



September 16, 2011

Chuck Hubert
Environmental Assessment Officer
Mackenzie Valley Review Board
Suite 200, 5102 50th Avenue,
Yellowknife, NT
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Dear Mr. Hubert

RE: Environmental Assessment EA0809-002, Prairie Creek Mine
Comments on Final Arguments

Canadian Zinc Corporation (CZN) is pleased to provide the attached comments on the Final Arguments submitted by parties at the conclusion of environmental assessment EA0809-002. Technical replies are provided, where necessary, by stating CZN's position with respect to recommendations made. Where recommendations are unchanged from Technical Reports, the Review Board is directed to CZN's comments on Technical Reports in Attachment 1. The contents of Attachment 1 should be read first since context is provided for some of our responses to the Final Arguments. Please note that our comments on Technical Reports contain no new information, and no timeline was provided by the Review Board for their submission.

Also attached is a final commitments table (Table 1), and the curricula vitae of the main individual consultants who provided deliverables for the environmental assessment process.

Yours truly,
CANADIAN ZINC CORPORATION

David P. Harpley, P. Geo.
VP, Environment and Permitting Affairs

COMMENTS ON PARTY FINAL ARGUMENTS

Aboriginal Affairs and Northern Development Canada (AANDC)

Water Management and Storage

Recommendation 2: Final selection of an additional water storage option must be done in conjunction with the determination of Site Specific Water Quality Objectives for Prairie Creek. If increased capacity associated with construction of an additional pond provides for the ability to meet Reference Condition Approach benchmarks as defined within the derivation process, that option must be selected and implemented.

The Review Board is directed to CZN's submission dated September 16, 2011 ("AANDC's Final Submission and Proposed Site-Specific Water Quality Objectives"). In that submission, we propose a Framework (Attachment 1) for selecting final Site Specific Water Quality Objectives (SSWQO's). CZN has committed to provide additional 'live' water storage capacity. In the Framework, we state that the additional water storage option that results in lower predicted receiving water concentrations will be preferred, **provided** the option is clearly superior to the alternative option in terms of predicted concentrations and reduced risk. We are not opposed to adopting the best option, provided it produces a significantly better result. We do not wish to be forced to adopt the best option, assuming we are already within risk-based indicators of no significant ecosystem change. The construction and operation of the additional facility would incur unnecessary and significant costs if it is only marginally better than the alternative, irrespective of the ability to meet Reference Condition Approach (RCA) benchmarks. Therefore, we respectfully ask the Review Board to endorse our Framework and deny this recommendation.

AANDC produced a similar Framework (their Appendix C). AANDC and CZN collaborated on the broad development of the Framework, and were successful in resolving nearly all of our respective issues. Some differences remain. However, when the results of RCA benchmark confirmation, further process water treatment testing and ecological risk assessments (ERA) are available, the differences may disappear. Until those results are available, we wish to retain some flexibility so that reasoned and balanced decisions can be made regarding costs, risks and environmental protection.

Site-Specific Water Quality Objectives

Recommendation 1: AANDC recommends that the Developer be required to establish and present Site Specific Water Quality Objectives for the Prairie Creek Mine, prior to the licensing phase, using the process defined within Appendix C.

The process referred to is AANDC's Framework for deriving SSWQO's. As noted above, CZN has provided a similar but slightly different Framework.

Recommendation 2: AANDC recommends that if, following pilot testing per the recommendations in the Developer's Desktop Study of Water Treatment Options, it is identified that Reference Condition Approach based Site Specific Water Quality Objectives can be readily achieved, then that treatment option(s) must be implemented during operations

Our response is the same as for additional water storage in Recommendation 2 above.

Recommendation 3: AANDC recommends that any ecological risk assessments conducted in accordance with the Site Specific Water Quality Objectives process follow the Terms of Reference as provided in Appendix D.

As for the Framework to derive SSWQO's, AANDC and CZN collaborated on the development of a Terms of Reference for ERA's. Our version is very close to AANDC's, and is provided in Attachment 2 of our September 16, 2011 letter.

Recommendation 4: AANDC recommends that Effluent Quality Criteria (i.e. Maximum Grab Concentrations) must be back calculated from Site Specific Water Quality Objectives based on the Developer's best estimate inflow prediction. (Consistent with Recommendation SSWQO/EQC #2, at June 24, 2011 Public Hearing)

In our proposed Framework for deriving final SSWQO's, we acknowledge that Effluent Quality Criteria (EQC) should be back calculated from the SSWQO's. However, CZN has been consistent through the EA process in stating that the discharge approach which provides the greatest operational flexibility, **and** results in the lowest impacts on the receiving environment, is a load-based approach. Operational flexibility occurs because greater loads can be discharged when receiving water flows are high, and are not unnecessarily constrained by concentration limits, except those that prevent the discharge of acutely toxic water. Impacts are lowest because loads are reduced during low flow periods, ensuring that receiving water concentrations do not change significantly by season. Therefore, we agree with the recommendation **provided** the reference to "Maximum Grab Concentrations" is omitted.

Recommendation 5: AANDC recommends that CZN must not discharge effluent that has concentration(s) above the stipulated Maximum Grab Concentrations in the Water Licence.

Consistent with our response to Recommendation 4 above, if this recommendation is reworded as follows, we would agree:

"AANDC recommends that CZN must not discharge effluent that exceeds the limits stipulated in the Water Licence."

Recommendation 6: AANDC recommends that any discharge from the end-of-pipe must meet the Maximum Average Concentrations as stipulated by the Surveillance Network Program in the Water Licence. Detailed instructions on the method and timing for sampling, deriving and reporting regulated average concentrations should be specifically outlined within the SNP.

Again, consistent with our response to Recommendation 4 above, if this recommendation is reworded as follows, we would agree:

"AANDC recommends that any discharge from the end-of-pipe must meet the limits stipulated in the Water Licence. Detailed instructions on the method and timing for sampling, deriving and reporting regulated discharges should be specifically outlined within the Surveillance Network Program (SNP)."

Our understanding is that end-of-pipe limits are stipulated in the Water Licence, not the SNP. The SNP commonly sets out the method and timing of sampling, and required measurements and analyses.

Tailings Management

Recommendation 1: All flotation tailings to be placed underground as paste backfill. Paste backfill should be comprised of a 5:1 overall ratio by weight of flotation tailings to DMS. No mine waste is permitted to remain on the Prairie Creek floodplain after closure.

Before responding to this recommendation, it is appropriate to review CZN's approach to mine development. The Prairie Creek Mine as it exists today is a legacy site. Mine drainage flows out of the lower portal by gravity. In the absence of mine development and the implementation of a robust mine closure solution, the drainage will have to be treated in perpetuity. This also means a human presence will be required on site in perpetuity. Cadillac's mine development proposal was to permanently store fine tailings on the Prairie Creek floodplain. Coarse tailings would be placed underground, but it is not clear that this would have prevented long-term mine drainage. When CZN considered its mine development proposal, it was decided that the responsible thing to do was to avoid permanent disposal of mine waste on the floodplain, and to backfill the mine workings so that treatment in perpetuity can be avoided. This decision is associated with great cost in terms of the paste backfill process.

In the preamble leading to this recommendation, AANDC makes the following comment:

“Previously, efficiencies and economics were key considerations for the proposed paste backfill design”.

With respect, it has always been CZN's intention to place all of the flotation tailings underground, and economics have never been a key consideration.

In response to the recommendation, CZN has committed to place all floatation tailings underground, and not to leave any paste on surface or in the Waste Rock Pile on mine closure. We disagree that paste backfill should be comprised of a 5:1 overall ratio by weight of flotation tailings to DMS. Depending on mine development constraints, this ratio may need to be raised or lowered. The first priority is to place all flotation tailings underground. The second priority is to place as much of the DMS underground as possible. As noted in our September 2, 2011 submission, the “expected case for backfill”, which is the basis for the 5:1 overall ratio, still includes contingencies in terms of ensuring excess void space would remain. Therefore, potential exists to increase the proportion of DMS backfilled, which would lower the overall flotation tails to DMS ratio. Consequently, we submit that this recommendation is inappropriate and unnecessary.

Recommendation 2: The volume of flotation tailings stored in the water storage pond during operations not to exceed a maximum of 50,000 m³ and no other surface storage of flotation tailings permitted during operations.

CZN has stated that up to 50,000 m³ of flotation tailings will need to be placed in the water storage pond (WSP) on start-up while mine openings are being created for backfill. The tailings would be stored below the 877 m elevation in the pond, and thus would not interfere with the ‘live’ storage above that elevation. CZN has also committed to develop additional water storage. Therefore, there is no technical or operational reason why a greater volume of tailings could be stored in the WSP, either on start-up or during operations, should the need arise. We do not expect such a need, but in the absence of other, significant surface storage locations, it is not considered appropriate to arbitrarily set an inflexible storage limit for the WSP. We suggest this recommendation be reworded as follows:

“The volume of flotation tailings stored in the water storage pond during operations not to exceed a maximum of 50,000 m³, unless authorized by the Inspector.”

We deliberately omitted the reference “no other surface storage of flotation tailings permitted during operations” because it is rendered unnecessary by Recommendation 4. We have no objection to Recommendation 4.

Recommendation 5: No paste tailings to be stored within the waste rock pile.

This is a CZN commitment.

Recommendation 6: DMS be segregated within the waste rock pile.

This is a CZN commitment.

Recommendation 7: Seepage from the waste rock pile be routed through the mine water circuit and be discharged in accordance with effluent quality criteria back-calculated from downstream site-specific water quality objectives. Installation of a seepage collection system for the Harrison Creek aquifer should be included in the development plan.

We agree with this recommendation. However, we would like to provide context to the second part of the recommendation.

The recommendation of a seepage collection system arose from the analysis of paste backfill components and the process confirming that all flotation tailings will fit underground. The nature of that analysis dictated that we be conservative in terms of densities of the placed paste, proportion of DMS material included, and the overall percentage of voids filled in order to demonstrate that total backfill of flotation tailings is feasible. The consequence is a potential increase in the volume of DMS reporting to the WRP. As noted in our September 2, 2011 submission, in reality, once all contingencies have been allowed for, the actual volume of DMS reporting to the WRP is likely to approach the volume assumed previously. Nevertheless, CZN requested pHase Geochemistry to perform a geochemical review to assess leachate chemistry in terms of previous predictions, and consider the impact on WRP seepage quality if the volume of DMS reporting to the WRP is as high as conservatively estimated. That review (appended to our September 2, 2011 submission) determined that some parameters in the seepage **might** (not will) increase from that estimated previously, but that the potential increase was within the range of estimation. In other words, it was concluded that there was no significant difference. Notwithstanding this result, CZN elected to take a precautionary approach and committed to segregating the DMS within the WRP, with DMS placement in upslope portions of the pile footprint so that additional control measures can readily be applied on mine closure, should they be required.

Concern was subsequently expressed regarding the potential for pile seepage to evade capture in the Seepage Collection Pond (SCP), and that “some seepage may report directly to Harrison Creek (e.g. sub-surface flow in the gravels of Harrison Creek)”. We refer to comments made by Robertson Geoconsultants in their Site Hydrogeology Report (March 2010), p. 39:

"It should be acknowledged that seepage from the proposed WRP to be placed in a side valley of Harrison Creek valley could contribute to the Zn load in the HCAA during active mining and post-closure. This potential source was not considered in our initial mixing calculations because

it was assumed that most (if not all) of this seepage would be collected directly by the mine workings and/or by a seepage collection system to be constructed at the toe of the proposed WRP".

Hence, our consultant believes there is a small risk of seepage evading capture, small enough not to warrant inclusion in mixing calculations (i.e. not significant). However, again, CZN agrees to take a precautionary approach. The footprint of the WRP and SCP consists of a thin colluvial cover over bedrock, or exposed bedrock. Gravels are not present. There is a small risk of seepage moving in the near surface zone evading the SCP. We propose to install a shallow groundwater interception system consisting of a cut-off trench along the toe of the WRP. The depth of the trench and other details will be confirmed as part of site investigations leading to detailed WRP design. The trench could either act as a collection drain, with drainage fed into the water management system, or a barrier intended to force seepage to surface for collection in the SCP. As noted above, we agree with AANDC's recommendation.

Recommendation 8: All development waste must be brought to surface and disposed in the waste rock pile.

As for Recommendation 1 above, as the project progresses towards completion (closure), and assuming it is apparent that excess void will remain, flexibility should remain to include either more DMS or development waste in the backfill. Preference will be given to DMS, but there may be occasions when leaving some development waste in the lowest levels of the mine is preferred. Therefore, we disagree with this recommendation.

Environment Canada

All vegetation clearing should be conducted either before May 7 or after August 10, to avoid the migratory bird breeding season. If active nests are found during activities conducted outside of these dates, the area should be avoided until nesting is complete (i.e. the young have left the vicinity of the nest).

For the area immediately south of the Mine, in the event a second pond is constructed there, CZN agrees to either comply with the recommendation or conduct a survey prior to clearing to confirm the absence of nesting migratory birds.

EC maintains that the bags proposed for concentrate storage are susceptible to tearing when exposed to the cold, sun and/or precipitation, the fashion in which they are sealed is neither durable nor air-tight and could be compromised during transit or transfer. As well, the specifications of the concentrate dictate that under frozen conditions, concentrate would not remain in a contained block if released during a spill scenario. As such, secondary containment is the recommended mitigation measure.

CZN has stated its position on this matter in our reply to EC's Technical Report (see Attachment 1). However, we wish to highlight some facts. The concentrate will have a sugar-like texture and will retain moisture which will be frozen in winter, which is when the concentrates will be transported. Therefore, there will be no dust. The bags will leave an un-heated, covered shed and travel by flat-deck trailer to another un-heated, covered shed. Note that other operations have used similar bags for concentrate transport in all seasons.

EC's commentary appears to focus on spill scenarios. Undoubtedly there will be occasions when a bag is ripped or spilled, but this will be accompanied by a full and complete spill response action. As discussed above, there will be no continuous, small loss of concentrate in a non-spill

scenario that could, over time, become significant. If we thought this would occur, we would not have proposed the bag method of concentrate transport. We have proposed monitoring to confirm our belief, and have committed to make changes if monitoring results indicate we are wrong. We remain convinced that secondary concentrate containment is not necessary nor practical given that the bags will need to be loaded and unloaded up to four times.

We also note the need for further broad evaluation of the proposed water management changes and water storage pond construction implications. While the Board may determine some of these issues can be addressed with appropriate measures or in the regulatory stage, EC would have concerns with closing the public record prior to thorough assessment of the impacts associated with the proposed additional water storage options.

We find this statement confusing. EC initially refers to water management changes and water storage implications, but concludes with reference to impacts associated with the water storage options. Is it the significance of the water storage options as they relate to effluent discharge quality, or is it the impacts associated with construction of the additional water storage? If it is the former, CZN has described its position with respect to water quality and environmental protection in the submission dated September 16, 2011. In the same document, we describe a process including additional water storage that could lead to lower SSWQO's. If it is the impacts associated with construction of the additional water storage, we believe EC has had ample time to review the proposals and provide comments with respect to their mandate. From their comments in their Final Submission, this appears to have occurred. As such, we believe their concerns are lacking in merit. We also note that no other government agency has voiced concerns about closing the public record.

Parks Canada

Recommendation 6: Management of traffic when wildlife are on/near the road will be detailed in the wildlife management plan, but will include:

- *Stopping traffic when caribou, moose, sheep, wolverine and lynx are within 50 m to allow them to cross.*
- *Only hazing when there is a danger to people or wildlife.*
- *Hazing only carried out by specific trained staff.*

We stand by comments made on PC's Technical Report in Attachment 1. We suggest the term "hazing" not be used, and that wildlife management approaches and terminology along the access road be consistent both inside and outside of the NNPR.

Recommendation 9: The following mitigation measures be implemented for the winter road.

Aspect	PC Recommended Mitigation	CZN Response
<i>Aggregate Source</i>	<i>Materials may only be removed for fill within 2 meters of the road bed and only where materials are unvegetated. After removal of aggregate slopes are to be contoured to accommodate drainage, to ensure stability, and to ensure the removal of materials is not obviously an impairment to aesthetics. Maximum amount of aggregate taken from the park be 8250 m³ (DAR Addendum (6000 m³ for TTF) and IR Round 2 PC 2-1 (5 km fill in park x .5m thick x 5m wide) plus 10% buffer = a maximum of 8250 m³.)</i>	Two metres is less than half of the road width and is unreasonable. We believe the rule of thumb used by AANDC when administering LUP's is that aggregate within 100 m of the road can be acquired as part of road construction. In the Sundog valley, there are hundreds of metres of accessible scree slopes on both sides of the road. No significant impacts or restoration requirements would arise by borrowing from these. The aggregate volumes required were estimates, but still insignificant in terms of the available supply. We oppose the limits.
<i>Water Source</i>	<i>If the total withdrawal could potentially exceed 7% of the volume of the lake, aquatic surveys must be conducted and a thorough quantitative assessment made to determine potential impacts before permitting.</i>	The DFO water withdrawal protocol is assumed to be conservative and protective of all lake systems. We propose to follow the protocol, and other restrictions are not considered necessary.
<i>Spills</i>	<i>Minimum response time to all locations in the park be 30 minutes. Materials at the location meeting minimum response time would be sufficient to contain an entire truck of all potential spill materials in a variety of environmental conditions. Barriers will be used in appropriate locations.</i>	The minimum response time cannot be accurately detailed as it will depend on truck traffic at the time. During the haulage season there will be many trucks at all hours and drivers will have spill response training, and every vehicle will have a spill kit. It is not practical to have a response team available within a 30 minute travel time. Several crews would have to be permanently stationed along the road. Response materials will be conveniently located to be accessible to response teams in transit to a spill location. As noted previously, CZN intends to review road conditions with a view to improving safety and reducing the risk of spills, and to develop more detail into a relevant and effective Spill Contingency Plan.

Aspect	PC Recommended Mitigation	CZN Response
<i>Bridges</i>	<i>Bridges over Funeral Creek and Sundog Creek are required to be designed to ensure wildlife passage beneath.</i>	The proposed permanent span over Sundog Creek is elevated several metres from the creek bottom, so likely would not be a wildlife movement barrier. However, there is a waterfall with a drop of about 2 m near the span location which would likely negate movement in the creek anyway. The Funeral Creek channel at the proposed bridge location is only about 1 m deep and 3-4 m wide. Wildlife can readily move across the channel upstream or downstream. A bridge high enough to allow them to pass under is impractical and unnecessary, and would require large ramps which themselves would be obstructions to wildlife movement.
<i>Avalanches</i>	<i>Conduct detailed risk assessments and mapping for avalanche risk. Wildlife sweeps will be required prior to control being initiated. No control will be used when large mammals are within 3 km of the control area.</i>	We agree that more assessment needs to be done regarding avalanche risks. However, our initial findings are that snow accumulations are not significant on the high elevation, wind-swept slopes where the highest risk of avalanche impacts on the road exists. If control measures are required, timing and location can be considered to minimize wildlife impacts, bearing in mind that surveys have indicated that usually very few animals are in close proximity to the road alignment. However, due to the short haulage season, transport operations cannot be stopped for any significant period (more than 24 hours), but due caution can be applied
<i>Karst and Permafrost</i>	<i>Obtrusive probing must occur along the road alignment in areas with near surface karst and suspected permafrost or weak layers. Road design will take into account avoidance of these features as a first measure, and mitigation to reduce risk as a second measure. Also, refer to our recommendation #1</i>	We believe suitable investigation, mitigation and monitoring proposals have been made by Golder Associates, and we intend to follow them.

Recommendation 10: Site Specific Water Quality Objectives (SSWQO's) be set based on the Reference Condition Approach to the degree possible.

CZN's recommended approach for deriving final SSWQO's is provided in the Framework submitted as Attachment 1 to our September 16, 2011 submission.

Recommendation 11: Additional water storage be required.

CZN has committed to this.

Recommendation 12: Additional treatment options and additional water storage be implemented where they enable the water quality to reach RCA SSWQO's. Risk assessments be conducted for parameters that are predicted to exceed RCA SSWQO's even with additional treatment and storage.

Please see our response to AANDC's Recommendation 2 under the title "Water Management and Storage".

Recommendation 13: A new water storage pond or an expansion to the existing water storage pond be constructed for a 1 in 1000 year flood and a 1 in 1000 year earthquake. Back slopes be designed to ensure adequate stability from landslides and earthquakes.

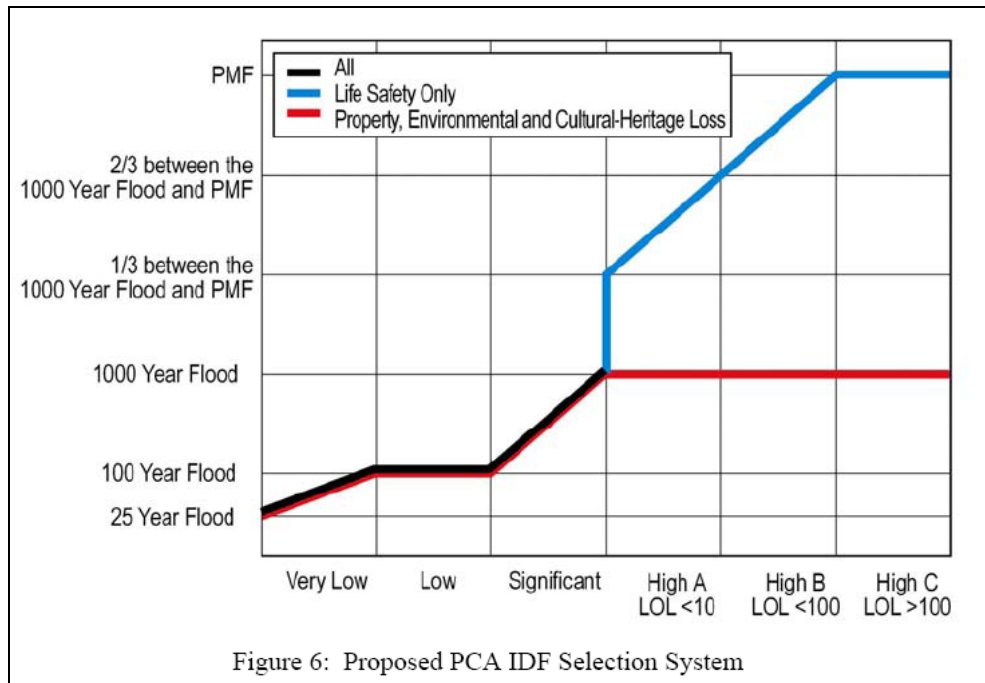
Regarding seismicity, a 1 in 1,000 year earthquake is consistent with assumptions that have and will be made for pond stability analyses.

Regarding flood magnitudes, the following informal comments were received from Northwest Hydraulics Consultants:

The recommendation relies in part on a document which describes the development of a national dam safety standard for Parks Canada. This document is available online and was obtained from the following location:

<http://www.cda.ca/proceedings%20datafiles/2009/2009-6b-03.pdf>

The Parks Canada recommendations for inflow design floods (IDF) are summarized in a figure which is reproduced below. Losses are classified from "very low" to "high" and refer to "incremental adverse consequences resulting from dam failure of mis-operation above those impacts which would occur under the same conditions (flood, earthquake or other event) but without the failure of the dam." The source document includes definitions for the levels of loss.



Source: Parks Canada Presentation at CDA 2009 Annual Conference

Parks Canada recommends a maximum 1000-year inflow design flood for scenarios of potentially “high” property, environmental, and cultural-heritage loss. “High losses are defined as: *“Extensive loss of fish or wildlife habitat or significant deterioration of critical fish and/or wildlife habitat with very little or no feasibility of being able to apply natural or assisted recovery activities to promote species recovery to viable population levels. Irreversible damage to significant provincially or federally designated cultural heritage sites.”* As noted above, the losses at issue are the incremental losses. A 1000 year inflow design flood would not be required if the same level of damage was already caused by a 1000-year flood without a dam failure.

Parks Canada is recommending that an expanded or new water storage pond be designed for a 1 in 1000 year flood. The question is whether it is necessary to apply this standard to the design of bank protection along a pond berm adjacent to Prairie Creek.

We address this question in two parts as follows:

1. **Parks Canada’s analysis for Prairie Creek does not provide information to suggest that the incremental consequence of a dam failure warrants classification as a “high” loss under the Parks Canada guidelines.**

Parks Canada provided “Reasonable Worse Case Impact” scenarios to support recommended mitigation measures along the winter road, but has not provided a similar impact scenario to justify the selection of a 1000 year inflow design flood. It is difficult to imagine that a dam breach would cause incremental adverse consequences that would warrant designation as a “high” consequence dam based solely on environmental loss. Significant bed mobilization, movement of spawning gravels, high velocity flow, bank erosion, channel shifting, and other disturbances to fish habit would all occur at much less severe floods and are a natural occurrence. We would expect that the consequences of a dam breach on fish habitat would not be much different than from naturally occurring major floods and that there would be a natural recovery.

2. The dam safety standards are for an “Inflow Design Flood”, and are not intended to be applied as a bank protection works design flood.

Dam safety inflow design flood guidelines were developed in the context of sizing spillways of sufficient capacity to contain and to pass design flows in a controlled manner. When an inflow design flood is exceeded there is a high risk of a rapid sudden failure. The water level will be above the design full supply level and a breach failure will initiate when water overtops unprotected parts of the dam embankment. The water storage reservoir(s) at the Prairie Creek mine are not on-stream facilities and there will be ample capacity to store storm event runoff from local drainage areas which can not be diverted around the facility. Inflow design flood criteria do not apply to the storage reservoir(s) at Prairie Creek.

Inflow design flood recommendations do not apply to bank protection designs because there is a relatively low risk of sudden catastrophic failure when the design event is exceeded. Riprap bank protection designs are mobile by design and can accommodate movement and/or loss of rock without compromising the integrity of the facility being protected. The berms for the water storage reservoir at Prairie Creek are massive, and the floods in Prairie Creek are flashy, which limits the duration of erosive flows. It would in our opinion be appropriate to design the bank armour for 200-year recurrence flows which we understand is the design standard for the existing berm. There may be some limited loss of rock during major flood events which could be subsequently repaired. A program of regular inspections and maintenance should be implemented regardless of the adopted design standard.

In summary, we expect that the incremental consequences of failure of the proposed water supply pond would not be classified as “high” and that an inflow design flood less than 1 in 1000 years would be indicated under the Parks Canada guidelines. Regardless, the facility is believed to have sufficient storage to hold the 1000-year inflow from the local drainage, and this satisfies the flood hydrology requirements of the dam safety standards for high consequence facilities.

We recommend that a 200-year flood be used for the design of riprap bank protection on the outer face of the pond berm which is exposed to Prairie Creek flows. Floods which exceed the design criteria would not be expected to threaten the integrity of the storage facility, provided that any necessary repairs are made and there is no risk of a cumulative loss of material during subsequent major events. The 200-year design standard is consistent with that used for the existing bank protection at the site and should satisfy normal regulatory requirements.

Recommendation 14: Thresholds of impacts and management action be established as follows:

<i>Level of impairment to algal or invertebrate communities within Nahanni NPR using a statistical distribution reference condition approach</i>	<i>Action</i>
<i>Sample falls within the 70% ellipse or less</i>	<i>Ongoing monitoring and assessment.</i>
<i>Sample falls within the 70-95% ellipse</i>	<i>Possible pending impairment to the ecological integrity of the Prairie Creek Aquatic Ecosystem in Nahanni NNPR – additional assessment is required as designed in consultation with Parks Canada and other parties.</i>
<i>Sample falls beyond the 95% ellipse</i>	<i>Significant adverse environmental impact</i>

The following comments were received from Hatfield Consultants:

The recommendation appears to stem from a presentation abstract from a recent (November, 2010) workshop about CABIN (EC's RCA protocol):

“Evaluating the impacts of mining on the ecological integrity of streams in the South Nahanni Watershed”, Garry Scrimgeour, Parks Canada, garry.scrimgeour@pc.gc.ca

Information in the abstract included the following:

As a partner in the Canadian Aquatic Biomonitoring Program (CABIN), Parks Canada Agency is using the RCA to: i) assess potential impairment due to industrial activities, and ii) support the development of a long-term surface water monitoring program for the South Nahanni Watershed. Water, benthic macroinvertebrates and select habitat variables were collected from 118 sites throughout the watershed in 2008 and 2009, and a RCA was applied to assess stream health. A preliminary assessment of the effects of mining operations on stream integrity is presented, and possible impacts were linked to concentrations of select contaminants within the stream food-web.

It appears this has not been published, which is problematic in terms of our review and consideration for adoption in the EA. Initial thoughts are as follows:

1. CABIN has specific sampling and analytical protocols that, while not unreasonable, may not align exactly with current CZN monitoring proposals. These may need to be revisited.
2. The reference ellipse describes the variability of benthic community structure at several (ideally many; typically dozens of) spatially distinct baseline locations with similar landscape features, against which the community at exposed sites is compared. What/where/how many (multiple) reference sites are being proposed for sampling for specific comparison with the Prairie Creek exposure area? Presumably this is answered in Scrimgeour's study. If he did assess the current communities downstream of the mine as indicated in the Abstract, did they fall within or outside the reference ellipses described in Recommendation 14? This current condition is

critically important for understanding whether the method can be successfully applied to Prairie Creek operationally.

3. The reference ellipse criteria of >70% (unstressed), >70-95% ("possible pending impairment") and >95% ("significant adverse effect") differ substantially from the standard CABIN criteria used in BEAST ("Benthic Assessment of Sediment"), the multivariate analytical model typically applied by the federal government in other jurisdictions and outlined in the CABIN Protocols document. In BEAST, >90% is considered "unstressed", >90-99% is considered "potentially stressed", >99% is considered "stressed", and >99.9% is considered "severely stressed" -- in other words (and to simplify), if the exposed site is similar to 90% of reference communities, in BEAST it is considered unstressed, and if it's similar to only 1 to 10% of reference communities, then it's considered "potentially stressed".

In Recommendation 14, an exposure site with a benthic community similar to between 5 to 30% of reference sites would be classified "possible pending impaired". It's important to understand why the bar for classifying a community as "possibly impaired" has been raised from 10% to 30% in Parks' recommendation relative to standard EC criteria. (Also note that by this definition, 30% of the reference sites used in the model would themselves be considered "possibly impaired".) The wording "possible pending impairment" sounds like "there is no impact, but it's sufficiently different from other reference sites that we should assume there might be one ", so, an extra-precautionary approach.

However, if Prairie Creek pre-operations already differ from 70% of reference sites, then this criterion cannot be used to assess real or potential impact. This is why the appropriateness of reference sites in the database is critical, and why, ultimately, before-after comparisons may be more relevant, as it is the change from baseline conditions in Prairie Creek, not necessarily similarity to other regional baseline conditions, that should define the operational impact of the mine. Therefore before adopting the CABIN approach outlined above, is recommended that a more commonly applied BACI (Before-After/Control-Impact) approach be considered while designing the AEMP. The BACI approach compares upstream reference "control" samples to downstream "exposure samples". It also considers how the downstream conditions change from baseline (before the mine starts operating) conditions. Because all the sampling would likely be performed on Prairie Creek, this approach may be more representative than the CABIN approach.

Therefore, before a full review and assessment of Scrimgeour's study has been completed, it is premature to consider the proposed application as a monitoring approach, much less recommend it for adoption by the Review Board.

Recommendation 15: No paste tailings to be stored on surface other than those contained within the paste plant itself.

This recommendation should be amended to include temporary flotation tailings storage in the WSP, then it will be consistent with CZN's commitments.

Recommendation 16: No paste tailings to be stored within the waste rock pile.

CZN has committed to this.

Recommendation 17: DMS be segregated within the waste rock pile.

CZN has committed to this.

Recommendation 18: Seepage from the waste rock pile be routed through the mine water circuit and be discharged in accordance with effluent quality criteria back-calculated from downstream site-specific water quality objectives. Installation of a seepage collection system for the Harrison Creek aquifer should be included in the development plan.

See CZN's response to AANDC's Recommendation 7 under the title "Tailings Management".

Natural Resources Canada

Predictions made in the DAR regarding leachate water quality from the paste backfill can be confirmed, by the proponent, through further testing and analyses. NRCan would be supportive of a commitment by the proponent to conduct this testing as early as practical, before irreversible actions are taken

As noted in our comments on NRCan's Technical Report (Attachment 1), CZN has made a commitment to perform additional testing (as a precautionary, confirmative step) as early as practical. However, there are limitations on how early this can be done with respect to the schedule of paste production and backfill. To conduct the work, samples must be collected from paste generated from the paste plant. At that point, paste production will have started, and the paste must be placed underground. In other words, some paste production and backfill will have occurred before the results of confirmatory tests have been completed. Note that the predictions to date are considered to be conservative. Therefore, the testing can be completed as early as practical, but not before some paste backfill has occurred. This is not considered to pose a significant risk.

Nahanni Butte Dene Band

CZN does not necessarily disagree with the intent of the Band's position, but we believe some comments are needed for clarity and context.

Where mineral and/or other material concentrations will be below standard end-of-pipe water quality guidelines for chronic toxicity, operational end-of-pipe objectives can be set reflecting the achievable concentrations. In other words, objectives lower than standard guidelines should be set where achievable using best available technology (and practices), particularly given the acknowledged sensitivity of Prairie Creek.

Water quality guidelines and objectives are considered and discussed with respect to receiving waters, not end-of-pipe discharges. CZN has proposed objectives, the majority of which are lower than standard guidelines.

Where certain concentrations exceed standard end-of-pipe guidelines for chronic toxicity, a risk assessment needs to be carried out to both determine the extent of the dilution zone required to achieve the guidelines and the impact on the aquatic environment of increased concentrations in the dilution zone. The impact of loading (averaging concentration discharges over time rather than applying fixed concentrations) has to be included in the risk assessment. This impact information needs to be reviewed by the community, in collaboration with Canadian Zinc and responsible agencies, before final objectives are set.

End-of-pipe numbers are usually referred to as Effluent Quality Criteria (EQC), and set by back-calculating from in-stream water quality objectives. EQC cannot exceed values specified in the Metal Mining effluent Regulation, and discharges cannot be acutely toxic. Dilution zones are typically where some chronic toxicity may exist prior to complete mixing. CZN has ensured that the zone of chronic toxicity will be very small by proposing to use an exfiltration trench. Depending on the effect of additional water storage and enhanced process water treatment on discharge concentrations, it may very well be that there will be no chronic toxicity by the time water discharged from the trench reaches the bed of the creek.

Risk assessments are proposed to be carried out when predicted concentrations do not meet established RCA benchmarks to the edge of the initial dilution zone (IDZ).

The writer appears to have misunderstood the load-based approach proposed by CZN for regulating discharges. It is not “averaging concentration discharges over time”. Regulation based on fixed concentrations only would mean that very low EQC concentrations would need to be set to avoid the potential for toxicity and exceedances of objectives during low creek flows because there would be no constraint on the volume of discharge. It would also mean that the discharge from the operation is unnecessarily constrained during high creek flows. Regulation based on loads would mean that discharge volumes or concentrations can vary, provided the sum is always lower than “allowable loads” the receiving environment can adsorb at any point in time based on creek flows. Upper limits could also be set on the concentrations. In summary, a load-based approach should have lower impacts because fluctuations in receiving water quality should be much less.

The community wants the use of dilution zones and loading to only be considered as a last resort and only where it can be demonstrated that no chronic toxicity in aquatic life will occur. The community wants to ensure minimal impacts downriver of the discharge point and also wants to ensure simpler and more consistent compliance monitoring procedures.

In general we agree, but as discussed above, we view the load-based approach as a tool to achieve these goals, whereas the writer appears to incorrectly assume that “loading” is a negative approach.

The community wants assurances that leaching of minerals from disposed tailings will not cause chronic toxicity in aquatic life downstream nor result in the need for long-term post-closure water treatment operations.

As noted above, the goal is always to minimize the extent of chronic toxicity. In terms of a need for long-term post-closure water treatment operations, this is what the site is currently facing unless a comprehensive mine closure plan is adopted that eliminates the existing mine drainage.

Dehcho First Nations

All of the issues raised are addressed by our responses to AANDC’s Final Submission (Recommendation 2 in section titled “Water Management and Storage”, Recommendations 1-3 in section titled “Site specific Water Quality Objectives”, and Recommendation 7 in section titled “Tailings Management”).

TABLE 1: FINAL COMMITMENTS TABLE

CONSULTATION	SOURCE
Continue to engage First Nations throughout the EA process.	DAR, section 7.2
Operate and participate in a Technical Advisory Committee (TAC) which will meet in the region three times annually to review and discuss mine operations and monitoring results, and other issues of mutual interest in the region.	DAR, section 7.3
Welcome NBDB, LKFN, other First Nation, and Government representation on the TAC.	Reply to IR2, Appendix J.
Appropriate collaborative monitoring initiatives with First Nations, Parks Canada and other regulatory agencies will be supported.	DAR, section 10.7.1
The Nahanni Butte community information representative position will be continued during operations.	DAR, section 11.3
CULTURE	
If possible heritage/cultural resources are found, they will be preserved and the authorities notified.	DAR, section 11.2
Deter and monitor un-authorized use of the access road and hunting.	DAR, sections 9.4.1 and 11.4
Employ an NBDB member as an environmental monitor.	Impact Benefits Agreement between NBDB and CZN, Jan. 20, 2011 (confidential).
Involve NBDB members in spill response training and inform the Band of any spills.	NBDB-CZN Meeting Report, June 10, 2010.
CZN will conduct a supplementary Archaeological Impact Assessment for the proposed road re-alignment from the Liard River near Nahanni Butte to Grainger Gap. The survey will occur after the road alignment has been confirmed more accurately.	Reply to IR GNWT6
SOCIO-ECONOMICS	
Impact Benefit Agreements will be negotiated with the Nahanni Butte Dene Band and the Liidlii Kue First Nation.	DAR, Appendix 19
Negotiate a Socio-Economic Agreement with the GNWT	Technical Meeting, Oct. 6, 2010
A hire-first policy for qualified local (Nahanni Butte) residents, then Dehcho residents, then northern residents, will be adopted.	DAR, section 11.1
Services and supplies will be sourced locally and across the north, provided these are competitive.	DAR, section 11.1
Employment of Dehcho residents and social impacts will be monitored via annual IBA reports, and details of mine employment, training and contracts given out will be provided. Such reports will also be the basis for reporting to regulators.	DAR, section 11.3
Employees will be offered a variety of mine related training courses, including skills training in their area of employment and in safety. The Mine scholarship program will continue.	DAR, Appendix 19

TABLE 1: FINAL COMMITMENTS TABLE

The Mine will work with communities and its leaders to develop and implement strategies to limit negative health outcomes, such as drug and alcohol abuse.	DAR, Appendix 19
The Mine will continue to be active in Study Area communities through sponsorship programs that will improve life for communities and those not benefiting from the Project directly.	DAR, Appendix 19
Applicants for work at the mine will be notified that should they be employed, they will have to make appropriate arrangements for child care in their absence.	Reply to IR GNWT7
Contractors and subcontractors will be required to sign an Employment Contract and Code of Conduct regarding adhering to policies such as northern employment criteria, which will be part of selection evaluation criteria. Information on potential employees will be passed on to contractors, and Study Area communities will be notified of construction and hiring timelines.	Reply to IR GNWT8
The Mine's socio-economic Adaptive Management System will consist of: a <i>Monitoring System</i> consisting principally of a year-long process of collecting and analysing data and trends regarding the outcomes from participation in the Project and more general socio-economic progress of the Study Area; and, a <i>Response System</i> consisting of a formal session to communicate results and receive input from representatives of the affected communities on areas where changes could improve outcomes and productivity.	Reply to IR GNWT10
After fulfilling obligations to IBA's and the Nahendeh Aboriginal Economic Council, the Mine will advertise its needs in regional newspapers and continue participation in regional NWT trade shows to communicate the opportunities associated with the project. A database of NWT qualified businesses related to various services and supplies will be maintained.	Reply to IR GNWT13
An annual operations report will be produced to provide the public with information regarding the production schedule at the Prairie Creek Mine, its employment record, and planned activities for the upcoming year. This report will inform Study Area, Deh Cho and NWT residents and regulators, and will include information on employment and business procurement.	Reply to IR GNWT15
CZN will identify jobs for which formal entry level educational requirements will be adjusted for Dene job applicants. For greater certainty,[sic] but subject to applicable law, CZN commits to requiring Dene to have a minimum Grade 10 for all entry level positions at the project, and will, from time to time, adjust formal entry level educational requirements for vacant positions in order to improve the acceptability of potential Inuit job applicants for these positions.	Appendix 30, Appendix A Socio-economic Commitments, B(9) page 15 , DAR
Where appropriate, CZN will consider ability, skills and experience as an equivalent to formal qualifications as identified in job descriptions.	Appendix 30, Appendix A Socio-economic Commitments, B(4) page 15, DAR

TABLE 1: FINAL COMMITMENTS TABLE

Dene employees will not be disciplined or terminated due to their inability to speak the English language, but may be transferred to a job requiring less knowledge of the English language or to a training program to suit them to another job. Such transfer will be at the discretion of CZN.	Appendix 30, Appendix A Socio-economic Commitments, B(11) p 16, DAR
Dene who do not possess knowledge of the English language, either written or verbal, will be given reasonable opportunities to qualify for jobs where lack of knowledge of the English language does not compromise the safety of the employee, safety of others or job performance.	Appendix 30, Appendix A Socio-economic Commitments, B(10) p 16, DAR
CZN expects to provide several summer positions for various responsibilities. The areas of work could relate to general labourers, office assistance or help with annual events held in neighbouring communities. These annual positions could be posted at the mine site, regional CZN offices, and advertised in local newspapers. Priority will be given to relatives of mine staff from the IBA communities.	Reply to IR GNWT 1-9 Q4
CZN will encourage and provide opportunities for advancement and promotion to employees.	Appendix 30, Section 2 p 5, DAR
CZN will ensure that its internal posting system for hiring personnel for the project will include posting at the project and in Nahanni Butte.	Appendix 30, Appendix A Socio-economic Commitments, B(5) page 15, DAR
CZN will develop recruitment and hiring policies and procedures that will encourage Dene employment at the project.	Appendix 30, Appendix A Socio-economic Commitments, B(3) page 15, DAR
It is the goal of Canadian Zinc's to enhance positive benefits and eliminate or at least reduce the impacts of negative effects. It will do this through a combination of its "hire first" program, offering a comprehensive benefits package to employees, making the Prairie Creek Mine site hospitable through numerous activities, programs and services, employ a community information representative to help with communications between employees and mine management, and to remain active participants in Study Area community events.	Appendix 19, Section 7.7.3.4, DAR
The focus is primarily on the participation of labour and business from the Study Area communities. However, opportunities will exist for any resident or business in the NWT.	Appendix 19, Section 7.3, DAR
Once CZN has fulfilled its commitments with its IBA holders, the company will promote the direct employment of NWT residents outside the Study Area promoting available employment positions with advertising in regional newspapers, and postings with NWT employment agencies. Some of these agencies would include MTS and the employment coordinators with various First Nation Bands in NWT. The company will consider a pick-up point in Yellowknife if employee numbers warrant it and it is economically justified.	Reply to IR GNWT 1-9 Q1

TABLE 1: FINAL COMMITMENTS TABLE

Much of the participation during construction will be local. This is particularly true for employment.	Appendix 19, Section 7.3.1.3, DAR
... CZN has undertaken to employ NBDB members as environmental monitors at the mine and for the access road. CZN is also looking to NBDB members first for the operation of checkpoints on the road to manage traffic and the possible use of the road by individuals not on mine business.	Reply to IR GNWT 1-12 Q2
CZN expects to follow the hiring preferences negotiated with its IBA holders. The order of priority CZN has been using for hiring applicants with similar qualifications can be defined as: 1. Members of the Nahanni Butte Dene Band 2. Members of the Liidlii Kue First Nation Band 3. Dene descendants within the Dehcho Region 4. Residence within the Northwest Territories 5. Others.	Reply to GNWT IR 1-8 Q1
As part of our responsibility to the Northwest Territory <i>[sic]</i> , we are strongly committed to employing and training people who are native to this area and/or are permanent residents. To achieve this, travel assistance will be provided for employees traveling from designated points of hire.	Appendix 30, Section 6, DAR
Should circumstances change in such a manner that different rotation schedules become more feasible, such options will be discussed with the mine's workforce.	Appendix 19, Section 7.7.3.3, DAR
Work rotations at the Prairie Creek operation are based on three week turnarounds (i.e., three weeks working followed by three weeks off).	Appendix 30, Section 3.2 p 6, DAR
Personnel that are not area residents will be flown-in to site on charter flights originating from 1 or 2 locations, such as Fort Nelson, Edmonton, Yellowknife or Vancouver. Employees will make their own way to these locations for pick-up. Personnel from local communities will be flown in on charter flights from Nahanni Butte, Fort Liard or Fort Simpson. NWT residents beyond these communities will make their own travel arrangements to these pick-up points.	Main Report, Section 6.26 page 247, DAR
CZN will be making commitments to apprentice positions with its IBA holders. The company expects to have several apprentice positions available with the project although priority will be given to CZN's IBA holders.	Response to IR GNWT 1-9 Q3
CZN will employ Dene apprentices, if available and if there are qualified tradesmen on site to supervise an apprentice.	Appendix 30, Appendix A Socio-economic Commitments, C(4) page 16, DAR
CZN will also endeavor to carry out relevant training programs that are offered through cooperation with other agencies in the Territory to support regional education and build up a further educated Territorial workforce.	Appendix 30, Section 2 page 5, DAR

TABLE 1: FINAL COMMITMENTS TABLE

<p>For the Study Area community as a whole, regarding additional investments in education, CZN will:</p> <ul style="list-style-type: none"> • Sponsor students attending higher education through a scholarship program. • Work with the NWT Mine Training Society and Aurora College to provide education and training opportunities. • Work with Study Area schools to provide details of its operations, its future labour and supply needs, and opportunities for students. • Work with Study Area communities and businesses to improve participation and productivity. • Remain very active in the communities through investments, sponsorships, promotions, and attendance at community events. 	<p>Responses to IR GNWT 1-11 Q1</p>
<p>CZN wishes to provide opportunities for participation by Dene in the development of the project, and that to do so training will be required to position Dene to take advantage of business and employment opportunities associated with the project.</p>	<p>Appendix 30, Appendix A Socio-economic Commitments, C(1) page 16, DAR</p>
<p>Through its Impact and Benefit Agreement holders and the Deh Cho First Nation, CZN is looking to invest in education and training specific to the needs identified by the Dehcho residents. Emphasis is on skills that are applicable to many job descriptions and not necessarily specific to mining.</p>	<p>Response to IR GNWT 1-11 Q1</p>
<p>Canadian Zinc will promote higher learning through a scholarship program, sponsor training in conjunction with the mine training society, take an active role in the schools and communities, and sponsor visits by school staff to site to help them understand better the environment and the possibilities for their students.</p>	<p>Appendix 19, Section 11.3, Table 11-1, DAR</p>
<p>Where an employee is required to have specific skills to operate equipment in the course of their duties, training will be provided.</p>	<p>Appendix 30, Section 2, DAR</p>
<p>The company is also committed to providing mentoring programs at the mine, ongoing school workshop presentations at local schools, and annual scholarships to promote the abilities of future generations within the Dehcho Region.</p>	<p>Response to IR GNWT 1-9 Q2</p>
<p>A general overview of CZN's Aboriginal and NWT procurement strategy is outlined below. CZN will focus on a general Northern procurement policy by adhering to the following principals:</p> <ol style="list-style-type: none"> Wherever practical, construction projects will be split into phases or segments so that small northern contractors and suppliers can have the opportunity to bid. Wherever practical, goods contracts will be tendered by grouping so that northern contractors and suppliers have the opportunity to bid and compete. Whenever practical, contracts for the supply of goods will be tendered in a manner which provides opportunities for northern contractors or suppliers. 	<p>Response to IR GNWT 1-13 Q7</p>

TABLE 1: FINAL COMMITMENTS TABLE

Canadian Zinc is committed to working with the community and business leaders to maximize the benefits from the Project. As a part of this commitment, Canadian Zinc will offer valuable guidance in areas where it has particular expertise such as management, industrial development, and organisation.	Appendix 19, Section 7.7.2, DAR
<p>CZN will focus on procurement of Aboriginal services with the following policy: "Aboriginal Business" means a business owned by one or more of the Participating First Nations, directly or through their respective development corporations, or a Member or Members of the Participating First Nations. The Aboriginal Business must comply with all the legal requirements to carry on business in the Dehcho region and must be certified by the relevant Participating First Nations and meet one of the following criteria:</p> <ul style="list-style-type: none"> i. Is a corporation or limited company with at least 51 percent of the company's voting shares beneficially owned by a Participating First Nation, a Participating First Nation development limited partnership or a Participating First Nation Member or Members; ii. Is a cooperative with at least 51 percent of the cooperative's voting shares beneficially owned by one or more Participating First Nations, a Participating First Nation development limited partnership or Participating First Nation Members; iii. Is a sole proprietorship, the proprietor of which is or is owned by one or more of the Participating First Nations, Participating First Nations development limited partnership or Participating First Nations Members; or, iv. Is a partnership, the majority interest in which is owned by one or more of the Participating First Nations, Participating First Nations development limited partnership or Participating First Nations Members, or in which the majority of benefits under the partnership agreement accrue to the Participating First Nations or Participating First Nations Member(s). 	Response to IR GNWT 1-15 Q2
CZN will endeavour to contract a bulk fuel service company located in the region, preferably close to the haul route, which has an established mobile spill response unit that would be available 24 hours a day.	Response to IR Parks Canada 2-9, Appendix I page 3
It is CZN's intent to provide IBA holders advance notice on all contracts and procurement opportunities. The specific timeframes are still in IBA negotiation. Further to this commitment, CZN expects to advertise sourcing needs in local and regional newspapers in the NWT, and notify local businesses of the project's requirements.	Response to IR GNWT 1-13 Q3
The focus is primarily on the participation of labour and business from the Study Area communities however opportunities will exist for any resident or business in the NWT.	Appendix 19, Section 7.3, DAR
CZN recognizes that businesses which maximize Dene content should, consistent with the terms of this schedule, be given preference in the provision of commercial services for the project.	Appendix 30, Appendix A Socio-economic Commitments, D(2) page 16, DAR

TABLE 1: FINAL COMMITMENTS TABLE

CZN will apply its local and NWT procurement policies during the reclamation phase.	Response to IR GNWT 1-13 Q5
... Canadian Zinc will discuss the importance of local hires with Aboriginal development corporations during and after IBA negotiations and make northern employment a criterion for evaluating proposals.	Appendix 19, Section 11.3, Table 11-1, DAR
CZN will emphasize local procurement by its contractors and will make this a valued component in how bids are evaluated. Businesses outside the Study Area will be encouraged to participate, and CZN will extend to them the same opportunities given to Study Area businesses should those companies be unable to fill certain contracts. CZN would prefer to offer contracts to NWT-based companies that can provide goods and services at a competitive price and meet local sub-contracting criteria.	Response to IR GNWT 1-13 Q4
In order to ensure that its contractors and subcontractors honour and adhere to all commitments made, CZN will ensure, through written contracts, that all such parties are aware and comply with all of the terms and conditions that are associated with such permits that are necessary for operating the Mine.	Main Report, section 2.2 page P.61, DAR
Much of the construction activities will be completed by contractors. These contractors will be encouraged to hire from within the Study Area communities. To facilitate this local participation, Canadian Zinc will <ul style="list-style-type: none"> • notify the Study Area communities of the construction schedule in advance of the activities, • set out a schedule of when the contractors will be hiring, • provide the names of past employees to the contractors, • provide the names of contractors and their contact information to the communities, and • pass applications from local labour to contractors. 	Appendix 19, Section 7.3.1.1, DAR
To improve the efficiency of CZN's employment policy, the company will coordinate information of potential employees to contractors, notify Study Area communities of construction timelines and timelines for hiring, and pass along applications from local workers to contractors.	Response to IR GNWT 1-8 Q2
As part of their ongoing employment, all employees will take part in cross-cultural training to assist with the development of positive working relationships at the mine.	Appendix 30, Section 2.2, DAR
As the project progresses, work will be required to study if and how the transfer of wealth is taking place.	Appendix 19, Section 7.7.5.1, DAR
Where necessary, as determined by CZN, signs, safety, regulations and job advertisements shall be translated.	Appendix 30, Appendix A Socio-economic Commitments, B(12) p 16, DAR

TABLE 1: FINAL COMMITMENTS TABLE

... regardless of their family situation, Canadian Zinc employees will have access to a comprehensive human resources package that includes programs to help reduce the negative aspects of rotational work. Camp life will include recreational activities, religious services, and access to the Internet. The camp itself is being designed such that each employee will have their own room. Programs will be offered throughout the year such as personal financial planning and those associated with seasonal and religious holidays. Counselling services will be available as a part of the overall employee compensation package. In addition, traditional Aboriginal events and activities will be planned and country foods will be served when available.	Appendix 19, Section 7.7.3.1, DAR
Canadian Zinc will continue to be active in the Study Area communities through sponsorship programs that will improve community life and that <i>[sic]</i> for those not benefiting from the Project directly.	Appendix 19, Section 11.3, Table 11-1, DAR
Canadian Zinc will have guidelines that outline the circumstances under which employees can return home prior to the completion of their rotation. The company will also have a leniency policy for new employees that will outline the circumstances under which workers need some time to adjust to work life and camp life. Canadian Zinc will also sponsor community events that help improve the quality of life for those not participating directing <i>[sic]</i> in mine employment and those who are on their three-weeks off.	Appendix 19, Section 7.7.3.1, DAR
CZN will provide an option for all its employees to participate in a comprehensive benefits plan coverage, which includes dental, medical, AD&D, life insurance (both short- and long-term disability coverage), as well as an employee assistance program.	Appendix 30, Section 4, DAR
CZN will provide at its cost regular but limited opportunities for Dene employees to communicate with immediate family in their home communities using satellite or other phone systems.	Appendix 30, Appendix A Socio-economic Commitments, E(2) page 17, DAR
every employee will be encouraged to participate in supplementary orientation seminars upon arrival at the site for the first time. Seminars will include, but may not be limited to, guidance on personal financial management, and review of employee benefits packages.	Appendix 19, Section 7.7.2, DAR
Canadian Zinc is committed to working closely with its employees, their families and communities to find solutions to challenges as they occur. The community information representative will be responsible for assisting employees and Canadian Zinc management communicate <i>[sic]</i> with one another when issues arise.	Appendix 19, Section 7.7.3, DAR
Life skills training will be made available on an as need <i>[sic]</i> basis through the Training Department. Life skills training programs provide employee assistance in coping with new situations from camp life, long distance commuting to basic financial planning that is needed as a result of increased income.	Appendix 30, Section 2.3, DAR

TABLE 1: FINAL COMMITMENTS TABLE

The employment assistance program (EAP) is designed to assist employees and their immediate family members with problems that may affect their well-being and/or their ability to perform their jobs. The EAP will be operated by a third-party professional counselling service (accessible in the first instance by phone) and services will be available to the CZN employees and their immediate family (spouse, partner and dependents).	Appendix 30, Section 4.1, DAR
The Human Resources Management Plan outlines the details related to alcohol and drug usage during an employee's time at Prairie Creek. In addition, the company will engage with the Study Area communities and encourage cooperation with government and non-government officials on a strategy that might limit the severity of this impact and ensure these people receive the help they need.	Appendix 19, Section 7.7.4.1, DAR
The on-site measures CZN would pursue to protect workers from the spread of communicable diseases include the following: <ul style="list-style-type: none">• Having trained medical personnel to identify communicable diseases• Providing advice regarding personal hygiene.• Designating potential areas to isolate infected workers if required• Pre-screening employment candidates with medical check-ups• Requesting employees to be up-to-date with their vaccinations• Post the contact number for the Chief of Public Health• Discuss possible outbreaks of STIs at Health & Safety meetings• Provide educational materials in the project's library	Response to IR GNWT 1-7 Q3
Highlighting CZN's Adaptive Management System will be: <ul style="list-style-type: none">• A <i>Monitoring System</i> consisting principally of a year-long process of collecting and analysing data and trends regarding the outcomes from participation in the Project and more general socio-economic progress of the Study Area.• A <i>Response System</i> consisting of a formal session to communicate results and receive input from representatives of the affected communities on areas where changes could improve outcomes and productivity.	Response to IR GNWT 1-10 Q1
CZN has committed to altering its programs where possible when existing ones are ineffective or problematic.	Response to IR GNWT 1-10 Q1
Canadian Zinc is committed to monitoring and reporting the socio-economic progress of the Study Area communities during the operation of its mine.	Appendix 19, Section 7.7.5.1, DAR
The annual report will include information on the socio-economic performance of the Study Area. These data will be gathered from secondary sources, including the NWT Bureau of Statistics and Statistics Canada. This information will be combined with knowledge gathered by company officials including community information officers working in the Study Area and communicating with active employees, their families, and other community members to determine the overall socio-economic changes taking place.	Response to IR GNWT 1-15 Q1

TABLE 1: FINAL COMMITMENTS TABLE

<p>The Company will generate an annual report on production, employment, procurement and socio-economic trends. It will be the principal communication tool that informs the public of the results from the Company's monitoring system. This monitoring includes information gathered from employees and their communities by the community information officers. Other company officials will remain active in the communities through their participation in sponsorships, promotions and investments. Information gathered "on-the-ground" will be combined with the technical approach used in gathering and reporting operations' data and socio-economic statistics.</p>	<p>Response to IR GNWT 1-10 Q1 pages 29-30</p>
<p>CZN will produce an annual report on its operations. It will provide the public with information regarding the production schedule at the Prairie Creek Mine, its employment record, and planned activities for the upcoming year. This report will serve as CZN's submission to inform Study Area, Deh Cho and NWT residents and regulators. The report will include information on employment and business procurement. The statistics reported will include:</p> <ul style="list-style-type: none">• total workforce, new hires, terminations, and total labour income,• training programs, number of participants, and apprenticeships,• gross value of operation expenditures, a list of procurement contracts, and participating Aboriginal and NWT businesses,• road access—the details of this information such as volume of commercial and non-commercial traffic depends on the final decision regarding road ownership and public access,• community activities, investments and sponsorships, and• a schedule of upcoming procurement opportunities and operational expenditures.	<p>Response to IR GNWT 1-15 Q1</p>
<p>[As noted in Table 9-1, The CZN Monitoring and Management System includes:</p> <ul style="list-style-type: none">• Impact and Benefit Agreement Reporting: Detailed reporting to communities with Impact and Benefit Agreements. The contents of these reports are subject to ongoing negotiations.• Employment Reporting: Annual reporting on total workforce, new hires, terminations, length of employment, labour income.• Procurement Reporting: Annual reporting on total expenditures for goods and services, list of goods and services required, upcoming requirements, total spending on First Nation businesses and NWT businesses.• Communication Strategy: Working with the communities through the IBA negotiations, establish a communication strategy with each community.• Annual Socio-Economic Report: Detailed report on mining activities, and the economic, social, cultural and socio-economic performance on the Study area.	<p>Appendix 19, Section 9, Table 9-1 , DAR</p>

TABLE 1: FINAL COMMITMENTS TABLE

Where the disclosure of information does not compromise confidentiality, data will be separated by ethnicity and geography; that is, Aboriginal versus non-Aboriginal, and Study Area communities versus the rest of the NWT and non-NWT. CZN will include all Status, non-Status, Métis, and Inuit as Aboriginal for the purpose of reporting ethnicity. NWT Residency will be defined as living in the territory.	Response to IR GNWT 1-15 Q3
Education relating to commodity prices, market fluctuations, supply/demand and operational costs will be made available to the public.	Response to IR GNWT 1-11 Q1
Significant monitoring of operations and the environment will occur during and after the Mine's life. CZN expects individuals from local communities to be involved in this, preferably as employees. CZN undertakes to share the monitoring results.	Main Report, Executive Summary page 23, DAR
FISH	
Any habitat losses will be replaced to the satisfaction of Fisheries and Oceans Canada (DFO).	DAR, section 10.2.4
DFO's <i>Operational Statements</i> for creek crossings, including span structures and ice bridges/snow-fills, will be adopted. Physical footprints will not be introduced within the high water mark of crossings, other than snow and ice.	DAR, section 10.2.4, and reply to IR2 DFO 2-5.
Disturbance of stream banks and riparian areas at stream crossings will be minimized. Stream banks will be protected as necessary, with the possible use of ice and/or matting. A stable road bed will be constructed adjacent to creeks and runoff control will be provided. Revegetation of riparian areas will be promoted.	DAR, sections 9.3.2 and 10.2.4
Temporary crossing structures and snow-fills will be removed at break-up.	DAR, section 10.2.4
Best management practice sediment controls will be adopted at the Mine and along the access road.	DAR, section 10.2.5
A sediment and erosion control plan will be developed for construction and operation of the access road as a condition of a new road LUP.	Technical Meeting, Day 2, Oct. 7, 2010
The 'DFO Protocol for Winter Water Withdrawal from Ice-Covered Waterbodies in the NWT' will be adopted for water supply from lakes for road construction. Appropriate data will be provided to DFO for approval before extraction occurs. Assessment data for creeks will be collected and DFO consulted for approval before extracting water from creeks. Expected water sources are the Mine well, Mosquito Lake and the Liard River. A short spur road to Mosquito Lake already exists and will be utilized. Other lakes will be quantified and water extracted based on the protocol. The main water use is expected to be for road bed construction. Creek crossings will be primarily by snow-fill. Clear span structures will be considered if conditions vary from those expected.	Reply to IR2 DFO 2-4.
Disruption of the only known spawning location in the area (bull trout in Funeral Creek) during the spawning period (mid-August) will be avoided.	DAR, section 10.2.4
The site policy of no fishing and any other unnecessary disturbance of the aquatic environment will be continued.	DAR, section 10.2.4

TABLE 1: FINAL COMMITMENTS TABLE

Sources of aggregate will not be situated in river beds or within the high water mark of alluvial fans. No additional access roads and/or crossings will be required to access aggregate sources.	Reply to IR DFO2, and IR2 DFO 2-2.
To reclaim the Funeral Creek road after Mine closure, coarse material or organic material will be placed adjacent to the creek to prevent sediment discharge until vegetation has established. Any channels flowing over the re-contoured road area will be armoured. Silt fence will be used where necessary to control sediment immediately after re-contouring. Materials will be placed on the road bed and not the bed of Funeral Creek	Reply to IR DFO9
For exfiltration trench construction, measures for isolation of the work area and protection of the creek will be further developed after a positive EA outcome and during detailed design, to the satisfaction of DFO. A construction water management plan and spill contingency plan would also be developed.	Reply to IR2 DFO 2-3.
A detailed habitat assessment of the proposed location of the exfiltration trench will be conducted in 2011. Design modifications and/or the incorporation of additional elements will be considered as part of detailed design to avoid habitat loss. If it is determined that habitat loss is unavoidable, a suitable habitat compensation plan will be developed, also during detailed design.	Reply to IR2 DFO 2-3.
On mine closure, the approach to decommissioning of the exfiltration trench will be determined in consultation with DFO.	Reply to IR2 DFO 2-3.
WILDLIFE	
Wildlife Mitigation and Monitoring and Flight Impact Management Plans	
The draft Wildlife Mitigation and Monitoring Plan (WMMP) will be updated during the permitting process. The plan will be considered a 'living' document, and further changes will be considered as necessary during operations, such changes being considered and discussed in the forum of the Technical Advisory Committee.	Reply to IR2 EC 2-3.
For caribou, wood bison, grizzly bear, wolverine, peregrine falcon, short-eared owl, horned grebe, rusty blackbird, olive-sided flycatcher, and common nighthawk, any mortality directly relating to the operation of the mine site or access road will trigger a review of mitigation strategies.	Reply to IR2, Appendix K.
The Nahanni Butte Dene Band will be consulted in the development of a wildlife management plan.	Technical Meeting, Day 2, Oct. 7, 2010
CZN welcomes NBDB, LKFN, other First Nation and Government representation on the Technical Advisory Committee (TAC).	Reply to IR2, Appendix J.
Flight Impact Management Plan	
The Flight Impact Management Plan will be reviewed and updated.	DAR, section 10.3
Flight paths to and from the mine will be considered according to the recommended guidelines for flying in caribou and sheep country, where feasible and within topographic and safety constraints.	Reply to IR2, Appendix K.

TABLE 1: FINAL COMMITMENTS TABLE

Wildlife Sighting /Monitoring / Reporting	
Wildlife sightings in proximity to the Mine site and access road will be recorded in a wildlife sightings log, including location, numbers observed and reactions.	DAR, section 10.3
Dead wildlife encountered in proximity to the mine site and access road will be recorded and geo-referenced.	Reply to IR2, Appendix K.
A Dall's sheep monitoring program will be implemented to ensure that Project-related effects on sheep are minimized. A monitoring plan is described in the draft Wildlife Mitigation and Monitoring Plan, and this is considered to be a response to Undertaking 23 from the Oct. 7, 2010 Technical Meeting.	Reply to IR2, Appendix K.
Appropriate collaborative monitoring initiatives with First Nations, Parks Canada and other regulatory agencies will be supported.	CZN letter dated Sep. 14 & 16, 2011
All relevant observations of wildlife (particularly of Dall's sheep, caribou, grey wolf, wolverine and grizzly bear) will be reported to mine environmental staff.	Reply to IR2, Appendix K.
All vehicles will be equipped with two-way radios. Wildlife sightings along the access road will be geo-referenced and reported to road supervisors.	Reply to IR2, Appendix K.
A radio call-in procedure will be implemented so that observations of caribou along the access road can immediately be relayed to the Road Operations Supervisor.	Reply to IR2, Appendix K.
A procedure will be implemented so that caribou observations made by aircraft pilots during transport of crews and materials will be reported to the Wildlife Monitor.	Reply to IR2, Appendix K.
Wildlife monitors will conduct ground surveillance during the initial mine start up and production period.	Reply to IR2, Appendix K.
Wildlife Monitors will conduct ground-based surveys of the access road (during winter operation), mine infrastructure sites, and the airstrip to assess caribou presence and identify caribou aggregations in the Project area.	Reply to IR2, Appendix K.
Summer maintenance work on the all season road will be voluntarily restricted to the period July-September. Wildlife monitors will check for nesting birds before work commences.	Reply to IR2, Appendix K.
If a nesting bird is found on site and eggs are present, monitoring will be conducted and efforts will be made to avoid the area. Any raptor nesting activity observed within 1.5 km of the Project will be reported to GNWT ENR.	Reply to IR2, Appendix K.
Any raptor nesting activity observed within 1.5 km of the Project will be reported to GNWT-ENR and Parks Canada.	GNWT Technical Report.
Measures aimed at reducing the number of birds that use the water storage pond (WSP) will be implemented.	Reply to IR2, Appendix K.
Wildlife Monitors will contribute to a detailed quarterly report of wildlife observations and incidents that occurred during the monitoring period. Reports will be submitted to First Nations, GNWT ENR, Environment Canada and Parks Canada.	Reply to IR2, Appendix K.

TABLE 1: FINAL COMMITMENTS TABLE

Bears	
Guidelines found in the “Safety in Grizzly and Black Bear Country” document will be followed to prevent and mitigate bear-human interactions.	Reply to IR2, Appendix K.
The appropriate regulatory agencies (<i>e.g.</i> , GNWT ENR and Parks Canada) will be informed of any incidents with problem bears or other wildlife prior to action, unless imminent worker safety is at risk.	Reply to IR2, Appendix K.
Bear use of habitats near mining infrastructure (<i>e.g.</i> spring foraging by bears in disturbed areas) will be documented.	Reply to IR2, Appendix K.
A warning system will be developed for site workers in connection with bear sightings, as well as a structure for reporting bear-human encounters.	DAR, section 10.3.1
Waste Handling	
An effective Waste Management Plan will be implemented, particularly as it relates to the disposal of food waste.	Reply to IR2, Appendix K.
Site workers will be encouraged to eat only in designated areas, . Workers will be made aware as part of site orientation when they start that food, food waste and wrappings are not to be left around the site or in buildings where un-controlled entry is possible.	Reply to IR2 PC2-7.
All food and garbage/waste will be stored in bear-proof areas or bear-proof containers, including at the transfer facilities.	Reply to IR2 PC2-7.
Food waste will be collected and incinerated on a daily basis.	Reply to IR2 PC2-7.
All chemicals and supplies will be stored in an enclosed warehouse structure. Small quantities will be transferred to their point of use (in the Mill or shops) as required.	Reply to IR2 PC2-7.
The transfer facilities will be closed, all fuel, waste and sewage removed, and free of all attractants outside of the haul season.	DAR, section 6.24.3 and Technical Meeting, Day 2
Safety and Training	
On-site personnel will be educated on the applicable policies and practices contained in the Wildlife Mitigation and Monitoring Plan.	Reply to IR2, Appendix K.
The guidelines for responding to bear encounters (contained in the Health and Safety Plan) will be reviewed and updated.	DAR, section 10.3
On-site personnel will receive basic bear awareness and safety training, including information on bear behaviour, how to avoid bear encounters, and how to respond to bears in the case of an encounter. Site environmental officers will be tasked with overseeing the program in terms of enforcement and effectiveness.	Reply to IR2 PC2-7.
On-site personnel will be discouraged from using areas outside of immediate work sites.	Reply to IR2, Appendix K.
Hunting, trapping and harvesting by site employees and contractors will be prohibited.	DAR, section 11.2
Pets will be prohibited on site.	Reply to IR2, Appendix K.

TABLE 1: FINAL COMMITMENTS TABLE

Access Road	
Maximum traffic speeds for all sections of the access road will be implemented accounting for road grade, curvature, adjacent sensitivities and sight-lines. Lower maximum speeds may be posted in the vicinity of sensitive wildlife areas.	Reply to IR PC4
A signage system will be employed along the access road to inform vehicle operators of vehicle/wildlife conflict areas.	Reply to IR2, Appendix K.
Vehicle operators will yield right-of-way to wildlife and will take all reasonable measures to avoid vehicle-wildlife incidents.	Reply to IR2, Appendix K.
When any SAR species is visible on the road, vehicle activity will cease until the animals have moved a safe distance away or are no longer visible.	Reply to IR2, Appendix K.
High snow banks along the access road will be avoided so that wildlife can avoid traffic. Failing this, lower snow banks will be left every 100 m to facilitate wildlife moving off the road surface.	DAR, section 9.4.1 and 10.3
To reduce noise along the access road, the use of engine retarders will be discouraged.	Reply to IR2, Appendix K.
Salt will not be used on the road alignment.	Reply to IR PC4
Public and Access	
Non-mine road traffic will be deterred from using the road by signage and operating a check-point and screening station near the south-eastern terminus of the access road, manned by representatives from the Nahanni Butte Dene Band.	Reply to IR2, Appendix K.
Unauthorized use of the access road, and evidence of land use such as hunting, fishing, camping, or firewood harvesting will be noted, deterred and reported.	Reply to IR2, Appendix K.
The south-eastern end of the access road will be blocked at specified locations after each hauling season with gates, berms, pits and/or boulders to discourage use.	Reply to IR2, Appendix K.
Non-mine vehicles, including all terrain vehicles (ATVs) and snowmobiles will be prohibited on site.	Reply to IR2, Appendix K.
OPERATIONS MANAGEMENT	
Existing Prairie Creek Mine buildings and structures were designed and constructed by Kilborn Engineering Ltd. to the National Building Code. All new facilities will be also.	IR reply, Appendix D.
During the detailed design phase, a deterministic hazard assessment (DHA) for the project site will be undertaken, including review of ground acceleration coefficients.	IR reply, Appendix D.
All personnel will receive appropriate training to ensure they are fully aware of health, safety and environmental policies and practices and able to perform tasks in compliance with established policies and legislation; and to ensure employees are fully aware and trained to respond to an emergency.	DAR, section 6.25
Aggregates for the Mine would be sourced from the on-site quarry and possibly other local sources. Any crushing required will occur set back from the creek with a buffer for runoff.	DAR, section 8.2.5

TABLE 1: FINAL COMMITMENTS TABLE

Explosives for Mine operations will be exclusively emulsions or sticks.	Reply to IR NRCan1
Reagents currently stored on the Reagent Storage Pad south of the Mine will be consumed during operations or taken off-site for disposal.	DAR, section 6.3.11.
Due care and precautions will be taken during the winter transfer of sulphuric acid from tankers to storage tanks.	DAR, section 8.2.4
All concentrates will be shipped in bags free of external concentrate dust . Any torn bags will be double-bagged, and any spillage cleaned-up completely.	DAR, section 6.24.3
Water for fire suppression will be taken from the water ring main.	DAR, section 6.3.15
Drummed hazardous waste will be collected in the Waste Transfer Area for off-site disposal by a registered carrier following all applicable regulations.	DAR, section 6.14
Waste motor and lubricating oil will either be blended with diesel fuel or used for incinerator ignition.	DAR, section 6.14
Existing infrastructure will be surveyed for asbestos-containing material, and any such material found will be removed and landfilled within the Waste Rock Pile footprint.	DAR, section 6.14
A solid waste facility will be operated consisting of a solid waste landfill for inert material, a fenced sewage sludge landfill and a landfarm for hydrocarbon contaminated soil.	DAR, sections 6.14 and 8.2.5
Heat traced pipe will carry process water and mine water to and from the Water Storage Pond. Lines will be inspected frequently, and will run along the access road and not next to Prairie Creek.	DAR, sections 6.3.15 and 8.8.4
A spill contingency plan for the Mine and access road will be reviewed and updated. The plan will include the transport, manufacture and use of explosives and components of explosives.	Reply to IR NRCan1 and IR2, Appendix I
Water treatment sludge will be combined with the backfill mix and taken underground, as will ash from the incinerator. In the unlikely event that monitoring and assessments during operations indicate that a period of water treatment needs to continue after mine closure, any sludge will be stabilized with cement and taken to a suitable disposal location. This might be a mine portal that has not been completely backfilled in order to accommodate the sludge, or part of the Waste Rock Pile before cover placement.	Reply to IR2 NRCan 2-6.
Annual geotechnical inspections of major structures (Water Storage Pond, Waste Rock Pile, Flood Protection Berm), and terrain in and around them, will be undertaken.	DAR, section 10.4.4
The Catchment Pond will be lined with a low permeability geomembrane, and the existing culvert to Harrison Creek will be retained for emergency use only.	DAR, section 8.7.2

TABLE 1: FINAL COMMITMENTS TABLE

The Catchment Pond discharge mechanism will include pumps on stand-by which can be activated to ensure sufficient discharge. The outfall line will have a valve or gate which can be temporarily closed, if necessary. Discharge of treated water to Prairie Creek during winter will occur via a pipeline from the WTP connected to the outlet culvert in the Catchment Pond. The pond would be isolated from the line to avoid freezing effects. There will be a safety return line from the Catchment Pond to the Water Storage Pond with installed pumps. The outfall line will have a valve or gate which can be temporarily closed, if necessary.	DAR, section 8.7.2, and reply to IR2 INAC 2-11.
The following plans will be developed: Water Storage, Treatment and Discharge Monitoring and Management Plan; Solid and Hazardous Waste Management Plan; Explosives Management Plan; Aquatic Effects Monitoring Plan.	DAR, section 10.7.3
Medical personnel will be on call 24/7 to provide medical, educational and counselling services..	Reply to IR GNWT7
Sub-contractors will be required to adhere to all of the Mine's commitments.	CZN May 6, 2011 letter to MVRB
The backfill of flotation tailings as paste will be maximized initially by minimizing use of DMS rock, and bringing all development rock to surface. These restrictions may be relaxed later in the mine's life provided it has been definitely determined that an excess mine void will remain after closure if the backfill strategy remains static.	CZN Sep. 2, 2011 letter to MVRB
All flotation tailings will ultimately be placed underground in mine openings. No flotation tailings will be placed in the WRP or left on surface after mine closure.	CZN Sep. 2, 2011 letter to MVRB
ROAD	
The existing Cat and Grainger Camp sites will be reclaimed. A small tote road to Grainger Camp from the new road alignment would be built for temporary access.	DAR, section 6.3.16
Kledo's general approach to road construction (Appendix B) will be adopted (although CZN is not committed to use Kledo).	Reply to IR2 PC2-1.
The western flank of the Silent Hills contains historic failures, and permafrost may exist along the Polje alignment. These areas will be examined in more detail during the detailed design phase of the project.	DAR, Appendix 16
Side hill cuts and fills will generally be avoided except where the evidence is that the ground is free of ice rich permafrost. Cut material will be used if appropriate, or used elsewhere, but not discarded downslope.	IR reply, Appendix D, and reply to IR2 PC 2-1.
The Polje re-alignment will include fill placement, but gaps/swales will be left so natural runoff flow directions are not significantly modified.	Reply to IR2 PC2-1.
Polje Creek will be spanned with a bridge structure which would remain for the duration of the Mine. The base of the deck will be at least 1 m above the normal high water mark. Abutments will be set-back from the top of bank.	Reply to IR2 PC2-1 and DFO 2-5.
All new road alignments will retain the organic layer as much as possible to insulate the underlying soil and limit the potential for permafrost thaw. Adequate drainage will also be provided to avoid unstable slopes.	DAR, section 10.4.2

TABLE 1: FINAL COMMITMENTS TABLE

A level road bed will be created using dozers with shoes fitted on the bottom of the blades. This will ensure minimal disturbance of the organic layer.	IR reply, Appendix E.
Regarding the accumulation of debris on the existing road from upslope, the information will be used to plan the road location with respect to the toe of the slope (in active debris areas).	IR reply, Appendix D.
A geotechnical investigation is proposed to support the final design of the access road. The investigation will focus on portions of the access route west of Km 85, specifically, the proposed polje by-pass and immediately west of Wolverine Pass.	IR reply, Appendix D.
The route east of Km 85 will be visually reviewed annually before the following winter. After the first winter of road operations, drainage management at and west of Wolverine Pass will be reviewed, as will the route west of Km 85 to assess the function of cross-road drainage.	IR reply, Appendix D.
Construction and maintenance activities will be continually overseen by supervisors who will ensure appropriate techniques are used such that sediment will not be produced during periods of thaw. This will also apply to seasonal road closure activities, including snow-fill removal.	Reply to IR2 DFO 2-5.
Road monitoring will occur during both construction and operation. During construction, monitoring will be daily to assess how recently constructed portions are performing, and to determine requirements for portions being constructed. During operations, monitoring would initially be daily, with a reduction in frequency as road performance becomes better defined. Drivers will report on road conditions and any areas of difficulty or requiring repair. Snow accumulations will also be monitored to assess the potential for avalanches.	Reply to IR2 PC2-1.
After the first year of construction, and following extreme rainfall events at any time, the re-alignments will be checked for areas of instability, specifically the creek crossings, areas of fill placement, and the switch-backs in the Silent Hills. Low over-flights of these areas are initially proposed to allow for inspection. If problem areas are suspected, follow-up inspections will be made by helicopter, and will include set-downs and the use of small tools (e.g. shovels) and readily transportable materials (e.g. silt fence), as necessary. More significant remedial work would be undertaken during construction in the subsequent road season.	Reply to IR2 DFO 2-5.
Closure activities for side hill cut areas will be formulated using the observations and experience gained during the operating period. It is envisaged that material replacement will occur in order to restore a stable natural slope and provide a suitable medium for revegetation. Measures will be incorporated into the restored slopes to maintain stable surfaces until a vegetation cover has been established	Reply to IR2 PC2-1.
All trucks on the access road will carry spill kits, and drivers must have read the spill contingency plan and be prepared for an appropriate spill response in relation to their load. Drivers must be suitably qualified and experienced.	DAR, section 10.1
All trucks will have communications, will be on alert for on-coming traffic or wildlife presence in the roadway and will be in contact with a controller.	DAR, section 10.1

TABLE 1: FINAL COMMITMENTS TABLE

All of the vehicles and equipment using the access road will be properly maintained and free of leaks. Stationary equipment will use drip pans.	DAR, section 10.1
Road use (including vehicle speeds and driving conditions) will be monitored by radio and inspections. A journey management system (JMS) will be used (see Appendix I of the IR2 response for details).	DAR, section 10.1
The access road bed will be sampled before and after the seasonal haul period as a check on potential contamination from concentrate losses.	DAR, section 10.1
Haul trucks collecting the bags (from the Mine) will pass through a wheel wash before leaving the concentrate storage shed.	DAR, section 9.2
The existing Controlled Road Use Plan will be modified for access road operations to promote safety and minimize the risk of accidents.	DAR, section 10.2
Potentially unstable areas and karst features within 200 m of the access road will be inspected at a frequency dependent on observed conditions and changes or lack thereof of those conditions.	DAR, section 10.4
Temporary crossing structures and snow-fills will be removed at break-up to avoid blockage and erosion.	DAR, section 10.2
A stable road bed will be constructed adjacent to creeks and provide for runoff control and minimize the dispersal of sediment during precipitation events.	DAR, section 10.2
Re-vegetation of riparian areas will be promoted to further reduce the potential for sediment dispersal.	DAR, section 10.2
Chemicals will be transported and stored in approved containers.	DAR, section 10.3.1
The Spill Contingency Plan (SCP) will address all potentially hazardous substances used at the Mine or transported along the road. The SCP will contain information that clearly states the responsible party for spill response and clean-up.	Reply to IR2, Appendix I.
Portable spill response equipment will be maintained no more than 50 km from any location along the road.	Reply to IR2, Appendix I.
The SCP will include details of spill responses for all types of ground conditions, including frozen and non-frozen ground, and with and without snow cover. Opportunities for the rapid spread of contaminants will also be considered, such as in karst areas.	Reply to IR2, Appendix I.
A trained spill response team will be maintained at the Mine. Operators at the Transfer Facilities will also receive appropriate spill response training. Training will include classroom study, equipment deployment instruction and spill exercises.	Reply to IR2, Appendix I.
Spill exercises will be undertaken in summer (initial training) and winter (final training) conditions, and in locations representing the range of environmental conditions that will exist on the road.	Reply to IR2, Appendix I.
The erection of a guard rail-type barrier on the outer edge of the road from Km 11-16 will be evaluated to reduce the risk of spills along this section where the grade is steep and a tributary of Funeral Creek exists below.	Reply to IR2, Appendix I.
Suitable locations for the construction of run-away lanes will be investigated for sections Km 11-16 and 19-22.	Reply to IR2, Appendix I.
Specific speed limits may be set for specific types of trucks and loads through sensitive sections.	Reply to IR2, Appendix I.

TABLE 1: FINAL COMMITMENTS TABLE

The road operations supervisor will place limits on hours of driving over a prescribed period.	Reply to IR2, Appendix I.
The road will be regularly inspected and maintained during the operating season to ensure optimal performance and minimize risks from poor road bed conditions.	Reply to IR2, Appendix I.
Trucks will be required to use chains from Km 0 to Km 29.	Reply to IR2, Appendix I.
To respond to spills, an Incident Command System (ICS) will be used that is widely used by governments and industry (see Appendix I of the IR2 reply for details).	Reply to IR2, Appendix I.
A silt or other form of curtain will be stored approximately mid-point between the mine and Funeral Creek ready for deployment to reduce flow in part of Prairie Creek adjacent to a spill.	Reply to IR2, Appendix I.
Control points will be established at key locations, and will include material to create temporary dams, absorbents, booms, board weirs and sand bags. Control points locations will include two upstream tributaries to Funeral Creek, on Sundog Creek just above the main falls and just before the fluvial outwash plain, and downstream of the Tetcela River and Fishtrap Creek crossings.	Reply to IR2, Appendix I.
Spill kits will be carried on vehicles with materials appropriate for the loads (i.e. type of sorbent). Comprehensive spill kits will be maintained at the mine site, Cat Camp, the Tetcela Transfer Facility, Grainger Gap, and the Liard Transfer Facility. Custom built and stocked road trailers dedicated to spill response, containing equipment, materials and tools will be considered.	Reply to IR2, Appendix I.
WATER STORAGE POND	
Mine water will be pumped up to the final sump on the 880 m level, 300 m from the 870 portal. From there, the water will be pumped to the Water Storage Pond. Back-up pumps will be available at the sump to ensure continuous pumping.	DAR, section 6.16.7
The existing pond will be converted into the Water Storage Pond (WSP), with remedial works to stabilize the backslope and a new synthetic liner.	DAR, section 6.3.7.
Repairs to the armour of the flood protection berm will continue when factors are favourable. Critical armour placement is complete. Follow-up work can be completed when circumstances permit, followed by embankment slope reconstruction.	DAR, Appendices 18C and 18D
The crest of the WSP will be at elevation 881 m. The operating water level will be between elevations 877 m and 880 m. The dam emergency spillway will be incrementally below the 881 m crest elevation. The spillway will be located in the eastern dyke of the WSP so that in the highly unlikely event of an emergency controlled discharge, flows would report to the site surface water management system inside the flood protection berm.	Reply to IR PC41
The WSP will be operated with a 1 metre freeboard which will be maintained at all times, unless a short-term emergency storage requirement occurs.	CZN May 6, 2011 letter to MVRB
Detailed design of WSP surface water diversion ditches will be completed after site grading plans have been prepared as part of final design. The	IR reply, Appendix D, and reply to IR2

TABLE 1: FINAL COMMITMENTS TABLE

ditches will be lined. Monitoring plans will be included. The upslope area will be graded. The frequency and magnitude of extreme events (rainfall, snowmelt) in terms of stability analysis and design of diversions will be considered further as part of detailed design.	INAC 2-6 and NRCan 2-2.
WATER	
A new Mine Water Contingency Plan will be developed.	DAR, section 10.7.2
Seepage from the Waste Rock Pile will be collected in a lined pond and transferred to the Water Storage Pond, as will drainage from the lined DMS rock and ore stockpiles. Pond size and emergency spillway details will be confirmed during final design.	DAR, sections 6.16.8 and 8.9.1, and IR reply, Appendix D.
The Waste Rock Pile lined seepage collection pond will be connected to the site water management system, either by pipeline or by borehole to the underground Mine workings. The pond will be sized to store 6500 m ³ with a 1 m freeboard (accommodating the 1 in 100 year storm event). The pond will have a spillway to discharge flows that exceed pond capacity. The spillway will be located to discharge the peak flows entering the pond without displacing the water already in the pond. Sediment accumulations will be monitored and removed, as necessary. The WRP will have diversions around the pile footprint to prevent runoff from outside the footprint reporting to the pile collection pond. WRP site preparation and pond construction will include oversight and approval by a qualified engineer. The operation plan will include adjacent vegetation preservation to maintain the slope cover	DAR, section 8.7.4 and Appendix 11, and IR reply, Appendix D.
Flows in Prairie Creek will be monitored continuously, and information relayed to the control room in the Water Treatment Plant.	IR2 reply, Appendix F.
Further investigation of the WSP will be undertaken to determine the northern extent of the clay layer and condition of embankment clay. During construction, a quality assurance program will be implemented to ensure the intent of the design is achieved. A maintenance program for the north slope and embankments will be developed and will form part of an Operations and Maintenance Manual. A series of slope inclinometers, thermistor strings and piezometers will be installed after construction. Results will be analysed by a qualified engineer. Measures will be taken to control vegetation growth and to monitor for erosion.	DAR, Appendix 12
A 1 metre freeboard will be maintained in the Water Storage Pond, and a lower operating level will be selected to maintain backslope stability. The water level will be closely monitored. Runoff from upslope will be diverted in lined ditches, west to Prairie Creek and east to the main camp ditch.	DAR, sections 8.7.5 and 8.8.1
If the dyke between the WSP and the Mine site were to fail, contaminated water could be released. The Catchment Pond outlets would be closed to contain the release. The Mill would stop operating so that process effluent is not being sent to the WSP or the treatment plant. The treatment plant would treat only Mine water and the water released from the WSP until the pond is repaired.	DAR section, 8.8.3

TABLE 1: FINAL COMMITMENTS TABLE

If a failure occurs upslope of the WSP that puts it out of commission, Mill operations may be stopped and all Mine water treated and discharged until the WSP is back in operation.	DAR, section 9.2
Only phosphate-free detergents will be used on-site. Alum will be added to precipitate phosphates. Sewage effluent will be pumped to the Water Storage Pond. Nitrogen concentrations will be minimized by using emulsion explosives with strict explosive management practices	DAR, sections 6.16.6 and 6.16.8, and reply to IR2 EC 2-1.
Sewage produced in outlying areas will be collected and transported to the Sewage Treatment Plant. Grey water will be treated the same as sewage.	DAR, section 6.16.6, and reply to IR2 PC2-7.
During construction, sedimentation from the WRP will be controlled using silt fencing, erosion control blankets or other technologies, as necessary. The completed drainage channels will include erosion and sedimentation control technologies. The performance of these channels will be monitored.	IR reply, Appendix D.
Discharge water quality and the receiving environment's ability to absorb the discharge will be closely monitored. Metals analysis capability will be available on site.	DAR, section 8.6 and NBDB-CZN Meeting Report, June 10, 2010.
During operations, data on actual and potential metal release from the Mine and WRP will be collected and assessed to further develop mitigation and monitoring plans for closure.	DAR, section 8.6
The Mine water treatment plant will be initially sized to treat 134 L/sec, but can be readily expanded to double the capacity (268 L/sec).	DAR, section 8.7.3
The WTP will include a clarifier to remove suspended matter and ensure discharge has low TSS.	DAR Addendum, section 7.1
The water treatment plants will have double pumping systems (one operating and one on stand-by). Stand-by power would operate both plants if power was lost from the main power plant	DAR, section 8.7.3
Treated water quality will be monitored closely to ensure discharge quality meets specified criteria. If water quality is unacceptable, discharge would be stopped by re-circulating the treated water inside the plant, then either the treatment capacity will be increased, or inflows from outside the plant will be stopped and flows will be diverted to the Water Storage Pond.	DAR, section 8.7.3
If discharge concentrations (to Prairie Creek) are higher than predicted, or monitoring detects changes which were not predicted, the response will depend on the parameters considered to be causing the problems, and when they occur. A review of water treatment schedule and performance will be undertaken in conjunction with toxicity studies in order to define the source of the variance from predictions.	Reply to IR2 EC 2-1.
An AEMP will be designed and implemented for the project in accordance with INAC's "Guidelines for Designing and Implementing Aquatic Effects Monitoring Programs for Development Projects in the Northwest Territories - 2007."	CZN May 6, 2011 letter to MVRB

TABLE 1: FINAL COMMITMENTS TABLE

Once water quality objectives (WQO's) for Prairie Creek have been determined and agreed to, the Mine will manage the project so that they are met consistently, unless un-related circumstances occur (such as unforeseen natural events) that prevent the Mine from doing so.	CZN May 6, 2011 letter to MVRB
The Mine will manage the project so that the WQO's are met at the assessment boundary, unless other circumstances occur beyond the Mine's control.	CZN May 6, 2011 letter to MVRB
The WQO's will be considered applicable for all mechanisms of effluent discharge from the project (e.g. one or two exfiltration pipes, etc.).	CZN May 6, 2011 letter to MVRB
The discharge of treated process water will not occur during the months of February and March.	CZN May 6, 2011 letter to MVRB
Treated process water discharge during other winter months will be less than in other seasons, and will be managed to ensure a minimum dilution ratio with creek water flow (see Appendix C) is maintained.	CZN May 6, 2011 letter to MVRB
Effluent that is acutely toxic will not be discharged.	CZN May 6, 2011 letter to MVRB
Effluent that does not meet the conditions of the Water Licence (e.g. EQC's) will not be discharged.	CZN May 6, 2011 letter to MVRB
Additional 'active water storage will be provided, either by modifications to the existing WSP or by building a second WSP.	CZN Aug. 21, 2011 letter to MVRB
If modifications to the existing WSP are proposed and include raising the dykes, the dyke adjacent to Prairie Creek would be raised by upstream methods to avoid any further encroachment on the floodplain.	CZN Aug. 3, 2011 letter to MVRB
If a second WSP is built, it will be double-lined, and set back at least 30 m from the normal high water mark of Prairie Creek. Water conveyed to and from the pond will be via pipelines equipped with pressure sensors, and a pressure drop would trigger the shut off of pumps delivering the water. The pipelines will be routed over lined ditches or other containment structures so that any spills will be contained.	CZN Aug. 3 and 21, 2011 letters to MVRB
The treatment of process water will be improved by either enhancing the currently proposed system, or adopting a precipitation-ion exchange system.	CZN Sep. 2, 2011 letter to MVRB
A consequence of initially maximizing the backfill of flotation tailings is a possibility of more DMS rock reporting to the WRP. Geochemical studies indicate changes in WRP leachate should not be significant. However, as a precaution, the DMS rock will be segregated from development rock and placed in the upslope portions of the WRP so that additional control measures to limit seepage can be implemented on mine closure, if required.	CZN Sep. 2, 2011 letter to MVRB

TABLE 1: FINAL COMMITMENTS TABLE

The majority of seepage from the WRP is expected to report to a seepage collection pond at the toe of the pile. The remainder is expected to percolate downwards and be captured in the cone of groundwater depression created by mine dewatering. There is a small risk that some subsurface seepage may evade the seepage collection pond and discharge to Harrison Creek. To mitigate this risk, a shallow groundwater interception system will be installed consisting of a cut-off trench along the toe of the WRP. The depth of the trench and other details will be confirmed as part of site investigations leading to detailed WRP design.	CZN Sep. 16, 2011 letter to MVRB
AIR	
The existing power generating units will be replaced with fuel efficient, compact generators with lower emissions. The existing exhaust stacks will be replaced with a single stack.	DAR, section 6.3.1
A new, low emission incinerator will be brought in to incinerate Camp waste daily. The waste stream will not include plastics or sewage sludge.	DAR, section 6.3.9.
Mitigation and adaptive management strategies and plans will be developed to minimize emissions related to fugitive dust and incineration.	DAR, section 10.5.
Air quality monitoring will likely include sampling for TSP, PM10 and PM2.5 at a minimum of one location on the project boundary (perhaps adjacent to the creek). Passive monitoring stations for SO2 and NO2 would likely be co-located with the particulate monitoring station(s). A dust-fall monitoring program on the project boundary and adjacent (off-site) to significant material handling locations would also be proposed. Assessment of program requirements will be conducted in consultation with EC/ENR	IR reply, Appendix M.
MINE CLOSURE	
Hydrogeological and geochemical data will be collected routinely during operations in order to update predictions of the behaviour of the backfill and groundwater and surface water quality after mine closure. Post-closure monitoring will include wells that monitor the mine 'pool', wells that monitor groundwater quality along the flow-path of metal release in bedrock and in the alluvial aquifers (HCAA and PCAA), and stations on Prairie Creek. Trigger levels linked to specified response actions will be set for selected monitoring wells to give an 'early warning' of a developing issue. Further study will be required during the operating period to better quantify the flow-path and attenuation mechanisms.	Reply to IR GNWT2, and reply to IR2 INAC 2-3.
All flotation tailings will ultimately be placed underground as a paste backfill. No mine waste will remain on the Prairie Creek floodplain after closure.	DAR, section 6.12.2
All sediment and tailings residues remaining in the WSP after closure will be recovered and included in underground backfill.	DAR Addendum, section 2

TABLE 1: FINAL COMMITMENTS TABLE

A natural cover will be placed on the WRP to limit infiltration and seepage and promote revegetation. The final composition of the cover will be based on WRP monitoring during operations. The water management ditches and other water control facilities will be upgraded, re-constructed or decommissioned as necessary. The seepage collection pond will be decommissioned once testing of runoff meets criteria. The Waste Rock Pile (WRP) final slope angle, cover design and runoff diversion structures will be designed to be stable in perpetuity	DAR, section 12 and Appendix 11, and reply to IR2 INAC 2-16.
Revegetation of the Mine site will rely on natural invasion to avoid introducing exotic species. Observations of natural revegetation around the mine site and along unused portions of the access road will be recorded to justify the adoption of this approach to reclaim disturbed areas.	DAR, section 12 and reply to IR GNWT2
Parks Canada wishes to initiate a study prior to road operations concerning techniques that might be used to improve revegetation and reclamation. Collaboration from the Mine was requested and agreed to in the form of accommodation/meals and assistance with transport.	Technical Meeting, Day 2, Oct. 7, 2010
For the first 3 years after closure, monitoring and inspections will occur monthly over the period March to November. Annual reports will be produced. In the following 5 years, monitoring and inspections will occur bi-monthly from May to September. In the final 5 years, monitoring and inspections will occur once a year in July (post-freshet). However, post-closure monitoring will continue until conditions have reached an equilibrium and stabilized, and it has been conclusively determined that no further closure activities are required.	DAR, section 8.9.4, and reply to IR2 NRCan 2-6.
Updates to the closure and reclamation plan, including updated water quality predictions, are proposed for the time of Water Licence renewal, normally every 5 years.	Reply to IR GNWT2

Curricula Vitae

CZN Consultants

Byard Maclean	– General Engineering and Metallurgy
Barrie Hancock	– Mine Engineering
Frank Palkovits	– Paste Engineering
David Lindeman	– Water Treatment Engineering
Anh-Long Nguyen	– Water Treatment Engineering
Sohan Basra	– Water Treatment Testing
Dave Caughill	– Geotechnical Engineering
Doug Pelly	– Terrain Engineering
Christoph Wels	– Groundwater
Bill Rozeboom	– Surface Hydrology
Gary Van Der Vinne	– Surface Hydrology
Shannon Shaw	– Geochemistry
Martin Davies	– Water quality and Aquatics
John Wilcockson	– Water quality and Aquatics
Chris Schmidt	– Wildlife
Dan Guertin	– Wildlife
Steve Moore	– Vegetation
Martin Rawlings	– Air Modelling
Antonio Freitas	– Air Modelling
Chris Madland	– Air Monitoring
Graham Clinton	– Socio-Economics

Byard MacLean, P.Eng. has 35 years experience in a variety of functions associated with development, design, operation and management of mining related projects .

EDUCATION

1977 M.A.Sc. Environmental Engineering, University of British Columbia
1971 B.A.Sc. Metallurgical Engineering, University of British Columbia

EXPERIENCE

Since 2006 SNC-LAVALIN INC., Vancouver, BC, Canada

Project Manager

- ♦ Aurcana Corporation – Shafer Silver Project, Texas: Basic design engineering services including flowsheet development, water and mass balance and equipment layout and sizing for a small silver leach mill.
- ♦ Canadian Zinc Corp., Prairie Creek Pb/Zn/Ag mine, Northwest Territories: Feasibility study started Q1 2011 to be issued Q3 2011. Pre-feasibility study (2008) which included the design and cost estimation of six new facilities; a DMS plant, a Paste Backfill plant, a Zinc oxide flotation circuit, a mine/mill water treatment plant, a replacement power plant with heat recovery and an operations camp expansion. Associated activities: financial modelling, transportation planning (concentrate & operating supplies) and permitting support.
- ♦ Newmont Mining Corporation – Hope Bay Gold Project, Nunavut: Madrid mill capital and operating estimates and mill layouts ranging from 3,000 to 16,000 tpd. Trade-off Studies: (1) Boston deposit transportation options (ore vs. concentrate), (2) SAG milling vs. High Pressure Grinding Rolls and (3) Power Generation & Distribution options. Facilities Designs: Truck shop and an HPGR circuit.



Senior Metallurgist

- ◆ QuadraFNX Mining Ltd. – Sierra Gorda Cu/Mo Project, Chile: The mill process component of a Pre-feasibility Study at 111,000 and 190,000 tpd.
- ◆ Barrick Gold Corp – Reko Diq Cu/Au Project, Pakistan: Multiple Account Assessment of power generation and concentrate delivery to port options, Concentrate pipeline booster station and terminal station (port) design basis and layouts.
- ◆ Zincore Metals Inc. – Yanque Zn Project: Waeltz kiln scoping study.
- ◆ Miramar Mining Corp. - Doris North Au Project, Nunavut: Prefeasibility study at 800 and 1400 tpd. This project is currently under construction.
- ◆ Aurora Energy Resources Inc. - Michelin Uranium Project Newfoundland: Cashflow Model

2006 - 2008 SAMADISH ENGINEERING LTD., Vancouver, BC, Canada

Consulting Metallurgist

- ◆ **Redhawk Resources Inc., Remac Zinc Project, British Columbia.**
Lead Process Metallurgist: Managed the development of a flotation strategy to produce a zinc concentrate from highly oxidized ore at the former Reeves MacDonald mine.
- ◆ **Commerce Resources Inc., Blue River Ta/Nb Property, British Columbia:**
Lead Process Metallurgist: Managed metallurgical testing programs at SGS Lakefield regarding Ta/Nb recovery studies.
- ◆ **Redhawk Resources Inc., Copper Creek Cu/Mo Project, Arizona.**
Owner Representative: Conducted process and capex/opex review associated with a Scoping Study by KD Engineering.

2005 INDUSTRIAL COPPER SYSTEMS LTD., Katanga Project, Democratic Republic of Congo

Project Manager

Installed and commissioned an EMEW copper electrowinning pilot plant at Gecamines Shituru copper/cobalt metallurgical plant in Likasi, DRC.

2001 - 2004 BENSON MAGNETICS LTD., Vancouver Island, B.C., Canada

Project Manager

Responsible for evaluation, design, permitting and First Nations consultation for a media grade magnetite mine waste and tailings re-processing operation at Benson Lake, Vancouver Island.

1996 – 1999 UNITED BOLERO DEVELOPMENT CORP., Buchans, Newfoundland, Canada

Project Manager

Responsible for the design, construction and commissioning of a tailings re-processing barite operation at Buchans, Newfoundland for the supply of drilling mud to the east coast offshore drilling industry. The feed for the operation came from the Buchans mine tailings ponds.

1991 – 1996 CANDORADO OPERATING COMPANY LTD., British Columbia, Canada

Mine Manager

The Company operated an agglomerated tailings gold heap leach operation at Hedley British Columbia. Responsibilities included permitting, operations management, government & community relations and final mine closure.

1987 – 1991 MAJOR GENERAL RESOURCES LTD., Newfoundland, Canada

President

Managed a junior exploration company with 40+ exploration interests across Canada which were acquired from Umex (Union Miniere Canada). The Company discovered and developed the Randell-jackman gold mine in Newfoundland that was subsequently sold to a mine operating company.

1980 – 1985 INTERNATIONAL IONARC INC., Texas Gulf Coast, USA

President

Reorganized an insolvent public technology company and converted it into a junior oil and gas exploration company with producing gas properties on the Texas Gulf Coast.

1978 – 1979 ENVIRONMENTAL PROTECTION SERVICE, ENVIRONMENT CANADA, Yukon, Canada

Manager, Engineering Services

Responsible for the implementation of federal environmental legislation in Yukon.

1972 – 1975 GRANDUC OPERATING COMPANY LTD., British Columbia, Canada

Mill Metallurgist/Operations General Foreman

Responsible for mill throughput maximization, metallurgical testing, operations budgets, manpower scheduling and company/union relations.

1972 BELL COPPER DIVISION (Noranda), British Columbia, Canada

Mill Shift Boss

Gained experience in mill commissioning and operations supervision.

1970 – 1972 B.C. MOLYBDENUM LTD., British Columbia, Canada

Junior Industrial Engineer/Mill Shift Boss

During the period of employment the mill throughput was increased for 9,000 to 12,000 tpd. Gained experience in mill operations and throughput optimization.

PROFESSIONAL ASSOCIATIONS

Association of Professional Engineers and Geoscientists of British Columbia,
(1974)

J.BARRIE HANCOCK

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Langley, BC
V1M 2X3

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FAX (604) 888-9543

CAREER PROFILE

A seasoned and results oriented Consulting Mining Engineer and Mining Analyst with over 30 years of global experience focused on mining operations, project evaluation and economic analysis for base metals, golds, uranium, coal, industrial minerals and other specialty metals.

EMPLOYMENT HISTORY

2008 - Present Director of Newstrike Resources Ltd., a Toronto based exploration company.

Continued work as independent Mining Consultant working on a number of projects. Main focus of work was working with Canadian Zinc Corporation on Prairie Creek. Worked on the mining section of Canadian Zinc's in-house pre-feasibility with SNC working on surface and processing.

1998 – 2008 Barrie Hancock & Associates Inc.

Barrie Hancock & Assoc. Inc. is an independent company whose President and Consulting Mining Analyst, Barrie Hancock, provide the following services to its clients:

- Publish Mining Investment Research Reports on mining and exploration companies. Currently publishes The Hancock Investment Letter – a newsletter which focuses on the mining/exploration business.
- Review the economics of mining projects in the development stage and current mining operations.
- Conducts analysis for target economic criteria of potential deposits being sought by exploration projects.

1987 – 1998 Evaluations Manager, Exploration COMINCO LTD., Vancouver, BC

- Initiated major concept to spin off international exploration subsidiary with a \$40M TSE/VSE IPO.
- Evaluated the economic viability of significant dollar value take-over offers for numerous mining companies.
- Prepared and presented senior executive summary of global markets and production capacity for copper, nickel and gold.
- Led workshop on “Project Evaluation and Due Diligence” at Prospectors and Developers Association Convention in Toronto.
- Analyzed economic viability of Century Zinc discovery in Australia (DCF_{RoR} and NPV) including evaluation of production costs for capital investment of \$1B.

- Examined evaluations of Voisey Bay preliminary exploration results in February and April, 1995 with associated stock prices of \$12 and \$20, identifying potential for \$50/share, followed by Inco acquisition for \$3B.
- Spearheaded evaluation of economic scenarios for major Chilean copper property where winning bid was US\$190M for 1/3 interest.

Barrie Hancock Page 2

1980 - 1987	Senior Mining Analyst COMINCO LTD. , <i>Vancouver, BC</i>
1976 - 1980	MINING ANALYST COMINCO LTD. , <i>Vancouver, BC</i>
1973 - 1975	MINE SUPERINTENDENT COMINCO LTD. , <i>Con Gold Mine, Yellowknife, NWT</i>
1972 - 1973	PLANNING ENGINEER, SHIFT BOSS, MINE FOREMAN GRANDUC OPERATING COMPANY , <i>Stewart, BC</i>
1969 - 1972	MINE CAPTAIN, SHIFT BOSS RHOKANA CORPORATION , <i>Kitwe (Zambian Copper Belt)</i>
1966 - 1969	CHIEF UNDERGROUND ENGINEER SHERRITT GORDON MINES LTD. , <i>Manitoba</i>
Prior to 1966	MINISTRY OF LABOUR , <i>Britain</i> ATTENDED UNIVERSITY. NATIONAL COAL BOARD , <i>U.K.</i>

EDUCATION

Bachelor of Science (Honours in Mining Engineering), University of Wales
 Member of the Association of Professional Engineers of BC
 Member of Canadian Institute of Mining and Metallurgy
 Higher National and Ordinary National Certificates, Qualified Mining Surveyor
 Shift Boss Certificate, BC
 Mine Rescue Certificates, NWT

- **Canadian Securities Course Certificate 1999**
- **Computer : MICROSOFT WORD and EXCEL**
- **PASSED THE EXAMS FOR THE CANADIAN. SECURITIES INSTITUTE**
- **PROFESSIONAL FINANCIAL PLANNING COURSE**
- **THE CANADIAN SECURITIES WEALTH MANAGEMENT TECHNIQUES COURSE**
- **PERSONAL**

Married, with 2 adult children

Interests include: Past - President and Co-Founder Vancouver Orpheus Male Voice Choir, Walking, reading and travel. Interested in the challenges of golf.

Education

*B.Eng. Mining Engineering,
Laurentian University ,
Canada, 1988*

*Geological Engineering
Technician, Cambrian
College, Canada, 1981*

Background

Mr. Palkovits is owner/Director of Mine Paste Engineering Ltd., providing mine audit, engineering and paste backfill services from scoping to feasibility studies, as well as senior technical oversight on paste or other backfill or tailings disposal projects. He graduated from Laurentian University with a B.Sc.Eng., Mining Engineering in 1988, and as a Geological Technician from Cambrian College in 1981.

Mr. Palkovits has extensive international experience in mine backfill and tailings disposal, exploring options and employing best practices including paste technology. He has worked on projects small and large, from 500 to +200,000 tpd, from wet, tropical locations in Brazil or Indonesia to the Atacama Desert.

From 2000 to August, 2010, Mr. Palkovits has been a senior team member at Golder Paste Technology Ltd., (PasteTec), managing and providing a key leadership role in consulting services, staff development, technical reviews, and project execution.

Prior to joining Paste Tec, (1981-2000) he was employed at INCO Ltd., (now VALE Canada Ltd.) in underground mining operations, having served as Chief Mine Engineering, front-line underground mine production supervision, and Special Projects Engineer.

His mining consulting experience includes paste technology for underground backfill and surface disposal of tailings (thickened tailings, dry-stack filter cake and paste applications). He has a broad range of experience in most commodities that includes gold, silver, base metals, potash, uranium, coal power plant combustion by-products (fly ash, bottom ash), phosphate and other precipitates, marine sediments/dredging and aggregates.

Mr. Palkovits is a registered Professional Engineer in the Province of Ontario.

Employment History***Mine Paste Engineering Ltd. (MPE) – Sudbury, Ontario***

Director (2010)

Sole Practitioner/Consultant – Mine engineering/optimization studies and audits. Specializing in mining methods, backfill systems, materials handling, and alternative tailings disposal technologies to enhance mine performance (productivity, profitability, environmental footprint, etc). Range of services from design and coordination of complete paste characterization testing campaign, scoping study, through to prefeasibility and feasibility studies. Provide technical oversight/review to ensure key project design intent carried through detailed design engineering and implementation of paste technology.

Golder Paste Technology Ltd. – Sudbury, Ontario

VP Consulting Services/Associate (2000 to 2010)

Consulting lead/reviewer/advisor on consulting studies from scoping through to

feasibility studies. Integral part of corporate strategy in laboratory development, market development, client workshop and operations/project initiatives. Provided senior oversight on all projects from scoping to feasibility studies, as well as design intent carried into detailed engineering. Project Director/Manager for all aspects of underground and surface paste projects. Managed study teams for projects ranging from scoping, prefeasibility and feasibility studies, detailed design engineering and implementation of paste technology at international project sites. Additional scope included successful business development of Latin American projects, with the building of a detail engineering team in Lima. Enhanced laboratory services including rheology, pump loops, flume cell, erosion cells, filtration, and bench-scale pilot plant work.

Inco Limited – Copper Cliff, Ontario

Roles included Chief Engineer, Engineering Supervisor, Mine Planning / Feasibility Study Project Manager – Garson, Crean Hill, Creighton, Levack, Frood and Ellen Pit Mines. (1981, 1988 to 2000)

Accident-free team in engineering/operations for duration of employment at Inco. As Chief Engineer, responsible for all mine engineering activities including staff requirements, budgets, safety, standards, long and short term planning, capital and operating development, production, backfill and surveying. Worked directly with management, operating and maintenance departments, requiring high degree of communication and team building skills.

Extensive experience in such areas as remnant mining (re-open old mining areas with new technologies), productivity improvement, shotcrete applications, drill selection and optimization, mining methods (sub-level cave, blast-hole including VRM, modified blast-hole, sub-level stoping, cut and fill, undercut and fill, inclined room and pillar, and remnant mining), and equipment selection (slushier, trucks, rail, conveyor systems).

Initiated and led a number of successful and innovative applications including up-hole Reverse Circulation production drilling methods in severely broken ground structures, design and operating coordination of contracted high-density backfill, mining methods changes, paste backfill improvements, and blind raising up to 80 feet.

Inco Limited – Copper Cliff, Ontario (Frood Mine)

Underground Front Line Production Supervisor & Special Project Foreman (1996 to 1998)

Responsible and accountable for all daily activities related to mine operations within unionised workforce including health and safety, development, shotcrete, drilling and production. High degree of interaction with production, maintenance and technical services departments. Successfully led the development and implementation of a Reverse Circulation drilling program exceeding targets.

Echo Bay Mines Ltd. – Lupin Mine, Northwest Territories

Technical Services / Mine Labourer (1983 to 1986)

Miner-in-training, tasked in drift development, production blasting, ore and rock handling (LHD, truck operator), raise mining and underground services. Worked in mine planning, surveying, grade control and mine planning. Isolated mine

camp; (4 weeks in, 2 weeks out rotation). Mining in permafrost, in very narrow veins to large bulk stoping.

Inco Limited – Copper Cliff, Ontario (Garson Mine)

Grade Control (Geology) (1981 - 1982)

Garson Mine – Beat Geological Grade Control Technician for 1800 tpd. Responsible for mineral reserve estimation, mapping, grade control, dilution, ore tracking for area of responsibility. Detailed experience in undercut and fill, cut and fill, narrow vein and large bulk mining techniques.

Phoenix Geophysics Ltd. – Ontario

Geophysical Technician (1980 to 1981)

Conducted induced polarization (IP) geophysical surveys on various remote projects within Ontario over two summer work periods.

Exploratech Services (Contracting) – Ontario

Partner, Claim Staking, Grass Roots Exploration (1980 to 1987)

Claim staking, conducting geophysical surveys, geological mapping, trenching, small diameter core drilling as a prospector and contractor.

PROJECT EXPERIENCE – KEY PROJECTS

Confidential Client	Integrated Mineral Waste Management Strategy – Corporate-level interdisciplinary initiative to develop a strategic plan with respect to productivity, profitability, environment and risk associated with mine backfill, tailings, smelter slag and mine waste rock disposal. Investigated alternative technologies and implications for Life of Mine/Business Plan. Base metal operations to 40,000 tpd.
Pechanga Nickel Russia	Senior technical review and workshop for Pechanga Management and Technical Design team. Provided recommendations and path forward for alternative tailings management using paste and thickened tailings. Production to 30,000 tpd.
Rio Tinto Copper Resolution Copper Mining LLC Arizona, USA	Senior review / corporate workshop for separate sulphide and rock tailings management strategy for large production operation. Investigated tailings site selection including conventional slurry, thickened tailings, paste and filter cake systems.
PT Freeport Indonesia Big Gossan Mine Irian Jaya, Indonesia	Plant to be commissioned in 2010. Feasibility study for 7,000 tpd U/G bulk high-sulphide Cu-Au mine. Innovative design for paste plant constructed entirely underground. Backfill strength testing included range of particle size, rheological performance and binder using cement and fly ash.
Freeport Morenci Project Arizona, USA	Prefeasibility Study for +200,000 tpd expansion study for tailings management. Tailings site selection study considering filter cake, paste and thickened tailings alternatives to conventional slurry disposal systems. Constraints included infrastructure, stability, large footprint (volume), property rights, river crossings, closure and dusting.
Goldcorp Inc. Red Lake Mine Ontario, Canada	Site assistance for quality control of paste backfill distribution system, including inspection of materials, equipment, procedure, and installation to ensure integrity of the system.

**PPL Montana
Colstrip SES**
Colstrip, Montana

Competed two plants for PPL Montana at Colstrip: plant for Units 3&4 commissioned in 2003; plant for Units 1&2 in 2009. Scoping to EPCM / commissioning of fly ash paste plant for the Colstrip Steam Electric Station (CSES), coal-fired power plant. Converted conventional slurry system to paste disposal, with significant cost savings, environmental mitigation and enhanced containment.

**Pouya Zarcán
Agh Darreh Project**
West Azerbaijan, Iran

Plant commissioned in 2004. Conducted testing, basic engineering, detail engineering/EPCM Support for 2,500 tpd gold mine tailings disposal system using deep tank paste thickening technology.

Minera Florida
Las Cenizas Mine, Chile

Prefeasibility study, laboratory testing and extensive pilot plant and flow loop site testing for surface disposal of thickened, paste application.

**Compañía Minera
Atacocha SA**
Cerra de Pascao, Peru

Prefeasibility Study for alternative technologies for underground backfill, tailings disposal and high-pressure pumping systems. Mine production rate is planned at 3,650 tpd producing copper, lead and zinc concentrates, at 4,000 m elev.

**Ca Minera Milpo
Cerro Lindo Mine**
Ica, Peru

Plant commissioned in 2005. Conducted prefeasibility study finalizing flowsheet and plant designs for paste backfill system design and filter cake dry tailings disposal system. Production rate: 5,000 tpd u/g lead/zinc mine. High-sulphide tailings challenge for backfill strength, binder selection and tailings management (re: acid rock drainage guidelines). Project within region of steep / difficult terrain, with El Nino storm events and high seismic conditions.

**Minsur S.A.
San Rafael Mine**
Puno, Peru

Plant commissioned in 2003. Conducted basic engineering study, defining paste backfill system and overall integration for this remote 2,500 tpd tin mine located at 4,500 m elevation. Design and conducted extensive laboratory characterisation and on-site pilot plant dewatering and flow loop pump test work. Implemented plant includes retro-fitted surface thickener, an underground filter /paste production system and cement/tin slag binder system.

**URSA Major Minerals
Shakespeare Project**
Ontario, Canada

Prefeasibility and feasibility study for tailings disposal by thickened tailings and rock co-disposal. Innovative waste-rock and tailings disposal technology has won a Consulting Engineers of Ontario award for work done at the Shakespeare project owned by URSA Major Minerals Inc.
(<http://www.ursamajorminerals.com/company/pdf/golder-paste-tech-award.pdf>)

**Skeena PCB Dredge and
Disposal System**
Prince Rupert, British
Columbia, Canada

Designed and commissioned the Fast-track Design/Build/Operate (DBO) plant in 2004, for a solids process sorting and dewatering system for a PCB contaminated marine sediment clean-up project (mineral and organic solids (large cobble, hogfuel/woodchips, fine saw dust, stones and fine silts). Dredging flow to 400 m³/h, requiring specific containment according to degree of particle size and contamination, within Department of Fisheries and Oceans guidelines.

Omya Inc.
Florence, Vermont, USA

Plant commissioned in 2008. Prefeasibility study leading to detail engineering /commissioning of the flotation tailings process plant for the Verpol operations. Investigation included process dewatering and material handling, geotechnical and geochemical analysis with respect to reagent fate and transport.

Newmont Minas Conga Northern Peru	Scoping to feasibility study for alternative tailings process and disposal technologies (thickened tailings, paste systems) for 100,000 tpd copper-gold tailings. Included extensive laboratory and field tailings characterisation study (geotechnical, dewatering, and geochemical) for final design.
Vale INCO Garson Ramp Mine Sudbury, Canada	Plant commissioned in 2008. Feasibility study to develop cost-effective mine backfill system. Concluded with high-density cemented hydraulic fill and development waste rock for high strength fill. Implemented in 2008 using modified mobile backfill plant at low capital cost.
Globestar Mining Cerro do Maimon Dominican Republic	Plant commissioned in 2008. Senior technical reviewer for tailings dewatering and plant design during scoping and feasibility study.
Iberian Minerals Corp. Minas de Aguas Tenidas S. A. (MATSA) Southern Spain	Plant commissioned in 2008. Conducted prefeasibility study defining plant location, underground distribution and tailings paste provision for surface disposal. Incorporated waste slag in backfill mix for improved environmental and cost effectiveness.
Anglo Base Metals Lisheen Mine Thurles, Ireland	Design of underground distribution system for 4 km shallow orebody, assessment of delivery times and cement hydration set-time, pipe diameters, and recommendations for implementation.
Vale Cristalino Project Para, Brasil	Prefeasibility study investigating 60,000 tpd copper tailings management project as a corporate objective to reduce tailings footprint, environmental impact and costs through dewatering system, including filter cake, paste and thickened tailings alternatives, as well as pump/pipeline and conveyor transport systems.
Vale Paragominas Mine Para, Brasil	Prefeasibility study investigating bauxite washing plant fine clay mud using paste and thickened tailings, pump/pipeline transport and deposition alternatives compared to dewatering ponds/dredging systems.
Atlas Iron Ridley Mine Project Pilbara, Australia	Alternative Tailings and Mine Waste Deposition for 100,000 tpd iron project; team participant in key strategy meeting and workshop to assist client in reaching a high-level decision re: alternative systems compared to conventional slurry containment (Golder Associates Corporation Innovation Award, Technically Innovative Solutions, Asbestiform minerals and ARD rock containment, 2009)
Vale Goro Project, New Caledonia	Senior review/audit of Goro project for 20,000 tpd nickel laterite residue slurry , investigating potential for paste and thickened tailings. Identified significant opportunities /synergies with overall project relative to conventional slurry containment.
Minerações Brasileiras Reunidas SA (MBR) Minas Gerais, Brazil	Conceptual engineering /material characterisation study for paste or thickened tailings disposal systems for iron ore tailings and overburden wastes at the Mutuca Mine and concentrator operations.
Caraiba Mine Pilar, Brazil	Senior mine audit/review to determine primary cause of backfill dilution and system operations, and extend design of distribution system. Recommendation implemented to reduce stope sizes to improve wall stability and minimize drill hole deviation and blast damage. Improvements were made in ore recovery and reduction of dilution caused by undermining of backfill.

Iamgold Corporation Niobec Mine Quebec, Canada	Third-party senior review of feasibility design for a paste backfill plant and underground distribution design. Recommendations adopted/implemented for major flow sheet selection, equipment performance and equipment selection.
Kinross Gold Corporation (Aurelian) Fruta del Norte, Ecuador	Senior third-party review of prefeasibility design for paste backfill plant and underground distribution design at the Fruta del Norte Project, Ecuador. Recommendations adopted/implemented for tailings/backfill testing, alternatives for flow sheet and equipment selection and considerations for alternative plant designs and optimization.
Kirkland Lake Gold Macassa Mine Kirkland Lake, Canada	Plant modifications made in 2009 and 2010 (on-going). Scoping and prefeasibility study, site review/audit of existing blended paste backfill operation. Recommendations for QA/QC for sand supply and monitoring of paste production, replacement/purchase of high-intensity mixer, re-piping of underground distribution system. Backfill plant operates at ~83 t/hr using sand and tailings blend.
Crowflight Minerals Inc. Bucko Mine Manitoba, Canada	Plant commissioned in 2010. Senior corporate team participant in strategic plan to ensure sound economics of operation. Major input with selection of mining method, and development of backfill system using high-density sand and tailings blend. Modified mobile plant identified as cost-effective solution, with rapid set-up/commissioning potential and winter-operability critical to success.
Yamana Gold Inc. Mercedes Project Sonora, Mexico	Plant to be constructed in 2010, 2011. Scoping and feasibility level study for 1,500 tpd underground gold project. Investigation included mine backfill systems (hydraulic fill, cemented rock fill, paste fill and blended paste fill) as well as surface disposal of dewatered tailings (thickened slurry, paste and filter cake). Use of waste rock in backfill improved closure plan, reduced footprint and reduced backfill and waste management costs.
Fortune Minerals Limited Nico Project NWT., Canada	Prefeasibility and feasibility study investigating underground and paste backfill disposal of tailings and mine waste. Key drivers included geochemistry, footprint, long-term closure and waste management costs. Paste and rock co-disposal (PasteRock) was determined to provide best practice. The current plan is for open pit with a production rate of 4,650 tpd.

MINES OPERATING EXPERIENCE

Inco Limited, Garson Mine Sudbury, Ontario, Canada	Chief Engineer and Mine Engineering Supervisor Brought in to Garson Mine to critically increase production and productivity. Successful and safe improvement from highest to lowest cost in Ontario operations within 8 months (1,800 tpd to 2,300 tpd). Led improvements in backfill, drill/blast optimization, scheduling and task management of operations.
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**Inco Limited
Frood Mine**
Sudbury, Ontario, Canada

Underground Mine Foreman one of few sub-level caving operations globally, gaining extensive engineering and operational experience. Responsible for health and safety, development, production (drilling, blasting, haulage and backfilling) as well as special projects. Achieved safe operation while meeting key production targets.

Mines Engineering Supervisor, responsible for mines engineering of the 4,250 tpd mine over a 4 year period, with steady safe and productive increase over 5 years. Key achievements – no injuries over 5 years; converted large area of mining to more productive mining method within first 12 months; initiated, design and implemented High Density Backfill System with mobile system; initiated innovative application of hollow-core soil nail (grouted rebar spilling) / shotcrete for development; lead team member for selection and implementation of INCO's first u/g Reverse Circulation (R/C) Production Drill for development and production drilling through broken and unconsolidated ground formations.

**Inco Limited
Levack Mine**
Sudbury, Ontario, Canada

Mines Engineering Supervisor, reporting to the Chief Mine Engineer (1991-1993). Responsible for mines engineering of the 2, 500 tpd mine. Significant milestones include: Accident-free engineering team for all day-to-day mine engineering activities, meeting target productions levels. Successfully implemented Inco's only "Elliot Lake Style Inclined Room and Pillar Stope" with excellent safety, productivity, recovery and dilution values. Oversaw the preparation and completion of the Levack Mine Closure Plan (1993).

**Inco Limited
Creighton Mine**
Sudbury, Ontario, Canada

Mines Engineering Supervisor, Div.I and Div.II. All day to day and long range safe planning/engineering for deep, high stress mining. Initiated use of shotcrete for production development areas, and converted ore pass arrangements from raises to bins to mitigate rock burst and long-term destruction of infrastructure.

Feasibility study manager for mining of the Creighton Deep (7,400 ft to 7,600 ft deep). Investigated options for ore haulage systems including vertical and conventional conveyors, electric and diesel truck haulage, and internal shaft deepening. Proposed and implemented first uses of shotcrete for major development reconditioning project in main production areas at Creighton Mine (1992). Technical oversight of the mine backfill system (cemented hydraulic tailings fill). Initiated re-use of crusher access destroyed by rock burst for Kiruna truck unloading, saving +\$25M. Extended integration of equipment for significant cost savings and operational effectiveness.

**Inco Limited
Crean Hill Mine**
Sudbury, Ontario, Canada

Mine Planner for 1,800 tpd mining, responsible for mine development and production, as well as oversight for mine backfill system. Bulk mining methods included Vertical Retreat and uppers mining methods. Managed the cemented hydraulic sand fill plant and sand supply contracts for mine backfill system. Successfully implemented Inco's first use of High Density Pipe (1988) for mine backfill with improvements to costs, productivity, and user acceptance. Preliminary feasibility study for Ellen Pit as an independent ramp-access mine.

PROJECT EXPERIENCE – ADDITIONAL PROJECTS

The following projects are a selection of scoping to feasibility projects involving testing, backfill and/or tailings disposal:

- Franco-Nevada Mines** – Midas Operation – Review of operations for backfill and tailings optimization;
- Coal Clean Corp.** West Virginia - Coal washing slimes disposal scoping study, material testing, flow loop;
- Vale S.A.** - Niquel do Vermelho Project, Brazil – Nickel laterite process residue dewatering and disposal study;
- Thompson Creek Minerals Corp.** – Mt. Emmons, USA – 13,000 tpd U/G paste plant study;
- Kobex Minerals Inc.** - Lucky Jack (Mt. Emmons), USA – Tailings disposal, hydraulic and paste backfill;
- Khan Resources Inc.** - Dornod Project, Mongolia – Thickened tailings and paste backfill study;
- Aurora Energy Resources Inc.**– Michelin Project, Canada – Thickened tailings disposal, hydraulic and paste backfill;
- Asian Mineral Resources** – Ban Phuc Mine, Vietnam – Paste backfill and pumping, pipeline system;
- Breakwater Resources Ltd.** - El Mochito Mine, Honduras – Paste tailings disposal system;
- Goldcorp (Opinaca)** – Eleonore Project, Canada – Hydraulic, CRF, paste and blended paste backfill, surface tailings dewatering (thickened tailings, filter cake, sulphides and rock tailings);
- Aurum Mining PLC.** – Andash Project, Kyrgyz Republic – Alternative tailings management study, 60,000 tpd.;
- Abacus Mining and Exploration Corp.** – Ajax Mine, Canada – 60 ktpd thickened tailings system;
- Iamgold Corporation** – Quimsacocha Project, Ecuador – Backfill and surface disposal alternatives study;
- Brazauro Resources Corp.** - Tocantinzinho Gold Project, Brazil – Alternative tailings disposal, 60 ktpd
- INCO Technological Services**, Voisey’s Bay Hydromet Process Residue Study – Alternative tailings disposal pilot plant test work, study for process residues (iron gypsum and neutralized leach residue);
- Voisey’s Bay Mining Ltd.** - Reidbrook and Eastern Deeps – Backfill scoping study and laboratory assessment for applicability of using reactive Pyrrhotite tailings and sand, binder alternatives for paste backfill;
- Electrical Generating and Transmission Company (CGTEE)** – Candiota Power Plant, Brazil – Dry fly ash to wet system plant design, pumping and pipeline system at 500 tph production rate.
- Vulcan Resources Pty.** -Kylähti Mine, Finland – Backfill system and tailings disposal alternatives at 1,500 tpd;
- Mosaic Potash** – K2 Mine, Saskatchewan – Audit, senior review of grouting backfill system, with recommendations for design and implementation
- Vale S.A.** - Taquouri-Vassouras Mine, Brazil – Potash mine to dispose of salt underground, study to consider utilizing paste backfill blend to increase recovery and improve stability;

- Lake Shore Gold Inc.** - Timmins West Mine – Alternative backfill and tailings disposal systems, considering paste, hydraulic slurry and filter cake. Selection of backfill system considered tailings and sand to improve strength, economics.
- Quadra FNX Mining Ltd.** – Levack Mine – Backfill system design and implementation for short and long-term requirements;
- Quadra FNX Mining Ltd.** – Podolski Mine – Cemented rock fill system design;
- Red Hawk Resources, Inc.** - Copper Creek Project, AZ, USA – backfill and surface disposal alternatives;
- Placer Dome Joint Venture** – Porcupine Project – Paste/thickened tailings system selection and design;
- Comaplex Minerals Corp.** - Meliadine Mine, Canada – Strategy/scoping study, permafrost and Arctic mining, backfill and tailings disposal alternatives;
- Anglo Base Metals** - Quebrada Blanca, Chile – Alternative tailings disposal study;
- Minera Florida S.A.** – Alhue Mine, Chile – Pilot plant and flow loop test work and scoping study;
- ALCOA S.A.** – Juriti Project, Brazil – Basic Engineering study for bauxite washing mud dewatering, pump and pipeline transport and disposal;
- Vale S.A.** – Target 118 project, Brazil – Assessment for mine backfill selection.

PRESENTATIONS - SEMINARS AND WORKSHOPS

A Seminar on Surface Impoundments (2010)

Client Seminar, Golder Associates Inc., Richmond Virginia, USA

Applicable for Professional Development Hours, Virginia

Paste 2010 Conference,

13th International Conference on Paste and Thickened Tailings

Toronto, Ontario, Executive Committee

Paste and Thickened Tailings Technology (2005, 2009)

Client Seminar, Golder Associates, Belo Horizonte, Brazil

Atlas Iron – Ridley Iron Project (2008)

Tailings and Waste Management Alternatives, Perth, Australia

Basics of Paste Backfill Technology (2010)

School of Engineering Seminar, Laurentian University Post-Graduate Studies

Sustainability of the Mineral Industry: Mine Waste Management (2010)

School of Engineering Seminar, Laurentian University Post-Graduate Studies

TRAINING

Canadian Mineral Processors / AMEC Short Course (CIM)

NI 43-101 for Mineral Processors, January, 2010

Emerging Technologies for Mine Waste Management

Professional Engineers and Geoscientists of BC. (April 2007)

Common Core for First Line Production Supervisor

Ministry of Education, Ontario, 1996

Instruction Training for Supervisors

Inco Ltd., 1996

Managing Safety: Techniques that Work for Line Supervisors

Dupont Safety Training Certificate

Leadership and Accomplishment

King, Chapman and Broussard

Total Quality Management

G. R. Technologies

Facilitation Skills

Practical Management of Canada

Ground Control Observation Techniques

Cambrian College

Ground Control for Non-Specialists

Laurentian University

Ontario Miner's Certificate

Inco Ltd., 1996

Basic Certificate of Mine Rescue

Ontario M.O.L.

American and Canadian Underwater Certification - SCUBA

PROFESSIONAL AFFILIATIONS

Professional Engineer in the Province of Ontario

Canadian Institute of Mining (CIM)

Canadian Mineral Processors (CMP)

PUBLICATIONS

Integrated Waste Management Strategy. S. Longo, K. Clarke-Whistler, F. Palkovits, Paste 2009 - 12th International Seminar on Paste and Thickened Tailings 2009

Better results from thickened tailings. F. Palkovits - Article in Canadian Mining Magazine 2008

Solutions through paste technology. F. Palkovits - Article in World Coal Magazine 2008

Thickened Tailings Offer Effective Disposal Alternatives. F. Palkovits - Article in Engineering & Mining Journal 2007

Towards Sustainability - Mine Waste and Paste Surface Co-Disposal. F. Palkovits, Shakespeare Project Sudbury, Canada 2007

Comparative Economic Assessment of Mine Backfill Systems. F. Palkovits - Int'l Seminar on Paste Cape Town, South Africa 2004

Paste Technology: Low Risk Alternative to Conventional Tailings Disposal Systems. F. Palkovits, P. Newman, R. Verburg - Sudbury Mining and the Environment, Sudbury, Canada 2003

Paste Application for Handling Coal Combustion By-Products to Reduce Impoundment Seepage. J. Johnson, G. Criswell, F. Palkovits - Tailings Dams 2002, ASDSO and USSD, Las Vegas, Nevada 2002

Application of Paste Technology for Disposal of Solid Wastes. F. Palkovits, M. Stochmal 2002

Mining through semi-unconsolidated material using shotcrete as primary support at Inco's Frood Mine. C.C. Langille, F. Palkovits and D. O'Donnell - CIM 13th Mine Operator's Conference, Sudbury, Canada 1997

Increasing value in mining operations through the application of paste, ACG Newsletter, 2009. N.Slade, S. Wilson, F. Felipe, and F. Palkovits.

AWARDS

Consulting Engineers of Ontario Award of Merit for Industry, Energy & Resources for work done at the Shakespeare project owned by URSA Major Minerals Inc., Canada, 2007.

Golder Associates Corporation, Innovation and Sustainability Award, for the INCO Integrated Waste Management Strategy Project, Canada, 2008.

Golder Associates Corporation Innovation Award, Technically Innovative Solutions, Asbestiform minerals and ARD rock containment, 2009.

Mr. David Lindeman, P.Eng, is a specialist in metallurgical process development and design, equipment procurement, scheduling and management. Mr. Lindeman has over 25 years experience in precious metal plant operating, consulting, process management and design study work on international projects. Experience includes: consultant to the mining and mineral processing industries in precious metal extraction, metallurgical process design and development; economic evaluation and cost optimization studies; project management for feasibility studies in gold and base metal recovery processes; scoping level assessments of extractive technologies and property development.

EDUCATION

1983 B.Sc., Metallurgy and Materials Science (Extractive Metallurgy), School of Metallurgy and Mining, University of Nottingham, UK

EXPERIENCE

Since 2011 SNC-LAVALIN INC, Vancouver, British Columbia
Senior Process Engineer

2006-2011 FLUOR CANADA., Vancouver, British Columbia
Principal Process Engineer

- ♦ Barrick Gold Corp., Dominican Republic: Lead Process Engineering for detailed engineering design, build and commission of a 24,000 tpd gold-silver and copper recovery facility utilizing sulphide precipitation (copper recovery), high density sludge (HDS) neutralization processes and SABC, Lime Boil, CIP Elution recovery processes.



2002 - 2006 BIOTEQ ENVIRONMENTAL TECHNOLOGIES INC., Vancouver, British Columbia

Project Engineer

- ◆ Phelps Dodge Blackwell Zinc Smelter: Project Manager for design build zinc/cadmium recovery water treatment plant. Phelps Dodge Copper Queen Mine, Bisbee, Arizona: Project Engineer for design build copper recovery water treatment plant. Raglan Mine, Quebec: Project Engineer for design build acid mine drainage treatment plant for nickel recovery.

1994 – Pres. STEYN GOLD CONSULTING LTD., Vancouver, British Columbia

President

- ◆ Cumberland Resources (Meadowbank Gold): Lead process design engineer for feasibility study and processing analysis of bulk rougher, cleaner, CIL gold recovery plant.
- ◆ Manhattan Minerals (Tambo Grande), Peru: Senior Project Metallurgist for feasibility study of an underground/open pit copper-zinc-lead-silver property.
- ◆ ITOS Tailings, Oruro, Bolivia: Process design and construction of a hot. Agitated acidic chloride leach, filtration lead-antimony-silver recovery plant.
- ◆ Greenstone Resources (Santa Rosa), Panama: Process engineer for feasibility study of CIL gold recovery process and land application disposal.
- ◆ Camboir (Omai) Guyana: Project metallurgist for detailed design and procurement for detailed engineering of 12,000 tpd CIP gold mill.

1995 – 2000 AMEC SIMONS, Vancouver, British Columbia

Senior Process Engineer

- ◆ Placer Dome Corp., (Las Cristinas) Venezuela: Basic Engineering study and evaluation of saprolitic and bedrock type ores for a gold/copper recovery facility bedrock type ores for a gold/copper recovery facility.
- ◆ Placer Dome Corp., (Musselwhite): Process engineer for detailed design, build and commission of a gold leach, CIP recovery facility.



1993 – 1995 GOLD PRODUCTION MANAGEMENT LTD., Reno, Nevada

Process Metallurgist

- ◆ Project Metallurgist for the detailed feasibility study of a copper-gold mill, heap leaching facility and process plant

1993 – 1995 KAPPES CASSIDAY & ASSOCIATES, Reno, Nevada

Process Metallurgist

1990 – 1992 KILBORN ENGINEERING PACIFIC LTD., Vancouver, British Columbia

Process Metallurgist

- ◆ Newmont Mining Corp., Nevada: Project Metallurgist for the detailed feasibility study of a copper-gold mill, heap leaching facility and process plant.

1990 FLUOR DANIEL WRIGHT ENGINEERS, Vancouver, British Columbia

Contract Metallurgist

1985 – 1990 ANGLO AMERICAL CORP. OF SOUTH AFRICA LTD., Free State, South Africa

Metallurgical Engineer

Plant Production Superintendent: Responsible for achieving targeted parameters, troubleshooting daily production targets, and setting and meeting long-term strategic objectives.

PROFESSIONAL AFFILIATES

Professional Engineer (P.Eng), British Columbia, BC

Mr. Anh-Long Nguyen, Eng., M.Sc., is a process engineer with more than 10 years of experience specializing in the water treatment industry for the mining, industrial and municipal sectors. He has acquired a solid background in the design and development of water treatment processes, including clarification, filtration and membrane systems. He has participated in all of engineering phases of a project, including pre-feasibility studies, basic and detail engineering, and start-up and commissioning. He has also acted as proposal manager where he was responsible for a team of specialist (engineers, designers and estimators) for the process design, technical and commercial risk evaluation, and cost estimate and proposal preparation. With SNC-Lavalin, he has participated in the development of a mine site water management plan where he identified water sources, looked at water quality, identified streams requiring treatment, and design water treatment processes to deal with these streams. Mr. Nguyen speaks English and French.

EDUCATION

- | | |
|------|--|
| 1998 | M. Sc. in Agricultural and Biosystems Engineering, McGill University, Ste-Anne-de-Bellevue, Quebec, Canada |
| 1996 | B. Eng. in Chemical Engineering with minor in Biotechnology, McGill University, Montréal, Québec, Canada |

EXPERIENCE

Since 2006 SNC-LAVALIN INC., Montréal (Québec) Canada

Process Engineer, Water Treatment Specialist, Mine Reclamation and Geotechnical Services division

- ◆ Guelb II, SNIM, iron enrichment plant in Mauritania (2010):
 - Package engineer for the wet concentration plant, the brackish water treatment plant, the deep well pumps and the water storage tanks
 - Participated in the technical evaluation of the proposals received
 - Participated in the review of the water consumption at the plant to define the needs for brackish and desalinated water



- ◆ Cobre Las Cruces, Inmet, copper mine in Spain (2010)
 - Reviewed and updated the water balance of the entire process plant based on its present state
- ◆ Potash One Legacy project, feasibility stage, Saskatchewan, Canada (2009-present):
 - Developed the conceptual design for the water treatment processes to produce potable water, process water and boiler feed water from lake water
 - Developed the conceptual design for the sewage treatment plant
 - Participated in the preparation of technical specifications for preliminary budgetary tenders and the technical evaluation of the budgetary proposal
- ◆ Rhourde Nouss, natural gas processing plant expansion, basic engineering, Sonatrach, Algeria (2009-present):
 - Technical reviewer in the process design for the potable / process water treatment plant and the oily wastewater effluent treatment plant
- ◆ Diavik Diamond Mine Inc., Lac de Gras (N.W.T) Canada (2006-2009) :
 - Coordinated and executed the start-up, commissioning and performance tests of the new water treatment plant expansion (NIWTP). Produced all of the relevant documentation (procedures, operation manual, training material) for the start-up.
 - Process engineer during the detailed engineering for the North Inlet Water Treatment Plant (NIWTP) expansion project
 - Evaluated the required modifications to the existing water treatment plant to operate the existing filters in parallel with the existing clarifiers
 - Evaluated water treatment technologies that would allow for the re-use of effluent process water within the process plant, thus reducing the consumption of fresh water at the plant
 - Participated in the commissioning of the existing water treatment plant which was modified in order to double its hydraulic capacity
 - Conducted an in-depth technology review of treatment processes for the removal of ammonia in water
 - Evaluated the benefits and drawbacks of each technology relative to the specific application at Lac de Gras (arctic conditions)



- Evaluated the order of magnitude capital and operating cost for each technology, as well as its impact on greenhouse gas emissions
- Presented findings in a technical report and before government officials
- ◆ Qatalum SA&PB Project, EPCM project for the construction of utilities for a new aluminum smelter in Qatar (2007-2009):
 - Participated in the conceptual design of the seawater effluent treatment process to treat seawater contaminated with non-oxidized SO₂ coming from the aluminum plant's sulfur dioxide scrubbers
 - Participated in the detailed engineering of the seawater effluent treatment plant, including coordination with other disciplines; coordination with vendors; updated PFD, P&ID, process description, HAZOP report and design reviews
 - Participated in the conceptual design of the wastewater treatment plant used to treat effluent from the caskhouse, vehicle wash, and other areas in the plant in order to re-use the treated effluent back in the process or for irrigation. The treatment plant includes an oil/water separator.
 - Participated in the detailed engineering of the potable water disinfection system, the disinfection and corrosion control of the closed cooling medium, and the electrochlorination system to produce a dilute solution of hypochlorite solution from seawater.
- ◆ Opémiska Mine, Chapais (Québec) Canada (2008):
 - Project manager for the development of an emergency response plan following the rupture of a tailings dam at the closed Opémiska mine
 - Coordinated with different disciplines for the conceptual engineering for the emergency work required
- ◆ Gaspé Mines Closure Project for Xstrata Canada, Murdochville, Québec, Canada (2006-2008):
 - Participated in the design of a new water treatment process to treat a neutral mine drainage using sodium hydroxide neutralisation. The new plant would replace an existing lime neutralization plant
 - Evaluated deliverables, budgets and schedule for this project
 - Coordinated with other disciplines and technical reviewers.
 - Provided technical support in the development of a technical document to support the Client's request for a new Certificate of Authorization for the new water treatment plant.



- Managed a water sampling campaign at the mine site in order to qualify the water sources that have not been investigated in the past to ascertain if additional treatment is required
 - Developed sampling and testing protocols for field technician
 - Supervised field work
 - Compiled and analysed the data collected; wrote technical report.
 - Developed and provided order of magnitude cost estimates of treatment options for the management and treatment of effluent that would be generated during the demolition work.
- ♦ Cobre Las Cruces, Inmet, Copper Mine, Spain (2006-2007):
- Developed the water treatment process for the production of process water from secondary municipal wastewater
 - Responsible for the preparation of specifications and technical documents for a turn-key tender for the supply and installation of a process water treatment plant and reverse osmosis plant.
 - Participated in the technical evaluation of the proposals and provided recommendations
 - Participated in the evaluation of the water balance and water quality at the plant, as well as in the development of the water management model of the plant
- ♦ Gold Reserves project, new gold mine, Brisas, Venezuela (2006):
- Responsible for the development of different options for the management and treatment of acid mine drainage (AMD) at the site
 - Designed and sized all treatment equipment and infrastructure required for each option
 - Provided order of magnitude capital and operating cost estimate and a net present value analysis of the different options.
- ♦ Geco-Willroy, Ontario, Canada (2006):
- Estimated the future annual operating costs for the existing treatment plant for a period of 10 to 20 years based on existing data.



2001-2006 DEGRÉMONT LTÉE., Montréal, Québec, Canada

& 1998-2000 Application engineer, commercial department

- ♦ Involved in the preliminary design for treatment of oily wastewater effluent from a caskhouse for a new aluminum smelter in Iceland
- ♦ Designed the first high-rate packaged dissolved air flotation (DAF) unit in Canada for a 2.16 MLD Drinking Water Treatment Plant Expansion, Lac Etchemin, Québec, Canada (2005-2006)
- ♦ Participated in the start-up and commissioning of a prototype high-rate DAF unit for temporary production of clarified water during the renovation work at water treatment plant in Contrecoeur, Québec (2005)
- ♦ Headed the development and standardisation of packaged high-rate dissolved air flotation units and dual media gravity filters
 - Produced all of the standard commercial documents (proposal, drawings, estimation) (2005).
- ♦ Designed, selected equipment, cost estimate, coordinated with other department to produce the proposal for the following projects:
 - New 418 MLD potable water plant for the city of Winnipeg, Manitoba (2003-2005)
 - 44.5 MLD drinking water treatment plant expansion, Gatineau (Aylmer), Québec (2004-2006)
 - 65.4 MLD municipal wastewater treatment plant for the municipality of Sydney, Nova Scotia, Canada (2003)
 - 627 MLD municipal wastewater treatment plant for Barquisimeto, Venezuela (2002)
 - Expansion project of the process water plant for Scott Paper, Crabtree, Québec, Canada (2002)
 - Supply of 8 degritter moving bridges for the existing grit removal basins for the city of Washington DC, USA (2001-2002)
- ♦ Conducted a preliminary study to evaluate options to increase the capacity of the existing process water treatment plant at INCO in Sudbury, Ontario, Canada (2004)
- ♦ Conducted a preliminary study to replace the existing demineralisation plant with a reverse osmosis system for Hydro-Québec, Québec, Canada (2002)



- ◆ Participated in the start-up, commissioning, process optimisation and performance test of municipal wastewater treatment plant for the municipalities of Laval, Beloeil, St-Jean-sur-Richelieu et Gaspé, Québec, Canada (1998-1999)

2000 IONICS INC., Watertown, Massachusetts, USA

Process Engineer, R&D department

- ◆ Participated in the maintenance and operation of an electrodialysis reverse (EDR) unit in Bermuda
- ◆ Involved in the site commissioning of a process water treatment plant taking tertiary treated sewage water and making boiler grade feed water in Luggage Point, Brisbane, Australia
- ◆ Conducted several pilot studies (Harding Dam, Pilbara, Australia, Stonington, Maine, USA) applying ultrafiltration membrane in the treatment of lake or reservoir water for the production of drinking water

PUBLICATIONS AND PRESENTATIONS

Nguyen A.L., "Dissolved Air Floatation at High Rise Rates: Results of Pilot Studies in North America", WCWWA 55th Annual Conference and Trade Show, October 27th, 2003

Nguyen A.L., Duff S.J.B., Sheppard, J.D., "Application of Feedback Control Based on Dissolved Oxygen to a Fixed-Film Sequencing Batch Reactor for the Treatment of Brewery Wastewater", Water Environment Research, Vol. 72, No. 1, 75-83 (2000)

ADDITIONAL TRAINING

2005 "Reverse Osmosis Water Treatment" – 3 day seminar, David H Paul Training Inc. (San Diego, CA)

PROFESSIONAL ASSOCIATIONS

American Water and Wastewater Association, since 2003

Ordre des ingénieurs du Québec (OIQ), affiliation no. 122858, since 1999

LANGUAGES

English, French



WORK EXPERIENCE (COUNTRIES)

Australia, Bermuda, Chile, United-States



SOHAN BASRA

Director, Global Water Treatment

PROFILE

Mr. Basra has over 30 years of experience in the mining industry ranging from milling and processing, analytical laboratory supervisor, to managing a technology based company focused on water treatment processes for the mining industry.

As the Director of Global Water Treatment at SGS-CEMI, Sohan is involved in all aspects of laboratory planning and operation with regard to Acid Base Accounting, heavy metal removal, solution purification, hydrometallurgical research and the full range of general metallurgical testing as well as High density sludge pilot plant testing at Red Mountain, California; Kerr McGee Chemicals, Mississippi; Tiwest, Western Australia, and Zortman, Montana.

Mr. Basra is involved in all aspects of engineering design of High Density Sludge Water Treatment Plants. He has worked on numerous engineering design projects for water treatment plants as a Senior Process Expert.

RELEVANT EXPERIENCE

Process Expert, Antamina Port Facilities, Compania Minera Antamina, Peru

Evaluate existing high density sludge treatment facility and recommend discharge criteria. Tasks included conducting an onsite pilot study to determine optimum HDS parameters for metals removal and preparation of cost estimate for potential facility upgrade.

Process Manager, Antamina Mine, Compania Minera Antamina, Peru

Develop a molybdenum removal process and evaluate existing in-situ treatment process for heavy metals removal. Tasks included conducting an onsite HDS pilot study to determine optimum HDS parameters for metals removal and recommend a process for molybdenum removal. In 2003, designed and commissioned an in situ treatment system for metals and TSS removal to meet the discharge criteria.

Process Expert, Pueblo Viejo – ARD Treatment, Barrick, Dominican Republic

Develop a preliminary design for ARD water treatment plant at the Pueblo Viejo Site that included developing process design criteria and equipment sizing, operation philosophy and cost estimation. Also, conducted an onsite pilot study to obtain engineering data, which was followed by a conceptual level engineering design.



SOHAN BASRA

Director, Global Water Treatment

Process Expert, Pueblo Viejo – CCD Neutralization, Barrick, Dominican Republic

Conduct two pilot studies to collect engineering data, the pilot study will be followed by feasibility level engineering design

Process Expert, Wolverine Mine, Yukon Zinc, Canada

Developed an in situ treatment process to meet selenium discharge criteria. Conducted a conceptual design and supplied an assembled trailer mounted activated carbon column treatment plant.

Process Expert, Minera GoldFields SA, Peru

Developed treatment options to quickly bring an existing discharge at the mine site into compliance with local regulations. The project involved conducting treatability testing to remove metals and suspended solids and developing preliminary design of settling pond.

Process Expert, Climax Molybdenum, Phelps Dodge, USA

Managed process engineering for the Phelps Dodge Sludge Management feasibility study at the Climax Mine in Colorado. Responsibilities included review existing documents and studies and oversee process design and conceptual engineering which included capital and operating cost analysis and an engineer-procure-construct schedule. Responsible for review of detailed engineering and will be commissioning the HDS plant scheduled to start in 2007.

Process Expert, Britannia Mine, Province of British Columbia, Canada

Responsible for process engineering, equipment sizing and specifications, review of detailed engineering and commissioning. Prior to detailed engineering, responsible for conducting two HDS pilot studies (1997 and 2002) to test different treatment options.



SOHAN BASRA
Director, Global Water Treatment

WORK EXPERIENCE

1999 Director Global Water Treatment, SGS-CEMI

Responsible for Water Treatment, Metallurgical and Environmental Research including management, supervision, recruitment, training, procedure development, and marketing. Lab experience includes:

- Full range of ARD characterisation work (ABA, shake flasks, humidity cells).
- Solution treatment for metal removal for both metallurgical processing and environmental clean-up, HDS on site piloting.
- Hydrometallurgical research including pressure leaching of zinc and copper concentrates, column leaching, solvent extraction and electrowinning.
- Development of an integrated pilot plant including pressure oxidation, atmospheric leaching, solvent extraction, electrowinning, effluent treatment.
- General metallurgical testing.
- Set-up and operation of High Density sludge treatment pilot plant.
- Problem solving related to difficult filtering materials, (i.e. coagulant, flocculant, filter aid, body filter, etc.)

1987 Research Metallurgist and Laboratory Manager, Coastech Research Inc.

Managed flotation, cyanidation, environmental and bioleaching projects. Liaised with clients regarding testing programs, project costs, and data reports.

Managed the bioleach, metallurgical, and environmental testing laboratory. Responsible for warehousing, shipping, receiving, purchasing and maintenance of equipment.

Bioleaching of refractory ore to improve gold and silver recovery. Constructed, installed and developed biomass. Operation of bioleach plant, and construction of continuous bioleaching systems.

Performed full scope of metallurgical testing and environmental soil weathering. Designed and constructed soil weathering cells with a humidifier to simulate wet weather conditions. Tested humidity cells on a weekly basis for metal extraction.



SOHAN BASRA

Director, Global Water Treatment

1984 Research Technician, Cominco Ltd.

Diversity of laboratory tasks in hydrometallurgy and pyrometallurgy including construction of a pilot plant for the production of wood preservative.

Worked on gallium arsenide development in making high purity metals. Designed and constructed high temperature multi-zone furnace for production of high purity arsenic.

1982 Laboratory Supervisor, Equity Silver Mines Ltd.

Supervised lab personnel including work schedules, employee evaluations, quality control, and delegation of duties.

1980 Senior Analyst, Equity Silver Mines Ltd.

Organising and assigned duties to assay offices' shift personnel.

1980 Analyst, Equity Silver Mines Ltd.

Analysis of blasthole and mill samples using atomic absorption method and maintaining the unit.

EDUCATION

1980 Diploma of Technology in Chemical and Metallurgical Technology
British Columbia Institute of Technology (BCIT)

ADDITIONAL TRAINING

Time Management
Attitude Problem-Solving
Team Building
Health & Safety at Hazardous Waste Sites (40 hours) "Superfund Site Certification"

**Education**

M.Sc. Geotechnical Engineering, University of Alberta, Alberta, Edmonton, Canada, 1992

B.A.Sc. Geological Engineering, University of Waterloo, Waterloo, Ontario, Canada, 1988

Golder Associates Ltd. – Edmonton

Dave is an Associate Partner and Senior Engineer with Golder Associates Ltd. and the Geotechnical Engineering Group Manager within the Golder Edmonton office. Prior to moving to Edmonton, Dave was the manager of the Golder Yellowknife office. He has 20 years experience in consulting and industry. He is a Geotechnical Engineer with particular expertise in geotechnical engineering for mining, project management, mine closure, Arctic engineering, slope stability analysis for open pit mines, analysis of underground openings and lab testing. Dave has performed geotechnical engineering services for open pit diamond, gold and coal mines, abandoned northern mines, underground salt and potash mines, the oil and gas industry, developers, manufacturing, transportation, and the oil sands industry.

Employment History***Golder Associates Ltd. –Victoria, BC***

Associate/Office Manager (2011 to Present)

Management of an office of 50 personnel. Project management and senior review engineer on geotechnical engineering and mine closure projects. Active in mining, mine closure and land development projects.

Golder Associates Ltd. – Edmonton, AB

Associate/Group Manager (2006 to 2010)

Manager of the Geoscience/Geotechnical Group. Project management and senior review engineer on geotechnical engineering and environmental projects. Active in mining, transportation, and land development projects.

Golder Associates Ltd. – Yellowknife, NT

Associate/Office Manager (2003 to 2006)

Management of an office of twelve personnel. Project management of environmental and geotechnical engineering projects. Site and dam inspection services for sites across the Northwest Territories.

Golder Associates Ltd. – Yellowknife, NT

Geotechnical Engineer/Office Manager (2001 to 2003)

Management of an office of eight personnel. Project management of a large environmental monitoring project. Site supervisor for a large pipeline investigation project. Management of a large quality control project. Site inspection services for sites across the Northwest Territories.

Golder Associates Ltd. – Calgary, AB

Geotechnical Engineer (1994 to 2001)

Field Engineer and stability analysis services for a wide variety of geotechnical projects. Performed site investigations and computer modelling of slope and waste dump stability for open pit mines. Computer modelling of underground openings for evaporite mines. Supervised laboratory research programs on the



geotechnical properties of tailings, soil, and rock. Supervised engineers-in-training. Laboratory Director of Golder Associates' Calgary geotechnical/materials testing lab.

University of Alberta – Edmonton, AB

Research Engineer (1992 to 1994)

Designed and supervised research programs on the treatment of oil sand tailings. Supervised the geotechnical portion of a field study on non-segregating tailings. Technical direction of a staff of two EITs. In-depth analysis of the performance of non-segregating tailings using a finite strain consolidation program.

Schlumberger – Edmonton, AB

Field Engineer (EIT) (1988 to 1990)

Geophysical logging of oil wells. Supervised and managed a crew of three and a wireline logging unit. Trained several new engineers. Provided analysis and quality control of logs and the calibration and maintenance of equipment.

SELECTED RELEVANT PROJECT EXPERIENCE

Diavik Diamond Mines
Yellowknife, NT,
CANADA

Project management of standing offer agreements to carry out environmental and engineering services to Diavik Diamond Mines Inc. Services offered under the agreements have included support for wildlife monitoring, hydrogeologic testing, geotechnical engineering including pit design, PKC facility review, blasting review, groundwater inflow modelling, underground design and pit wall mapping, and borehole televiewer and core logging services.

AECOM/PWGSC
Yellowknife, NT,
CANADA

Task manager for two tasks as part of the preliminary design for remediation of the Giant Mine Project, Yellowknife NWT. Tasks include identification and investigation of sufficient soil and rock borrow for remediation tasks and preliminary design of tailings and sludge pond remediation.

Canadian Zinc
Nahanni Butte, NT,
CANADA

Completion of annual reviews of the Water Storage Pond flood protection measures and embankments, preparation of the preliminary design for the Water Storage Pond and Waste Rock Storage Facility, review or design of other facilities on site.

DIAND
Yellowknife, NT,
CANADA

Project Manager for aquatic and wildlife monitoring and ecological and human health risk assessment at the abandoned Tundra Mine. The monitoring data and risk assessment results were used by the client to assist in the preparation of the remediation plan for the site.

**Miramar Giant and Con
Mines**
Yellowknife, NT,
CANADA

Project Manager for environmental effects monitoring projects for both the Giant and Con Mines in Yellowknife. The projects consisted of developing the initial monitoring study of the Environmental Effects Monitoring program under the new Metal Mines Effluent Regulations. The projects are three years in duration and include field programs as well as the development of a study design.



De Beers Canada
Yellowknife, NT,
CANADA

Management of the environmental site monitoring activities carried out at the Snap Lake site. Activities that were coordinated included wildlife monitoring, water quality sampling, air quality monitoring, ARD monitoring, vegetation and wildlife health, lake level and stream monitoring, and habitat monitoring.

Mackenzie Gas Project
Inuvik, NT, CANADA

Site supervision of a crew of five personnel for the geotechnical investigation for the Mackenzie Gas Project proposed pipeline within the Inuvialuit Settlement Region. Investigation methods included auger, air rotary, and test pitting. Provided direction to the geophysical and surveying crews. Areas investigated included river crossings, pipeline alignment, and potential borrow source areas.

Diavik Diamond Mines
Lac de Gras, NT,
CANADA

Management of a team of up to 16 people carrying out quality control services for construction of a large dike. Services provided included laboratory testing and field observations of aggregate placement, plastic concrete, jet grout, and structural concrete.

Cleveland Potash
Saltburn, UK, CANADA

Rock mechanics analysis and review to determine the implications of mining to greater depth, to determine the potential for modifying the layout to achieve greater extraction in the shallower areas and to review the roof support procedures. Analysis involved both two-dimensional and three-dimensional modelling.

Canadian Salt
Windsor, ON, CANADA

Analysis of underground instrumentation data. Predictions of the potential for roof failures related to the thickness of the overlying salt beam and vertical convergence. Short- and long-term subsidence prediction analysis.

ASIA-PACIFIC
Udon Thani, Thailand,
CANADA

Underground mine design for inclusion in a bankable feasibility study for a proposed potash mine.

Canadian Salt
Pugwash, NS, CANADA

Pillar review to track pillar performance with time. Design of new deeper mine level, including sill thickness, room and pillar sizes.

Sifto Canada Inc.
Goderich, ON, CANADA

Two- and three-dimensional finite difference analysis of the underground mine area adjacent to three shafts to determine the effect of new mining on the performance of the shafts.

Morton Fairport Salt Mine
Ohio, CANADA

Analysis of creep and floor heave in a salt mine using a finite difference computer program. Recommendations for methods to reduce or prevent floor heave in rooms and access ways.

Solvay Trona Mine
Wyoming, CANADA

Analysis of the buckling of pillars during a large underground mine collapse.

Cominco Potash Mine
Saskatchewan,
CANADA

Analysis of the stresses beneath a potash mine as a function of the width of the mine opening, to determine the potential of hydraulic fracturing beneath the mine.

Potash Corporation of Saskatchewan
New Brunswick,
CANADA

Analysis of creep and the associated deformations and stresses in slopes and ramps in a potash mine due to creep of the potash and backfill. Determination of the allowable separation between stopes.



Resumé

DAVE CAUGHILL

Morton International Louisiana, CANADA	Analysis of the shear stresses near a shaft due to intentional flooding of a nearby drift and preliminary design of bulkheads in the room adjacent to the shaft. Analysis of gas outbursts beneath an existing mine. Annual pillar review to track pillar performance with time.
AKZO Salt New York, CANADA	Study of large-scale pillar failure and mine flooding. Predictions of the effect of room width on yield pillar performance.
Fording Coal, Whitewood Edmonton, AB, CANADA	Two- and three-dimensional stability analysis of a highwall beneath a dragline, both during dragline operation and dragline walkback. Evaluation of groundwater conditions and spoil pile stability.
Golden Sunlight Mine Montana, CANADA	Analysis of creep of a large slide using a finite difference computer program. Two- and three-dimensional stability analysis of rock waste dumps, open pit slopes, and the reactivation of an ancient landslide.
Fording Coal, Genesee Alberta, CANADA	Two-dimensional stability analysis of spoil pile beneath a dragline during dragline operation. Annual geotechnical review of highwall and spoil pile performance.
Prairie Coal, Costello Estevan, SK, CANADA	Stability analysis of highwall and spoil piles for a new mine and analysis of geophysical logs and groundwater data in support of the stability analysis.
Golden Sunlight Mine Montana, CANADA	Logging of core, supervision of drilling, monitoring piezometers, and field inspection for indications of movement of an ancient landslide. Stability analyses of waste rock dumps.
Newmont Gold Mine Nevada, CANADA	Three-dimensional stability analysis of pit slope to allow expansion of the current pit.
Manalta Coal, Vesta Alberta, CANADA	Stability analysis of a highwall beneath a dragline for several new mining configurations. Field inspection of a recurring upper highwall low instability zone.
Manalta Coal, Highvale Alberta, CANADA	Stability analysis of spoil side mining for three different draglines.
Prairie Coal, Utility Saskatchewan, CANADA	Stability analysis and evaluation of dragline bench stability and evaluation of a highwall failure.
Newmont Gold Mine Nevada, CANADA	Three-dimensional finite difference modelling of an underground operation at the base of a pit slope.
Barrick Gold Nevada, CANADA	Three-dimensional finite difference modelling of a pit slope to determine the potential effect of deepening the pit on the potential for movement along a fault zone within the pit wall.
Fording Coal Alberta, CANADA	Pre-feasibility level geotechnical design for a potential strip coal mine.



PROFESSIONAL AFFILIATIONS

Professional Engineer, APEGGA, Alberta.

Professional Engineer, NAPEGG, Northwest Territories

Professional Engineer, APEGBC, British Columbia

Member, Canadian Geotechnical Society

**Education**

B.A.Sc. Geological Engineering, University of British Columbia, British Columbia, 1974

Calgary***Principal, Senior Geotechnical Engineer***

Doug is a senior geotechnical engineer with more than 35 years of experience in geotechnical consulting in western Canada. Doug has performed numerous geotechnical and engineering geology assessments for railways, earth embankments, dams, highways, utility corridors, pipelines, deep foundations and deep excavations. He has also conducted assessments of the potential for slope failures and other natural hazards as they may affect planned or existing developments.

Employment History***Golder Associates Ltd. – Calgary, Alberta***

Senior Geotechnical Engineer, Principal (2006 to Present)

Senior geotechnical review and project direction for infrastructure associated with transportation and oil sands projects.

Golder Associates Ltd. – Calgary, Alberta

Senior Geotechnical Engineer, Associate (1998 to 2006)

Reviewed and managed major developments including dams, structures, urban development, upstream oil and gas and infrastructure. Completed dam design and dam safety assessments.

Thurber Engineering Ltd. – Calgary, Alberta

Senior Geotechnical Engineer (1997 to 1998)

Senior geotechnical engineer based in Calgary focusing on work in the urban development, oil and gas facilities and infrastructure sectors.

AGRA Earth & Environmental Limited – Calgary, Alberta

Senior Geotechnical Engineer, Unit Manager (1992 to 1997)

Senior geotechnical engineer and manager responsible for the operation of a major technical business unit. Duties included technical review, business planning and financial control.

AGRA Earth & Environmental Limited – Nanaimo, British Columbia

Senior Geotechnical Engineer, Office Manager (1987 to 1992)

Senior engineer and manager responsible for a regional, multidisciplinary engineering consulting office. Duties included technical involvement in variety of project types as well as business development and planning.

Island Geotechnical Services Ltd. – Nanaimo, British Columbia

Owner/Principal (1977 to 1987)

Owner and principal of a small geotechnical/materials testing consulting firm.



Dr. F. Patton, P.Eng., B.C. Hydro, Golder, Brawner & Associates Ltd.

– Vancouver, British Columbia

Field Geologist/Geotechnical Engineer (1974 to 1977)



PROJECT EXPERIENCE – POWER

Proposed Wind Farm
Medicine Hat, Alberta

Golder undertook a geotechnical foundation investigation of a select number of proposed wind turbine locations within a planned wind farm in Southern Alberta. The project involved specific investigation of some turbine locations and general reconnaissance of others. Characterization of ground type along potential buried cable routes was also provided. Mr. Pelly provide senior geotechnical review for this project.

River Water Intake
Peace River, Alberta

Various river water intake sites were considered for a proposed nuclear power generations facility. Golder provided preliminary geotechnical assessment of the likely ground conditions at the prospective river water intake sites along with an assessment of the valley wall stability adjacent to those sites. Mr. Pelly provided senior geotechnical review for this work.

Nuclear Power Plant Site
North Central Alberta

As part of an early stage assessment of prospective sites for a proposed nuclear power generation plant, Golder provided geotechnical/geological input to the site selection process. This work generally involved an assessment of available geological data, however, preliminary geotechnical testholes were undertaken at one site. Mr. Pelly provided senior geotechnical review of this assignment.

Wind Farms
Various Locations,
Manitoba

As part of an environmental assessment and permitting assignment, Golder provided input with respect to the likely ground conditions at proposed wind turbine sites in Southern Manitoba. Mr. Pelly provided senior technical review for this aspect of the project.

PROJECT EXPERIENCE – OIL SANDS - INFRASTRUCTURE

**StatOil SAGD Project -
Cheecham Terminal**
Fort McMurray, Alberta

Senior technical review of product storage terminal and pumping station facility. Geotechnical issues at this site included the potential for consolidation with depth below large product storage tanks as well a deep foundation design for other facilities on site and related ancillary structures.

**Kearl Oil Sands Project
- Miscellaneous
Specialist Services**
Fort McMurray, Alberta

Oversight of a multi-disciplinary team that provided specialist technical support to the EPC team for various aspects of the current developments at the Kearl main site. Assignments have included frost heave potential for piles installed at the main electrical substation, review of storm water management facilities, assessment of various embankment stability issues, review of haul road granular structure and potential frost effects in engineered fill placed under winter conditions.

**Kearl Oil Sands Project
- MSE Wall Shear Key
Excavation**
Fort McMurray, Alberta

Provided senior review and project oversight for a geotechnical team that assessed the temporary stability of an excavation up to 30 m deep. The excavation was for a shear key composed of compacted granular soils below a (subsequently constructed) 20 meter high mechanically stabilized earth (MSE) retaining wall. This wall is within the OPP area of the Kearl main site. The assignment included IFC drawings for temporary excavation slopes and seepage interception facilities.



**Kearl Oil Sands Project
- 240 kV Power Line**
Fort McMurray, Alberta

Reviewed the global slope stability of select powerline tower locations, with specific emphasis on power line towers located within or near a currently stable historic landslide approximately 1km in length. This assignment included a review of likely existing stability conditions and development of an on-going monitoring process that is intended to provide an early warning of renewed movement, should that occur. As a result of this assessment, one tower location was eliminated and others adjusted to compensate. Mr. Pelly was responsible for the team that investigated the conditions at the tower locations and provided senior technical review of the work.

**Kearl Oil Sands Project
- River Water Intake**
Fort McMurray, Alberta

Investigated and assessed the slope stability conditions of planned permanent and temporary excavation slopes up to 35 meters high for the river water intake pumphouse and related facilities for the Kearl Oil Sands Project. Mr. Pelly was responsible for a geotechnical team that provided daily slope performance monitoring during the excavation process and periodic monitoring until the temporary excavation had been re-filled.

In addition, he oversaw a multi-disciplinary team that provided specialist technical support to the project management team for the River Water Intake, including H₂S gas safety management, saline groundwater characterization, groundwater interception and management, saline soil stockpile management, excavation spoil stockpile stability, common fill qualification, frost penetration modelling and insulation, PDA monitoring for pile foundations for ancillary structures, IFC drawings for river edge reinstatement, bathymetric surveying adjacent to intake screens, review of upstream wing wall design from a hydraulic and fisheries perspective, review of pipeline installation impact on slope stability and other related services.

**PTI Wapiso Creek
Camp - Septic Field
Siting Study**
Fort McMurray, Alberta

A preliminary geotechnical study was carried out to assist PTI with the siting of a municipal scale sewage disposal facility using ground infiltration as the disposal method. The purpose of the study was to identify land areas of sufficient size that appear to be primarily composed of sandy soils potentially suitable for ground disposal. Mr. Pelly was responsible for the surficial geological interpretive aspects of this work. A combination of test holes in selected areas, review of bare earth, hillshade LiDAR images, stereo airphotos and published surficial geological information was used as part of this assignment.

**Shell Grosmont
Venture - Granular
Resource Assessment**
Wabasca, Alberta

Responsible for a study of potential granular sources within the Grosmont Venture lease lands as well as adjacent lands. This information included remote sensing using stereo airphotos along with helicopter supported reconnaissance. The information from this study was used as part of the granular procurement strategy for the project.

**Shell Grosmont
Venture - Trial Plant
Site**
Wabasca, Alberta

A proposed plant site for a field trial was investigated for the purpose of the planning and design. Mr. Pelly was responsible for the geotechnical aspects of this work with particular emphasis on site preparation, pile foundation design and all-weather access construction.



**Shell Grosmont
Venture - Trial Plant
Site Pipeline Routing**
Wabasca, Alberta

Alternative pipeline routes for product produced from a proposed field trial plant were investigated. These routes included several proposed stream crossings and wetland crossings. Mr. Pelly was responsible for the preliminary geotechnical characterization of the alternative routes using remote sensing techniques such as stereo air photos along with field reconnaissance photos. Anticipation of likely drilling conditions for a number of significant HDD pipeline installation segments was a key part of this assignment.

**ET Energy Project -
Access Route
Selection**
Fort McMurray, Alberta

This project is located on the northern boundary of Ft. McMurray and intends to use proprietary methods for bitumen extraction. Mr. Pelly was responsible for the geotechnical aspects of access route selection, investigating and rating at a preliminary level a number of potential routes connecting Highway 63 north of Ft. McMurray to the project site. Natural slope stability, particularly those portions of the slope affected by the presence of the Clearwater Formation, strongly influenced the final route recommendations.

**Total Energy Joslyn
Creek Mine - Granular
Resource Assessment**
Fort McMurray, Alberta

Worked with the geological personnel within Total to identify and characterize at a preliminary level potential granular resources within and adjacent to the Total leases. This assignment used background understanding of the surficial geology, physical site reconnaissance along with remote sensing techniques such as stereo air photos and LiDAR bare earth, hillshade images to identify potential granular resources.

**Total Energy Joslyn
Creek Mine - Joslyn
Creek Realignment**
Fort McMurray, Alberta

Responsible for the preliminary assessment of natural slope stability along a tributary of the Ells River which is planned for use as part of the Joslyn Creek Realignment project and fisheries habitat compensation. A key geotechnical aspect of this work was the characterization of the Clearwater Formation material into which the small stream valley has been incised. Through-going, weak, clay rich layers within the Clearwater Formation are anticipated to be responsible for continuous slope failures that are believed to form the valley walls. This project involved deep, continuously cored drilling along with the associated core logging and laboratory testing for characterization purposes.

In addition, Mr. Pelly is responsible for the geotechnical aspects of the detailed design and specifications for the Joslyn Creek Realignment and Temporary Stream Re-routing Project currently under development.

**EnCana Foster Creek -
Gathering Pipeline**
Cold Lake, Alberta

Responsible for the geotechnical characterization of anticipated construction conditions for a proposed pipeline from a series of well pads to the Encana plant site. The proposed pipeline route was through a significant amount of organic terrain. A series of shallow boreholes along with terrain mapping techniques using stereo air photos and LiDAR bare earth, hillshade images were used to characterize this pipeline route.

**Shell Jackpine Mine -
Khahago Creek
Diversion Project**
Fort McMurray, Alberta

Characterization of geotechnical conditions along the planned creek diversion, including specific conditions at hydraulic structures and embankments. Mr. Pelly was involved with the review of the geotechnical aspects of the design and specifications for this work.



**Shell Pierre River -
Fisheries Habitat
Compensation Lake**
Fort McMurray, Alberta

Geotechnical review of several conceptual lake configuration options and locations. Geotechnical concerns included: natural slope stability, the presence of extensive peat deposits and potential borrow sources for common and select fill. Estimations of consolidation and stability of the peat due to mineral fill placement overlying the peat were made.

**PetroCanada Fort Hills
Project - Fisheries
Habitat Compensation
Lake**
Fort McMurray, Alberta

Senior geotechnical engineer responsible for all geotechnical aspects of the design and construction of a 15 hectare fisheries habitat compensation lake planned for a location adjacent to the Athabasca River within the Fort Hills Oil Sands Project lease area. This assignment included conceptual planning through to detailed design, specifications and initiation of the first phase of construction. Specific features of the project included geotechnical design of mature landforms separating the proposed lake from the Athabasca River, geotechnical implications of significant groundwater inflow, temporary access IFC drawings for construction down unstable valley slope of the Athabasca River, characterization of the Devonian Limestone for excavation and construction materials purposes and characterization of McMurray Formation oil sands expected to be encountered by proposed lake excavation.

**OPTI Canada - Nexen
Long Lake SAGD
Project**
Fort McMurray, Alberta

This assignment involved the preliminary siting of a proposed storm water retention pond for this major heavy oil extraction project. Mr. Pelly worked with a multi-disciplinary team to establish an appropriate site, from a geotechnical perspective, for this facility within the constraints established by the Environmental Impact Assessment and the physical project needs.

**Tar River Diversion
and Compensation
Lake**
Fort McMurray, Alberta

CNRL has developed a no net loss lake for fish habitat compensation. The development is combined with diversion of the Tar River. Mr. Pelly was responsible for geotechnical review of the construction drawings and construction specifications.

PROJECT EXPERIENCE – LANDFILLS

**County of Grande
Prairie Landfill**
Grande Prairie, Alberta

Was responsible for the development of construction documents for the construction of a small (<10,000 tonnes/yr.) regional landfill facility. The design included the use of site soils as clay liners and the installation of a comprehensive groundwater monitoring system.

**Alberta Special Waste
Treatment Landfill
Facility**
Alberta, Canada

Project Manager responsible for Quality Assurance during the placement of final capping for a major cell within the landfill facility associated with the waste treatment plant. The landfill cells contain cement stabilised hazardous waste and incinerator slag and involve multilayer lining and capping systems. The site is in an area of relatively high precipitation, which presents significant materials handling challenges during placement of liners and clay caps.



**Regional District of
Nanaimo Regional
Landfill**
Nanaimo, British
Columbia, Canada

Reviewed and assembled available geological and hydrogeological information for the purposes of assessing various landfill siting options. Over 20 sites were assessed as part of this assignment resulting in the selection of two candidate sites for detailed geotechnical evaluation. Subsequently, carried out geotechnical investigations on the candidate sites and presented the information at public participation planning sessions.

PROJECT EXPERIENCE – SITE REMEDIATION

**Highway Embankment
Spill**
Chip Lake, Alberta

A tank truck accident resulted in the release of petroleum product onto an embankment beside Highway 16 near Chip Lake. A portion of this product penetrated into the highway embankment soils and remained on site following the initial site clean-up. Final remediation of the site required the removal of the hydrocarbon impacted soils and replacement with clean soils. Mr. Pelly was responsible for developing an excavation program that maintained the stability of the highway embankment.

**Truck Pad Hazardous
Waste Treatment
Facility**
Swan Hills, Alberta

A new concrete pad has been constructed at the Swan Hills Hazardous Waste Treatment Facility. The purpose of this pad is to provide containment for potential hydrocarbon spills during transference between transport trucks and the storage facilities on site. Mr. Pelly was responsible for technical review of the secondary and tertiary liner systems and for the shoring installed to protect the adjacent tank farm.

Light Industrial Site
Alberta, Canada

This project involved the removal of hydrocarbon impacted ground immediately adjacent to, and below, the foundations of this warehouse structure. Mr. Pelly worked with the project team to develop a practical excavation and replacement program while maintaining support for the building foundations and floor slab.

Light Industrial Site
Alberta, Canada

This project involved the removal of hydrocarbon impacted ground adjacent to the foundations for this single storey office / warehouse building. The project used incremental excavation and replacement to remove the hydrocarbon impacted ground while maintaining support for the adjacent foundations.

**Rossland Service
Station**
Edmonton, Alberta

This project involved the removal of hydrocarbon impacted soils to a depth of about 6 meters below the ground surface. Mr. Pelly worked with the project team to develop an excavation process that allowed essentially a vertical cut along the property line adjacent to a major urban road. Incremental excavation procedures coupled with good compaction control during fill replacement resulted in successful completion of this assignment.

**Site Remediation Koch
Charlotte Lake Facility**
Alberta

This project involved the assessment and development of remediation plans for various sites in the vicinity of this facility. Mr. Pelly was responsible for the co-ordination of a multi-disciplinary team that characterised the site conditions and provided site quality assurance during the remedial work.



PROJECT EXPERIENCE – UPSTREAM OIL AND GAS FACILITIES

Chinook Ridge Gas Plant
Grande Prairie, Alberta

Provided senior technical review and project direction for a preliminary drilling investigation for a planned gas plant on Chinook Ridge, south of Grande Prairie. Specific geotechnical issues at this site involved re-use of native ground for general site fill and the presence of very coarse granular soils that may be an obstruction for installation of deep foundations.

Shell Compressor Station
Grande Prairie, Alberta

Provided senior technical review and project direction for a detailed investigation for a compressor site, south of Grande Prairie, Alberta. The project involved characterization of surficial soils, definition of the bedrock surface, recommendations with respect to installation of rock socketed piles, assessment of stability and long term settlement related to placement of mineral fill over peat as well as review of site drainage and storm water management issues. Construction review services were provided.

Husky Sikanni Compressors
Fort St. John, BC

Provided senior technical review and project direction for drilling investigation and geotechnical foundation design for two compressor sites in the Sikanni Chief area of B.C. The project involved characterization of surficial soils and weak bedrock as founding materials for piled foundations for the compressors and ancillary structures.

Shell Carmon Creek Gas Plant Expansion
Peace River, Alberta

Provided senior technical review for a siting study for potential plant expansion sites adjacent to the existing complex. The project involved establishing a general understanding of likely ground conditions based on field reconnaissance, review of stereo airphotos and review of exploratory test holes available in the general area. Two of the proposed sites were subsequently selected for more detailed geotechnical drilling investigation and analysis.

BP Ojay Camp Slope Stability Hazards Study
Tumbler Ridge, BC

Assessed large scale potential natural hazards that could affect the subject camp site. The information provided was used by the client as part of a natural hazards management system for corporate facilities in the region.

Cross Alta Compressor
Beiseker, Alberta

Senior geotechnical review for a planned compressor station near Beiseker, Alberta. Services involved geotechnical investigation along with recommendations for foundation design as well as site preparation. IFC drawings for compressor pad construction, secondary containment general layout, access construction and service areas were prepared for this project.

Penn West Drill Pad
Swan Hills, Alberta

Geological review of large natural historic landslides that are known to exist in the general vicinity of this proposed facility. The purpose of the work was to confirm that the proposed drill pad site will be located outside of the limits of the historic landslides and will not likely be affected by their presence. Mr. Pelly undertook the analysis for this assignment.

Proposed Heavy Oil Well Site
Lindbergh, Alberta

This proposed well site for PetroVera is to be located within a surficial sand deposit up to 10 m thick. This sand deposit acts as a shallow aquifer. Mr. Pelly developed a lease construction program that included a natural clay liner to provide protection for the shallow aquifer from both drilling and operation activities.



**Progress Energy Gas
Plant**
BC, Canada

Mr. Pelly oversaw the site investigation and provided technical review for the geotechnical aspects of site preparation and foundation design for this gas processing plant in northeastern B.C.

**Paramount Resources
Well Site**
NT, Canada

This discovery well site south of Fort Liard was developed in sloping ground and required cuts and fills of up to 9 meters. Mr. Pelly worked with a multi-disciplinary team to develop practical erosion mitigation strategies that took advantage of existing site materials and conditions.

Well Abandonment
Swan Hills, Alberta

A well north of Swan Hills has been affected by movement of near surface soil and rock so that down-hole service tools cannot be used to fully abandon the well at depth. The near surface movement has affected the upper 33 metres of the well. Mr. Pelly reviewed a plan to install a shaft around the subject well to a depth of about 35 metres. The purpose of the shaft is to allow access to the distorted portion of the well casing and tubing so that repair can be undertaken and the well abandoned.

**Pembina Pipelines
Storage Facility**
Valleyview, Alberta

This project involved the rehabilitation of an old existing tank at this facility. Mr. Pelly was responsible for the assessment of the ground conditions and developing the appropriate secondary containment system for the rehabilitated tank. The investigation confirmed the presence of thick natural clay deposits at this site and a new secondary containment system was developed that took advantage of the natural, low-permeability soils at this site.

**Koch Oil Storage and
Blending Terminal**
Hardisty, Alberta

Geotechnical investigation and foundation design for five large oil storage tanks with diameters ranging from approximately 30 metres to 60 metres. The investigation involved the use of a piezocone to penetrate dense sands and investigate soft glacio-lacustrine silt and clay that exists at depth.

**Moss Lake and
Portage Compressor
Sites**
Alberta, Canada

Geotechnical site investigation and foundation design for these two compressor sites near Lac La Biche, Alberta Steel pipe pile foundation design recommendations for the compressors and ancillary structures were provided. The Portage site involved the installation of a large communications tower with significant peak uplift loads on the foundations. Various tension pile alternatives and configurations were considered.

PROJECT EXPERIENCE – DAMS AND EMBANKMENTS

**Canyon Dam Tunnel
Rehabilitation**
Canmore, Alberta

Golder was retained by TransAlta to review the current conditions within a low level outlet tunnel for this dam which is part of the Spray Lakes Reservoir system. The assignment included development of design of rehabilitation works within the tunnel and production of IFC drawings for that work. Mr. Pelly provided project direction for this assignment.



Potential Hydro Sites
Central Alberta

A review of two potential hydro power sites in Central Alberta was undertaken. Golder provided geotechnical/geological assessment of the two sites for the purposes of supporting a preliminary project costing exercise. This work included a review of available borehole information, available geological mapping, stereo air photos and bare earth, hillshade images developed from LiDAR data. Mr. Pelly provided senior technical review and project direction for this assignment.

**Carseland – Bow Canal
Rehabilitation (Reach
2)**
Carseland, Alberta

The Carseland – Bow Canal is part of a major irrigation system in the southern part of Alberta. The canal was initially constructed several decades ago and is currently in a multi-year program of repair and rehabilitation. Mr. Pelly was involved with the geotechnical aspects of canal widening and re-grading, for Reach 2 including an assessment of the stability of the proposed new excavation slopes. A key issue on this project was the potential erodability and frost susceptibility of the exposed soils. Construction of Reach 2 was completed in the spring of 2004.

**Meridian Dam Pre-
Feasibility Study**
Medicine Hat, Alberta

The Meridian Dam is a large embankment dam proposed for a location on the South Saskatchewan River a short distance upstream of the Alberta – Saskatchewan border. The intent of the pre-feasibility study was to determine the economic viability of the proposed water supply project and to assess the environmental and economic impact of the proposed reservoir. Mr. Pelly was responsible for the conceptual geotechnical design of the dam and appurtenant structures. He also assessed the effects on transportation as well as oil and gas infrastructure and provided input to the project team during the cost estimation process.

**Bearspaw Dam Safety
Review**
Calgary, Alberta

The Bearspaw Dam is a water control and hydro-electric generation facility on the Bow River upstream from Calgary. The dam is operated by TransAlta Utilities Ltd. Mr. Pelly provided geotechnical input to a recently completed dam safety review at that site.

**Wabamun Power Plant
Lagoon**
Wabamun, Alberta

A dam safety review of the embankments that form the lagoon at the Wabamun Power plant has recently been completed. The purpose of the review was to provide confirmation to the owner, TransAlta Utilities Ltd. that the facilities meet the requirements of the CDA Dam Safety Guidelines. Mr. Pelly was responsible for technical review of the geotechnical aspects of this project.

**Waterton Dam Safety
Review**
Waterton, Alberta

The Waterton Dam is a zoned earth fill dam up to 56 meters in height, located on the Waterton River in the southwest corner of Alberta. Major reviews of dam safety issues at this important dam are undertaken approximately every 5 years. Mr. Pelly was responsible for the geotechnical aspects of the 2000/2001 safety review and co-ordinated the activities of the multi-disciplinary review team. Special aspects of the review involved the establishment of appropriate earthquake design criteria and undertaking a preliminary assessment of the effects of earthquake loads on the stability of the dam.



**Iron Ore Company of
Canada Dump Ponds**
Labrador, Canada

As part of a major tailings confinement project, the Iron Ore Company of Canada is planning the construction of a series of ponds designed to capture emergency and on-going discharges from the various portions of the tailings transportation system. The ponds are located within areas of old tailings with high ground water levels and are designed to be dredged annually. Mr. Pelly was responsible for the geotechnical aspects of the dump pond designs and co-ordinated the development and production of the construction drawings and specifications.

**Iron Ore Company of
Canada, Tailings
Confinement Dykes**
Labrador, Canada

This project involves the construction of tailings confinement dykes within Wabush Lake, Labrador, to provide confinement for on-going tailings production from the nearby mining operations. The dykes will be constructed of coarse rock fill and are to be placed in up to 20 meters of water. The dykes will be in excess of 15 kilometers in total length when fully constructed. Mr. Pelly was responsible for the development and production of the construction drawings and specifications for this project, including the development and exploitation of borrow sources for various construction materials.

**Beauvais Lake Dam
Rehabilitation**
Pincher Creek, Alberta

Beauvais Lake Dam is a small earth fill dam that forms a recreational lake in southwestern Alberta. Floods associated with heavy precipitation 1995 overtopped a portion of this dam, causing minor damage to the embankment and outlet works. A plan to upgrade the dam and increase its capacity to pass the design flows has been developed and implemented by Alberta Environment. Mr. Pelly undertook the detailed site investigation and was responsible for the geotechnical aspects of the rehabilitation design. Construction of the upgraded dam and spillway was completed in the spring of 2004.

Arrowsmith Lake Dam
Parksville, BC

Arrowsmith Lake is located on a tributary of the Englishman River on Vancouver Island. The reservoir formed by the dam is acts as a balancing reservoir for the Englishman River, allowing water extraction while maintaining vital minimum flows for fisheries purposes. The lake is located on the flanks of Mr. Arrowsmith and is surrounded with glacially modified bedrock terrain. Mr. Pelly carried out the preliminary geological assessment of the dam site and reservoir, including an assessment of the potential borrow sources and construction access restrictions.

Water Supply Dam
Addis Ababa, , Ethiopia

Preliminary design for a water supply dam located northwest of Addis Ababa in Ethiopia was carried out with funding assistance from CIDA INC. The dam was intended to be an earth fill structure and the water was to be conveyed from the reservoir to Addis Ababa through a combination of pipelines, open canals and a 4 km long rock tunnel. Mr. Pelly was responsible for the administration of this project.

PROJECT EXPERIENCE – FOUNDATIONS/DEEP EXCAVATIONS

**EnCana Tower (The
Bow) - Preconstruction
Condition Survey**
Calgary, Alberta

Senior review and project direction for a pre-construction condition survey of streets, sidewalks and building facades for buildings adjacent and across the street from the proposed deep excavation for The Bow tower.



**Foothills Medical
Centre**
Calgary, Alberta

Senior review and project direction for the McCaig Tower foundations and deep excavation. The foundations included deep, cast-in-place concrete piles. A feature of this project was the undertaking of a full scale Osterberg Cell pile load test to confirm both end bearing and skin friction components of pile design. The results of the test allowed savings in both diameter and depth of the production foundation piles.

Technical review of aspects of the excavation shoring and foundation design for a new 4 level underground parkade immediately adjacent to the McCaig Tower was also provided.

**Marbella Properties
Development**
Calgary, Alberta

Senior review and project direction for a preliminary geotechnical investigation for a proposed hi-rise commercial / residential development adjacent to the Stampede Grounds. This proposed development would include a deep excavation to accommodate potentially up to 6 levels of underground parking. A feature of this site is the presence of thick saturated gravel within the excavation zone and control of water inflow to the excavation would be a key design and construction issue.

**7th Avenue and 8th
Street SW Commercial
Building**
Calgary, Alberta

Senior review and project direction for a preliminary and detailed geotechnical investigation for a proposed hi-rise commercial building on 7th Avenue, S.W. between 8th and 7th Streets, S.W. in Calgary. This development included a shored excavation to accommodate 3 levels of underground parking immediately adjacent to a City park and the LRT on 7th Avenue.

**Recreation Complex
Upgrades**
Banff, Alberta

Senior technical review and project direction for a geotechnical investigation for a major upgrade of an existing skating arena and curling rink in the Town of Banff. A geotechnical issue that arose at this site was the potential for liquefaction of thick deposits of sandy soils at this site due to shaking from the design earthquake. Additionally, differential settlement associated with the placement of new site fill and new building loads adjacent to the existing structure was addressed during site preparation.

Bentall Development
Calgary, Alberta

Senior technical review and project direction for a preliminary geotechnical investigation for a proposed residential hi-rise building at 16th Avenue and 12th Street SW, in Calgary. This building is proposed to include a deep, shored excavation that may accommodate up to 5 levels of underground parking.

**Keephills Power Plant
Expansion**
Keephills, Alberta

The Keephills facility is a coal fired power generation plant, constructed in the early 1980's. A 900 MW expansion to the plant was proposed for 2001 and a geotechnical investigation for that expansion was undertaken. Golder Associates Ltd. was retained, on behalf of a major international design/build contractor to provide a quality assurance function during the geotechnical field investigation and laboratory analysis. Mr. Pelly oversaw the review team and provided additional geotechnical input for use by our client in the preliminary design and bid preparation process.

**Goreway Power Plant
Expansion**
ON, Canada

Mr. Pelly acted as project manager for a Golder review team that provided geotechnical input to a major international design/build contractor bidding for the expansion project. The team reviewed existing geotechnical data and provided recommendations regarding various foundation design and construction options.



Marquis Condominium Development
Calgary, Alberta

Review of exposed ground conditions during the excavation for a two level below ground parkade for this 17 storey residential tower in downtown Calgary. The assignment involved preparation of technical specifications for the excavation and shoring contract, monitoring of adjacent structures, review of foundation conditions, compaction control and concrete testing.

ICT Building, University of Calgary
Calgary, Alberta

Geotechnical investigation and foundation design for the 8 storey Information & Communications Technology Building at the University of Calgary. This building is founded on bored, belled, cast-in-place concrete piles that extend up to 24 meters below the ground surface. The assignment included review of pile installation, compaction control of backfill and concrete testing for the piles, foundations and superstructure of the building.

TCPL Tower
Calgary, Alberta

Review of geological conditions exposed during excavation of the below ground parkade structure for this 37 storey office tower in downtown Calgary. The excavation extended 15 to 18 meters below adjacent street level and was shored with a tied back H-pile and timber lagging shoring system. The assignment involved continuous inspection during the installation of the shoring, review of exposed foundations conditions, review of the installation of permanent drainage facilities and compaction control of the backfill surrounding the completed structure. The assignment also included concrete testing for the structure, including sampling and testing of 80 mPa design strength concrete.

Banff Springs Hotel
Alberta, Canada

Review of geological conditions exposed during excavation for the foundations of an addition to the Banff Springs Hotel. Adverse bedrock orientation and the configuration of the proposed excavation required that the existing building façade be supported with a shotcrete and rock anchor shoring system.

3rd Street Parkade
Calgary, Alberta

Review of the foundation conditions of an existing multi-level, above ground parkade at 3rd Street and 9th Avenue S.W. in downtown Calgary. Plate bearing tests were carried out to confirm the allowable bearing capacity of the existing footings to assess their capacity to carry additional structural load.

Koch Oil Storage and Blending Terminal
Alberta, Canada

Geotechnical investigation and foundation design for five large oil storage tanks with diameters ranging from approximately 30 - 60 metres. The investigation involved the use of a piezocone to penetrate dense sands and investigate soft glacio-lacustrine silt and clay that exists at depth.

Ninth Avenue Parkade
Calgary, Alberta

Site investigation and geotechnical design for the foundations of a multilevel parkade structure between 5th and 6th Streets on 9th Avenue S.W. This project involved an excavation approximately 7 meters in depth below adjacent street level. Variable groundwater levels were accommodated in the floor slab and below grade wall designs.

Prince's Island Estates
Calgary, Alberta

Site investigation, geotechnical design, and construction inspection of a 10-storey condominium project, adjacent to the YMCA, in downtown Calgary. This project involved an excavation for underground parking approximately 5 to 6 meters below the adjacent ground surface. Accommodations for potential high groundwater levels associated with flooding in the Bow River were made in the design of the floor slabs and foundation walls.



Emergency Power Project
Alberta, Canada

Investigation, foundation design and construction supervision for this fast-tracked power project in Tanzania. Practical combinations of sound geotechnical principles with local construction techniques resulted in the saving of several weeks in a tight construction schedule.

Eau Claire Lookout
Calgary, Alberta

Site investigation and geotechnical design of a 12-storey condominium project on 2nd Ave. between 7th and 8th Street S.W. in downtown Calgary. This project involved an excavation up to approximately 5 meters below adjacent street level. Unusually high groundwater levels during winter construction were encountered on this project and were accommodated in the foundation construction process.

Log Dewaterer, Harmac Pulp Mill
Alberta, Canada

Investigation, design and construction inspection of a large crane used to remove log bundles from the ocean adjacent to the Harmac Pulp Mill. This project involved the construction of high tensile capacity, cast-in-place concrete filled steel pipe piles in a marine condition.

Peter Lougheed Hospital Expansion
Calgary, Alberta

Senior geotechnical review of the investigation, design and foundation construction for a major addition on the west side of the hospital. This project involved a basement excavation for the addition as well as drilled cast-in-place concrete piles.

PROJECT EXPERIENCE – PIPELINES

Water Pipeline
Vermilion, Alberta

As part of regional upgrades to the water supply system in vicinity of the Town of Vermilion, a new 14 km long pipeline was proposed. To limit surface disturbance associated with the construction of this line, most of the line length was planned to be installed using trenchless techniques. Golder undertook an investigation along the proposed pipeline route and provided a characterization of the ground conditions encountered. Mr. Pelly provided senior technical review for this project. The pipeline was successfully installed using trenchless techniques.

HDD Crossing of Slave River
Slave Lake, Alberta

A proposed crossing of the Slave River, downstream from Slave Lake is proposed using HDD pipeline installation techniques. Golder provided a preliminary assessment of the likely ground conditions along with a recommended HDD drill path. Mr. Pelly provided senior technical review for that project.

Fort Hills Project - Proposed Pipeline
Fort McMurray, Alberta

Golder provided environmental and regulatory support services to the pipeline company for a proposed sales line from the Fort Hills Oil Sands Project. Mr. Pelly provided geotechnical input to the environmental services package, particularly with respect to the assessment of natural slope stability issues that may affect the proposed pipeline route.



HDD Failure Grande Prairie, Alberta	A directionally drilled pipeline installation was being constructed from a drill pad to pass under a regional resource access road, an existing pipeline and an adjacent protected forest area. The planned exit for the HDD drill path was approximately 30 m higher than the entrance and approximately 300 m horizontally. The drill encountered saturated sand and gravel and produced significant water/mud flow from the drill hole collar. The flow was significantly more than could be contained on the drill pad. Golder worked with the resource company to stop the flow, properly abandon the hole and plan a new drill path. Mr. Pelly provided senior technical review for this work.
Gas Gathering System Buffalo Lake, Alberta	A sales line from a gas well system operated by Cordero Energy was installed across a relatively narrow portion of Buffalo Lake using HDD techniques. Golder was responsible for the investigation of the geological conditions along the proposed 400 meter long HDD route and to develop a conceptual drill path. Mr. Pelly was the senior technical reviewer for the HDD portion of this project.
Shell Basin Centered Gas Project Grande Prairie, Alberta	Shell Canada Inc. completed a number of gas well tie-ins during the winter of 2006 within their Basin Centered Basin Centred Gas project south of Grande Prairie. Golder investigated the ground conditions for the number of small directionally drilled crossings of swamps and small creeks within this gathering system. Mr. Pelly was the senior geotechnical reviewer for the geotechnical aspects of this project.
North Saskatchewan River Crossing Drayton Valley, Alberta	A pipeline route that involves a crossing of the North Saskatchewan River was proposed for a location approximately 30 km southwest of Drayton Valley. The proposed pipeline route parallels existing conventional and drilled crossings of the river. Golder was responsible for the preliminary assessment of the geological conditions along the proposed 300 meter long HDD route as well as the preliminary planning of the proposed drill path. Mr. Pelly was involved in this project as senior technical reviewer.
Gas Gathering System Grande Prairie, Alberta	Shell Canada Inc. proposed a crossing of Nose Creek, south of Grande Prairie to connect gas wells to their gathering system. The creek is within a glacial outwash valley that contains abundant deposits of coarse cobbly material. Golder was responsible for the preliminary assessment of the geological conditions along this proposed 200 meter HDD crossing as well as two other small creek crossings along the proposed pipeline route. The project was planned for construction in the winter of 2006/2007 but is currently on hold. Mr. Pelly undertook the field reconnaissance portion of this assignment and is the senior technical reviewer for continuing work.
Pipeline Trench Fill Performance Review BC, Canada	Spring run-off in the first year following winter construction caused localized trench fill erosion and deposition of sediment into a nearby fish-bearing stream. Mr. Pelly reviewed the geotechnical aspects of this construction and provided an opinion regarding the probable causes of the event. A component of this situation was the formation of a continuous void hundreds of meters long adjacent to the pipeline due to thawing/consolidation of fill within a circular zone around the pipe while the remainder of the trench fill remained frozen.



**Winter Geotechnical
Drilling Program (ISR)**
NT, Canada

ColtKBR on behalf of the McKenzie Gas Project undertook a winter geotechnical drilling program within the Inuvialuit Settlement Region in 2003. For this program Golder Associates provided a number of technical field crews to supervise drilling and test pitting programs set up for this project. Mr. Pelly provided management support for this program and worked with the geotechnical project team towards the successful completion of this work.

**Winter Geotechnical
Drilling Program (GSA)**
NT, Canada

ColtKBR on behalf of the McKenzie Gas Project undertook a winter geotechnical drilling program within the Gwich'in Settlement Area in 2003. For this program Golder Associates provided a number of technical field crews to supervise drilling and test pitting programs set up for this project. Mr. Pelly provided management support for this program and worked with the geotechnical project team towards the successful completion of this work.

Gas Gathering System
NT, Canada

A 70km gas gathering system is proposed by Anadarko Canada Corporation to service their wells northeast of Fort. Liard. The system will include a gas mainline, laterals, processing facilities, and an all weather access road. The project is located within discontinuous permafrost terrain. The project included the review of a number of minor stream crossings and the assessment of those crossings for pipeline installation using Horizontal Directional Drilling techniques. Mr. Pelly was responsible for putting together an overall geological understanding of the likely conditions along the route and worked with the client's field personnel to adjust the proposed route to take advantage of ground conditions wherever possible.

**Pipeline Routing –
Long Lake SAGD
Project**
Long Lake, Alberta

A geotechnical assessment of a proposed route for the sales line from the Opti-Nexen Long Lake project was carried out. The assessment included a review of available air photos and a site reconnaissance of individual water crossing locations along the route. Horizontal Directional Drilling techniques were planned for use at each of the crossings. Mr. Pelly was responsible for the geotechnical aspects of this work and provided conceptual drill path drawings and a recommended investigation program for use in planning the construction and crossing specifications.

**Hay River Drilled
Crossing**
Northeast BC, , Canada

Husky Oil installed a gas gathering pipeline in 2004 to service a number of their wells just west of the Alberta / B.C. border. Part of the route of this pipeline crosses the Hay River, a major, flat gradient stream and horizontal directional drilling techniques were used to undertake this crossing. Mr. Pelly was responsible for the overall management of the geotechnical aspects of this project and provided senior geotechnical review for the investigation, the HDD drill path design, specifications and construction supervision.

**Little Hay River Drilled
Crossing**
Rainbow Lake, Alberta

Husky Oil installed some oil gathering lines to service existing wells in this area west of Rainbow Lake, Alberta. The crossing of the Little Hay River involved both an oil line and a produced water pipeline. The crossing was undertaken using directional drilling techniques. Mr. Pelly was responsible for the assessment of the likely geotechnical conditions at this site and the development of a conceptual drill path for planning purposes.



Hotchkiss River Drilled Crossing
Manning, Alberta

ARC Resources has installed a pipeline crossing the Hotchkiss River north of Manning, Alberta. Mr. Pelly was responsible for assessing the likely geotechnical conditions at this site and providing a conceptual drill path for planning and decision making by the client. The pipeline was installed in 2004 and encountered conditions similar to those anticipated.

Pipeline Construction Permitting Support
Northeast BC,, Canada

Golder Associates provided permitting support for the 2005 pipeline construction program for the Husky Oil pipeline system in Northeast B.C. The project included geotechnical assessment of approximately 30 stream crossings, resulting in the recommendations for the use of horizontal directional drilling techniques for approximately 15 crossings. Due to floodplain widths and setback requirements, these crossings range from about 120 meters in length to 400 metres. Mr. Pelly was responsible for the geotechnical aspects of this work and was the senior technical reviewer on the project.

Proposed Grewatsch Creek Drilled Crossing
Fort St. John, BC

Thunder Energy proposed construction of a crossing of Grewatsch Creek, approximately 150km northwest of Fort. St. John, B.C. This crossing involves a steep, unstable slope on the north side of the creek and will result in a horizontal directionally drilled path approximately 250 meters in length with 60 meters elevation difference from entry to exit location. Mr. Pelly has provided an overall geotechnical assessment of the likely conditions at this site and has provided suggestions for alternate routes to consider that will reduce the technical difficulties associated with the proposed horizontal drilling program.

Proposed Chicken Creek Gas Pipeline
Fort Nelson, BC

A single well gas tie-in was proposed by Murphy Oil for the environmentally sensitive Chicken Creek Valley, southwest of Fort Nelson. Mr. Pelly was project manager and geotechnical lead for a multi-disciplinary team that examined various construction methods and detailed route adjustments intended to avoid or minimize site disturbance. Issues considered included impact to vegetation, impact to wildlife, and risk to the pipelines due to a highly active mountain stream, mountain slope stability, winter constructability, post-construction access restriction, emergency access, post-construction reclamation, and end-of-life abandonment. A practical construction plan was developed, acceptable to both the proponent and the regulators.

Bittner Creek Pipeline Replacement
Prince George, BC

Husky Oil has replaced a short section of oil transmission pipeline near Prince George, B.C. The subject section of pipeline underlay a small seasonal stream known at Bittner Creek. Mr. Pelly was responsible for the pre-construction geotechnical investigation program aimed at assessing the ground conditions at this site. The team also assessed the fisheries habitat conditions of this site and developed an isolated trench construction program acceptable to the regulators.

Cameron Hills Gas Gathering System
NT, Canada

As part of an on-going post-construction reclamation project Golder Associates has provided Paramount Resources with a reclamation plan focussed on controlling surface drainage and encouraging re-vegetation along this pipeline right-of-way through discontinuous permafrost terrain. Mr. Pelly was responsible for the geotechnical aspects of this work, including discussions with regulators on these issues. The project also involved review of fill embankment performance for the approach fills for permanent access bridges constructed at the major streams.



Maxhamish Lake to Fort Liard Gas Gathering System NT, Canada	Site drainage and erosion issues on a specific well site required rehabilitation to augment the existing system. Mr. Pelly was responsible for assessing the site conditions and providing a winter program to improve drainage and erosion protection conditions on site.
Numac Joffre Pipeline Alberta, Canada	Review of valley wall geological conditions in advance of crest to crest HDD crossing of tributary of Red Deer River. The review was based on air photo interpretation and geological mapping of exposures within the valley. The crossing was subsequently installed successfully.
Mooselake River Crossing Bonnyville, Alberta	Review of geological conditions in advance of 170 m shore to shore HDD crossing of Mooselake River, downstream of Moose Lake, near Bonnyville. The review was based on air photo terrain analysis and on site assessment of ground conditions. The crossing was subsequently installed successfully.
Prophet River Crossing Fort Nelson, BC	Geological reconnaissance, drill hole investigation and geophysical assessment of proposed 400 meter shore to shore HDD crossing of Prophet River, south of Fort Nelson. Assignment included compilation of geological report for the proposed crossing, including establishment of recommended drill path.
CWNG Pipeline Canmore, Alberta	Review of exposed soil and rock conditions at various locations along this route, and provision of geotechnical recommendations for trench excavation and re-instatement. Provision of geotechnical input to the design and construction of the conventional crossing of the Bow River, near Canmore.
Thicksilver Pipeline Project Alberta, Canada	Geotechnical assessment of potential crossing options for the Beaver River Crossing. Both directionally drilled and conventional crossings were considered.
Ranger Pipeline Yukon, Canada	Review of available geological information from published sources, recent boreholes and stereo air-photos. The information was used to assess the feasibility of directionally drilling a crossing through a mountain saddle. Other crossing locations were significantly restricted by the risk of re-activating past mountain slope failures.
Palliser Pipeline Project McNeill, Alberta	This proposed pipeline in South Central Alberta involved approximately 250 km of mainline and up to 700 km of laterals. The project included route selection and assessment of river and creek crossings as well as the investigation and preliminary design of several directional drill crossings of major streams. In particular, Mr. Pelly was involved with the preliminary design of a directional drill crossing of the South Saskatchewan River near McNeill, Alberta.
North Caroline Gas Pipeline, Amoco Petroleum Alberta, Canada	Existing gas pipeline in area of periodically active slope movement. Assessment of air photos and review of site conditions following recent slope movement.
Vancouver Island Gas Pipeline Nanaimo, BC	Major buried gas pipeline route 480 km long with three marine crossings. Reconnaissance assessment of portions of the route with particular emphasis on stream crossings between Nanaimo River and Qualicum River.



**Water Supply Pipeline
Twinning**
Nanaimo, BC

30 km long, 1.2 m diameter water supply pipeline for the City of Nanaimo. Detailed, pre-construction assessment of ground conditions along the proposed route, including investigation and remediation of the crossing of an abandoned, near surface, coal mine access tunnel.

PROJECT EXPERIENCE – TRANSPORTATION/ACCESS ROUTES

**Highway 27 Re-
Routing**
Olds, Alberta

Golder has undertaken a preliminary geotechnical assessment for proposed re-routin of Highway 27 past the Town of Olds. Prospective routes extend around the Town to the north and to the south. This assignment provided input to a functional planning study examining the two major re-routing options. Mr. Pelly provide senior technical review for this work.

Highway 22X Twinning
Calgary, Alberta

Golder has undertaken a preliminary geotechnical assessment of a proposed highway twinning project for 16.5 km of highway east of Calgary. This assignment provided input to a functional planning study for the proposed twinning project. The study included a review of route and intersection options for Highway 791 where it meets with Highway 22X. Mr. Pelly provided senior technical review for this assignment.

**TransCanada Highway
Twinning Project - km
76 to km 81**
Lake Louise, Alberta

Golder has undertaken a geotechnical investigation for this section of highway upgrading west of Lake Louise to the BC border. This work was done as part of a P-3 team for this project. The assignment has included geotechnical recommendations and design for bridge structures, MSE retaining walls, major culverts, the animal underpass at km 76, major cut stability and related topics. Mr. Pelly has provided senior review for portions of this work.

**TransCanada Highway
Twinning Project - km
59 to km 68.5**
Lake Louise, Alberta

Golder undertook a geotechnical investigation and provided detailed geotechnical recommendations for the design of this section of highway upgrading through Banff National Park, east of Lake Louise. This assignment included a review of natural slope stability, detailed design of pile foundations for structures, field review of some of the pile installations, static pile load tests, re-use of excavated ground as road embankment fill, retaining walls, major culverts and animal overpasses. This assignment also included investigation and design recommendations for an animal underpass at km 76, an animal overpass east of the Jasper Highway interchange and a pedestrian underpass adjacent to the Village of Lake Louise. Mr. Pelly provided senior technical review for most of this work and was the overall project direct.

South LRT Extension
Edmonton, Alberta,
Canada

The City of Edmonton proposed a southward extension of the LRT system from the existing University Station. Twin 6 m diameter tunnels were planned to extend from the University Station, to a cut and cover section approximately 300 m away. The alignment passes under two existing University buildings. Golder Associates was responsible to characterize the ground conditions at this site. Mr. Pelly was project manager for this assignment and co-ordinated the efforts of geotechnical and hydrogeological personnel from the Calgary and Mississauga offices. The project has been constructed.



Highway 36:02 Lethbridge, Alberta	Reconnaissance & site investigation for a large bedrock/soil failure on the valley wall of the Chin Coulee Reservoir in southern Alberta. Further movement of this slide mass could affect a regional highway immediately adjacent to the slide crest. Analysis of precipitation records was carried out identifying possible threshold conditions for failure and to estimate the frequency of future slide movement events.
Highway 3:06 Pincher Creek, Alberta	Review of air photos to determine history of slope instability on the Oldman River valley wall immediately adjacent to the highway.
Mile 16.0 Fording Subdivision, CP Railway Sparwood, BC	Review of existing cut and fill slopes for 1/3 mile long segment adjacent to an operating railway. Assignment included mapping surficial soils and bedrock exposures, establishing probable slide mechanisms and developing remediation options.
Kilometre 535, Alaska Highway Public Works Canada Fort Nelson, BC	Review of 30 to 40 metre high rock cuts constructed as part of upgrading work on the Alaska Highway. This assignment included characterizing the anticipated cut conditions and reviewing proposed cut slope angles and ditch volumes. In addition, review of constructed rock cuts was also carried out to confirm exposed conditions and to assess the effects of blasting on the constructed cuts.
Hay River Highway Chip Seal NT, Canada	Project management and overview of a chip seal project on approximately 40 km of northern 2-lane highway.
Drill Site Access, Tarragon Oil and Gas BC, Canada	Geotechnical review of proposed 17 km access route, with three significant stream crossings and the development of a lease site on sloping ground.
Inland Island Highway Parksville to Qualicum Beach Parksville, BC	This 4-lane divided highway by-passes the towns of Parksville and Qualicum Beach. Mr. Pelly was involved in the detailed investigation and geotechnical design of the proposed highway.
Nanaimo Bypass Nanaimo, BC	This 4-lane urban highway provides a north-south traffic route through the City of Nanaimo. Work involved preliminary route selection, avoiding the abandoned underground coal mines where practical. Subsequent assignments included detailed investigation and design of a segment of the route, with particular attention to the issues associated with construction over abandoned coal mines. Remediation techniques included dynamic consolidation and select grouting of segments of the abandoned mines.
Malahat Highway Victoria, BC	This assignment included reconnaissance, site characterization and design recommendations for a 4-lane divided highway through mountainous, rocky terrain. The work involved both widening of the existing route and the selection and design of new segments of highway.
Various Sites BC, Canada	Numerous urban residential and collector roads in various municipalities in B.C. and Alberta. Services have included routing assessments, detailed investigation and design, construction supervision / quality control and failure analysis of subgrade and pavement structures.



PROJECT EXPERIENCE – NATURAL HAZARDS/SLOPE FAILURES

**Natural Slope Stability
Assessment**
Calgary, Alberta

Golder has provided a preliminary review of the natural slope stability along the edges of the Glenmore Reservoir, immediately south of the Glenmore Trail Causeway. The length of shoreline is approximately 1.8 km. The purpose of the review was to provide planning recommendations for the development of an extension to the Regional Pathway system through this area. Mr. Pelly provided senior technical review and project direction for this assignment.

**Natural Slope
Stabilization**
Calgary, Alberta

Golder has undertaken an investigation and analysis of recent slope failures that have occurred in southeast Calgary on the Bow River valley slope that exists between Deerfoot Trail and Blackfoot Trail near Southland Drive. The slope failure(s) have an accumulated length of approximately 600 m along the slope. This assignment included developing a stabilization design and the production of IFC drawings and specifications for this work. Mr. Pelly has provided senior technical review and project direction for this work.

**Prairie Creek Mine
Access Route**
Nahanni Butte, NT

A winter access route from the Liard Highway to the mine was constructed in the 1980's, was used two seasons and has remained dormant since that time. The current mine owners are planning to re-activate this seasonal access route, part of which is now within the expanded Nahanni National Park. Mr. Pelly provided an assessment of the terrain hazards that exist along the proposed route and provided recommendations for route adjustments to avoid some of the terrain challenges. Of particular note is a section of the existing route that passes through an intensely karstified landscape. An alternative route that avoids these landscape features has been proposed as part of the current route plans.

**Waskasoo Creek
Valley Slope Stability**
Red Deer, Alberta

This assignment involved the assessment of slope stability conditions affecting 3 houses on Grandview Boulevard in Red Deer, Alberta. Periodic movement of portions of the valley slope has occurred since the subject houses were constructed in the 1950's. Recent movements have caused minor distress to the subject houses and significant damage in the rear yards. A concern existed that future slope movements could significantly damage the houses. Mr. Pelly was responsible for the development of mitigation options that could be implemented in a staged approach.

Bester Residence
Alberta, Canada

This residence is located near the crest of a steep slope in Canmore, Alberta. The property was affected by flooding due to a broken water service resulting in water damage within the basement level of the house and emergency excavation around the outside of the building foundation. A concern existed with respect to the potential long term effects of the flooding on the building foundations and overall slope stability. Mr. Pelly undertook an assessment of the site conditions, provided recommendations for improved site drainage and provided comments on the overall slope stability issues.

Highway 36:02
Alberta, Canada

Reconnaissance & site investigation for a large bedrock/soil failure on the valley wall of the Chin Coulee Reservoir in southern Alberta. Further movement of this slide mass could affect a regional highway immediately adjacent to the slide crest. Analysis of precipitation records was carried out identifying possible threshold conditions for failure and to estimate the frequency of future slide movement events.



**Mile 16.0 Fording
Subdivision, CP
Railway**
BC, Canada

Review of existing cut and fill slopes for 1/3 mile long segment adjacent to an operating railway. Assignment included mapping surficial soils and bedrock exposures, establishing probable slide mechanisms and developing remediation options.

Terrain Mapping
Golden, BC

TSIL D mapping was carried out in several watersheds totalling about 70,000 hectares within the Golden Forest District. Highly variable terrain presented a significant air photo interpretation and mapping challenge.

**Bourgeau Parking Lot
at Sunshine Ski Resort**
Banff, Alberta

Preliminary assessment of slope conditions adjacent to the existing parking lot for the purpose of potential expansion of the parking area. Assessment of rock fall and avalanche hazard was involved.

**Petrocan Gas Well on
Trutch Creek**
BC, Canada

Site reconnaissance and geotechnical assessment of an existing sour gas well located within a large soil and rock landslide.

**Canadian Natural
Resources Babcock
Mountain**
BC, Canada

Site reconnaissance and geotechnical assessment of two existing sour gas wells on Babcock Mountain in an area of large, post-glacial landslides. The investigation included surface plant, access routes and pipeline routes.

**Service Road Failure,
Amoco Petroleum**
Alberta, Canada

Site investigation and recommendations for remediation of a small slope failure adjacent to a pipeline corridor and service road.

**Slope Failure, Shell
Jumping Pound Plant**
Alberta, Canada

Geotechnical assessment of site conditions and review of existing information on a periodically recurring slope failure at the Shell Jumping Pound plant.

**Middlesprings
Subdivision**
Banff, Alberta

Preliminary reconnaissance, site investigation and assessment of a potential old landslide within the proposed Middlesprings development in Banff.

**North Shore Stability
Assessment**
BC, Canada

Preliminary assessment and development of detailed investigation program to provide guidelines to the City of Nanaimo regarding development on or adjacent to the ocean slopes in the northern portion of the city.

PROJECT EXPERIENCE – COAL MINES

**Grande Cache Coal
Mine**
Hinton, Alberta

Review of rock fall analysis and the design of screens to control potential rock fall from planned mine development that will be physically located upslope from an important regional highway.

Sheerness Coal Mine
Hanna, Alberta

Senior geotechnical review and overall project direction for initial engineering investigation, project design, project specifications and construction monitoring for a small sedimentation pond at the Sheerness Mine.



**In-Situ Coal
Gasification Project**
Drayton Valley, Alberta

Preliminary geological, hydrogeological and geotechnical review of a proposed trial in-situ coal gasification project. The intent of this study was to assemble and assess available geological information so that the technical feasibility of a trial gasification project could be determined. Mr. Pelly was responsible for overall project direction for these technical aspects.

Highvale Coal Mine
Alberta, Canada

The Highvale Mine, located in central Alberta, is the largest open cast coal mine in Canada. The mine has an annual output of approximately 12 million tonnes of thermal coal, all of which is consumed by two major coal fired power generation stations, Sundance and Keephills. Commencing in 2003, the Golder team has been providing ongoing geotechnical input for Prairie Mines & Royalty Ltd., the mine operator. Mr. Pelly is responsible for the activities of the team, which includes a quarterly geotechnical review of the mine operations.

Genesee Coal Mine
Alberta, Canada

The Genesee Coal Mine is an open cast, dragline operation located in Central Alberta. The Genesee mine provides coal exclusively for the nearby Genesee coal fired power plant. Mr. Pelly is responsible for the Golder team that provides on-going geotechnical assistance to Prairie Mines and Royalty Ltd., the operators of the Genesee Mine and is responsible for the annual geotechnical review of the operation of the mine.

Whitewood Coal Mine
Wabamun, Alberta

The Whitewood Coal Mine is an open cast, dragline operation located in Central Alberta. The Whitewood Mine provided coal exclusively for the nearby Wabamun coal fired power plant. Mr. Pelly was responsible for the Golder team that provided on-going geotechnical and hydrogeological assistance to Prairie Mines and Royalty Ltd., the operators of the Whitewood Mine. The Wabamun plant is now shut down and the mine has ceased operations.

Proposed Coal Mine
Brooks, Alberta

This proposed coal mine near Brooks, Alberta is intended to serve a proposed coal fired power plant constructed adjacent to the mine. Mr. Pelly was part of a geotechnical team that provided a preliminary geotechnical assessment of the proposed coal mine operations. The preliminary assessment was part of an overall environmental assessment of the proposed operations.

**Fording River Coal
Mine**
Fording River, BC

Fording Coal Limited operates a mountain coal mine that supplies metallurgical coal for export. Mr. Pelly was responsible for a geotechnical investigation aimed at identifying suitable material for use in the planned raising of a tailings empoundment dyke on the property.

PROJECT EXPERIENCE – COAL MINE SUBSIDENCE

Three Sisters Resort
Canmore, Alberta

This major community development in Canmore includes most of the land of the former Canmore Mines. Mr. Pelly has been involved in the assessment, investigation and mitigation of risks associated with the proposed development, including risks to buildings, underground services, roadways and the general public. This work has been carried out under a detailed set of guidelines instituted by the Town of Canmore.



Proposed Regional Hospital
Drumheller, Alberta

Review of available information and detailed site investigation was undertaken at the site of this proposed regional hospital in Drumheller. Numerical hazard assessment techniques were used to communicate the small risk associated with construction on the proposed site, leading to a positive decision to accept the site.

RCMP Building
Lethbridge, Alberta

Review of available information regarding abandoned coal mines that exist in the vicinity of the subject building was carried out prior to construction.

Mine Plan Compilation
Nanaimo, BC

Archival research and compilation of abandonment plans of coal mines within the Nanaimo and Cumberland Fields on Vancouver Island. The compilation involved many mines in various seams extending over many square miles. Much of the coal mine fields exist within the boundaries of present day Nanaimo and Cumberland.

Coast Hotel
Nanaimo, BC

Detailed investigation, design and construction control of the construction of foundations for this 17 storey hotel on the waterfront in Nanaimo. Foundations included drilled, cast-in-place, concrete piles extended through to the base of the shallow abandoned coal mines that underlie this building.

Caprice Theatre
Nanaimo, BC

Detailed investigation, design and construction control of the foundations for this twin theatre building in Nanaimo. Abandoned coal mines underlie 100% of this site within 20 to 55 feet below the floor level. Foundations consisted of bulk concrete fill within the mines as well as drilled, cast-in-place concrete piles extended to the underside of the coal mine.

Various Residential and Commercial Structures
Nanaimo and Canmore, BC and Alberta

In excess of 100 individual residences, subdivisions and commercial developments have been constructed over abandoned coal mines following assessment of the subsidence hazards and institution of remedial measures to mitigate the risks.

PROJECT EXPERIENCE – INTERNATIONAL: EAST AFRICA

Songo Songo Gas to Electricity Project
East Coast, Tanzania

This is a US\$250 Million project that will develop gas reserves near Songo Songo Island, south of Dar es Salaam, Tanzania. The project involves the construction of a marine gathering system, a gas processing plant on Songo Songo Island, 22 km of marine pipeline and 270 km of terrestrial pipeline to bring the gas to Dar es Salaam. The gas will be primarily used to generate electricity for the power grid for the country. Mr. Pelly reviewed the geology for Songo Songo Island as well as along the marine and terrestrial routes, and has examined the crossing options at the Rufiji River, the major stream draining central Tanzania.



**Central Material
Testing Laboratory –
Institutional
Strengthening**
Dar es Salaam,
Tanzania

The Central materials Testing Laboratory (CML) is the main construction materials quality control facility for the Tanzanian Ministry of Works. In conjunction with the World Bank funded Integrated Roads Projects I and II, the CML was to provide QA/QC services for the various roads projects throughout the country. The project was aimed at increasing the capability and reliability of the CML organization. The first phase of the work involved an assessment of the physical and technical upgrading needs and the provision of a redevelopment plan. Future program steps involve upgrading the administration and human resources. Mr. Pelly was project manager for this assignment.

**Lower Ruvu Water
Treatment Plant**
Bagamoyo, Tanzania

The Lower Ruvu River provides much of the water supply for Dar es Salaam. The Lower Ruvu Water Treatment Plant uses a run of the river weir intake to obtain water for the Dar water supply system. Mr. Pelly carried out a preliminary geotechnical investigation for a proposed expansion and repair/upgrade for the Lower Ruvu Plant.

**Emergency Power
Project**
Dar es Salaam,
Tanzania

Investigation, foundation design and construction supervision for a fast-tracked power project in Tanzania were carried out by Mr. Pelly and a local crew. Practical combinations of sound geotechnical principles with local construction techniques resulted in the saving of several weeks in a tight construction schedule.

Chalinze Highway
Chalinze, Tanzania

Failures in the asphaltic concrete surfacing for a stretch of highway near Chalinze, west of Dar es Salaam, occurred shortly after construction. A review of the asphalt mixes and placement techniques was carried out in order to help resolve a contract dispute. Mr. Pelly was project manager for this assignment.

Sam Nujoma Road
Dar es Salaam,
Tanzania

Upgrading and resurfacing of this arterial route within Dar es Salaam was carried out by a para-statal road construction company. Asphalt concrete mix designs were developed using crushed coral limestone aggregate and quality control services were provided during construction. The work has resulted in a relatively low maintenance surface for this highly used route.

Water Supply Dam
Addis Ababa,, Ethiopia

Preliminary design for a water supply dam located northwest of Addis Ababa in Ethiopia was carried out with funding assistance from CIDA INC. The dam was intended to be an earth fill structure and the water was to be conveyed from the reservoir to Addis Ababa through a combination of pipelines, open canals and a 4 km long rock tunnel. Mr. Pelly was responsible for the administration of this project.

PROJECT EXPERIENCE – INTERNATIONAL: WEST AFRICA

**Satellite Town Housing
Estate Storm Water
Outfall**
Lagos, Nigeria

Provided geotechnical review and design recommendations for a storm water outfall pipeline from a housing estate to Porto Novo Creek. The assignment included a field investigation carried out by hand due to poor access conditions. In conjunction with the civil engineering consultants, practical design and construction solutions, which addressed both the technical needs of the project and access needs for the community, were developed. Construction of the outfall was completed in 2001 and is in service.



Ugborodo New Town Escravos River, Nigeria

Provided geotechnical review and design recommendations for a proposed new town site, located near the mouth of the Escravos River in the Niger Delta. The town site is intended to support a population of several thousand persons. The site has been partially developed through the placement of dredged sand fill along with some surface drainage channels, though no housing or other infrastructure has yet been constructed. The assignment included review of a detailed subsurface investigation carried out in 2000 along with an associated laboratory program. Geotechnical recommendations for preliminary design purposes were developed based on this information.

PROFESSIONAL AFFILIATIONS

Member, Association of Professional Engineers, Geologists & Geophysicists, Alberta (APEGGA)

Member, Association of Professional Engineers and Geoscientists, British Columbia (APEGBC)

Member, Canadian Geotechnical Society

Member, Canadian Society of Civil Engineers

CHRISTOPH WELS

EDUCATION

Ph.D., Hydrogeology, University of British Columbia, 1995
Fellowship, Environmental & Soil Chemistry, Syracuse University, 1991
M.Sc., Watershed Hydrology, Trent University, Ontario, 1989
B.Sc., Environmental Sciences, Trent University (Freiburg University), 1985

PROFESSIONAL REGISTRATION

Professional Geoscientist, APEGBC
Professional Geologist, APEGGA
Licensed Geologist/Hydrogeologist, Washington State

EXPERIENCE

SUMMARY

Christoph Wels has over 20 years of experience in: design & implementation of site investigations and monitoring of mine impacts on groundwater resources; the development of groundwater flow and solute transport models to study current impacts and to evaluate the effectiveness of remedial activities; the design of mine dewatering systems for open pit and underground workings; study of waste rock hydrology including physical characterization, field monitoring and numerical modeling of key processes (infiltration, internal air flow and seepage); and the design of engineered covers for waste rock and tailings using numerical modeling and field trials.

Christoph Wels has been a third-party reviewer of pre-feasibility investigations, permitting documents and technical studies of mining projects on behalf of government agencies, mining companies and other consulting firms for project in Canada (YT, NWT, Labrador), USA, Australia, Germany and Chile.

PROJECT EXPERIENCE (SELECTED STUDIES)

MINE PERMITTING & BASELINE STUDIES

Prairie Creek Mine, NWT (2008-present) for Canadian Zinc (CZN)

- Design & implement groundwater monitoring program at Prairie Creek Mine
- Prepare hydrogeological baseline study for DAR application
- Develop groundwater flow model for Prairie Creek Mine site
- Assist CZN in DAR submission and EA process

Granites Gold Mine, Australia (2008 - present) for Newmont Australia

- Complete groundwater baseline study required for permitting of the Dead Bullock Soak (DBS) Deep U/G project;
- Develop a 3D groundwater flow model of the DBS Deeps U/G project to assess groundwater inflow and potential impacts on open pits backfilled with tailings
- Predict groundwater impacts for alternative options of tailings storage facilities (Quorn North and GTD South) at the Granites using groundwater flow and transport model
- Provide recommendations for final selection of TSF expansion at the Granites for permitting

CHRISTOPH WELS

GROUNDWATER IMPACT & SEEPAGE CONTROL STUDIES

Las Tortolas Mill Site, Chile (2010-present) for Anglo American Chile (AACH)

- Detailed site characterization program (drilling and installation of monitoring wells) to delineate the seepage plume downstream of the Main Dam of the Las Tortolas TSF and the El Bosque irrigation areas
- Develop and calibrate groundwater flow and solute transport models to assess future groundwater impacts and seepage interception options
- Design of seepage interception systems for the Muro Principal and the El Bosque areas

El Soldado Mine Site, Chile (2010-present) for Anglo American Chile (AACH)

- Detailed site characterization program (drilling and installation of monitoring wells) to delineate the seepage plume from the El Torito TSF in the Estero de Cobre valley
- Develop and calibrate groundwater flow and solute transport models to assess future groundwater impacts and seepage interception options
- Design of seepage interception systems for the Muro Principal and the El Bosque areas

Granites Gold Mine, Australia (2006 - present) for Newmont Australia

- Complete detailed site characterization to evaluate impacts on local groundwater due to historic seepage from tailings storage facilities (paddock TSFs and backfilled open pits)
- Develop 3D groundwater flow and solute transport model to assess future migration of seepage plume at the Granites;
- Design & Implement seepage recovery systems for GTD01/03 and Bunkers Hill TSFs

Anvil Range Mining Complex, Yukon Territory (2004 - 2009) for Deloitte Touche (Interim Receiver on behalf of Federal Government of Canada)

- Assess acid rock drainage from waste rock piles and design seepage interception system
- Develop water & load balance model for Rose Creek Tailings Storage Facility
- Design Groundwater Interception System for Alluvial Aquifer (using pumping tests and 3D MODFLOW model)

TAILINGS WATER BALANCE STUDIES

Steeptank and Millenium Mine, Ft McMurray, Alberta (2010 - 2009) for Suncor Energy Ltd.

- Perform water balance studies to understand the drying and consolidation of polymerized mature fine tailings (TMFT) using laboratory and field tests
- Assist Suncor in planning and operation of its Tailings Reductions Operations (TRO)
- Assist Suncor in monitoring and management of monitoring data
- Optimize tailings management to reduce water losses and make-up requirements

Escondida Mine, Chile (2007 - 2009) for BHP Billiton

- Review historic and proposed future tailings management for Laguna Seca TSF
- Design & implement a tailings characterization program (in-situ and laboratory)

CHRISTOPH WELS

- Develop and calibrate a water balance model for Laguna Seca TSF to assess water losses and make-up requirements
- Optimize tailings management to reduce water losses and make-up requirements

Collahuasi Mine, Chile (2002 - 2004) for Minera Dona Ines de Collahuasi (MDIDC)

- Design & implement a tailings characterization program (in-situ and laboratory) for tailings from Ujina and Rosario pits
- Develop and calibrate a water balance model for Pampa de Pabellon TSF to assess water losses and make-up requirements

Chuchicmata Mine, Chile (2002 - 2003) for Codelco

- Design & implement a tailings characterization program (in-situ and laboratory) for tailings in Tranque de Talabre
- Develop and calibrate a water balance model for Tranque de Talabre TSF to assess water losses and make-up requirements

MINE CLOSURE PLANNING

Rum Jungle (Abandoned) Mine Site, Australia (2010 - present) for NT Dept of Resources (Australia)

- Design & implementation of a detailed hydrogeological site characterisation (incl. drilling, well installations, and hydraulic testing);
- Groundwater flow and groundwater quality monitoring to assess impact of ARD on East Finnis River and local bedrock aquifer(s);
- Development of a 3D groundwater flow model to assess current seepage conditions and contaminant loading to the East Finnis River and the local aquifer(s);
- Assessment of alternative closure strategies using the 3D groundwater flow model;

Mt Morgan (Abandoned) Mine Site, Australia (2003 - present) for Qld. Dept Natural Resources (Australia)

- Design & implementation of a detailed hydrogeological site characterisation (incl. drilling, well installations, and hydraulic testing);
- Groundwater flow and groundwater quality monitoring to assess impact of ARD on Dee River and local aquifer;
- Development of a 3D groundwater flow model to assess current seepage conditions and contaminant loading to the Dee River and the local aquifer(s);
- Assessment of alternative closure strategies using the 3D groundwater flow model;

Giant Mine, NWT (2001 - 2006) for SRK Canada and DIAND

- Participation in “Hydrogeological Expert Meetings” to review and critique hydrogeological studies carried out at the Giant Underground Gold Mine prior to 2001;
- Participation in hydrogeological studies in support of the Arsenic Trioxide Management Study;

CHRISTOPH WELS

- Development of a 3D groundwater flow model (as senior supervisor) to assess current groundwater conditions at the Giant Underground Mine and to evaluate closure options (reflooding, partial reflooding etc.);

Woodcutters Mine, Northern Territories, Australia (2000 - 2009) for Newmont Australia.

- Hydrogeological field investigation (drilling) and design of a groundwater monitoring program
- Development of a 3D groundwater flow and transport model (using MODFLOW & MT3D) to assess reflooding of underground workings/open pit and post-closure groundwater quality
- Development of a 2D seepage model (using HYDRUS) to determine fate of seepage from waste rock pile
- Assistance in the development of closure criteria & post-closure monitoring

Questa Mine Tailings Impoundments, Questa, New Mexico, U.S.A. (1997-2002) for Molycorp Inc.

- Development of a Closure Plan for Questa Tailings Facility
- Modeling of infiltration through soil covers into tailings (using SOILCOVER) to assess alternative designs of a soil cover for final closure of the tailings facility
- Modeling of seepage (using SEEP/W) through tailings to predict the rate of dewatering of tailings over time
- Development of a regional and local 3D groundwater flow model to evaluate fate of tailings seepage in local and regional aquifer systems
- Design, Instrumentation and Monitoring of Test Plots to measure the performance of storage covers

THIRD PARTY REVIEW

Abandoned Mines in Yukon Territory, Canada (2011-present) for Dept. of Energy, Mines and Resources, Yukon Government

- Technical advisor to the Yukon Government on hydrogeological issues related to care & maintenance and closure of abandoned mines in the Yukon Territory
- Review of technical studies on seepage mitigation and performance reviews of existing seepage interception systems at the Faro Mine (Yukon Territory)

Collahuasi Mine, Chile (2010-present) for X-Strata, Anglo American, and Mitsui

- Technical review of three groundwater models developed by Collahuasi's consultants to predict future groundwater extraction from Coposa basin, Michincha basin and Rosario Pit
- Assess feasibility and risks of groundwater supply for mine expansion to 160 ktpd

Las Tortolas and El Soldado Mines, Chile (2008) for Anglo American Chile (AACH)

- Review groundwater impacts due to tailings seepage at Los Tortolas and El Torito tailings impoundments;
- Review groundwater modeling completed by local consultants;
- Recommend preferred seepage mitigation options for tailings seepage plumes;

Cantung Mine, NWT (2008) for Indian & Northern Affairs Canada (INAC)

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- Review & comment on the Abandonment & Reclamation Plan for the Cantung Mine
- Review hydrogeological & hydrogeochemical studies for the Cantung Mine and provide recommendations to INAC on its adequacy
- Assist INAC in the review of the Water License Application for the Cantung Mine

Tamerlane Pine Point Pilot Project, NWT (2007) for Mackenzie Valley Environmental Impact Review Board (MVEIRB)

- Review hydrogeological aspects of EA application
- Provide review comments and recommendations to MVEIRB
- Attend technical session on EA application on behalf of MVEIRB

PROFESSIONAL HISTORY

2011-present	Corporate Consultant, Robertson GeoConsultants Inc. (Canada)
2001-2010	Principal, Robertson GeoConsultants Inc. (Canada)
1995-2001	Senior Hydrogeologist, Robertson GeoConsultants Inc. (Canada)
1989	Hydrogeologist, Chalk River Laboratories, AECL, Ontario
1985-86	Hydrochemist, Freiburg Municipality, Germany

SELECTED PUBLICATIONS

Wels, C. and R. Zapata, 2010, "Assessment of Tailings Seepage from In-pit Tailings Storage Facility Using a 3D Groundwater Flow Model", Paper presented at Mine Closure 2010, June 2010, Santiago, Chile.

Zapata R. Wels, C. and J. Bourne 2010, "Assessment of Post-Closure Flooding of Potentially Acid-Generating (PAG) Waste Rock Backfilled into Bonanza Ledge Open Pit, Canada", Paper presented at Mine Closure 2010, June 2010, Santiago, Chile.

Wels, C., Laura Findlater and Chris McCombe, 2009, "Contaminant Load Balance Study for Mount Morgan Mine, QLD, Australia". Paper presented at Securing the Future and 8th ICARD, June 23-26, 2009, Skellefteå, Sweden.

Wels, C. and Laura-Lee Findlater, 2009, "Groundwater Modeling as a Tool for Closure Planning: Prediction of Zinc Transport for Alternative Cover Scenarios". Paper presented at Securing the Future and 8th ICARD, June 23-26, 2009, Skellefteå, Sweden.

Wels, C., Findlater, L., and C. McCombe, "Assessment of Groundwater Impacts at the Historic Mount Morgan Mine Site, Queensland, Australia. In proceedings of the 7th International Conference on Acid Rock Drainage, St Louis, MO, 26-30 March 2006.

Wels, C., Robertson A. MacG., Madariaga, P.M., 2004, "Water Recovery Study for Pampa Pabellon Tailings Impoundment, Collahuasi, Chile". In proceedings of the 11th Annual Conference on Tailings and Mine Waste, Vail, Colorado, USA, 10-13 October, 2004.

CHRISTOPH WELS

Wels, C., Findlater, L., Shaw, S. and Laurencont, T., 2004, "Mt Morgan Mine - A Case Study of ARD Impacted Groundwater". In proceedings of Mine Water 2004 - Process, Policy and Progress, Newcastle upon Tyne, United Kingdom, 20-24th September, 2004, pp. 235-245.

Wels, C. and Robertson, A. MacG, 2003, "Conceptual model for estimating water recovery in tailings". In proceedings of the 10th International Conference on Tailings and Mine Waste, Vail, Colorado, USA, 12-15 October, 2003, pp. 87-94.

O'Kane, M., and C. Wels, 2003, "Mine Waste Cover System Design – Linking Predicted Performance to Groundwater and Surface Water Impacts", In proceedings of the Sixth International Conference on Acid Rock Drainage, Cairns, Queensland, Australia, 14-17 July, 2003, pp. 341-350.

Shaw, S., Wels, C., Robertson, A., Fortin, S., and B. Walker, 2003, "Background characterization study of naturally occurring acid rock drainage in the Sangre de Cristo Mountains, Taos County, New Mexico", In proceedings of the Sixth International Conference on Acid Rock Drainage, Cairns, Queensland, Australia, 14-17 July, 2003, pp. 605-616.

Wels, C., Lefebvre, R., and A. Robertson, 2003. "An Overview of Prediction and Control of Air Flow in Acid-Generating Waste Rock Dumps", In proceedings of the Sixth International Conference on Acid Rock Drainage, Cairns, Queensland, Australia, 14-17 July, 2003, pp. 639-650.

Wels, C., 2002. "Use of Waterloo barrier in progressive reclamation of hydrocarbon plume", Proceedings of 55th Canadian Geotechnical and 3rd Joint IAH-CNC and CGS Groundwater Specialty Conferences, Niagara Falls, pp. 537-544, October 20-23, 2002.

Wels, C., S. Fortin, and S. Loudon, 2002. "Assessment of store-and-release cover for Questa tailings facility, New Mexico", Proceedings of 9th International Conference on Tailings & Mine Waste, Fort Collins, pp. 459-468, January 27-30, 2002.

Wels, C., S. Loudon and S. Fortin, 2002. "Factors influencing net infiltration into mine rock piles at Questa Mine, New Mexico", Proceedings of 9th International Conference on Tailings & Mine Waste, Fort Collins, pp. 469-478, January 27-30, 2002.

Shaw, S., C. Wels, A. Robertson, and G. Lorinczi, 2002. "Physical and geochemical characterization of mine rock piles at the Questa Mine, New Mexico", Proceedings of 9th International Conference on Tailings & Mine Waste, Fort Collins, pp. 447-458, January 27-30, 2002.

Lefebvre, R., A. Lamontagne, C. Wels, and A. MacG. Robertson, 2002. "ARD production and water vapour transport at the Questa Mine, New Mexico", Proceedings of 9th International Conference on Tailings & Mine Waste, Fort Collins, pp. 479-488, January 27-30, 2002.

Wels, C., M.O'Kane, S. Fortin, and D. Christensen, 2001. "Infiltration Test Plot Study for Mine Rock Piles at Questa Mine, New Mexico", American Society for Surface Mining Society for Surface Mining and Reclamation, Albuquerque, New Mexico, pp. 195-209, June 3-7, 2001.

Wels, C., M.O'Kane, and S. Fortin 2001. "Assessment of water storage cover for Questa tailings facility, New Mexico", American Society for Surface Mining Society for Surface Mining and Reclamation, Albuquerque, New Mexico, pp. 500-513, June 3-7, 2001.

Wels, C., A. MacG. Robertson and A. T. Jakubick, 2000. "A Review of Dry Cover Placement on Extremely Weak, Compressible Tailings", CIM Bulletin 93 (1043): pp. 111-118. September 2000.

Wels, C., U. Barnekow, M. Haase, M. Exner and A. T. Jakubick, 2000. "A Case Study on Selfweight Consolidation of Uranium Tailings", Paper presented at Uranium 2000; Conference held September 9-15, 2000, Saskatoon, Saskatchewan.

CHRISTOPH WELS

Wels, C., S. Shaw and M. Royle, 2000. "A Case History of Intrinsic Remediation of Reactive Tailings Seepage for Questa Mine". Paper presented at the ICARD 2000 Conference, Proceedings Volume 1, pp. 441-458, May 2000, Denver, Colorado.

Wels, C. and A. MacG. Robertson, 1998. "Assessment and management of Risks relating to Covers for Metal Leaching and Acid Migration", Paper presented at the 5th Annual BC Metal Leaching/ARD Workshop, December 9 - 10th 1998, at Vancouver, BC.

Wels, C., L. Smith, and R.D. Beckie, 1997. "The Influence Of Surface Sorption On Dispersion In Parallel Plate Fractures" J. Contam. Hydrology 28:95-114.

Wels, C., L. Smith, and T.T. Vandergraaf, 1996. "The Influence Of Specific Surface Area On Transport Of Sorbing Solutes In Fractures: An Experimental Analyses", Water Resources Res. 32: 4943-4954.

Wels, C. and L. Smith, 1994. "Retardation Of Sorbing Solutes In Fractured Media", Water Resources Res. 30: 2547-2563.

Wels, C., R.J. Cornett, and B.D. LaZerte 1991. "Hydrograph Separation: Comparison Of Isotopic And Chemical Tracers", J. Hydrology 122:253-274.

Senior Hydrologist

Education

MBA, University of Alberta,
1986

B.Sc. in Civil Engineering,
with distinction, University
of Alberta, 1978

License/Affiliations

Registered Professional
Engineer, Province of
Alberta

Registered Professional
Engineer, State of
Washington

Member, Canadian Water
Resources Association

Member, Washington State
Water Resources Advisory
Committee

Years Experience

30

Areas of Expertise

Surface water hydrology
analysis and modeling for
water supply and flood
hazard assessments.

Stormwater management
regulations and best
management practices,
Washington and Alberta.

Water rights policy and
administration in Alberta,
Washington, and Hawaii.

Expert witness analysis and
testimony on environmental
impacts of development
projects.

Mr. Rozeboom is an engineering hydrologist with wide experience in the assessment and management of surface water resources. During 30 years of employment in government service and consulting practice he has conducted watershed assessment, water supply, stormwater management, river crossing, and flood protection projects in geographic settings encompassing western and northern Canada, the western United States, Hawaii, and the West Indies.

When employed by the Hawaii Water Commission from 1988 through 1992, Mr. Rozeboom established the institutional framework to implement the 1987 Hawaii Water Code. In Washington State through 2005, he was an active member of the Washington State Department of Ecology Water Resources Advisory Committee, and participated in both the Central Puget Sound Regional Water Resources Initiative and Ecology's Water Use Measurement Technical Advisory Group. He has been retained as a technical expert in several legal proceedings and has testified before land use hearing examiners and the Washington State Pollution Control Hearings Board.

Mr. Rozeboom has a solid record of satisfied clients. His active long term clients include the city of Snoqualmie (since 1994), Yukon Energy Corporation (since 2007) and Canadian Zinc (since 2008). His services for the city of Snoqualmie have continued to the present through transitions which include three political administrations, several turnovers in client senior staff, and his return to Canada in 2005.

Employment History

Northwest Hydraulic Consultants

November 1992 – present. Senior hydrologist and project manager with Northwest Hydraulic Consultants in the firm's Seattle office from 1992 through 2005 and Edmonton office since July 2005.

Hawaii Commission on Water Resource Management

June 1988 - November 1992. Hydrologist with the State of Hawaii Commission on Water Resource Management. Implemented new programs for water rights certification and dispute resolution under the 1987 State Water Code.

Self Employed

September 1986 - May 1988. Performed engineering and management consultant services. Work included two overseas assignments for water supply development projects in St. Lucia and in Montserrat, West Indies.

University of Alberta / Alberta Environment

September 1984 - August 1986. Full-time MBA student and graduate assistant. During summer periods, conducted field research studies for Alberta Environment Hydrology Branch of carriage losses from natural channels.

Northwest Hydraulic Consultants

January 1979 - May 1984. Project engineer with Northwest Hydraulic Consultants, Edmonton office. Managed and conducted projects involving field inspections, river surveys, scale model design and testing, hydrologic and river engineering assessments, and computer model development.

Alberta Environment Water Survey Section

Summers, 1976 – 1977. Water survey technologist with Alberta Environment Water Survey Section. Responsible for streamflow metering, lake water level surveys, equipment servicing, data reduction, and rating curve development.

William A. Rozeboom, MBA, P.E., P.ENG.

Project Experience (starting with most recent as of March 2011)

Water Supply Outlook Forecast Review. Conducted a detailed review of current methods, models, and agency practices for forecasting seasonal flow volumes in the western U.S. and Canada. Findings are being used to update Alberta Environment forecast procedures.

Ivanhoe Tamarack EIA Review. Third party hydrology specialist for Alberta Environment's review of the Environmental Impact Assessment for the Tamarack SAGD project in northern Alberta. (ongoing)

Paintearth Mine Water Management. Performed hydrologic assessments to develop a water management plan for open pit mine expansion and site reclamation activity at the Paintearth Mine which supplies coal for the Battle River generating station in eastern Alberta. (ongoing)

Genessee Mine Extension Environmental Assessment. Assessed surface water hydrologic impacts for the extension of the open pit Genessee Mine which supplies coal for the Genessee generating station in central Alberta. Assisted in developing a water management plan to minimize impacts. (ongoing)

Canadian Zinc Prairie Creek Mine Bank Protection and Outfall. Site inspections 2008 through 2010 of bank protection works for mine flood protection berms and an access road through Nahanni National Park, Northwest Territories. Evaluated alternative wastewater outfall sites and designs, responded to regulator information requests, and collaborated in the design of fish habitat compensation works. (ongoing)

Yukon Southern Lakes Hydrologic Routing Study. Managed the development and validation of a HEC-ResSim routing model of the Yukon River basin upstream from the Yukon Energy Whitehorse Rapids Generating Station, simulating daily flows and water levels in each of the basin's six major lakes. Simulations cover a 50-year period of historical record and address variable outlet conditions, complex interactions between several of the major lakes, and alternative operating strategies. (ongoing)

Snoqualmie Ridge Drainage Reviews and Environmental Monitoring. As the city's on-call drainage engineer for 1994-2005, determined the acceptability of hydrologic analyses, drainage plans, and stormwater facility designs for the 2,000-acre mixed used development at Snoqualmie Ridge Phases 1 and 2. Coordinated sub-consultant reviews of water quality, fisheries, and wetlands issues, and oversaw the interpretation of over 10 years of multidisciplinary post-construction monitoring data. Monitoring and drainage review work continues to the present. (ongoing)

TBG Clay Pit Water Management Plan. Developed a water management plan and conceptual outfall designs for disposal of accumulated water from a clay pit north of Fort McMurray and for subsequent operation phase water management.

Izok Mine Environmental Assessment. Discipline lead to characterize and assess potential surface water hydrology impacts relating to a proposed metal mine beneath Izok Lake in Nunavut, and an access road from the mine site to a northern port facility.

Parsons Creek Resources Environmental Assessment. Discipline lead to characterize and assess potential surface water hydrology impacts from a proposed limestone quarry in the floodplain of the Athabasca River north of Fort McMurray.

Suffield National Wildlife Area Infill Drilling Environmental Assessment. Discipline lead to characterize and assess potential surface water impacts relating to EnCana's proposed natural gas infill development in the Suffield National Wildlife Area in southern Alberta.

South Saskatchewan Water Management Plan Technical Review. Conducted a detailed review, on behalf of Treaty 7 First Nations, of the October 2005 draft Water Management Plan for the South Saskatchewan River Basin. Participated in meetings with First Nations representatives and co-authored a technical review report.

William A. Rozeboom, MBA, P.E., P.ENG.

Vantage Point Stormwater Management Plan. Developed and applied a HSPF hydrologic model to assess impacts of a central Alberta rural residential development on downstream stormwater volumes and peak flows, and devised mitigation strategies.

Whitemud Creek Sensitive Area Assessment. Implemented a hydrologic monitoring and assessment program for a unique lake within the McTaggart Sanctuary nature preserve along Whitemud Creek in the city of Edmonton. Recommended measures to mitigate the hydrologic effects of urban development planned for the area uphill from the lake.

Great Divide SAGD Environmental Assessment. Developed, calibrated, and applied a HSPF model to identify and quantify surface water hydrology impacts related to the Great Divide SAGD oil sands development in northern Alberta.

Shepard Energy Centre Water Withdrawal Impact. Performed an assessment to determine if proposed net flow diversions from the city of Calgary Bonnybrook Wastewater Treatment Plant to the Shepard Energy Centre would be material to the Bow River and other water users.

Athabasca River Outfall Design. Oversaw development of a River-2D hydraulic model of the Athabasca River adjacent to the Beaver River Lodge north of Fort McMurray, and provided recommendations for the location and conceptual design of a new wastewater outfall.

Banff Bow River Outfall Design. Performed site inspections and hydrologic and hydraulic analyses for the Bow River at the Banff wastewater treatment plant. Prepared design details and a preliminary construction plan for an upgraded (replacement) wastewater outfall.

Hilliards Bay Marina Conceptual Design. Conducted a feasibility level design for a proposed marina on Lesser Slave Lake in north central Alberta. A design which included dredging of a channel and an armoured breakwater was developed to provide marina boat passage for the expected range in lake water levels and shoreline positions, and to withstand ice and wave action forces.

Peace River Region Hydraulic Capacity Assessments. Performed hydrologic and hydraulic analyses for Alberta Infrastructure and Transportation to address drainage problems at six problem sites across the region. Problems were the result of varied local conditions including obstructed or un-maintained drainage paths, beaver activity, and structural failures. Developed designs and costs for improvements.

Boyle - Amisk Lake Water Supply Assessment. Developed and calibrated a continuous simulation water balance model of Amisk Lake to determine its reliability as a future source of raw water supply for the Village of Boyle. Assessed impacts of proposed municipal withdrawals on lake levels and on the frequency and duration of zero flows at the lake outlet.

Michel Creek Bank Armour Construction Inspection. Provided construction supervision and prepared as-built reports for riprap bank armoring at two Terasen Gas pipeline crossings of Michel Creek in the Crowsnest Pass area of southern B.C.

Fort St. John - Peace River Outfall. Developed a River 2D hydraulic model of the Peace River to assess river hydraulic conditions in the vicinity of proposed wastewater outfall for the City of Fort St. John. Prepared design drawings for outfall placement.

Westlock/Clyde Regional Water Supply Assessment. Conducted a hydrologic assessment of the suitability of the Pembina River near Westlock as a source of raw water supply for a regional system. The assessment included consideration of instream flow needs and active water licenses for consumptive withdrawals.

Meander River Water Supply Assessment. Conducted a hydrologic assessment of the suitability of the Hay River near Meander River as a source of community raw water supply. The assessment included consideration of instream flow needs and active water licenses for consumptive withdrawals.

Faro Mine Hydrology. Reconciled incomplete available water level and streamflow data collected by others at multiple sites along North Rose Creek in preparation for closure of a mine site near Faro, Yukon. Performed flood routing analyses at a flow-through rock drain embankment along the channel.

William A. Rozeboom, MBA, P.E., P.ENG.

Green River Strategic Assessment. Managed a multi-agency assessment of reservoir regulation, land use, and water extraction impacts on tributary and main-stem streamflow in the Green River watershed in western Washington. Analysis methods developed in this work are being applied to other basins as a means to identify reach-specific areas of water quantity impact and mitigation opportunities.

Shared Strategy Instream Flow Assessment Pilot Project. Co-managed the study design for an instream flow pilot study in the Stillaguamish River basin with county and tribal partners. Study objective was to demonstrate a procedure using HSPF and EDT models to quantify the impacts of urbanization, land cover change, and water use on stream flow, water quality, and salmon populations.

SeaTac Airport 3rd Runway Review. Reviewed technical and regulatory elements of the stormwater management plan and related documents submitted for Section 401 State Water Quality Certification for the SeaTac airport third runway project. Identified significant errors in the hydrologic modeling and analyses. Concerns were corroborated by third-party reviews and led to substantial overhauls of the stormwater plan modeling and facility designs. Provided expert testimony before the State of Washington Pollution Control Hearings Board.

Kent Third Avenue Pump Station Hydraulic Design. Managed the analyses and hydraulic design of two stormwater pump stations to augment existing gravity stormwater systems in the City of Kent. Detailed analyses were performed with a continuous-simulation hourly routing model using HSPF-derived inflows and historic Green River water levels. Evaluated various combinations of pump capacity and operating rules to efficiently achieve a target 25-year level of flood protection.

Snoqualmie Ridge II Master Drainage Plan. Retained by the City of Snoqualmie to provide detailed technical reviews of Master Drainage Plans, Environmental Impact Statements, and engineering plans prepared by Quadrant Corporation for the 730-acre Phase II Snoqualmie Ridge development. The site is the headwater area for several small streams and an extensive network of more than 60 on-site wetlands, all of which are vulnerable to site hydrologic changes. Worked closely with city and staff and environmental consultants to incorporate Low Impact Development techniques and to implement a program for post-construction monitoring.

Stillaguamish Basin Instream Flow Hydrology. Performed a hydrologic evaluation of flows in the Stillaguamish River basin, Water Resource Inventory Area 5. The work was in support of a Washington Department of Ecology proposal to promulgate an instream resources protection rule in the basin. Developed data transposition techniques in which locally available data were paired with representative long-record stations to determine site-specific streamflow statistics. Developed and provided hydrographs showing the 5, 10, 20, 50, 80, and 90 percent daily exceedance values for each of fourteen instream flow study sites.

Cedar River Section 205 Project Interior Drainage Assessment. Performed an interior drainage assessment for the levee/floodwall system constructed as a Section 205 Flood Protection Project along the lower Cedar River in the city of Renton. Identified and mapped areas at risk of interior flooding during high river conditions, based on a review of storm drain drawings and field surveys of critical overflow points.

Valterra View Estates Flow Splitter Design. Designed a flow control structure for a proposed residential development located uphill from Snohomish County Diking District No. 2. The flow control structure limits seasonal flow volumes through the diking district to pre-development levels and bypasses excess volumes to a tightline to the Snohomish River. Used HSPF hydrologic modeling to establish flow duration performance targets and to demonstrate satisfactory seasonal performance.

Mount Vernon Surface Water Management Plan Update. Managed the updating of hydrometeorological data sets for previously-developed HSPF models. Recalibrated an HSPF model of Maddox Creek to new streamflow data collected at the city urban growth boundary, using FEQ hydraulic model results to define flood storage conditions in the lower watershed. Work in progress includes detailed assessments of drainage problem areas in the Freeway Drive basin and lower Maddox Creek basin.

Dungeness River Hatchery Water Supply. Reviewed water rights certificates for the state-run fish hatchery on the Dungeness River to identify constraints which would influence the design or operation of a new intake. Performed a hydrologic assessment of published river flow data and identified flood flow and flow duration characteristics necessary for the hydraulic design of the new intake.

William A. Rozeboom, MBA, P.E., P.ENG.

Green River Water Quality Assessment Storm Delineations. Developed and implemented techniques to identify discrete runoff events from continuous streamflow data in daily and hourly formats. This work was performed in support of a multi-year assessment of water quality and quantity data being collected at 13 sites in the Green-Duwamish Watershed. Developed continuous hydrograph separation techniques which produced reasonable results both for isolated storms and within prolonged complex runoff events.

Mill Creek/Mullen Slough Chronic Flooding. Conducted wet weather ground and aerial surveys to document chronic flooding conditions in the lower Mill Creek (Auburn) and Mullen Slough basins in south King County. Evaluated historical hydrometric data and determined the representativeness of the observed conditions. Identified constricting reaches and point obstructions where targeted drainage improvements would provide relief from chronic flooding.

Snoqualmie River – North Bend Flood Insurance Study. Provided a technical review of Snoqualmie River HEC-RAS models and floodplain mapping developed by the Corps of Engineers for a Flood Insurance of the Snoqualmie River and its major tributaries at North Bend. The work was performed on behalf of the City of Snoqualmie, located immediately downstream and potentially affected by the map revisions. In two major cycles of review, identified technical discrepancies which resulted in unjustified flood level increases and which were successfully resolved through meetings and discussions with the Corps and with FEMA.

Seattle South Park Storm/Tide Design Events. Developed a 48 year continuous simulation sequence of urban runoff and tidally-influenced flooding of the City of Seattle South Park area which drains to the Duwamish River. Performed future-conditions hydrologic runoff computations with HSPF and wrote FORTRAN computer code to perform continuous simulation hydraulic routing of inflow, storage, and tidally-restricted outflow. Identified historic events representing 2-year through 100-year design storm/tide sequences.

Chain Lakes Dam Break Analysis. Constructed and debugged a Version 2 FLDWAV model for dam breach inundation studies of the North Dam of the Chain Lakes Reservoir, located in Southern Alberta about 100 km south of the City of Calgary. Prepared pre-processor input templates to expedite code preparation for this unstable model. Performed model debugging support on an on-call basis for the duration of the study.

South Heart Dam Break Analysis. Developed a beta-version FLDWAV model of the South Heart River below the South Heart Reservoir in north-central Alberta, updating previous DAMBRK and DWOPER models developed for the study reach by Alberta Environment. Performed dam breach and inundation modeling for a series of assumed reservoir return inflows, and assisted in the interpretation results.

Kent Third Avenue Storm System Modeling. Performed hydrologic modeling with HSPF and storm drain network modeling with EPANET of the storm drain improvements proposed for the collection system to a new pump station under design. Confirmed pipe sizes necessary to satisfy drainage requirements.

Snoqualmie River Floodway Certifications. In separate studies, performed hydraulic assessments of water level impacts which would result from proposed developments within the federally-regulated Snoqualmie River floodway through the City of Snoqualmie. Assessments were performed and appropriate mitigation measures were developed for a large multi-field municipal park, a commercial building within the City's Historic District, and various residential lot improvements. Prepared technical documentation in support of the "no-rise" certification required by FEMA and by the City's municipal code.

Mitigation Wetland Design. Performed site inspection and hydrologic modeling services for a mitigation wetland proposed for a gravel mine near Arlington in Snohomish County. Evaluated watershed conditions and basin hydrology for the proposed impact and mitigation sites, and through HSPF modeling identified the wetland depth-duration inundation characteristics which would result under alternative mitigation and basin restoration design alternatives.

Crossings at Pine Lake Drainage Review. Performed a technical review of drainage analyses, stormwater facilities, and wetland and stream impacts from the proposed residential development of a 56-acre site on the Sammamish Plateau. The site has several large wetlands and drains to two streams. Findings were expressed in letter reports and as testimony before the City of Sammamish Hearing Examiner.

William A. Rozeboom, MBA, P.E., P.ENG.

Cowlitz River Flood Analysis. Reviewed the controlled flow releases from the Cowlitz River Mossyrock Dam during flood events in November 1995 for compliance with FERC license requirements. Assessed alternative reservoir operating scenarios to determine the extent to which operating practices contributed to downstream flood damages. Testified at trial in Thurston County Superior Court.

Ledger Lake Wetland Impact Assessment. Performed hydrologic modeling and data analyses to evaluate potential impacts of city of Mount Vernon stormwater discharges to the Ledger Lake wetland complex. Modified a daily water balance simulation model of the area to incorporate a proposed pump station at the lake outlet, and to assess future water level conditions for comparison with existing conditions. Interpreted the model results in the context of regulatory guidelines for allowable wetland water level fluctuations.

Snoqualmie Ridge Post-Construction Monitoring Program. Provided technical review and regulatory oversight for a multi-disciplinary post-construction monitoring program to assess impacts of the 1,300-acre Snoqualmie Ridge Mixed Use Development. The development drains to numerous wetlands and fish bearing streams and is one of the first projects in King County to implement the requirements of the 1998 King County Surface Water Design Manual. The monitoring plan was developed to assess the performance of representative stormwater facilities, to determine if impacts to wetlands and streams were within the tolerances predicted by the project EIS, and to take remedial measures as necessary.

Snoqualmie River HEC RAS Modeling. Managed the updating of an existing HEC RAS hydraulic model of the Snoqualmie River at Snoqualmie to assess impacts of proposed modifications to the dam crest at the Snoqualmie Falls Hydroelectric Project. Work included a field survey, verification of model calibration to observed summer water level data, and hydraulic analyses to identify project water level impacts affecting summer river access and recreational opportunities.

Mill Creek Salem Hydrologic and Hydraulic Modeling. Developed, calibrated, and applied hydrologic and hydraulic models to assess flood control alternatives for Mill Creek at Salem, Oregon. HEC 1 and HEC HMS models were developed of the 104 square mile upper basin, calibrated to the record flood of February 1996, and applied to compute design flow hydrographs for current conditions and future scenarios with regional detention facilities. Developed and calibrated an unsteady flow branched network hydraulic model, UNET, for 15 network reaches describing Mill Creek and its tributaries which flow through the city of Salem. The UNET model was calibrated to high water mark data and very limited hydrograph data from the record flood of February 1996, and updated to incorporate flood reduction works constructed after flood event.

February 1996 Postflood Report. Managed the preparation of a postflood report for the Portland District Corps of Engineers (COE) providing comprehensive qualitative and quantitative documentation of the major storm which struck the Pacific Northwest in February 1996, causing record or near-record flooding in many basins. Archived and summarized more than 1,200 hydrometeorological data sets from USGS, NOAA, COE, and NRCS sites, developed storm isopluvial maps, determined storm intensity and flood discharge return periods, assessed flood control operations at 13 COE flood control reservoirs and 4 Section 7 flood control projects, and described COE flood fight activities.

Thunder Ridge Erosion Control. Provided expert advice, on behalf of a downstream landowner, on the adequacy of site erosion control measures at the 50-acre Thunder Ridge Estates Subdivision development in Snohomish County. Confirmed through a site inspection that the development erosion control did not comply with required Best Management Practices, and prepared documentation which led to a stop work order.

Mount Vernon Riverbend Stormwater Alternative. Determined the hydraulic effects of discharging stormwater from 230 acres of the City of Mount Vernon to low lying fields outside the City limits. The fields are located in a diked meander loop of the Skagit River, and interact with the river by seepage flows and a flap-gated culvert. Developed a daily water balance model of the area and calibrated seepage functions and soil specific yields to reproduce historic conditions. Determined design parameters for alternative pump station and culvert improvements to mitigate impacts of the proposed stormwater discharge.

Clarewood Development Review. Assessed drainage patterns and flood risk for properties downstream of the proposed Clarewood development in Pierce County. Provided expert testimony at a development hearing on the uncertain performance of infiltration facilities to be constructed upslope of an area with past flooding problems and the downstream flood impact risk associated with the development as proposed.

William A. Rozeboom, MBA, P.E., P.ENG.

Lake Chelan Hydroelectric Project PMF Study. Developed and calibrated a HEC-1 model of the Lake Chelan basin to determine PMF rain-on-snow lake inflow and outflow hydrographs for the Lake Chelan Hydroelectric Project. The basin consists mostly of rugged mountain terrain with very steep precipitation and temperature gradients which greatly affecting local snowpack and precipitation amounts. Calibration was made to historic flood events, and PMF simulations evaluating alternative reservoir operational scenarios were made in accordance with National Weather Service and Federal Energy Regulatory Commission guidelines.

North Fork Issaquah Creek Floodplain Mapping. Updated an existing HSPF hydrologic simulation model of the North Fork basin to determine flood quantiles for current land use conditions, and developed a HEC-2 hydraulic model to determine floodplain boundaries for 1.2 miles of channel ending at the confluence with the main stem Issaquah Creek. Flood flows and floodplain boundaries in the lower portion of the study reach were determined to be influenced significantly by inter-basin flood flows originating from the main stem channel and which overtop a ridge between the basins during major floods.

Snoqualmie Ridge Golf Course Drainage Reviews. Provided technical reviews of stormwater management plans and permanent utility plans and specifications for the Snoqualmie Ridge Golf Course on the Lake Alice Plateau above Snoqualmie Falls. Reviews were made for technical accuracy and compliance with City ordinances and MDP and EIS documents. The work required analyses of numerous requests to depart from the approved MDP and standard facility designs for purposes of golf course aesthetics and to construct a large lake combining functions of water quality treatment and storage of recycled water. Results were expressed by detailed review memoranda, meetings with the City and applicant, and participation at meetings of the City Planning Commission.

Wenatchee Alluvial Fan Flood Hazard Review. Reviewed flood hydrology and flood hazard mapping for alluvial fan streams in the City of Wenatchee to address a 20-year old dispute over the extent of 100-year flood hazard. Evaluated methodologies and assumptions used by previous studies, and developed updated flood hydrology estimates analyses based on HEC-1 modeling, regional analysis, and a 90-year archival record of flooding from local newspaper reports. Performed hydraulic analyses with the Federal Emergency Management Agency's FAN alluvial fan model. Study results led to an 80% reduction of the regulatory flood hazard zone, relieving more than 500 property owners from the need to purchase federal flood insurance.

Nevada Flood Insurance Hydrology Studies. Updated hydrology studies and determined design flows for FEMA floodplain mapping of three mountain streams in Washoe County near Reno and the North Las Vegas Wash Flood Control Project near North Las Vegas, Nevada. Design flows for the Washoe County streams were determined from a regional analysis to be governed by a population of relatively rare (about 50-year and higher return periods) cloudburst events accompanied by high sediment and debris loads. Existing HEC-1 models for the North Las Vegas Wash were reviewed and updated to improve estimates of 500-year flows. Methodologies used in the previous analyses had substantially underestimated 500-year flows by overlooking the loss of flow control when the 100-year design capacity of a major flood control facility is exceeded.

Washington Watershed Assessments. Conducted surface water assessments of the Deschutes, Snohomish, and Walla Walla Water Resource Inventory Areas under a statewide program of initial watershed assessments for the Washington State Department of Ecology (DOE). The purpose of this work was to characterize the "health" of the surface water resources in each watershed to facilitate decision-making by DOE on water rights applications. Examined available flow data in relation to established instream flow regulations, and conducted time-series assessments of streamflow and precipitation data to determine whether there were indications of declining minimum or average annual flows unrelated to natural climatic fluctuations.

Faro Mine Dam Break Analysis. Developed and debugged a DAMBRK model to perform dam breach simulations for a water supply reservoir at an abandoned mine in Yukon territory.

Mount Vernon Regional Drainage Analyses. Used HSPF simulation models of current and future land use conditions in the City of Mount Vernon to identify drainage problems along main stem channels throughout the city. Developed designs and costs for proposed alternative solutions including pump stations, regional detention pond facilities, and culvert replacements.

William A. Rozeboom, MBA, P.E., P.ENG.

Snoqualmie Ridge Parkway Plan Reviews. Reviewed Stormwater Management Plans, Erosion and Sediment Control Plans, and construction drawings for stormwater aspects of the 3.2-mile long Snoqualmie Ridge Parkway. Principal stormwater facilities include water quality/detention ponds, biofiltration swales, and a large-diameter high-flow bypass pipeline. The high-flow bypass pipeline is sized to convey excess flow from the Parkway and the adjoining Snoqualmie Ridge and Falls Crossing sites for direct discharge into the Snoqualmie River. Plans and drawings were reviewed for technical accuracy and for compliance with the King County Surface Water Design Manual, City of Snoqualmie ordinances, and project MDP and EIS documents. Coordinated subconsultant reviews of water quality and wetlands issues and facilities.

Mount Pinatubo Regional Hydrologic Analysis. Conducted a regional analysis of rainfall and streamflow data for the Mount Pinatubo region, assessed data reliability, prepared isopluvial maps of 2- through 500-year rainfall amounts for 24-hour through 5-day durations and, through HEC-1 modeling, developed flow duration and flood frequency curves for 39 potential sediment and flood control project sites on major streams affected by the 1991 eruption of Mount Pinatubo. Study results were published in COE Technical Report GL-94-16, Post Eruption Hydrology and Hydraulics of Mount Pinatubo, The Philippines.

Falls Crossing Master Drainage Plan (MDP) Review. Reviewed Draft MDP hydrologic and flood impact analyses submitted to the City of Snoqualmie for approval of a development partially located within the Snoqualmie River floodplain. Coordinated reviews of water quality and wetlands issues by subconsultants.

Cedar Hills Gaging Services and Data Processing. Responsible for operation of a six-station gaging network at the Cedar Hills landfill for a period of one year to identify and eliminate persistent data discrepancy problems. Conducted field tests and theoretical reviews which positively identified two principal problems: control elevations which had been incorrectly reported on "as-built" drawings, and inaccuracies in the technical manual used to derive theoretical rating curves for multiple-orifice outlet structures. Developed revised stage-discharge relationships which eliminated the data discrepancies, and provided training to client staff in data processing and reporting practices.

Snoqualmie Ridge Master Drainage Plan (MDP) Review. Reviewed Draft MDP hydrologic analyses and conceptual facility designs submitted to the City of Snoqualmie for mixed use development approval. Reviewed hydrologic analyses for adequacy of HSPF model calibration and measures proposed to deal with uncertainty in the analyses. Reviewed conceptual facility designs for feasibility and compliance with applicable development standards. Coordinated reviews of water quality and wetlands issues by subconsultants.

Myrtle Creek Flood Study Review. Reviewed flood hydraulics and floodplain mapping studies for the Town of Myrtle Creek located at the confluence of Myrtle Creek and the South Umpqua River. The work was undertaken on behalf of the Federal Emergency Management Agency to resolve a 4-foot discrepancy in the 100-year flood elevation as reported by two other federal agencies. The discrepancy was resolved by identification of an error in one of the earlier analyses.

Snoqualmie Parkway EIS and SMP Reviews. Managed a multidisciplinary review of water quantity, water quality, and wetlands elements of Environmental Impact Statement materials and supporting documents submitted to the City of Snoqualmie for the proposed Snoqualmie Ridge Parkway. Subsequently reviewed the Stormwater Management Plans (SMP) and construction drawings for compliance with applicable standards and representations made in the environmental impact process. The work was undertaken for the City of Snoqualmie under the direction of the Director of Community Development.

Evans Creek HSPF Model Calibration. Calibrated the EPA's Hydrologic Simulation Program - Fortran (HSPF) to streamflow and wetland water level data collected at four sites in the Evans Creek West catchment of the proposed Northridge/Redmond Ridge Urban Planned Development in King County.

Cedar Hills Hydrologic Data Review. Reviewed the accuracy of rain and flow data being collected at the Cedar Hills landfill to determine downstream impacts and for future calibration of a hydrologic model. Identified erroneous records through double-mass analysis, reviewed implications of stage measurement and theoretical rating curve errors, and recommended measures for improving data accuracy.

William A. Rozeboom, MBA, P.E., P.ENG.

Supermall Downstream Impact Assessment. Developed current and future land use HSPF simulation models for the proposed Supermall of the Great Northwest to identify downstream impacts. Linked hourly HSPF simulation results to a finite difference unsteady flow model, FEQ, and assessed water level impacts through a complex system of wetlands, ditches and culverts to the downstream receiving channel.

Hawaii Water Use Inventory. Implemented Hawaii State Water Code legislation requiring registration of all wells and stream diversions statewide, declaration of water use, and monthly reporting of water use. Gave public workshops on water code requirements, developed systems, procedures, and databases to analyze and manage the contents of 7,300 declarations of water use, acted on all declarations, and coordinated field survey activities for verification of water facilities and uses.

Hawaii Database Development. Developed computer databases to track processing of Hawaii well and stream diversion works construction permits, to inventory wells, stream diversions, and water uses statewide, and to target specific groups by geographic area and/or activity for mailings of notices and informational materials.

Hawaii Water Rights and Dispute Resolution. Administered the first contested case hearing before the Hawaii Commission on Water Resource Management, including mediating discussions between opposing expert witnesses, preparing the Findings of Fact, and drafting the Commission's Decision and Order. Prepared the Findings of Fact report which led to the designation of the Island of Molokai as a Water Management Area. Prepared Departmental testimony to the Legislature on proposed amendments to the State Water Code.

Hawaii Satellite-Linked Water Resources Data Collection. Initiated and developed a pilot program for collecting real-time precipitation and other water resources data via satellite from remote areas in Hawaii.

Bank Protection Research. Conducted a comprehensive review of alternative methods of streambank protection, seeking those that would provide cost-effective alternatives to conventional riprap protection for highway bridges in Alberta. Computed present value project life costs of promising alternatives, considering allowable velocities, maintenance costs, local availability of materials, and transportation costs.

Jasper Park Lodge Water System Analysis. Conducted computer analysis of recirculating water system for Jasper Park Lodge; identified causes and recommended solutions to problems of low water pressure and fluctuating water temperatures.

Water Utility Privatization Study. Determined rate structures and impact on consumers which would result from the privatization of water and sewerage facilities for small municipalities.

Montserrat, W.I., Integrated Resource Development Project. Provided specialist water resources input on a five-person multidisciplinary mission in Montserrat, W.I. for the Canadian International Development Agency. Determined design and construction specifics and costs for small dam and irrigation projects to facilitate agricultural self-sufficiency.

St. Lucia W.I. Roseau River Carriage Loss Assessment. Determined water losses which would result from using a natural channel to transmit water from a proposed water storage reservoir to downstream agricultural users.

St. Lucia W.I. Roseau Basin Water Development Program. Provided hydrologic input toward site selection for a water supply reservoir in St. Lucia, W.I. Reviewed reliability of available hydrometric data and extended streamflow records using rainfall records and computer modeling techniques. Estimated low-flow sequences to determine reservoir storage needs, and design floods for spillway sizing. Conducted training with local personnel for computer use and hydrologic techniques.

School Financial Planning Model. Refined a prototype computer model to project finances over a 5-year horizon based on scenarios of economic and demographic growth, required facilities, debt structure, salary rates, and programs of government financing.

City of Yellowknife Municipal Financial Assessment. Assessed the impact of the City's 5-year capital improvements plan on financial stability and tax rates.

William A. Rozeboom, MBA, P.E., P.ENG.

Ross Creek Basin Surface Water Supply. Developed a computer simulation model which accounted for varying precipitation, evaporation, runoff and water consumption within the Ross Creek Basin in southern Alberta. The model was used to develop a 50-year sequence of natural runoff conditions and to assess alternative water supply management proposals.

Peace River Basin Surface Water Supply. Determined surface water supply characteristics from limited streamflow records based on regional correlations and frequency analyses, and computed reliable water supplies for 22 communities in northwest Alberta based on intake characteristics, current and projected water consumption, and existing reservoir facilities.

Pipeline River Crossings. Conducted field surveys and determined hydraulic design parameters of scour, bank erosion and 1.100 year high water levels at 32 river crossings of the Alaska Highway Gas Pipeline and 7 river crossings of the Alberta Deep Basin Pipeline.

Gull Lake Regulation Study. Developed and calibrated a computer simulation model to determine causes of historical declines in lake levels and assessed the effectiveness of alternative lake management scenarios on the basis of historical hydrological conditions.

Carriage Loss Investigations. Designed and coordinated a field research study to monitor carriage losses over 60 km of natural channel in Southern Alberta; analyzed field data to determine the magnitude, uniformity, and causes of losses. Reviewed and evaluated all previous studies conducted to assess carriage losses in natural channels in Alberta and Saskatchewan, and developed techniques to predict carriage losses which affect reservoir release flows into natural channels.

Isle Lake - Lac Ste. Anne Stabilization. Developed and implemented a computer simulation model to examine proposals to stabilize lake water levels.

Alaska Highway Gas Pipeline Route Hydrology. Six-month in-house assignment with the Yukon Pipeline Design Joint Venture design team. Provided hydrotechnical input on small basin hydrology and for development of drainage and erosion control criteria.

Berry Creek Channel Losses. Determined channel losses affecting reservoir release flows over 12 km of natural channel in southern Alberta.

Willow Creek Water Supply. Determined causes of winter water supply shortage at communities drawing water from Willow Creek below Chain Lakes Reservoir in southern Alberta.

Little Bow Basin Water Supply. Assessed basin water supplies as affected by internal runoff and inter-basin water diversions.

Whitford Lake Basin Management. Developed a comprehensive study program to establish an engineering data base and methodologies to evaluate drainage and flood control projects in the Whitford Lake Basin in central Alberta.

Buffalo Bay - Horse Lakes Management Program. Developed a computer simulation model to assess water levels and discharges in the Buffalo Bay - Horse Lakes complex in north-central Alberta under alternative management schemes.

Rat Creek Bridge Crossings. Conducted field surveys, determined hydraulic design parameters, and designed abutment armoring for two single-span bridge crossings in central Alberta.

McLeod River Bank Stabilization. Conducted field surveys and designed rip-rap armoring for bank stabilization at a railway bridge in central Alberta.

Channel Ice Surveys. Conducted winter ice and breakup surveys at 52 river crossings encountered along the British Columbia segment of the proposed Alaska Highway Gas Pipeline.

Red Deer River Floodplain Development. Determined open water and ice jam design flood levels and developed measures for floodplain development in Red Deer, Alberta.

William A. Rozeboom, MBA, P.E., P.ENG.

St. Mary Canal Sedimentation. Conducted field bed load transport studies to assess sources and mechanisms of canal sedimentation in southern Alberta.

Dickson Dam Diversion Tunnel Model Study. Constructed and tested a 1:54 scale physical model of dual 5.5 m diameter diversion tunnels. Assessed and optimized intake and outlet flow patterns, minimized transition losses, and assessed outlet scour. Supervised construction of a 1:70 scale model of the 60 m wide, 190 m long service spillway for the dam project.

Port McNeill Harbour Breakwater Model Study. Constructed and tested a 1:100 scale physical model of the Port McNeill harbour region in British Columbia. Developed a breakwater design to shelter a proposed harbour expansion from ocean waves.

Elbow River Channel Improvement. Conducted field surveys and designed channel improvements to increase Elbow River side-channel flows in the Calgary, Alberta. The work was undertaken to demonstrate city ownership of riparian lands and to discourage encroachment by adjacent private landowners.

Harvey Creek Channelization Model Study. Constructed and tested 1:15 and 1:25 scale physical models of a steep 12 degree channel in British Columbia. Assessed the stability of 1.0 m diameter boulders under flood conditions, and flow patterns through transitions and curves in an engineered reach of channel.

Cooling Pond Circulation Model Studies. Constructed and tested physical scale models of cooling ponds formed in natural topography for three thermal generating stations in central Alberta: the Calgary Power Ltd. Keephills Thermal Plant, the Edmonton Power Genesee Power Project, and the Alberta Power Ltd. Sheerness Generating Station. Assessed alternative dike arrangements to optimize circulation patterns under conditions including thermally stratified flow and adverse wind shear.

Sundance Helper Cooling System Model Study. Developed 1:12 scale model of a 20 m long sump bay with a 2.1 m diameter, 100,000 GPM pump intake. designed baffles to produce smooth intake flows, and determined intake energy losses.

Field Surveys. Conducted hydrometric surveys over two summers of more than 100 rivers and lakes throughout the Province of Alberta. Responsibilities included surveying of seasonal lake level elevations, streamflow gauging by wading and bridge crane methods, sampling of suspended sediment at bridge and cableway sites, hydrographic soundings and mapping of lake bottom contours, field servicing and repair of strip-chart water level recorders, and assisting in the construction and installation of housings and equipment for stream gauge stations.

Publications

"Use of a Scale Model to Improve Pond Circulation," Proceedings of the Specialty Conference on Computer and Physical Modeling in Hydraulic Engineering; Chicago, Illinois; August, 1980.

"Carriage Losses in Natural Channels in Southern Alberta," with S.J. Figliuzzi. Proceedings of The 1986 Canadian Hydrology Symposium on Drought: The Impending Crisis?; Regina, Saskatchewan, June 1986.

"U.S. Television Programs in the International Market: Unfair Pricing?" with C. Hoskins and R.K. Mirus. Journal of Communication, (Spring 1989) Vol. 39, No. 2, pp. 55-75.

Principal

Education

B.Sc. Civil Engineering,
University of Alberta, 1983

M.Sc. Civil Engineering
(Hydraulics), University of
Alberta, 1986

License/Affiliations

Member, The Association of
Professional Engineers,
Geologists, and
Geophysicists of Alberta

Member, The Association of
Professional Engineers and
Geoscientists of the
Province of British Columbia

Member, The Association of
Professional Engineers,
Geologists, and
Geophysicists of the N.W.T.

Member, The Canadian
Society for Civil Engineering

Member, Canadian
Standards Association -
Canadian Highway Bridge
Design Code Loads and
Load Factors Subcommittee

Years Experience

26

Areas of Expertise

Cold Regions Engineering

Environmental Hydraulics

River Engineering

Hydrology

Hydrographics

Mr. Van Der Vinne has 26 years of experience in various fields including cold regions engineering, river engineering and environmental hydraulics. He has experience in ice breakup processes, hydraulics of ice covered rivers, ice forces on bridge piers, pier vibration, river engineering, open channel hydraulics, sedimentation, scour, hydrology, river mixing processes, contaminant transport, fishway hydraulics, and fish habitat enhancement. Much of his experience has been in collecting and analyzing data from harsh environments. He also has expertise running a number of numerical models.

Selected Project Experience

Cold Regions Engineering

Evaluation of Ice Platform at Fort McMurray, AB: Evaluated deflection test results to determine ice bearing capacity and creep deflection for geotechnical testing in Athabasca River.

Evaluation of Ice Platform at Suncor, AB: Evaluated deflection test results to determine ice bearing capacity and creep deflection for geotechnical testing in Athabasca River.

Measurement of Ice Characteristics on the Peace River, AB: Collated and summarized ice data collected over two winter seasons on the Peace River for improvement of modeling of ice processes.

Evaluation of Ice Effects on Fish Barrier at Port Washington, WI:

Evaluated ice loads and frazil effects for fish barrier at power plant intake.

Evaluation of Ice Platform at Cross Lake, MN: Evaluated deflection test results to determine ice bearing capacity and creep effects for installation of girders for bridge over the Nelson River.

Evaluation of Ice Platform at Rainy River, ON: Estimated ice bearing capacity and creep effects for bridge maintenance work from ice cover.

Evaluation of Ice Platform at Alemeda Dam, SK: Evaluated deflection test results to determine ice bearing capacity and creep effects for installation of new bulkhead in dam through a slot in the reservoir ice cover.

Preliminary Design of the Mackenzie River Bridge near Fort Providence, NWT: Evaluated ice loads and ice jam levels for pier design.

P. Gary Van Der Vinne, M.Sc., P.Eng.

Evaluation of Ice loads on Peace River Weir near Dunvegan, AB: Evaluated ice loads and frazil effects for weir design.

Evaluation of Clearwater River Ice Bridge near Fort McMurray, AB: Evaluated deflection tests and determined ice bearing capacities for timber haul.

Evaluation of Athabasca River Ice Bridge near Fort McMurray, AB: Conducted deflection tests and determined ice bearing capacities for gravel haul.

Evaluation of Athabasca River Ice Bridge near Fort Mackay, AB: Conducted deflection tests and determined ice bearing capacities for hauling construction equipment and gravel to CNRL mine project.

Design of the Four Bears Bridge over Lake Sakakawea, ND: Evaluated growth and deterioration of ice in the reservoir for ice load analysis.

Evaluation of the bearing capacity and creep of ice drilling platforms in the Athabasca River, AB: Designed procedure for test the ice platforms and determined the allowable weights and occupation times for the drill rig.

Evaluation of the Effects of Power Production on the Ice Regime in the Peace River, AB: Calibrated a numerical model to predict ice cover progression and melting in the Peace River to determine the effects of power production.

Design of the McLeod River Bridge Pier Re-enforcement near Peers, AB: Evaluated transverse ice forces for a severely skewed bridge pier.

Evaluation of North Saskatchewan River Ice Bridge near Willingdon, AB: Conducted deflection tests and determined bearing capacities for gravel haul ice bridge.

Design of the Nelson River Pipeline Bridge near Hwy 77, Fort Nelson, BC: Specified design ice forces for bridge piers.

Design of the Bow River Bridge for the Deerfoot Extension, Calgary, AB: Specified design ice forces for bridge piers.

Design of the St. John River Bridge at Jemseg, NB: Evaluated ice loads on exposed piles below elevated pile cap.

Design of the Cree River Bridge at Wapata Lake, SK: Specified design ice forces for bridge piers.

Design of the Athabasca River Bridge at Whitecourt, AB: Specified design ice forces for bridge piers.

Design of the McLeod River Bridge at Whitecourt, AB: Specified design ice forces for bridge piers.

Evaluation of Riviere des Rocher Ice Bridge near Ft. Chipewyan, AB: Investigated causes of limited ice growth during construction and specified allowable loads based on bearing capacity tests.

Evaluation of Bearing Capacity of Lake Ice Sheet near Canmore, AB: Evaluated allowable loads and associated creep rates for an ice platform used for movie set.

P. Gary Van Der Vinne, M.Sc., P.Eng.

Evaluation of 1997 Freeze-up Event on North Saskatchewan River at Edmonton, AB: Documented extent of high ice levels caused by collapse of ice cover during freeze-up.

Evaluation of Ice Related Flooding on the Kananaskis River, AB: Investigated the effects of flow regulation on the formation and accumulation of ice in the channel downstream of the power plant.

1997 Ice Jam Flooding at Peace River, AB: Investigated the events leading to 1997 ice jam flood at the Town of Peace River.

Frost Probes Servicing across Alberta: Planned and coordinated repair or replacement of soil temperature monitoring sites for Alberta Transportation and Utilities.

Design of Erosion Protection at Tuktoyaktuk, NWT: Analyzed drainage and insulation requirements for concrete slab revetment and determined layout of slabs and associated riprap.

Design of Ice Platform for Suncor Bridge, AB: Assisted in specifying ice thicknesses required to support heavy loads during bridge construction and for transporting mine equipment across the river.

Evaluation of Ice Platform for White River Bridge Construction, YK: Evaluated allowable loads and associated creep rates for an ice platform used for erecting bridge girders.

Peace River Ice Study, AB: Determined hydraulic characteristics for ice jam levels and investigated the causes of the 1992 flood at the Town of Peace River.

Design of Wharf at Rankin Inlet, NWT: Analysed wave heights, tidal fluctuations, ice forces, and riprap protection for design of docking facility for barges.

Design of Rossdale Water Intake, Edmonton, AB: Selected design ice forces for the intake structure.

Design of the Suncor Bridge over the Athabasca River, AB: Selected design ice forces for piers and modeled the effect of cofferdam construction on potential ice jam profiles in the vicinity of the bridge.

Characterization of an ice breakup wave on the Athabasca River at Ft. McMurray, AB: Coordinated the data collection and modeling of an ice breakup wave.

Deterioration of an ice cover on a small pond: Evaluated albedos and heat transfer coefficients of snow and ice from two years of measured snow and ice thicknesses and densities.

Bearing capacity of the Fort McPherson ice bridge, NWT: Designed ice strength testing program and evaluated bearing capacity of the ice bridge.

Ice load estimates for the Little Red Deer River, AB: Developed, planned, and evaluation of ice breakup observations as well as analysis of expected ice forces.

Rational Approach to Estimating Ice Forces on Alberta Streams: Developed a theoretical framework to estimate ice forces on bridges piers from hydrological and meteorological data.

Evaluation of the Economic Impact of River Ice Jams in Canada: Developed and conducted a survey of agencies dealing with river ice across Canada as well as summarized and evaluated the information collected.

P. Gary Van Der Vinne, M.Sc., P.Eng.

An Evaluation of the Estimation of Ice Forces from the Dynamic Response of a Massive Bridge Pier:

Evaluated pier vibration and ice force data collected at Hondo, Alberta to determine whether pier acceleration measurements could be used to determine ice forces.

Ice force measurements at Hondo, AB: Summarized and evaluated three years of ice force measurements relative to previous measurements.

River Engineering and Hydrology

Hydrotechnical assessment of improvements to the Hwy 63 bridge over the Athabasca River at Ft

McMurray, AB: Evaluated hydrology, hydraulics, and ice loads for bridge expansion.

EIA for Oilsands Mining Project near Fort Mackay AB: Evaluated effects of project on water supply and drainage on the lease.

Hydrotechnical design Inputs for the Great Bear River Bridge, NWT: Evaluated hydrology, hydraulics, and ice loads for design of bridge.

Hydrotechnical information for the proposed Okanagan Lake Bridge, BC: Evaluated water levels, wave heights and ice loads for a new floating bridge at Kelowna.

Flow Forecasting in the Battle River at Forestburg, AB: Developed statistical flow forecast model for basin upstream of Forestburg for input in reservoir model.

Design of the Elk River Bridge near Lodgepole, AB: Evaluated hydrology and hydraulics for design of new bridge.

Preliminary Design of the Blackwater River Bridge, NWT: Evaluated hydrology, hydraulics and channel stability for design of bridge.

Preliminary Design of the Donnelly River Bridge, NWT: Evaluated hydrology, hydraulics and channel stability for design of bridge.

EIA for SAGD Oilsands Project near Fort Mackay AB: Evaluated effects of project on water supply and drainage on the lease.

Design of the Lobstick River Bridge near Entwistle, AB: Evaluated hydrology, hydraulics and scour for design of new bridge.

Preliminary Design of the Mackenzie River Bridge near Fort Providence, NWT: Evaluated hydraulics and scour for bridge design.

Design of Culvert for Small Creek at TransAlta's Sundance Generating Station, AB: Provided hydrologic and hydraulic design for culvert under Hwy 627.

Preliminary Evaluation of 20 Bridge Crossings on the Mackenzie Highway, NWT: Inspected 20 proposed crossing sites and provided preliminary hydrologic and hydraulic design values.

Design of Five Bridges on the Mackenzie Highway, NWT: Provided hydrologic, hydraulic and ice design values for bridges over Mackenzie River tributaries.

P. Gary Van Der Vinne, M.Sc., P.Eng.

Review of Road Drainage Options to Alleviate Flooding near Northstar, AB: Determined design runoff volumes and peak flows and determined adequate channel and culvert sizes.

An Evaluation of Providing Flood Control at Fort McMurray by a Staged Diking Approach, AB: Assisted in determining dike profiles and fill volumes for estimating dike costs.

Inspection of River Protection Works at Bridges in Alberta: Inspected and evaluated the integrity and effectiveness of river training structures at 20 bridge sites.

Design of Erosion Protection for the Blackstone River Bridge near Nordegg, AB: Designed erosion protection for headslope of existing bridge after flood damage to existing headslope.

Design of Erosion Protection for the East Prairie River Bridge at Enilda, AB: Designed erosion protection for headslope of existing bridge after flood damage to existing headslope.

Evaluation of Erosion Protection for the Saddle River Bridge near Rycroft, AB: Evaluated the stability of erosion protection for headslope of existing bridge and designed riprap repairs and drain to upgrade the headslope protection.

Investigation of Scour and Erosion at Bridges in Northern Alberta: Evaluated past and present scour and erosion measurements at 47 bridge sites.

Scour and erosion on the North Saskatchewan River near Drayton Valley, AB: Evaluated historical scour and erosion measurements at the bridge and groin.

Field measurements of forces on an individual element of riprap: Contributed to instrument design and developed monitoring program. Evaluated forces from initial data collected from monitoring program.

Evaluation of scour and related flow processes on the Oldman River near Brocket, AB: Evaluated the hydraulic and scour performance of the bridge piers and river training structures.

Hydraulic characteristics of the Wapiti River near Grande Prairie, AB: Reviewed hydraulic and scour analysis at bridge and evaluated riprap stability of nose protection on groin.

Hydraulic characteristics of the Smoky River near Watino, AB: Reviewed hydraulic and scour analysis at bridge.

Hydraulic characteristics of the Bow River near Cluny, AB: Reviewed hydraulic and scour analysis at bridge.

Environmental Hydraulics

Measurement of storm sewer discharge by dye dilution, Edmonton, AB: Calibrated flow measurement weirs in two storm sewers by determining discharges by measuring diluted dye concentrations.

Cabin Creek Culvert Fish Habitat Compensation Hydrology and Hydraulic Analysis, AB: Evaluated hydrology and hydraulics of existing culverts to improve fish passage.

Water Quality at Water Intake in Saskatoon, SK: Provided advice for water quality modeling of potential contaminants at intake site.

P. Gary Van Der Vinne, M.Sc., P.Eng.

Dye Dilution Test for Calibration of Outfall Flume at Pulp Mill near Grande Prairie, AB: Planned and carried out a dye dilution test to independently determine the effluent discharge in a flow metering flume.

Tracer Dye Studies in the Lower Athabasca River, AB: Planned and carried out five constant head dye tests between Fort McMurray and Embarras and calibrated a numerical model to determine the mixing coefficient for each reach.

Water Quality Characteristics of WWTP Outfall in Yukon River at Whitehorse, YK: Developed water quality model to determine effects of changes in location on outfall plume to determine best location of outfall.

Ice and Water Quality Characteristics of WWTP Outfall in Yukon River at Carmacks, YK: Calibrated water quality model to assess the changes in river water quality due to outfall plume.

Modelling of Potential Oilspill in the North Saskatchewan River, AB: Calibrated two-dimensional flow model over river to provide velocity field for oilspill transport model and provided advice on development of oilspill model.

Modelling of Transverse Mixing of the Thermal Effluent Downstream of the Genesee Power Plant, AB: Simulated river water temperatures and contaminant concentrations using a transverse mixing model.

Hydraulic and Ice Studies Yukon River Bridge Crossing at Dawson City, YK: Calibrated water quality model to assess the changes in river water quality due to the effects of the bridge abutments on the sewage discharges upstream.

Near Field Mixing Characteristics of the North Saskatchewan River at Edmonton, AB: Evaluated near field mixing characteristics at 3 major and 14 minor outfalls discharging into the North Saskatchewan River within the City of Edmonton for a range of outfall and river flow rates.

Modelling of Transverse Mixing of Thermal Effluent Downstream of the Rosedale Power Plant, AB: Simulated river water temperatures in both summer and winter conditions using a transverse mixing model designed to incorporate heat transfer and ice melting.

Simulation of Water Quality Parameters in the Assiniboine River below Brandon, MB: Simulated various water quality parameters using WASP model to determine effects of proposed hog processing effluent on river water quality.

Fish Habitat Enhancement Structures Inventory: Designed, coordinated and evaluated a survey of existing habitat structures in Saskatchewan, Manitoba and Northern Ontario.

Inventory of disturbed sites and sediment sources in the Scotch Creek basin, BC: Evaluating the basin flood frequencies from regional discharge data.

Performance of stream habitat structures in southwestern Alberta: Estimated flood frequencies and hydraulic characteristics of the structure sites and evaluated the stability of the structures.

Winter travel time and mixing characteristics, Peace River: Shaftesbury Ferry to Notikewin River, AB: Planned and coordinated a large scale under-ice tracer dye test and evaluated the travel times and mixing characteristics from the test results.

Hydrology and surface water quality of Syncrude Mildred Lake operation, AB: Modeled the effects of planned mine site reclamation on salinity in the Athabasca River using a 2-D numerical mixing model.

P. Gary Van Der Vinne, M.Sc., P.Eng.

Distribution of dissolved contaminants in Bow River below Canada Creosote site, AB: Planned and coordinated a two-dimensional steady state tracer dye test to delineate the contaminant plume. Evaluated the transverse mixing coefficient for a 2-D model and estimated contaminant loading rates for various discharges.

Winter Low Flow Tracer Dye Studies, Athabasca River, AB: Athabasca to Bitumount: Planned and coordinated three large scale under-ice tracer dye tests and evaluated the travel times and mixing characteristics from the test results.

Transverse Mixing Coefficients in the North Saskatchewan River, AB: Evaluated transverse mixing coefficients from various sources and calibrated a 2-D unsteady numerical mixing model.

Mixing Characteristics of a Spill Pathway between Yellowhead Trail and the Rosedale Water Treatment Plant, Edmonton, AB: Planned and coordinated tracer dye tests in a storm sewer and in the river and evaluated the travel times and dilution rates of a potential chemical spill.

Tracer Dye Studies on the North Saskatchewan River, Edmonton to Saskatchewan Border: Planned and coordinated two open water and two under-ice tracer dye tests and evaluated the travel times and mixing characteristics from the test results.

Travel Time and Longitudinal Dispersion Characteristics on the Ice-Covered Wapiti and Smoky River: Planned and coordinated three under-ice tracer dye tests and evaluated the travel times and longitudinal mixing characteristics from the test results.

Low Flow Winter Travel Time Characteristics of the Athabasca River, Hinton to Athabasca, AB: Coordinated five large scale under-ice tracer dye tests and evaluated the travel times and longitudinal mixing characteristics from the test results.

Hydrologic, Hydrogeologic, Thermal, Sediment, and Channel Regimes of the Tri Creeks Experimental Basin, AB: Evaluated the water and sediment yields of three forested basins to determine the effects of various logging practices.

An Experimental Study of the Hydraulics of Vertical Slot Fishways: Assessed both uniform and non-uniform flow characteristics of fishways using scale models.

Delineation of heated water jets: Measured the spreading rates of various configurations of heated surface jets in laboratory flumes.

Hydrographics

Summer and Winter Surveys of the Athabasca River to Assess Fish Habitat, AB: Planned and coordinated two winter and three summer bathymetric surveys to define bed topography and cross-sections and calibrated a two-dimensional flow model used to assess fish habitat suitability.

Survey of the Athabasca River at Bitumount to Assess Fish Habitat, AB: Coordinated bathymetric survey to define bed topography and cross-sections for use in a two-dimensional flow model used to assess fish habitat suitability.

Winter Survey of the Athabasca River at Fort Mackay to Assess Fish Habitat, AB: Planned and coordinated winter bathymetric surveys to define bed topography, cross-sections, and velocities for use in a two-dimensional flow model used to assess fish habitat suitability.

P. Gary Van Der Vinne, M.Sc., P.Eng.

Survey of the Athabasca River at Fort Mackay to Assess Fish Habitat, AB: Planned and coordinated bathymetric surveys to define bed topography and cross-sections for use in a two-dimensional flow model used to assess fish habitat suitability.

Flood Plain Study of North Saskatchewan River at Edmonton, AB: Planned and coordinated bathymetric survey to extend flood plain study upstream and downstream of city.

Survey of the North Saskatchewan River at Edmonton, AB: Planned and coordinated bathymetric surveys to define bed topography to determine the thalweg location for navigation purposes.

Survey of the North Saskatchewan River at Garden River to Assess Fish Habitat, SK: Planned and coordinated bathymetric surveys to define bed topography and cross-sections for use in a two-dimensional flow model used to assess fish habitat suitability.

Survey of the South Saskatchewan River at Rattlesnake Hole to Assess Fish Habitat, AB: Planned and coordinated bathymetric surveys to define bed topography and cross-sections for use in a two-dimensional flow model used to assess fish habitat suitability.

Survey of the Assiniboine River to Assess Fish Habitat, MB: Coordinated bathymetric surveys to define bed topography and cross-sections at three sites for use in a two-dimensional flow model used to assess fish habitat suitability.

Hydrographic Database for Peace-Athabasca Delta, AB: Designed GIS database of historical hydrographic data in the delta.

Water Intake in the North Saskatchewan River near Genesee, AB: Planned and coordinated bathymetric survey to assess scour in the vicinity of spurs protecting water intake.

Survey of the Bow River at proposed Deerfoot Trail Bridge near Calgary, AB: Planned and coordinated bathymetric survey to define bed topography and cross-sections for the design of the new bridge.

Survey of the Athabasca River at Whitecourt, AB: Planned and coordinated bathymetric survey to define bed topography, cross-sections, and existing scour for the design of a second highway bridge.

Survey of the McLeod River at Whitecourt, AB: Planned and coordinated bathymetric survey to define bed topography, cross-sections, and existing scour for the design of a second highway bridge.

Survey of the Smoky River at Canfor Bridge, AB: Planned and coordinated bathymetric survey using GPS to survey scour holes and cross-sections near a bridge with a failed footing.

Water Intake in the North Saskatchewan River at Genesee, AB: Planned and coordinated bathymetric survey using GPS for erosion protection at water intake.

Water Intake in the Bow River at Cochrane, AB: Planned and coordinated bathymetric survey for proposed water intake and produced contour maps of the river bed.

Survey of the Bow River at Fish Creek, Calgary AB: Planned and coordinated bathymetric survey for fish habitat study.

Rossdale Water Intake in the North Saskatchewan River: Planned and coordinated bathymetric survey using GPS for proposed water intake.

P. Gary Van Der Vinne, M.Sc., P.Eng.

Instream Flow Needs Study in the Assiniboine River, MB: Contributed to the planning and analysis of bathymetric surveys of a fish habitat site.

Technical Publications

Van Der Vinne, G. and D.D. Andres, 2003. In-situ deflection measurements of ice bridges: results and implications on design. Proceedings of the 12th Workshop on the Hydraulics of Ice Covered Rivers: Winter Environments of Regulated Rivers. Committee on River Ice Processes and the Environment, Hydrology Section, Canadian Geophysical Union, Edmonton, Alberta.

Andres, D. and G. Van Der Vinne, 1998. "Effects of Climate Change on the Freeze-up Regime of the Peace River." Proceedings of the 14th IAHR International Symposium on Ice: Ice in Surface Waters. Potsdam, NY, USA, Pp. 153-158.

Neill, C.R., E.K. Yaremko, G. Van Der Vinne, and D. Andres, 1995. "Under-Ice Hydraulics and Mixing in Regulated Peace River". Proceedings of the 8th Workshop on the Hydraulics of Ice Covered Rivers: Winter Environments of Regulated Rivers. Committee on River Ice Processes and the Environment, Hydrology Section, Canadian Geophysical Union, Kamloops, British Columbia, Pp. 159-186.

Van Der Vinne, G. and D.D. Andres, 1990. "Longitudinal Dispersion in the Ice-covered Athabasca River", Northern Hydrology Symposium, National Hydrology Research Institute, Saskatoon.

Van Der Vinne, G., T. Prowse, and D.D. Andres, 1990. "Economic Impact of River Ice Jams in Canada", Northern Hydrology Symposium, National Hydrology Research Institute, Saskatoon.

Kochtubajda, B. D.D. Andres, and G. Van Der Vinne, 1990. "Towards Real-Time Runoff Forecasting in Small Rural Alberta Basins", Eighth AMS Hydrometeorology Conference, Kananaskis Park, Alberta.

Van Der Vinne, G. and D.D. Andres, 1988. "Forest Harvesting and Sediment Yield in the Tri Creeks Basin", Canadian Hydrology Symposium, National Research Council of Canada, Banff, Alberta.

Van Der Vinne, G. and D.D. Andres, 1988. "Forest Harvesting and Water Yield in the Tri Creeks Basin", Canadian Hydrology Symposium, National Research Council, Banff, Alberta.

Van Der Vinne G., 1987. "The Hydrology of the Tri Creeks Watershed." Proceedings of the Third Annual Applied Aquatics Workshop, Edmonton, Alberta. Alberta Research Council contribution series number 1475.

Van Der Vinne, G., 1986. "Hydraulics of Vertical Slot Fishways." M.Sc. Thesis, Department of Civil Engineering, University of Alberta, 130 pp.

Rajaratnam, N., G. Van Der Vinne, C. Katopodis, 1986. "Hydraulics of Vertical Slot Fishways." ASCE, Journal of Hydraulic Engineering, Vol. 112, No. 10. pp. 909-927.

Rajaratnam, N., C. Katopodis, G. Van Der Vinne, 1985. "M1-type Backwater Curves in Denil Fishways." Proceedings, Proc. 7th Canadian, Hydrotechnical Conference, Saskatoon, SK, Vol. 1B, pp. 141-156.

RESUME

Shannon Shaw, B. Sc., M.Sc., P.Geo (BC)
Senior Geochemist

Ms. Shaw is a senior geochemist and mineralogist with approximately 15 years of experience in environmental consulting for the mining industry. Her areas of specialization are in acid rock drainage and metal leaching prediction, mine waste management, alternative evaluations, risk assessments and multi-stakeholder consultations.

Education:

B.Sc. (Geological Sciences and Chemistry), Queen's University, Kingston, Ontario, Canada
M.Sc. (Geological Sciences), University of British Columbia, B.C., Canada

Summary of Experience:

Apr. '09 to present: President and Senior Geochemist, pHase Geochemistry Inc.
Aug. '05 to Mar. '09: Senior Geochemist, MESH Environmental Inc.
Feb. '05 to Jul. '05: Geochemist/Mineralogist, Mehling Environmental Management Inc.
Oct. '96 to Jan. '05: Geochemist, Robertson GeoConsultants Inc.
1996: Small scale mineralogical consulting contracts
1994 to 1995: Teaching Assistant, University of British Columbia, B.C., Canada.
1993 to 1994: Teaching and Research Assistant, Queen's University, Kingston, Ontario, Canada.

Affiliations:

Association of Professional Engineers and Geoscientists of British Columbia (APEGBC)
Society for Mining, Metallurgy and Explorations (SME)
Canadian Institute of Mining (CIM)
International Mine Water Association (IMWA)

Awards:

Recipient of Business in Vancouver's Forty Under 40, 2010

Areas of Expertise:

- Assessment of acid rock drainage (ARD) and metal leaching (ML) potential for mine site components and wastes.
- Prediction of surface and ground water quality and impacts.
- Development of ARD/ML prevention, control and closure strategies.
- Alternative evaluations
- Risk assessments

Select & Recent Project Experience:

- Gold Fields La Cima, Cerro Corona Mine, Peru – Geochemical specialist for ARD/ML evaluations including a field barrel program of more than 100 barrels, waste management planning, water monitoring auditing and delineation of associated risks.
- Selwyn Chihong Mining Ltd., Selwyn Project, Yukon, Canada – Geochemical characterization of waste rock, tailings and mine infrastructure associated with the proposed Selwyn Project.
- Victoria Gold Corporation, Eagle Gold Project, Yukon, Canada – Geochemical characterization of drill core to support feasibility studies and permitting applications.
- Avanti Mining Inc., Kitsault Project, BC, Canada - Geochemical characterization of drill core to support feasibility studies and permitting applications.
- Niblack Project LLC., Niblack Project, Alaska, USA – Geochemical characterization testing of drill core, development of operational verification testwork program, QA/QC testing and reporting in support of exploration program and drift development.
- North American Tungsten Corporation, Cantung Mine, NWT, Canada – Geochemical characterization of waste rock, pit walls, historic and recent tailings, participation in Water License hearings, contributions to the Abandonment and Restoration Plan.
- Minera Alumbrera Ltda., Alumbrera Mine, Argentina – Geochemical characterization and modelling to predict current and future pore water concentrations associated with the tailings.
- Eldorado Gold, Sao Bento Mine, Brazil – Field reconnaissance, sampling and geochemical characterization of waste rock, underground wall rock and tailings for closure planning.
- Newcrest Mining Ltd, Cadia East Project, Australia – Geochemical characterization of drill core and metallurgical tailings for the Environmental Assessment of the Cadia East expansion project.
- St. Ives Gold Mine Co Pty Ltd, Western Australia – Sampling of existing waste rock piles for characterization of ARD/ML potential by location and rock type, interpretation of data to assist in future waste management planning, including consideration of salinity and reclamation aspects; assessment of residual cyanide species and long term leaching potential for waste and spent ore associated with a proposed heap leach expansion.
- Newcrest Mining Ltd, Telfer Gold Mine, Australia – Assessment of the adequacy of existing physical and chemical characterization of tailings and waste materials to support the Telfer Sustainable Mine Closure Plan, in assoc. with Fawcett Mine Rehabilitation Services Pty Ltd.
- Bolivar Gold Corp., Choco Project Expansion, Venezuela – Gap analysis for expansion scoping study, covering ARD/ML, cyanide management, tailings supernatant quality and water management aspects.
- Goldcorp Inc., Peak Gold Mine, NSW, Australia – Review and gap analysis of tailings geochemical data, including identification of closure issues and considerations; follow up analyses in support of a closure cover design by O’Kane Consulting Pty Ltd.
- Newmont Jundee Operations, W.A., Australia – Site wide characterization programme for waste rock and pit walls with interpretation and implications for long term waste management and void water quality.

Publications:

- Shaw, S.C. and Jamieson, H.E. (1994): Attenuation of Metals by Secondary Minerals in Tailings from the Geco Mine, Ontario, Canada. In *Geological Society of America Annual Meeting Program with Abstracts*, Seattle, Washington, pp. 126.
- Jamieson, H.E., Shaw, S.C. and Clark, A.H. (1995): Mineralogical Factors Controlling Metal Release From Tailings at Geco, Manitouwadge, Ontario. In: *Sudbury '95, Mining and the Environment* CANMET, vol 1, pp. 405-413.
- Shaw, S.C., Groat, L.A., Jambor, J.L., Blowes, D.W., Hanton-Fong, C.J. and Stuparyk, R.A. (1996): Comparative Mineralogical Study of Base Metal Tailings With Various Sulfide Contents, Oxidized in Laboratory Column Oxidation and Field Lysimeter Studies. *Environmental Geology*, vol 33 (2/3), pp. 209-217.
- Robertson, Andy MacG. and Shaw, Shannon C. (1998). *Alternatives Analysis for Mine Development and Reclamation*. In *Mine Reclamation and Remediation*, Proceedings of the Twenty-second Annual British Columbia Mine Reclamation Symposium, Penticton, B.C., Sept. 14-17, pp. 51-62.
- Robertson, Andy MacG., Shaw, Shannon C. and Devenny, David (1998). *Post Mining Sustainable Use Plans vs Closure Plans*. In *Mine Reclamation and Remediation*, Proceedings of the Twenty-second Annual British Columbia Mine Reclamation Symposium, Penticton, B.C., Sept. 14-17, pp. 95-110.
- Robertson, Dr. A. MacG., Broughton, Linda and Shaw, Shannon (1998). *Acid Rock Drainage; Its Assessment, Prediction and Control*. Short Course Presented to the United States Environmental Protection Agency, Region 10, Seattle, WA, October 14-15.
- Robertson, A. MacG. and Shaw, S.C. (1999). The Concept of Custodial Transfer of Mined Land. In *Proceedings of Mine, Water & Environment*, Seville Spain, September 13-17, 1999. Vol 1, pp 765-771.
- Shaw, S., Robertson, A. MacG., and Maehl, W.C. (1999). Material Characterization and Prioritization of Remedial Measures at the Zortman/Landusky Mine Sites. In *Proceedings of the 2000 Billings Land Reclamation Symposium*, Billings, Montana, March 20-24, 2000, pp. 346-358.
- Robertson, A. MacG. and Shaw, S.C. (1999). A Multiple Accounts Analysis for Tailings Site Selection. In *Proceedings of Sudbury '99 Mining and the Environment*, Vol. 3, pp. 883-892.
- Shaw, S. (2000). Geochemical Characterization and Water Quality Predictions for the Zortman/Landusky Reclamation Project. In *Proceedings of the Eight Annual Mine Design, Operations & Closure Conference*, Montana, April 16-20, 2000.
- Wels, C., Shaw, S. and Royle, M (2000). A Case History of Intrinsic Remediation of Reactive Tailings Seepage for Questa Mine, New Mexico. In *Proceedings from the Fifth International Conference on Acid Rock Drainage*, Vol. 1, pp. 441-462.
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- Shaw, S.C. and Robertson, A. MacG. (2001). *Geochemical Predictions of the Landusky Spent Ore Heap Leach Pads and Implications for Water Management*. Presented at the British Columbia ARD Workshop, November, 2001.
- Shaw, S., Wels, C., Robertson, A. and Lorinczi, G. (2002). *Physical and Geochemical Characterization of Mine Rock Piles at the Questa mine, New Mexico*. In Tailings and Mine Waste '02, proceedings of the Ninth International Conference on Tailings and Mine Waste, Fort Collins, Colorado, USA, 27-30 January 2002, pp. 447-458.
- Adams, D. J., T. Pickett, and S. Shaw. (2002). *Water Treatment Issues and Biotreatment Solutions for the Spent Ore Heap Leach Pads: Landusky Mine, Montana*. Presented/Published at the American Society of Mining and Reclamation. Lexington, KY. June 9-13, 2002.
- Shaw, S., Wels, C., Robertson, A., Fortin, S., and B. Walker (2003). *Background characterization study of naturally occurring acid rock drainage in the Sangre de Cristo Mountains, Taos County, New Mexico*. In Proceedings of the Sixth International Conference on Acid Rock Drainage, Cairns, Queensland, Australia, 14-17 July, 2003, pp. 605-616.
- Robertson, A. MacG., and Shaw, S. (2004): "*Use of the Multiple Accounts Analysis Process for Sustainability Optimization*". In Proceedings of the SME Annual Meeting, Denver, Colorado, USA, 23-25 February, 2004.
- Robertson, A. MacG. and Shaw, S. (2004): *The Multiple Accounts Analysis of Pit Backfilling*. Presentation published in Proceedings of the 12th Annual Mine Design, Operations & Closure Conference, Polson, Montana, USA, 25-29 April, 2004.
- Wels, C., Findlater, L, Shaw, S. and Laurencont, T. (2004). Mt. Morgan Mine – a case study of ARD impacted groundwater. In proceedings of Mine Water 2004 – Process, Policy and Progress; International Mine Water Association, pp. 235-246.
- S. Shaw, S. Dunlap and B. Maehl (2004). Evaluating the relative risks of pit reclamation alternatives at the Golden Sunlight Mine (Montana, USA); a multiple accounts analysis. In proceedings of Mine Water 2004 – Process, Policy and Progress; International Mine Water Association, pp. 77-84.
- Shannon Shaw, Jason Martin, Greg Meiers, Mike O'Kane, Christoph Wels (2006). Characterization of the Waste Rock and Pit Walls and the Jundee Mine Site in Western Australia and Implications for Long-term Issues. Paper presented at the 2006, 7th ICARD, March 26-30, 2006, St. Louis MO. Published by ASMR.
- International Atomic Energy Agency (2008). Co-author of an IAEA technical document: Best Practice in Environmental Management of Uranium Mining, currently in press.
- Williams, D.R., Shaw, S., Jepson, W., Gammons, C. And Kill Eagle, J. (2009). Zortman-Landusky: Challenges in a Decade of Closure, Paper submitted to the 2009, Securing the Future and 8th ICARD, June 22-26, 2009, Skellefteå, Sweden.

Workshops/Short Courses:

- Robertson, A., Broughton, L and Shaw, S. (1998). Acid Rock Drainage: Its Assessment, Prediction and Control. Short course presented to U.S. Environmental Protection Agency, Region 10, Seattle, WA, October 1998.
- O'Kane, M., Wels, C., Shaw, S., Newman, G., Fawcett, M. and Ayres, B. (2003). Closure of Mine Waste Storage Facilities - Linking Cover System Performance to Impacts on Groundwater and Surface Water Receptors. Short course presented at the 6th International Conference on Acid Rock Drainage (ICARD) Cairns, Australia, July, 2003.
- Robertson, A. and Shaw, S. (2003). Predicting and Managing ARD in Mining. Short course delivered at UBC Mining Studies – Summer Institute, Vancouver, BC, July 2003.
- Robertson, A. and Shaw, S. (2004). Predicting and Managing ARD in Mining. Short course presented at UBC Mining Studies – Summer Institute, Vancouver, BC, June 2004.
- O'Kane Consultants Inc., Mehling Environmental Management Inc. and Robertson GeoConsultants Inc. (2005). Closure of Mine Waste Storage Facilities – Linking Cover System Performance to Impacts on Groundwater and Surface Water Receptors. Workshop for The Canadian Institute, Best Practices for Mine Waste Management Vancouver, BC, Canada, June 6-7, 2005
- Robertson, A. and Shaw, S. (2006). Predicting and Managing ARD in Mining. Short course presented at UBC Mining Studies – Summer Institute, Vancouver, BC, May 2006.
- Robertson, A. and Shaw, S. (2007). Predicting and Managing ARD in Mining. Short course presented at UBC Mining Studies – Summer Institute, Vancouver, BC, May 2007.



MARTIN DAVIES, M.E.S., R.P.Bio. **Senior Environmental Specialist and Partner**

SUMMARY OF EXPERIENCE

Martin Davies has eighteen years of experience in environmental ecology, monitoring and management, in Canada and internationally. Mr. Davies has participated in a wide variety of environmental studies, including: aquatic environmental effects monitoring and environmental assessments for various pulp-and-paper, metal-mining and oil-and-gas facilities; water, sediment and fish-tissue monitoring, including trace contaminants such as dioxins/furans, PAHs, and trace metals; ecological investigations of fish health, ecology and migration; benthic and intertidal community dynamics; environmental modelling; and environmental applications of remote sensing and GIS. From 2000 to 2002, he served as Vice President of Hatfield's Indonesian operations, where he was responsible for project management and implementation, quality control and assurance, and daily operational issues. He currently serves as Senior Environmental Specialist at Hatfield Consultants in West Vancouver, and has been a Partner at the firm since 2004.

EDUCATION

- 1993 Master of Environmental Studies, School for Resource and Environmental Studies, Dalhousie University, Halifax, NS
- 1990 Bachelor of Science (Marine Biology/Environmental Studies), McGill University, Montréal, QC

CAREER SUMMARY

- 2002 to Present Hatfield Consultants, North Vancouver, BC
Senior Environmental Specialist and Partner
- 2000 to 2002 PT Hatfindo Prima, Bogor, West Java, Indonesia
Vice President
- 1993 to 1999 Hatfield Consultants Ltd., West Vancouver, BC
Environmental Specialist
- 1991 Beak Engineering Ltd., Brampton, ON
Engineering Technician

PROFESSIONAL MEMBERSHIPS AND CERTIFICATIONS

- Registered Professional Biologist in British Columbia (R.P.Bio.)
- Certified Electrofishing Crew Supervisor

LANGUAGES

English, French, Bahasa Indonesia

COUNTRY EXPERIENCE

Canada, United States, Indonesia, Australia, Viet Nam, Cambodia, Thailand, East Timor, Lao PDR, China



KEY PROJECT EXPERIENCE***Environmental Assessment and Monitoring – Canada***

- **Regional Aquatics Monitoring Program (RAMP), Oil Sands Region, Alberta** – Water and Sediment Quality Component Manager for a multi-year, multi-disciplinary environmental monitoring program undertaken for a multi-stakeholder group in the Athabasca oil sands region. Coordinated and participated in project design, four-season field investigations, and management and coordination with other component programs, including fisheries, benthic ecology, aquatic vegetation, and acid-sensitive lakes. **2003, Ongoing**
- **Environmental Effects Monitoring, 10 Inland and Coastal Pulp Mills, British Columbia** – Project Manager or Project Director for Environmental Effects Monitoring (EEM) programs at several marine and freshwater pulp mills in western Canada. Coordinated and participated in detailed field investigations and assessments of benthic, intertidal and riparian communities, water and sediment quality surveys, and fish and shellfish surveys. **1993 to 1999; 2003, Ongoing**
- **Environmental Effects Monitoring, Two Metal Mines, Northwestern British Columbia** – Project Manager/Director for Environmental Effects Monitoring programs in the vicinities of two metal mines in northwestern British Columbia. Coordinated and participated in detailed field investigations and assessments of fish and benthic communities, and water and sediment quality surveys. **2005, Ongoing**
- **State of the Aquatic Environment Report for the Mackenzie River Basin** – For the Mackenzie River Basin Board (MRBB), Project Manager for development of a State of the Aquatic Environment report for the Mackenzie River basin, focussing on environmental aspects of oil sands development, climate change, and hydroelectric power development, and integrating science-based information and Aboriginal traditional knowledge. **2009, Ongoing**
- **Expert Advice Regarding Marine Environmental Effects of an Oil Pipeline Project** – For the National Energy Board (NEB), provided expert scientific/technical advice regarding marine environmental aspects of the proposed Northern Gateway pipeline project from northern Alberta to Kitimat, BC. **2010, Ongoing**
- **Closure Planning for a Metal Mine, Northwestern British Columbia** – Contributed to the update of a metal mine's closure plan, specifically focussing on assessment of post-closure water quality issues. This involved development and implementation of a series of interconnected water quality models (including a 3D hydrodynamic model) to predict water quality in the receiving environment over the first 100 years post-closure, interpretation of results relative to regulatory benchmarks, and participation in closure-planning workshops. **2009 to 2010**
- **Fate and Effects of Selenium in Waters Receiving Metal Mine Discharge** – For Northgate Minerals Corp. and in cooperation with partner consulting firms, coordinated and implemented selenium fate and effect studies in a watershed receiving high-selenium seepage waters, including sampling and assessment of water, sediment, aquatic plants, benthos, and fish, and toxicological effects of selenium on fish larval development. **2006, Ongoing**
- **Development of a Site-Specific Water Quality Objective (SSWQO) for Sulphate** – For Highland Valley Copper/Teck Resources, and in conjunction with a consulting toxicology laboratory, Project Director for development of a proposed hardness-based SSWQO for sulphate for a small stream receiving tailings-water seepage, involving acute and sublethal toxicity testing of laboratory and site waters using various test species and varying concentrations of sulphate and hardness, derivation of a site-specific objective, and discussions with the BC Ministry of Environment regarding its application. **2008 to 2009**

- **Summary of Water Quality and Aquatic Ecosystem Health in Alberta-Northwest Territories Transboundary Waters** – For Alberta Environment (AENV), Project Director for a data review, compilation and retrospective analysis regarding water quality, aquatic ecosystem health, and sources of effluent and contamination in all transboundary watersheds flowing from Alberta to the Northwest Territories, for use in negotiating a transboundary water quality agreement between Alberta and the NWT. **2008 to 2009**
- **Chlorinated Dioxin/Furan Monitoring at Coastal Pulpmills in British Columbia** – Project Manager for dioxin/furan trend monitoring in the vicinity of several coastal pulpmills in British Columbia. Supervised field studies and analysis of dioxin and furan concentrations in finfish, crabs, and sediments, including data interpretation and quality assurance/quality control. **1995 to 1999 (six mills); 2004, Ongoing (two mills)**
- **Baseline Studies and Impact Assessment for a Proposed Metal Mine Expansion, Northwestern British Columbia** – Carried out aquatic environmental baseline studies and contributed to the preparation of an environmental impact assessment, for the proposed expansion of the Kemess Mine in northwestern British Columbia, including extensive field studies of fish and fish habitat in lakes and creeks of the project area. **2003 to 2007**
- **Technical Assessment of a Proposed Mine Effluent Discharge, Northwestern British Columbia** – For Huckleberry Mines Ltd., Project Manager for a Technical Assessment (per the BC *Environmental Management Act*) of a submerged discharge to release tailings pond water to Tahtsa Reach. Coordinated modeling assessment of potential effects on ambient water quality, and development of a long-term monitoring plan to verify assessment predictions. **2005 to 2006**
- **Fish Health Assessment in Richardson Lake and the Old Fort River, Athabasca Delta, Alberta** – For the Athabasca-Chipewyan First Nation (ACFN), Project Manager for an assessment of the health of traditionally harvested fish species in Richardson Lake and the Old Fort River, and of tissue burdens of mercury and selected radionuclides in these fish. **2005 to 2006**
- **Long-Term Water Quality Monitoring for the Province of Alberta, Oil Sands Region, Alberta** – For Alberta Environment (AENV), coordinated and implemented AENV's long-term water quality sampling program in the lower Athabasca River and Muskeg River watershed in northeastern Alberta. Program included development of standard operating procedures, maintenance of continuously recording data sondes, field sampling, and data validation. **2005 to 2007**
- **Expert Witness, Regarding Effects of a Mine Wastewater Discharge, British Columbia** – Provided expert testimony to the BC Environmental Appeals Board regarding potential environmental effects of discharging mine tailings water to a large river. **2006**
- **Water Quality Modeling for Conversion of Mine Wastewater Discharge into a Small Hydro Project, McCleese Lake, British Columbia** – Coordinated modeling assessment of potential effects of conversion of a wastewater (tailings supernatant) discharge from an inactive mine into a small hydro generation facility. Worked with hydrodynamic modellers using water quality and regulatory guidelines/criteria to assess effects on modified water discharge on ambient river quality. **2003 to 2004**
- **Assessment of Intertidal Habitat Compensation Structures at Ballantyne Pier, Vancouver, British Columbia** – For the Vancouver Port Authority, designed and implemented an assessment of the effectiveness of intertidal habitat structures installed below a shipping terminal in Vancouver Harbour, to determine the effectiveness of these structures at providing habitat for local intertidal invertebrates. Involved field studies and comparisons of intertidal invertebrates from the terminal and from nearby reference areas. **1999**

- **Mark/Recapture Study of Largescale Sucker Migration in the Fraser River, British Columbia** – Project Manager for a one-year mark/recapture study of largescale suckers (*Catostomus macrocheilus*) in the Fraser River from Prince George to Soda Creek. Over 1,500 fish were tagged with Floy fabric tags; radio-tags were attached to 20 additional fish. From recapture results, population estimates, short-and medium-term movement, and spawning migration patterns were determined. **1997 to 1998**
- **Fisheries Sensitivity Mapping of Shuswap Lake, British Columbia** – For Department of Fisheries and Oceans (DFO), developed and implemented an environmental sensitivity mapping system for shoreline areas of Shuswap Lake, integrating oblique aerial photography interpretation, bull trout and sockeye salmon habitat suitability indices, and other factors. **1996 to 1997**
- **Assessment of Increased Effluent Discharges on Aquatic Environmental Quality, Quesnel River Pulp Company, Quesnel, British Columbia** – Predicted effects of increased effluent flow from Quesnel River Pulp Company on water quality and benthic communities in the Fraser River. Involved development of a simple model to examine effects of changes in water quality expected to result from changes in effluent flow. **1996**
- **Environmental Site Assessment of Landfill Leachate Seepage, Quesnel, British Columbia** – Assessed environmental impacts of leachate seepage from a woodwaste landfill site on aquatic, riparian and terrestrial communities in the vicinity of a contaminated lake. Involved biophysical habitat assessments, water and sediment quality analyses, and recommendations on future environmental management options. **1996**
- **Strait of Georgia Fisheries Sustainability Study, British Columbia** – Compiled a biophysical inventory of marine and terrestrial ecosystems of the Georgia Basin, including the Strait of Georgia, eastern Vancouver Island, and southwestern mainland British Columbia, and examined commercial and recreational resource uses within this region. Involved compilation and interpretation of data from a wide variety of literature sources, including salmon escapement data for 155 mainland and island streams. **1994 to 1996**
- **Effects of Eurasian Watermilfoil on Littoral Ecology of Shuswap Lake, Department of Fisheries and Oceans, West Vancouver, British Columbia** – Conducted a comprehensive two-year research program examining the effects of Eurasian watermilfoil infestation on the littoral ecology of Shuswap Lake. Involved biophysical habitat assessments, aerial photograph interpretation, shoreline surveys of adult sockeye spawning, littoral vegetation surveys, snorkel and beach seine surveys, and sampling of benthos, zooplankton, flying insects, emergent insects, and juvenile and adult fish. **1994 to 1996**
- **Environmental Assessment of a Chlorine Dioxide Spill, MacMillan Bloedel Ltd., Powell River, British Columbia** – Examined effects of a chlorine dioxide spill on receiving environments in the Powell River area. Involved compilation and analysis of oceanographic data, intertidal community surveys, and water quality surveys. **1995**
- **Assessment of the Community Salmonid Enhancement and Restoration Fund, Ministry of Agriculture, Fisheries and Food, Victoria, British Columbia** – Undertook a program evaluation of the Community Salmonid Enhancement and Restoration Fund (CSERF), a Provincial program which provided funds to Aboriginal and community groups for salmonid enhancement and fisheries training projects. Involved site visits, habitat assessment, interviews with project and program staff, and an overall evaluation of the success of the CSERF program. An evaluation of selected CSERF projects was undertaken the following year as a follow up to the original work. **1994 and 1995**

Environmental Assessment, Monitoring and Management – International

- **Survey of Dioxin/Furan Emissions from the Indonesian Pulp and Paper Industry** –Team Leader for a survey of chlorinated dioxin and furan discharges from various pulp and paper facilities in Indonesia, for the World Bank and in conjunction with the Indonesian Environment Department (KLH). The project involved sampling and analysis of various media (air emissions, liquid effluent, sludge, and product) at eight facilities across Java and Sumatra. **2010**
- **Expert Review of the Environmental Assessment of a Proposed Integrated Pulp-and-Paper Facility and Forest Plantation, Guangxi, China** – For the United Nations Development Programme (UNDP), was overall Team Leader for an expert review of environmental assessment documents for a bleached Kraft pulpmill, paper mill, and associated forest plantations, including coordination and synthesis of component reviews by Chinese and international experts, and expert technical inputs regarding predicted environmental effects of the mill complex. **2008**
- **Environmental Monitoring Design Advice for a Proposed Pulpmill, Tasmania, Australia** – Advised Gunns Ltd. regarding best-practice in monitoring of potential effects of effluent discharge from a planned bleached Kraft pulpmill to the Bass Strait. Included design recommendations and participation in regulatory workshops. **2007 to 2008**
- **Incremental Environmental Assessment of an Offshore Oil and Gas Facility, Java Sea, Indonesia** – For Premier Oil, managed and implemented a revision of environmental assessment and permitting documents for combined oil and gas production platform in the Java Sea, near the Indonesia-Malaysia-Vietnam border. Involved study design, field surveys, and technical document review and revision. **2002**
- **Water Quality Monitoring and Methods Assessment for an Independent Power Producer, East Java, Indonesia** – Designed and undertook water quality sampling and assessment of existing sampling and analytical methods used for water quality monitoring programs for an independent power producer in East Java, Indonesia. **2002**
- **Rapid Biodiversity Assessment, Bintuni Bay, Irian Jaya, Indonesia** – For BP Indonesia, designed and managed a multi-disciplinary investigation of flora and fauna in a coastal area of eastern New Guinea, involving international scientists from various academic and research institutions worldwide (Harvard University, Smithsonian Institution, Bishop Museum, Western Australia Museum, Wageningen University, Czech Academy of Sciences), and Indonesian scientists from various national research institutes. **2001 to 2002**
- **Vegetation Ecology/Reclamation Ecology Studies in Alpine and Sub-alpine areas of a High-Altitude Metal Mine, Irian Jaya, Indonesia** – Project management, quality control and editorial support to the development of comprehensive studies of vegetation ecology and reclamation trials in sub-alpine and alpine areas of the PT Freeport Indonesia Contract of Work area. **2000 to 2002**
- **Biodiversity Surveys of Birds and Mammals, Irian Jaya, Indonesia** – Project Coordinator for development and implementation of field studies of bird and small mammal populations of the mine area of the PT Freeport Indonesia Contract of Work area. **2000**
- **Field Guide to Birds of Mimika Regency, Irian Jaya, Indonesia** – Quality control and editorial support to the development of a general-audience guide to the avifauna of Mimika Regency, Irian Jaya, for PT Freeport Indonesia. This bilingual guide included hand-painted plates, and involvement of international experts from Indonesia and the Netherlands. **2000**
- **Dioxin/Furan Laboratory Training and Development, Viet Nam** – Assistant Project Manager for a project to train Vietnamese scientists and technicians in the collection, preparation and analysis of various environmental media (soils, sediments, biological tissues, etc.) for concentrations of chlorinated dioxins and furans. **1997 to 1998**

- **Environmental Screening of Low-Cost Housing Development, Indonesia** – Undertook an environmental screening study to CIDA Inc. standards for a proposed low-income housing development in Bandung, West Java, Indonesia. **1998**
- **Environmental Impact Assessment of Two Coal Mines, Kalimantan, Indonesia** – Contributed to management and planning of studies related to environmental impact assessments (AMDALs) of two open-pit coal mines proposed by PT Arutmin Indonesia (subsidiary of BHP Minerals Ltd.), and an associated saltwater port facility in southeast Kalimantan, Indonesia. **1996**
- **Resort Facility Development, Ko Yao Yai, Southern Thailand** – Contributed to authorship and participated in field studies for an environmental assessment of a large resort development proposed for Ko Yao Yai, near Phuket, Thailand. Work involved compilation of information regarding fisheries and biological resources potentially at risk, and included consultation with scientific and government authorities in southern Thailand and a site visit. **1996**

Remote Sensing and GIS Applications

- **Using RADARSAT for Improving Fisheries Management and Food Security in the Mekong River Watershed, Southeast Asia** – Coordination of GIS development and implementation from a variety of remote sensing and other spatial information, to delineate seasonal changes in flooded fish habitats in the Tonlé Sap watershed, and evaluate and demonstrate the utility of RADARSAT imagery for wetlands and fisheries habitat delineation and monitoring. **1999 to 2002**
- **Development of Remote Sensing and GIS Approaches to Support Humanitarian Demining in Viet Nam** – RS/GIS manager for a project to develop technology support tools for survey, identification and removal of unexploded ordnance (UXO) from areas of central Viet Nam severely impacted by war. Involved collection of information from government archives regarding historical war activities, use of declassified Corona spy satellite imagery and aerial photography, modern satellite imagery (Landsat-7 ETM+, Ikonos, Radarsat), and declassified military air combat and herbicide application databases, and field investigations. Resulting outputs were used to support humanitarian demining efforts in the region. **2001 to 2002**
- **GIS for Ecological Restoration (GIS-ER), Irian Jaya, Indonesia** – Project Manager for development of a customized GIS application for the management and maintenance of data related to reclamation activities and regional biodiversity for PT Freeport Indonesia. **2000 to 2002**
- **Operational Flood Monitoring in the Red River Delta, Viet Nam** – Coordinator for collection and integration of various spatial information with remote sensing products in a queriable GIS database, to be used in conjunction with Web-server technology to allow near-real-time analysis and delivery of remotely-sensed flooding data to regional governments in flood-prone areas of Viet Nam. **2000 to 2001**
- **GlobeSAR China Program Workshops** – Along with a group of Canadian remote sensing scientists, presented lectures regarding applications of RADARSAT satellite imagery to flooding and coastal zone management issues to Chinese academic researchers and public sector managers in several Chinese cities (Beijing, Nanjing, Chengdu, Haikou). **1999**
- **Using RADARSAT to Assess Residual Environmental Effects of War in Viet Nam and Laos** – Assistant Project Manager for an assessment of residual environmental effects of war in the Mekong River drainage using RADARSAT and other remote sensing imagery (e.g., Corona, SPOT, LANDSAT). Involved acquisition and interpretation of radar and optical satellite imagery of areas of Viet Nam and Laos heavily impacted by herbicide spraying, bombing, land clearing and other activities. **1997 to 1998**

- **Riparian Classification and Fisheries Sensitivity Mapping, Swuswap Lake, British Columbia** – For DFO, conducted a shoreline classification of Shuswap Lake, through aerial ortho-photo interpretation and other sources of fisheries and habitat information. Developed a biophysical classification system for littoral habitat features and a GIS-based relational database describing habitat polygons. Fisheries sensitivities of foreshore areas of Shuswap Lake were determined and mapped utilizing the habitat and fisheries use database. **1995 to 1996**

Environmental Engineering

- **Beak Engineering Ltd., Brampton, Ontario** – Contributed to design and on-site construction of a pilot-scale activated sludge treatment system operated in a newsprint production mill at Iroquois Falls, Ontario. Independently operated treatment plant and monitored performance for three months, including conducting chemical and toxicological testing of effluents. **1991**
- **N. McCubbin Consultants Inc., Foster, Québec** – Contributed to the design and programming of several process modelling studies using the GEMS simulation package and AutoCAD. Wrote and edited sections of studies concerning process alterations and environmental engineering, primarily for the kraft pulp industry. Clients included Environment Canada, Ontario Ministry of Environment, Boise-Cascade Ltd. (International Falls, MN), Sitka Pulp and Paper Ltd. (Sitka, AK), Cascades Inc. (Matane, QC). **1989**

LIST OF REPORTS AND PUBLICATIONS

Available upon request.

SUMMARY OF EXPERIENCE

Mr. Wilcockson is an Environmental Specialist with over 10 years experience working as a consultant for a variety of clients including government agencies, pulp and paper, oil and gas, transportation mining operations and international donor agencies. His areas of expertise include aquatic and terrestrial toxicology, environmental monitoring, statistical analyses, ecological and human health risk assessment, food chain modelling and ecological impact assessment. Mr. Wilcockson has managed numerous environmental studies investigating the effects of contaminants on aquatic and terrestrial resources. He has conducted field work and training in several Asian countries, and has developed interactive computer tools for environmental management. Currently, he is the project manager/assistant project manager for environmental monitoring programs for a number of pulp and paper mills and metal mines in British Columbia.

EDUCATION

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| 1997 | Master of Science – Biological Sciences, Simon Fraser University, Burnaby, British Columbia, Canada |
| 1991 | Post Baccalaureate Diploma in Environmental Toxicology, Simon Fraser University, Burnaby, British Columbia, Canada |
| 1990 | Bachelor of Science – Biochemistry, University of British Columbia, Vancouver, British Columbia, Canada |

CAREER SUMMARY

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|-----------------|--|
| 2006 to Present | Environmental Scientist - Hatfield Consultants Ltd., North Vancouver, British Columbia, Canada |
| 2004 to 2006 | Environmental Scientist – Golder Associates Ltd., North Vancouver, British Columbia, Canada |
| 1999 to 2004 | Environmental Scientist – EVS Environment Consultants, North Vancouver, British Columbia, Canada |
| 1993 to 1999 | Research Associate – Simon Fraser University, Burnaby, British Columbia, Canada |
| 1997 to 1998 | Research Associate – Exxon Biomedical, East Millstone, New Jersey, USA |

PROFESSIONAL AFFILIATIONS

- Registered Professional Biologist (R.P.Bio), British Columbia, Canada

LANGUAGES

- English

KEY PROJECT EXPERIENCE***Ecological Effects Monitoring and Statistical Data Analysis***

- **Environmental Assessment, Columbia River, British Columbia Canada** – Project manager for an environmental assessment of the Lower Columbia River. Project included the compilation and analysis of a large analytical data set including concentrations of contaminants in water, sediments and biota. The assessment included a literature review of toxicity information and an assessment of potential effects. Project deliverables included a data synthesis report and a searchable database. Client: Columbia River Integrated Environmental Monitoring Program. **2007 to 2008**
- **Environmental Assessment, Logan Lake, British Columbia Canada** – Project manager for an assessment of potential impacts arising from a large mine. Project is ongoing and includes the collection of water, sediment and biota samples for micro-pollutant analysis. Each year, new data is compiled and analyzed and compared to historical data. Every three years, an assessment of potential effects is conducted and trends in micro-pollutant data are discussed. Client: Highland Valley Copper Mine, Teck Resources Ltd. **2006, Ongoing**
- **Pulp and Paper EEM, Various** – Project manager for an assessment of potential environmental impacts to large rivers arising from two pulp and paper mills. Project is ongoing and includes the collection of water, sediment and biota samples for micro-pollutant analysis. Responsibilities include designing and implementing environmental monitoring studies, providing guidance to mill staff, and liaising with regulatory agencies. **2005, Ongoing**
- **Sediment Quality Assessment, Victoria, British Columbia, Canada** – Principal Investigator for an assessment of sediment quality in Victoria Harbour. Sediment chemistry, toxicity, and benthic community data were reviewed and summarised. Statistical analysis was applied to extract trends in the data set and to uncover factors potentially causing ecological impacts. Client: Transport Canada. **2002 to 2003**
- **Sediment Quality Assessment, Vancouver, British Columbia, Canada** – Analyzed sediment data associated the Iona sewage outfall. Conducted multivariate statistics (principle component analysis and non-metric multi-dimensional scaling) and correlation analysis on sediment chemistry and benthic community data. Client: Greater Vancouver Regional District. **2001 to 2002**
- **Analysis of Micro-pollutants in Sediment, Victoria, British Columbia, Canada** – Conducted statistical analysis on sediment micro-pollutant data downstream of a large sewage outfall. Principal Component Analysis was applied to uncover spatial and temporal trends in data set. Also used non-parametric correlation tests, and non-parametric hypothesis tests. Client: Capital Regional District. **2001 to 2002**

Computer-Based Management Tools

- **Risk Based Management Tool, Department of National Defence** – Principal investigator for designing a risk based environmental management tool for DND's Pacific Operations. Tool was designed to rank the risk of various practice activities based on the type of activity, the severity of potential impacts and the probability of impacts occurring. DND Operations is expected to use the tool to help plan future practice operations. Client: Canadian Department of National Defence, Canada. **2006**

- **Revisions to the CCME National Classification System, Ottawa, Ontario, Canada** – Principal investigator for revising the CCME National Classification System for ranking contaminated sites. Reviewed the existing CCME NCS, made recommendation for improvements and developed a new electronic national classification system. The focus of the revisions was to only make changes that provided significant improvement in terms of greater objectivity and consistency with the current risk assessment approach and framework. Client: Canadian Council of Ministers for the Environment (CCME). **2005**

Environmental Risk Assessment

- **Ecological Risk Assessment, Comox, British Columbia, Canada** – Project Manager for an ecological risk assessment for a former bulk fuel storage facility. This project evaluated the impact of groundwater-borne hydrocarbons on a sensitive salt marsh habitat that supported both small mammal and seabird populations. Client: Shell Canada. **2002**
- **Ecological Risk Assessment, North Vancouver, British Columbia, Canada** – Project Manager for a risk assessment of impacts arising from hydrocarbon-contaminated groundwater entering Burrard Inlet. This project assessed the impact of dissolved polycyclic aromatic hydrocarbons on fish and marine invertebrates. A literature-based effects assessment was conducted to derive site-specific concentration standards. Client: TransLink. **2001**
- **Ecological Risk Assessment, New Westminster, British Columbia, Canada** – Project Manager for a risk assessment of impacts arising from hydrocarbon-contaminated groundwater entering the Fraser River. This project assessed the impacts of petroleum hydrocarbons and polycyclic aromatic hydrocarbons on fish and aquatic invertebrates. An equilibrium partitioning model was applied to estimate hydrocarbon concentrations entering the river. Client: Shell Canada. **2001**
- **Screening-level Risk Assessment, Pilot Bay, British Columbia, Canada** – Principal Investigator for a screening-level risk assessment of impacts arising from smelter waste being used on a dirt road. This project assessed the impacts on terrestrial and aquatic organisms living adjacent to the road. Sampling and analysis was designed to differentiate potential impacts arising from the road and those as a result of historical land use, and measured impacts on a series of potential receptors, including plants, soil invertebrates, small mammals, and birds. Client: British Columbia Ministry of Highways. **2001**
- **Screening-level Risk Assessment, Castlegar, British Columbia, Canada** – Project Manager for a screening-level risk assessment of impacts arising from a train derailment. This project assessed the impact on fish and aquatic invertebrates of potential exposure to iron, extractable hydrocarbons, and sulphate found in surface water and groundwater leachate. Client: Canadian National Railway. **2004**

Mathematical Modelling

- **Metal Speciation/Biotic Ligand Modeling, Hope Bay, Nunavut, Canada** – Used a biotic ligand model to derive a site-specific water quality guideline for copper. The guideline was designed to be protective of aquatic organisms downstream of a proposed tailings pond. Client: Miramar Mining Corporation. **2004**
- **Food Chain Model, PCBs, San Francisco, California, USA** – Constructed a food chain model for PCBs in San Francisco Bay. The model predicted tissue concentration of PCBs in three important sport fish from sediment and water concentrations. The model will be used by regulators to manage PCB loadings to San Francisco Bay. Client: San Francisco Estuary Institute. **2003**

- **Food Chain Model, PCBs and PAHs, New Jersey, USA** – Used mathematical models to describe a short simulated food chain. Used flounders, clams, and contaminated Hudson River sediment. Work performed at Exxon Biomedical, New Jersey. Applied a concentration-based, steady state kinetic model based on the approach used by Robert Thomann, Manhattan College. Client: Exxon. **1998**

International Project Experience

- **Risk Assessment, Indonesia** – Advisor and component manager for an ecological risk assessment assessing potential impacts associated with an industrial outfall to a tropical riverine environment. Primary contaminants of concern were ammonia, hydrocarbons and metals. A literature review of toxicity information was conducted to support the risk assessment. Fieldwork was conducted for TOTAL Indonesia in the Mahakam Estuary, East Kalamantan, Indonesia. **2009 to 2010**
- **Risk Assessment, Philippines** – Project manager for a **World Bank** project to investigate human health and environmental impacts associated with burning waste in the Philippines. The primary contaminants of concern were dioxins/furans. Fieldwork was conducted in Iloilo, Philippines in order to collect air, sediment and tissues of aquatic organisms. Data was be used in a risk assessment to predict potential human health impacts. **2009**
- **International Capacity Building, Malaysia, Cambodia and Laos** – Provided human health risk assessment training to government agencies in Malaysia, Cambodia and Lao as part of a World Bank project on Persistent Organic Pollutants (POPs). Also created web-based tools for prioritizing contaminated sites based on their need for investigation and for estimating human health risk. **2008 to 2009**
- **Human Health Risk Assessment, Vietnam** – Participated in a study of residual Agent Orange contamination associated with the Da Nang Air Base in Da Nang, Vietnam. Conducted field work, analyzed data and used a screening-level risk assessment to characterize potential human health risks. Client: Ford Foundation and Office 33 of the Vietnamese Department of National Defence.



Education

B.Sc., Zoology (Honours),
University of British
Columbia, Vancouver, BC,
1971

Golder Associates Ltd. – Burnaby

Employment History

Golder Associates Ltd. – Burnaby, BC

Associate / Senior Project Manager (2006 to Present)

Carry out environmental impact assessments (EIAs) for land development, transportation, energy, mining and resource development projects.

SEACOR Environmental Inc. – Vancouver, BC

Senior Project Manager (2001 to 2006)

As Senior Biologist/Project Manager carried out EIAs for land development, transportation, energy, mining, and resource development projects.

URS/Norecol, Dames & Moore, Inc. – Vancouver, BC

Senior Project Manager (1997 to 2001)

As Senior Biologist/Project Manager carried out EIAs for land and recreation developments, transportation, resource development projects, and biophysical inventory and mapping projects.

Hatfield Consultants Ltd. – West Vancouver, BC

Senior Biologist (1995 to 1997)

As Senior Biologist carried out EIA and biological monitoring projects.

Norecol, Dames & Moore, Inc. – Vancouver, BC

Wildlife Biologist/Project Manager (1981 to 1995)

As Wildlife Biologist/ Project Manager carried out EIAs for transportation, mining and resource development projects in British Columbia and the Yukon.

B.C. Research – Vancouver, BC

Research Officer I, II (1975 to 1981)

As Wildlife Biologist carried out EIAs for mining projects in British Columbia and Northwest Territories.

BC Fish and Wildlife Branch, UBC – Vancouver Island, BC

Field Biologist (1972 to 1973)

As Field Biologist carried out blue grouse and coastal black-tailed deer winter range research projects on Vancouver Island.

F.F. Slaney and Company Ltd. – Vancouver, BC

Wildlife Biologist (1971, 1973 to 1975)



PROJECT EXPERIENCE – COAL MINING

**Horizon Mine Coal
Project, Hillsborough
Resources**
northeastern BC

Managed and coordinated multi-disciplined environmental baseline studies for Hillsborough Resources' coal development project located south of Tumbler Ridge. The project involved extensive baseline surveys over a two-year period, including: establishing aquatic monitoring programs for stream invertebrates, periphyton, sediment and water quality; hydrology monitoring stations with automated instrumentation; a dustfall monitoring network; wildlife inventory with seasonal ground and air surveys; Terrestrial Ecosystem Mapping at 1:20,000 and 1:10,000 scale; and, fisheries inventory. Also participated in public and First Nations consultation. The baseline surveys were in preparation for an application document to the provincial government for a Project Certificate under the British Columbia Environmental Assessment Act review process.

**Five Cabin-South
Ridge Coal Project,
Anglo American**
northeastern BC

Initiated and coordinated environmental baseline studies program for Anglo American's coal exploration area located south of Tumbler Ridge, in the Kinuseo Creek watershed. Established an aquatic sampling network (water quality, stream sediment, hydrology, fish, aquatic biota) and carried out initial wildlife surveys. The study area was contiguous with the Horizon Mine Coal Project area, so that field surveys could be carried out concurrently.

**Greenhills Mine
Project, Westar**
Elkford, BC

Project Manager for Stage 1 and 2 submissions of the Greenhills Mine project in the Fording River area of southeast BC. Coordinated and managed seasonal field surveys to meet provincial government requirements for project approvals and permitting. Carried out wildlife surveys, habitat assessment, and habitat mapping technical components, plus fisheries and water quality surveys. Completed a series of helicopter surveys to document winter distribution of wildlife in the mine site and adjacent Fording River Valley from the Dry Creek area north to Eagle Mountain. Coordinated and managed report preparation and production of Stage 1 and 2 submissions to BC Government.

**Sage Creek Coal
Project, Lornex Mining
(Sage Creek Coal)**
southeastern BC

Coordinated field components for a Stage 2 report on a major coal mining proposal in the Flathead Valley. Led wildlife and vegetation surveys and mapping, including habitat surveys, habitat assessment, aerial surveys in winter and spring, and small mammal trapping. The project area included sensitive riparian habitats in the floodplain of Howell and Cabin creeks and important habitat elements for grizzly bears. Coordinated preparation and production of the Stage 2 report for submission to the BC Government.

**Fording Coal Limited
Eagle Mountain Project**
Elkford, BC

Project Manager for detailed environmental inventory and impact assessment for a major mine extension project at Fording Coal Operations. Carried out wildlife ground and aerial surveys, compiled and analysed data, and mapped habitat units. The study assessed range use by elk, bighorn sheep, and deer and assessed potential impacts of habitat loss from expansion of the mine to Eagle Mountain. Managed and coordinated technical studies by other disciplines and preparation and production of Phase 2 study report.

**Review of Ungulate
Food Habits, Cominco**
Trail, BC

Completed a review and compilation of ungulate food habitats related to planning for land reclamation at Fording River Operations.



**Fording Coal Limited
Henretta Creek Project**
Elkford, BC

Coordinated field work, data analysis, and reporting phases of a detailed inventory of wildlife use in a proposed mine extension area along a tributary valley of the Fording River. Field study included pellet transect surveys, browse plots, and wildlife observation stations.

**Fording Coal Limited
Brownie Creek Coal
Licenses**
Elkford, BC

Coordinated field work, data analysis, and reporting of a detailed inventory of wildlife and aquatic resources for a coal licence block being considered for coal waste disposal in the upper Kilmarnock Creek drainage. Field studies included winter and spring helicopter surveys to document ungulate distribution and range use, general wildlife inventory, and habitat assessment.

**Crows Nest Resources
Line Creek Project**
Sparwood, BC

Conducted detailed wildlife and habitat surveys for a proposed coal mine development in the Elk Valley and prepared wildlife sections of Stage I and Stage II reports submitted to the BC Government. Survey methods included ungulate pellet counts, browse surveys, and direct observations of the project area. Studies included detailed habitat descriptions and mapping, with a focus on habitat use by elk. Follow-up monitoring studies as part of Stage III were carried out along permanent transects over a two year period to quantify elk use of the Grave Lake winter range, which was the location of the plant site for the project. Habitat management recommendations were provided to CNR for consideration in future development of the project.

**Crows Nest Resources
Byron Creek Collieries**
Michel, BC

Conducted wildlife and habitat surveys in preparation for an EA of proposed coal mine expansion at Coal Mountain in the upper Corbin Creek valley, southeast of Sparwood.

**J-Pit Mine Extension,
Westar**
Sparwood, BC

Coordinated field and reporting aspects and production of application for BC Coal's expansion of open pit mine activities in the Elk Valley north of Sparwood.

**Mine Waste Disposal
Assessment, Westar**
Sparwood, BC

Led wildlife and habitat assessment for an assessment of coal waste and tailings disposal options in the Elk Valley for BC Coal's Elkview operations.

**Hosmer-Wheeler Coal
Mine, Kaiser
Resources Canada**
Hosmer, BC

Carried out wildlife and habitat assessment of Kaiser Resources' proposed coal mine near Hosmer, BC in an area east of Highway 3. Field surveys involved ungulate pellet and browse surveys, habitat assessment and general wildlife observations. Prepared wildlife report sections for submission of Stage I and II documents for mine approval to BC Government.

**Quinsam Coal Project,
Brinco Mining and
Quinsam Coal**
Vancouver Island, BC

Carried out baseline field surveys of aquatic environments as part of the Stage II mine application approvals process. Surveys included sampling in stream and lake ecosystems as part of pre-operational baseline monitoring. Coordinated preparation of Stage II submission to BC Government for project approval.

**Northeast Coal Block,
Denison Mines**
northeastern BC

Conducted detailed wildlife surveys of Quintette and Saxon coal project areas. Field work included winter helicopter surveys of ungulate distribution, habitat assessment, ungulate pellet transects, browse surveys, bird observations, and small mammal trapping. Prepared wildlife and habitat report sections for Stage 1 and Stage 2 reports of the Quintette Coal Project for submission to BC Government. Prepared wildlife baseline reporting on the Saxon coal properties.

Sukunka Coal Mine
northeastern BC

Conducted detailed wildlife surveys for proposed coal project south of Chetwynd. Studies included winter helicopter surveys to document ungulate distribution and range use, summer pellet and browse surveys, and habitat assessment.



PROJECT EXPERIENCE – METAL MINING

**Jennings Property,
Agnico-Eagle**
Southern Yukon

Senior Wildlife Biologist and terrestrial resources lead on Agnico-Eagle's Jennings prospect in the southern Yukon. Responsible for senior level planning and review of seasonal field surveys (fall, late winter, spring) and full program of baseline studies.

Huckleberry Mines Ltd.
central BC

Senior Wildlife Biologist on environmental assessment of Main Zone Optimization Project. Assessed potential for impacts from tailings disposal site TMF3 on listed and regionally important wildlife species. Provided senior review of technical baseline report and a subsequent Wildlife Mitigation and Management Plan.

**Prairie Creek Mine,
Canadian Zinc
Corporation**
NWT

Senior Wildlife Biologist responsible for preparing vegetation and wildlife assessment report for Canadian Zinc Corporation's Developer's Assessment Report for the Prairie Creek Mine site in the South Nahanni region of NWT. Completed on site wildlife reconnaissance and flew reconnaissance level wildlife survey in June 2006 of the access road corridor between the mine site and the Liard River. Prepared responses to Information Requests subsequent to government review of the DAR. Provided consultation on design of winter surveys for the mine access road and reviewed results of winter caribou surveys. Provided senior review and coordination of a Draft Wildlife Mitigation and Monitoring Plan for the mine site and access road operation.

**TTM Resource Chu
Mine**
north central BC

Senior Terrestrial Biologist for baseline vegetation and wildlife studies of a proposed molybdenum mine operation in the region south of Vanderhoof, BC. Prepared detailed work plans and coordinated preliminary wildlife surveys and ecosystem analysis for BC Environmental Assessment Act process, and provided senior review of technical field survey reporting.

**Kudz-Ze-Kayah
Project, Cominco**
Finlayson Lake Area, YT

Senior Wildlife Biologist for assessment of a proposed metal mine. The mine site and associated haul road are in the traditional range of the Finlayson caribou herd, and also supports a large population of moose. Traditional First Nations use of the area was a key factor in the environmental assessment process. Carried out field wildlife inventory surveys, habitat mapping, reporting, assessment of impacts on wildlife and habitat, and prepared a wildlife mitigation and impact management plan. Participated in a fall wildlife survey to document caribou and moose range use. Also conducted baseline monitoring programs for water quality and sediment, and in collaboration with the First Nation, collection of vegetation samples for baseline metals analysis.

SNIP Mine Closure
northwestern BC

Coordinated preparation of mine closure documents for gold mine located in the Iskut River area. Led technical coordination of input from various discipline specialists, in preparation for a final mine closure plan.

**Golden Bear Project,
Chevron Minerals and
NA Metals**
northwestern BC

Conducted field studies and provided technical coordination of preliminary environmental studies for development of a gold mine and road access. Assessed road access options along a corridor from near Telegraph Creek to the mine site, across previously inaccessible terrain. Coordinated environmental permitting and monitoring for access road construction.



SNIP Project
northwestern BC

Coordinated technical components of multi-disciplined environmental studies and Stage 1 Environmental Impact Assessment (EIA) of a gold mining project in the Iskut River area.

**Kutcho Creek Project,
Sumitomo Mining/Esso
Minerals**
northwestern BC

Coordinated technical EIA components for a proposed copper mine, including coordination of field surveys for wildlife, water quality monitoring, and hydrology monitoring. Responsible for coordination of reporting and production of Stage 2 report for submission to BC Government under the Mine Review Process.

**Energex Minerals AI
Project**
north central BC

Coordinated EA studies for a proposed gold mine in the Toadoggone area of northcentral BC. Coordinated assessment of the Omineca Mine Access Road Extension to the proposed mine site from the Cheni Gold mine project. Conducted aerial wildlife surveys, vegetation surveys, and seasonal water and hydrology sampling programs. Coordinated and prepared major report submissions to the BC Government including Stage 1 report and road extension assessment report.

**Cheni Gold's Lawyers
Project**
northcentral BC

Coordinated EIA studies and prepared Stage 1 report submission to the BC Government for a gold mine in the Toadoggone region. Coordinated environmental monitoring for construction of road access extension from the northern terminus of the Omineca Mine Access Road to the mine site.

PROJECT EXPERIENCE – ENERGY

**Zero Emission
Developments Inc.
Wind Energy Projects**
Port Hardy, Taylor,
Peachland,
Summerland, BC

Project Manager and Senior Biologist on four proposed small scale wind energy projects throughout BC. Provided senior review and liaison with provincial and federal government agencies. Seasonal field surveys included ecosystem inventory, rare plant surveys and a wide range of wildlife, including bats, herptiles, breeding songbirds, and migrating birds. Focus of studies was on listed plant and wildlife species and species at-risk habitat analysis.

**Northwest
Transmission Line
Project, BC Hydro**
Northwest BC

Senior Wildlife Biologist and Terrestrial Task Lead for implementation stage of major electrical transmission line to be constructed between Terrace and Bob Quinn Lake. Responsible for planning and oversight of wildlife studies required prior to line clearing and for providing senior wildlife review for Golder's construction auditing function.

**Interior to Mainland
Transmission Line
Project, BC Hydro**
Southwest BC

Senior Wildlife Biologist and Terrestrial Task Lead for implementation stage of major electrical transmission line upgrades to be constructed between Nicola and Coquitlam, BC. Responsible for planning and oversight of wildlife studies required prior to line clearing and for providing senior wildlife review for Golder's construction auditing function.

**Nicomen Wind Energy
Project, Premier
Renewable Energy**
Lytton, BC

Vegetation and Wildlife Task Lead for a proposed wind energy project located in the uplands between Lytton and Spences Bridge, BC. Responsible for technical coordination and planning of vegetation and seasonal wildlife surveys in a remote mountainous study area. Field surveys included ecosystem inventory and rare plant surveys, seasonal ground and air wildlife surveys, bat surveys, and species at-risk habitat analysis.



**Marten Ridge Wind
Energy Project,
Premier Renewable
Energy
Fernie, BC**

Vegetation and Wildlife Task Lead for a proposed wind energy project located in the Rocky Mountains east of Fernie, BC. Responsible for technical coordination and planning of vegetation and seasonal wildlife surveys. Field surveys included ecosystem inventory and rare plant surveys, bat surveys and seasonal wildlife surveys.

**Banks Island Wind
Energy Project, North
Coast Wind Energy
Corp.
north-central coast, BC**

Wildlife Task Lead for a two-year detailed wildlife investigation of a proposed wind energy project located on the northern part of Banks Island, on the north-central coast of BC. Project involves a large wind farm area and a transmission line route connecting to the mainland east of Prince Rupert. Wildlife investigations involved seasonal studies of wildlife in the marine and upland environment. Focal species and groups included raptors, songbirds, marine birds, waterfowl, sandhill cranes, marbled murrelet, ungulates, carnivores, bats and furbearers. Field survey methods included use of radar for bird migrations and movements, bat detectors, remote cameras for sandhill crane habitat use, breeding bird surveys, raptor call play-back surveys, and wildlife habitat capability/suitability assessment. Derivative products to be produced in GIS include wildlife habitat suitability mapping.

**Sage Creek Coal
Project
southeastern BC**

Prepared wildlife and resource use components of an EA for a proposed 230 kV electric transmission line from the Crows Nest area through the Flathead Valley to service the proposed Sage Creek Coal Project located north of the Canada-USA border. Issues of note included ungulate populations and the potential impacts on the local and regional grizzly bear population.

**500 kV Nicola to
Wardner Powerline, BC
Hydro
interior BC**

Led wildlife component of a multi-disciplinary assessment for a 500 kV powerline through the southern interior of British Columbia, between the Nicola Valley and Wardner (east of Cranbrook). Identified wildlife resource values along corridors from existing information sources and field reconnaissance information. Provided consultation for broad corridor and specific route alignment selection as part of the Ian Hayward Associates study team.

TRAINING

Wildlife/Danger Tree Assessor (British Columbia), BC Environment/MOF

***Introduction to RIC Wildlife Species Inventory Certificate, BC
Environment***

Level 1 First Aid

PROFESSIONAL AFFILIATIONS

Registered Professional Biologist, College of Applied Biology of British Columbia

**Education**

*M.Sc. Wildlife Ecology,
Simon Fraser University,
Burnaby, British Columbia,
2009*

*B.S. Biology, Saint
Michael's College,
Colchester, Vermont, 2002*

Golder Associates Ltd. – Burnaby***Wildlife Biologist***

Daniel is a Wildlife Biologist in the Environmental/Social Resources Group in Golder's Burnaby, British Columbia office. He has a M.Sc. in wildlife ecology from Simon Fraser University, Burnaby, British Columbia. Daniel's background is diverse, having studied a variety of species and habitats throughout North America and abroad. He has been involved in all aspects of project completion including project design, development and budgeting, data collection, statistical analysis and interpretation, and reporting. His technical project experience includes live-capture and immobilization of carnivores, furbearers, ungulates, small mammals and birds, ground and aerial telemetry, habitat surveys, aerial surveys, remote camera surveys, snow-tracking, non-invasive genetic sampling, and biological monitoring of environmental contaminants. He has also participated in breeding bird surveys and seabird research.

Employment History***Golder Associates Ltd. – Burnaby, BC***

Wildlife Biologist (2010 to Present)

Member of the Environmental and Social Resources Group. Responsible for terrestrial resource assessment, environmental impact assessment, species at risk investigations, environmental permitting, auditing and compliance monitoring, data analysis, report and proposal writing.

British Columbia Conservation Foundation – Surrey, BC

Wildlife Biologist (2010 [2011 Volunteer])

Field biologist for the trans-boundary North Cascades wolverine research project in British Columbia and Washington State.

Center for Wildlife Ecology – Burnaby, BC

Wildlife Biologist (2005 to 2009)

Principal investigator for a river otter research project along the coast of southern Vancouver Island, British Columbia.

Environment Canada – Delta, BC

Wildlife Biologist (2004 to 2005)

Field biologist for a trans-boundary trumpeter swan research project in British Columbia and Washington State.

Institute for Wildlife Studies – Arcata, CA

Wildlife Biologist (2004)

Lead field biologist for the Santa Catalina Island fox recovery project.

Smithsonian Institution – Front Royal, VA

Wildlife Biologist (2002 to 2004)

Field biologist with the Wildlife Ecology Research Group.



PROJECT EXPERIENCE – WILDLIFE ASSESSMENT

Crowsnest Coal Mining Ltd. British Columbia	Field lead for baseline wildlife surveys for the proposed Coal Creek project. Conducted wildlife habitat plots and encounter transects following BC Wildlife Habitat Rating Standards and the BC Field Manual for Describing Terrestrial Ecosystems.
BC Hydro British Columbia	Field lead for a pre-construction raptor stick nest survey for BC Hydro's 335 km Northwest Transmission Line alignment. Designed and conducted a RISC-compliant aerial survey of the entire transmission line right-of-way via helicopter.
Zero Emission Energy Developments British Columbia	Field lead for a raptor stick nest inventory survey for the Port Hardy Wind Energy Project. Designed and conducted a RISC-compliant aerial survey of the entire Project area via helicopter.
Dover OpCo Dover Project Alberta	Field assistant for an assessment of ungulate distribution and abundance in the Dover lease area. Conducted an aerial survey of the entire Project area by helicopter.
Canadian Natural Resources Ltd. Alberta	Field assistant for assessment of wildlife presence, distribution and abundance in three CNRL lease areas. Conducted ground-based snow-track surveys, for ungulates, carnivores, and small mammals.
Canadian Zinc Corporation Northwest Territories	Field lead for caribou occupancy survey in the Prairie Creek Mine area. Designed and conducted two aerial caribou surveys via fixed-wing aircraft. Conducted occupancy modelling to predict the probability of caribou occurrence in and around the Prairie Creek Mine site.
Agnico-Eagle Mines Ltd. Yukon	Field lead for reconnaissance-level wildlife surveys for the proposed Jennings Project. Designed and conducted three aerial ungulate surveys via helicopter in addition to ground-based snow-track surveys for ungulates, carnivores, and small mammals.
Huckleberry Mine Ltd. British Columbia	Field lead for assessment of the potential impacts of a tailings facility expansion on species at risk. Conducted wildlife habitat plots and encounter transects following BC Wildlife Habitat Rating Standards and the BC Field Manual for Describing Terrestrial Ecosystems. Detailed potential project-related effects on wildlife species at risk, and recommended general and specific mitigation and management measures to be implemented for project construction.
Ledcor British Columbia	Field lead for assessment of the potential impacts of a proposed road upgrade on species at risk in northeast BC. Conducted wildlife habitat surveys following BC Wildlife Habitat Rating Standards and the BC Field Manual for Describing Terrestrial Ecosystems. Detailed potential project-related effects on wildlife species at risk, and recommended general and specific mitigation and management measures to be implemented for project construction.



**ATCO Electric
Transmission Line
Project**
Alberta

Field lead responsible for coordinating and conducting a species at risk investigation on proposed transmission line corridors in east-central Alberta. The work included detailed field surveys of wildlife (primarily raptors) and their associated habitats with the objective of identifying the proposed alignment options that are most likely to avoid impacts to sensitive wildlife and wildlife habitat.

Innergex
British Columbia

Field lead for assessment of potential impacts of a proposed road upgrade on species at risk for the Kwoiek Creek Hydroelectric Project. Conducted wildlife habitat plots and encounter transects following BC Wildlife Habitat Rating Standards and the BC Field Manual for Describing Terrestrial Ecosystems. Also conducted RISC-compliant presence/non-detected inventory of western screech owl for associated transmission line right-of-way.

**British Pacific
Properties**
British Columbia

Conducted remote-camera surveys and other transect surveys for documenting wildlife species and important wildlife habitat features associated with a proposed residential development site near Cypress Mountain, BC.

PROJECT EXPERIENCE – WILDLIFE MONITORING AND RESEARCH

**BC Conservation
Foundation**
British Columbia

Field biologist for the trans-boundary North Cascades wolverine research project. Conducted live-capture, chemical immobilization, and satellite collaring of wolverines as well as remote-camera surveys and snow-track surveys.

**Center for Wildlife
Ecology**
British Columbia

Principal investigator for research project examining river otter population ecology and contaminant exposure along the coast of southern Vancouver Island, BC. Responsible for developing project objectives and all aspects of project coordination and implementation, including field surveys, data collection and statistical analysis, reporting, and preparation of scientific manuscripts.

University of Wyoming
Washington & Alaska

Field biologist solicited to assist with two UWY river otter research projects. 1) Assisted with the live-capture and chemical immobilization of river otters in the San Juan Island Archipelago, Washington. 2) Assisted with the identification and monitoring of river otter latrine sites in coastal Prince William Sound, Alaska.

Environment Canada
British Columbia

Field biologist for the trans-boundary Sumas Prairie trumpeter swan research project. Conducted live-capture and radio-collaring of swans as well as aerial and ground telemetry.

Environment Canada
British Columbia

Field biologist solicited to assist with three Environment Canada research projects. 1) Assisted with live-capture and blood sampling of adult glaucous-winged gulls at active island nesting colonies in the Strait of Georgia, BC. 2) Assisted with the collection of rhinoceros auklet and storm petrel eggs from active island nesting colonies off the coast of BC. 3) Assisted with bald eagle nest surveys in the Fraser Valley, BC via helicopter.

**University of Northern
British Columbia**
British Columbia

Field biologist for a research project studying the impact of a wind energy development site on migratory birds. Conducted avian mist-netting, line-transect surveys, and nightly radar surveys.



Curriculum Vitae

DANIEL GUERTIN

**Institute for Wildlife
Studies**
California

Lead field biologist for the Santa Catalina Island fox recovery project. Responsible for all aspects of project coordination and implementation, including data management and analysis and report production. Coordinated and performed live-trapping, immobilization, and radio-collaring of foxes as well as aerial and ground telemetry. Also responsible for educational outreach and providing information to the public.

Smithsonian Institution
China

Lead field biologist for a research project examining Asiatic black bear ecology in China. Responsible for all aspects of project design, coordination and implementation. Conducted live-capture, immobilization, and GPS-collaring of bears.

Smithsonian Institution
Virginia

Field biologist for a research project examining the effectiveness of a single injection immunocontraception for controlling white-tailed deer populations. Conducted live-capture, immobilization, and radio-collaring of female deer. Administered contraceptive to restrained deer. Also performed ground telemetry, spotlight surveys, and pellet surveys.

Smithsonian Institution
Virginia

Field biologist for a research project examining the impact of white-tailed deer overabundance on forest and agricultural resources in the mid-Atlantic states. Conducted live-capture, immobilization, radio-collaring, and ground telemetry of deer. Also conducted avian mist-netting, small mammal trapping, vegetation surveys, and harvest yield surveys inside deer exclosure plots.

Smithsonian Institution
Virginia

Field biologist for a small mammal inventory in eight national parks in the mid-Atlantic states. Conducted small mammal trapping surveys.

**Minnesota Department
of Natural Resources**
Minnesota

Field biologist solicited to assist with two research projects in northern Minnesota
1) Conducted live-capture, immobilization, and radio-collaring of black bears during summer as well as bear den investigations during winter. 2) Assisted with live-capture, immobilization, and radio-collaring of wolves.



TRAINING

Flying in the Wire and Obstruction Environment

Utilities/Aviation Specialists Inc., 2011

Modelling Patterns and Dynamics of Species Occurrence

Proteus Wildlife Research Consultants, 2011

Standard First Aid (Industry)/Level C CPR/AED

St. John Ambulance, 2009

H2S Alive

Enform, 2010

The Chemical Immobilization of Wildlife

Canadian Association of Zoo and Wildlife Veterinarians, 2009

Design and Analysis of Mark-Recapture Studies

Columbia Mountains Institute of Applied Ecology, 2008

Pleasure Craft Operator Course

Canadian Coast Guard, 2005

ATV Rider Course

ATV Safety Institute, 2004

PUBLICATIONS

Refereed Journal Articles

Guertin, Daniel A., M. Ben-David, Alton S. Harestad and John E. Elliott. Fecal Genotyping Reveals Demographic Variation in River Otters Inhabiting a Contaminated Environment. *Journal of Wildlife Management* (Accepted)

Seymour, Matthew S., Katheryn E. Ott, Daniel A. Guertin, Howard N. Golden, David B. McDonald and M. Ben-David. Early Holocene glacial retreat isolated river otter populations along the Pacific coast.. *Conservation Genetics* (In Review)

Guertin, Daniel A., Alton S. Harestad, Merav Ben-David, Ken G. Drouillard and John E. Elliott. Fecal genotyping reveals individual variation in local exposure of river otters to persistent contaminants. *Environmental Toxicology and Chemistry*, 29 (2010), 275-284.

Guertin, Daniel A., Alton S. Harestad and John E. Elliott. Summer feeding habits of river otters inhabiting a contaminated coastal marine environment. *Northwest Science*, 84 (2010), 1-8.

Elliott, John E., Daniel A. Guertin and Jennifer M. E. Balke. Chlorinated hydrocarbon contaminants in feces of river otters from the southern Pacific coast of Canada, 1998-2004. *Science of the Total Environment*, 397 (2008), 58-71.

Other

Lofroth, Eric C., Daniel A. Guertin and Heidi M. Schindler. Preliminary inventory of wolverines in the Dawson Creek timber supply area. A report to BC Timber Sales, Dawson Creek, British Columbia, Canada. (2010).

RESUME Steve M. Moore



STEVE M. MOORE, B.E.S., B.A.
Senior Wildlife Biologist / Environmental Scientist

EDUCATION

B.E.S., Environment and Resource Studies (Honours), University of Waterloo
B.A., Economics, University of Waterloo
Diploma, Fish and Wildlife Management, Sir Sandford Fleming College

AFFILIATIONS

Member, International Association for Impact Assessment
Environment Canada's, Canadian Wildlife Service's Regional Bird Conservation program that assesses the status of bird species in northern Canada.
Government of the Northwest Territories, Department of Environment and Natural Resources' Plant Committee for assessing the conservation status of plants

Mr. Moore is a wildlife biologist with more than 29 years of experience in northern, western and eastern Canada. For 24 of those years Steve has been based in Yellowknife working primarily on arctic projects for government, industry, aboriginal and non-government clients. Steve has extensive experience carrying out field environmental baseline and monitoring surveys in northern Canada for birds (waterfowl, passerines, raptors), mammals (grizzly bears, carnivores, caribou, bison, and other species), aquatic resources, and vegetation/wildlife habitat, using a variety of ground and aerial techniques. In recent years he has carried out such baseline studies for a number of mining and oil and gas clients and other developments in the Northwest Territories and Nunavut.

Mr. Moore has wide ranging experience in wildlife and botanical research, which as included population surveys for big game, birds, marine mammals, small mammals, fish populations, amphibians, endangered flora and fauna, *etc.* Mr. Moore is a senior wildlife biologist based in EBA's Yellowknife office. He has more than 29 years of broad ranging experience in ecology, resource management and baseline surveys. In addition to animal and plant studies, Mr. Moore has been involved in limnological work for many years. He has been involved and led many aquatic programs in the Yukon, NWT and Nunavut. In recent years, he has participated in many environmental assessments, wildlife monitoring and baseline study programs in the Northwest Territories including several stages of BHP's environmental assessment for Sable, Beartooth and Pigeon, TCWR Joint Venture Seasonal Overland Road, De Beers Diamonds 2005 Environmental Assessment, BHP's EKATI™ Diamond Mine Wildlife Monitoring Programs 1996-2000, and Lytton's 1997 baseline study program for the Jericho Diamond project. Mr. Moore was involved with the Snare River Hydro project in the NWT where he designed and conducted the necessary biological program for characterizing the biological components of the Snare River.

His main areas of expertise include the following:

- Baseline wildlife, monitoring wildlife, botanical work, and water quality;
- Environmental impact assessments (wildlife, vegetation and water quality); and
- Ecological Assessments.

CONTAMINATED LAND AND RISK ASSESSMENT

De Beers Canada Inc., Water Quality Monitoring, Kennady Lake Exploration Camp, NT, 2002 - 2008

- Between 2002 and 2008, Mr. Moore has designed and prepared the water quality monitoring Quality Assurance/Quality Control program, and the water quality surveillance network program and the Cuttings Containment Facility (CCF) decant program.

Tibbitt to Contwoyto Winter Road Joint Venture (multiple diamond mining companies), Annual Environmental Monitoring, Tibbitt to Contwoyto Winter Road, NT, 2006 - 2008.

- Carried out the 2006 to 2008 annual monitoring program of the portages and associated camps along the winter road with respect to environmental conditions, environmental site assessments (hydrocarbon and metal concerns), and waste management practices.

BASELINE WILDLIFE, WATER QUALITY, AND HYDROLOGY ASSESSMENT

Peregrine Diamonds Ltd., Baseline Environmental Studies, DO27, NU, 2007 - 2008

- Acted as the project manager and technical member for designing, carrying out, analyzing, and reporting two years of baseline environmental studies for future regulatory applications and approvals through the Nunavut Impact Review Board (NIRB). Mr. Moore conducted barren-ground caribou, breeding bird, raptor, waterfowl, carnivore and carnivore den, and wildlife habitat studies within a study area. She also provided environmental training services to local Aboriginal assistants hired by Peregrine.

Avalon Rare Metals Inc., Baseline Environmental Studies and Impact Assessment, Nechalacho Mine and Former Pine Point Mine Site, NT, 2008 to 2010

- Conducted baseline breeding bird, waterfowl, and wildlife habitat assessments at the Thor Lake and Pine Point project sites, acted as technical advisor during community information sessions.

Tyhee Gold Corp., Baseline Environmental Studies and Impact Assessment, Yellowknife Gold Project, NT, 2005 - 2008

- Mr. Moore designed and implemented the wildlife and water quality surveys for Tyhee Gold Corp., which included barren-ground caribou, moose, breeding bird, waterfowl, owl, carnivore and carnivore den, and water quality surveys for a proposed gold mine northeast of Yellowknife in 2005 to 2008.

Advanced Explorations Inc., Baseline Environmental Studies, Roche Bay Magnetite Project, NU, 2006 - 2010

- Mr. Moore was the Project Manager for environmental work conducted on behalf of Advanced Explorations Inc.. This work included designing and implementing terrestrial wildlife, sea mammal and water quality surveys. These baseline environmental programs included surveying barren-ground caribou, waterfowl and sea birds, breeding birds, raptors, marine mammals, water quality, and stream flow velocities. Mr. Moore analyzed the field data, compared results with published data in the region, and described existing baseline environmental knowledge suitable for future submissions to the NIRB.

**Education**

*B.A.Sc. Civil Engineering,
University of Toronto, 1985*

Mississauga**Employment History****Golder Associates Ltd. – Mississauga, Ontario**

Air Quality and EA Specialist (2005 to Present)

Responsible for the provision of senior support, technical guidance and expertise on air quality, and environmental assessments in Canada and internationally. Specific roles include the management and direction of large multi-disciplined assessments, providing specialized expertise in the areas of atmospheric sciences and air quality assessments, as well as the provision of expert testimony at hearings.

Golder Associate Ltd. – Calgary, Alberta

Senior Air Quality Engineer (1998 to 2005)

Responsible for the provision of air quality expertise in Canada and internationally as well as helping develop air quality services in western Canada. Specialized in the areas of atmospheric sciences; air quality assessment; dispersion modelling; environmental assessments; emission inventories; transportation air quality impact assessments; air quality and meteorological monitoring programs; the evaluation of air quality, noise and odour impacts and expert testimony.

SEACOR Environmental Eng. Inc. – Vancouver, British Columbia

Senior Air Quality Engineer (1996 to 1998)

Responsible for the development, marketing and provision of corporate air services to clients across Canada.

B.H. Levelton & Associates Ltd. – Vancouver, British Columbia

Senior Air Quality Engineer (1991 to 1996)

Responsible for the development, marketing and provision of air modelling and assessment services to clients in British Columbia.

Acres International Ltd. – Niagara Falls, Ontario

Senior Air Quality Engineer (1991 to 1991)

Responsible for the development, marketing and provision of air quality services to support Acres' worldwide clients. Additional responsibilities included development of corporate strategies for servicing U.S. clients.

SENES Consultants Ltd. – Richmond Hill, Ontario

Air Quality Engineer (1987 to 1991)

Responsible for the development and provision of air quality and noise services to support project work across North America.



PROJECT EXPERIENCE – EXPERT TESTIMONY

**Canadian Natural
Resources Limited;
Horizon Project**
Fort McMurray, Alberta,
Canada

Golder was retained by Canadian Natural to provide expert witness testimony in the Joint Federal/Provincial Panel hearing regarding the proposed Horizon Oil Sands Project in the Athabasca Oil Sands Region. Specific roles included the completion of hearing materials, review of intervener submissions, hearing preparation and participation as a panel member during the hearing.

**City of Toronto; 6
Lloyd Avenue**
Toronto, Ontario,
Canada

Golder was retained by the City of Toronto to provide expert testimony before the Ontario Municipal Board the proposed application for a zoning change to allow the development of a mixed residential-commercial project on a former industrial site at 6 Lloyd Avenue in Toronto. Specific roles included the compilation of hearing materials, review of hearing submissions, preparation of formal submissions and participation as an expert witness during the hearings.

**Imperial Oil Resources
Limited - Kearl Oil
Sands Project**
Fort McMurray, Alberta,
Canada

Golder was retained by Imperial Oil to form part of an expert witness panel to provide expert testimony in the Joint Federal/Provincial Panel hearing regarding the proposed Kearl Oil Sands Project in the Athabasca Oil Sands Region. Specific roles included the compilation of hearing materials, review of intervener submissions, hearing preparation and participation as a panel member during the hearings.

**Imperial Oil Resources
Limited - Mackenzie
Gas Project**
Yellowknife, Northwest
Territories, Canada

Golder was retained by Imperial Oil, as the principal proponent, to support and participate, as expert witnesses, in a series of hearings before a Joint Federal Review Panel regarding the proposed Mackenzie Gas Project. Specific roles included the compilation of hearing materials, review of intervener submissions, hearing preparation and participation as a panel support member during technical hearings.

**Lehigh Inland Cement
Limited - Substitution
Fuel Project, Appeal
Board Hearings**
Edmonton, Alberta,
Canada

Golder was retained by the proponent to provide expert witness testimony in the Environmental Appeals Board hearing regarding the Environmental Protection and Enhancement Act (EPEA) approval granted to Lehigh Inland Cement for its Substitution Fuel Project in Edmonton. The work included the completion of supplementary responses and hearing preparation for the air quality component of the Board hearing. Specific responsibilities included the preparation of affidavits, review of appellant affidavits, hearing preparation and participation as a panel member during the hearing.

**PanCanadian
Resources Inc. -
Christina Lake Thermal
Project**
Conklin, Alberta, Canada

Golder was retained by PanCanadian to provide expert witness testimony at the Energy and Utilities Board (EUB) hearing regarding the proposed Christina Lake in situ oil sands project in northeastern Alberta. Specific roles included the review of intervener submissions, hearing preparation and participation as a panel member during the hearing.

**Paramount Resources
Ltd. - Cameron Hills
Extension Project**
Fort Liard, Northwest
Territories, Canada

Golder was retained by Paramount Resources to provide expert witness testimony at the Mackenzie Valley Environmental Impact Review Board (MVEIRB) hearing regarding the proposed expansion of the Cameron Hills Project near Hay River, NT.

**Shell Canada Limited -
Jackpine Mine - Phase 1**

Fort McMurray, Alberta,
Canada

Golder was retained by Shell Canada to provide expert testimony at the Joint Federal/Provincial Panel hearing regarding the proposed Horizon Oil Sands Project in the Athabasca Oil Sands Region. Specific roles included the completion of hearing materials, review of intervener submissions, hearing preparation and participation as a panel member during the hearing.

**Suncor Energy Inc. Oil
Sands - Project
Millennium**

Fort McMurray, Alberta,
Canada

Golder was retained by Suncor Energy to provide expert witness testimony at the Energy and Utilities Board (EUB) hearing regarding the proposed Millennium upgrading and mining project in the Athabasca Oil Sands Region. Specific roles included the review of intervener submissions, hearing preparation and participation as a panel member during the hearing.

PROJECT EXPERIENCE – OIL SANDS DEVELOPMENTS

**Canadian Natural
Resources Limited -
Horizon Project EIA**

Fort McMurray, Alberta,
Canada

Golder Associates was responsible for the completion of the environmental impact assessment (EIA) for the Canadian Natural Resources Limited (CNRL) Horizon integrated oil sands mine and upgrading project. The air quality sections of the EIA evaluated cumulative air pollutant concentrations and acid deposition across the Oil Sands Region, using the CALPUFF dispersion model (3-D mode). The EIA made use of Golder's regional emissions database and 3-D meteorological data set, which covers the area from Fort Chipewyan in the north to the Cold Lake area in the south. Specific roles on the project included: providing overall direction to the air quality components; liaison with clients, regulators and stakeholders; participation in project workshops; providing input to the project engineering team with respect to mitigation strategies; and participating as an expert witness in the Joint Panel Hearings.

**Canadian Natural
Resources Limited -
Primrose and Wolf
Lake Expansion (PAW)**

Bonnyville, Alberta,
Canada

An air quality assessment was completed to support the application for the expansion of the Primrose and Wolf Lake in-situ Oil Sands developments at the southern edge of the Cold Lake Air Weapons Range. The air quality assessment formed part of a comprehensive environmental impact assessment (EIA) for the project. Project and cumulative regional emissions were calculated and modelled to determine ground-level pollutant concentrations and acid deposition. The dispersion modelling was performed using CALPUFF, run in 2-D mode. A noise assessment was also completed as part of the EIA, to evaluate the facility and traffic noise levels likely to result from varying stages of project development. Specific roles included providing the overall direction for the air and noise components of the work; preparation of the relevant volume of the EIA; working closely with other disciplines to facilitate the assessment of air emissions effects on the environment; participation in regulatory workstation and responding to supplemental information request.



**Canadian Natural
Resources Ltd. - SRU
Stack Height
Assessment**
Fort McKay, Alberta,
Canada

As part of the engineering design and optimization process for the Horizon Project, Canadian Natural were seeking a modification to the approved height for the sulphur plant stack. To support these modifications, Golder conducted an assessment of ground-level SO₂ concentrations and acid deposition rates associated with approved and proposed stack heights. Specific roles on the project included providing the overall direction for the air assessment; preparation of the relevant documentation provided to the regulators and responding to supplemental information request.

**Canadian Natural
Resources Ltd. -
Airport Noise
Assessment**
Fort McKay, Alberta,
Canada

Golder Associates was retained to conduct a noise assessment of a proposed airport on the Canadian Natural Horizon Project site. The noise assessment was part of an application for a License of Occupation and included assessing long-term and short-term noise levels from air traffic at the site. The assessment used the CadnaA AzB noise model to demonstrate that the resulting noise levels would meet the EUB long-term (24-hour) and WHO short-term noise levels (1 hour) noise criteria. Roles on the project included providing senior technical support, report preparation and senior review.

**Cumulative
Environmental
Management
Association -
Sensitivity Mapping**
Northeastern, Alberta,
Canada

Golder was responsible for a detailed project to map receptor sensitivity to acid deposition in the Oil Sands Region for the Cumulative Environmental Management Association (CEMA). The project made use of acid deposition predictions made using the CALPUFF dispersion model (3-D mode) to update earlier studies highlighting soils and water bodies that might be affected by emissions from the existing and planned developments in the region. A significant component of the study involved the integration of air quality predictions and mapping of sensitive soils into a GIS model for the Oil Sands Region. Roles with the project included liaising with Association members; working with other disciplines to help coordinate the effective exchange of data; and presenting some of the project findings to the Association members. Roles in the project included liaising with Association members, working with other disciplines to help coordinate the effective exchange of data and presenting project findings.

**EnCana Energy -
Christina Lake
Monitoring Program**
Fort McMurray, Alberta,
Canada

Golder was responsible for the development of an air quality monitoring program for the Christina Lake Thermal Project in the Athabasca Oils Sands Region of Alberta. The ambient monitoring consisted of four static exposure stations and one continuous station collecting. The program included options and recommendations for monitoring locations and equipment based on the requirements of the Alberta Monitoring Directive. Specific roles included overall direction and helping with the documentation provided to the regulators to allow evaluation of the suitability and effectiveness of the planned program.



**NOx-SOx Management
Working Group - Acid
Deposition
Management Options**
Northeastern Alberta,
Canada

Golder were retained to as part of an ongoing series of projects for the NSMWG committee reviewing possible air quality options for the Athabasca Oil Sands Region. The initial stage of the project conducted a regional analysis of possible soils impacts using exposure times of 30, 50 and 100 years. The results of the integrated air quality and GIS analysis produced estimates for the areas of soils at risk from acid-forming emissions for each township in the region. The second stage of the project took the analysis several steps further by evaluating the cumulative effects of historic acid deposition on regional soils over the last 32 years (1970 to 2002), as well as the expected deposition from planned and approved projects for the next 15 (2003 to 2017) and 30 (2018 to 2032) years. As part of this project it was necessary to develop an annual emissions profile for the region and predict acid deposition rates using the CALPUFF 3-D dispersion model. Specific roles on the project included the overall management of the work; liaising with members of the Working group at the outset of the project to ensure the initial direction was focused; coordinating with the other discipline team to provide the necessary outcome in a timely manner and presenting interim finding to the Working Group members.

**Imperial Oil Resources
Limited - Kearl Oil
Sands Project**
Fort McMurray, Alberta,
Canada

Golder Associates was retained by Imperial Oil to complete the environmental impact assessment (EIA) for the Kearl Oil Sands Project. The air quality sections of the EIA evaluated cumulative air pollutant concentrations and acid deposition across the Oil Sands Region, using the CALPUFF dispersion model (3-D mode). The EIA made use of Golder's regional emissions database and 3-D meteorological data set, which covers the area from Fort Chipewyan in the north to the Cold Lake area in the south. Specific roles on the project included: providing overall direction to the air quality components; liaison with clients, regulators and stakeholders; participation in project workshops; providing input to the project engineering team with respect to mitigation strategies; and participating as an expert witness in the Joint Panel Hearings.

**OPTI Canada Inc.-
Burnt Lake Bitumen
Upgrader**
Burnt Lake, Alberta,
Canada

Prepared an air quality report that was included as part of two applications to the Alberta Environmental Protection agency and the Energy and Utilities Board (EUB) to construct an upgrading facility adjacent to a thermal oil extraction project in the Burnt Lake region of Alberta. The work involved: determining the criteria pollutant emissions of SO₂ and NO_x from the facility; conducting a dispersion modelling analysis of the emissions with consideration given to Baseline, Application and Cumulative Effects impacts. Modelling was performed using both the ISCST3 model and CALPUFF for short range and long range transport, respectively. Specific responsibilities included considerable client liaison; co-ordination of the report preparation; regulatory liaison and responding to supplemental information requests.



**OPTI Canada
Inc./Nexen Canada Ltd.
- Long Lake Project**
Fort McMurray, Alberta,
Canada

Golder was responsible for the preparation of the environmental impact assessment (EIA) and subsequent project update for the Long Lake Project, which includes an integrated steam assisted gravity drainage (SAGD) facility and upgrading complex. The air quality assessment included an evaluation of the cumulative air concentrations and acid deposition using the CALPUFF dispersion model (3-D mode). The project update made use of the Golder regional emissions and 3-D meteorological data sets, covering the area from Fort Chipewyan to south of the Cold Lake area. The use of these data sets made the update predictions consistent with the assessment approaches used on the majority of applications filed in the Oil Sands Region, as well as the work being conducted for the NOx-SOx Management Working Group (NSMWG). In addition, the use of the large study area and greater number of sources were effective in addressing all of the concerns raised by Saskatchewan Environment. Specific roles and responsibilities on the project included the overall direction of the air and noise components; liaison with client, regulatory and stakeholder group; participating in stakeholders and regulatory meetings; working with the project engineering team to ensure that effective two-way communications were maintained; completion of the air and noise sections of the EIA and completion of supplemental information requests.

**OPTI Canada Inc. -
Ambient Monitoring**
Anzac, Alberta, Canada

Golder was responsible for commissioning an ambient air quality monitoring station near the community of Anzac as part of the baseline air studies for the Long Lake Project. The program, which operated for 12 months, included support and participation from several of the in situ oil sands developers with existing or planned projects located to the south of Fort McMurray. Specific roles and responsibilities included: the direction of the work and liaison with regulators, clients and regional working groups regarding the program progress.

**OPTI Canada Inc. -
Long Lake Pilot Project**
Anzac, Alberta, Canada

Golder was responsible for the preparation of an air quality assessment for the Long Lake Pilot Project, which is a scaled down version of the Long Lake commercial Project. This project includes a small-scale integrated steam assisted gravity drainage (SAGD) facility at the site of the proposed commercial scale SAGD and upgrading complex. The air quality assessment included an evaluation of the cumulative air concentrations and acid deposition using the CALPUFF dispersion model (3-D mode). Given the proximity to the commercial scale project and the timing of the application, regulators required a far more comprehensive air quality assessment that is usually required of a project of this scope. Specific responsibilities included considerable client liaison; co-ordination of the report preparation; regulatory liaison and responding to supplemental information requests.

**PanCanadian
Resources Inc. -
Christina Lake Project**
Conklin, Alberta, Canada

Golder was responsible for the preparation of the environmental impact assessment of the Christina Lake Thermal Project, which was the first commercial Steam-Assisted Gravity Drainage (SAGD) development to receive approval in Alberta. The work was completed for PanCanadian Resources Ltd., which have subsequently merged with Alberta Energy Corporation to form EnCana Energy. Specific project responsibilities included supporting the air quality and noise evaluations, co-ordination and preparation of responses to air quality and noise supplemental requests from outside agencies and non-government organizations and participation in the EUB hearings.



**Petro-Canada -
Meadow Creek Project**
Fort McMurray, Alberta,
Canada

Golder was responsible for the completion of the environmental impact assessment (EIA) and application to develop a Steam-Assisted Gravity Drainage (SAGD) project in the Athabasca Oil Sands Region. The air quality component of the project evaluated acid deposition in the region as well as local and regional concentrations of sulphur dioxide, nitrogen dioxide, particulate matter, secondary particulates, carbon monoxide, reduced sulphurs, volatile organic compounds, trace metals and polycyclic aromatic hydrocarbons, using the CALPUFF model in the 3-D mode. Specific roles on the project included: overall directions of the air and noise sections; liaison with regulators and the engineering design teams; responding to supplemental information requests; participating in regulatory workshops; and participating in the preparation for the planned EUB hearing regarding the project. However, the hearing was cancelled by the Board once an amicable agreement was reached between Petro-Canada and the key stakeholder opposed to the project.

**Rio Alto Exploration -
Kirby Project**
Lac La Biche, Alberta,
Canada

Golder was responsible for the completion of the environmental impact assessment (EIA) and project application for the development of this Steam-Assisted Gravity Drainage (SAGD) project on the northern edge of the Cold Lake Air Weapons Range. The air quality assessment completed for the EIA evaluated local and regional concentrations of sulphur dioxide, nitrogen dioxide, particulate matter, secondary particulates, carbon monoxide, reduced sulphurs, volatile organic compounds, trace metals and polycyclic aromatic hydrocarbons using the 3-D CALPUFF model. The assessment also evaluated the cumulative acid deposition in the region and assessed possible impacts on the receiving environment. Specific roles on the project included overall directions of the air and noise sections; liaison with regulators and the engineering design teams, responding to supplemental information requests and participating in regulatory workshop.

**Shell Canada Limited -
Jackpine Mine – Phase
1**
Fort McMurray, Alberta,
Canada

Responsible for the direction of the air quality components of the recent environmental impact assessment (EIA) of the Jackpine Mine – Phase 1 oils sands mine for Shell Canada Limited. As part of the EIA, Golder was responsible for the completion of the air quality components of the project, which included the use of the Golder's regional emissions database and 3-D meteorological data set. The air quality assessment evaluated air concentrations and acid deposition resulting from cumulative emissions sources across the Oil Sands Region, spanning from Fort Chipewyan in the north to the Cold Lake area in the south. Air quality predictions were made using the CALPUFF dispersion model, run in the 3-D mode. Specific roles on the project included: providing overall direction to the air quality components; liaison with clients, regulators and stakeholders; and participation in project workshops.



**Suncor Energy Inc., Oil
Sands - Project
Millennium**
Fort McMurray, Alberta,
Canada

As part of the environmental impact assessment (EIA) and application for the Project Millennium expansion, Golder was responsible for the preparation of a comprehensive air quality assessment. The air assessment evaluated local and regional concentrations of selected compounds of concern, and evaluated acidic deposition impacts across the region. After the submission of the EIA, the bulk of the work involved the preparation of responses to supplemental requests from outside agencies. Interaction with local stakeholders and the communication of the assessment results was essential in the months prior to the hearings. Finally, the work required the participation in the project hearings as an expert witness on the environmental panel.

**Suncor Energy Inc. -
Firebag In-Situ Oil
Sands Project**
Fort McMurray, Alberta,
Canada

Golder was responsible for the completion of the environmental impact assessment (EIA) and application to develop a Steam-Assisted Gravity Drainage (SAGD) project in the Athabasca Oil Sands Region. The project EIA included the evaluation of community and regional concentrations and regional acid deposition from cumulative activities in the area. The Firebag Project EIA represented the first application to use the CALPUFF 3-D dispersion model for simulating concentrations and acid deposition patterns. Specific roles on the project included overall directions of the air and noise sections: liaison with regulators and the engineering design teams, responding to supplemental information requests and participating in regulatory workshop. A key component for the success of the project was addressing specific regulatory and stakeholder concerns early assessment process through consultation and project workshops.

**Suncor Energy Inc. -
Firebag Amendments**
Fort McMurray, Alberta,
Canada

Prepared amendment applications and an air quality assessment for a series of approval amendments at the Firebag SAGD Project and the Firebag ETS Project. The air quality assessment completed for the amendments evaluated local and regional concentrations of sulphur dioxide, nitrogen dioxide, particulate matter, secondary particulates, carbon monoxide, reduced sulphurs, volatile organic compounds, trace metals and polycyclic aromatic hydrocarbons using the 3-D CALPUFF model. Specific roles on the project included overall directions of the air work: liaison with regulators and the engineering design teams and responding to supplemental information requests.

**Suncor Energy Inc -
Suncor South Tailings
Ponds**
Fort McMurray, Alberta,
Canada

Golder was responsible for the completion of the recent environmental impact assessment (EIA) of the Suncor South Tailings Pond Project for Suncor Energy Inc. As part of the EIA, Golder was responsible for the completion of the air quality components of the project. The air quality assessment evaluated air concentrations of volatile organic compounds and total reduced sulphur compounds resulting from cumulative emissions sources across the Oil Sands Region. Air quality predictions were made using the CALPUFF dispersion model, run in the 3-D mode. Specific roles and responsibilities on the project included overall directions of the air and noise sections: liaison with regulators and the engineering design teams, responding to supplemental information requests and participating in regulatory workshop.



**Suncor Energy Inc. -
Millennium Coker Unit
Assessment**
Fort McMurray, Alberta,
Canada

Golder was retained by Suncor Energy Inc. to aid in the preparation of the application for construction and operation of the Millennium Coker Unit (MCU) Project. The air quality component of this application involved the quantification of SO₂ and NO_x emissions from the proposed Project. A dispersion modelling assessment of SO₂ emissions was performed using the CALPUFF model run in dynamic (3-D) mode. The assessment considered normal operations and two flaring scenarios. Results of the assessment were discussed in comparison with air quality criteria and in terms of likelihood of occurrence. Responsibilities included providing regulatory and strategic guidance, direction of the air components of the project and providing senior technical review of the modelling and reporting.

**Syncrude Canada Ltd.
- Approval Amendment**
Fort McMurray, Alberta,
Canada

As part of the ongoing modifications and design considerations at the Syncrude Mildred Lake upgrader facility, Golder Associates was retained to provide an assessment of the Syncrude Emissions Reduction Project. This assessment involved modelling a variety of emission scenarios to determine the benefits associated with the installation of a Flue Gas Desulphurization (FGD) system. While the assessment focused on changes to ground-level SO₂ and Potential Acid Input (PAI), consideration was also given to how the project could affect the levels of trace air compounds in regional communities. Specific roles on the project included overall directions of the air work: liaison with client and engineering design teams and responding to supplemental information requests.

**Syncrude Canada Ltd.
- Episodic Modelling**
Fort McMurray, Alberta,
Canada

An air quality dispersion modelling assessment was conducted to evaluate the impact of upset emissions from the Syncrude Mildred Lake facility near Fort McMurray, Alberta. The project involved modelling variable hourly emissions data from sources in the region using the CALPUFF dispersion model to evaluate the effects of facility emissions during coincident with selected upset events at the facility. In addition, meteorological conditions during a brief period of high hydrogen sulphide concentrations were evaluated to determine potential impacts as well as the contribution of each source to the observed concentrations. The specific roles on the project included overall directions of the air work: liaison with client and liaison with the engineering teams.

PROJECT EXPERIENCE – MINING

**Amok Resource Ltd. -
Cluff Lake Mine
Ventilation Study**
Northwestern
Saskatchewan, Canada

Participated in the analysis and calibration of a mine ventilation model designed to provide estimates of Radon and Radon-Daughter concentrations within active uranium mine. The model was calibrated using measurements taken within the underground mine at Cluff Lake, Saskatchewan. The results of the on-site measurements were compared to the model predictions to confirm the accuracy of the model.



**Barrick Peru (Minera
Barrick Misquichilca) -
Alto Chicama Gold
Mine EIA
NW Peru**

Golder was retained by Barrick to complete an environmental assessment of the proposed Alto Chicama Gold Project in Peru. The air assessment used the CALPUFF dispersion model was used to determine ground-level concentrations of criteria compounds that were then compared with Peruvian and World Bank criteria. As part of the air assessment, emissions from mining equipment, stationary sources, on-site fugitive dust and dust from the access road were all considered. Specific roles included senior technical review and helping respond to supplemental information requests.

**Barrick Gold - Buzwagi
Gold Mine EIA
Tanzania, Africa**

Golder was retained by Barrick to complete an environmental assessment of the proposed Buzwagi Gold Project in Tanzania, Africa. The integrated environmental assessment presented a comprehensive evaluation of project impacts on the physical, biological and human elements of the environment. The assessment was conducted in accordance with Tanzanian, World Bank and International Finance Committee Guidance, and demonstrated compliance with local and international standards. Specific roles included overall direction and senior technical review of the atmospheric assessment (i.e., air and noise). In addition, was responsible for working with the client management team to complete the overall environmental assessment in preparation for delivery to the Tanzanian authorities.

**BC Ministry of Energy
Mines and Petroleum
Resources - Gravel Pit
Reclamation Manual
British Columbia,
Canada**

Prepared the sections of the BC Gravel Pit Reclamation Manual dealing with the mitigation and control of air quality impacts; specifically, fugitive dust releases. Manual included a series of practical solutions that can be used by gravel pit operators to minimize the environmental impacts from the operation and reclamation of gravel pits in British Columbia.

**Cadomin
Environmental
Coalition - Air and
Noise Review of
Cardinal River Coal
Cadomin, Alberta ,
Canada**

Provided an independent evaluation of the air quality assessment prepared in support of a proposed expansion to the Cardinal River Coal facility near Cadomin, Alberta. Work involved a review of the air quality components of the permit application documents and the recommendation of additional mitigation measures that could be adopted by Cardinal River Coals to minimize potential air quality impacts.

**DeBeers Canada
Mining Inc. - Snap Lake
Diamond Project EIA
Snap Lake, NWT,
Canada**

Golder was retained by DeBeers to help prepare a comprehensive EIA for a proposed diamond mine project located to the northeast of Yellowknife, NWT. The air quality assessment involved the evaluation and selection of dispersion models, quantification of the current and future air emissions for the construction, operation and closing phases of the project. Specific roles and responsibilities included providing the overall direction for the air sections, senior technical review, interaction and liaison with the engineering team, responding to supplemental information requests, participation in stakeholders' information sessions and participation in the technical hearing.



**DeBeers Canada
Mining Inc. - Snap Lake
Diamond Project Air
Monitoring**
Snap Lake, NWT,
Canada

Golder has been providing ongoing support to DeBeers Canada for applications to the Government of the Northwest Territories to construct and operate an underground diamond mine located to the northeast of Yellowknife, NWT. The scope of work for the air monitoring programs included equipment site selection, installing, maintaining and calibrating the equipment, as well as developing standard operating procedures for the collection of samples, and completing monitoring reports. Specific roles on the project included senior technical review, client and regulatory liaison.

**Diavik Diamond Mine -
Air Quality and Dust
EMS Components**
Northwest Territories,
Canada

Golder was responsible for preparing the facility Environmental Management System (EMS) for the operations of an open pit diamond mine in the Northwest Territories. The manual was designed to become part of the day-to-day operations at the mine to ensure that the environmental effects remain at acceptable levels. One component of the EMS dealt with managing the potential air quality and dust emissions from the project during the construction and operating phases of the development.

**K.J. Beamish Limited -
Air Quality
Assessment –
Campbell Quarry**
Cardin, Ontario, Canada

Completed a dust impact assessment of a proposed limestone quarry. The assessment, used successfully in an Ontario Municipal Board hearing, required the application of state-of-the-art techniques to predict and describe particulate dispersion in the atmosphere.

**Miramar Mining
Corporation - Ambient
Air Quality Monitoring**
Bathurst Inlet, Nunavut,
Canada

Miramar Mining Corporation is planning to develop the Doris North gold mine near Cambridge Bay, on Victoria Island in Nunavut. Golder was retained to provide background air quality and meteorological monitoring services in support of their permit application process. The program included a Hi-Volume sampler to measure airborne particulate levels and a meteorological monitoring program. Responsibilities included the overall direction of the air works and providing senior technical review.

**Miramar Mining
Corporation - Doris
North Gold Project EIS**
Bathurst Inlet, Nunavut,
Canada

Golder Associates prepared an air quality and noise assessment for the Miramar Doris North Gold Project located near Bathurst Inlet, Nunavut. The assessment was prepared to support the Environmental Impact Study for submission to the Nunavut Impact Review Board. Specific roles and responsibilities included providing the overall direction for the air and noise sections, senior technical review, and responding to supplemental information requests.

**Mobil Mining and
Minerals - Health Risk
Evaluation of the Use
of Phosphogypsum**
Houston, Texas, USA

Completed a study to determine possible health risks associated with the use of phosphogypsum as a construction aggregate material in the Houston, Texas area of the United States. Project used extensive atmospheric modelling to assess both on-site and off-site exposure pathways for users and maintenance personnel.



**Xstrata Nickel -
Kabanga Nickel Project**
Tanzania, Africa

Golder was retained by Xstrata to complete the environmental baseline monitoring and subsequent environmental assessment of the proposed Kabanga Nickel Project in Tanzania, Africa. The integrated environmental assessment presented a comprehensive evaluation of project impacts on the physical, biological and human elements of the environment. The assessment was conducted in accordance with Tanzanian, World Bank and International Finance Committee Guidance, and demonstrated compliance with local and international standards. Specific roles included overall direction and senior technical review of the atmospheric assessment (i.e., air and noise).

PROJECT EXPERIENCE – OIL & GAS DEVELOPMENTS

**Anadarko - Air Quality
Evaluation of the P-16
Well**
Fort Liard, NWT,
Canada

Conducted a well-test flaring assessment of the P-16 well near Ft. Liard, NWT. The project involved the estimation of emissions from the well during the testing period and a dispersion modelling assessment to determine the resulting ground-level SO₂ concentrations. The well was located in complex terrain and the dispersion modelling was completed using the ISCST3 model. As a result of the dispersion modelling results, a management plan was developed to determine the optimal conditions and timeframe within which the well test could proceed with minimal environmental impacts. Specific roles on the project included overall directions of the air work, liaison with the client and engineering design teams and liaison with regulators regarding the air components of the project.

**BC Star Partners
Limited - Stone Creek
Gas Processing
Facility**
Chetwynd, BC, Canada

Served as Project Manager and Principal Investigator for an air assessment of the SO₂ emissions from a continuous flare stack at the proposed facility near Chetwynd, British Columbia. Study was commissioned to re-model the facility emissions using the CTDMPPLUS dispersion model so as to more accurately assess the potential ground-level SO₂ concentrations. Modelling results showed that the concentrations predicted using CTDMPPLUS were significantly lower than those estimated using simplified models. Specific roles on the project included completing the dispersion modelling, liaison with the client and report preparation.

**Canadian Natural
Resources Limited - C-
31 Battery**
Cold Lake, Alberta,
Canada

Golder completed an air quality and noise assessment to address potential impacts resulting from the construction and operation of a gas dehydration facility in the NWT. Ground-level concentrations were predicted for normal operations, emergency flaring events and noise levels resulting from the facility were assessed and compared with EUB sound level limits. Greenhouse gas emissions were estimated and compared to national and provincial emissions. Finally, an impact assessment was completed on the residential effects of the project and the overall significance of each impact was discussed. Specific roles on the project included overall directions of the air work and liaison with the client and engineering teams.



**Chevron Canada
Resources - Air Quality
Evaluation of the K-29
Facility**
Fort Liard, NWT,
Canada

A well-test flaring assessment was completed for a proposed gas processing facility near Ft. Liard, NWT. The project involved the estimation of facility emissions and a dispersion modelling analysis of the SO₂ emissions from a flare. The site location was in very complex terrain and required the use of the CTSCREEN model to determine the necessary flare height that would result in no predicted concentrations in excess of the ambient SO₂ guidelines. Specific roles on the project included overall directions of the air work and liaison with the client and engineering teams.

**Chevron Canada
Limited - Dense Gas
Dispersion Modelling**
Vancouver, BC, Canada

Conducted a dispersion modelling analysis of the potential effects of heavier than air releases associated with operations at the Chevron Burnaby refinery and tank farm. The modelling made use of state-of-the-art modelling techniques that considered not only the effects of topography on the dispersion of the clouds, but also evaluated the likelihood of concern in the nearby residential areas. Specific roles on the project included overall management of the air modelling, liaison with the model developers and liaison with the client as well as report preparation.

**Consumers' Co-
operative Refineries
Ltd. - Regina Refinery
Expansion Project**
Regina, Saskatchewan,
Canada

An air quality impact assessment was completed for the proposed expansion of the Consumer's Co-op Refineries Ltd. (CCRL) refinery and upgrading complex located in Regina Saskatchewan. As part of the assessment Golder conducted a review of the existing monitoring data and completed dispersion modelling for the existing facility and the expanded facility. To complete the modelling both the ISCST3 and CALPUFF models were used. Specific roles on the project included overall directions of the air work and liaison with the client and engineering teams.

**Consumers' Co-
operative Refineries
Ltd. - Expansion Flare
Stack Modelling**
Regina, Saskatchewan,
Canada

Conducted dispersion modelling of three upset flaring scenarios for a proposed expansion at the Consumers Co-operative Refineries Ltd. facility in Regina. This work was a follow-up to air quality assessments of a proposed facility expansion in 1999 and 2000. Specific roles on the project included overall directions of the air work and liaison with the client and engineering teams.

**Marathon Energy
Limited - Slave Lake
Development**
Slave Lake, Alberta,
Canada

Performed an air quality impact assessment to evaluate the maximum ground level concentrations resulting from the expansion of the existing Slave Lake gas gathering system. Additionally, calculation of facility emissions and refined dispersion modelling for the proposed construction of a compressor station and processing facility were conducted. Specific roles on the project included overall directions of the air work, liaison with the client and engineering teams and report preparation.

**Marathon Energy
Limited - Twinning
Battery and Liege Gas
Plant**
Northeastern Alberta,
Canada

Golder was retained to complete a dispersion modelling assessment of the SO₂ and NO_x emissions from a pair of gas processing facilities in northeastern Alberta, as part of an application to amend the operating permits. The evaluations made use of the existing modelling analyses, and current regulatory guidance for such modelling, to determine the maximum ground-level concentrations adjacent to the sites. Specific roles on the project included overall directions of the air work, liaison with the client and engineering teams and report preparation.



**Paramount Resources
Limited - Assessment
of the East Liard
Development**
Fort Liard, NWT,
Canada

Golder conducted an air quality dispersion modelling assessment of the Liard East drilling and well evaluation program. This assessment was part of a comprehensive evaluation of the potential vegetation, wildlife and socio-economic impacts of the program. The assessment included the evaluation of gas compositions and emissions from the proposed well tests, as well as development of a meteorological data set, and the completion of refined dispersion modelling using ISCST3 to determine regional and local air pollutant concentrations. The assessment also provided an evaluation of the preferred options for dealing with gasses released during these well tests. Specific roles on the project included overall directions of the air work, liaison with the client and engineering design teams and liaison with regulators regarding the air components of the project.

**Paramount Resources
Limited - Assessment
of the Cameron Hills
Development Facilities**
Fort Liard, NWT,
Canada

The Cameron Hills project is a gas development that straddles the Alberta/NWT border. An air quality, noise and greenhouse gas evaluation was submitted to the government of the NWT and the National Energy Board (NEB) as part of a comprehensive EIA completed for the application process. The assessment included the preparation of a facility emissions inventory, development of a meteorological data set, and the completion of refined dispersion modelling to determine regional and local air pollutant concentrations. Specific roles on the project included overall directions of the air work, liaison with the client and engineering design teams and liaison with regulators regarding the air components of the project.

**Paramount Resources
Ltd. - Cameron Hills
Extension Project**
Fort Liard, NWT,
Canada

The Cameron Hills project is an oil and gas development that straddles the Alberta/NWT border. Golder Associates was retained to complete the Developer Assessment Report (DAR) for the project. The DAR included the assessment of additional gas wells and potential future development. The air quality assessment included the preparation of a facility emissions inventory and the completion of refined dispersion modelling to determine ground-level concentrations of specific criteria compounds. Specific roles on the project included overall directions of the air work, liaison with the client and engineering design teams, liaison with regulators regarding the air components of the project, senior technical review of the relevant report sections and participation in the Mackenzie Valley Environmental Assessment Review Board (MVEIRB) hearing regarding the project.

**Ranger Oil Limited -
Environmental
Assessment of the P-
66A Well**
Fort Liard, NWT

Golder was retained to evaluate the possible air quality and noise impacts associated with a gas dehydration facility located in the Liard river district of the NWT. The project presented unique challenges due to the complex terrain adjacent to the site. The results of the air modelling and emissions evaluation were incorporated into the facility designs to ensure that operations could proceed without adversely affecting the local air quality. Specific roles on the project included overall directions of the air work and liaison with the client and engineering teams.



**Plummers Road
Residents' Group -
Sour Gas Well —
Intervenor Review**
Southern Alberta,
Canada

Golder was retained to provide an independent review of a sour gas well planned for a rural community near Millarville, Alberta. The project focussed on reviewing the proponent reports and meeting with the local residents to explain the findings in clear concise language. The main purpose was to help the local residents understand the air quality implications of the planned well. Specific roles on the project included overall directions of the air work, liaison with the client team and participation in a public meeting in the community to describe and explain the previously completed air work to local residents.

**Westcoast Energy Inc.
- Pine River Gas Plant
– Phase I Expansion**
Chetwynd, BC, Canada

This environmental assessment was conducted to evaluate the potential impacts on air quality, water quality, waste disposal, vegetation and wildlife of the plant expansion. The air dispersion modelling was completed using both the RTDM and CTSCREEN dispersion models and focused on evaluating ground-level SO₂ concentrations in the hills surrounding the plant. Specific roles on the project included overall directions of the air work, liaison with the client and engineering teams and report preparation. The final EIA report was successfully submitted to the National Energy Board for approval.

**Westcoast Energy Inc.
- Pine River Gas Plant
– Meteorological
Monitoring**
Chetwynd, BC, Canada

An advanced meteorological monitoring station was installed and operated at the Pine River gas plant, near Chetwynd, BC. The project necessitated the development of system specifications for a meteorological monitoring station capable of collecting on-site readings needed to run the CTDMPLUS dispersion model. Harsh climatic conditions and remote location of the site presented unique problems, previously not encountered in projects of this type. An exceptionally high data capture rate was achieved by developing rigorous protocols for remote site interrogation and on-site inspection. Specific roles on the project included the development of tender documents, participation in the selection and commissioning of the system, ongoing system maintenance as well as the synthesis and reporting of the collected data.

**Westcoast Energy Inc.
- Pine River Gas Plant
– Modelling and
Assessment of SO₂**
Chetwynd, BC, Canada

Served as Project Manager and Principal Investigator for an advanced air quality assessment of the SO₂ emissions from the proposed plant expansion. Study made use of site-specific meteorological data and the CTDMPLUS dispersion model to provide a refined assessment of the air quality impacts likely on terrain above the stack elevation. Study results were utilized to support the permit application for the plant.

**Westcoast Energy Inc.
- Pine River Gas Plant
– Phase II Expansion**
Chetwynd, BC, Canada

Completed an extensive assessment of the continuous and flaring emissions from the proposed plant expansion. Study made use of site-specific meteorological data and the CTDMPLUS dispersion model to provide a refined assessment of the air quality impacts likely on terrain above the stack elevation. This U.S. EPA model has advantages over the typical models applied as it accounts more accurately for the manner in which pollutants interact with hills. An assessment of flaring emissions made use of a sophisticated statistical approach to ascertain the likelihood that high ground-level concentrations would occur. Study results were utilized to refine the proposed plant design in order to minimize the potential air quality impacts. Specific roles on the project included overall management of the air modelling work, as well as the preparation of the air sections of the report.



Westcoast Energy Inc.
- Pine River Gas Plant
– SO2 Monitoring
Framework
Chetwynd, BC , Canada

This study helped established a monitoring framework to evaluate the potential vegetation impacts resulting from continuous stack and intermittent flaring emissions of SO₂ from the proposed expansion to the Pine River Gas Plant. Study made extensive use of site-specific meteorological data and refined dispersion modelling techniques to identify those areas most likely to be at risk from plant emissions. Specific roles on the project included the management of the air work, as well as the preparation of the final report.

Westcoast Energy Inc.
- Grizzly Valley
Expansion
Northeastern BC,
Canada

A detailed assessment covered the impacts on air quality, water quality, waste disposal, vegetation and wildlife of the planned expansion of a sour gas processing capabilities for the Grizzly Valley gas basin. Study's key element was the evaluation of a proposed expansion to the Pine River gas plant near Chetwynd, British Columbia. Included the use of state-of-the-art atmospheric dispersion models and site-specific meteorology to evaluate the potential for impacts from the plant emissions on the surrounding terrain. An application for the project was submitted to the National Energy Board for consideration. Specific roles on the project included the management of the air components, the completion of the dispersion modelling and the preparation of the air sections of the EIA.

Westcoast Energy Inc.
- Proposed Tumbler
Ridge Gas Plant
Tumbler Ridge, BC,
Canada

Was responsible for the air quality components of a detailed environmental assessment evaluating potential impacts on air quality, water quality, waste disposal, vegetation and wildlife of the planned construction and operation of a new sour gas processing plant near Tumbler Ridge, British Columbia. As part of the project, an advanced meteorological monitoring station was installed and operated in the vicinity of the proposed facility to the south of Tumbler Ridge. Specific roles on the project included the management of the air components, the completion of the dispersion modelling, the preparation of the air sections of the EIA, participation in the selection and commissioning of the meteorological system, along with performing the ongoing maintenance of the system and synthesizing and reporting of the collected data.

Westcoast Energy Inc.
- McMahon Gas Plant –
Meteorological
Monitoring
Taylor, BC, Canada

An advanced meteorological monitoring station was installed in the vicinity of the McMahon gas processing facility in Taylor, British Columbia, based on the unprecedented success of the meteorological monitoring programs at the Pine River gas plant near Tumbler Ridge. Detailed site specifications and operation protocols were prepared to ensure that the quantity and quality of data from the station was comparable with the other site operated for Westcoast Energy. Specific roles on the project included the development of tender documents, participation in the selection and commissioning of the system, ongoing system maintenance as well as the synthesis and reporting of the collected data.

Westcoast Energy Inc.
- McMahon Gas Plant
Dispersion Modelling
Taylor, BC, Canada

Served as Project Manager and Principal Investigator for a detailed evaluation of the SO₂ impacts on the complex terrain surrounding the sour gas processing facility in Taylor, BC. Had overall responsibility for the provision of the air quality modelling services, including the reporting and liaison with regulators. The study was notable in its successful use of sophisticated meteorological data gathered in the community as inputs to the CTDMPLUS dispersion model. Specific project roles included the overall management, participation in the data preparation and dispersion modelling, the preparation of the final report as well as liaison with the client team and regulators regarding the assessment.



**Westcoast Energy Inc.
- Community of Taylor
– Cumulative NOX
Modelling**
Taylor, BC , Canada

This cumulative evaluation of the NOx emissions in the community of Taylor considered combined impacts of the industrial, residential and motor vehicle emissions on the air quality in the community. Dispersion modelling was done using a combination of the CTDMPLUS and ISC3 dispersion models. Chemical transformations of the emitted pollutants were done using both deterministic and probabilistic methods. The modelling results were then compared to local observed concentrations to confirm consistency and applicability of the methods used. Specific project roles included the overall management, participation in the data preparation and dispersion modelling, the preparation of the final report as well as liaison with the client team and regulators regarding the assessment.

**Westcoast Energy Inc.
- New Aitken Creek
Gas Plant – EIA**
Northeastern BC,
Canada

This assessment covered the impacts on air quality, water quality, waste disposal, vegetation and wildlife of the proposed gas plant. Report was submitted to the National Energy Board for approval; however, the final decision on the project is pending a jurisdictional decision from the Supreme Court of Canada. Specific roles on the project included the management of the air components, the completion of the dispersion modelling and the preparation of the air sections of the EIA.

PROJECT EXPERIENCE – PIPELINES

**BC Star Partners
Limited - Rigel Booster
Station – Air Modelling**
Northeastern BC,
Canada

An air quality modelling evaluation of the combined emissions from two natural gas booster stations located in northeastern British Columbia. Maximum ground-level concentrations in the vicinity of the facility were determined using screening modelling techniques. Study results were used in support of air quality permits for the site. Specific roles on the project included the overall management, client liaison, completion of the dispersion modelling and preparation of the final report.

**CEMIG - Pipeline
Consequence Analysis**
Brazil

Participated in the analysis of possible pipeline failures in residential areas of Brazil using a combination of consequence models with local meteorological conditions to determine the likelihood of risk to people living in the area. Specific roles on the project included the development of assessment scenarios, senior technical review, participation in the release modelling and preparation of the final report.

**Mackenzie Gas Project
- Environmental Impact
Assessment**
Northwest Territories,
Canada

Golder participated as a member of the consortium responsible for the development of the Environmental Impact Assessment of the Project. The air quality assessment included the completion of baseline monitoring, the determination of project emissions, the evaluation of possible air quality impacts as well as an evaluation of potential effects related to climate change. Specific roles on the project include senior technical, responsibility for the preparation of the air quality components of the EIA as well as participation in public meetings and workshops held to communicate project findings to stakeholders and solicit input from effected parties.



**Paramount Resources
- Sheha Pipeline**
Fort Liard, NWT,
Canada

Golder was responsible for completing the environmental assessment of the Sheha production field and associated pipeline infrastructure for Paramount Resources. Due to the location of the project, the development required approval from the federal, territorial and British Columbia regulators. Specific roles on the project included overall responsibility for the air and noise sections of the assessment, coordination of the modelling assessment, preparation of the air and noise sections of the assessment as well as responding to supplemental information requests and regulatory input.

**TransGas Inc. -
Pipeline Consequence
Analysis**
Saskatoon,
Saskatchewan, Canada

Analysis to determine the extent of flammable clouds and heat risks resulting from a pipeline failure was conducted in a mixed rural- residential area of Saskatoon. The study combined the results of consequence models with local meteorological conditions to determine the likelihood of risk to people living in the area. Specific roles on the project included the development of assessment scenarios, senior technical review, participation in the release modelling and preparation of the final report.

**Transredes S.A. -
Yabog South Gas
Pipeline EIA**
Bolivia

The project involves the preparation of an Environmental and Socio-economic Impact Assessment of expanding (looping) an existing 440 km gas pipeline between Rio Grande (Bolivia) and the Argentinean border. The EIA was completed to Bolivian National requirements as well as the supporting financial institutions. Specific responsibilities included completing a screening level evaluation of the potential air and noise impacts associated with the project construction and operations.

**Westcoast Energy Inc.
- Australian and
Bubbles Compressor
Stations**
Merritt, BC, Canada

Served as Project Manager and Principal Investigator for an air quality evaluation of NOx emissions from the main-line compressor stations in the vicinity of Merritt, British Columbia. The study made use of statistical modelling techniques to determine those areas most likely to experience elevated NOx and NO2 concentrations in the complex terrain around the stations. Specific roles on the project included the overall management, participation in the dispersion modelling and preparation of the final report.

**Westcoast Energy Inc.
- Beg Booster Station**
Northeastern BC,
Canada

An air quality modelling evaluation of the emissions from a gas booster stations located in north-eastern British Columbia. Maximum ground-level concentrations in the vicinity of the facility were determined using screening modelling techniques, and used to support the application for air permits at the site. The specific roles on the project included the overall management, participation in the dispersion modelling and preparation of the final report.

**Westcoast Energy Inc.
- CS-1 Compressor
Station Modelling**
Taylor, BC, Canada

Served as Project Manager and Principal Investigator for an air quality evaluation of expected continuous NOx emissions from the main-line natural gas compressor station in Taylor, BC. Study was commissioned to respond to information requested from the National Energy Board and made use of statistical modelling techniques to determine those areas most likely to experience elevated NOx and NO2 concentrations. Specific roles on the project included the overall management, participation in the dispersion modelling and preparation of the final report.



**Westcoast Energy Inc.
- Jedney Booster
Station**
Northeastern BC,
Canada

An air quality evaluation of the emissions from a natural gas booster station in northeastern British Columbia using screening modelling techniques. Study results were used in support of air quality permits for the site. Specific roles on the project included the overall management, participation in the dispersion modelling and preparation of the final report.

**Westcoast
Transmission Inc. -
Mainline Compressor
Emission Modelling**
Northeastern BC.,
Canada

Conducted an evaluation of the potential air quality impacts due to continuous NOx emissions from a series of five main-line natural gas compressor stations located in the Pine and Fraser river valleys in northern British Columbia. Consideration was given to both the simple and complex terrain modelling at each facility, depending on the local topography. Specific roles on the project included the overall management, participation in the dispersion modelling and preparation of the final report.

**Westcoast Energy Inc.
- Nig Booster Station**
Northeastern BC,
Canada

An air quality modelling evaluation of the emissions from a natural gas booster station in north-eastern British Columbia. The maximum ground-level concentrations were determined using screening modelling techniques and the results used in support air permitting for the site. Specific roles on the project included the overall management, participation in the dispersion modelling and preparation of the final report.

PROJECT EXPERIENCE – POWER UTILITIES

**Bruce Power – Bruce A
Refurbishment for Life
Extension and
Continued Operations**
Kincardine, Ontario,
Canada

Golder was retained to complete the environmental assessment of the refurbishment and restart of units at the Bruce A nuclear generating station and the potential use of new fuel consisting of slightly enriched uranium in the reactors. The environmental assessment study report was completed in December 2005 and the project was approved following a public hearing in spring 2006. The reactors are expected to commence operation in 2009. Specific roles included overall direction and senior technical review of the atmospheric assessment (i.e., air and noise).

**Bruce Power -
Nanticoke New Build
Project**
Nanticoke, Ontario,
Canada

Golder was retained to complete the environmental assessment of the proposed 3,000 MW nuclear power plant near Nanticoke, Ontario. The environmental assessment is being completed under the Canadian Environmental Assessment Act as a panel review EA. Specific roles included overall direction and senior technical review of the atmospheric assessment (i.e., air and noise). This application was withdrawn by the proponent prior to filing.

**Bruce Power – New
Nuclear Power Project**
Kincardine, Ontario,
Canada

Golder was retained to complete the environmental assessment of Canada's first new reactors in a generation. In September 2006, Bruce Power announced its intention to proceed with planning for 4,000 MW of new nuclear power at the Bruce site. The project involves consideration of up to four Generation III+ reactors in addition to the enhanced CANDU 6. The 30-month environmental assessment study is expected to be subject to a panel review. Specific roles included overall direction and senior technical review of the atmospheric assessment (i.e., air and noise), as well as responding to regulatory supplemental questions. This project was withdrawn by the proponent prior to panel hearing.



**Canadian Niagara
Power Inc. - Table
Rock Hydro Plant –
Compliance Review**
Niagara Falls, Ontario

Reviewed of the compliance with environmental regulations at the Canadian Niagara facilities in Niagara Falls. The bulk of the operations in Niagara Falls were built in the early part of the century and required the preparation of detailed compliance plans to assist the company in prioritizing the remedial measures that were required at the facility.

**EPCOR - Genessee
Expansion Project**
Wabamun, Alberta

Golder Associates were retained by EPCOR to assist them in the planning and development of the proposed expansion to the Genessee coal fired power plant to the west of Edmonton. Project responsibilities included the preparation of briefing and position papers on potential environmental issues and participation in strategic planning sessions with the project and engineering teams. Specific roles included the provision of strategic advice with respect to potential air issues associated with the planned development.

**Invenergy –
Environmental
Assessment**
Sarnia, Ontario, Canada

Golder was retained by Invenergy to complete an environmental assessment of a 570 MW natural gas-fired, combined cycle electricity generation facility under O. Reg. 116/01. The assessment focussed on air quality and related human health issues and the development of an extensive public engagement program to convey project information to the public. Specific roles included overall direction and senior technical review of the atmospheric assessment (i.e., air and noise).

**Liberty Energy –
Environmental
Assessment of
Biosolids Power Plant**
Hamilton, Ontario,
Canada

Golder was retained to complete the environmental assessment for a 10 MW biosolid/biomass fired power plant in Hamilton, Ontario. The environmental assessment was carried out under the Electricity Project Regulation in Ontario. Specific roles included technical oversight of the assessment, working with the client team to respond to elevation request by stakeholders, and compiling technical responses and additional information for submission to the Minister to facilitate the decision making process.

**Manitoba Hydro -
Selkirk and Brandon
Generating Stations –
Life Extension**
Manitoba

This study focused on evaluating the environmental impacts associated with extending the operating life of two thermal generating stations. Specialized technical input was provided for the evaluation of impacts from the emissions of standard air pollutants, as well as the evaluation of air quality and visibility impacts from cooling towers. Specific roles on the project participation in the dispersion modelling and providing input to the report.

**Northland Power –
Royal Windsor Energy
Centre**
Mississauga, Ontario,
Canada

Golder was retained by Northland Power to complete an environmental assessment of an 850 MW natural gas electricity generation facility under O. Reg. 116/01. The assessment focussed on air quality and related human health issues and the development of an extensive public engagement program to convey project information to the public. Specific roles included overall direction and senior technical review of the atmospheric assessment (i.e., air and noise).



**Northwest Territories
Power - Air Quality
Evaluation**
Northwest Territories,
Canada

Golder completed an air quality assessment of 21 power generating stations in the Northwest Territories was completed for Northwest Territories Power Corporation (NTPC). The work involved a preliminary screening of all sites, followed up by detailed evaluation of sites with possible health risks, as identified in the screening analysis. The detailed evaluation involved refined emissions calculations and dispersion modelling to predict ground-level impacts of selected compounds. Specific roles on the project included the provision of senior technical input as well as senior review.

**Northwest Territories
Power - Deline Station
Air Modelling**
Yellowknife, NWT,
Canada

Golder conducted a stack height assessment for the Northwest Territories Power Corporation (NTPC) Deline power generating station. The purpose of this assessment was to quantify the benefits of increased stack heights on the predicted ground-level concentrations of air quality parameters in the vicinity of the site. Specific roles on the project included the provision of senior technical input as well as senior review.

**Ontario Power
Generation (Managed
by Nuclear Waste
Management Office) –
Deep Geologic
Repository Project**
Kincardine, Ontario,
Canada

Golder was retained by Ontario Power Generation (OPG) to complete the environmental assessment of a deep geological repository for low and intermediate level wastes. The facility is scheduled to be the first repository in Canada and is designed to accept wastes from Ontario's 20 nuclear reactors. This project is now being managed by the Nuclear Wastes Management Office (NWMO) on behalf of OPG. Responsible for the overall direction, supervision and technical quality for the project, as well as fulfilling the specific role as the contract Project Manager.

**Sithe Global – Sluse
Road Peaking Station**
East Gwillimbury,
Ontario, Canada

Golder was retained by Sithe Global to complete an environmental assessment of a 350 MW natural gas peaking generation facility under O.Reg. 116/01. The assessment focussed on air quality and related human health issues and the development of an extensive public engagement program to convey project information to the public. Specific roles included overall direction and senior technical review of the atmospheric assessment (i.e., air and noise).

**TransAlta Utilities
Limited - Wabamun
Thermal Station – Life
Extension**
Wabamun, Alberta ,
Canada

Golder Associates participated in the review of ways to extend the life of the Lake Wabamun Power Plant in central Alberta. The Wabamun facility is a mine-mouth coal fired generating station that started operations nearly 30 years ago. The study involved a comprehensive evaluation of air quality in the region, with a focus on identifying the key contributors to the local ground level concentrations of airborne particulate matter. A key source of emissions was the contribution from mobile sources. The project also involved participation with a multi-stakeholder group of concerned parties to address the possible concerns associated with the facility. Specific roles on the project included the management of the air components, provision of senior technical input as well as the preparation of the report.



PROJECT EXPERIENCE – FOREST PRODUCTS INDUSTRIES

**Canadian Pulp & Paper
Association -
Dispersion Modelling
of PM10 and PM2.5
Canada**

Conducted a series of dispersion modelling analyses on the PM10 and PM2.5 emissions from two Kraft pulp mills in western Canada as part of an evaluation of the implications of the proposed Canada-Wide standards for fine particulate matter. Specific roles on the project included the overall management, provision of senior technical input, liaison with the client and facilities, input and participation in the modelling as well as the preparation of the report. At the conclusion of the analysis, a brief presentation was made to the members of the CPPA sub-committee dealing with the implications of the regulations on the Canadian pulp and paper industry.

**CANPAR Industries -
Dispersion Modelling
Grand Forks, BC,
Canada**

An air quality modelling evaluation of the formaldehyde emissions from a forest products facility in Grand Forks, British Columbia. Screening dispersion modelling of the facility emissions was performed to determine the maximum ground-level concentrations in both simple and complex terrain. Modelling results were utilized to support a provision air permit application for the facility. Specific roles on the project included the overall management, completion of the modelling and analysis as well as report preparation.

**Enderby Forest
Products - Emissions
Monitoring and
Evaluation
Enderby, BC, Canada**

Involved in the design and implementation of a testing program to determine the atmospheric emissions that would result from the addition of waste paint into a wood waste gasifier at a sawmill in central British Columbia. The results of the emission tests were incorporated into dispersion models to establish the possible exposures to residents that live near the facility. Specific roles included the overall management, input into the development of test and evaluation protocols, provision of senior technical advice as well as the preparation of the report.

**Footner Forest
Products - Project
Screening
High Level, Alberta,
Canada**

Golder were retained to assist Footner Forest Products in preparing a project screening and project proposal report for a planned oriented strand-board (OSB) facility in High Level, Alberta. Specific roles included the management of the air components, completion of a screening evaluation of potential air issues, preparation of the relevant sections of the report and participation in a local workshop to answer questions from local residents and stakeholders.

**Louisiana Pacific
Canada Limited -
Ambient Air Monitoring
Swan Valley, Manitoba,
Canada**

This ambient monitoring program was part of the permitting requirements for an OSB facility in west central Manitoba. The project included the operation and maintenance of air quality and meteorological measurements gathered at two stations. Responsibilities included the distillation of the data and preparation of extensive monitoring reports which were submitted to the local regulators. The project also required participation in air quality guideline workshops with regulatory agencies trying to establish air guidelines for formaldehyde. Specific roles on the project included overall management, provision of senior technical input, report preparation, as well as liaison with the client team and regulators.



PROJECT EXPERIENCE – AGRICULTURE AND FEED INDUSTRIES

**Alberta Agriculture,
Food and Rural
Development (AAFRD)
- Environmental
Assessment of
Intensive Agriculture**
Alberta, Canada

Participated in the assessment of potential environmental effects of increasing the levels of intensive agricultural activity in the province of Alberta. Specific responsibilities included the development of simplified evaluation methods to determine the relative impacts on air quality from several provincial growth scenarios.

**Checkerboard Foods
Limited - Noise
Assessment and
Odour Assessment of
a Processing Facility**
Newmarket, Ontario,
Canada

A noise and odour assessment was conducted on an operating processing facility in a residential area of Newmarket Ontario. Originally located in an industrial area, residential expansion has resulted in homes being located adjacent to the facility. In response to numerous complaints from the residents, the client commissioned the assessment aimed at identifying remedial measures that would allow for continued operations and minimal impacts on nearby residents. Specific responsibilities included on-site monitoring as well as developing mitigation plans aimed at reducing noise impacts on neighbouring homes.

**MSA Terminals Limited
-Dust and Odour
Evaluation of a
Feedmill**
Abbotsford, BC, Canada

The MSA terminals facility is located in the heart of Abbotsford in close proximity to residential homes. Despite efforts from the facility operators to address the air quality concerns, a confrontational situation had developed with several neighbours. Responsibilities on the project included: visiting the most concerned residents in their homes; identifying the key concerns of the residents; explaining and communicating the actions taken by the operator; developing an engineering report; and recommending a mitigation plan. The planned mitigation would have involved input from residents, government and the operator.

**Pacific Bio-Waste
Recovery Society -
Odour Evaluation of a
Fish Composting
Facility**
Campbell River, BC

Conducted an odour evaluation of a fish composting facility to be operated in Campbell River, BC. Responsibilities included the determination of the likely odour emissions, off-site odour impacts and optimal mitigation techniques. Specific responsibilities included overall management, development of projected emissions, dispersion modelling to determine potential effects and report preparation. An expert deposition was also provided as part of an environmental appeal board hearing called in response to opposition from residents regarding the approval granted to the project.

**Ralston Purina Canada
- Noise Assessment of
the Woodstock Feed
Mill**
Woodstock, Ontario,
Canada

Conducted noise assessments of a feed mill located in Addison, Ontario. A mitigation program was developed with input from the plant personnel, local residents and a series of on-site noise measurements to ameliorate the off-site noise impacts. Specific responsibilities included on-site monitoring, liaison with regulators, plant personnel and local residents, the development of mitigation plans and project reporting.

**Ralston Purina Canada
- Noise Assessment of
the Woodstock and
Addison Feed Mills**
Woodstock, Ontario,
Canada

Conducted noise assessments of a feed mill located in heart of Woodstock, Ontario. A mitigation program was developed with input from the plant personnel, local residents and a series of on-site noise measurements to ameliorate the off-site noise impacts. Specific responsibilities included on-site monitoring, liaison with regulators, plant personnel and local residents, the development of mitigation plans and project reporting.



PROJECT EXPERIENCE – INDUSTRIAL CLIENTS

**Bombardier Inc. -
Comprehensive
Certificate of Approval
(Air) Preparation**
Downsview, Ontario,
Canada

Performed comprehensive emissions inventory and dispersion modelling of aerospace manufacturing facility in Downsview, Ontario in support of permit in accordance with requirements of Ontario Ministry of Environment (MOE). Specific roles on the project included providing senior technical input regarding the dispersion modelling.

**Campion Marine -
Dispersion Modelling
of Industrial Odours**
Kelowna, BC, Canada

Screening dispersion modelling was performed to determine the potential ground-level concentrations of styrene resulting from the venting emissions from a fibreglass boat manufacturer in Kelowna, British Columbia. Study made use of screening dispersion modelling techniques to determine the maximum and peak ground-level concentrations of styrene in the surrounding areas. Specific roles on the project included the overall management, regulatory and client liaison, completion of the modelling and analysis as well as report preparation.

**Diapac Industries -
Dispersion Modelling
and Permitting**
Squamish, BC, Canada

An air quality modelling assessment of industrial emissions from a plastics manufacturer in Squamish, British Columbia. Study utilized screening dispersion modelling techniques to determine the maximum off-site concentrations in support of an air permit applications. Consideration was given to the simple and complex terrain in the vicinity of the plant. Specific roles on the project included the overall management, completion of the modelling, regulatory liaison and analysis as well as report preparation.

**Ebco-Hamilton
Partners -Dispersion
Modelling**
Burnaby, BC

Conducted a screening dispersion modelling analysis of the air quality concerns associated with the operation of an AirCare testing facility in a mixed residential/institutional area of Burnaby. The AirCare vehicle-monitoring program requires annual exhaust testing for all light duty vehicles operating in the Lower Fraser Valley. The possible air quality impacts of the vehicles queuing up at the testing facilities were assessed using screening dispersion modelling techniques to determine the maximum off-site concentrations. Specific roles on the project included the overall management, completion of the modelling, client and regulatory liaison and analysis as well as report preparation.

**GWIL Industries -
Dispersion Modelling**
Winfield, BC, Canada

An air quality modelling assessment of styrene emissions from an industrial incinerator located in Winfield, British Columbia. Study utilized screening dispersion modelling techniques to determine the maximum off-site concentrations in the simple and complex terrain located in the vicinity of the plant. The modelling results were used to support the provincial air permit application for the plant. Specific roles on the project included the overall management, completion of the modelling and analysis as well as report preparation.

**ITT Aimco Corporation
- Fugitive Dust
Assessment**
St. Catharines, Ontario

Project evaluated the fugitive dust emissions from a ferrous metal foundry in St. Catharines, Ontario. Study involved a series of air monitoring stations and the development of a phased mitigation program to minimize off-site impact. Specific roles on the project included the overall management, public and regulatory liaison, participation in public meetings and the development of staged mitigation plans.



**Kelowna Industrial
Plastics -Dispersion
Modelling and Odour
Evaluation**
Kelowna, BC, Canada

Screening dispersion modelling was performed to determine the potential ground-level concentrations of styrene resulting from the venting emissions from a fibreglass reinforced plastics fabrication facility in Kelowna, British Columbia. Specific roles on the project included the overall management, completion of the modelling and analysis as well as report preparation.

**Lafarge Construction
Materials Limited -
Ambient Air Quality
Monitoring**
Calgary, Alberta,
Canada

Provided consulting services to Lafarge regarding a proposed gravel pit east of Calgary, Alberta. Work included preparation of a monitoring plan and guidance to Lafarge on placement options for a particulate and meteorological monitoring system in the vicinity of the proposed operation. Specific roles on the project included providing senior technical review and direction.

**Lehigh Inland Cement
Limited - Substitution
Fuel Project**
Edmonton, Alberta,
Canada

Golder Associates were retained to prepare the Environmental Protection and Enhancement Act (EPEA) application for the proposed conversion of the Lehigh Inland Cement facility in Edmonton to allow the use of coal as a primary fuel. The project involved a detailed review of the facility emissions and resulting off-site concentrations, and evaluation of current operations, recommendations for future mitigation. Specific roles included the management of the air components, regulatory and client liaison, senior technical input and direction, preparation of the report and responding to supplemental information requests.

**Shield Source -
Assessment and
Environmental
Monitoring Program**
Peterborough, Ontario,
Canada

An air quality assessment was completed to determine derived release limits (DRLs) for tritium at a facility that makes tritium-illuminated signs. Air dispersion models were used to derive concentrations and aerial deposition rates for tritium from the site, and an environmental pathway model was used to translate these concentrations and deposition rates into dose rates to critical receptors. Responsibilities included providing senior technical input and support to the project team and for the report preparation.

**Vancouver Port
Corporation - Vanterm
Computainer Facility –
Initial Air Quality
Evaluation**
Vancouver, BC, Canada

An evaluation of the likely air quality impacts due to the increased truck traffic and decreased on-site activity resulting from the proposed computainer facility at Vanterm site at the foot of Clark Street. Study incorporated an evaluation of changes in vehicle emissions using the most up to date techniques. Specific roles on the project included the overall management, completion of the modelling and analysis as well as report preparation.

PROJECT EXPERIENCE – GOVERNMENT AND INSTITUTIONAL

**Alberta Environment -
Provincial Waste
Incinerator Inventory
Project**
Alberta, Canada

A survey of existing waste incinerators across the province of Alberta was conducted. The project was used to characterise the number and operating parameters of existing incinerators and involved the development, distribution and analysis of results of a survey for multiple targeted sectors. Specific roles included the provision of senior technical support and direction.



**BC Ministry of
Environment Lands
and Parks - Mobile
Source Emissions
Inventory – Province of
British Columbia**
British Columbia,
Canada

Development of a mobile air emissions inventory for the province of British Columbia. As part of the project, it was necessary to develop up to date inventory techniques which coordinated the approaches used by the Federal and regional governments. Specific roles on the project included the development of refined base quantities, emission rates and temporal factors to help better represent the emissions from the transportation sector, as well as client liaison and report preparation.

**Canadian Association
of Petroleum
Producers (CAPP) -
Review of the Draft
NWT Code of Practice**
Northwest Territories,
Canada

Golder were retained by the Canadian Association of Petroleum Producers (CAPP) to complete a review of the draft Code of Practice for the Upstream Oil and Gas Industry produced by the Government of the Northwest Territories (GNWT). As part of the contract it was necessary to compare the draft guide with similar documents in Canada and North America, and to ensure that Code of Practice provides clear and relevant guidance that can be practically and safely applied. Roles included the management of the review and participation in a face-to-face meeting with representatives of the GNWT.

**Canadian Petroleum
Producers Institute -
Comparison of Urban
Ambient Air Quality**
Canada

An evaluation of the ambient air quality in a selected number of urban centres in Canada and the United States was performed on behalf of the Canadian Petroleum Producers Institute. The evaluation included a comparison of the monitored air quality against both Canadian and U.S. standards. Specific roles included the overall management, development of assessment techniques, preparation of the report and presentation of the findings in Ottawa.

**City of Toronto – 6
Lloyd Avenue Peer
Review**
Toronto, Ontario,
Canada

Golder was retained by the City of Toronto to complete a peer review of odour and noise studies submitted to the City with respect to the development of a mixed residential-commercial project on a former industrial site at 6 Lloyd Avenue in Toronto. Specific roles included the review of submissions by the project developer and opposing parties, the preparation of an independent peer review for consideration by the City in making their decision whether to approve or oppose the project. In addition, Golder provided ongoing support to City staff leading up to participation as an expert witness during the Ontario Municipal Board hearings.

**Greater Vancouver
Regional District -Air
Quality Management
Plan/Stage 2**
Vancouver, BC, Canada

Responsibilities included the review of current and proposed motor vehicle emission regulations in North America, as well as forecasting the likely emissions from mobile sources using the latest emissions modelling and forecasting methodologies. Specific roles included a review of the management options available to address mobile source emissions in the region and preparations of relevant report sections.

**Greater Vancouver
Regional District -
Backcast and Forecast
of the 1990 LFV
Emission Inventory**
Vancouver, BC, Canada

Motor vehicle emissions in the 1990 Lower Fraser Valley Emissions Inventory were used to estimate the emission levels in 1985, 1995, 2000 and 2005 using the most current emissions modelling and forecasting methodologies available. Specific roles included input on likely changes in emission rates and traffic activity with time.



PROJECT EXPERIENCE – TRANSPORTATION

**BC Ministry of
Transportation - Air
Quality Assessment –
West End of
Vancouver**
Vancouver, BC, Canada

This study made use of innovative field monitoring techniques and state-of-the-art models to evaluate the current status of the air quality in the West End of Vancouver. Unlike most ambient air quality monitoring programs, the measurements of the carbon monoxide levels along the roadways in the study area were made on a continuous basis in the areas where pedestrians would be exposed. Comparisons of the monitored results and the dispersion modelling estimates showed a generally good agreement; however, differences were noted in areas where high emitting vehicles were monitored. Study results were used in the public consultation process. Specific roles included the overall management, input to the monitoring program, the emission estimates and subsequent modelling as well as the report preparation.

**BC Ministry of
Transportation -
Current and Future Air
Quality in the West
End**
Vancouver, BC, Canada

A study built on the findings of earlier projects and made use of refined transportation estimates for the current and future vehicle behaviour in the West End of Vancouver. Predictive dispersion modelling was performed using the latest models and most up to date emission estimates. Study findings were to be used in developing a short list of proposed options for the upgrade of the First Narrows Crossing. Specific roles included the overall management, emission estimates, dispersion modelling and report preparation.

**BC Ministry of
Transportation - First
Narrows Crossing Air
Quality Assessment
Study**
Vancouver, BC, Canada

Study used state-of-the-art models to estimate the likely emissions and air quality impacts associated with the existing traffic conditions, as well as a comparative evaluation of the proposed solutions. The results of the comparative evaluation were used by the Ministry when trying to select the optimal solution for upgrading the First Narrows Crossing. Specific roles included the management of the air section, emission estimates, dispersion modelling and report preparation.

**Boundary
Infrastructure Project -
Highway 10 Expansion
Project EIA**
Burnaby, BC, Canada

As part of the Boundary Infrastructure Project, a number of roadway improvements are being proposed to improve traffic flow in Greater Vancouver. Since part of the funding for these improvements comes from the federal government, it was necessary to complete an environmental assessment of the project in accordance with the Canadian Environmental Assessment Act (CEAA). The air quality evaluation included an assessment of changes in air quality projected to occur as a result of the proposed expansion, and provision of air quality predictions to the health assessment team. Specific roles included senior technical advice and direction, participation in the preparation of the report, responding to supplemental information requests from regulators, interaction and liaison with the client team as well as regulatory agencies involved in the review process.

**City of Kelowna - City
of Kelowna
Transportation Study**
Kelowna, BC, Canada

An evaluation of the current and future air emissions from motor vehicle in the City of Kelowna planning area. Study made use of available emission models, and results of the transportation forecasting models to determine if the air quality in Kelowna is expected to improve or degrade as a result of increased vehicle activity and more stringent vehicle emission standards in the future. Specific roles included the overall management, development of assessment techniques that interfaced with the available traffic forecast models, emission estimation, preparation of the report and presentation of the findings in Kelowna.



**City of Nanaimo -
Sheton Truck Access -
Air Assessment**
Nanaimo, BC, Canada

An evaluation of the likely air quality impacts due to the re-routing of truck traffic adjacent to residential dwellings in Nanaimo. Study incorporated an evaluation of changes in vehicle emissions as well as using dispersion modelling to determine likely impacts at the homes along the planned route. Specific roles included the management of the air section, emission estimates, dispersion modelling and report preparation.

**City of North York - Air
Quality Evaluation of
the City Centre Ring
Road**
North York, Ontario,
Canada

Study assessed the air quality impacts from a proposed traffic by-pass on nearby residential areas and made extensive use of state-of-the-art dispersion and emission models to account for the behaviour of reactive vehicle exhausts adjacent to the roadway. Specific roles included the management of the air section, emission estimates, dispersion modelling and report preparation.

**Greater Vancouver
Regional District -
Mobile Source
Emissions Inventory -
Lower Fraser Valley**
Vancouver, BC, Canada

Development of a detailed mobile source air emissions inventory for the Lower Fraser Valley. Inventory techniques were developed during the project to ensure the greatest accuracy possible, as well as conformity with other transportation planning initiatives in the area. Specific roles on the project included the development of refined base quantities, emission rates and temporal factors to help better represent the emissions from the transportation sector, as well as client liaison and report preparation.

**National Emission
Inventory Task Group -
Road Dust
Assessment**
Vancouver, BC, Canada

Participated, as part of the National Pollutant Release Inventory (NPRI) program, in a study of dust emissions from urban roadways. Responsibilities including the scheduling and planning of the sampling program, collecting samples, analyzing the results and developing suitable emission factors to be used in national emissions inventories. Specific roles included overall management, field monitoring, emission estimation and report preparation.

**Transport Canada -
Trans-Canada Highway
Twinning Project,
Phase III**
Banff, Alberta, Canada

Transport Canada are proposing to commence Phase III of the Trans-Canada Highway Twinning Project through Banff National Park. This federally funded project required the completion of an environmental evaluation in accordance with the Canadian Environmental Assessment Act (CEAA). Qualitative evaluations of potential air quality and noise impacts were completed as part of the assessment. Specific roles included providing senior technical advice and reviewing the relevant report sections.

PROJECT EXPERIENCE – WASTE MANAGEMENT

**Biowaste Management
Limited - Odour
Evaluation of a Waste
Composting Facility**
Langley, BC, Canada

Completed an evaluation of the potential odours from a domestic waste composting facility located in the community of Langley, BC. An integral component of the study was the recommendation of suitable mitigation measures to ensure that nearby residents would not be adversely effected. Specific roles included overall management, regulatory liaison, assessment and report preparation.



**Canadian Turbo
Limited - Air
Assessment of a Soil
Remediation System**
Nanaimo, BC, Canada

Completed an air quality and noise evaluation of a small incinerator designed to treat emissions from a soil stripping system in Nanaimo, BC. The study quantified the noise and air emissions from the incinerator and evaluated the effects at the nearby homes. Specific roles included development of monitoring strategies, regulatory liaison, assessment and participation in the report preparation.

**Caribou Regional
District - Kimberly
Landfill**
Kimberly, BC, Canada

Conducted an evaluation of the waste management practices at the Kimberly Landfill to identify the possible sources of odours affecting the nearby residential homes. As part of the evaluation, a series of mitigation measures were proposed to mitigate the odours off-site. Specific roles included client and regulatory liaison, assessment, development of mitigation plans and report preparation.

**City of Niagara Falls -
Noise and Odour
Assessment –
Mountain Road Landfill**
Niagara Falls, Ontario,
Canada

Completed a noise and odour assessment of an expansion to a landfill in Niagara Falls, Ontario. Work involved environmental approvals, public liaison, predictive modelling and impact assessment. Specific roles included development of emissions, dispersion modelling, participation in the report preparation and participation in public meetings with stakeholders.

**City of Welland -
Demonstration Canal
Dredging Project**
Welland, Ontario,
Canada

Completed an evaluation of the potential air quality impacts associated with a demonstration-dredging project on stretches of the Welland River. The overall project was focussed on the remediation of river sediments by selective dredging in the most effected areas. Specific roles included development of assessment and monitoring strategies, regulatory liaison as well as senior review and technical input.

**Envirogreen
Technologies Limited -
Waste Destruction
Facility**
Princeton, BC, Canada

Participated in an ongoing evaluation and approval process for a waste destruction facility in Princeton, BC. The facility used an innovative approach for the treatment of contaminated soils that utilized the energy bound within the soils as a fuel in the thermal treatment process. Specific responsibilities included: the evaluation of regulatory requirements; recommendations for monitoring; interaction with operations personnel to optimize the efficiency; and regulatory liaison. The ongoing dialogue with the regulatory agencies was essential in achieving timely issuance of permits and approvals for the facility. Specific roles included overall management, the development of monitoring and assessment strategies, regulatory and client liaison, participation in the monitoring program as well as report preparation.

**Greater Vancouver
Regional District - Air
and Noise Assessment
for the Ashcroft Ranch
Landfill**
Ashcroft Ranch, BC,
Canada

Golder was retained by the Greater Vancouver Regional District to provide technical support for the development of the proposed Ashcroft Ranch Landfill. The support included site design engineering and an environmental impact assessment including a comprehensive air quality and noise assessment. The air assessment included a climate and meteorological data summary, reporting of air monitoring data, assessment of criteria air pollutants, dustfall and odour assessment, as well as green house gas emission estimates. The noise assessment included a field baseline survey and model predictions of continuous and impulsive noise sources. Specific roles included senior technical input and review, regulatory and client liaison as well as report preparation.



**Kamloops Airport - Air
Assessment of a Soil
Remediation System**
Kamloops, BC, Canada

Completed a dispersion modelling evaluation of the emissions from a soil stripping system was designed to remove ethylene glycol in the soil at the Kamloops Airport. The study focused on determining the exposures of local residents to elevated concentrations of the compound. Kamloops Airport is located in very complex terrain that effected the predicted concentrations in the vicinity of the site. Specific roles included development of monitoring strategies, emission estimation, dispersion modelling, regulatory liaison and participation in the report preparation.

**Municipalities of
Lincoln, Grimsby and
West Lincoln - Noise
and Odour
Assessment – Niagara
Road 12 Landfill**
Southern Ontario ,
Canada

Completed a noise and odour assessment of a proposed expansion to the Niagara Road 12 landfill. The site was located in south Central Ontario. The bulk of the project work involved environmental approvals, public liaison, predictive modelling and impact assessment. Specific roles included development of emissions, dispersion modelling, participation in the report preparation and participation in public meetings with stakeholders.

**Municipality of
Metropolitan Toronto -
Air Quality & Dust
Assessment –
Avondale North Clay
Borrow**
Vaughan, Ontario,
Canada

An air quality and dust assessment of a large clay borrow operation associated with the Keele Valley Landfill. Assessment involved a baseline air quality monitoring program, the development of site-specific emission data, public and regulatory liaison, interaction with legal council in preparation for the hearings, assessment of potential health impacts, and review of existing and proposed regulations in North America. Specific roles included the development of estimation of emissions, dispersion modelling, regulatory and client liaison, the development of a monitoring strategy to develop site-specific emission factors, responding to supplemental questions and information requests, participation in the report preparation and participation in hearing preparation.

**Municipality of
Metropolitan Toronto -
Commissioner Street
Commingled Facility**
Toronto, Ontario,
Canada

Completed a comprehensive evaluation of the potential noise from the commingled waste sorting facility on the grounds of the old Commissioner Street Incinerator. An integral component of the study was the recommendation of suitable mitigation measures to ensure that nearby residents would not be adversely effected. Specific roles included the monitoring of noise levels, the assessment of potential effects, the development of mitigation strategies and participation in the report preparation.

**Municipality of
Metropolitan Toronto -
Commissioner Street
Incinerator**
Toronto, Ontario,
Canada

A comprehensive modelling assessment and risk assessment was completed on the possible atmospheric releases that would result from the renewed use of the Commissioner Street Incinerator in Toronto. The study was completed as part of an evaluation of the overall waste management planning study to evaluate the possible options for addressing municipal waste in the Greater Toronto area. Specific roles included estimation emissions, dispersion modelling, assessment of effects and report preparation.



**Municipality of
Metropolitan Toronto -
Pickering Landfill
Odour Evaluation**
Pickering, Ontario,
Canada

An in-depth study to determine odour release rates and potential off-site odour impacts from a large municipal landfill site in Pickering, Ontario. Study made use of novel emission sampling techniques and a novel statistical approach for evaluating community odour complaints. Also made extensive use of computer dispersion modelling techniques to predict and correlate the off-site odour levels with the existing and projected odour release levels. Specific roles included participation in field monitoring, estimation emissions, dispersion modelling, assessment of effects and participation in the report preparation.

**Municipality of
Metropolitan Toronto -
Real-Time
Monitoring/Prediction
System**
Vaughan, Ontario,
Canada

Project involved the development of a real-time pollution prediction and control system for a large clay extraction operation associated with the Keele Valley Landfill, Ontario. The computer control system which utilized real-time (on-site) meteorological data, predictive modelling results, computer graphics and expert system technology, advised in which areas of the pit operations could proceed without exceeding the air quality standards off site. Specific roles included the design of and participation in the field monitoring program, the development of software that could evaluate weather conditions on a real-time basis, dispersion modelling, the development of a management protocol, client liaison and participation in the preparation of reports.

**Simcoe County -
Innisfil Landfill Life
Extension Project**
Innisfil, Ontario, Canada

Completed an air quality and dust assessment of a proposed expansion to a landfill north of Toronto. Work was prepared for presentation to a hearing board and involved the application of state-of-the-art techniques to predict and describe particulate behaviour, public liaison, and the interaction with legal council in preparation for the hearings. Specific roles included the estimating emissions, dispersion modelling, review of mitigation plans, assessment of effects, participation in report preparation, regulatory and client liaison and participation in public meetings.

**Township of West
Lincoln - Ontario
Waste Management
Corporation**
South Central Ontario,
Canada

Participated in an air quality evaluation of the proposed OWMC special waste handling facility in West Lincoln Ontario. The facility was the focus of extensive hearings and public meetings where the concerns of the local residents were highlighted. Specific roles included development of supplemental questions and information requests, review of previous assessment studies, estimation of emissions, dispersion modelling, recommendations regarding potential mitigation strategies and participation in the report preparation.



TRAINING

Introductory Environmental Noise Courses

Ontario Ministry of Environment, 1988

Certificate Environmental Noise Courses

Ontario Ministry of Environment, 1988

Fundamentals of Dispersion Modelling

Trinity Consultants, Toronto, 1989

Environmental Legislation and Compliance

University of Toronto Continuing Education, Toronto, 1991

Performance Mastery Workshop

UBC Executive Programs, Vancouver, 1993

Air Quality Management Course

UBC Continuing Education, Matsqui, 1994

Air Quality Management Workshop

UBC Continuing Education, Kelowna, 1995

Air Quality Management Workshop

UBC Continuing Education, Kelowna, 1995

Allan Bonner Communications Training Course

1998

Client Services

Golder U, 2002

Communication & Interpersonal Skills

Golder U, 2002

Train the Trainer

Golder U, 2003

Contracts and Liabilities

Golder U, 2004

PROFESSIONAL AFFILIATIONS

Association of Professional Engineers, Geologists and Geophysicists of Alberta

PUBLICATIONS

Other

Rawlings, M.A., G.D. Unrau and W.E. Speller, 2002. Air Quality Assessments in the Athabasca Oil Sands Region: An Airshed Approach. The Resources 2 Reserves 2 Results Conference, Calgary, AB, November.

Rawlings, M.A., S.A. Scott-Longley and G. Unrau, 1998. Evaluation of Particulate Concentration in Hinton and Skookumchuck. The Canadian Pulp and Paper Association, Air Quality Sub-Committee Meeting, Toronto, ON, November.



Rawlings, M.A. and K.L. Currie, 1997. Overview of Canadian Environmental Business – A Consultants Perspective. Presented to the UBC Chapter of the Canadian Society of Chemical Engineers.

Rawlings, M.A., 1995. Estimates of the Current and Future Air Quality in Kelowna Due to Motor Vehicle Emissions, Air Quality Management Workshop, Kelowna, BC, March.

Rawlings, M.A., L. Lauzon and J. Petersen, 1995. Meteorological Observations in Complex Terrain. The Canadian Meteorological and Oceanographic Society (CMOS) Annual Congress, Kelowna, May.

Rawlings, M.A. and K.L. Currie, 1993. A Comparison of Ambient Air Quality in Major Urban Areas in Canada and the United States, CPPI Report No. 93-1, ISBN 1-1895582-97-0.

Rawlings, M.A., W.C. Edwards, J.G. Wilkin, R. Dunlop and M. Virani, 1993. Development and Use of the 1990 Emissions Inventory for the Lower Fraser Valley Region in British Columbia, AWMA, the Emission Inventory - Perception and Reality, Pasadena, October.

Rawlings, M.A. and K.L. Currie, 1992. Overview of Canadian Air Quality C A Comparison of Ambient Air Quality in Major Urban Areas in Canada and the United States, CANMET, Reformulated Gasolines: Issues and Options for Canada, Aylmer, P.Q. October.

Rawlings, M.A., 1992. The Fugitive Dust Model (FDM): Its Use and Application in Canada, Canadian Institute for Research in Atmospheric Chemistry/Air & Waste Management Association Joint International Conference on Atmospheric Chemistry, Toronto, Ontario, January.

Rawlings, M.A., 1991. Ethics, the Environment and Engineers: What is an Engineer's Ethical Responsibility for the Environment, Presented at a Student Professional Awareness Conference, McMaster University, Hamilton, Ontario, February.

Rawlings, M.A., D.B. Chambers, et al, 1991. Standard Development: Can We Learn from the Nuclear Industry, Air & Waste Management Association, Ontario Section, Spring Conference, Hamilton, Ontario, April.

Rawlings, M.A., D.B. Chambers, J.D. Phyper, et al, 1988. The Development of the Assessment of Incinerator Risk (A.I.R.) Model Society for Risk Analysis, Annual Conference, Washington.

**Education**

D.Sc. Environmental Planning, Federal University of Rio de Janeiro, Brazil, (in progress)

M.S. Chemical Engineering, University of São Paulo, Brazil, 2006

B.S. Chemical Engineering, Federal University of Minas Gerais, Brazil, 2000

Languages

Portuguese – Fluent

English – Fluent

Spanish - Intermediate – Fluent

Rio de Janeiro**Employment History****Golder Associates – Rio de Janeiro, Brazil**

Senior Chemical Engineer / Project Manager / Group Manager – Environmental Studies and Engineering (2010 to Present)

Responsibilities include management and technical participation in projects related to wastewater treatment system evaluation and design, water use optimization, air emissions treatment and environmental studies for industries, mining and oil and gas facilities. Responsibilities also include proposal and budget preparation, contact with clients and environmental agencies, coordination of internal team and subcontractors, financial control of the projects, commercialization and business planning and development.

Golder Associates – Mississauga, Canada

Air Quality Engineer / Project Manager (2009 to 2010)

Responsibilities include management and technical performance in projects related to air emissions management and air quality studies. Responsibilities also include proposal and budget preparation, contact with clients and environmental agencies, coordination of internal team and subcontractors, financial control of the projects and commercialization.

Golder Associates – Rio de Janeiro, Brazil

Senior Chemical Engineer / Project Manager / Group Manager - Air Emissions and Wastewater Services (2005 to 2009)

Responsibilities include management and technical performance in projects related to wastewater treatment system evaluation and design, water use optimization, air emissions treatment and environmental studies for industries. Responsibilities also include proposal and budget preparation, contact with clients and environmental agencies, coordination of internal team and subcontractors, financial control of the projects, commercialization and business planning and development.

Golder Associates – São Paulo, Brazil

Chemical Engineer / Project Manager (2003 to 2005)

Responsibilities include management and technical performance in projects related to wastewater treatment system evaluation and design, water use optimization, air emissions treatment and environmental studies for industries. Responsibilities also include proposal and budget preparation, contact with clients and environmental agencies, coordination of internal team and subcontractors, financial control of the projects and commercialization.

Golder Associates – Rio de Janeiro, Brazil

Chemical Engineer (2001 to 2003)

Technical performance in projects related to air emissions and wastewater treatment processes, risk analysis and environmental studies for industries and oil and gas facilities.

Golder Associates – Belo Horizonte, Brazil



Chemical Engineer (2000 to 2001)

Technical performance in projects related to air emissions treatment processes in industries and environmental assessment.

Universität Greifswald – Greifswald, Germany

Trainee at the Biochemistry Department (1999)

Participation in development of projects concerning computational modeling of chemical reactions and studies about biomaterials.

FEAM – Minas Gerais Environmental Agency – Belo Horizonte, Brazil

Trainee at the Air Quality Department (1999)

Participation in studies concerning air quality at metropolitan region of Belo Horizonte.



PROJECT EXPERIENCE – WATER TREATMENT AND AIR QUALITY SERVICES

Votorantim Metals
Três Marias – MG, Brazil

Technical responsible for the evaluation an existing physical-chemical WWTS in a zinc processing plant in order to check the feasibility to add additional wastewater streams. Preparation of mass / water balances to determine flow rate and composition of future wastewater, evaluation of hydraulic capacities of the equipments of the WWTS and chemical behaviour of the reactions face the new composition of the wastewater.

**Votorantim Metais -
Serra da Fortaleza
Mine**
Passos - MG, Brazil

Technical responsible for preparation of mass / water balance for an industrial complex with nickel mine, ore processing plant, smelter, sulphuric acid plant and tailing / wastewater dams to determine future characteristics of final process wastewater discharged from the site.

**U.S. Steel Canada -
Lake Erie Works**
Nanticoke, Ontario,
Canada

Technical responsible for preparation of a Technology Benchmarking Report regarding control of air emissions from coke plant and by-products plant in an integrated steel mill.

**U.S. Steel Canada -
Hamilton Works**
Hamilton, Ontario,
Canada

Technical responsible for preparation of a Technology Benchmarking Report regarding control of air emissions from coke plant and by-products plant in an integrated steel mill.

Nova Chemicals
Sarnia, Ontario, Canada

Technical responsible for review of air emission inventory for an oil refinery.

**Ministry of Natural
Resources**
Ontario, Canada

Technical responsible for preparation of a life cycle assessment and greenhouse gases emission inventory to determine GHG emission efficiency of aggregate facilities in Ontario, as part of a study on future aggregate availability and alternatives in Ontario.

Lafarge Canada Inc.
Ontario, Canada

Technical responsible for preparation of a Best Management Practices Plan for control of fugitive dust emissions from a quarry.

AES
Brazil

Project manager and technical responsible for preparation of a greenhouse gases emission and removal inventory system at corporate level, including seven energy and telecommunication companies owned by the client. System developed following IPCC and GHG Protocol orientations, allowing easy and low cost update of the inventory.

**Petrobras - Petróleo
Brasileiro S/A**
Macaé – RJ, Brazil

Project manager and technical performance in a project comprising bench scale tests, pilot tests, conceptual and detailed design of treatment system for effluents from oil terminal containing ammonia and phenols.

**Petrobras - Petróleo
Brasileiro S/A**
Angra dos Reis – RJ,
Brazil

Project manager and technical performance in a project comprising bench scale tests, pilot tests, conceptual and detailed design of treatment system for effluents from oil terminal containing ammonia and phenols.



**Petrobras - Petróleo
Brasileiro S/A**
Macaé – RJ, Brazil

Evaluation of treatment methods for effluents from an oil terminal. Participation on the identification of methods and bench scale tests to evaluate treatments for removal of phenols, ammonia and barium from the production water operated at the Terminal, as well as technical-economical feasibility study comprising the treatment methods evaluated and specification of upgrades for the existing wastewater treatment plant.

**Petrobras - Petróleo
Brasileiro S/A**
Angra dos Reis – RJ,
Brazil

Evaluation of treatment methods for effluents from an oil terminal. Participation on the identification of methods and bench scale tests to evaluate treatments for removal of phenols, ammonia and barium from the production water operated at the Terminal, as well as technical-economical feasibility study comprising the installation of a new treatment plant.

Bunge Fertilizantes
Araxá – MG, Brazil

Responsible for assessment of the water and wastewater management in an industrial complex (mine, beneficiation, sulfuric acid and fertilizer production); preparation of water balances at the level of production plants and at the level of the industrial complex, including process and hydrological data; evaluation of current and future risks of this management to environment, finance and image of the company; economic evaluation and conceptual design of alternatives to optimize water use and minimize water consumption and wastewater generation as well as associated risks and costs. The project included identification of methods and bench scale tests to remove phosphorus, fluorides, calcium, magnesium and suspended solids from phosphate tailings, which reaches 3000 m³/h in the full scale operation.

Bunge Fertilizantes
Cajati – SP, Brazil

Responsible for assessment of the water and wastewater management in an industrial complex (mine, beneficiation, sulfuric acid, phosphoric acid and fertilizer production); preparation of water balances at the level of production plants and at the level of the industrial complex, including process and hydrological data; evaluation of current and future risks of this management to environment, finance and image of the company; economic evaluation and conceptual design of alternatives to optimize water use and minimize water consumption and wastewater generation as well as associated risks and costs.

VALE
Brazil

Project manager and technical responsible for elaboration of a corporate manual for selection, design, operation, maintenance and monitoring of treatment systems for oily wastewater

VALE
Rio de Janeiro – RJ,
Brasil

Project manager and technical responsible for evaluation of corporate O&M manuals for sewage treatment systems and oil / water separators.

VALE
Mariana – MG, Brazil

Evaluation of treatment methods for effluents from chemical lab in a mine plant. Responsible for identification of methods and bench scale tests to evaluate feasibility of treatments to remove metals, boron and surfactants from the lab effluents.

VALE
Rio de Janeiro – RJ,
Brazil

Project manager and technical responsible for a study to survey and define guidelines for wastewater management in a coal mine complex.



Eaton Corporation
Caxias do Sul – RS,
Brazil

Air study and wastewater treatment system study for an auto parts manufacturing plant. Project manager and technical responsible for evaluation of conditions and efficiency of the existing biological wastewater treatment systems, recommending operational and structural modifications to improve its performance; and evaluation of conditions of existing air emissions at the site, developing an air emission sampling plan.

Petrobras - Petróleo Brasileiro S/A
São Mateus do Sul –
PR, Brazil

Design and implementation of a Biofilter to treat VOC's/odorous air emissions from wastewater treatment plant in a refinery. Project manager and responsible for design, procurements, installation and coordination of subcontractors.

Petrobras - Petróleo Brasileiro S/A
Cubatão – SP, Brazil

Design and implementation of a Biofilter to treat VOC's/odorous air emissions from wastewater treatment plant in a refinery. Project manager and responsible for design, procurements, installation and coordination of subcontractors.

CSN – Companhia Siderúrgica Nacional
Volta Redonda – RJ,
Brazil

Evaluation and conceptual design of modifications to increase capacity of a existing Biofilter in a steel mill. Project manager and responsible for design of the required modifications to existing system to treat additional odorous air emissions from oily wastewater treatment plant.

CSN – Companhia Siderúrgica Nacional
Volta Redonda – RJ,
Brazil

Implementation of a Biofilter in a steel mill. Responsible for coordination of subcontractors and installation of the System to treat odors from the oily effluent treatment plant.

LITOGRAFICA Uberlândia
Uberlândia – MG, Brazil

Design and implementation of a Biofilter for a lithographic industry. Project manager, participation on the design of the system and responsible for supervision of the installation of the System to treat VOC's/odors from the printing and varnishing process.

Petrobras - Petróleo Brasileiro S/A
Cubatão – SP, Brazil

Evaluation of VOC's air emissions from wastewater treatment plant in a refinery and feasibility study concerning the implementation of a Biofilter. Project manager and responsible by the air emissions sampling and feasibility study about the implementation of a Biofilter to treat the emissions.

Confidential Client
Brazil

Participation in the development of a new biotechnologic route for the extraction of phosphorus from rock phosphate.

PROJECT EXPERIENCE – ENVIRONMENTAL ASSESSMENT

Votoranim Metals
Barra Mansa – RJ, Brazil

Project manager and responsible for economic evaluation in a study concerning decommissioning of an area used for disposal of solid wastes.

Bunge Fertilizantes
Brazil

Responsible for the development of a dynamic and probabilistic computer model using the software GoldSim® to support corporative decision making. The model comprised environmental aspects, impacts, risks and associated costs related to ten industrial sites, including two industrial complex.

Bunge Fertilizantes
Brazil

Due Diligence in six industrial unities comprising mines, ore processing plants and chemical plants. Participation on the evaluation of environmental liabilities according the Statement of Financial Accounting Standards No. 143, "Financial Accounting Standards Board – FASB".



Fosfertil-Ultrafertil
Brazil

Due Diligence in one maritime terminal and seven industrial unities comprising mines, ore processing plants, chemical plants and ore pipelines. Participation on the evaluation of environmental liabilities according the Statement of Financial Accounting Standards No. 143, "Financial Accounting Standards Board – FASB".

Ministerio de Energia y Minas
Peru

Environmental assessment in a Lead, Copper and Zinc Smelter located in La Oroya – Peru. Responsible for the assessment of the environmental impacts in terms of air, superficial water, sediments, soil and groundwater quality due to changes in the production process, composition of raw materials and increase in production.

VALE
Paragominas – PA,
Brazil

Project manager and technical responsible for conducting an environmental assessment for a gas station of a mine complex. The assessment includes evaluation of the conditions of the structures for wastewater control, as well as identification of the environmental aspects and impacts related to its operations.

Confidential Client
Brazil

Due Diligence in a steel mill. Participation on the evaluation of environmental liabilities in the whole steel mill site and in external properties.

Petrobras - Petróleo Brasileiro S/A
Rio de Janeiro – RJ,
Brazil

Fugitive air emissions inventory at an oil maritime terminal. Participation on the identification and calculation of fugitive emissions from tanks, pipelines and loading/unloading operations.

Petrobras - Petróleo Brasileiro S/A
Brazil

Fugitive and point air emissions inventory for eight oil maritime terminal. Participation on the identification and calculation of fugitive emissions from point sources, tanks, pipelines and loading/unloading operations.

PROJECT EXPERIENCE – RISK ANALYSIS

Votorantim Metals
Barra Mansa – RJ, Brazil

Project manager on a decommissioning study comprising site assessment and human healthy risk analysis for a area used for disposal of industrial wastes.

Petrobras - Petróleo Brasileiro S/A
Macaé – RJ, Brazil

Risk analysis in a gas processing plant of an oil terminal. Responsible for the elaboration of a Preliminary Hazard Analysis and vulnerability analysis.

Petrobras - Petróleo Brasileiro S/A
Barra Mansa – RJ, Brazil

Quantitative Risk Analysis in a seatgate. Responsible for the identification of hazard scenarios, calculation of frequencies, consequences and individual and societal risks.

Petrobras - Petróleo Brasileiro S/A
Rio das Flores – RJ,
Brazil

Quantitative Risk Analysis in a seatgate. Responsible for the identification of hazard scenarios, calculation of frequencies, consequences and individual and societal risks.

Petrobras - Petróleo Brasileiro S/A
Rio de Janeiro – RJ,
Brazil

Integrated Risk Analysis comprising one oil maritime terminal, one gas maritime terminal and associated pipelines. Participation in the elaboration of a risk management plan and responsible for the risk modeling using the software GoldSim®.



PROFESSIONAL AFFILIATIONS

CREA-MG – Regional Council of Professional Engineers and Architects – Minas Gerais State

CREA-RJ – Regional Council of Professional Engineers and Architects – Rio de Janeiro State

CREA-SP – Regional Council of Professional Engineers and Architects – São Paulo State

PUBLICATIONS

Other

FREITAS, A. H. A. Integrated Risk Assessment for Environmental Management. Dissertation (Master) - Escola Politécnica, Universidade de São Paulo, São Paulo, 2006.

FREITAS, A.H.A. Integrated Risk Assessment for Water and Wastewater Management. VIII Italian / Brazilian Symposium of Environmental Engineering. Rio de Janeiro, 2006.

FREITAS, A.H.A. Biofilter for Odor and VOC Treatment. VIII Italian / Brazilian Symposium of Environmental Engineering. Rio de Janeiro, Brazil, 2006.

FREITAS, A.H.A. Rapid Tests for Evaluation of Toxicity in Industrial Effluents. Report presented for the subject Advanced Oxidative Processes for Wastewater Treatment (Master), Universidade Federal do Rio de Janeiro. Rio de Janeiro, 2003.

FREITAS, A.H.A., CICHOCKI, A., FIGUEIRA, J.A.F. Air Emissions, Odor and Volatile Organic Compounds Elimination. Gerenciamento Ambiental Magazine, May/June, 49-52. São Paulo, Brazil, 2002.



Education

B.Sc. Environmental Science, Royal Roads University (RRU), Victoria, BC, 2000

Honours Graduate Integrated Environmental Planning Technology, Selkirk College, Castlegar, BC, 1999

Golder Associates Ltd. – Calgary

Air Quality Scientist

Mr. Madland has worked as an air quality scientist in the Calgary office since 2000. He received an Environmental Planning Technology Diploma from Selkirk College in 1999 and a B.Sc. in Environmental Science from Royal Roads University (Victoria, BC) in 2000.

Chris has been involved in a wide range of projects in western and northern Canada and the Pacific Northwest United States. He has a range of experience in ambient monitoring programs including siting, permitting, installation, maintenance and reporting for the mining, manufacturing, oil and gas and the utilities sectors. He has contributed to the emissions profile development for many of the EIAs that have been produced by Golder Associates since 2000 and has coordinated the air quality component of several regulatory applications. Mr. Madland's specialty is ambient air quality and meteorological monitoring program development, operation and management.

Employment History

Golder Associates – Calgary, Alberta

Air Quality Scientist (2000 to Present)

Air quality scientist assisting on Environmental Impact Assessments, emission inventories and ambient air quality monitoring projects. Responsibilities include project management, air monitoring, data analysis, emission calculations, environmental management planning modelling, hearing preparation, meteorological data analysis preparation, regulatory guidance, regulatory liaison, client liaison, report peer review, report preparation and supplemental responses.

British Columbia Hydro – Castlegar, British Columbia

Student Biologist (1998 to 2000)

Participated in various reservoir and dam management programs, produced documents supporting BC Hydro's application for ISO 14001 certification.



PROJECT EXPERIENCE – VARIOUS

**Catalyst Paper, Powell
River Division, Landfill
Expansion
Environmental Appeal
Board Hearing**
Powell River, British
Columbia

Golder prepared an application for a permit under the B.C. Environmental Management Act for a proposed landfill expansion at Catalyst Paper Corporation's Powell River mill in Powell River, B.C. The B.C. Ministry of Environment approved the expansion; however several local residents and community associations appealed the decision. Mr. Madland participated as an expert witness with matters related to air quality at the Environmental Appeal Board hearing.

**AMEC Earth and
Environmental Limited
Mackenzie Gas
Pipeline EIA**
Northwest Territories

As part of a consulting consortium, Golder was responsible for the completion of the air quality components of the Environmental Impact Assessment (EIA). The air quality assessment evaluated air pollutant concentrations and acid deposition resulting from cumulative emission sources across the length of the proposed pipeline, from the Mackenzie Delta in the north to Zama, Alberta in the south. Air quality predictions were made using the CALPUFF dispersion model (2-D mode). This project also included participation in the regulatory review and public hearings. Air Component/Discipline Lead and Emission Coordinator responsible for emission calculations, data analysis, QA/QC, hearing preparation and report preparation.

**Anadarko Canada
Corp. East Liard Gas
Gathering System**
Deh Cho Region,
Northwest Territories

Anadarko proposed to build a pipeline to link the existing Chevron K-29 well site with the existing Anadarko A-68 well site, north of Fort Liard, Deh Cho Region, NWT. Golder completed both the air quality and noise assessment for the dehydration and compression facility at the start of the pipeline, and the compressor station situated along the pipeline. Responsible for data analysis and report preparation.

**Nimbus Projects
Tiverton Battle River**
Stettler, Alberta

Nimbus Projects, acting on behalf of Tiverton Petroleum, retained Golder to assess ambient SO₂ concentrations resulting from the expansion of an oil battery located northeast of Stettler, Alberta. Solution gas flaring was planned to increase from 3,000 m³/day to 12,000 m³/day. Responsible for emission calculations, QA/QC, report preparation and project management.

**Imperial Oil Ltd. Kearl
Oil Sands Project**
Fort McMurray, Alberta

Golder was responsible for the completion of the Environmental Impact Assessment (EIA) of the Kearl Oil Sands mine for Imperial Oil. As part of the EIA, Golder was responsible for the completion of the air quality components of the project, which included the use of the Golder's regional emissions database and 3-D meteorological dataset. The air quality assessment evaluated air concentrations and acid deposition resulting from cumulative emissions sources across the Oil Sands Region, spanning from Fort Chipewyan to the Cold Lake area. Air quality predictions were made using the CALPUFF dispersion model, run in the 3-D mode. Responsible for emission calculations and QA/QC.



**Dynatec Corporation
Ambatovy EIA
Madagascar**

Golder was retained by Dynatec Corporation to complete an Environmental Impact Assessment (EIA) for a nickel/cobalt mine in Madagascar. The EIA included assessments of air quality and noise for the open pit mine, slurry pipeline, processing plant, tailings facility and port expansion. The air quality assessment included an ambient air quality component (SO₂, NO_x and others) as well as dust deposition, which was of particular concern in the ecologically diverse region. Responsible for emission calculations, QA/QC and data analysis.

**DeBeers Canada Inc.
Snap Lake Monitoring
Snap Lake, Northwest
Territories**

The Snap Lake Diamond Mine EIA was in preparation for several years. The original development was owned by Winspear; however, DeBeers later purchased the project. In addition to the EIA, Golder was responsible for the operation and maintenance of the ambient air and meteorological monitoring at the site. Air Component/Discipline Lead and Emission Coordinator responsible for regulatory liaison, emission calculations, QA/QC, air monitoring and data analysis.

**Diavik Diamond Mines
Inc. EIA Review
Lac de Gras, Northwest
Territories**

Golder was retained by Diavik Diamond Mines Inc. to complete a peer review of the original EA completed for the Diavik diamond mine in Lac de Gras, NWT. Responsible for QA/QC and report peer review.

**PCL Construction
Management Inc. Dust
Management Plan
Calgary, Alberta**

Golder was retained by PCL Construction Management to provide a dust management plan for the University of Calgary, Health Research Innovation Centre project located at the Foothills Hospital. Project Manager responsible for emission calculations, air monitoring, data analysis, air/environmental management planning and report preparation.

**KeySpan Energy
Canada Fugitive
Emission Monitoring
Rocky Mountain House,
Alberta**

Golder was retained by KeySpan Energy Canada to identify sources of H₂S and hydrocarbons from the Strachan gas plant through emissions monitoring. Air Component/Discipline Lead responsible for air monitoring, data analysis, QA/QC and report preparation.

**TransAlta Utilities
Corp. Centralia Mine
Washington**

Golder completed baseline field work for TransAlta's Centralia Mine in Washington State. The project was managed out of the Golder Calgary office. However, air and noise monitoring was conducted by the Golder Gainesville office. Air Component/Discipline Lead responsible for air monitoring, data analysis, QA/QC and report preparation.

**Suncor Energy Inc.
Voyageur Project EIA
Fort McMurray, Alberta**

Golder was responsible for the completion of the Environmental Impact Assessment (EIA) for the Suncor Voyageur Project. The air quality sections of the EIA evaluated cumulative air pollutant concentrations and acid deposition across the Oil Sands Region, using the CALPUFF dispersion model (3-D mode). The EIA made use of Golder's regional emissions database and 3-D meteorological data set, which cover the area from Fort Chipewyan to the Cold Lake area. Responsibilities included air monitoring, data analysis and report preparation.



Resumé

CHRIS MADLAND

**Canadian Natural
Resources Ltd.
Primrose East Oil
Sands Project**
Cold Lake, Alberta

Golder was retained to prepare an Environmental Impact Assessment (EIA) for the Canadian Natural Primrose East Oil Sands Project. This Steam-Assisted Gravity Drainage (SAGD) project is an expansion of the existing Canadian Natural Primrose and Wolf Lake facilities. Air quality and noise assessments were completed as part of the EIA. Responsibilities included noise monitoring.

**BacTech Mining
Mckinnon Creek Mine**
Revelstoke, British
Columbia

During early project planning BacTech Mining commissioned a meteorological monitoring program in the vicinity of a former metals mine. BacTech planned to develop a gold, lead and zinc deposit approximately 45 km north of Revelstoke, B.C. Golder was responsible for conducting the EIA, based on permitting and approval in 2006. The mine was planned to be underground and ore processing was planned to be done using a bioleach system. Project Manager responsible for air monitoring, data analysis and report preparation.

**Plains Marketing
Joarcam Truck
Terminal**
Joarcam, Alberta

Plains Marketing applied to construct a truck terminal facility located on a five hectare site in Central Alberta. The facility is required to provide a collection point for locally produced crude oil for shipment through the Joarcam Pipeline system to markets in Edmonton and elsewhere. Golder was retained to provide technical input to Plains Marketing for the EUB permit. As part of this, a Noise Impact Assessment (NIA) and an air quality assessment were completed. Responsibilities included QA/QC and emission calculations.

**Advantage Oil and Gas
Ltd. Sweetgrass
Assessment**
Sweetgrass, Alberta

Advantage Oil and Gas Ltd. retained Golder to provide air dispersion modelling predictions of ground-level sulphur dioxide (SO₂) concentrations from the proposed operation of the Sweetgrass sour gas facility flare. The modelling was requested to provide information to interested stakeholders during the application process. Air Component/Discipline Lead and Emission Coordinator responsible for emission calculations, QA/QC, data analysis and report preparation.

**Redcliff Industries
EPEA Renewal**
Redcliff, Alberta

Golder was retained to assist Redcliff Industries (a fibreglass manufacturer) with their EPEA approval renewal process. The renewal application required an air quality modelling assessment. Air Component Discipline Lead and Emission Coordinator responsible for emission calculations, QA/QC, data analysis, QA/QC and report preparation.

**Canadian Natural
Resources Ltd.
Primrose North
Monitoring**
Cold Lake, Alberta

Canadian Natural Resources retained Golder to prepare an application to AENV for a continuous air quality monitoring station and four passive air monitoring stations near the Primrose North Oil Sands Facility. Responsibilities included air monitoring, data analysis and report preparation.

**EnCana Corp. Foster
Creek Monitoring
Program**
Foster Creek, Alberta

Golder conducted a siting assessment in accordance with the Alberta Air Monitoring Directive for the installation of a continuous air quality monitoring trailer at the Foster Creek site. Project Manager responsible for air monitoring, QA/QC, environmental management planning model, regulatory guidance and report preparation.



**EnCana Corp.
Christina Lake Project
Debottlenecking and
Expansion**
Christina Lake, Alberta

Golder was retained by EnCana to assist in approval amendments associated with the Phase 1B Debottlenecking and Expansion at the Christina Lake Thermal Project. The Christina Lake Thermal Project is a SAGD project located in Alberta's Athabasca oil sands region. The work included completing the air quality and noise assessments, required as part of the approval amendment applications to Alberta Environment and the Alberta Energy and Utilities Board (EUB). The air quality assessment included establishing an air emission profile for the project, as well as determining the air quality impacts using the CALPUFF dispersion model. Responsibilities included emission calculations and data analysis.

**Ivanhoe Mines Inc. Oyu
Tolgoi Dust
Management Plan**
Mongolia

Ivanhoe Mines Inc. needed to manage widely-dispersed fugitive dust associated with operations planned for southern Mongolia at the Oyu Tolgoi site. One of the most difficult aspects of managing dust generation in this location is the local climate. Golder developed a dust management plan that included controls and monitoring. Air Component/Discipline Lead responsible for emission calculations, data analysis, environmental management planning and report preparation.

**UEX West Bear
Baseline Air Quality
Monitoring**
Northern Saskatchewan

Golder was retained by UEX to undertake environmental baseline monitoring studies at a uranium deposit in northern Saskatchewan to support a pending application to develop an open-pit mine at the site. The air and noise team designed and implemented a baseline air monitoring program for particulates radon, SO₂ and NO₂. Air Component/Discipline Lead responsible for air monitoring, data analysis and report preparation.

**Dundee George &
Goose Meteorological
Monitoring**
Bathurst Inlet, Nunavut

Golder was contracted to maintain two meteorological stations installed in August 2004 at two exploration camps near Bathurst Inlet, Nunavut. Work included calibration, repair, download and reporting of data from stations at George and Goose Lakes. Air Component/Discipline Lead responsible for air monitoring, data analysis, QA/QC and report preparation.

**Catalyst Paper, Elk
Falls Division Dustfall
Monitoring Program**
Campbell River, British
Columbia

Golder prepared an application for a permit under the B.C. Environmental Management Act for a proposed landfill expansion at Catalyst Paper Corporation's Elk Falls mill in Campbell River, B.C. Air quality work included characterizing dustfall at the site through a monitoring program. Air Component/Discipline Lead responsible for air monitoring, data analysis, QA/QC and report preparation.

**Fossil Water Catalyst
Facility Air
Assessment**
Fort Saskatchewan,
Alberta

Fossil Water proposed a catalyst recycling facility near Fort Saskatchewan, Alberta. Golder was retained to provide an assessment of air quality and to assist with various application components. Air Component Discipline Lead, Modelling Coordinator and Emission Coordinator responsible for emission calculations, air dispersion modelling, QA/QC, data analysis and report preparation.



**Suncor Energy Inc.
Firebag Odour
Assessment**
Fort McMurray, Alberta

Suncor requested Golder's assistance with the identification and control of odour issues at the Firebag Facility. Golder performed preliminary monitoring at the Firebag site to identify potential sources of odour and helped to address this issue. Ongoing work has led to Golder being asked to develop an on-site fugitive emissions inventory. Responsible for emission calculations, air monitoring, and data analysis.

**Erco Worldwide
Monitoring Data
Review and Analysis**
Saskatoon,
Saskatchewan

Golder was retained to conduct a review and analysis of the ambient air quality data collected in the vicinity of the ERCO Worldwide chemical production facility located in Saskatoon, Saskatchewan. This review and analysis was completed as part of a comprehensive State of the Environment report. Responsibilities included data review, analysis and report preparation.

**Siksika Environmental
Ltd. Environmental
Training**
Siksika Reservation,
Alberta

Golder was retained to provide technical training and job shadowing opportunities for selected employees of Siksika Environmental Ltd. Training was provided in the siting, operation and maintenance of ambient air monitoring equipment. Developed and delivered an introduction to air quality monitoring course.

**Miramar Mining
Corporation Ambient
Air Quality Monitoring**
Bathurst Inlet, Nunavut

Miramar Mining Corporation is developing a gold mine near Cambridge Bay on Victoria Island, Nunavut. Golder was retained to provide background air quality and meteorological monitoring services in support of their permit application process. A Hi-Volume sampler and meteorological monitoring program was implemented during the summer months. Responsibilities included program development, instrument selection and procurement, installation and training of on-site staff in the maintenance of monitoring components. Also responsible for data analysis, QA/QC and reporting for this project.

**Cogema Resources
Inc. Monitoring Data
Review and Analysis**
Saskatchewan

Golder was retained to conduct a review and analysis of the ambient air quality data collected in the vicinity of the Cogema McLean uranium mine. Responsibilities included the coordination of data acquisition and subsequent analysis, as well as report preparation.

**Chevron Canada Ltd.
M-25 Meteorological
Monitoring**
Fort Liard, Northwest
Territories

This project involved implementing and managing a meteorological monitoring program at the Chevron Canada F-25 and K-29 wells near Ft. Liard in the Northwest Territories. The parameters monitored at each site included wind speed, wind direction temperature and solar radiation. Responsibilities included limited client liaison.

**EnCana Energy
Christina Lake
Environmental
Management**
Christina Lake, Alberta

Golder was responsible for the development of an air quality monitoring program for the Christina Lake Thermal Project in the Athabasca Oils Sands Region of Alberta. The ambient monitoring consisted of four static exposure stations and one continuous station. The program included options and recommendations for equipment purchase and monitoring station locations based on the requirements of the Alberta Monitoring Directive. Documentation was prepared to provide regulators with the information necessary to evaluate the suitability and effectiveness of the planned program. Involved in the siting of the continuous and the static stations and oversaw the installation of the monitoring program hardware. Responsible for the ongoing coordination of the program, data quality assurance and reporting.



Resumé

CHRIS MADLAND

**EnCana Energy
Christina Lake Thermal
Project Monitoring
Program**
Christina Lake, Alberta

An air quality and meteorological monitoring plan and on-site assessment program were conducted to evaluate facility emissions from the Christina Lake Thermal Project. The project involved the establishment of an air quality and meteorology monitoring station, interpretation of data and regular reporting and liaising with government officials on behalf of the client. Involved in the siting of the continuous and the static stations, and oversaw the installation of the monitoring program hardware. Also responsible for the ongoing management of some components of the program, data quality assurance and reporting. (2001)

**Norske Skog Inc.
Crofton Landfill**
Vancouver Island, British
Columbia

Golder implemented a dust-fall and meteorological monitoring program at a water reservoir adjacent to the Norske Skog landfill in Crofton, B.C. The objective of the program was to assess the impact of dust emissions from the landfill on the water reservoir. The monitoring program consisted of monthly sampling of two dust-fall canisters, which were analyzed for dust-fall amounts and trace metal concentrations. Responsibilities included support for the field staff and siting process.

**DeBeers Canada
Mining Inc. Snap Lake
Diamond Mine
Monitoring Program**
Snap Lake, Northwest
Territories

Golder provided ongoing support to DeBeers Canada for applications to the Government of the Northwest Territories to construct and operate an underground diamond mine in the vicinity of Snap Lake, NWT. This support included siting, installation, maintenance and calibration of equipment for monitoring programs, as well as development of standard operating procedures and environmental management plans for sample collection and completion of monitoring reports. Also responsible for annual ambient air quality and meteorological monitoring reporting, QA/QC and ongoing client support for the monitoring programs.

**Lafarge Construction
Material Limited
Ambient Air Quality
Monitoring**
Calgary, Alberta

Provided consulting services to Lafarge regarding a proposed gravel pit east of Calgary, Alberta. Work included the preparation of a monitoring plan and guidance to Lafarge on placement options for a particulate and meteorological monitoring system in the vicinity of the proposed operation. Contributed to the monitoring plan and proposal, coordinated the station siting process, procured all necessary monitoring hardware, installed and calibrated the requisite systems, QA/QC and coordinated ongoing client support and reporting.

**Domtar Canada Ltd.
Particulate Monitoring**
Cochrane, Alberta

Conducted short-term particulate monitoring services to Domtar Canada using hi-volume sampling devices. The objective of the work was to obtain estimates of airborne total suspended particulate (TSP) levels in the vicinity of an excavation site. Responsibilities included monitoring plan preparation equipment procurement, installation and calibration, and reporting.

**Inmet Mining
Corporation Izok
Meteorological
Monitoring**
Izok Lake, Nunavut

This project involved implementing and managing a meteorological monitoring program at the Izok Lake Project in Nunavut. The parameters monitored at each site included precipitation, wind speed, wind direction, temperature and solar radiation. The meteorological monitoring formed part of a comprehensive program designed to establish baseline hydrologic and climatic conditions at the proposed mine site. Responsibilities include supervising on-site installation of the meteorological station.



Resumé

CHRIS MADLAND

**OPTI Canada/ Nexen
Canada Air Quality
Modelling Course**
Calgary, Alberta

Through the Golder Institute, Golder prepared a comprehensive two-day course designed to introduce the concepts of dispersion modelling and air quality assessment in the Oil Sands Region. The course comprised eight modules ranging in topic from oil sands history to hands-on modelling exercises using SCREEN3 and CALPUFF. Designed, constructed and demonstrated a scaled Plume Model.

**Miramar Mining
Corporation Doris
North Gold Project EIS**
Bathurst Inlet, Nunavut

Golder prepared an air quality and noise assessment for the Miramar Doris North Gold Project located near Bathurst Inlet, Nunavut. The assessment was prepared to support the Environmental Impact Study (EIS) for submission to the Nunavut Impact Review Board. Air Component/Discipline Lead responsible for air monitoring, data analysis, QA/QC, environmental management planning and report preparation.

**OPTI Canada Inc. Long
Lake Project EIA and
Project Update**
Anzac, Alberta

Golder was responsible for the preparation of the Environmental Impact Assessment (EIA) and subsequent project update for the Long Lake Project, which includes an integrated Steam-Assisted Gravity Drainage (SAGD) facility and upgrading complex. The air quality assessment included an evaluation of the cumulative air pollutant concentrations and acid deposition using the CALPUFF dispersion model (3-D mode). The project update made use of the Golder regional emissions and 3-D meteorological data sets, covering the area from Fort Chipewyan to south of the Cold Lake area. The use of these data sets made the update predictions consistent with the assessment approaches used on the majority of applications filed in the Oil Sands Region, as well as the work being conducted for the NOX-SOX Management Working Group (NSMWG). In addition, the use of the large study area and greater number of sources were effective in addressing all of the concerns raised by Saskatchewan Environment. Responsibilities included ambient air quality data analysis and report preparation.

**Lehigh Inland Cement
Limited Substitution
Fuel Project**
Edmonton, Alberta

Golder was retained to prepare the Environmental Protection and Enhancement Act (EPEA) application for the proposed conversion of the Lehigh Inland Cement facility in Edmonton to allow the use of coal as a primary fuel. The project involved a detailed review of the facility emissions, estimation of resulting off-site concentrations, evaluation of current operations and recommendations for future mitigation. Liaison with regulators during the application process formed an integral part of the air quality assessment. Golder assisted Lehigh Inland through the hearing process and provided expert testimony. Responsibilities included calculation of fugitive emissions, report preparation and technical support of the air quality team that attended the hearings.

**Petro-Canada Oil and
Gas Meadow Creek
Project EIA**
Fort McMurray, Alberta

Golder was responsible for the completion of the Environmental Impact Assessment (EIA) and application to develop a Steam-Assisted Gravity Drainage (SAGD) project in the Athabasca Oil Sands Region. The air quality component of the project evaluated acid deposition in the region as well as local and regional concentrations of sulphur dioxide, nitrogen dioxide, particulate matter, secondary particulates, carbon monoxide, reduced sulphurs, volatile organic compounds, trace metals and polycyclic aromatic hydrocarbons. The CALPUFF model (3-D mode) was used for this assessment. Assisted with emissions calculations and with report preparation.



Resumé

CHRIS MADLAND

**Chevron Canada
Resources Air Quality
Evaluation of the K-29
Facility**
Ft. Liard, Northwest
Territories

A well-test flaring assessment was completed for a proposed gas processing facility near Ft. Liard, NWT. The project involved the estimation of facility emissions and a dispersion modelling analysis of the SO₂ emissions from a flare. The site location was in very complex terrain and required the use of the CTSCREEN model to determine the necessary flare height that would result in no exceedances of the ambient SO₂ guidelines. Involvement in the project included client liaison.

**DeBeers Canada Inc.
Diamond Mine EIA**
Snap Lake, Northwest
Territories

Golder completed an air quality assessment as part of a comprehensive EIA for a proposed diamond mine northeast of Yellowknife, NWT. The project involved the evaluation and selection of dispersion models, quantification of the current and future air emissions for the construction, operation and closing phases of the project. Additional support was provided to the client in response to stakeholders' questions and concerns for the technical hearing. Responsibilities included calculation of fugitive emissions, QA/QC and report preparation.

**DeBeers Canada Inc.
Snap Lake Monitoring**
Snap Lake, Northwest
Territories

The Snap Lake Diamond Mine EIA was in preparation for several years. The original development was owned by Winspear; however, DeBeers later purchased the project. In addition to the EIA, Golder was responsible for the operation and maintenance of the ambient air and meteorological monitoring at the site. Responsibilities included QA/QC.

**Shell Canada Ltd.
Jackpine Mine-Phase 1
EIA**
Fort McMurray, Alberta

Golder was responsible for the completion of the recent Environmental Impact Assessment (EIA) of the Jackpine Mine – Phase 1 Oil Sands mine for Shell Canada. As part of the EIA, Golder was responsible for the completion of the air quality components of the project, which included the use of the Golder's regional emissions database and 3-D meteorological data set. The air quality assessment evaluated air concentrations and acid deposition resulting from cumulative emissions sources across the Oil Sands Region, spanning from Fort Chipewyan in the north to the Cold Lake area in the south. Air quality predictions were made using the CALPUFF dispersion model, run in the 3-D mode. Responsibilities included calculation and summary of facility and regional emissions, and report preparation.

**Government of Canada
Public Works Air
Quality Management
Plan & Review
Development**
Esquimalt, British
Columbia

Golder was retained to prepare a review of the air quality management and monitoring systems currently in place at the Esquimalt Graving Dock near Victoria BC. Project Manager responsible for data analysis, emission calculations, environmental management planning modelling, literature review, meteorological data analysis preparation, regulatory guidance, QA/QC, report preparation and client liaison.

**National Oilwell Varco
National Pollutant
Release Inventory
(NPRI)**
Leduc, Alberta

Golder was contracted to complete the federal 2006 National Pollutant Release Inventory (NPRI) for National Oilwell Varco. Project Manager responsible for data analysis, regulatory guidance, QA/QC, report preparation and client liaison.



Resumé

CHRIS MADLAND

**Strateco Resources
Uranium Exploration
Project Meteorological
Station Installation**
Northern Quebec

Golder was retained to install a meteorological monitoring station at the Strateco Resources base camp in northern Quebec. Component/Discipline Lead responsible for meteorological data analysis preparation, report preparation, meteorological monitoring, training and client liaison.

**DeBeers Canada Inc.
Snap Lake Monitoring**
Snap Lake Alberta

Golder has been responsible for the on-going operation, maintenance and support of the ambient air and meteorological monitoring at the Snap Lake site. Component/Discipline Lead responsible for air dispersion modelling, air monitoring, data analysis, emission calculations, environmental management planning modelling, meteorological data analysis preparation, regulatory liaison, QA/QC, report preparation, client liaison and training.

**Catalyst Paper
Corporation Powell
River Dustfall
Monitoring**
Powell River, British
Columbia

Golder was retained to prepare an application for a permit under the B.C. EMA for a proposed landfill expansion at Catalyst Paper Corporation's mill in Powell River, B.C. The application included a requirement for characterizing dustfall at the site through a monitoring program. Component/Discipline Lead responsible for air monitoring, data analysis, environmental management planning modelling, meteorological data analysis preparation, regulatory guidance, regulatory liaison, QA/QC, report preparation and client liaison.

**Khan Resources
Meteorological Station
Installation**
Mongolia

Golder provided baseline air quality and meteorological support to Khan Resources for a uranium mine in Mongolia. The project included training of on-site personnel to conduct the on-going portion of the program once installation was complete. Component Discipline Lead responsible for air monitoring, meteorological data analysis preparation, report preparation, meteorological monitoring, client liaison and meteorological monitoring training.

**Catalyst Pulp & Paper
Crofton Dustfall
Monitoring**
Crofton, British Columbia

Golder was retained to summarize the dustfall monitoring done for Catalyst Pulp & Paper in Crofton. This data was used for their annual report. Responsibilities included air monitoring and report peer review.

**Hope Bay Mining Ltd.
Doris North Gold Mine
EIA**
South of Cambridge
Bay, Nunavut

Hope Bay Mining retained Golder Edmonton to provide on-going support following completion of an Environmental Impact Assessment (EIA) for their gold mine in Nunavut. The project required that Air Quality and Noise Management Plans be developed. Component/Discipline Lead responsible for air dispersion modelling, air monitoring, emission calculations, meteorological data analysis preparation, report preparation and client liaison.

**Shell Grosmont
Venture In-situ Oil
Sands Project Baseline
Studies**
Wabasca, Alberta

Golder was retained to complete baseline noise, air quality and meteorological data collection for the Shell Grosmont in-situ oil sands project west of Fort McMurray. Component/Discipline Lead responsible for air monitoring, meteorological data analysis preparation, regulatory guidance, QA/QC, report preparation and client liaison.

**DeBeers Canada Inc.
Gahcho Kue Review**
Gahcho Kue, Northwest
Territories

Golder was retained by DeBeers to conduct a peer review of a draft Environmental Impact Assessment (EIA) for their Gahcho Kue Project. The review included the EIA methodology and all technical components, including air quality and noise. Responsibilities included report peer review.



Resumé

CHRIS MADLAND

**Alliance Pipeline
Hazard Assessment**
Saskatchewan

Golder was retained to conduct a hazard assessment of a potential accidental condensate release associated with waste heat recovery at the Alliance Kerrobert facility. Responsibilities included data analysis, hazard assessment and report preparation.

**EXH Engineering
Services Ltd. Mobile
Asphalt Plant Air
Monitoring**
South of Calgary,
Alberta

Golder was retained to conduct a short- term volatile organic compound and polycyclic aromatic hydrocarbon emissions monitoring program for a mobile asphalt plant just south of Calgary. Project Manager responsible for air monitoring, data analysis, report preparation and client liaison.

**DeBeers Canada Inc.
Snap Lake Diamond
Mine Monitoring**
Snap Lake, Alberta

Golder has been responsible for the on-going operation, maintenance and support of the ambient air and meteorological monitoring at the Snap Lake site. Ambient air monitoring compound include particulate matter (TSP, PM10, PM2.5) sulphur dioxide and nitrogen dioxide. Meteorological monitoring includes measurement of wind speed, wind direction, temperature, relative humidity, solar radiation and precipitation. Component/Discipline Lead responsible for air dispersion modelling, air monitoring, data analysis, emission calculations, environmental management planning modelling, meteorological data analysis preparation, regulatory liaison, report preparation, client liaison and training.

**Great Western
Minerals Group Hoidas
Lake Monitoring**
Hoidas Lake,
Saskatchewan

The Hoidas Lake facility (Great Western Minerals Group) is a remote rare earth elements mining exploration camp in the northwest corner of Saskatchewan. Golder conducted a baseline air quality monitoring program at the site to provide data to support a potential Environmental Impact Assessment. Component/Discipline Lead responsible for air monitoring, data analysis, meteorological data analysis preparation, regulatory guidance, QA/QC, report preparation and client liaison.

**Fortune Minerals Nico
Mine Monitoring
Program**
Northwest Territories

Fortune Minerals is planning to develop an underground/open-pit mine approximately 160 km northwest of Yellowknife. Golder was retained to assist Fortune with their application to the Mackenzie Valley Land and Water Board for a Class B water license. This included technical assistance with a feasibility study for Nico Mine open pit and underground project. Ongoing work includes supporting an on-site meteorological and air quality monitoring program. Component/Discipline Lead responsible for air monitoring, data analysis, meteorological data analysis preparation, regulatory guidance, QA/QC, report preparation and client liaison.

**Confidential Client Oil
Processing Facility
Hazard Assessment**
Alberta

Golder conducted a hazard assessment of a potential uncontrolled hydrogen sulphide (H₂S) release from an oil processing facility under a range of meteorological conditions. Project Manager responsible for hazard assessment and report preparation.



TRAINING

Construction Safety Training System

First Aid

OSSA Training

H2S Alive

Cold Lake Air Weapons Range Orientation

Bear Awareness

Class 1 First Aid with Transportation Endorsement, Alberta and BC

Snowmobile Training

Helicopter Safety

Wilderness First Aid

ATV Training

Tower Climbing and Electrical Awareness

Class 1 Driver's License with Air Brake Endorsement

Certified Crew Supervisor – Backpack Electro-shocking

Swift Water Rescue and Powerboat Safety Awareness

Health and Safety Inspections, Module 3

RESUME

GRAEME PAUL CLINTON

514 Knutsen Court, Yellowknife, Northwest Territories, X1A 2Y5, (867) 873 8008

PROFESSIONAL QUALIFICATIONS

MA (Economics), Simon Fraser University (1995)

B. Commerce (Finance and Economics, Honours), University of Saskatchewan (1994)

EMPLOYMENT HISTORY

Principal

Impact Economics, Yellowknife

(January 2004 – Present)

Senior Economist

Economic Services

The Conference Board of Canada, Ottawa/Yellowknife

(February 1999 – December 2003)

Research Associate

Economic Forecasting

The Conference Board of Canada, Ottawa

(May 1996 - January 1999)

EXPERIENCE SUMMARY

Mr. Clinton has built a wide variety of skills working as a professional economist for over 15 years. Graeme is the Principal at Impact Economics offering economic services in a range of development areas, including Northern resource development, socio-economic impact assessments, regional economic analysis and reporting, Aboriginal development planning, and public policy development.

Previously, Graeme held the position of Senior Economist at the Conference Board of Canada. Graeme's thorough comprehension of development economics was honed while working internationally in Ukraine on the *Economic Modelling and Forecasting Project* where he conducted daily technical and training activities, along with some administrative and management duties. He was a member of the Conference Board's national and provincial forecasting teams and was the Board's principal government analyst.

Graeme comes to his work with a strong, theoretical, knowledge base, enhanced by an outstanding academic record in quantitative analysis, development economics and international finance.

PROJECT EXPERIENCE

Current Activities

For Seabridge Gold, Inc., managing and developing the Socio-economic Baseline Study for the Courageous Lake Gold Project.

For the Industry, Tourism, and Investment Division within the GNWT, estimating impacts of future resource development scenarios in the NWT.

For the Nunavut Anti-Poverty Secretariat, research and reporting on poverty issues in Nunavut.

Current Research and Development

NWT Economic Impact Model: update and model testing

Nunavut Economic Impact Model: data collection, research, and satellite model development

Recent Industry and Business related

For De Beers Canada Inc, developing the Economic Impact Report for the Gahcho Kué Mining Project and providing Quality Control on the Environmental Impact Statement.

For Canadian Zinc Corporation, developing the Socio-Economic Impact Assessment for the company's Prairie Creek Mine.

For Sakku Investment Corporation, writing the newsletter *2009 Nunavut Economic Review*.

For the Government of the Northwest Territories, updating the *NWT Mine Models* for all potential resource developments in the Territory.

For Canadian North, researching the economic impact of northern airlines in the NWT and Nunavut.

For the Mining Association of Canada and the NWT-Nunavut Chamber of Mines, authoring the *2008 NWT Diamonds* report.

For De Beers Canada Inc., analysing the employment record of the Snap Lake Diamond Mine against De Beers' commitments to hiring and developing the *Employment Report* for inclusion in De Beers' *Snap Lake Socio-Economic Report*.

For Indian and Northern Affairs Canada, developing a Toolkit to assist Aboriginal development corporations improve the outcomes of their joint ventures in the NWT.

For Zinifex Canada Inc./OZ Minerals, acting as senior technical advisor to the socio-economic discipline lead for the Environmental Assessment of Zinifex Canada Inc.'s Izok Lake Mine, Road and Port Project (this work was conducted as a sub-consultant to Gartner Lee Ltd.).

Recent Northern and Aboriginal Economic Development

For the National Economic Development Committee for Inuit Nunangat, writing the report *Understanding Development in Inuit Nunangat*.

For Nunavut Economic Forum, authoring the *2005, 2008 and 2010 Nunavut Economic Outlook*.

For the Kivalliq Socio-Economic Monitoring Committee, facilitating the committee's meeting and developing its *2009 and 2010 Annual Reports*.

For Nunavut Tunngavik Incorporated, advising on its submission to the Government of Canada as part of the 2009-10 federal budgetary process.

For the Nunavut Economic Forum, advising on its comments to the Government of Canada related to the design of the Northern Economic Development Agency.

For Indian and Northern Affairs Canada, writing economic working papers: *The Impediments to Economic Growth in the NWT*, *The Merits of Economic Growth in the North*, and *Community Economic Development Revisited, A Research Paper Investigating the Misdirected Implementation of CED Principles*.

For the Nunavut Economic Forum, writing *Qaniyiyuq II, The Journey Continues* a Discussion on the Renewal of the Strategic Investments in Northern Economic Development Program for Nunavut, and *Qaniyiyuq, Preparing for the Journey* a Response To Preliminary Consultations with Nunavut by the Honourable Larry Bagnell, Parliamentary Secretary to the Minister of Indian Affairs and Northern Development.

For Qaujisaqtiit Society, investigating the contribution of non-government and non-profit organisations to Nunavut's economic, social and environmental well-being.

For NWT Treaty 8 Corporation, developing the report Economic and Social Development on Akaitcho Dene First Nations' Land.

For Heritage Canada, researching economic growth and labour supply issues in the NWT, with particular attention paid to diversity management issues and social inclusion.

For NWT Regional Program Management Advisory Committee and Indian and Northern Affairs, facilitating and designing Committee's four year *Strategic Plan*.

For Transport Canada, providing socio-economic research for Canada's Arctic communities as well as coastal Cree communities in Quebec, Ontario and Manitoba for input into a study assessing Canadian Arctic shipping.

For Indian and Northern Affairs Canada, reviewing and revising the federal government's *Community Economic Development Program Annual Report*.

For Indian and Northern Affairs Canada, investigating joint ventures in the NWT for the purpose of providing advice to Aboriginal development corporations for their future business arrangements.

For Indian and Northern Affairs Canada, authoring a discussion paper

For Nunavut Tunngavik Incorporated, writing

For the Nunavut Economic Forum, authoring the 2005 Nunavut Economic Outlook, An Update on Five Years of Progress.

For the Government of the Northwest Territories, completing a comprehensive review of economic programming within the GNWT.

For the Nunavut Association of Municipalities, researching the territory's infrastructure gaps and developing a planning mechanism for prioritising infrastructure investment in communities.

In Nunavut, working with the Sivummut Economic Development Group in creating the territory's *Nunavut Economic Development Strategy*.

For Indian and Northern Affairs Canada, studying the Aboriginal food and fur industries as they relate to community economic development and improved food autonomy within Aboriginal communities.

For the Government of the Northwest Territories, investigating the territory's medium- and long-term economic strategy and publishing *Setting the Pace for Development, an NWT Economic Outlook*.

For Heritage Canada, developing a methodology to assess the contribution of the Arts and Crafts Industry to Nunavut's economic development.

For the Government of Nunavut, the Nunavut Tunngavik Corporation and Indian and Northern Affairs Canada, developing *Nunavut's Economic Outlook* – the Territory's first long-term economic forecast – which focussed on the development of Nunavut's four forms of wealth-creating capital.

General Applied Macroeconomics

For the Tourism Division in the GNWT, developing a user guide for the Tourism Economic Impact Model.

Designed and built the NWT Economic Impact Model to evaluate how the opening and closing of major projects affect people in the North.

For the NWT Economic Development Advisory Forum, writing and communicating results from simulations of NWT's Input-Output model of the territorial economy.

For General Motors, delivering a monthly and quarterly forecast of automobile sales in Canada, reporting on industry and market conditions.

For the British Columbia Medical Association, studying the long-term impact of an ageing population on the cost of health care to the provincial government.

For the British Columbia Department of Finance, studying the impact of provincial government spending initiatives and tax policy changes on the BC economy, including an analysis of policy suggestions developed at the *BC Business Summit*.

For the Conference Board's Canadian and Provincial Outlooks, producing the forecast for federal and provincial government activities, provincial demographics, Canada's agriculture sector, and several provincial economies.

International Economic Development

For the Canadian International Development Agency, working on the *Economic Modelling and Forecasting Project in Ukraine*. The project was designed to provide government officials with an understanding of economic policy issues during the country's transition to a free-market system. The primary tool for delivering this training was the construction and application of a socio-economic database and a macroeconomic model. At times during the project's second year, acted as project co-ordinator.

Other

Contributing author to the Arctic Communications Infrastructure Report: *A Matter of Survival, Arctic Communication Infrastructure in the 21st Century*, prepared for the Northern Communications and Information Systems Working Group.

Extensive modelling work within the National and Provincial Medium-Term Forecasting Models including the national and provincial government blocks, the provincial trade, residential investment, and employment blocks, and several output blocks.

Federal and provincial budget analysis and evaluation.

Attachment 1

Comments on Government Agency Technical Reports

COMMENTS ON GOVERNMENT AGENCY TECHNICAL REPORTS

Canadian Zinc Corporation (CZN) is pleased to provide comments below on the Technical Reports submitted by government agencies as part of environmental assessment EA0809-002. Technical replies to the reports are provided, where necessary, by stating CZN's position with respect to recommendations made. Recommendations that CZN has no comments on are not included. Where the status of a particular issue has been superseded by a submission or commitment since the Technical Reports were issued, this is noted.

Aboriginal Affairs and Northern Development Canada (AANDC)

Site Specific Water Quality Objectives and Effluent Quality Criteria

Recommendation 1: INAC recommends that the Developer be required to establish and present Site Specific Water Quality Objectives (SSWQO's) for the Prairie Creek Mine using the Reference Condition Approach consistently across all parameters. A committee consisting of the Developer and interested parties to the Environmental Assessment will evaluate the appropriateness and practicality of these generated SSWQO's. The committee will report back to the Review Board with a recommendation on appropriate SSWQO's for Prairie Creek, prior to the Review Board's closure of the public registry for EA0809-002.

CZN does not agree that it is necessary to establish SSWQO's for the Prairie Creek Mine using the reference condition approach (RCA). We believe parameter concentrations can be higher than RCA values, and still not pose a significant risk for adverse effects or ecological change.

Recommendation 2: INAC recommends that Effluent Quality Criteria (i.e. Maximum Grab Concentrations) must be back calculated from SSWQO's based on the Best Estimate inflow prediction.

We understand that the establishment of Effluent Quality Criteria (EQC) is the purview of the Mackenzie Valley Land and Water Board (MVLWB), CZN believes that a simple, fixed concentration approach for EQC is impractical because of the substantial seasonal variation of receiving water flow rates. CZN has proposed a load-based approach to discharge control, which would ensure SSWQO's are met and also allow flexibility in site water management.

Recommendation 3: INAC recommends that CZN must not discharge effluent that has concentration(s) above the stipulated Maximum Grab Concentrations in the Water Licence.

In principle CZN is in agreement, except that the concentrations should vary based on discharge and creek flows.

Recommendation 4: INAC recommends that any discharge from the end-of-pipe must meet the Maximum Average Concentrations as stipulated by the Surveillance Network Program (SNP) in the Water Licence. Detailed instructions on the method and timing for sampling, deriving and reporting regulated average concentrations should be specifically outlined within the SNP.

As for Recommendation 3. We expect the MVLWB to outline the basis for and mechanism of how discharge concentrations may vary in the SNP.

Water Management and Storage

Recommendation 1: INAC recommends that the Developer provide the following information regarding tailings and water management prior to closure of the public record for EA0809-002:

a) A detailed mining and paste backfill schedule be produced by CZN to demonstrate that float tailings will not accrue in Cell A of the WSP.

This was completed following the Public Hearing as an undertaking dated July 7, 2011.

b) A detailed description of all operational contingencies that may be implemented to maintain the working capacity of the WSP for the life of the mine, if or when required.

This was provided in Table 1 attached to a May 6, 2011 letter from CZN to the Review Board. The motivation for this recommendation is that AANDC feels there is insufficient storage capacity in the Water Storage Pond (WSP) for unforeseen events. CZN does not believe AANDC has adequately accounted for CZN's plans and contingencies. CZN simulated four scenarios of mine water inflow covering a wide range of flows. Process water flows remain constant, so are predictable. Redundancy of capacity in the Water Treatment Plant (WTP), spare part availability and back-up power will mean that WTP operation, when required, will have very little down-time. AANDC made an error in the example given on page 15 of their report. They state that an EQC or acute toxicity failure in early spring could mean that the 10,000 m³ contingency would be exceeded in approximately 4.4 days. The error is that such a failure would be due to process water treatment from Cell A, but that cell would have an available storage contingency of approximately 35,200 m³ at that time (AANDC assumed the contingency for Cell B, the mine water cell). This contingency would provide approximately 40 days of process water storage without treatment.

Since the Public Hearing, CZN has been in discussions with AANDC and other parties regarding SSWQO's, and as a compromise, has proposed to meet stricter objectives. A consequence of this is a need for additional storage capacity in order to provide greater water management flexibility. Hence, CZN has committed to increase storage capacity and contingency volumes.

In-Stream Mercury Concentrations

Recommendation 1: INAC recommends that CZN collect and analyze additional samples (seasonally representative) using a sufficiently low detection limit to permit development of a site specific water quality objective for mercury in Prairie Creek using the Reference Condition Approach.

This sampling has been initiated, although CZN has not agreed to adopt an objective based on the RCA using the data.

Recommendation 2: INAC recommends that CZN identify whether increases in mercury concentrations resulting from their discharge can meet this Reference Condition Approach objective, and quantify the level of impact in Prairie Creek resulting from increased concentrations of mercury.

CZN has demonstrated that an objective can be met which will avoid significant impacts. CZN has also demonstrated that bio-accumulation and bio-availability of mercury is highly unlikely.

Initial Dilution Zone (IDZ) and Dilution in Prairie Creek

Recommendation 1: INAC recommends that in-stream water quality must meet SSWQO's, derived using the Reference Condition Approach, at the edge of a predefined assessment boundary (e.g. vertical mixing zone, horizontal mixing zone, NNPR boundary). The location of the assessment boundary for the Prairie Creek Mine would have to be determined in conjunction with the establishment and evaluation of SSWQO's for Prairie Creek

CZN has proposed to meet objectives protective of the environment (not objectives based on the RCA) at the edge of an IDZ that is 100 m from the point of discharge. We note that the NNPR boundary is approximately 7 km downstream, and that there will be additional dilution and attenuation of parameters by the time the water reaches this location.

Effluent Discharge

Recommendations 4: INAC recommends that no effluent be discharged via the culvert into Harrison Creek unless an emergency situation has been declared for the site by the Mackenzie Valley Land and Water Board (MVLWB). Any discharges to Prairie Creek via Harrison Creek must be short term in duration to avoid potentially increased effects to the environment from the mine site. During this scenario a specific Emergency Plan, approved by the MVLWB, must be followed by CZN. This Emergency Plan should include a complete shut down of mining and milling operations.

An emergency situation could occur at very short notice, in a matter of hours. The site is remote and external communications are not always reliable. Therefore, it is impractical to require the MVLWB to declare an emergency before discharge via the culvert into Harrison Creek occurs. We agree that any discharges to Prairie Creek via Harrison Creek must be short term in duration. However, we disagree that the discharge should include a complete shut down of mining and milling operations. The operations could likely continue without any influence on the Catchment Pond. A restriction of not releasing treated water to the Catchment Pond during a discharge to Harrison Creek would be appropriate.

Post-Closure Conditions

Recommendation 1: INAC recommends that post closure water quality must meet SSWQO's derived using a Reference Condition Approach. This would be determined in conjunction with the establishment and evaluation of SSWQO's for Prairie Creek.

We agree that post closure water quality must meet objectives that are protective of the environment, but as for operations, we do not agree that these must be based on the RCA.

Recommendation 2: INAC recommends that CZN develop a Preliminary Closure and Reclamation Plan, during the regulatory phase prior to water licence issuance. The plan must be developed in consultation with regulators, stakeholders and other interested parties. The plan should developed in accordance with INAC's Mine Site Reclamation Guidelines (January 2007) or subsequent version.

CZN does not agree with this recommendation, or the preamble supporting it that contains the following statements:

- “There is little discussion or details on the predicted long-term performance of closed mine components”
- “CZN has provided very little assessment of the post-closure impacts to Prairie Creek”
- “CZN has not indicated what they would do if the groundwater monitoring plan identified poor water quality entering Prairie Creek”

The sources of potential post-closure impacts are mainly the backfilled underground workings and the covered waste rock pile. Extensive simulations and predictions were completed to assess post-closure impacts. Predictions indicated that objectives will be met, although this will be confirmed by monitoring. The contingency if monitoring indicates that objectives may not be met is to ‘pump and treat’ water from the mine ‘pool’ until conditions have stabilized.

CZN provided a draft Closure and Reclamation Plan (CRP) in DAR Appendix 27, supported by the extensive geochemical and water quality predictions contained in other parts of the document. The creation of another document during the regulatory phase will only be a consolidation of existing information and will serve no real purpose. The questions to be answered at this point are: Has the proposed development properly planned for closure? Are the proposed closure actions feasible? Are post-closure impacts significant, and if yes, can they be mitigated? We believe these questions have been answered. Investigation and monitoring data will be collected during the initial period of mine operation which can be used to update predictions of potential post-closure impacts. We submit that a more appropriate timing for a CRP update would be after 5 years when the Water Licence is renewed, at which time the results of updated predictions will be available. At that time, current guidelines can be used.

Aquatic Effects Monitoring Program (AEMP) and Adaptive Management

Recommendation 1: INAC recommends that Canadian Zinc Corporation follow the “Guidelines for Designing and Implementing Aquatic Effects Monitoring Programs for Development Projects in the Northwest Territories, June 2009” in the development of its Aquatic Effects Monitoring Program, action levels, and related management response framework for the Prairie Creek Mine. This work should commence in conjunction with the establishment and evaluation of SSWQO’s for Prairie Creek.

We agree, although we believe the work can be completed during the licencing phase, and CZN would not object to an approved AEMP being a condition of the Water Licence.

Access Road – Land Disturbance, Road Construction and Operation

Recommendation 1: INAC recommends that local ground temperature measurements define the commencement of road construction activities using equipment other than low pressure ground vehicles, in areas where road construction relies on frozen ground.

The following advice was provided by Kledo Construction. Based in Fort Nelson, Kledo undertakes considerable winter road construction in the region:

“Kledo is unaware of any other locations or projects that require the installation of ground temperature cables to measure ground temperature (frozen conditions) to determine weight bearing capacity. In the description provided by INAC, these are simple single point data collection devices, but the ground conditions (soil type and depth) can be highly variable along the length of the road. The road can change from deep muskeg to deep rock in places. The depth of the cables can be highly subjective and it is unclear what circumstances would permit a

decision key on proceeding with the water trucks or other equipment. Experienced supervisors and equipment operators are able to manage the early phases of road construction by their observations of ground conditions and the impact of overnight freezing temperatures. We feel that the use of temperature measuring devices is unnecessary.”

Recommendation 2: INAC recommends that local ground temperature measurements define the duration of the road operating season, in areas where road operation relies on frozen ground.

For the same reasons as those given in Recommendation 1, we disagree. Inspectors and operators are better able to make decisions based on experience, and observations on ground conditions and the ability to support vehicles without rutting or other impacts.

Access Road – Permafrost Degradation, Road Construction and Operation

Recommendation 1: INAC recommends a permafrost assessment be conducted along the access route to identify areas requiring implementation of measures to ensure the integrity of the underlying permafrost. Road construction/operation methods to maintain the organic layer in permafrost areas should be defined in advance of initial road construction.

CZN has previously indicated an intention to investigate specific areas that might contain permafrost along the proposed road re-alignments. The areas are immediately west of the Polje Creek crossing, and south-east of Wolverine Pass through the Silent Hills. Investigation of the existing alignment is not considered necessary. Investigations will include the installation of thermistors, and results will be used to determine suitable road construction/operation methods.

2. INAC recommends that construction of access through side slopes containing permafrost, specifically ice rich ground, should be avoided where possible. Where unavoidable, site-specific stabilization measures should be developed and approved by regulators prior to implementation.

We agree, except that, as measures may need to be developed or modified according to conditions at the time, approval should be the responsibility of the Inspector only so as not to impede construction progress.

3. INAC recommends that ground temperature monitoring data should be collected along the access road itself and in adjacent undisturbed terrain where permafrost is present, to evaluate the success of operational measures to prevent the degradation of underlying permafrost.

See answer to Recommendation 1 above.

Access Road – Sediment Inputs

Recommendation 1: INAC recommends that a Sediment and Erosion Control Plan be developed in advance of mine operations. This Plan should include an assessment of the erosion sensitivity of the mine site as well as proposed watercourse crossings along the access route. Further, site-specific mitigation measures to prevent erosion should be defined.

CZN has already committed to produce a sediment control plan for the access road. However, we see no need for such a plan for the mine site. There will be no disturbance of watercourses in the mine area since the majority of structures already exist. The waste rock pile (WRP) will be a new structure and will have runoff diversions. The WRP detailed design document will include specifications for the diversions and measures to limit sediment production and dispersal.

Recommendation 2: INAC recommends that erosion control measures identified within the Plan be implemented in advance of operations.

Erosion control measures for the road will be implemented at the time of road construction, since road access will be required to allow their implementation. The creek crossing at Km 22.5 will be avoided by use of a span structure. The Polje Re-Alignment avoids three creek crossings in favour of one crossing with a span structure. The other re-alignments will move the road out of lowlands and away from waterbodies. All of these measures are positive in terms of erosion control.

Recommendation 3: INAC recommends that routine monitoring of erosion susceptibility at watercourse crossings along the access road should be conducted. If issues are identified, maintenance/mitigation measures should be implemented in as timely a manner as possible.

CZN has already committed to this also.

Access Road – Post Closure

Recommendation 1: INAC recommends that the Closure and Reclamation Plan include the entire length of the access road.

The CRP in Appendix 27 of the DAR addressed the main components of the proposed changes to the access road and transfer facilities. A land use permit already exists for the existing access road. We agree that a CRP for the road should include the entire road. However, we suggest that a CRP for the road at the permitting stage need only consider broad concepts, which can be fleshed-out with detail as operational history and experience is accumulated.

Access Road – Spills

Recommendation 1: INAC recommends that an assessment of the risk and consequence of spills along the access road be conducted by product type. This evaluation should dictate operational procedures, implementation of preventative/mitigative measures, and response measures for potential spills.

In Appendix I of our March, 2011 2nd Information Request reply, we conducted an assessment of the risk and consequence of spills along the access road by product type. We also provided mitigation measures in response to the assessed risks, and undertook to review these for effectiveness and implementation as part of the process for development of a suitable Spill Contingency Plan. We remain of the opinion that this is the appropriate course.

Environment Canada

Water and Effluent

Recommendation 1: Any change from background water quality will potentially result in changes to the ecosystem. Setting objectives for Prairie Creek downstream of the proposed mine will require a value judgment be made as to the degree of change which is acceptable, and determining how far down the receiving environment stream change is acceptable. Environment Canada is available for further discussions on appropriate SSWQO's, but will defer to Parks Canada and the Board on making this determination.

In general, CZN is in agreement with “a value judgment be made as to the degree of change which is acceptable” (to the ecosystem). We believe the water quality objectives we have proposed will result in little to no change to the ecosystem within the NNPR, and we believe the park boundary is the location where consideration of the ‘degree of change’ should be made.

In the “degree of change” judgment, an important aspect requires consideration, and it is the existing downstream water quality. Water quality downstream of the Mine in the park is different from that upstream, as recorded by the Environment Canada monitoring data. It is not clear what part of the difference is related to the signature of natural mineralization, of which the Mine area is surely the largest, and what part of the difference is related to Mine development-related discharges. However, the relative contribution of each is immaterial to the ‘degree of change’ question. Given that the mine development has been present for over 30 years, the existing downstream ecosystem has adapted to downstream water quality, and that water quality should be the basis for the ‘value judgment’.

Recommendation 2: EC notes that low detection limits will be needed for the on-site analytical instruments, if they are to be used for aquatic effects monitoring, and thus to evaluate whether the mine is meeting water quality objectives.

CZN plans to analyse for metals on-site to allow for timely tracking of water quality. Given the concentrations likely to be required in the discharge, relatively low detection limits will be required. However, on-site analyses will not be relied on for important regulatory samples. Duplicate samples representing 10-20% of the total will be sent off-site for analysis, and the important regulatory samples can be included in the off-site batch.

Recommendation 3: Winter baseline water quality data for Prairie Creek should be augmented to strengthen the dataset, and CZN should subsequently review the SSWQO's.

This sampling has been initiated with the intention of using the data in a process to establish final SSWQO's at the permitting stage.

Recommendation 4: Low level mercury analysis should be done for upstream samples, both in summer and under ice, and results used to re-evaluate the SSWQO for mercury.

As for Recommendation 3.

Recommendation 5: The nitrite SSWQO discrepancy should be clarified, with the lower value deemed more appropriate.

This will also be completed as per Recommendation 3.

Effluent Quality

Recommendation 6: Alteration of the water quality in Prairie Creek will need to be minimized through achieving the best possible effluent quality, and careful management of discharges. Further details should be developed to determine if the use of a load-based approach would be feasible.

CZN believes that the effluent discharge approach that will result in the lowest potential for impacts is the load-based approach, where the load discharged is varied according to flows in the

receiving environment. The allowable load for discharge at any point in time is based on discharge and creek flow measurements in real time, discharge concentrations based on on-site analysis of metals, and previously defined upstream concentrations.

Recommendation 7: Maintaining the 500:1 ratio of creek water to process water would also rely on real-time flow data; this option should be further developed.

If a load-based approach to discharge control is adopted, real-time flow data will be required, and CZN agrees to work with regulators to address uncertainties.

Recommendation 8: Increasing storage capacity of the WSP should be evaluated for feasibility and implications on water balance and management.

The August 21, 2011 submission by CZN included a commitment to develop additional storage capacity.

Contaminants Management

Recommendation 16: EC recommends that the Proponent develop and implement a Contaminant Loading Management Plan (CLMP). The CLMP should be developed in consultation with EC and the GNWT and should include but not be limited to the following:

- *Identification of potential sources of contaminant loading;*
- *Description of all potential mitigation approaches available, including all of the mitigation strategies used at other mines;*
- *Identification of mitigation approaches to be employed at the Prairie Creek mine;*
- *Description of the monitoring program, including both baseline monitoring and monitoring during mining operations;*
- *Description of trigger levels or action levels above which adaptive management and contingency plans need to be implemented;*
- *Description of adaptive management and contingency plans to be employed if trigger levels are exceeded;*
- *Annual reports presenting the following information:*
 - *Results from the dust fall and soil monitoring program;*
 - *Assessment of the effectiveness of current mitigation; and*
 - *Description of any adaptive management or contingency employed*
- *Monthly data reports within thirty days following the reporting month for at least the first year after mine operations and the transport of concentrate begins.*

In principle, CZN is not opposed to writing a CLMP. This would be a suitable document to consolidate the relevant information on mitigation, monitoring, trigger levels, adaptive management and reporting. However, we believe the relevant information largely already exists in previous documents, and we do not foresee developing new or additional mitigation approaches. Regarding data reports, we believe the suggested monthly frequency is onerous and unnecessary. Predictions indicate that emissions will not be significant, and any dust fall will not accumulate rapidly. We suggest an initial quarterly report schedule, with reports submitted before the end of the next quarter. This schedule should be reviewed after the first 2 years, and adjusted accordingly.

Recommendation 17: EC recommends that the Proponent employ secondary containment on the flat deck trailers during the transport of lead/zinc concentrate to mitigate spillage or escapement due to bag malfunctions or accidents.

In their Technical Report, Environment Canada continues to inappropriately compare the historical activities of the Red Dog Mine and Pine Point Mine to the Prairie Creek proposal. The historical activities of the mines included bulk transport of concentrates in open trucks, year-round. As noted in our 1st IR reply, the Prairie Creek bagged concentrate transportation plan is modelled after the Eskay Creek mine which produced a zinc/gold concentrate requiring multiple storage locations, with bags transported by both road and rail between the mine and the smelter. Due to the short winter road haulage window, the Prairie Creek Mine also requires interim storage locations (three, Tetcela, Liard and Fort Nelson) serviced by trucks prior to rail gondola loading.

A detailed bagging strategy for Prairie Creek is provided in Appendix N. CZN's focus is to have clean bags leaving the bagging plant and the concentrate storage shed. The filled bags will be cleaned with a compressed air lance before leaving the bagging building so that no concentrate is transferred to the floor in the concentrate storage building. If the bags are punctured at any of the storage areas, the punctured bag will be slipped into a new bag and any spillage recovered (as per the Eskay operating method). Trucks shall not enter the concentrate storage building. A simple truck-loading bay similar to the Eskay load out at Kitwanga will be used where the trucks drive by, not through, the concentrate storage shed so that they cannot track concentrate out of the building. Because of the multiple storage locations needed for Prairie Creek, and the handling involved, secondary containment is not practical. Further, with the proposed bagging strategy and the fact that hauling will occur in winter (the concentrates will be frozen), we do not believe secondary containment is necessary. We will be undertaking sampling and dust monitoring along the haul route to verify assumptions and the effectiveness of mitigation measures.

Prairie Creek should not be compared to the Red Dog Mine in terms of concentrate management. The Red Dog operation is all season, with one road transfer from the mine to the port site. Red Dog now transfers bulk concentrate in mechanically sealed truck containers. These do not have secondary containment. Capstone Mining's Minto Mine in the Yukon was transporting bagged concentrates on open flat-deck trailers after start-up. Since they are an all season operation without multiple storage locations, they have since changed to mechanically sealed truck containers.

Wildlife

Recommendation 23: The primary mitigation measure for each species should be avoidance. The proponent should avoid contact with or disturbance to each species.

We agree, to the extent possible and practical.

Recommendation 24: The proponent should consult with Parks Canada and the Government of the Northwest Territories (GNWT-ENR) and appropriate status reports, recovery strategies, action plans, and management plans to identify other appropriate mitigation measures to minimize impacts on Woodland Caribou (Boreal and Mountain populations), Grizzly Bear, Wolverine, Peregrine Falcon, Wood Bison, Short-eared Owl, Rusty Blackbird from the project.

The Draft Wildlife Management Plan developed by CZN outlines approaches for mitigation measures to minimize impacts to wildlife, including the listed species. Agency comments on the

plan will be incorporated into a revised document. CZN will consult with government agencies when the need for additional mitigation measures is identified for species at risk.

Recommendation 25: The proponent should develop monitoring plans for each species in accordance with any applicable status reports, recovery strategies, action plans, and management plans and in consultation with Parks Canada, the GNWT and EC.

The Draft Wildlife Management Plan developed by CZN outlines monitoring plans for caribou (mine site and road) and Dall's sheep (primarily mine site). Since operation of the haul road will be from early winter to late winter, effects on listed birds are not expected to occur; therefore, monitoring is not considered necessary. The mitigation measures outlined in the Draft Wildlife Management Plan deal with grizzly bears and wolverines, primarily through management of waste materials at the mine site and along the haul road, and measures to reduce potential for conflict between workers and bears. These mitigation measures will be further developed through on-going updates to the Draft Wildlife Management Plan by CZN. Potential issues related to operation of the haul road and bison near Nahanni Butte will be addressed in on-going updates to the Draft Wildlife Management Plan by CZN. Possible approaches for dealing with bison have been discussed with NWT ENR (Nick Larter) and are associated with use of GPS units in haul trucks and radio communication of bison locations to alert other drivers to those locations. This approach has been used along the Liard Highway in the past and can be adapted for the Prairie Creek haul road.

Recommendation 26: Vegetation clearing and roadbed preparation for existing and proposed sections of the mine access road should be conducted either before May 7 or after August 10, to avoid the migratory bird breeding season.

CZN will carry out vegetation clearing and roadbed preparation along the proposed new sections of the access road outside of the specified migratory bird breeding season. Where summer maintenance activities are necessary for the western portions of the haul road (near the mine), a bird nest survey will be carried out prior to the work. If an active nest is found, then a no-work buffer of 20 m will be established around the nest location until the nest is no longer active. CZN is familiar with the Active Migratory Bird Nest Survey protocols of CWS and will follow those protocols.

Recommendation 27: Vegetation clearing for the waste rock storage area should also take place outside of the migratory bird breeding season.

The footprint of the Waste Rock Pile is a sparsely vegetated, rocky area, previously disturbed by access roads and drill pads (see Figure 6-14 in the DAR). The area is frequently utilized on an annual basis. The potential for the presence of migratory birds is low. Further, site clearing activities are most likely to occur in the summer when snow is absent and conditions are usually dry. Therefore, it is impractical and unnecessary to restrict vegetation clearing to outside of the migratory bird breeding season for this area.

Recommendation 28: For upper sections of the access road undergoing summer maintenance, CZN should conduct nest surveys before work commences. If an active nest is found, the area should be avoided until nesting is completed (i.e. the young have left the vicinity of the nest).

See answer to Recommendation 26 above.

Recommendation 29: Environment Canada recommends that the Proponent undertake the following predator control measures:

- *All wildlife should be prevented from gaining access to liquid and solid waste and other wildlife attractants such as petroleum products;*
- *All structures should be designed to preclude nesting and roosting sites for avian predators (including ravens) or den sites for mammalian predators. The proponent may consult with EC-CWS staff regarding design measures that could be taken;*
- *Orientation for project personnel should include best practices with regard to waste management and avoiding wildlife; and,*
- *Regular surveillance of facilities and project waste sites for the presence of wildlife to ensure that the predator control measures are effective.*

We agree, The Draft Wildlife Management Plan prepared by CZN outlines approaches and measures for handling and storage of potential attractants at the mine site and along the haul road. These approaches and measures will be further developed through subsequent updates to the Draft Wildlife Management Plan.

DFO

Recommendation 2: DFO recommends that fish passage be maintained at all times of the year and that specific parameters be monitored to ensure fish passage such as temperature, flow, and total suspended solids.

Exfiltration trench design includes the objective and provision for fish passage year-round. CZN commits to temperature, flow and TSS monitoring when discharge to the trench is occurring. Depending on the magnitude of inflows underground, and the resulting water management strategy, there may be a significant period in winter when no discharge to the trench occurs. Monitoring as described would not be necessary during such a period.

Recommendation 5: DFO recommends that CZN follow DFO's "Protocol for Winter Water Withdrawal from Ice-covered waterbodies in the NWT" as well as "DFO Freshwater Intake End-of-Pipe Fish Screen Guidelines". Bathymetry on all lakes should be provided to DFO prior to the regulatory phase, as well as an indication of the effect of drawdown on the bathymetry resulting from winter water withdrawal.

CZN commits to following the said protocols, and to providing bathymetry for lakes proposed to be used for water withdrawal. CZN understands that bathymetry must be provided and DFO's approval gained before water withdrawal can occur. However, we do not agree that this should occur prior to the regulatory phase. The timing of data collection should remain flexible and subject to the overall project schedule and development plan.

Recommendation 7: DFO recommends that CZN ensure that aggregates will not be removed from within the high water mark of any streams or rivers, and to identify borrow site locations such that potential stream crossings to access them can be identified.

CZN will ensure that aggregates will not be removed from within the high water mark of any streams or rivers. Proposed borrow site locations were identified on road maps contained in Appendix C to the 2nd IR reply. We also confirmed that additional stream crossings were not required to access them.

Recommendation 8: DFO recommends that CZN develop and implement an Aquatic Effects Monitoring Program (AEMP) to monitor and detect change in the Prairie Creek aquatic ecosystem. A multi-trophic approach (such as the INAC's 2009 Aquatic Effects Monitoring Program Guidelines) should be used. The AEMP should be within an adaptive management framework, where thresholds, triggers and management actions are identified.

See answer to AANDC, 'Aquatic Effects Monitoring Program (AEMP) and Adaptive Management', Recommendation 1.

Recommendation 9: DFO recommends that CZN develop a comprehensive Closure and Reclamation Plan in consultation with, and to the satisfaction of all interveners.

See answer to AANDC, 'Post-Closure Conditions', Recommendation 2.

Parks Canada

Access Road

Recommendation 2: After each spill, adequate monitoring occur to assess the impacts and effectiveness of clean-up. If the spill occurs within the karst area, monitoring should occur for an extent appropriate to the potential of impacts in the karst system.

We agree that after each spill, adequate monitoring should occur to assess the impacts and effectiveness of clean-up. We believe this monitoring should be tailored to the nature of the spill and the location, no matter where it is. The road does not cross exposed karst pavement. Where the road crosses karst, there is a soil cover for the most part. Therefore, the impact of any spills may be quite superficial, and pose no risk to the underlying karst. In this case, monitoring need not be any different to what would occur in non-karst areas.

Recommendation 3: Monitoring of the approximately 10 km of road through the intense karst landscape will include the following:

- *Initial recording of sinkhole features and other closed depressions would consist of specifically identifying, briefly characterizing and photographing each feature within a zone at least the maximum diameter of karst subsidence features in the area. Each feature would be mapped onto ortho-corrected, high resolution satellite imagery and given a unique identifier. The attributes of each feature, along with associated photos and other related data (date, category of sink hole, etc.) would be handled within a geographic information system. (Response to IR Round 1 Parks_Canada 9.3).*

This accurately reflects the recommendations made by Golder Associates in their reply to Parks Canada's 1st round IR 9.3 (see Appendix D to the 1st IR round reply).

- *Monitoring of sinkhole features and other closed depressions be carried out within a zone width that is at least the maximum diameter of karst subsidence features, by re-photographing the corridor and making an image comparison with the original image. (IR Round 1 Parks_Canada 9.3) Monitoring of formation and development of new sinkholes and caves by visual inspection, and monitoring of settlement within the karst area to assess if road operations are impacting the karst. Minimum frequency of visual monitoring should be twice yearly during times of limited to no snow cover.*

The first part of the above paragraph is also consistent with the recommendations made by Golder Associates in their reply to Parks Canada's 1st round IR 9.3. Golder proposed to conduct monitoring 200 m either side of the access road. Any differences in features, or new features, occurring in this zone would be recorded. Regarding monitoring frequency, Golder recommended "that the review of potential subsidence features be repeated after the first winter of road operation, and a decision made at that time regarding the frequency of review thereafter, depending on the results obtained". We understand that the expected change in subsidence features, if any change occurs at all, would be very slow over a prolonged period. Therefore, we believe Golder's suggestion is appropriate rather than a fixed, pre-determined, minimum twice yearly interval.

- *Monitoring of surface water flow patterns (and potentially quantity) in the intense karst region adjacent to the road to assess if road operations are altering the natural drainage patterns.*

We agree that surface water flows should be monitored, but from the perspective of erosion and sedimentation control. The road is not expected to have any significant effect on surface flow patterns, and certainly not to a degree that would warrant the monitoring of flow quantities, which will vary according to climatic and gross terrain morphology (i.e. slumps) factors. This is a winter road proposal and surface waters would be frozen during operations.

- *Monitoring of surface water quality in the intense karst region to assess if road operations are altering the quality of water.*

Unless there is a significant spill, and monitoring of the spill site indicates that all spilled material may not have been recovered, routine surface water monitoring is considered to be unnecessary. Also, access to monitoring locations would be onerous when the road is not available. However, monitoring during the open water season could be considered on an opportunistic basis if other work is occurring in the area, but surface water quality monitoring should not be the prime reason for the work.

- *Monitoring of groundwater originating or passing under the intense karst region to assess if road operations are altering groundwater levels and background groundwater quality.*

We strongly disagree with this recommendation based on justification and technical considerations. Regarding justification, see our answer to Recommendation 2 above. Also, there is no credible scenario where road operations could significantly alter groundwater levels. Groundwater quality data would be of interest if there is a significant spill, and monitoring of the spill site indicates that all spilled material may not have been recovered. However, it would be more practical to monitor surface water quality downstream of where groundwater discharge to surface water is expected to occur, and to monitor seeps or springs. Groundwater movement in karst terrain is notoriously heterogeneous. A significant number of monitoring wells could be installed and still fail to intersect the main pathways of flow. Therefore, groundwater monitoring with wells is considered impractical.

Recommendation 4: Monitoring for invasive species should occur along the road corridor and any associated footprint of the development. The extent and design of this monitoring should be based on the biological attributes of potential invading species.

Two surveys for invasive species were conducted recently and did not detect any. The potential for invasive species introduction to the area, and survival, appears to be low. Periodic monitoring may be appropriate to verify this. However, this monitoring should initially be no more frequent than every 3 years, and less frequent if surveys continue not to detect invasive species.

Recommendation 6: Management of traffic when wildlife are on/near the road will be detailed in the wildlife management plan, but will include:

- *Stopping traffic when wildlife are within 50 m to allow them to cross.*

The draft Wildlife Mitigation and Monitoring Plan (WMMP) has language providing guidance to avoid vehicle-animal collisions. The recommendation as worded could unnecessarily restrict traffic movements that are not a risk to wildlife. If wildlife are within 50 m of the road AND are moving in a direction indicating that they will cross the road, then it may be prudent for traffic to stop and wait for them to cross. If wildlife are within 50 m of the road but are not moving in the direction of the road, or not moving at all, then traffic should reduce speed and proceed with caution.

- *Only hazing when there is a danger to people or wildlife.*

We believe hazing means different things to different people, and for that reason should not be used. In this context, we assume it means moving animals from a traffic area. Depending on how this is done, and by whom, this might be considered to be harassment. In general, CZN commits to work with regulators and to incorporate the appropriate legislative and regulatory details into the WMMP, as required. We understand that it is not uncommon for companies to have a General Wildlife Permit in order to move animals off an airstrip. We are unsure whether a similar permit would be required to move animals off the roadway, both inside and outside of the park.

- *Hazing only carried out by specific trained staff.*

Moving animals from the roadway would ideally be performed by trained staff, and this should certainly be strived for. However, traffic cannot be expected to wait for trained staff if such people are not in the immediate vicinity. A practical protocol might be to have the driver radio base, and if staff cannot be available quickly, direction can be given on how the driver should proceed. This would be included in the WMMP, and in the package of materials provided to all drivers so that a minimum level of understanding of appropriate actions should exist at the outset.

Recommendation 7: Monitoring of wildlife will include:

- *Measures of Mountain Woodland Caribou distribution (e.g., site occupancy) and population vital rates (e.g., pregnancy rates) in the Prairie Creek watershed and along the road.*

Surveys to document woodland caribou site occupancy were completed in winter 2010/2011 (mid-December 2010, and mid to late February 2011) and provided sufficient data to enable the planning of mitigation measures to reduce the potential for impacts from operation of the entire length of the haul road.

Occupancy modelling conducted for the study area based on the winter surveys showed evidence of caribou occurrence in the Prairie Creek Mine area and upper Prairie Creek valley during winter. However, animals were mostly to the north of the access road, and numbers were low in immediate proximity to the road. In terms of what this translates into in terms of potential impacts, it is perhaps appropriate to consider periods of sensitivity. Calving and post-calving are typically the most sensitive periods, followed by the rut (breeding). A recent doctoral thesis by John Nagy (University of Alberta, Fall 2011) reported activity periods for mountain woodland caribou in the Mackenzie Mountains, Northwest Territories and Yukon Territory, Canada, 1993-2009 (Table 3-7 in Nagy's thesis); calving was 26 May-11 June; post-calving 12-23 June; and the rut 9-25 October. Hence, these periods fall outside of the access road construction and operation window.

We note that efforts to conserve mountain caribou are on a herd basis and focussed on sensitivity and overall population effects. The occupancy modelling results do not change the concepts for management of haul road traffic and wildlife mitigations as they relate to woodland caribou in proximity to the haul road. The need for monitoring of woodland caribou population vital rates has also not been established in relation to the haul road. The potential for effects should drive monitoring requirements, and no significant potential has been defined. CZN will be collecting considerable data in the form of sightings during haul road operations, and compiling this in a log as per the WMMP. The kind of monitoring advocated by Parks Canada is properly aligned with a research objective, and as such, is a government mandate. CZN has stated on the record that we are willing to collaborate on, and support worthy research endeavours. In this case, we do not believe it is necessary or appropriate for us to lead the kind of monitoring envisaged.

- *Wildlife interactions, observations, hazing etc.*

Section 6.0 of the Draft WMMP outlines the proposed approach to be taken by CZN for monitoring of wildlife with respect to haul road traffic. The subsections under Section 6.0 provide the following:

- Qualifications of the Wildlife Monitor;
 - Responsibilities of the Wildlife Monitor;
 - Training of the Wildlife Monitor;
 - Incident reporting structure for the Wildlife Monitor;
 - Outline of ongoing monitoring procedures of wildlife along the haul road; and
 - Communication procedures the Wildlife Monitor will use to alert haul road traffic to the presence of wildlife along the haul road.
- Measures of moose distribution (e.g., site occupancy) along the road corridor east of Cat Camp in Nahanni National Park Reserve.

The rationale for this information is not considered to be justified. Moose are known to occur in winter along the haul road east of Cat Camp. The winter surveys recently carried out, notably the February survey, identified large numbers of moose tracks and some observations of moose along the haul road, east of Cat Camp. It is not clear what additional survey results will achieve since moose are not a threatened species.

- *Wildlife attractant inspections including all storage facilities.*

The Wildlife Monitor will assist in carrying out inspections of potential wildlife attractants. Section 5.3.3 of the Draft WMMP outlines the key principles of waste management for the mine and haul road, and provides the key points of the waste management approach. Specific details of waste management will be developed further with updates to the Plan.

- *Track surveys and incidental observations for predators of caribou along the road and at the mine site.*

Carrying out specific track surveys is not included in the Draft WMMP, or as a specific duty of the Wildlife Monitor. The Wildlife Monitor will record observations of larger wildlife, their tracks along the haul road in winter, including wolves, and enter these observations into the wildlife observation database. We do not see specific track surveys as a necessity for mitigation associated with road operations.

Mine Site

Parks Canada (PC) did not provide recommendations with respect to water quality and the mitigation of impacts. They concluded that “Based on the information provided by the proponent, there is not confidence in the proposed approach to mitigate any potential significant adverse impacts to Prairie Creek’s aquatic ecosystem and therefore the ecological integrity of Nahanni. Due to our concerns and uncertainty regarding the potential for significant adverse impacts, Parks Canada is unable to provide advice in relation to this to the Review Board”. In our opinion, Parks Canada presented a flawed analysis. Some examples are as follows:

- Page 21, “Table 3 indicates treated mine water will be a part of the effluent for all months when effluent is released”. We believe PC may have meant treated process water. The table indicates this would not be discharged in February and March. If PC meant treated mine water, CZN’s original statement has been misunderstood.
- Page 22, “In the latest “best estimate” water quality predictions, Canadian Zinc predicted water quality in Prairie Creek within Nahanni would have levels of cadmium, lead, selenium, zinc, mercury, ammonia, nitrate and sulphate exceeding SSWQO’s based on the RCA approach”. PC are referring to a simulation of the water quality that would result if the proposed licence limits were adopted (May 12, 2011, Appendix C, Tables 49, 53 and 57), and the discharge equaled those limits. We stressed that it was not a true assessment, but did serve to indicate that additional regulatory controls are necessary. PC made no mention of the true assessment of predicted water quality (Tables 21-44) that met the SSWQO’s.
- Page 23, “mercury within the park predicted in Table 8 is above RCA SSWQO for most low flows and average flows in October”, and “mercury was once again predicted to be above SSWQO’s for 7 months of the year at average flows and 9 months of the year at low flows”. In both cases, these were again fictitious “what-if” assessments of a proposed licence limit, predicted water quality based on real scenarios were ignored.
- Page 24, “Natural Resources Canada has identified that additional testing is needed to provide confidence in the predictions of water quality draining from the mine after closure. Given that once the paste backfill is placed in the mine, there are no mitigative measures that can be taken if predictions prove incorrect, additional testing is warranted”.

Both statements are incorrect. Natural Resources Canada proposed plans for testing and monitoring during operations to validate predictions. CZN proposed a mitigation strategy in the form of pumping and water treatment if predictions are incorrect until such time as conditions have stabilized sufficiently.

Therefore, we conclude that PC's water quality assessment is not reliable.

Recommendation 8: Locations for monitoring aquatic effects include sites within the park. In addition, we recommend a decision response system be established with thresholds

CZN agrees that there should be aquatic effects monitoring sites within the park. CZN will work with Parks Canada and the Aquatic Effects Monitoring Program technical advisory group to establish monitoring sites. We suggest the sites utilized by Spencer, 2008 should be considered.

Natural Resources Canada

Recommendation 3: NRCan suggests that environmental management plans for the access road include a decision tree or toolbox that includes the available mitigation options and the criteria to be utilized to select from these options.

We do not think it is appropriate to pre-determine a mitigation option for a specified environmental management issue. All such issues are site-specific, and may require a specific approach or combination of approaches to achieve the desired results, and the pre-determined mitigation option may not be the most appropriate approach. CZN expects that annual road construction will be supervised by a qualified and experienced general foreman who will decide on the most appropriate mitigation approach for each circumstance.

Recommendation 10: NRCan recommends that the proponent conduct a more detailed/larger scale (1:50,000 or better) mapping, inventory or risk assessment of landslides in the highly landslide susceptible terrain such as the western part of Prairie Creek mine and eastern reaches of the access road to properly evaluate past, present and future geohazards for mine facilities and access road, before final detailed design and construction of the project.

With respect to the access road, Golder Associates recommended that satellite imagery be gathered for specific sections of the route and be used to produce a more detailed interpretation of existing stability issues and surficial geology zones. The sections noted were from Km 57 (Polje Creek) to Km 85 (Tetcela Transfer Facility), and from Wolverine Pass to the Liard River. Golder did not provide recommendations for the mine site. No further mapping is considered necessary because the slopes near the mine site have been stable for over 30 years, and nearly all proposed structures have already been built.

Recommendation 12: Prior to operation, as part of planning for hydrogeology and geochemistry data collection and the further studies of attenuation mechanisms, the developer should document and resolve the following questions:

The questions listed for this recommendation were the subject of a conference call between NRCan and Shannon Shaw, geochemical consultant to CZN. A meeting report was submitted to the Review Board dated July 8, 2011. We believe most of the questions were resolved, however regarding paste leachability and further testing during the early operating period, there was a difference of opinion. NRCan want the appropriate information on the paste to be available

before the paste is in-filled and difficult to retrieve. Ms. Shaw does not agree that testing is necessary before backfilling. The predictions to date are considered to be conservative. Large scale test work would be undertaken during operations to verify predictions and plan for closure. Mitigation is also available in the form of the ability to control the release of groundwater interacting with the paste backfill after mine closure, if required (pump and treat). In any event, NRCan's request is not practical. Site operations will be well underway at the time of the first paste production, and stopes will be ready for backfilling to allow for the advance of mining.