)
- pumping 365 days per year versus 6 mos.??

Questions on Tailings Groundwater?

Tailings Relocation Studies

John Brodie,

SRK + Contractors

Literature Research

- Searches of international scientific and engineering data bases
- Truck and shovel common
  - Arid settings, small deposits, unconfined deposits
- Hydraulic methods
  - Very few references

Case Histories

- Pinto Valley, EPA project, 38 million tons
- Eastmaque Gold, Kirkland Lake, Ont.
- Giant Mine, Yellowknife, 2.3 million tons
- ERG Project, Timmins, Ont., < 1 million ? tons
- South Africa, 8 sites, through put 0.2 to 1.8 million tons per month

Case Histories

- Hydraulic mining is not common in N.A.,
- S.A. experience suggests that it is a viable technology – arid working conditions
- Recent experience in Chile
  - Volume is similar order of magnitude
  - Seasonal operation

Study of Three Relocation Methods

- Two options (total and partial relocation)
- Three methods (dredge, monitor, mechanical)
- For each method:
  - – Contractor's scope
  - – Recommended equipment
  - – Mine plan
- Comparison of methods (risks and costs)

Contributors

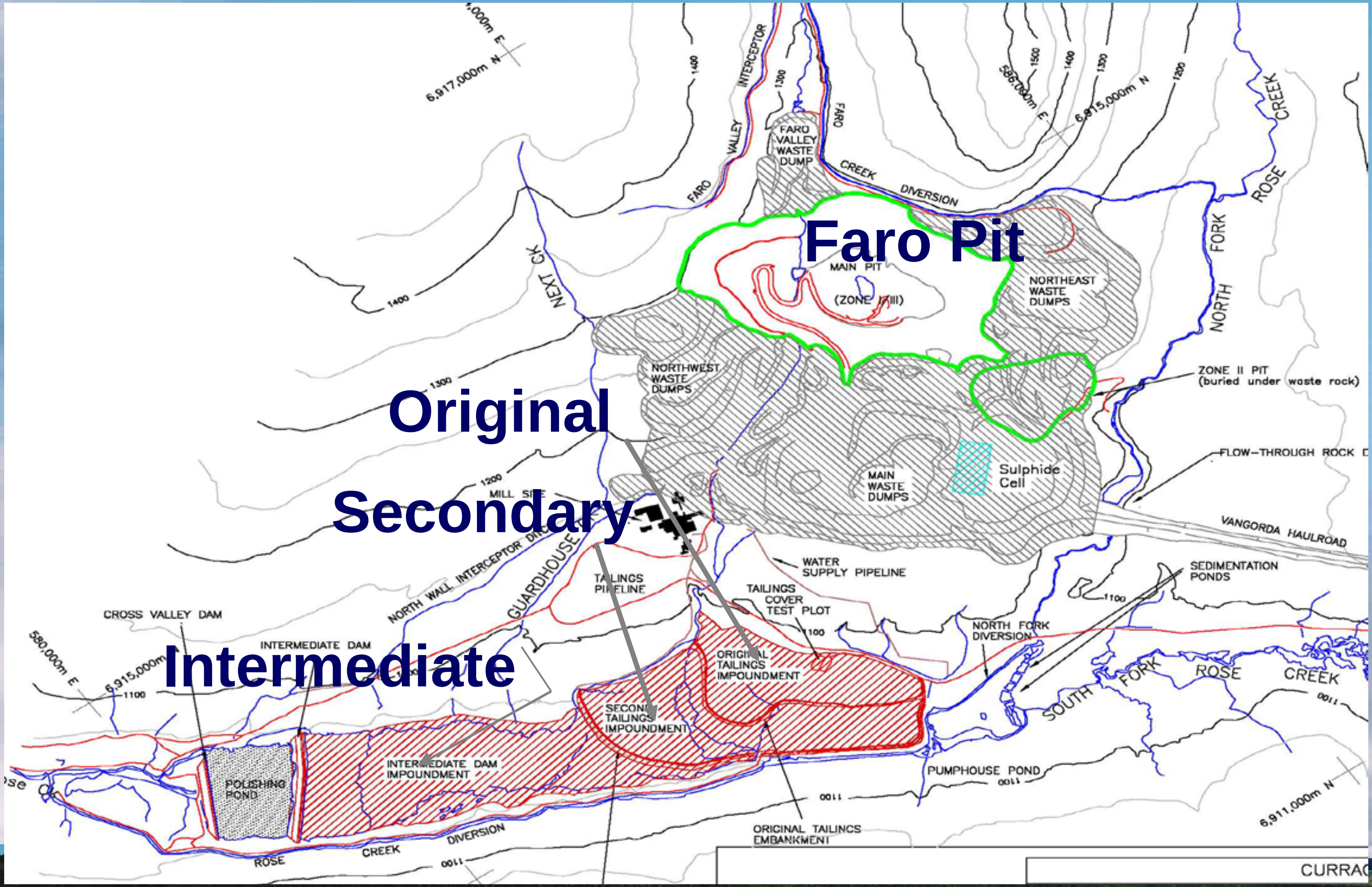
- Ernie Zuccolin, FRPD/EZC
- David Jansson, ECPM
- Keith Byram, Pelly Construction

Study Objectives

- Develop conceptual designs and preliminary costs for various systems to relocate all or a portion of the tailings to the Faro Pit.
  - Dredging
  - Hydraulic monitoring
  - Mechanical methods
- Consider water management and water treatment issues.

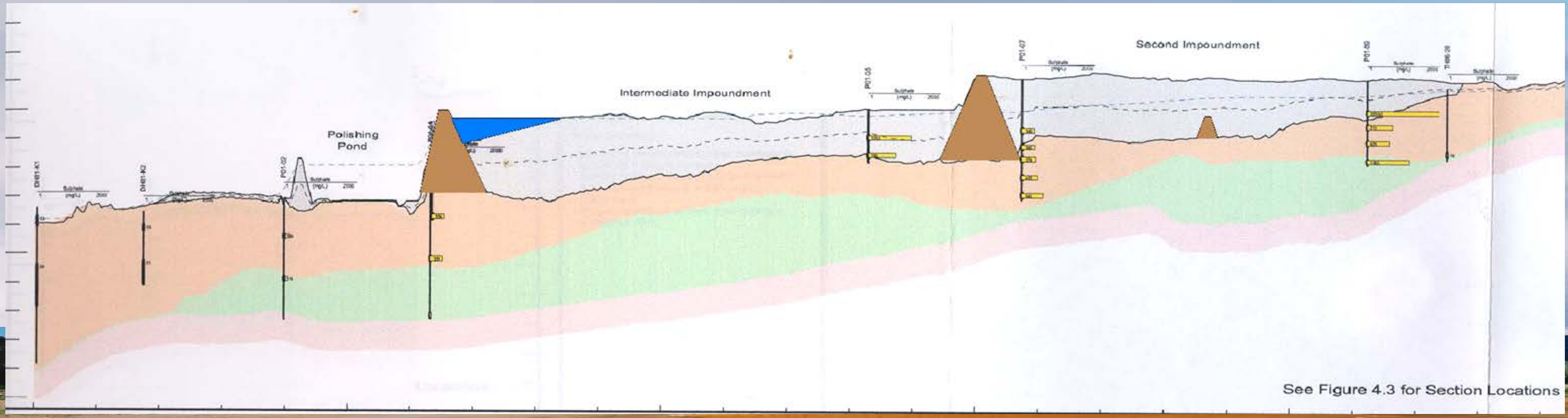
Relocation Concepts

Relocation Concepts



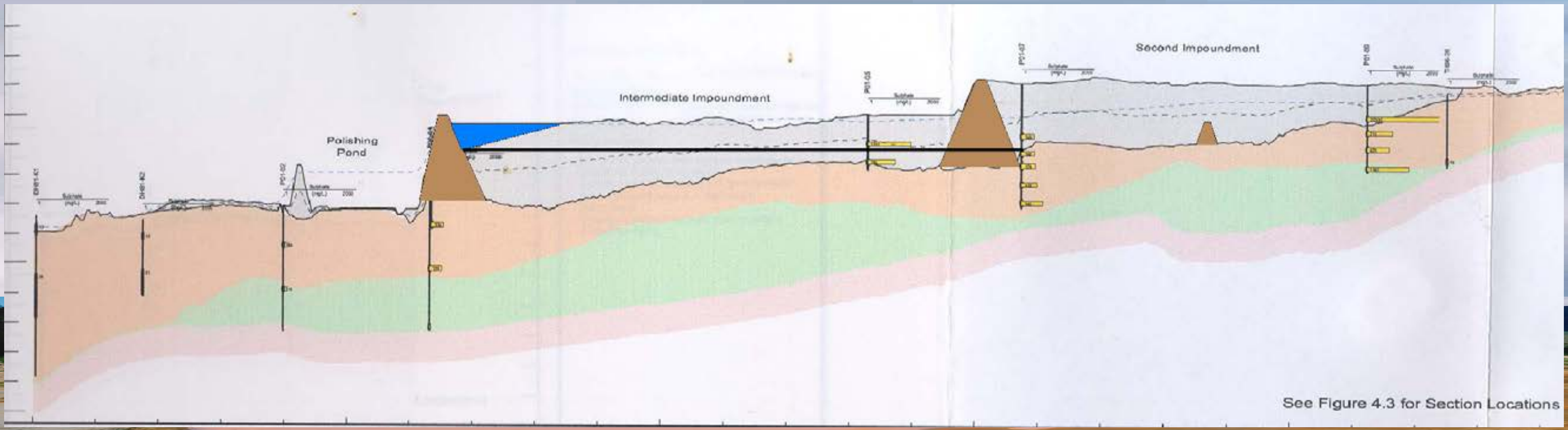
Two Relocation Options

- ❑ Total tailings relocation (57 million tonnes)
  - – Relocate all tailings to the Faro Pit
  - – Remove all or part of original and secondary dams (and breach the Intermediate Dam & CV Dam)



Two Relocation Options

- Partial tailings relocation (43 million tonnes)
  - Relocate tailings above elev. 1042 m
  - Remove most of the tailings from the original and secondary impoundments
  - Close with 3 m water cover; freeboard is adequate, so a raise of the Intermediate Dam is not required.



Dredging Method

Typical Dredge Arrangement

Typical Dredge Arrangement

Dredging – Main Equipment

- Portable suction dredge
- Cables and winches to raise/lower suction pipe
- Centrifugal main pump powered by diesel or electric drive motors
- Two spud system
- Portable pontoons
- Floating discharge pipeline
- Support boats

Dredge – Mine Plan

- Excavate starter pit in original impoundment
- Float the dredge
- Cut in 1 to 2 m lifts until original and secondary impoundments are gone
- Use mechanical equipment as necessary to remove dams
- Repeat the process at the Intermediate impoundment
- Mechanical equipment for final cleanup of floor

Dredge – Mine Plan

Concern at Secondary Dam

Dredge - Mine Plan

- Operating season assumed to be 7 months/year
- Time to complete:
  - For total relocation: 5 years
  - For partial relocation: 5 years

Hydraulic Monitoring Method

Typical Monitoring System

Typical Monitoring System

Typical Monitoring System

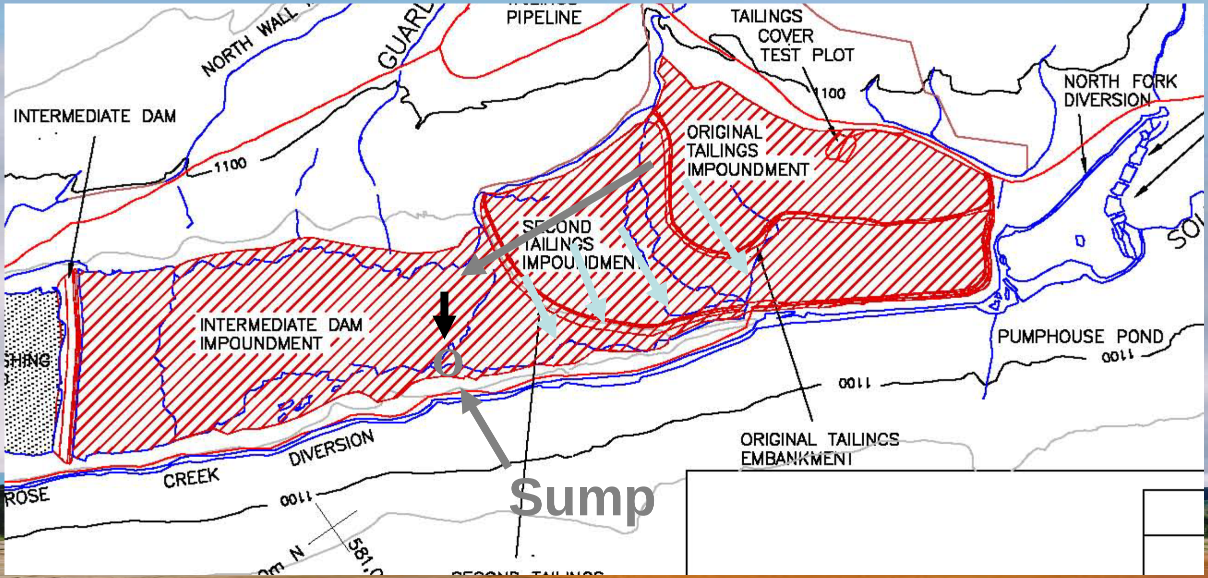
- 20 m faces

Hydraulic Monitoring – Equipment

- Six operating hydraulic monitoring guns with four spares
  - Skid-mounted
  - Electrically operated from a weatherproof cabin
- The cabin will be on wheels and elevated to ± 2 metres above ground level, thereby allowing the operator full visibility of the operation
- Sump with various screen sizes and a pump/pipeline system to deliver the tailings to the Faro Pit

Hydraulic Monitoring – Mine Plan

- Plan not defined as part of current study
- 1991 study by Kilborn/Webster defined a plan for an equivalent to the partial relocation option



Hydraulic Monitoring - Mine Plan

- Operating season assumed to be 6 months/year
- Time to complete (current information):
  - For total relocation: 12 years
  - For partial relocation: 9 years

Mechanical Method

Mechanical – Equipment

- Cat 776, 135 tonne wagons
- D11 size dozer
- Large capacity belt loader

Mechanical - Mine Plan

- Improve roads for hauling (grades and alignment)
- Tailings pushed to the belt loader, which loads the trucks
- Trucks haul to the pit.
- **Entire approach is based on the equipment being able to traffic on the tailings**

Mechanical - Mine Plan

- Operating season assumed to be 7 months/year
- Time to complete (current information):
  - For total relocation: 7 years
  - For partial relocation: 5.4 years

Comparison of Risks

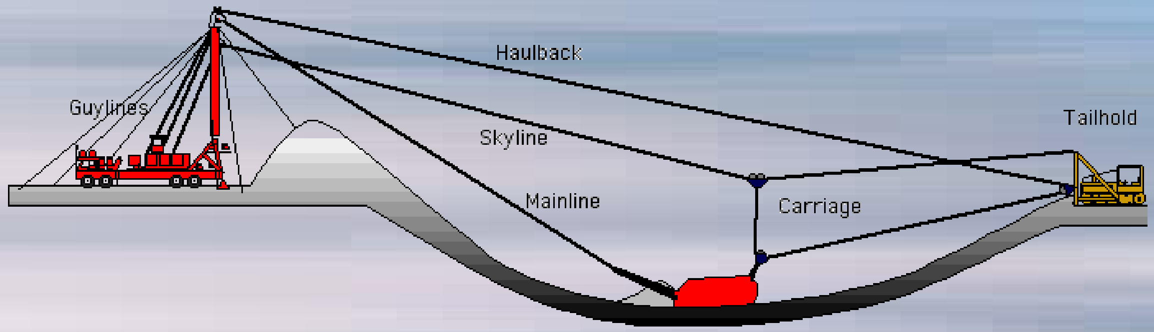
- Dredge
  - Large pond leads to increased seepage losses and increased risk of failure of the secondary dam
  - Must be complemented by mechanical methods to remove coarse granular portion of dams and cleanup the basin floor

Comparison of Risks

- Hydraulic Monitoring
  - Technical feasibility
  - Seepage losses expected to be less than dredging
  - Less risk of dam failure (internal slope failure within the tailings is possible)
  - Must be complemented by mechanical methods to remove coarse granular portion of dams and cleanup the basin floor

Comparison of Risks

- **Mechanical**
  - Approach depends on the equipment being able to traffic on the tailings
  - Needed to complement select aspects of the other methods
  - Alternatives such as Sauerman/Cresent drag scraper limited by materials and/or area size



Comparison of Costs

	Total Relocation	Partial Relocation
Dredging		
Total Cost	$115 - $130 M	$103 - $108 M
Cost/tonne	$2.01 to $2.27	$2.38 to $2.51
Hydraulic Monitoring		
Total Cost	~ $115 M	~ $100 M
Cost/tonne	~ $2.00	> $2.00
Mechanical		
Total Cost	$92 M	$70 M
Cost/tonne	$1.61	$1.63

Costs not in Table

- Engineering and supervision
- Lime addition
- Excavation of old dams (up to $5 million)
- Incremental cost of removing ~1 m of natural soil ($5 to $10 million) and rehabilitating stream
- Any required groundwater treatment
- Any costs at Pit

Conclusions

- There are technical risks for all methods
  - Environmental risks highest with dredging
  - The mechanical method is unlikely to be stand alone (trafficability) but is needed with either/both of the other methods.
- Water treatment issues are similar for all options
- Water management issues most severe for dredging (more water, seepage)

Questions on Tailings Relocation

Attachment 6 – Area's of Interest from Group Exercise

Areas of Interest from June 23, 2004

1. Maintaining hunting and fishing access

2. Environmental protection

2.1 Water, fisheries and habitat

2.2 Wildlife and habitat

2.3 Safe access to healthy country foods

2.4 Long term risk of resources

3. 100 Year Risks

3.1 Long term physical and chemical stability

3.2 Funding and political will

3.2.1 Money for ongoing activities

3.3 Consequences of erosion and degradation

3.4 Consequences of design based on unknowns and flawed assumptions

3.5 Management of growing volume of sludge

4. What are the international implications of the closure work

4.1 Yukon River

4.2 Yukon Salmon Agreement

5. Community and economic benefits

5.1 Long-term economic opportunities

5.2 Future prospecting

5.3 Capacity building and skills training

6. Cost effectiveness

6.1 Relative to other contaminated sites

6.2 Relative to other objectives

7. Fisheries use

7.1 First Nations

7.2 Recreational

8. Protection of human health

8.1 Drinking water

8.2 Use of plants

8.3 Workers and public

9. Technical

9.1 Standards and performance criteria

9.2 Alternative technologies

9.3 Tailings removal or control

9.3.1 If not removed, how are they stabilized

10. Downstream risks

10.1 Water quality

10.2 Concern for inundation of valley and rivers with tailings

10.3 Land loss associated with water treatment sludge

11. Restoration of productive fish habitats

11.1 To levels equal or exceeding pre-mine levels

12. Assurance of funding

12.1 Long-term

12.2 Precedent setting cost requirements for industry and government

13. Develop better understanding of long-term intended land use

13.2 Regulatory obligations

13.3 People's views and expectations

14. Participation and collaboration in planning process

15. Is the final plan practical and integrated

16. Maximum reduction or elimination of federal liability

16.1 No transfer to Yukon Government

17. Eliminate opportunity for catastrophic failure

18. Promotion of biodiversity for long term

19. Long-term requirement for maintenance

20. Aesthetics

20.1 Visual

21. Effect of climate change

22. Rehabilitation to maximum degree of naturalness

23. Historic interest

24. Public perception

24.1 Positive

24.2 Negative

25. Staff stability

26. Precautionary principle

27. Acceptable time frame

Mine Area Studies

2002-2004

Overview

- Review of physical risks
- Waste rock geochemistry
- Waste dump water balances
- Waste dump water quality predictions
- Pit lake water quality predictions

Review of Physical Risks

Project Objective

- Examine failure risks associated with major site components

Major Elements Considered

- Dams
  - ~~FWSD, Original Tailings Dam, Secondary Dam, Intermediate Dam, Cross Valley Dam~~
- Pits
  - Faro, Vangorda, Grum
- Diversions
  - Faro Creek, Vangorda Creek, ~~Rose Creek~~
- Waste Dumps
  - Faro Northeast, Vangorda, Grum

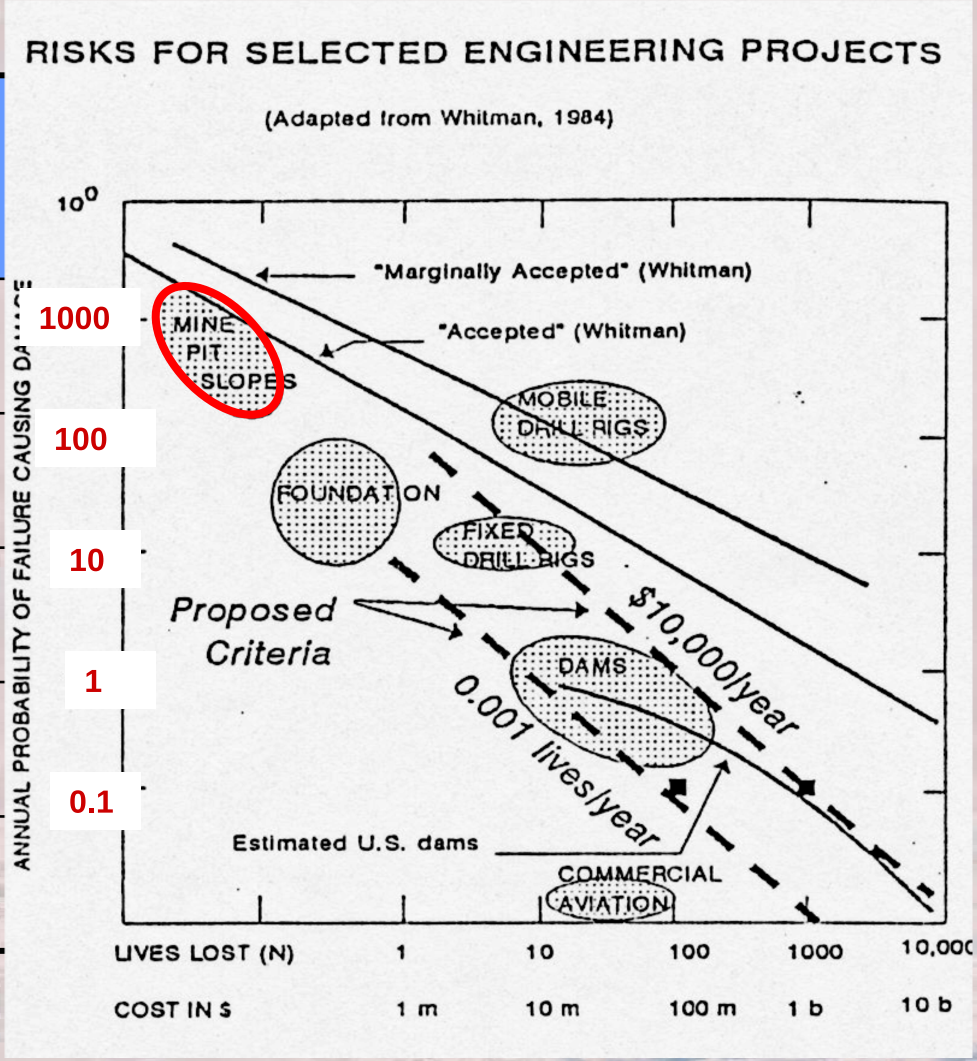
Study Results – Pit Walls

Grum North Wall

Failure Mode	**Probability (in 10,000)**
Static failure	0.1
Earthquake	0.004
Extreme precipitation	0.5
20% Weakened foundation	0.06
High phreatic level	0.1
Total probability of failure	**0.5**

Study Results - Pit Walls

Pit Wall	Failure Probability (in 10,000)
Faro North Wall	10
Faro East Wall	200
Vangorda Northwest Wall	25
Grum North Wall	1
Grum East Wall	0.6



Study Results - Waste Rock Piles

Waste Rock Pile	Failure Probability (in 10,000)	Consequence	Risk Rating
Faro Northeast	0.5	Short-term contamination of Rose Creek Sediments contained by Rock Drain Damage to seepage collection system	Moderate
Vangorda	0.3	Damage to seepage collection ditch	Low
Vangorda into Little Creek Pond	0.4	Failure into pond and potential overflow	Low
Grum	0.3	Damage to seepage collection system	Low

Conclusions

- **Pit Walls**
  - Designed for failure
  - Consequences are small except for possible effects on diversions
  - Consider establishing required “setback” for any surface works

Conclusions

- **Waste Rock Piles**
  - Generally adequately designed
    - Currently low probability of failure
    - Minor consequences in most cases → Low risk
  - But if dumps are above water or dam → Moderate risk
    - e.g. Faro Northeast Dump above North Fork
  - Consider criteria that includes
    - Precipitation, infiltration and phreatic levels
    - Deformation analysis rather than dynamic FOS

Waste Rock Geochemistry

Project Objective

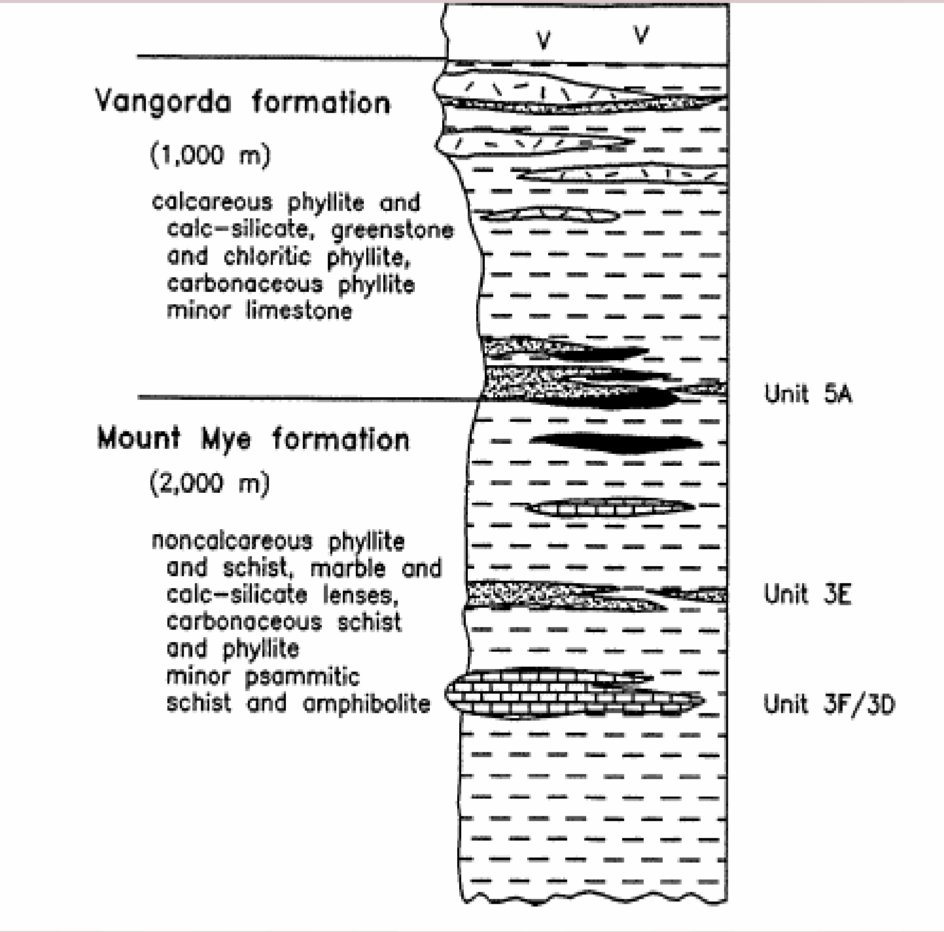
- Evaluate current sources of contaminants
- Predict future changes in contaminant concentrations

Tasks

- Review of Existing Information
- Seep Surveys
  - 2002 and 2003
- Surface Waste Rock Mapping
- Test Pits
- Waste Rock Drilling
  - Drilling, logging, sample analysis
  - Instrument installation
- Laboratory tests
  - Static tests
  - Column tests

Effects of Geology (1)

- Mineralization is “sulphide rock”
  - Not all sulphide rock is ore
  - Surrounding rock is also partly mineralized
- Rock “below” ore contains low carbonate
- Rock above ore contains more carbonate
- Anvil Batholith (“granite”) heated and altered the Faro area rock
- Structurally complex



Effects of Geology (2)

- Mineral sources of contaminants:
  - Pyrite – Fe, sulphate, acidity, (Cu, As, Co , Ni)
  - Sphalerite – Zn, Cd, Mn
  - Chalcopyrite - Cu
  - Galena - Pb
  - Carbonate minerals – Mn
  - Sulphosalts – As, Sb, Cu
- Main elements of concern are:
  - Zn, Cd and Mn under both neutral and acidic conditions.
  - Copper under acidic conditions

Effects of Management Practices

- ❑ Faro
  - – Prior to late 1970’s
    - Sulphide waste rock was not selectively managed
  - – 1970’s to 1990
    - Sulphide waste rock was placed in at least two “cells”.
- ❑ Vangorda Plateau
  - – Sulphide cell constructed in Grum Dump
  - – Sulphide segregated and placed in upland part of Vangorda Pit waste rock dump

Effects of Time

Stage 1 - Dissolution of carbonates

- pH>8
- low metals and sulphate

Stage 2 - Sulphide oxidation accelerates

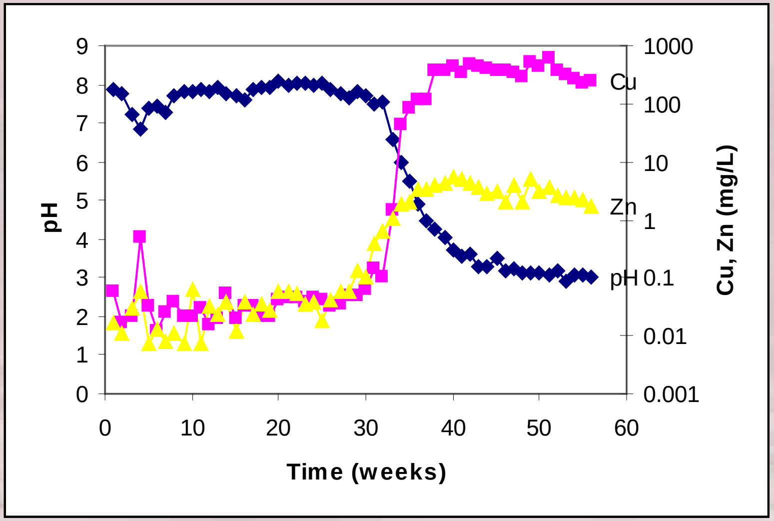
- pH between 7 and 8
- increasing Zn and SO_4

Stage 3 - Acid rock drainage

- pH<4
- high SO_4, Zn, Cd, Mn

Stage 4 - Long term

- pH increases,
- SO_4, Zn, Cu decrease, Pb increases



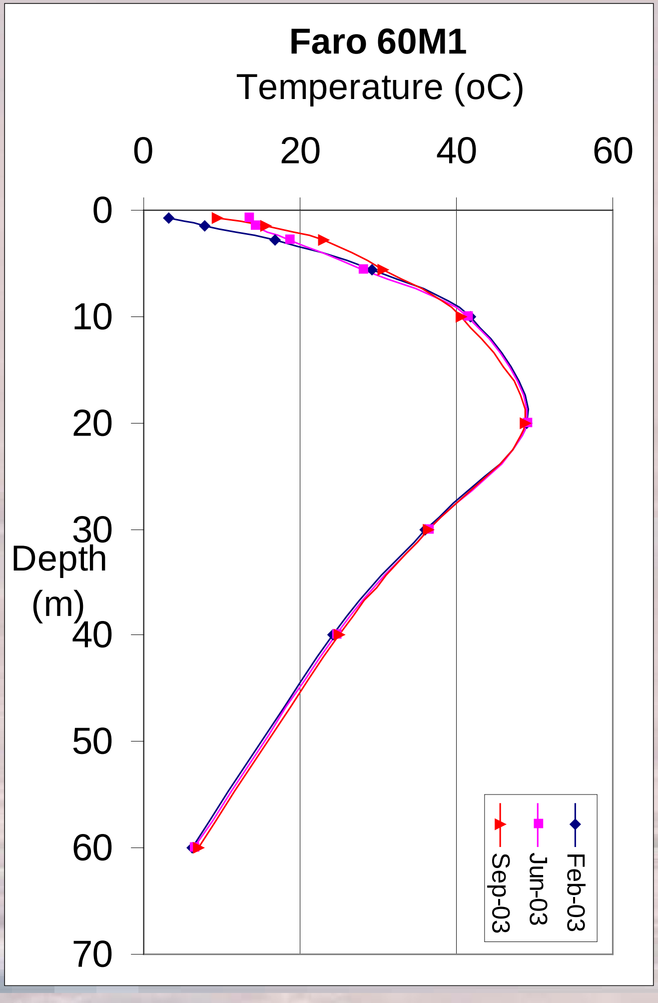
Faro Waste Rock Classification

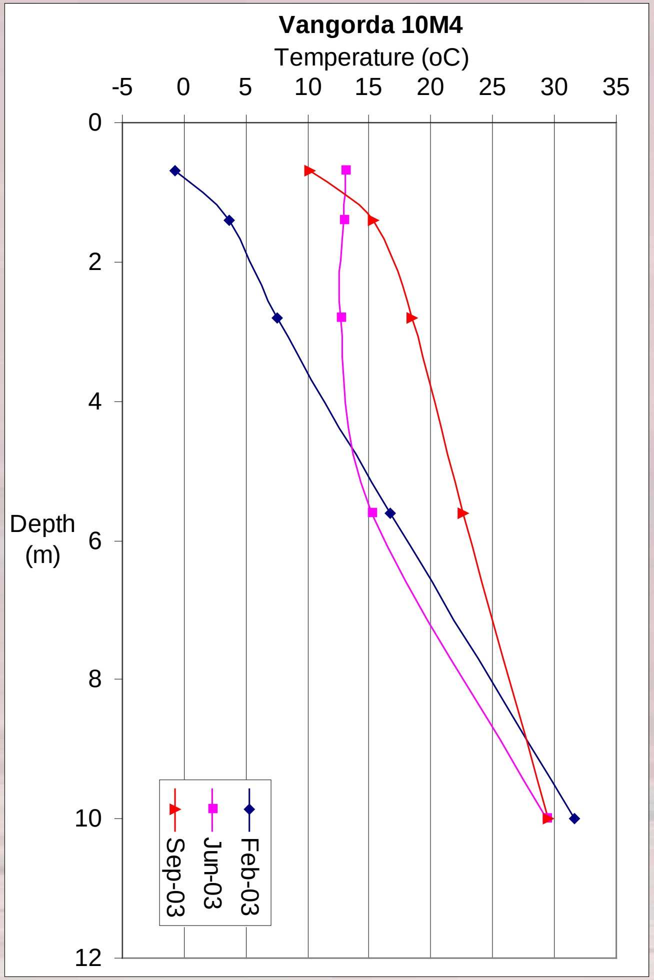
Rock Type	Overall Classification	Acid Onset Time Frame	Metal Leaching
Schist (1D)	Non-acid generating unless mixed with sulphide	Delayed (decades)	-
Alteration Envelope	Acid generating	Immediate	Zn, Cd, Mn, Cu, Fe, Ni.
Sulphide Rock	Potentially acid generating	Immediate	Zn, Cd, Mn, Cu, Fe, Ni.
Calc-Silicate	Acid consuming	-	None
Intrusive	Uncertain	Delayed (decades)	Zn

Vangorda Waste Rock Classification

Rock Type	Overall Classification	Acid Onset Time Frame	Metal Leaching
Non-calcareous Phyllite	Acid consuming unless mixed with sulphide	-	Zn
Sulphide Rock	Potentially acid generating	Immediate to delayed (decades)	Zn, Cd, Mn, Cu, Fe, Ni.
Carbonaceous Phyllite	Potentially acid generating	Delayed (years to decades)	Zn
Calcareous Phyllite	Acid consuming	-	Zn
Chloritic Phyllite	Acid consuming	-	Zn

Progress of Oxidation





Faro Seepage Types

- Type 1
  - Non-acidic, relatively dilute, zinc <5 mg/L
  - Upper NW Dumps
- Type 2
  - Non-acidic, sulphate near 2000 mg/L, zinc 4 to 595 mg/L
  - Ore and LGO stockpiles, NE flowing toward pit
- Type 3
  - Acidic, zinc>40 mg/L
  - Ore and LGO stockpiles, NE flowing toward pit

Vangorda/Grum Seepage Types

- Type 1a
  - Non-acidic, low zinc <0.03 mg/L.
- Type 1b
  - Non-acidic, zinc 2 to 5 mg/L.
  - Dowgradient from Grum sulphide cell
- Type 2
  - Similar to Faro Type 2, but higher zinc.
- Type 3
  - Similar to Faro Type 3, but higher zinc.

Conclusions re. Understanding

- Rock type control on water quality understood
- Timing of changes in water chemistry understood
- Thermal effects on oxygen transport only tested over small areas, short time
- Some scientific uncertainties remain but very little can be done to resolve them
  - Continue seepage monitoring

Conclusions – By Area

- Faro (mature, Stage 3)
  - Sulphide rock already acidic
  - Schist may become acid (time frame of decades)
- Grum (Stage 1 and 2)
  - Sulphide rock not widely acidic
  - Seepage chemistry expected to worsen as acidic water breaks through
- Vangorda (Stage 2 and 3)
  - Friable sulphides already acidic
  - Seepage chemistry expected to worsen

Waste Rock Water Balances

Rick Janowicz

YG Hydrology

Project Objective

- Develop improved estimate of the amount of water infiltrating into the waste rock dumps at each of the mine areas

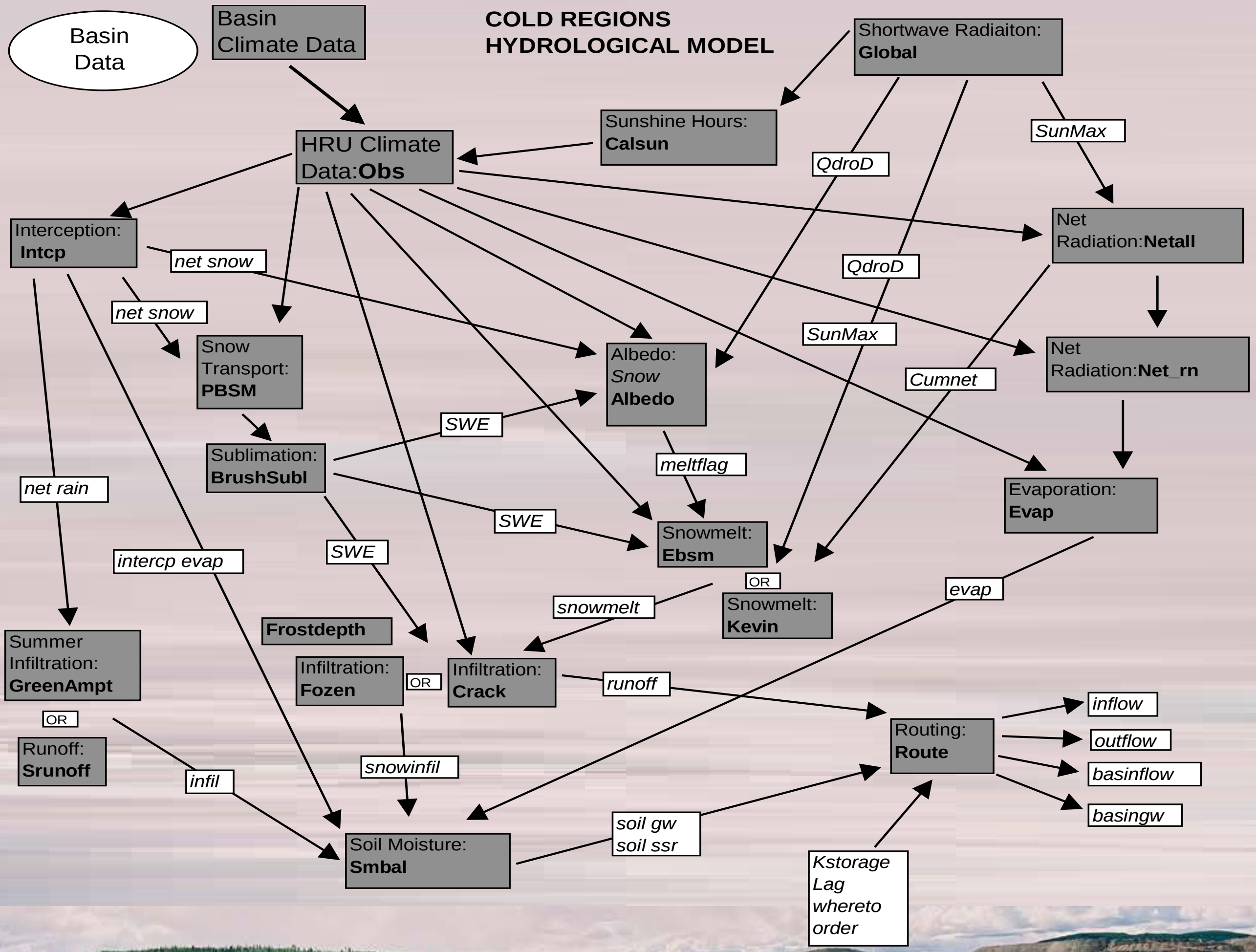
Project Scope

- 2003
  - – Install meteorological stations
  - – Develop preliminary water balance estimates

Results to Date

- Meteorological stations established in December, 2003

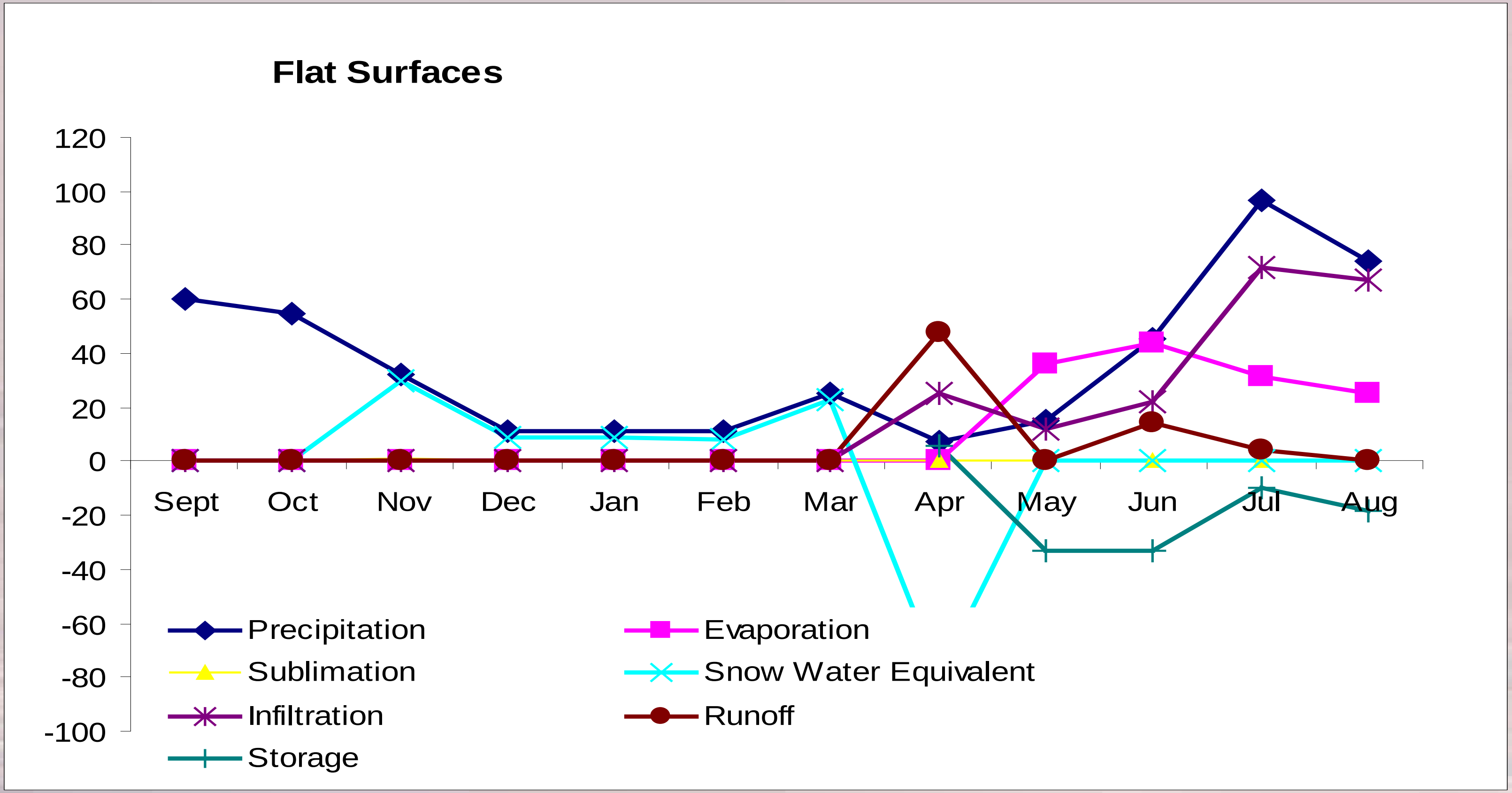
Cold Regions Hydrologic Model



Hydrologic Response Units

- Flat surfaces
- Slopes
  - North, East, South, West
- Bubble dumps

Preliminary Water Balance



Preliminary Water Balance

- Infiltration around 45-55% of precipitation
- Surface runoff around 15% of precipitation
- Evaporation around 30-40% of precipitation

Plans for 2004

- Weir installations
- Met station data collection
- Revised CRHM runs in December 2004

Dump Water Quality Predictions

Project Objective

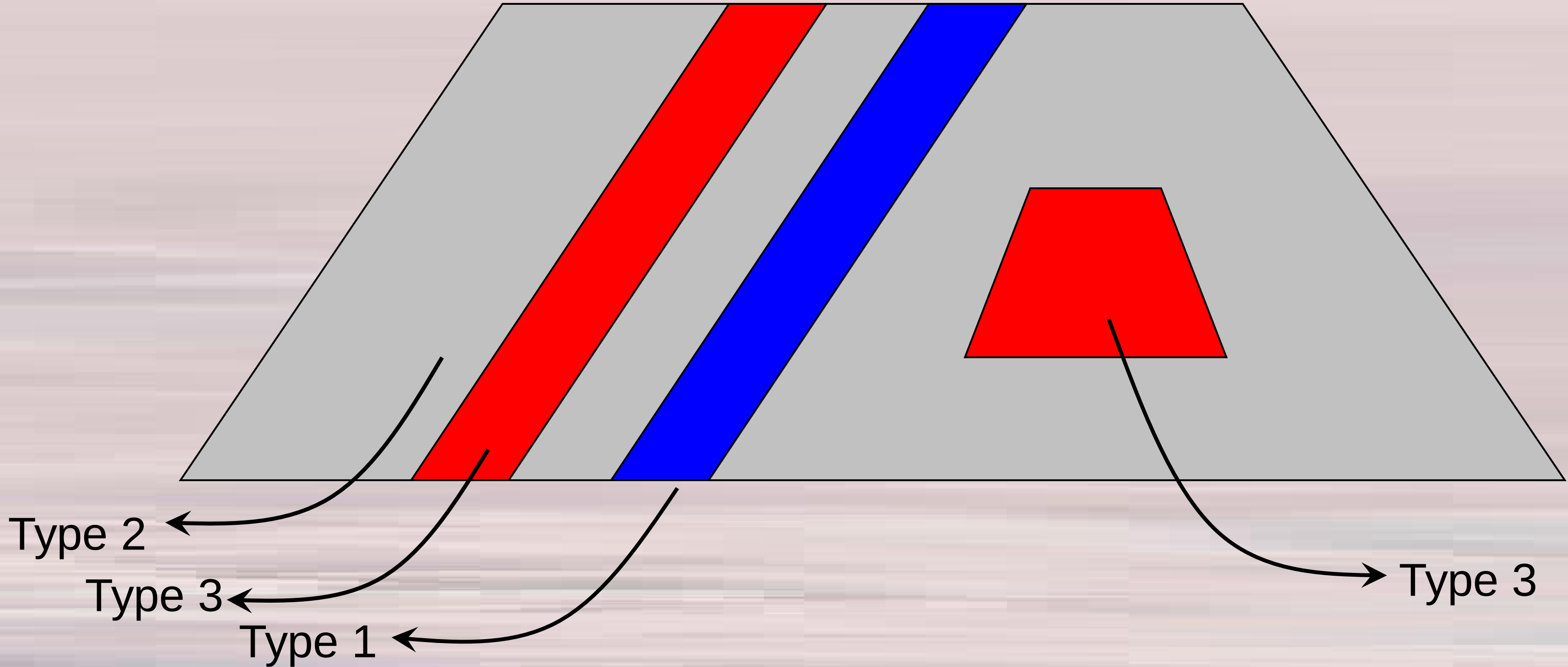
- Estimate concentrations and loadings of contaminants in water draining from waste rock

Empirical Estimation Method

- Assign water chemistry based on rock type, mixing and age

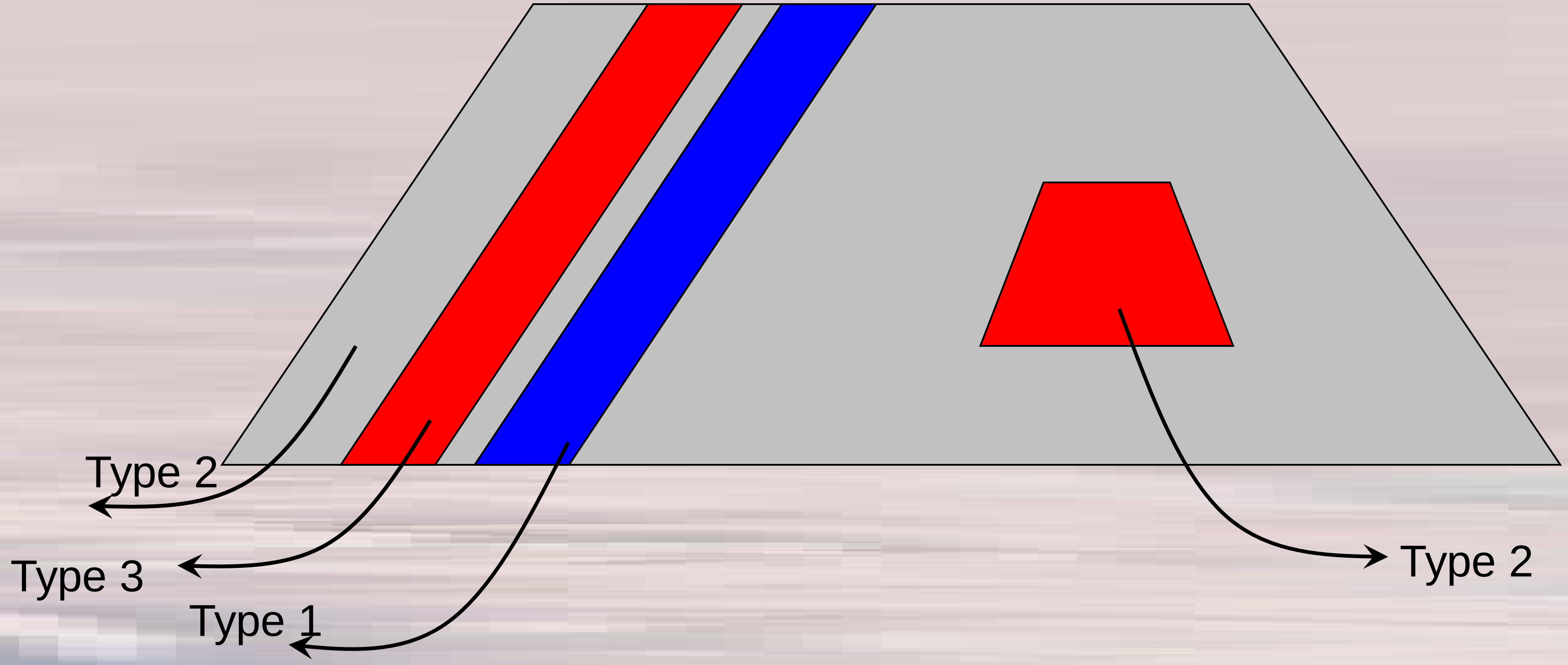
Empirical Estimates

- Faro Waste Rock, high sulphide proportion, poorly mixed



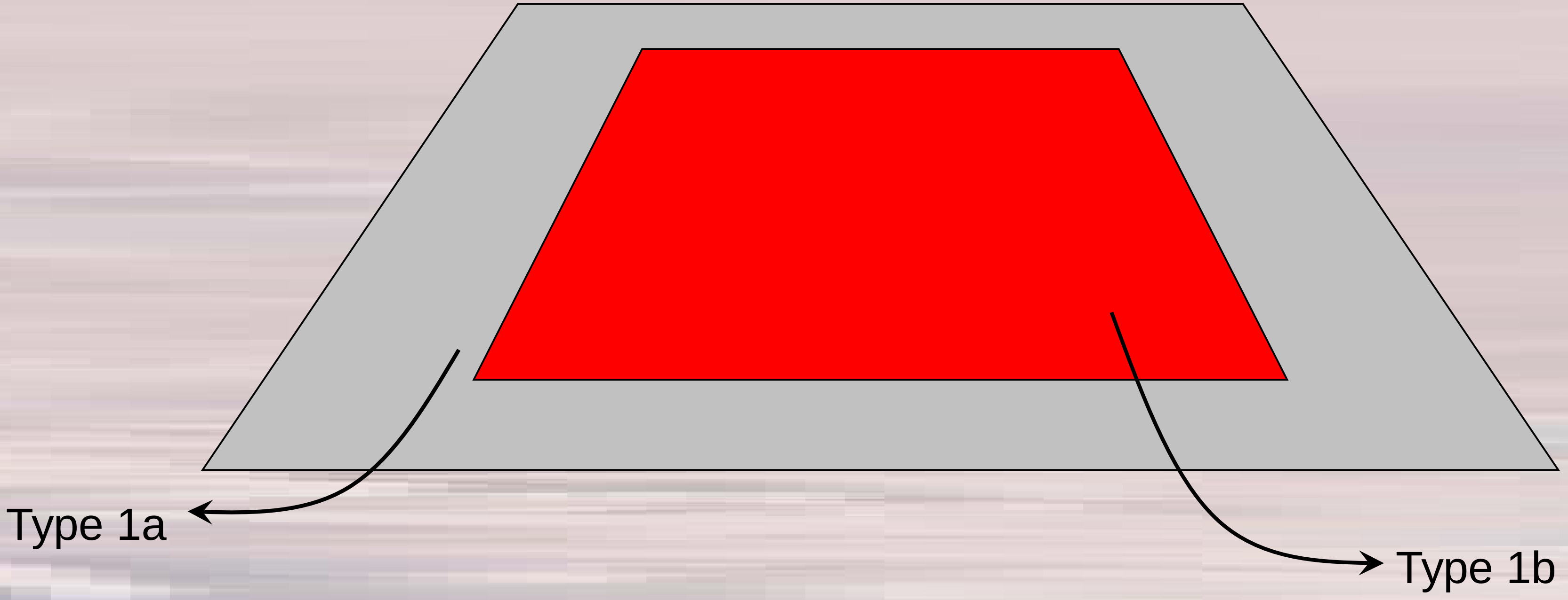
Empirical Estimates

- Vangorda Waste Rock, young, high sulphide proportion, poorly mixed



Empirical Estimates

- Grum Waste Rock, high sulphide proportion in sulphide cell, young



Spreadsheet Model

- Estimate flow from each dump
  - Infiltration as % of mean annual precipitation
  - Waste dump plan areas
- Estimate concentrations from each dump
  - Rock type proportions
  - Seepage types (choice of statistic)
- Spreadsheet estimates average concentrations and loadings (tonnes/year) for each element

Faro Results

- ❑ Current zinc load
  - – 111 tonnes/year
  - – 87% from ore and LGO stockpiles
    - • ~1% of rock mass
- ❑ Future zinc load
  - – 117 tonnes/year
  - – 83% from ore and LGO stockpiles.

Vangorda/Grum Results

- Grum
  - Current zinc – 0.2 tonnes/year
  - Future zinc – 61 tonnes/year
- Vangorda
  - Current zinc – 2 tonnes/year
  - Future zinc – 91 tonnes/year

Pit Lake Studies

Project Objectives

- Establish the intermediate and long term water quality
- Provide basis for developing closure strategies for the Faro, Grum and Vangorda pit lakes

Pit Lake Water Quality Estimates

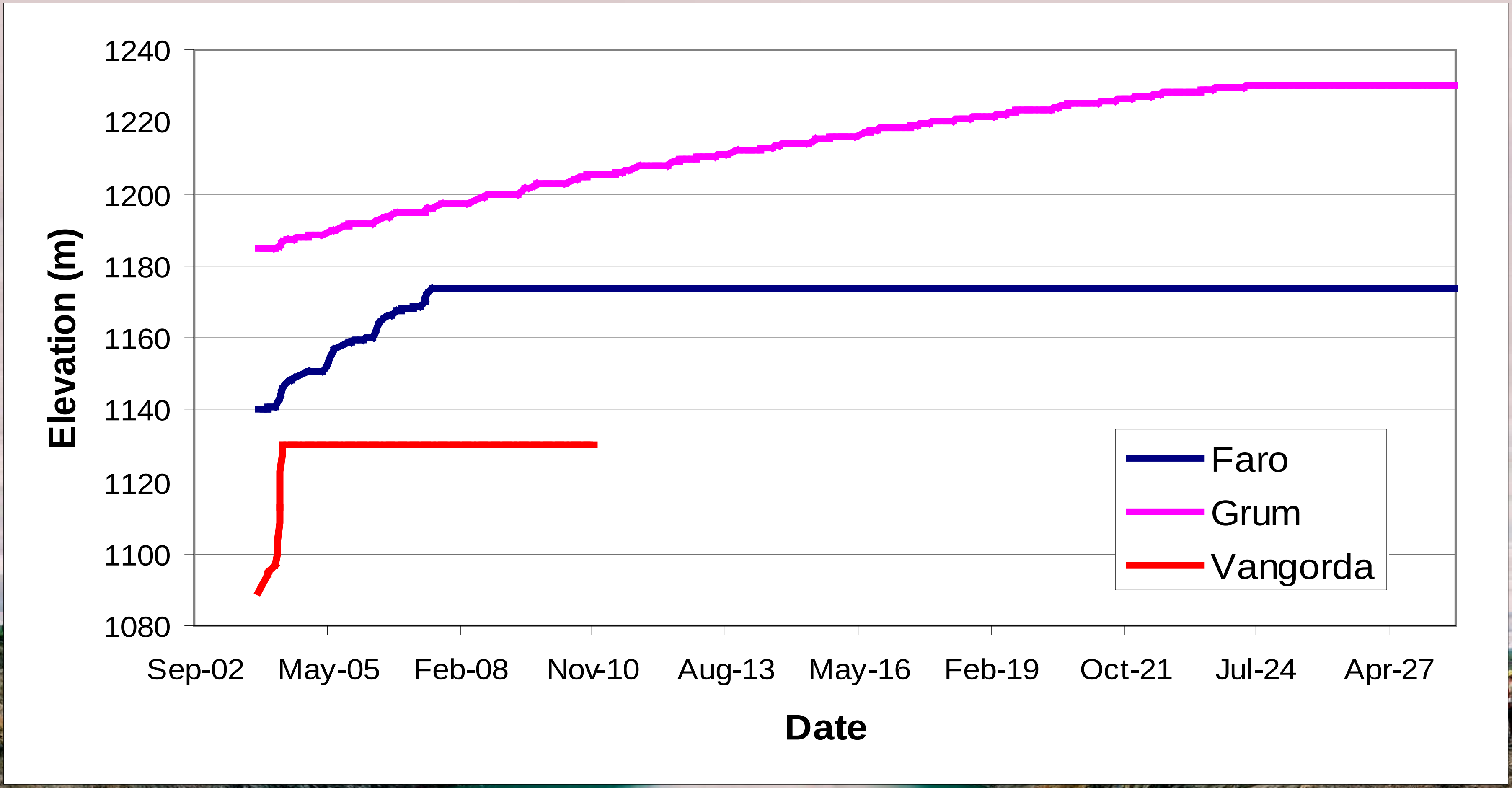
- Current pit lake water quality
- Pit catchment hydrology
- Pit capacity curve
- Pit lake limnology
- Contaminant sources
- Mass balance calculations

Current Water Quality

Parameter	Units	Faro	Grum	Vangorda
pH		6.87 - 7.89	7.49 - 8.08	6.54 - 7.35
Acidity	mg/L	18 - 65	2 - 28	151 - 221
Sulphate	mg/L	486 - 793	424 - 461	1080 - 1280
Iron	mg/L	0.04 - 22	0.06 - 0.17	0.15 - 28
Manganese	mg/L	2.2 - 3.4	0.45 - 0.66	30 - 43
Zinc	mg/L	1.4 - 11	4.4 - 12	91 - 124

Pit Lake Flooding Estimates

- Use catchment hydrology and volume elevation curves to predict flooding rates

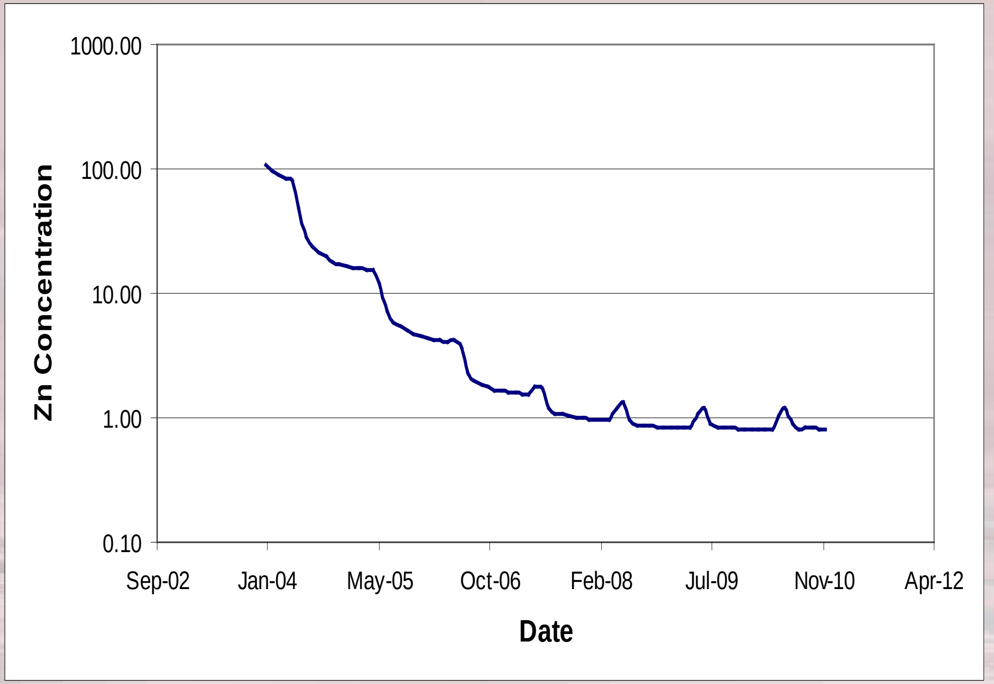


Pit Lake Water Quality Estimates

- Assume completely mixed lakes
- Account for contaminant sources
  - Pit wall rocks
  - Waste rock within pit lake catchment
- Mass Balance Calculations
  - Monthly

Estimated Pit Lake Water Quality

- ❑ Flow-through pits
  - – Faro
    - Zinc → 2 mg/L
  - – Grum
    - Zinc → 0.3 mg/L
  - – Vangorda
    - Zinc → 1 mg/L



Conclusions

- Flow-through pits could reach levels of zinc that are manageable by biological treatment

Mine Area Closure Methods

Methods Considered in 2003 and 2004 Technical Studies

Mine Area Methods

- ❑ Methods studied in 2003 and 2004
  - – Waste rock covers
  - – Seepage collection
    - • Grum Dump example
  - – Clean water diversions
    - • Vangorda Creek example
  - – Pit lake treatment
- ❑ Other methods under technical review

Waste Rock Covers

Possible Cover Objectives

- Isolate waste to prevent direct contact with human and wildlife
- Enhance long-term stability of surfaces
- Assist re-vegetation
- Reduce volume of acidic drainage
  - Runoff
  - Infiltrations
- Minimize further oxidation

Study Components

- Review related site literature
- Characterize potential cover materials
- Document site specific constructability issues that would affect any cover design decision
- Conduct scoping level numerical modeling to estimate cover performance
- Initiate large scale testing

Vangorda Cover

- 10-Year old cover
- 2 m thick cover
  - 1 m loosely compacted till
  - 1 m highly compacted till
- Constant 2.5H:1V slope
- Not vegetated

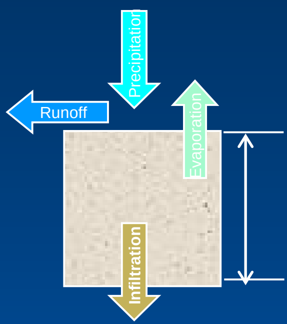
Vangorda Cover

Overburden Dump Vegetation Trial

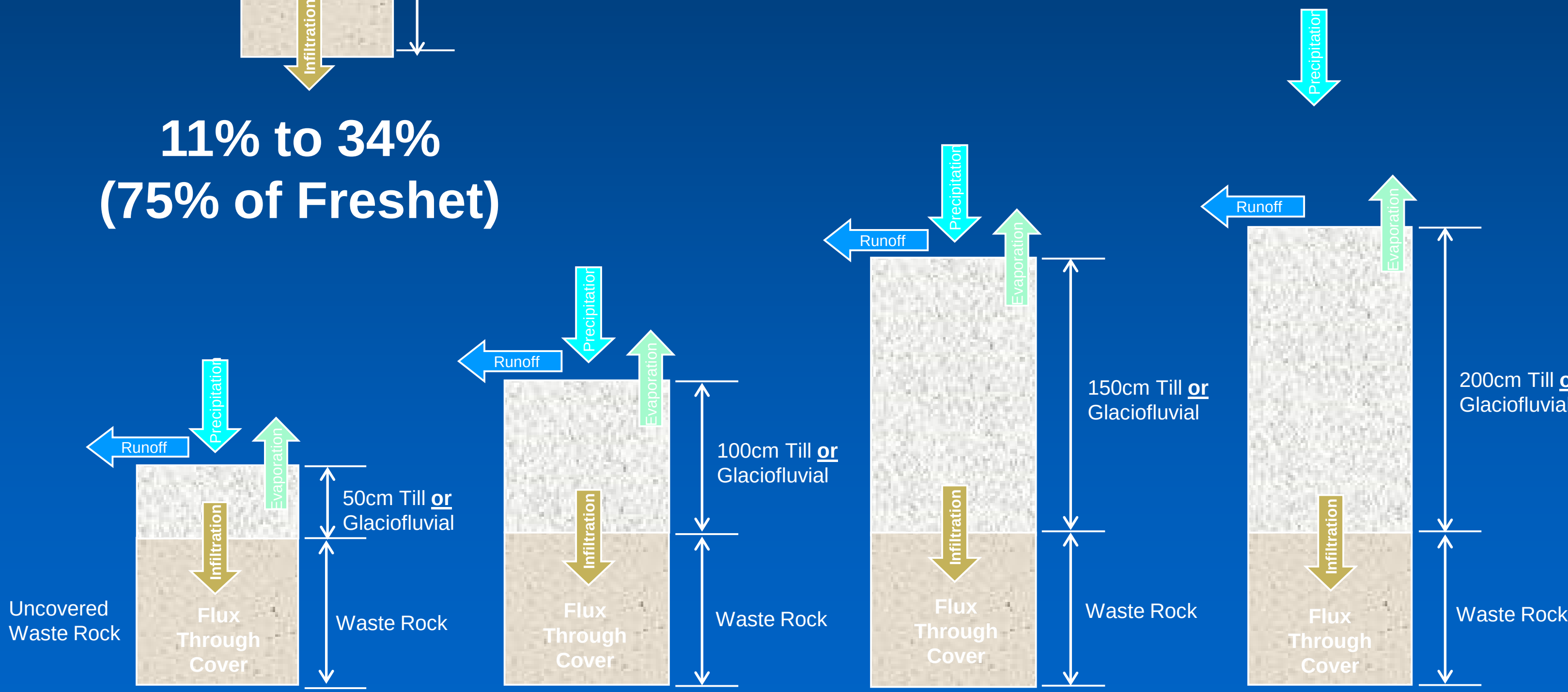
Till Material

- Well graded sandy-clay to clayey-sand
- Saturated hydraulic conductivity at 95% Standard Proctor density
  - 10^{-6} to 10^{-7} cm/sec
- In-situ density
  - 90% Standard Proctor
  - 10^{-4} to 10^{-5} cm/sec
- SWCC complex
  - Likely dual porosity

Mathematical Modeling



11% to 34%
(75% of Freshet)



All mono-layer covers give flux between 1% and 5%

Re-Sloping Requirements

- Cannot place or compact cover material on slopes greater than 2.5H:1V
- Assume re-slope all areas > 2.5H:1V
  - Faro - 3.1 million m^3 (2.4%)
  - Grum - 0.42 million m^3 (1.8%)
  - Vangorda - 0.6 million m^3 (1.8%)
- Total re-sloped waste rock pile area
  - 602 ha

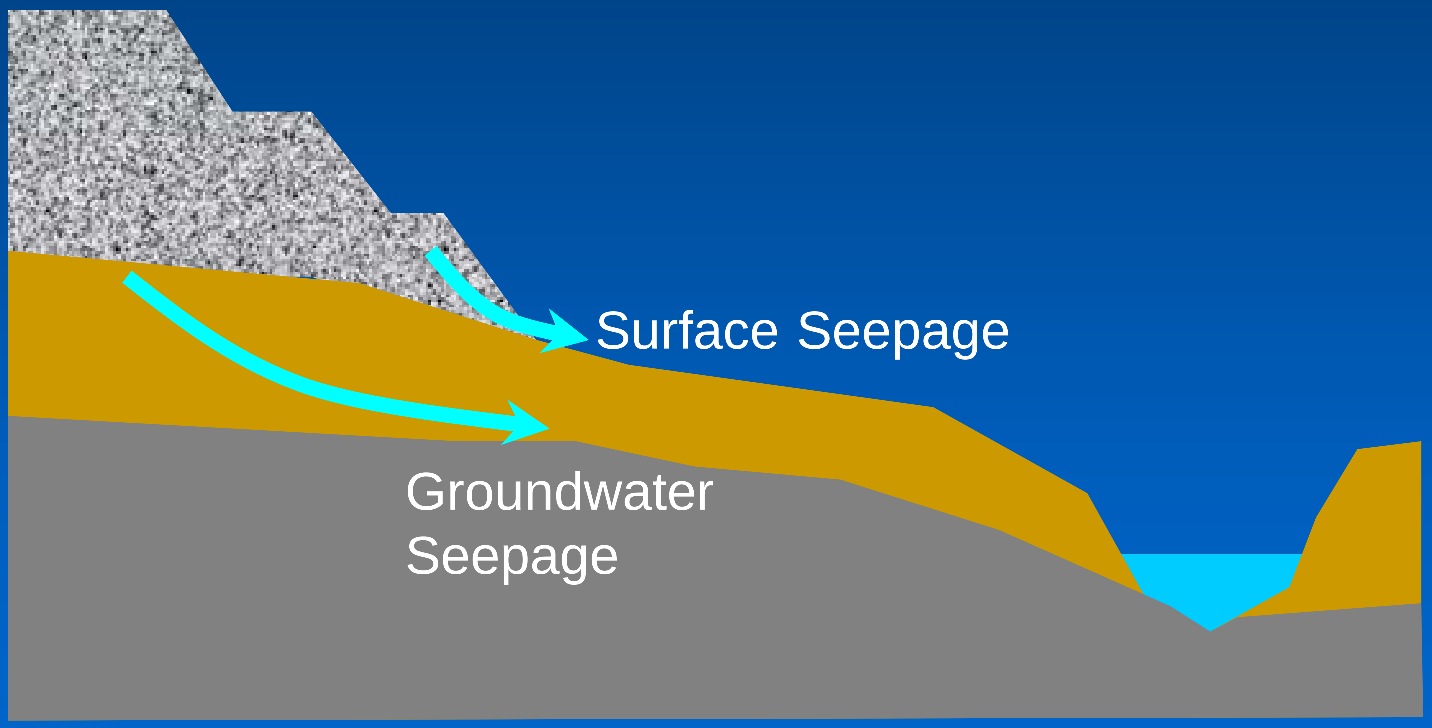
Waste Rock Covers 2004

- Field test of covers
  - Large scale construction
  - Instrumentation
  - Multi-year monitoring program
- Improved modeling
  - Slope effects
  - Long-term effects
- Cost estimates

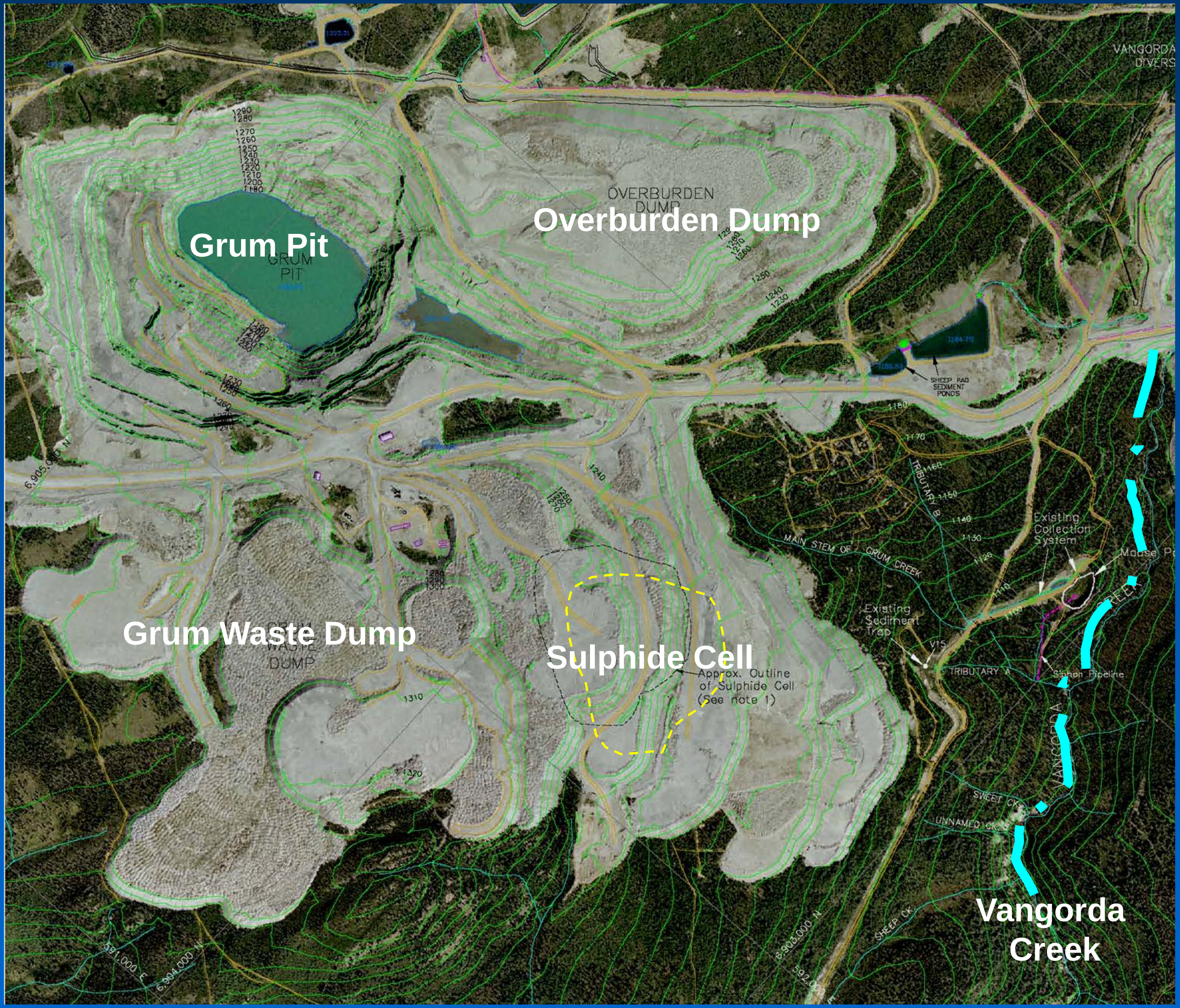
Grum Seepage Collection

Seepage Collection Objectives

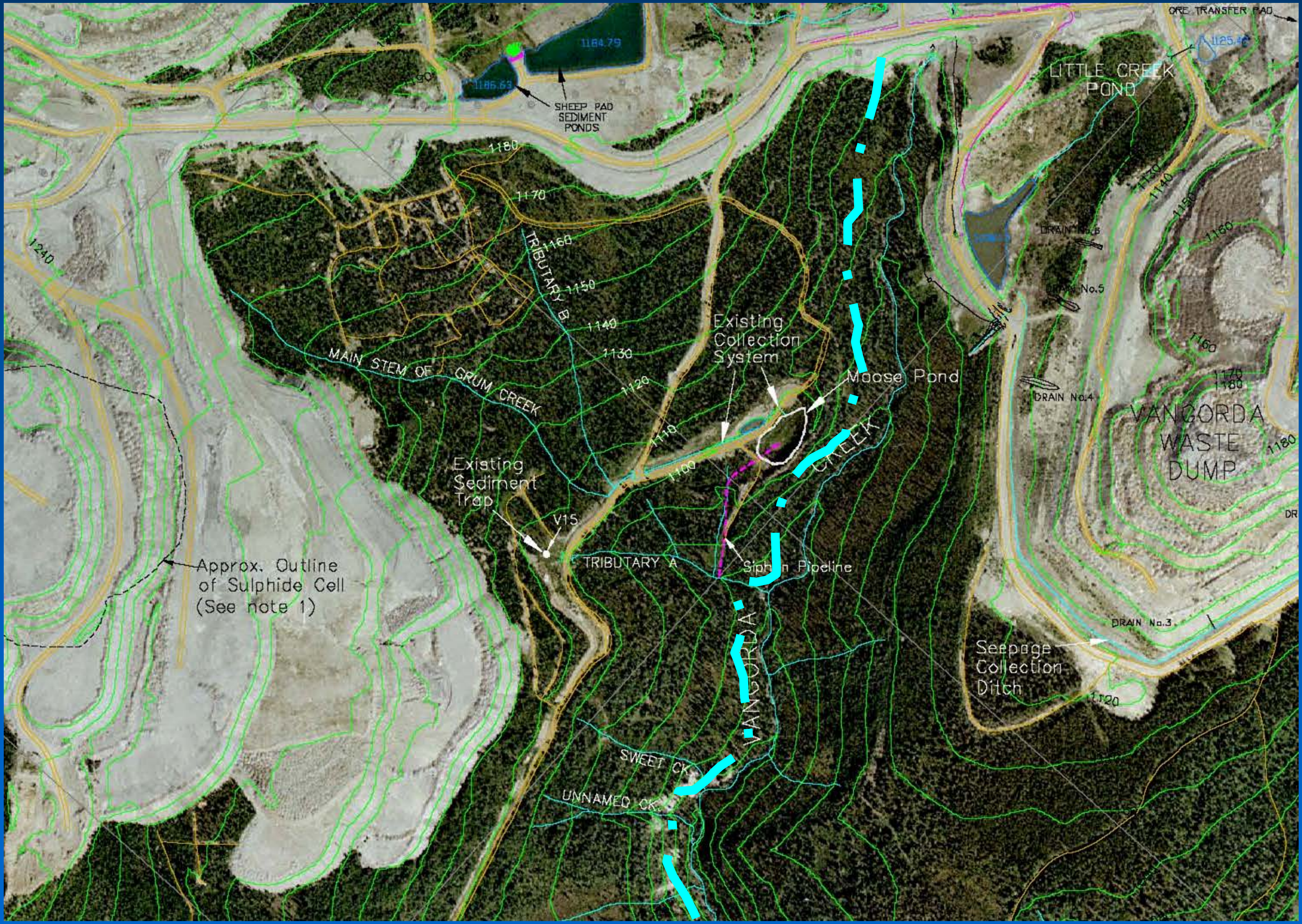
- Collect contaminated surface and groundwater before it reaches creeks



Grum Seepage Collection Study 2003

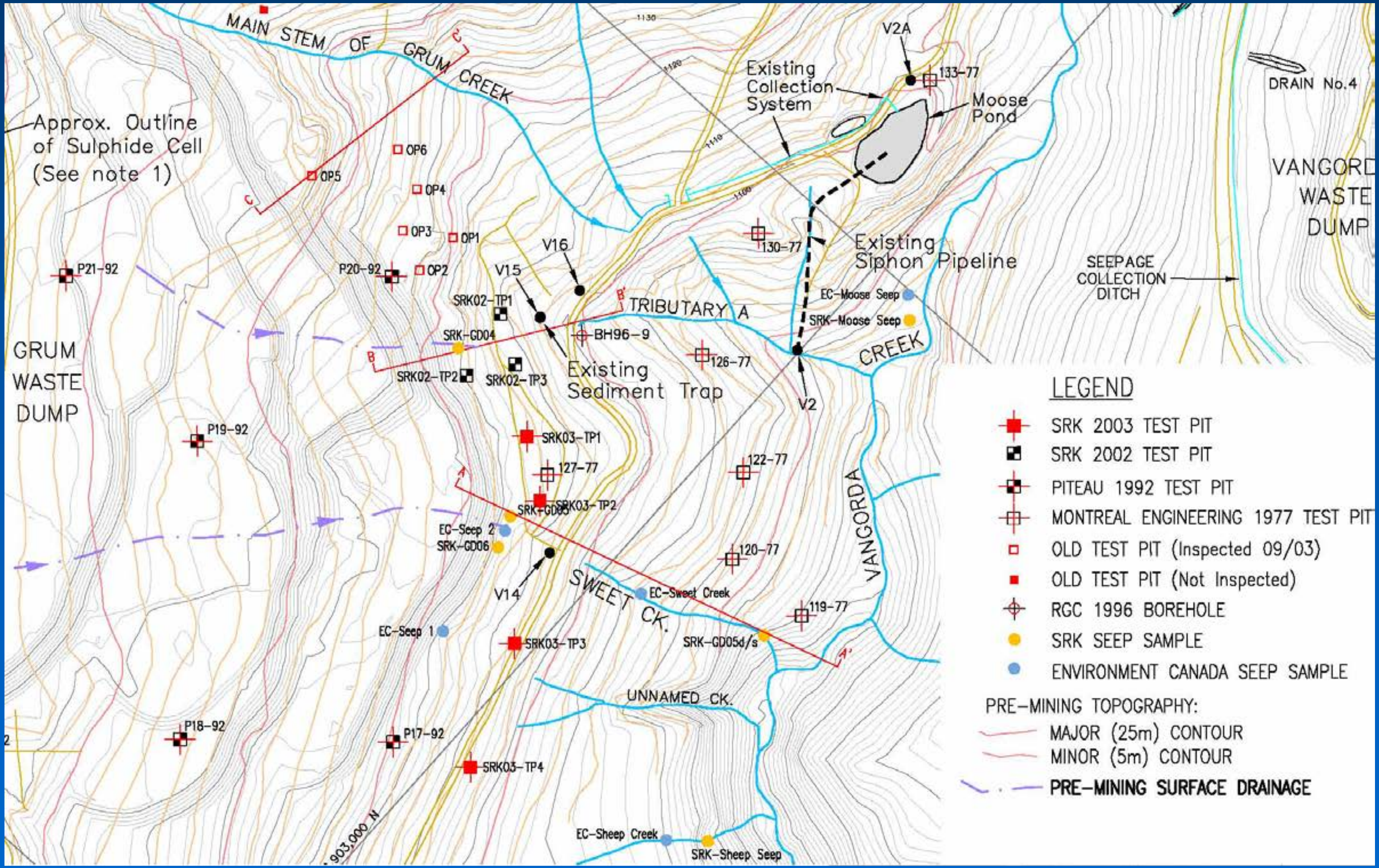


Grum Dump and Vangorda Creek



Surface Water

Geotechnical Database



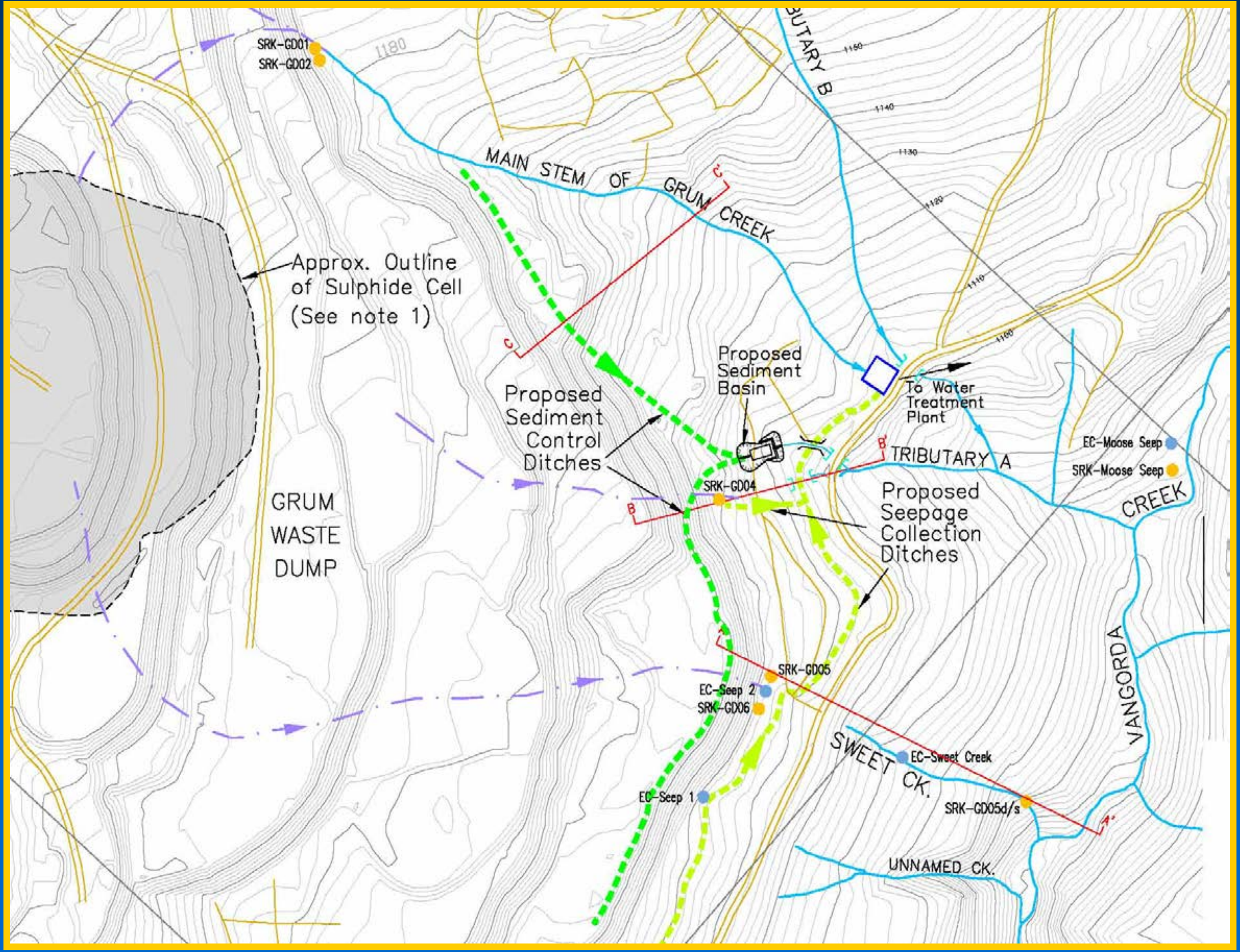
Soil Conditions

- Along the toe of the dump, the soil is quite variable
- To the west the soil consists of 1 to 2 m of glacial till over fractured bedrock
- To the east, no bedrock was encountered and soil consists of 1 to 2 metres of sand and gravel over a silty till

Water Quality

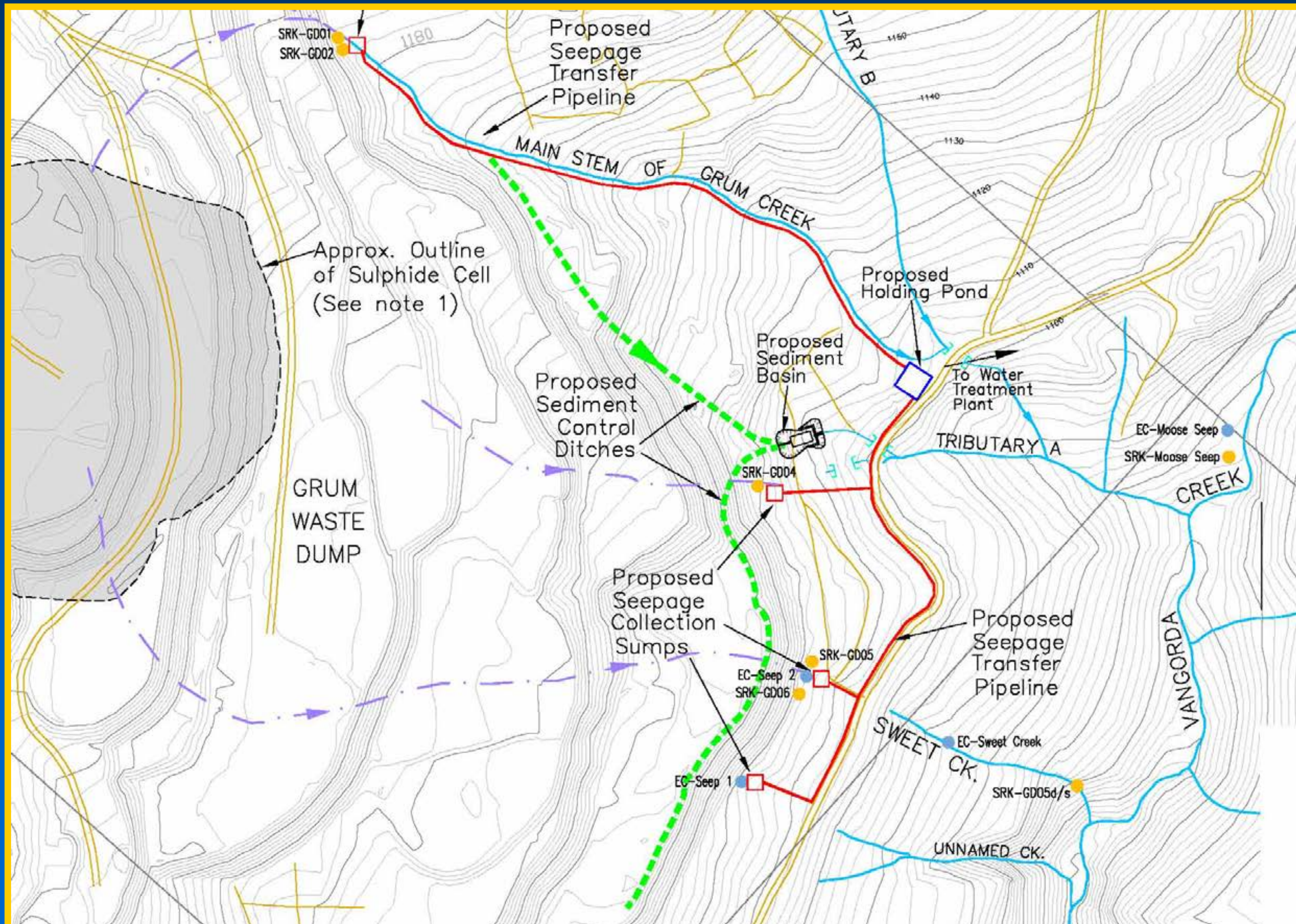
- Grum seeps are neutral to slightly alkaline
- Zinc ranges from 2 to 5 mg/L
- Sulphate greater than 500mg/L
  - Trend of increasing sulphate

Option 1



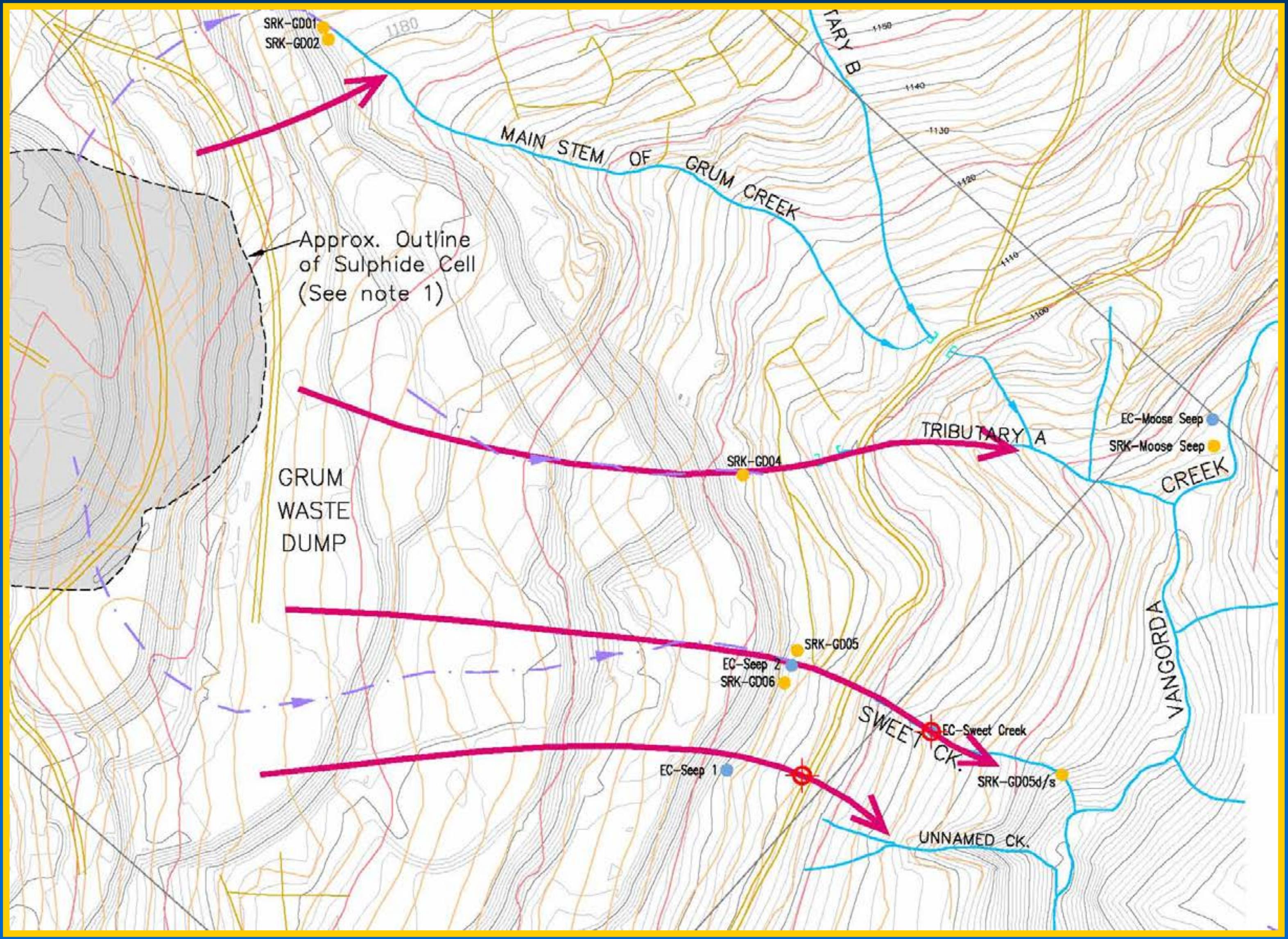
SRK-GD01
SRK-GD02
1180
MAIN STEM OF GRUM CREEK
TRIBUTARY B
Approx. Outline of Sulphide Cell (See note 1)
Proposed Sediment Control Ditches
Proposed Sediment Basin
To Water Treatment Plant
TRIBUTARY A
EC-Moose Seep
SRK-Moose Seep
CREEK
SRK-GD04
Proposed Seepage Collection Ditches
GRUM WASTE DUMP
SRK-GD05
EC-Seep 2
SRK-GD06
SWEET CK.
EC-Sweet Creek
SRK-GD05d/s
VANGORDA
EC-Seep 1
UNNAMED CK.

Option 2



SRK-GD01
SRK-GD02
1180
Proposed Seepage Transfer Pipeline
MAIN STEM OF GRUM CREEK
TARY B
1150
1140
1130
1120
1110
1100
Approx. Outline of Sulphide Cell (See note 1)
Proposed Holding Pond
Proposed Sediment Basin
To Water Treatment Plant
Proposed Sediment Control Ditches
TRIBUTARY A
EC-Moose Seep
SRK-Moose Seep
CREEK
GRUM WASTE DUMP
SRK-GD04
Proposed Seepage Collection Sumps
Proposed Seepage Transfer Pipeline
SRK-GD05
EC-Seep 2
SRK-GD06
VANGORDA
SWEET CK.
EC-Sweet Creek
SRK-GD05d/s
EC-Seep 1
UNNAMED CK.

Option 3



SRK-GD01
SRK-GD02
1180
MAIN STEM OF GRUM CREEK
Approx. Outline of Sulphide Cell (See note 1)
GRUM WASTE DUMP
SRK-GD04
TRIBUTARY A
EC-Moose Seep
SRK-Moose Seep
CREEK
VANGORDA
SRK-GD05
EC-Seep 2
SRK-GD06
SWEET CK.
EC-Sweet Creek
SRK-GD05d/s
EC-Seep 1
UNNAMED CK.

Conclusions

- Many good options available for collecting surface water
- Possible to collect some of the groundwater seepage using trenches, but not all
- System of wells needed to capture all of the groundwater

Seepage Collection 2004

- Review by Dr. Christoph Wels
  - All data from wells below toe of Faro, Grum and Vangorda dumps
  - Identify trends and possible future collection requirements
  - Determine if collection systems can be designed and costed
  - Recommend additional field work where needed
- Report expected by end of June

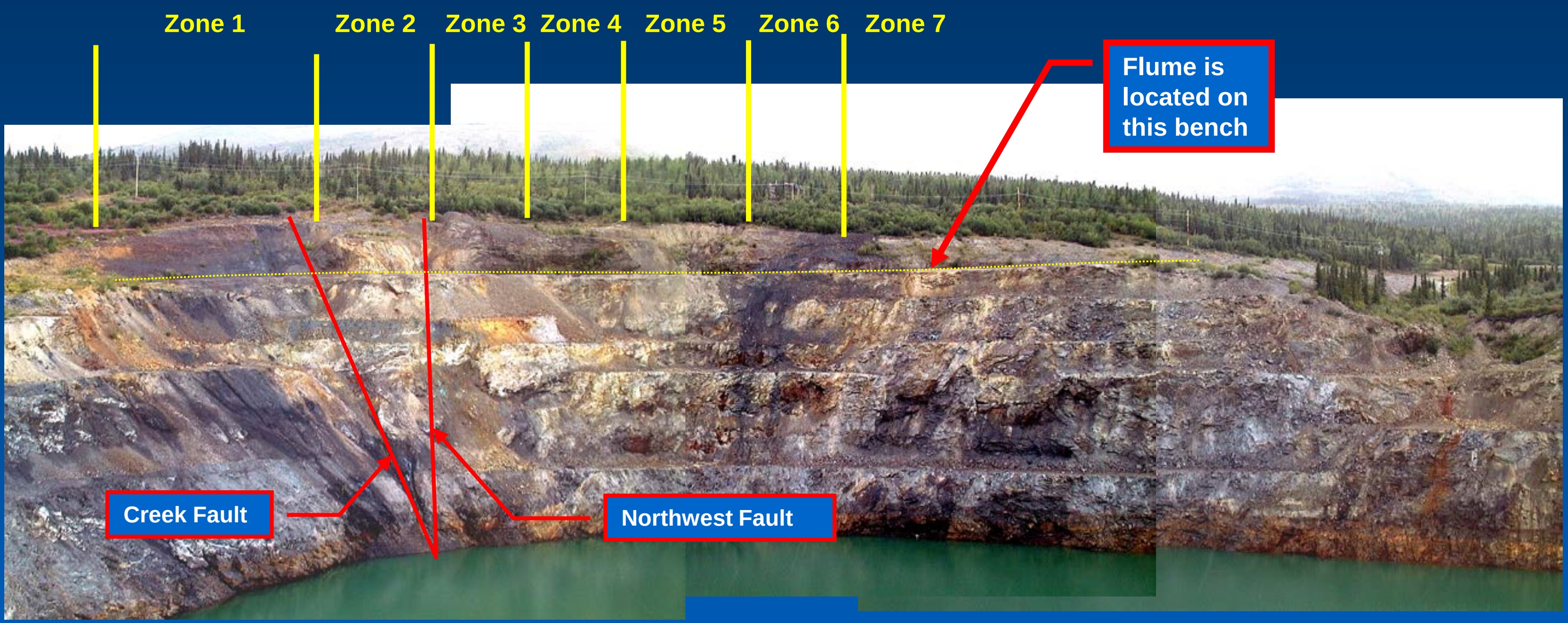
Vangorda Creek Diversion Options

Objective and Context

- Objective
  - The objective of this study is to identify alternative preliminary designs and costs for the long-term closure management of Vangorda Creek (VC)

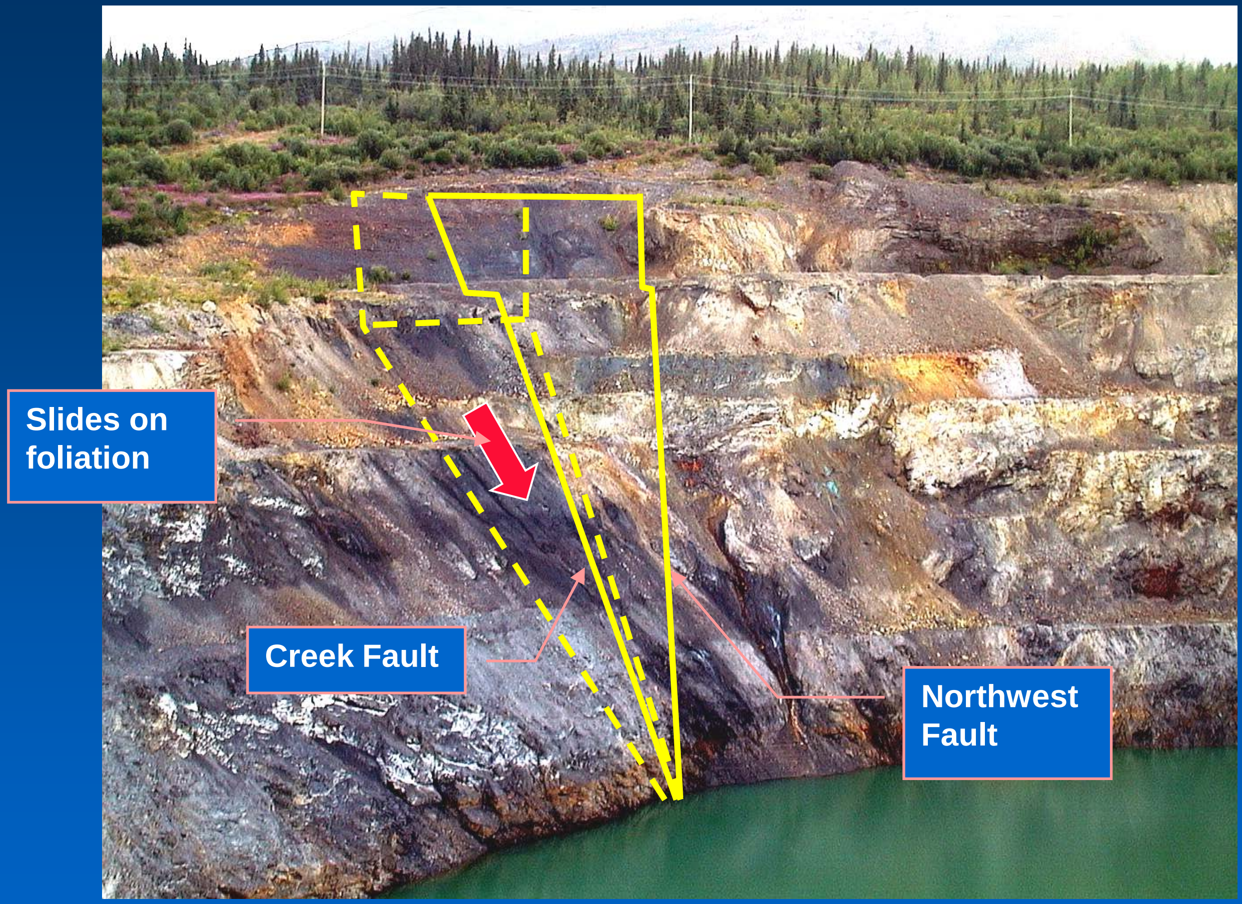
Existing Diversion

Pit Wall Stability - Northwest Face



Northwest Face of Vangorda Pit, August 10, 2002

Potential Wedge Failure



Stability of potential wedge formed by Northwest Fault and Creek Fault, with foliation as sliding plane. Analysis shows that failure is not kinematically possible. The wedge is tapered towards the free face of the slope and cannot move outwards.

Pit Wall Stability

- Above the flume
  - – Sloughing and ravelling of the pit walls along the northwest fault line is expected to continue
    - Over time ravelling back ultimately to the current location of the flume
  - – Rock falls from the pit slope
    - Zones 3, 5 and 6

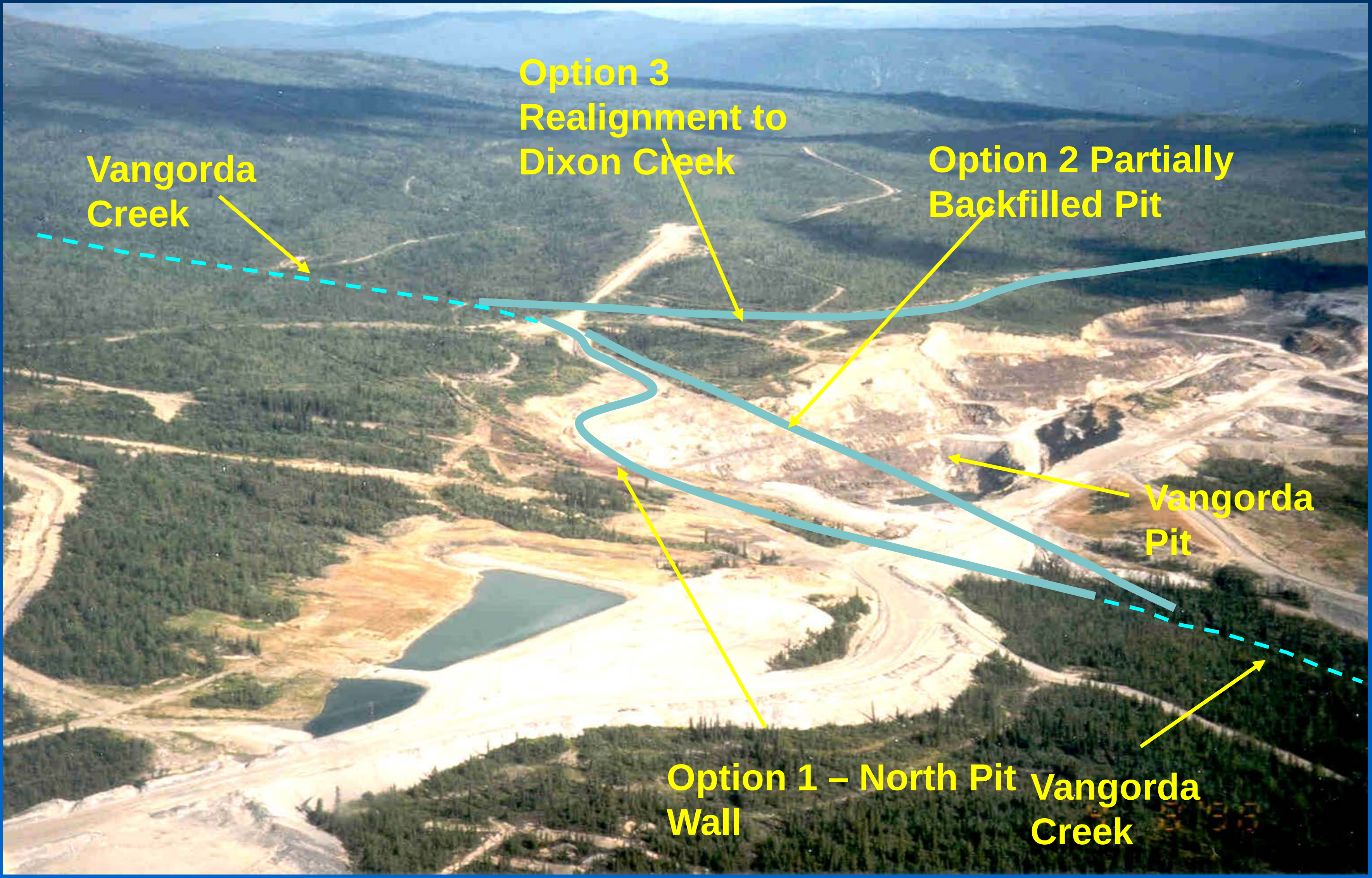
Pit Wall Stability

- ❑ Below the flume
  - – Currently stable
    - • likely remain so over the next 5-10 years
  - – Over the long term
    - • Overall probability of a slope failure that would breach the diversion is 1:400

Alternatives Assessment

- Three options
  1. Diversion around North Perimeter of Vangorda Pit (Upgrade Existing alignment)
  2. Partially backfill open pit to create a causeway and realign creek into a constructed channel over the backfill causeway
  3. Relocate Vangorda Creek to Dixon Creek to the South


Option 1 – North Pit Wall
Option 2 Partially Backfilled Pit


Option 3
Realignment to
Dixon Creek
Vangorda
Creek
Option 2 Partially
Backfilled Pit
Vangorda
Pit
Option 1 – North Pit
Wall
Vangorda
Creek

Comparison of Options

1	$3,400,000	Pit wall stability and potential for breach of diversion. Remedial actions for short-term stability. Design and cost does not include optional toe buttress.
2	$9,800,000	Few hydraulic limitations but significant cost in backfilling of rock. Reduction in live water storage volume. Cost includes $8.9 million for handling of waste rock.
3	$1,400,000	Effect on geomorphology of Dixon and Shrimp Creeks.

Other Diversion Methods

- Faro Creek
  - Similar issues
    - Pit wall stability
  - Similar options
  - Short list of two likely options

Pit Lake Treatment

Project Objectives

- Can we add something to the pit lakes to clean the water?
- Physical considerations – stratification
- Chemical considerations - treatment

Pit Lake Stratification

- **Dr. Greg Lawrence**
- Assess whether layers that form in pit lake will be permanently stable
  - Thermocline
    - Heating / Cooling
  - Chemocline
    - salinity

Pit Lake Stratification

- ❑ Concluded that stability depends on whether creeks flow through pit lakes
- ❑ If diversions still in place
  - Likely will be permanenet stratification
- ❑ If Vangorda and Faro Creeks are routed through pits
  - Flow energy will cause mixing and disrupt layering

Survey of Pit Lake Treatment

- CANMET
- Literature search
  - application to *in-situ* treatment
  - status of the technology (commercially available, pilot-scale, laboratory-scale and conceptual stage)
  - effectiveness in removing metals
  - capital and operating costs
  - sustainability of treatment process systems

Survey of Pit Lake Treatment

Technology	Amendment	Example
Bioremediation	fertilizer	Island Copper Mine pit lake
	sugar, alcohol phosphate	Sweetwater pit lake (SRB)
	ethylene glycol	Sulphate Reduction Bacteria (SRB) Systems
Precipitation	lime	Neutra-mill - Anchor Hill Pit Lake
Precipitation/ adsorption	lime	Berkeley pit lake
Adsorption	Kaolin Amorphous Derivative (KAD)	Berkeley pit lake KAD process
	Ferric Oxyhydroxide	McLaughlin south pit lake
Cementation	Se removal	Berkeley pit lake

Survey of Pit Lake Treatment

- Island Copper pit lake
- Zinc would be 3-5 mg/L
- Fertilization every 10 days
- Zinc maintained at 0.3 mg/L

Survey of Pit Lake Treatment

- Conclusions from 2003
  - Lime treatment
    - Proven performance
  - Biological
    - Promising technology where conditions are right

Pit Lake Treatment 2004

- Results of sludge stability tests
  - – Zinc hydroxides start todissolve if pH goes into neutral range
  - – Therefore adding lime directly to pits is probably not a good idea
- Focus on biological treatment

Pit Lake Treatment 2004

- Biological treatment tests
  - Laboratory studies underway
    - Can organisms survive
    - What is best fertilizer mix
  - Field test in Grum Pit scheduled for July
  - Physical stability study if treatment works
- Report
  - October 2004

Other Mine Area Methods

Methods

- Water treatment
  - – Current and HDS methods
  - – Sludge disposal
- Backfill waste rock into pits
  - – Fill pits
  - – Backfill only problem rock
- Revegetation
- Combinations
  - – Cover only some areas
  - – Relocate others

Attachment 9 – Revised List of Areas of Interest from Group Exercise #3

Areas of Interest Summary Exercise June 24, 11.30am.

- Long Term protection of environment and human health
- Short and long term physical and chemical stability
- Need for integrated closure plan
- Community and economic benefits
- Cost effectiveness
- End land use to support maximum beneficial use of the site
- Standards and performance criteria
- Environmental mitigation (off-site), restoration (on-site) and enhancement
- Biodiversity
- Long term requirement for maintenance
- Restoration of productive fish habitats to levels equal or exceeding pre-mine levels

Attachment 10 – Summary of Presentation on Hydraulic Mining of Tailings by David Jansson from South Africa

Summary of Presentation on Hydraulic Mining of Tailings by David Jansson from South Africa

- South African mining industry is very different. Very often tailings management is contracted out and Jansson has worked for these large companies for many years.
- In hydraulic re-mining of tailings, the tailings are liquefied for gravity feed to sump pump.
- There is a lot of remining of old taiings dumps for reprocessing.
- During the hydraulic mining process you can go bottom up but you end up working in your own mud it is better to mine from the top down. It is cleaner and dryer.
- **Faro is small and will not be able to work in the dry**
- Example for application to Faro from Chile ~4000 masl in a very narrow and long valley. Disputada Mine, Chile 38M tonnes in 4 years, summer working only.
  - They did not want the dredging method because it required a large pool of water with attendant. Also potential risks especially related to seismic.
  - **This project evolved into 25 year project to move 90M tonnes including some dredging in some areas.**
  - This project can be used to provide a direct comparison on dredging vs. hydraulic mining
  - They "blended" fines, mids and slimes to reduce pipe wear.
  - The slurry pump had to achieve 192 m vertical and 48 km vertical.
  - The cold climatic conditions are somewhat similar to Faro: mid May stop for winter in Chile.
- Faro: 57M tonnes, narrow valley, 4-5 km pump length, 150 m vertical, summer work only, distinct fine vs. coarse zones. The Chile example provides many of the operating parameters for us.
- First mine area: original and part of secondary impoundment because it is top and driest; sump (4X4 m X 8m). Pump to "shore" from a series of smallish spindle pumps where the main sump pump is located.
- Pump at 45% solids; could thicken to 75% for less water and better settlement in the Faro pit.
- Put in a diversion berm after initial mining to divert clean precipitation into Rose Creek.
- Mine in 8m layers – more may cause sloughing and unsafe and awkward work conditions.
- Start in Intermediate Impoundment in 2nd or 3rd season. Slowly at first to allow drying between seasons.
- May need booster pumps en route to pit. Deposit in south end near Zone II pit or near barge.
- The mining plan must be flexible based on the conditions encountered
- This plan provides local work; does not require specialized personnel; can be made more or less labour intensive as desired for employment numbers. It is hard work though.
- *How to thicken to 75%?*
  Use a special kind of thickener. A company in Salt Lake City has been contacted for ideas.
- *Why not deposit the tailings underwater – this might prevent resuspension and has Canadian examples via floating barge and underwater pipe?*
  Jansson has not done this.
- *Explain the water management. Is water from Rose Creek or internal?*
  Use water from the pit and slurry back into the pit. Don't use Rose Creek because this would just bring more water into the system.
- *How can you transfer precipitation to Rose Creek immediately after re-mining?*
  Clean to the natural ground including any depressions or old borrow areas. Maybe move to a smaller gun if it is >3 m deep. Best to avoid truck and shovel.
- *Can you re-mine the dams or do you have to dig them out?*
  The dykes would have to be removed by shovel and truck due in part to not being able to create any density out of granular soils.
- *How do you make the initial cut?*
  Start monitoring downwards to 8m deep by 20 m wide.
- *What about very wet slimy slimes, how to work these off?*
  Put the gun on a float in place of skids and drag along with cables. We did this in Australia. The depth of cut is less. This is likely not going to be problem at Faro.
- Is 75% achievable?
  Yes, all diamond mining in S. Africa are this way.
- *What mining rate for could be used at Faro?*

1,000 tonnes/hr with 6 monitors working plus 3 being moved. Approximately 26,000 tpd; 800,000 t per month for 6 mos/year (maybe variable pending weather).

- Can this be accelerated?
  Not really practical due to space limitations, could go to 18 inch monitors as a world's first but not practical. Only can do by extending the operating season.
- *What about the test trial?*
  Permafrost needed to be tested. We used a high pressure washer to cut tailings and it went easily – very good result.
- *What about worker exposure with respect to health and safety risk?*
  Yes you can get sprayed with mud but it can be done safely. Operators get a break when their gun is being relocated (i.e. 3 of 9 at any time). Operator also has a cabin to work within.
- *How does this input affect the February costing?*
  Yes, we adjusted the February costing to about $2.00/tonne. Specifically, $0.74 for the re-mining operation (labour, piping, etc) and we added in pumping which was not "in" the February numbers.
- *What s the energy cost for pumping to the pit?*
  Needs to be provided.