May 28, 2013

FORMER POLARIS MINE SITE, NUNAVUT

Proposed Long-Term Geotechnical Monitoring Program

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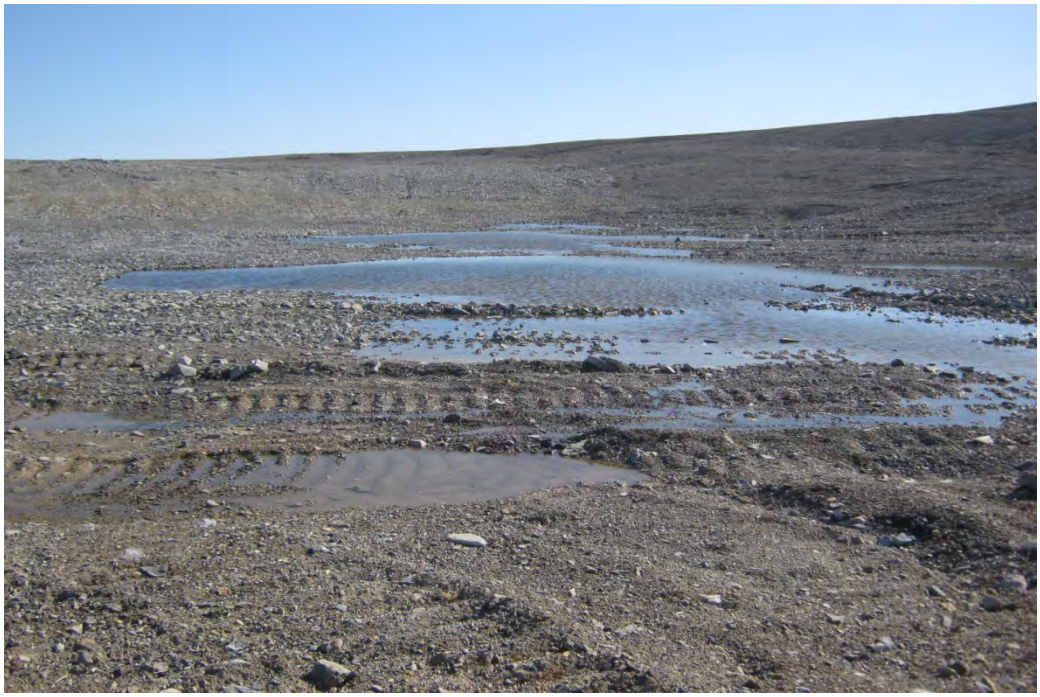

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REPORT

Golder Associates

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1.0 INTRODUCTION

Teck Metals Ltd. (Teck) retained Golder Associates Ltd. (Golder) to develop a long-term geotechnical monitoring program for the decommissioned Polaris Mine on Little Cornwallis Island, Nunavut.

The decommissioned Polaris mine site is located on Little Cornwallis Island approximately 120 km northwest of Resolute, Nunavut. Figure 1 presents the general arrangement of the decommissioned former Polaris mine site (the Site).

1.1 Site History

The Polaris mine was operated by Teck between 1981 and 2002 and decommissioned in 2003 and 2004. Site facilities comprised an underground mine, concentrator plant, concentrate storage shed, dock, airstrip, tailings impoundment, freshwater intake on Frustration Lake, various site access roads, a limestone quarry, a shale quarry, and support infrastructure including fuel storage, camp, warehouse, etc. Decommissioning and reclamation of the site involved demolition of all structures and excavation of all soils contaminated by metals and hydrocarbons. All demolition waste and contaminated soil was either placed underground or in engineered landfills. Access roads between Garrow Lake, Frustration Lake and in the immediate vicinity of the previously active mining operations were decommissioned by rounding the shoulders of each road, removing culverts, and re-establishing natural drainage patterns. Facilities related to the airstrip were removed during decommissioning but the landing surface remains intact and has been used during the post-closure monitoring period. Little Cornwallis Island airstrip (referred to as LCI by local pilots) is also used occasionally by passing airplanes for emergency landings. Teck maintained a small temporary camp near Loon Lake during the post-closure monitoring period that was relocated near the ocean in 2010 and removed from the Site in September 2011. The temporary camp area was regraded after the camp and other remaining post-closure equipment and supplies were relocated to the shore of Polaris Bay in preparation for removal from the Site.

The marine foreshore area and slope in the vicinity of the former concentrate storage shed on the west side of the island were regraded to relatively gentle slopes during decommissioning. The graded slopes are interrupted by access roads and ramps. The shoreline area in the immediate vicinity of the former dock structure is almost flat. Four portals for mine access and exploration activities have been sealed, backfilled and graded to match the surrounding slopes.

Little Red Dog Quarry, located at the northwest end of the airstrip was backfilled partially with demolition debris and metals contaminated soils and subsequently capped with rockfill. The remnant quarry walls above the level of the capping layer are benched and serve to catch ravelling material as the slopes gradually weather. Safety berms extend around the quarry perimeter, and additional safety measures in the form of a ditch and a high berm exist at the end of the airstrip. Thermistors were installed through the rockfill capping layer into the underlying landfilled materials at Little Red Dog Quarry. The Operational Landfill, located at the south end of the former mine facility area, was regraded and capped with rockfill during decommissioning. Thermistors were installed in the Operational Landfill at four locations during operation of the mine. The existing thermistor installations were modified following closure of the landfill to monitor the new cap, however only two of the four installations were successfully modified in 2005. The following year all four thermistor installations were restored to full function along with improvements to the data collection system and insulation at ground surface. Thermistors and dataloggers have been continuously monitoring ground temperature in the Operational Landfill since 2006. Landfill thermistor data was downloaded and reported annually from 2007 through to 2011 by Teck.

Ground temperature data measured by thermistors installed at the Little Red Dog Quarry Landfill and Operational Landfill indicates that the landfilled waste is frozen and that permafrost has extended up into the overlying rockfill cover effectively encapsulating waste materials in ice as designed.

The ground surface over the underground mine workings experienced significant settlement during mine operations. During decommissioning, this area was backfilled with non-hazardous solid waste, covered with rockfill, and regraded. Detailed topographic survey measurements of the ground surface over the underground mine workings were carried out during annual post-closure inspections from 2005 through 2011 and no further ground deformations were detected during the annual post-closure topographic surveys.

The New Quarry was a source of shale during mine construction, operations and decommissioning. It has been reclaimed by backfilling stripped materials against the quarry perimeter walls. Two erosion gullies at the south end of the New Quarry were repaired and lined with rip-rap to form an erosion resistant channel for drainage from Loon Lake. Access roads across the site were decommissioned and culverts were removed to restore natural drainage crossings that would not require ongoing maintenance. All-Terrain-Vehicles (ATVs) were driven on these access roads to facilitate post-closure inspection and monitoring. A rockfill jetty remains at Frustration Lake that was constructed for the freshwater supply intake during operation of the mine. Freshwater pumps and piping between the mine and Frustration Lake were removed during decommissioning.

At Garrow Lake, the former tailings disposal area, the impoundment dam and wave break structure were breached during decommissioning to return water levels to pre-development levels and to eliminate structures requiring long-term monitoring and maintenance. The central part of the main dam was breached and a rip-rap lined channel was constructed. Decommissioning of the impoundment dam lowered the water level in Garrow Lake by approximately two and one half metres to its pre-development level. The condition and stability of the reinstated Garrow Lake shoreline was monitored for several years after the dam was breached and was observed to be stable. Since the site was decommissioned and pre-development water levels were reinstated, natural wave and ice processes have resulted in the deposition of gravel along the south shore of Garrow Lake in front of the breached wave break structure. Topographic survey measurements of the natural gravel berm near the former wave break structure were carried out by Teck from 2007 through 2011.

1.2 Scope of Work

The scope of work included the following tasks:

1. Development of a long-term geotechnical monitoring program for the Site.
2. Compilation of available Polaris underground mine records (provided by Teck) and preparation of plan and cross-section drawings to illustrate the extent of underground mine workings.
3. Review available mine records and post-closure survey data to carry out an assessment of the potential for additional subsidence at ground surface over the long-term over the underground mine workings.
4. Identification of mitigation measures that could be implemented should additional subsidence occur over the underground mine workings that poses a hazard to humans or wildlife.
5. Estimation of long-term geotechnical monitoring costs and potential hazard mitigation measure costs for financial assurance purposes.
6. Preparation of this report summarizing the recommended long-term geotechnical monitoring program, potential area that could experience future subsidence, potential hazard mitigation measures (if required), and cost estimates for financial assurance purposes.

2.0 ASSESSMENT OF LONG-TERM SUBSIDENCE POTENTIAL

2.1 Available Information

Available information that was reviewed included underground mine records and post-closure topographic survey data. Underground mine plans by level are included in Appendix A. Figures 2 and 3 are cross-sections illustrating underground mine levels and stopes. Appendix B presents results of post-closure topographic surveying that indicate no further subsidence has been detected since 2005.

2.2 Discussion on Mining Methods and Subsidence Mechanisms

Most of the mining at Polaris, and particularly the mining of the Keel Zone and the Keel Abutment Pillar, was undertaken by longhole open stoping with concurrent placement of backfill. The backfill was prepared from waste rock that was quarried on surface. This was fed underground in a series of vertical raises. In the Keel Zone itself, the mining involved the extraction of a series of primary stopes (each approximately 15 wide in the north-south direction) which were individually backfilled before the secondary stopes between them (each approximately 18m wide in the north-south direction) were in turn excavated and then backfilled. Almost all of the backfill was comprised of quarried rock which was mixed with either a small measured quantity of water so that it froze over a period of time (typically over a period of 2 years after being placed in the stope), or with a measured quantity of cement slurry that cured over a period of several weeks. In this way, the fill gained sufficient strength that it remained in a permanently stable condition, even during short periods of exposure as the rock beside it was excavated in small progressive increments, and these excavations were then in turn also backfilled.

All of the stopes mined at Polaris were excavated and backfilled in this same general manner. The backfilling was required to achieve a high percentage extraction of the ore and was not a discretionary activity. The only significant excavations in the mine that were not backfilled were the access excavations of typical approximate size 4.5m by 4.5m which even if they collapse in the future, are too small to result in any deformations on surface.

Not all of the backfill was placed tight to the back of the stopes. It was very important to backfill the primary stopes tight to the back so that the secondary stopes beside them could be excavated without experiencing significant dilution. This was achieved in places by levelling and pushing the fill with scoop trams and/or dozers to within about 1.0m to 1.5m of the back, then sealing of the top of the primary stope, and topping it up with a shale and water slurry. This slurry was placed under warm conditions and was termed “summer fill”. It subsequently froze so that it was reasonably tight to the back.

The secondary stopes were excavated between neighbouring primary stopes. Each secondary stope was excavated and backfilled in small increments from east to west, with each increment being backfilled from surface. The backfill placed using raises from surface filled most of the secondary stopes but formed cones at the top that either froze or gained strength once the cement cured. In this way, the immediate back of the secondary stopes was supported by a series of frozen or cemented cones. Beneath the cones, the stopes were completely filled with backfill. The result of this was that the secondary stopes were not completely filled over the entire back, although most of the secondary stopes, with the exception of the relatively small voids around and between the cones, were completely filled. In some localized areas, sections of the back of the secondary stopes failed upwards. This occurred mostly towards the far east of the Keel Zone, in the vicinity of 199 Stope which reportedly peaked up 35m, 202 Stope where a large block of unmined ore displaced into the stope, and

210 Stope (see Stope numbers noted on Figures 2 and 3). These back failures stabilized above the stopes and were backfilled to the maximum extent possible, and generally fairly completely, to facilitate ongoing mining.

There is no direct indication that the 18m wide secondary stopes that experienced back failures caved up to surface as individual unraveling failures. Rather a somewhat continuous subsidence trend aligned in the north-south direction developed on surface on the east side of the Keel Zone. This subsidence trend extended progressively to the north across the tightly filled primary stopes and less tightly filled secondary stopes. Between approximately 194 and 215 Stopes, the subsidence trend developed into a trough or graben-type depression that was approximately 200m long, 70m wide, and 10m deep. This graben-type trough referred to as a "sinkhole" was bounded on the west side by a very prominent single structure that was likely the 1500 Fault (identified on some of the mining plans) or a nearby parallel fault. The trough was defined or bounded on the east side by a slightly more diffuse series of north-south trending fractures. The block may have rotated slightly, particularly with the influence of the eastern abutment, but more generally, it moved downwards as a rigid-type block onto the tight fill of the primary stopes and the cones and underlying fill of the secondary stopes, and any other remaining voids which could not be effectively backfilled.

Subsidence also progressively occurred to the west of the graben–type trough. Initially this was controlled or restricted by the presence of the Keel Abutment Pillar which provided a stabilizing influence. In turn however this pillar was also mined and backfilled. This resulted in the merging of the Keel Zone and Panhandle extraction areas and the integration of the two associated subsidence zones to form a relatively uniform subsidence profile with vertical displacements of between 1.5m and 2.5m. In this way, the entire area above the Keel Zone and Panhandle subsided onto the backfill below, compressing it. The final subsidence profile at the conclusion of mining was a graben-type trough on the east side of the Keel Zone where the rock had displaced vertically down onto the fill approximately 10m, and the remaining area above the integrated Keel Zone and Panhandle that had also displaced down onto the fill approximately 2.0m. In both cases, the rock overlying the mined out areas displaced onto the fill in a relatively uniform manner.

In mid-2002, just prior to the completion of mining, the subsidence monuments that were being surveyed indicated that some areas were subsiding at a relatively fast rate as the overlying rock displaced down, compressing the backfill. The cracks that appeared on surface during the entire mining period were mapped on a regular basis until mining ceased in 2002. The pattern of cracks that were evident on surface conformed reasonably well with the outer limits of the integrated Panhandle and Keel mining, with the cracks associated with the graben-type trough being prominent on the east of the Keel Zone. Mining was completed in 2002, and the ground surface profile was re-contoured soon after this. Post-closure monitoring was established in 2005 in the area of previous subsidence. No additional significant surface deformations were surveyed during the post-closure monitoring of the ground surface over the underground mine workings from 2005 to 2011. Figure 4 presents a plan view of surface cracks that were surveyed during mine operation prior to 2002 compared to cracks surveyed post-closure from 2005 through 2011.

The general subsidence profile that developed on surface above the mined area, and the pattern of surface cracking that was mapped on surface prior to re-contouring, conform well with the footprint of the mining and backfilling activities that were undertaken, and with the overall mechanism of the overlying rock moving down onto the backfill and compressing it. The Keel and Panhandle areas were almost completely extracted over an area of approximately 500m by 250m and the rock above the mined area has almost certainly completely subsided onto the fill by now without any bridging or arching.

There is no evidence in the past of any individual voids above individual secondary stopes or around the backfill cones unravelling and caving up to surface, and it is unlikely that this will occur in the future now that the overlying rock has displaced onto the fill in this uniform manner. However, there is no way of guaranteeing with absolute certainty that there is not a void somewhere that may start to unravel sometime in the future and progressively cave up to surface. Under these conditions, some local cracking and settlement may become evident on surface in the future. There is no rational way of predicting where this subsidence might occur, and there is no longer value in continuing with routine topographic surveying of the ground surface area over the underground mine workings. This combined with a low probability of any further subsidence occurring indicates that the best approach to ongoing monitoring is visual inspections with the main objective of identifying any surface cracks and significant depressions that may be indicators or pre-cursors of possible more significant subsidence movements. Visual inspections and topographic surveys of the ground surface over the underground mine workings were carried out on an annual basis during the 7 year post-closure monitoring period with no observations of problematic surface cracks or significant depressions that may be indicators or pre-cursors of possible more significant subsidence movements.

2.3 Area of Potential Long-Term Subsidence

Because all mining ceased approximately 10 years ago and most of the voids underground are backfilled, the most lateral extent of any potential additional subsidence that may pose a safety concern, if it occurs, would likely be just slightly beyond the previously observed surface cracks. Figure 4 presents a plan view of previously observed and surveyed surface cracks and the potential area of subsidence that could pose a hazard to humans or wildlife. If cave mining methods had been undertaken as opposed to open stoping, then surface subsidence could have extended further out than the limit shown on Figure 4, but with the type of stoping and backfilling that was undertaken at the Polaris mine, the peripheral extent of effects on surface are less. Although it may be possible to detect some minor settlement at surface beyond this limit using very accurate surveying systems, any subsidence beyond this limit should not pose a hazard to humans or wildlife.

2.4 Recommended Subsidence Hazard Mitigation Measure

If future geotechnical inspections observe additional surface cracking and depressions, these will need to be investigated and a decision made on how to mitigate any hazards and safety concerns. Potential hazard mitigation measures could include:

- Backfilling of depressions or voids with rockfill;
- Placement of boulders as a physical barrier around the hazard;
- Postage of signage around the hazard; or
- Fencing of ground surface over the underground mining works.

The recommended mitigation measure, should additional subsidence be observed that poses a hazard to humans or wildlife be observed, is construction of a perimeter safety fence. Although it may be possible to backfill a small depression with a small excavator that could be mobilized to site on a fixed wing airplane, backfilling a significant sized depression would require mobilizing heavy construction equipment to quarry, haul and place a large volume of rockfill. Boulders and signs would not completely restrict access to the hazard by animals or humans. For these reasons, fencing is considered the best mitigation measure for a large deep depression or void that poses a hazard to humans or wildlife, if one were to develop at the Site in the future.

Installation of perimeter safety fencing around mine hazards is a common mitigation measure in populated mining communities and is considered a suitable mitigation measure for the former Polaris mine site, if required.

The location and extent of a perimeter safety fence will need to be based on the actual extent of subsidence and observations made at the time. In the unlikely event that the entire mine area would need to be fenced, the maximum extent would be as shown on Figure 5. The recommended safety fence would be 1.8m (6 ft) high, galvanized steel, industrial-quality fencing. The total length of fencing shown on Figure 5 is 1360m.

3.0 LONG-TERM GEOTECHNICAL MONITORING PROGRAM

3.1 Areas Inspected

Areas of the decommissioned mine site that were inspected during the seven year annual post-closure monitoring period (2005 through 2011) included the following:

- Garrow Lake Area (shoreline, wave break structure and breached dam);
- Frustration Lake Jetty and Access Road;
- New Quarry Area;
- Ground surface area over underground mine workings (former Subsidence Area);
- Operational Landfill;
- Little Red Dog Quarry Landfill;
- Mine Portals;
- Marine Foreshore Adjacent to Former Dock; and
- Temporary Camp Area.

Monitoring of the Garrow Lake shoreline was discontinued in 2009 after several years of inspections and erosion monitoring indicated that the shoreline was stable. The former temporary camp area was inspected after camp removal in 2011 and further monitoring of this area is not required. The New Quarry area, Frustration Lake jetty and access roads were observed to be stable during the post-closure monitoring period (2005 through 2011) therefore ongoing monitoring of these areas is not required.

Long-term geotechnical monitoring of the following areas is recommended:

- Ground surface area over underground mine workings;
- Operational Landfill;
- Little Red Dog Quarry Landfill;
- Mine Portals;
- Garrow Lake wave break structure and breached dam; and
- Marine Foreshore Adjacent to Former Dock.

3.2 Geotechnical Monitoring Frequency

Operations at the Polaris Mine ceased in 2002. Mine closure and remediation activities were completed in 2004. Annual post-closure geotechnical inspections were carried out from 2005 through 2011, a period of seven years after closure of the mine site was completed. During this seven year post-closure monitoring period the Site was observed to be physically stable and therefore ongoing annual geotechnical monitoring is not considered necessary.

The Department of Indian and Northern Affairs Canada Contaminated Sites Program prepared a guidance document entitled "Abandoned Military Site Remediation Protocol" (INAC, 2009) that describes a rationale and outlines a recommended schedule for long-term monitoring of Distant Early Warning (DEW) Line sites in northern Canada. This guidance document has been used to develop a reasonable long-term monitoring frequency for remediated, stable sites in the high Arctic. This same approach is considered reasonable to determine a post-closure frequency of monitoring for the decommissioned Polaris mine site given its high Arctic location and that it is a remediated, stable site. Post-closure monitoring of DEW line sites is separated into two phases; Phase 1 during years 1 through 5 and Phase 2 in years 7, 10, 15, and 25. Given that annual geotechnical inspections have already occurred for 7 straight years since remediation of the Polaris mine site was completed in 2004 (year 0), it is reasonable to assume that Phase 1 monitoring has been completed and that Phase 2 monitoring has commenced. If 2004 was Year 0 then the completed 2011 annual inspection was Year 7. Therefore the next geotechnical inspection event should occur in Year 10 (2014) with subsequent inspection events in Year 15 (2019) and Year 25 (2029). This approach is consistent with the monitoring frequency laid out in the INAC (2009) protocol used for decommissioned DEW Line sites. Subsequent to the 2029 inspection, the long-term monitoring program should be reviewed and the ongoing inspection frequency and scope should be re-evaluated at that time.

Table 1 summarizes the proposed frequency of geotechnical inspection events at the former Polaris mine site.

Table 2: Summary of Post-Closure Geotechnical Monitoring Program

Phase	Years Since Closure	Calendar Year	Areas Inspected (access)	Duration
1 (Annual)	1	2005	▪ Garrow Lake Area (ATV) ▪ Frustration Lake Jetty and Access Road (ATV) ▪ New Quarry Area (ATV) ▪ Ground surface over underground mine workings (ATV) ▪ Operational Landfill (ATV) ▪ Little Red Dog Quarry Landfill (ATV) ▪ Mine Portals (ATV) ▪ Marine Foreshore (ATV) ▪ Temporary Camp Area (ATV)	2 to 3 days
	2	2006		
	3	2007		
	4	2008		
	5	2009		
2 (Reduced Frequency)	6	2010		
	7	2011		

Phase	Years Since Closure	Calendar Year	Areas Inspected (access)	Duration
	10	2014	▪ Ground surface over underground mine workings (foot) ▪ Operational Landfill (air) ▪ Little Red Dog Quarry Landfill (air) ▪ Mine Portals (air) ▪ Garrow Lake Dam (air) ▪ Marine Foreshore (air)	2 to 3 hours
	15	2019		
	25	2029		
	>25	Review frequency and scope in 2029		

3.3 Geotechnical Monitoring Approach

The primary objective of the long-term geotechnical inspections will be to assess the physical condition of decommissioned mine areas for evidence of slope instability, erosion or other landform instabilities that could present a safety hazard to either humans or wildlife.

The ground surface over the underground mine workings should be inspected on foot for surface cracks and/or settlement depressions that could pose a safety hazard to either humans or wildlife.

It should be possible to adequately observe the Operational Landfill, Mine Portals, Marine Foreshore Area, Little Red Dog Quarry Landfill and Garrow Lake Dam from the airplane before or after landing at the site. Any erosion that is not detectable from the air should not be significant enough to cause concern. The following is a summary of problematic conditions for each area that should be identifiable from air:

- The Operational Landfill should be inspected for slope failures that may expose waste.
- The Little Red Dog Quarry Landfill should be inspected for exposed waste protruding through the rockfill cover.
- The backfilled Mine Portal slopes should be inspected for slope failures that could allow access to the underground mine workings.
- The Garrow Lake Dam breach channel should be inspected for slope failures that may prevent or interfere with drainage of Garrow Lake to the ocean.
- The Marine Foreshore Area should be inspected for slope failures or major erosion causing discharge of sediment to the ocean.

If issues of concern are observed from the air then a follow-up inspection could be carried out from the ground. If required, an ATV could be flown to site to facilitate ground based inspections of any areas of concern identified from the air. Ground inspection of an area of concern on ATV would likely be coordinated with Garrow Creek water sampling.

3.4 Future Landfill Ground Temperature Monitoring

Thermistors were installed at both the Operational Landfill and the Little Red Dog Quarry Landfill to measure permafrost aggradation up into the waste and rockfill cover. Post-closure ground temperature monitoring carried out through 2011 indicates that the landfilled waste is frozen and that permafrost extends into the overlying rockfill cover effectively encapsulating the waste. In the event that future geotechnical inspections identify problems or potential concerns with landfill cover performance then it may be possible to measure landfill ground temperature using the existing thermistors installed in the landfills to verify the depth of active thaw. Even if the data loggers are no longer functioning, it should be possible to take manual ground temperature readings directly from the thermistors with a hand-held readout box. If it is not possible to measure ground temperature with the thermistors (i.e., either with the data loggers or manually with a readout box), then another possible contingency measure would be to measure the depth of the active thaw layer by hand digging down from surface until frost is encountered. Regardless, future measurement of landfill ground temperature should not be required unless future geotechnical inspections identify problems or potential concerns with landfill cover performance.

4.0 COST ESTIMATES

The following sections describe how costs for long-term geotechnical inspection and subsidence hazard mitigation, if required, were estimated to care for the Site until 2029, at which point it is proposed that the geotechnical monitoring program be reviewed again in conjunction with regulators.

4.1 Geotechnical Inspection

As discussed above, we have assumed that geotechnical inspections will be carried out in 2014, 2019 and then every 10 years thereafter (as outlined in Table 1 above). However, after completion of the geotechnical inspection in 2029, the ongoing inspection frequency will be evaluated and a less frequent inspection schedule may be recommended going forward (i.e., less frequently than every 10 years). The costs associated with each geotechnical investigation were estimated to be approximately $38,000 per event. All costs were estimated in 2012 Canadian dollars and include a 15% allowance for taxes and a 15% contingency. A detailed breakdown of the geotechnical inspection cost estimate per event is shown in Table C-1 of Appendix C.

4.2 Subsidence Hazard Mitigation

If future geotechnical inspections observe significant ground surface settlement or large surface cracks over the underground mining works that create a hazard to humans and animals then a review of potential hazard mitigation measures should be undertaken at that time.

Construction of a perimeter safety fence around the hazard is considered the most suitable and effective mitigation measure, should a significant ground surface depression or void develop over the underground mine workings develop that poses a hazard to humans or wildlife. The estimated initial installation cost of 1360 m of fencing around the area shown on Figure 5 is $1,050,000. To maintain the fence in perpetuity, it is considered reasonable to assume that major repairs involving replacement of 400m of fencing would have to be carried out every 20 years at a cost of $330,000 per repair event. All costs were estimated in 2012 Canadian dollars and include a 15% allowance for taxes and a 15% contingency. Detailed cost estimates for initial fencing installation and maintenance (i.e., major repairs every 20 years) are summarized in Table C-2 of Appendix C.

5.0 CONCLUSION

It is recommended that geotechnical inspections be carried out in 2014, 2019, 2029 and then the ongoing long-term geotechnical monitoring program should be reviewed. Should additional subsidence that poses a hazard to humans or wildlife be observed and other forms of mitigating the risk are not practical, then the installation of perimeter safety fencing around the area should be considered as a mitigation measure. The location and length of such a perimeter safety fence will need to be based on the actual extent of subsidence and observations made at the time. The maximum expected area of potential subsidence and perimeter fencing that may be required in the future to protect human and wildlife safety is shown on Figure 5. If any future subsidence occurs, the area of fencing required will likely be much smaller than this area. Estimated costs for future geotechnical inspections and installation of safety fencing, if required, are presented in Appendix C.

Development of the proposed long-term geotechnical monitoring program and review of potential future subsidence over the underground mine workings was carried out by Darrin Johnson, P.Eng. and Ross Hammett, P.Eng. Resumes of the authors of this report are included in Appendix D.

Report Signature Page

GOLDER ASSOCIATES LTD.

Original Signed By	***Original Signed By***
Darrin Johnson, P.Eng. Geotechnical Engineeer	Ross Hammett, P.Eng. Principal

DCJ/RH/dcj

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FIGURES

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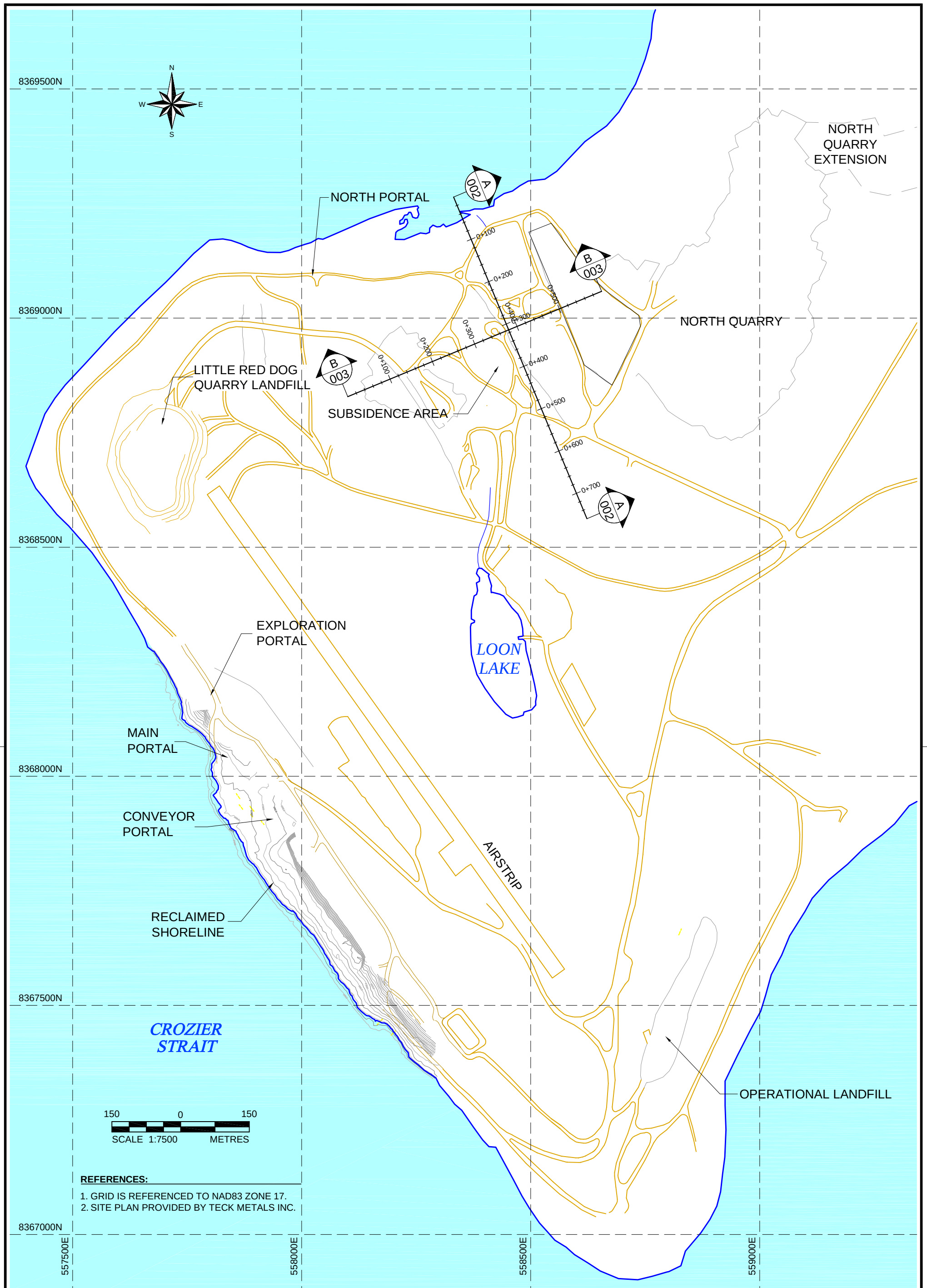

REFERENCES:

1. GRID IS REFERENCED TO NAD83 ZONE 17.
2. SITE PLAN PROVIDED BY TECK METALS INC.

Golder Associates
Mississauga, Ontario, Canada

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REVIEW	RH

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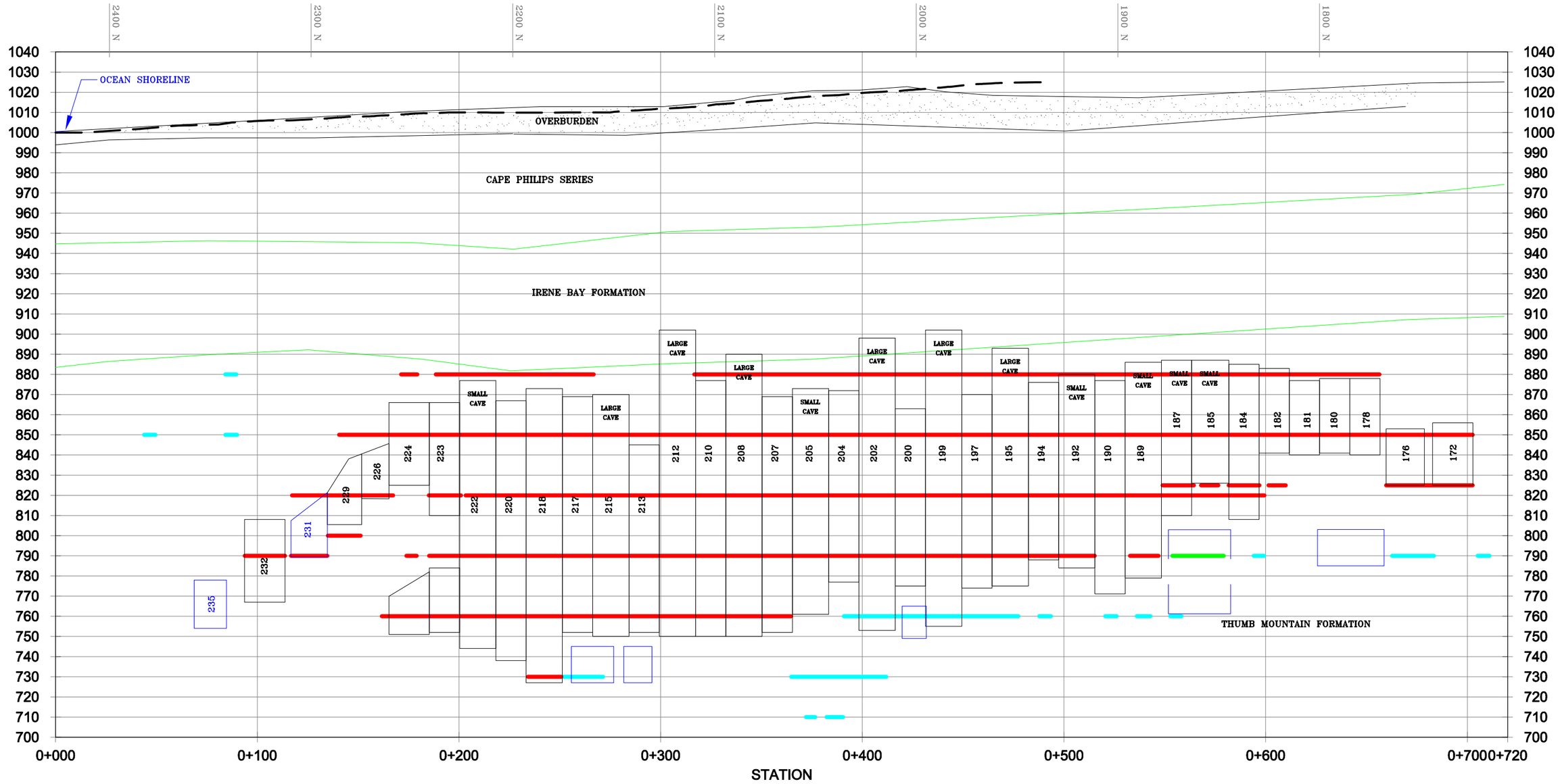
FORMER POLARIS MINE PLAN

TECK METALS - SUBSIDENCE ASSESSMENT

FIGURE 1



LEGEND:

- GROUND SURFACE
- MINE LEVEL (BACKFILLED)
- MINE LEVEL (NON-BACKFILLED)
- MINE LEVEL (ACCESS)
- 224 — MINE STOPE NUMBER

40 0 40
SCALE 1:2000 METRES

Golder Associates
Mississauga, Ontario, Canada

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CROSS-SECTION A-A' (1500 EAST)

TECK METALS - SUBSIDENCE ASSESSMENT

FIGURE 2

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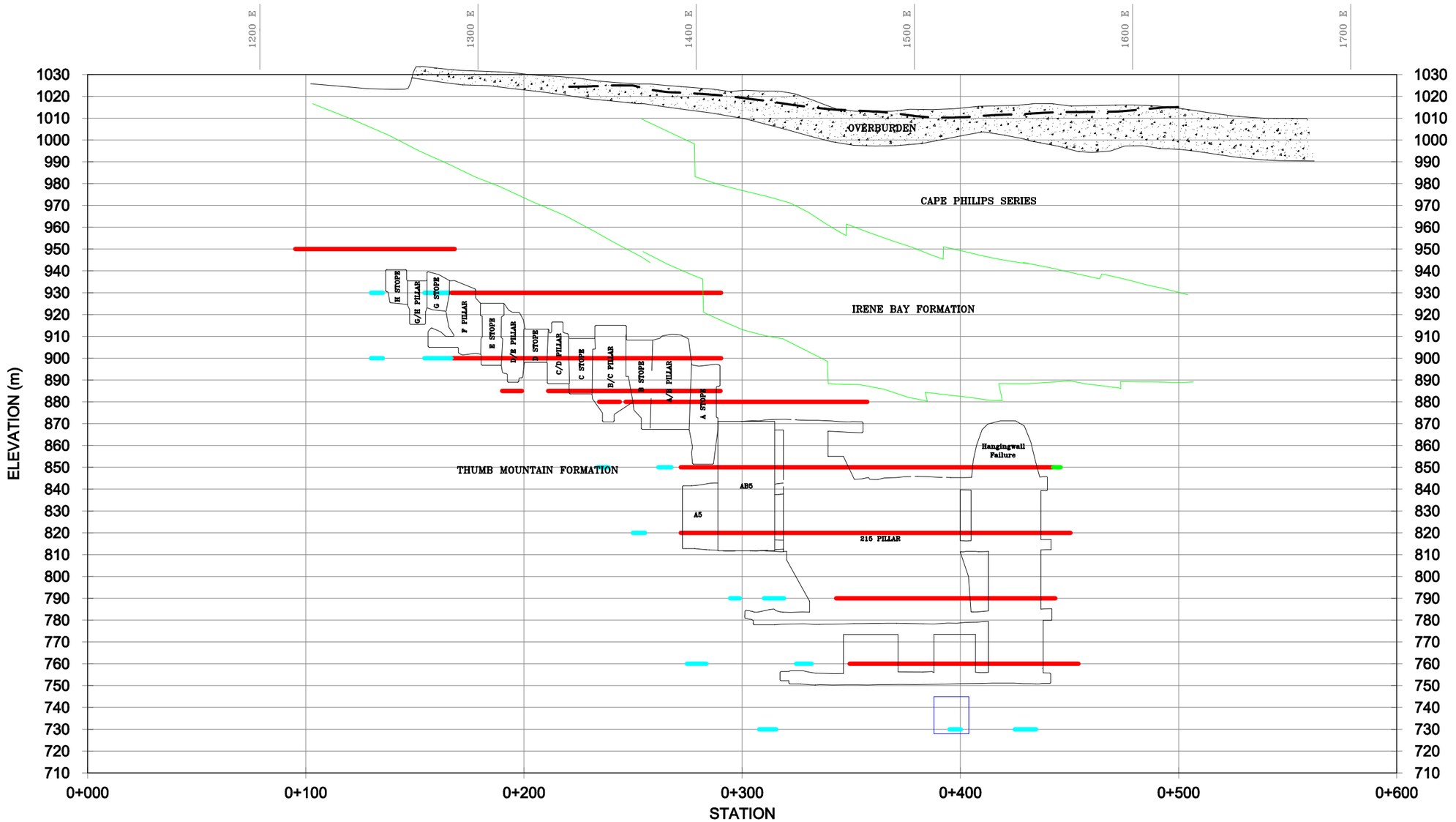

LEGEND:

- GROUND SURFACE
- MINE LEVEL (BACKFILLED
- MINE LEVEL (ACCESS)
- 224 MINE STOPE NUMBER

40 0 40
SCALE 1:2000 METRES

Golder Associates
Mississauga, Ontario, Canada

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CROSS-SECTION B-B' (2150 NORTH)

TECK METALS - SUBSIDENCE ASSESSMENT

FIGURE 3

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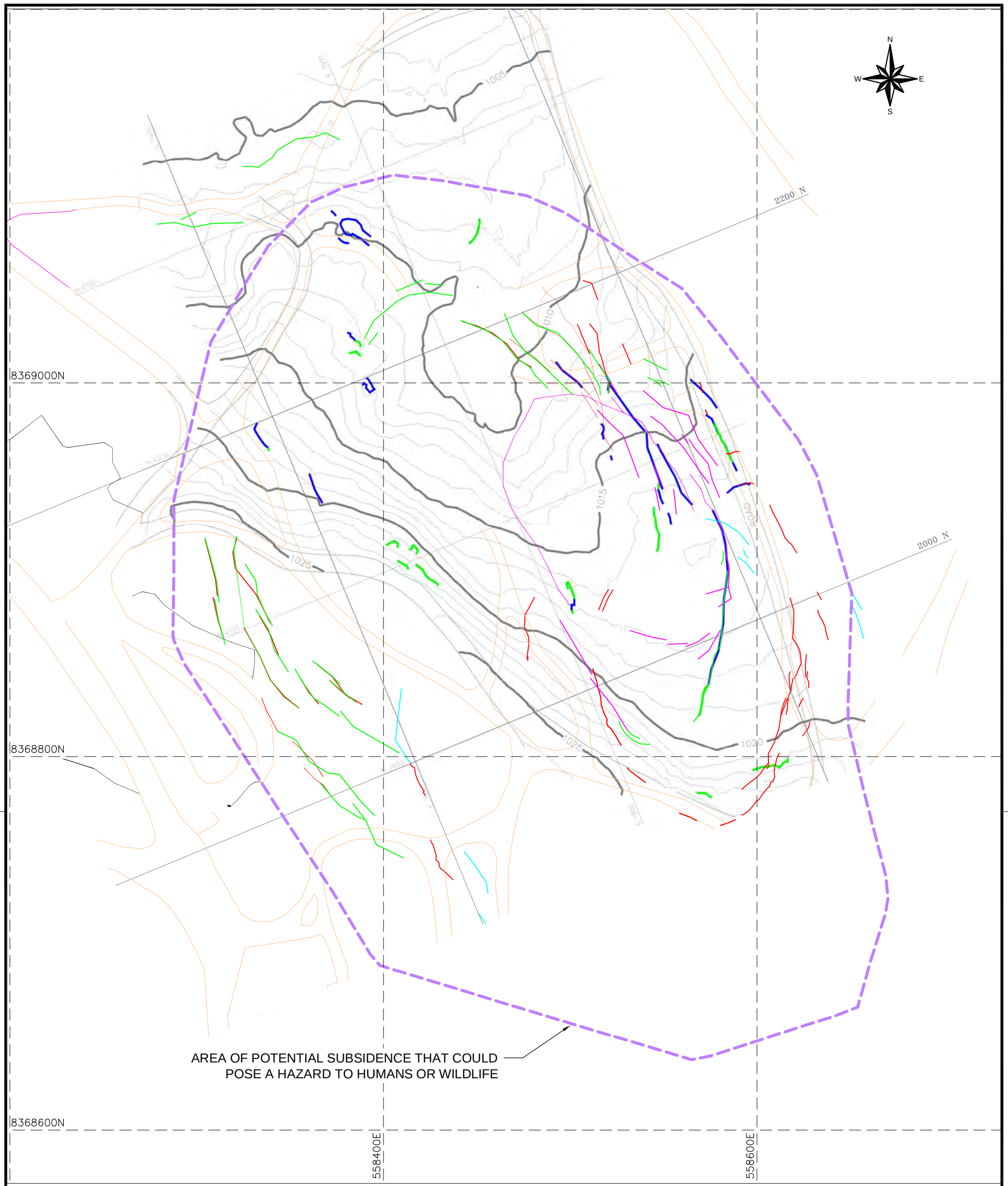
PLOT DATE: November 19, 2012
FILENAME: T:\Projects\2012\12-1118-0022 (TECH RESOURCES, Resolute)\-AC-\1211180022AC004.dwg



OBSERVED SURFACE CRACKS (DATE SURVEYED)

- 2011
- 2005-2010
- 2002
- 2001
- 2000
- 1999
- 1998
- 1997
- 1996
- 1995

NOTES:

1. GRID IS REFERENCED TO NAD83 ZONE 17.
2. CRACK INFORMATION BASED ON FILE: PM-2011-AREA-8-SHEET-2.PDF AND SUBSIDENCE MASTER.DWG PROVIDED BY TECK METALS

40 0 40 80
SCALE 1:2000 METRES

Golder Associates
Mississauga, Ontario, Canada

SCALE	AS SHOWN
DATE	Nov. 19, 2012
DESIGN	EPT
CAD	MY
CHECK	DCJ
REVIEW	RH

FILE No. 1211180022AC004.dwg
PROJECT No. 12-1118-0022 REV.

TITLE

PREVIOUSLY OBSERVED SURFACE CRACKS RELATED TO SUBSIDENCE

TECK METALS - SUBSIDENCE ASSESSMENT

FIGURE 4

PLOT DATE: November 19, 2012
FILENAME: T:\Projects\2012\12-1118-0022 (TECH RESOURCES, Resolute)\-AC-\1211180022AC005.dwg

N
W
E
S

A 002
B 003
B 003
A 002

8369200N
8369000N
8368800N
8368600N

0+100
0+200
0+300
0+400
0+500
0+600
0+700

LEGEND:

- 2011 GROUND SURFACE CONTOUR (1m)
- 2011 GROUND SURFACE CONTOUR (5m)
- AREA OF POTENTIAL SUBSIDENCE THAT COULD POSE A HAZARD TO HUMANS OR WILDLIFE
- APPROXIMATE LIMIT OF PERIMETER FENCING (IF REQUIRED)

APPROXIMATE LIMIT OF PERIMETER FENCING
(IF REQUIRED)

REFERENCES:

1. GRID IS REFERENCED TO NAD83 ZONE 17.
2. SITE PLAN PROVIDED BY TECK METALS INC.

150 0 150
SCALE 1:7500 METRES

558200E
558400E
558600E

Golder Associates
Mississauga, Ontario, Canada

SCALE	AS SHOWN
DATE	Nov. 19, 2012
DESIGN	EPT
CAD	MY
CHECK	DCJ
REVIEW	RH

FILE No. 1211180022AC005.dwg
PROJECT No. 12-1118-0022 REV.

TITLE

AREA OF POTENTIAL SUBSIDENCE THAT COULD REQUIRE FUTURE PERIMETER FENCING

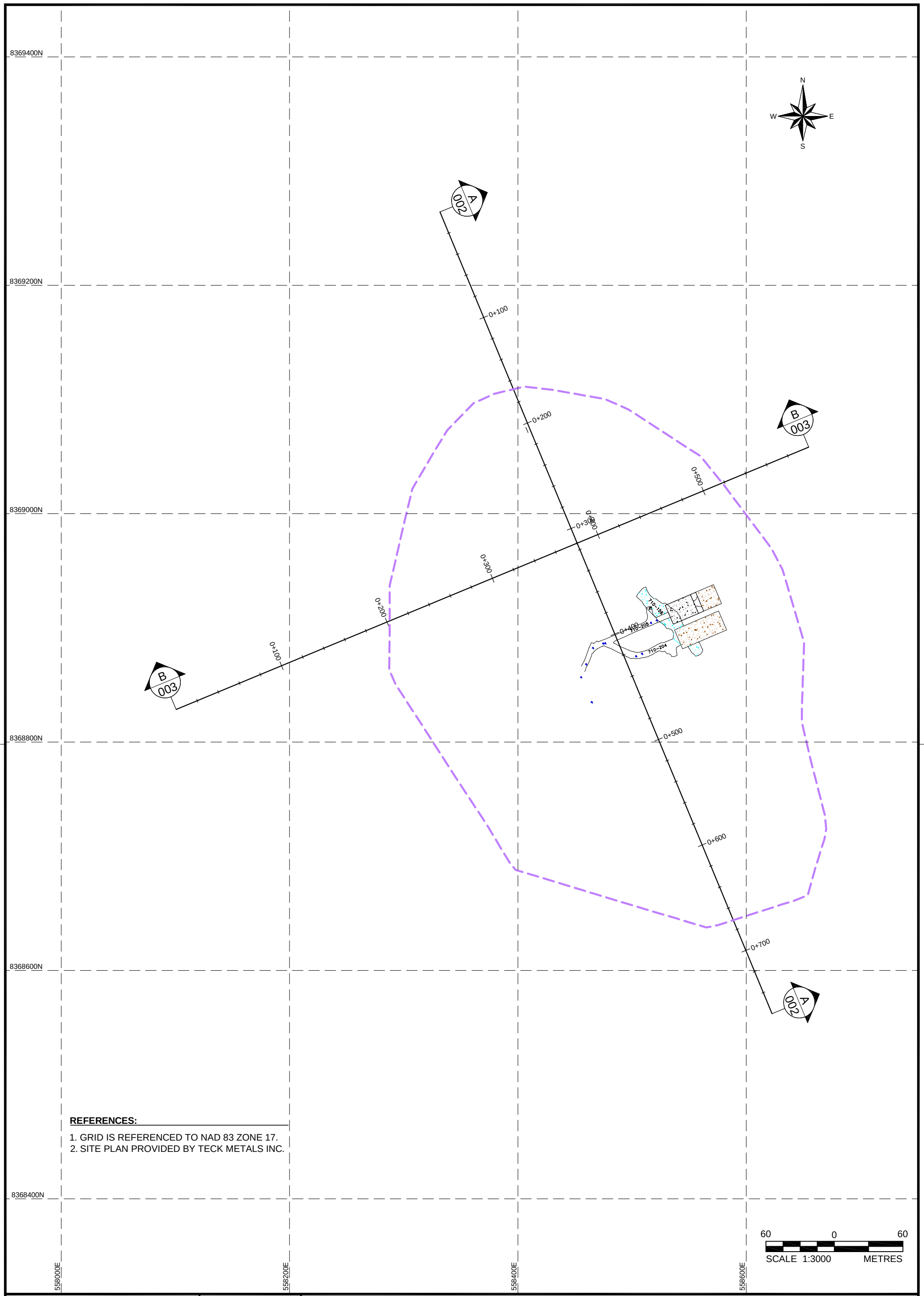
TECK METALS - SUBSIDENCE ASSESSMENT

FIGURE 5

APPENDIX A

Mine Level Plans

PLOT DATE: November 19, 2012
FILENAME: T:\Projects\2012\12-1118-0022 (TECH RESOURCES, Resolute)\-AC-\1211180022AC00A1-15.dwg



REFERENCES:

1. GRID IS REFERENCED TO NAD 83 ZONE 17.
2. SITE PLAN PROVIDED BY TECK METALS INC.

Golder Associates
Mississauga, Ontario, Canada

SCALE	AS SHOWN
DATE	Nov. 19, 2012
DESIGN	EPT
CAD	MY
CHECK	DCJ
REVIEW	RH

FILE No. 1211180022AC00A1-15.dwg
PROJECT No. 12-1118-0022 REV.

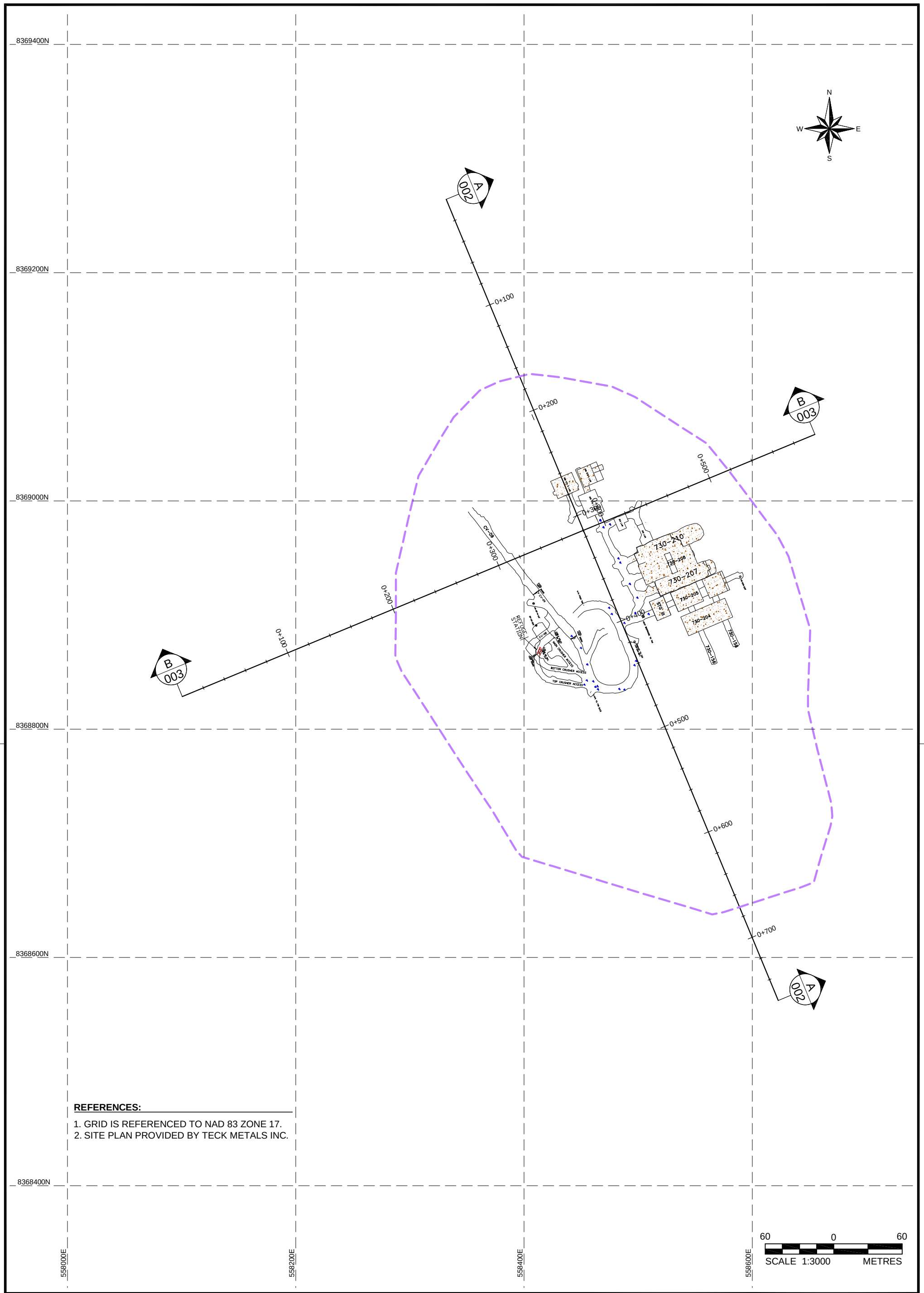
TITLE

LEVEL 710 PLAN VIEW

TECK METALS - SUBSIDENCE ASSESSMENT

FIGURE **A-1**

PLOT DATE: November 19, 2012
FILENAME: T:\Projects\2012\12-1118-0022 (TECH RESOURCES, Resolute)\-AC-\1211180022AC00A1-15.dwg



REFERENCES:

1. GRID IS REFERENCED TO NAD 83 ZONE 17.
2. SITE PLAN PROVIDED BY TECK METALS INC.

Golder Associates
Mississauga, Ontario, Canada

SCALE	AS SHOWN
DATE	Nov. 19, 2012
DESIGN	EPT
CAD	MY
CHECK	DCJ
REVIEW	RH

FILE No. 1211180022AC00A1-15.dwg
PROJECT No. 12-1118-0022 REV.

TITLE

LEVEL 730 PLAN VIEW

TECK METALS - SUBSIDENCE ASSESSMENT

FIGURE **A-2**

PLOT DATE: November 19, 2012
FILENAME: T:\Projects\2012\12-1118-0022 (TECH RESOURCES, Resolute)\-AC-\1211180022AC00A1-15.dwg

8369400N
8369200N
8369000N
8368800N
8368600N
8368400N

558000E
558200E
558400E
558600E

N
W
E
S

A 002
B 003
B 003
A 002

0+100
0+200
0+300
0+400
0+500
0+600
0+700

760-225
760-220
760-217
760-213
760-210
760-207
760-204
760-202
760-200
760-197
760-194
760-218
760-215
760-214
760-208
760-206
760-205
760-199
760-189
760-187
760-157
760-155
760-153
760-190
CV-109
CV-110
770-205
USE FUEL STATION

REFERENCES:

1. GRID IS REFERENCED TO NAD 83 ZONE 17.
2. SITE PLAN PROVIDED BY TECK METALS INC.

60 0 60
SCALE 1:3000 METRES

Golder Associates
Mississauga, Ontario, Canada

SCALE	AS SHOWN
DATE	Nov. 19, 2012
DESIGN	EPT
CAD	MY
CHECK	DCJ
REVIEW	RH

FILE No. 1211180022AC00A1-15.dwg
PROJECT No. 12-1118-0022 REV.

TITLE

LEVEL 760 PLAN VIEW

TECK METALS - SUBSIDENCE ASSESSMENT

FIGURE
A-3

PLOT DATE: November 19, 2012
FILENAME: T:\Projects\2012\12-1118-0022 (TECH RESOURCES, Resolute)\-AC-\1211180022AC00A1-15.dwg

8369400N
8369200N
8369000N
8368800N
8368600N
8368400N

558000E
558200E
558400E
558600E

N
W
E
S

A 002
B 003
B 003
A 002

0+100
0+200
0+100
0+200
0+300
0+300
0+400
0+500
0+500
0+600
0+700

790-235
790-231
790-224
790-223
790-222
790-220
790-218
790-217
790-215
790-213
790-212
790-210
790-208
790-207
790-205
790-204
790-202
790-200
790-199
790-197
790-196
790-194
790-192
790-190
790-189
790-187
790-185
790-784

NOP-2
235-1
#46
V(355)
V(380)
CV-10
V(659)
800-1
V(346)
V(336)
V(285)
KEX-5
KEX-3

153
155
159

60 0 60
SCALE 1:3000 METRES

REFERENCES:

1. GRID IS REFERENCED TO NAD 83 ZONE 17.
2. SITE PLAN PROVIDED BY TECK METALS INC.

Golder Associates
Mississauga, Ontario, Canada

SCALE	AS SHOWN
DATE	Nov. 19, 2012
DESIGN	EPT
CAD	MY
CHECK	DCJ
REVIEW	RH

FILE No. 1211180022AC00A1-15.dwg
PROJECT No. 12-1118-0022 REV.

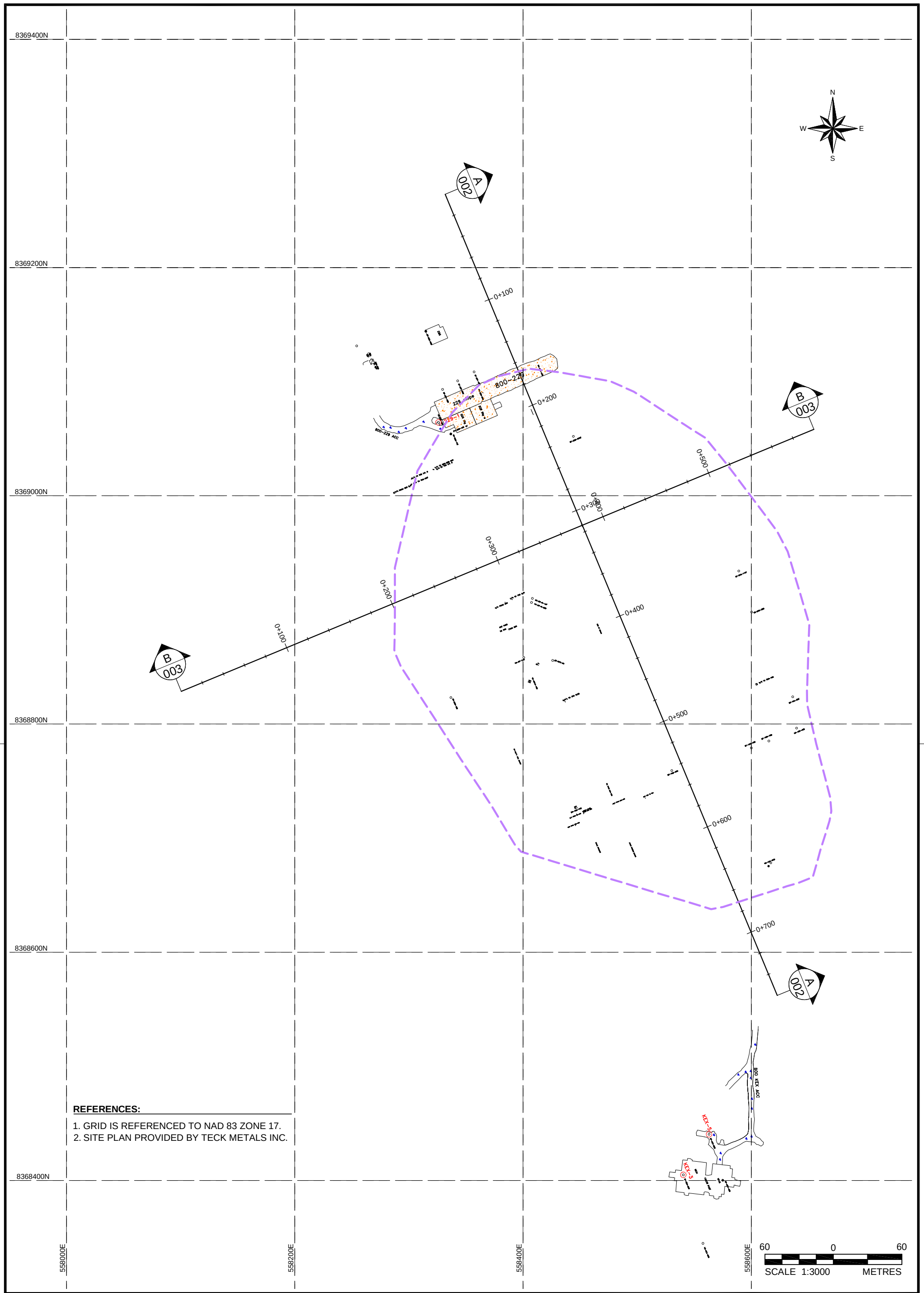
TITLE

LEVEL 790 PLAN VIEW

TECK METALS - SUBSIDENCE ASSESSMENT

FIGURE
A-4

PLOT DATE: November 19, 2012
FILENAME: T:\Projects\2012\12-1118-0022 (TECH RESOURCES, Resolute)\-AC-\1211180022AC00A1-15.dwg



REFERENCES:

1. GRID IS REFERENCED TO NAD 83 ZONE 17.
2. SITE PLAN PROVIDED BY TECK METALS INC.

Golder Associates
Mississauga, Ontario, Canada

SCALE	AS SHOWN
DATE	Nov. 19, 2012
DESIGN	EPT
CAD	MY
CHECK	DCJ
REVIEW	RH

FILE No. 1211180022AC00A1-15.dwg
PROJECT No. 12-1118-0022 REV.

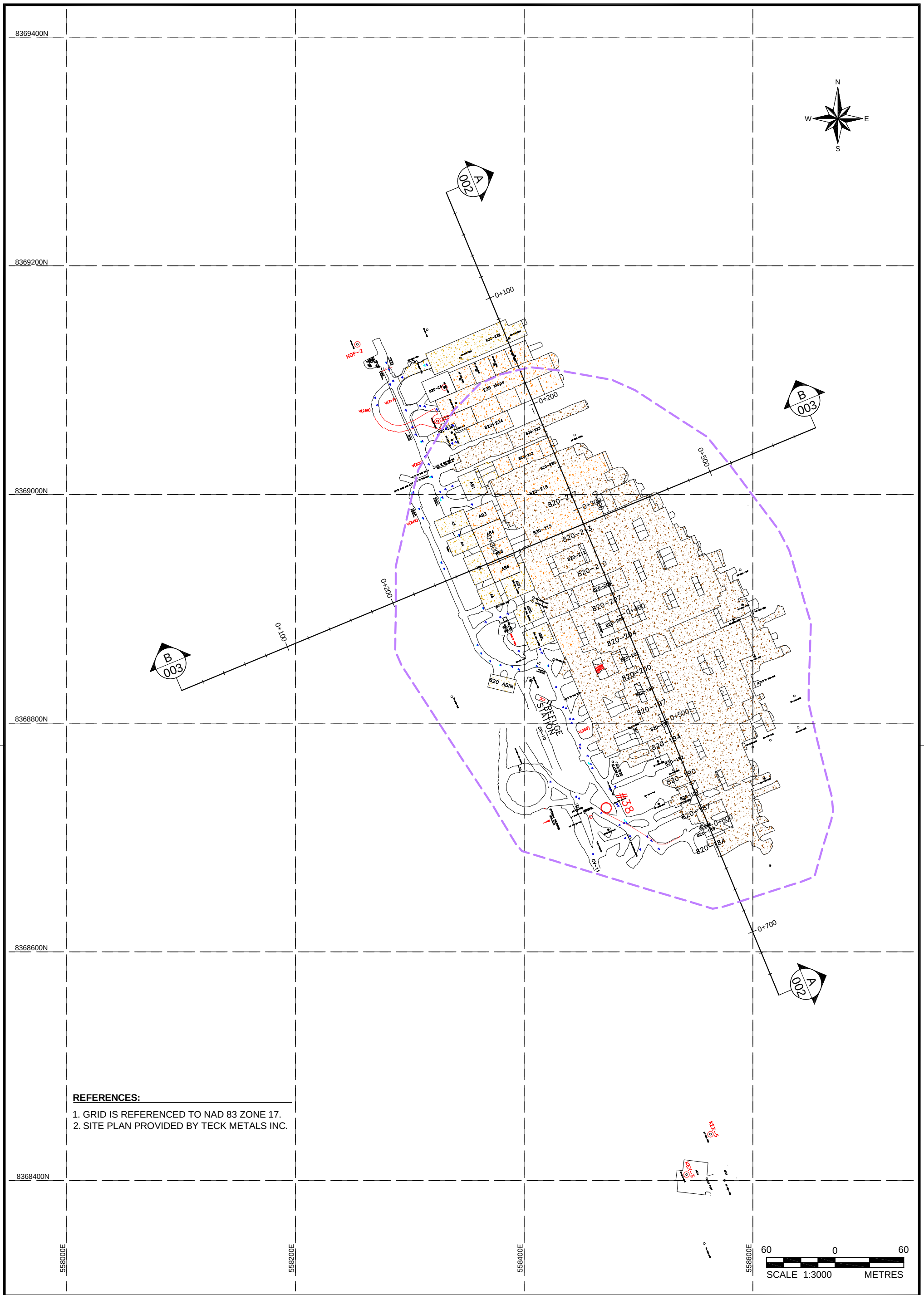
TITLE

LEVEL 800 PLAN VIEW

TECK METALS - SUBSIDENCE ASSESSMENT

FIGURE
A-5

PLOT DATE: November 19, 2012
FILENAME: T:\Projects\2012\12-1118-0022 (TECH RESOURCES, Resolute)\-AC-\1211180022AC00A1-15.dwg



REFERENCES:

1. GRID IS REFERENCED TO NAD 83 ZONE 17.
2. SITE PLAN PROVIDED BY TECK METALS INC.

Golder Associates
Mississauga, Ontario, Canada

SCALE	AS SHOWN
DATE	Nov. 19, 2012
DESIGN	EPT
CAD	MY
CHECK	DCJ
REVIEW	RH

FILE No. 1211180022AC00A1-15.dwg
PROJECT No. 12-1118-0022 REV.

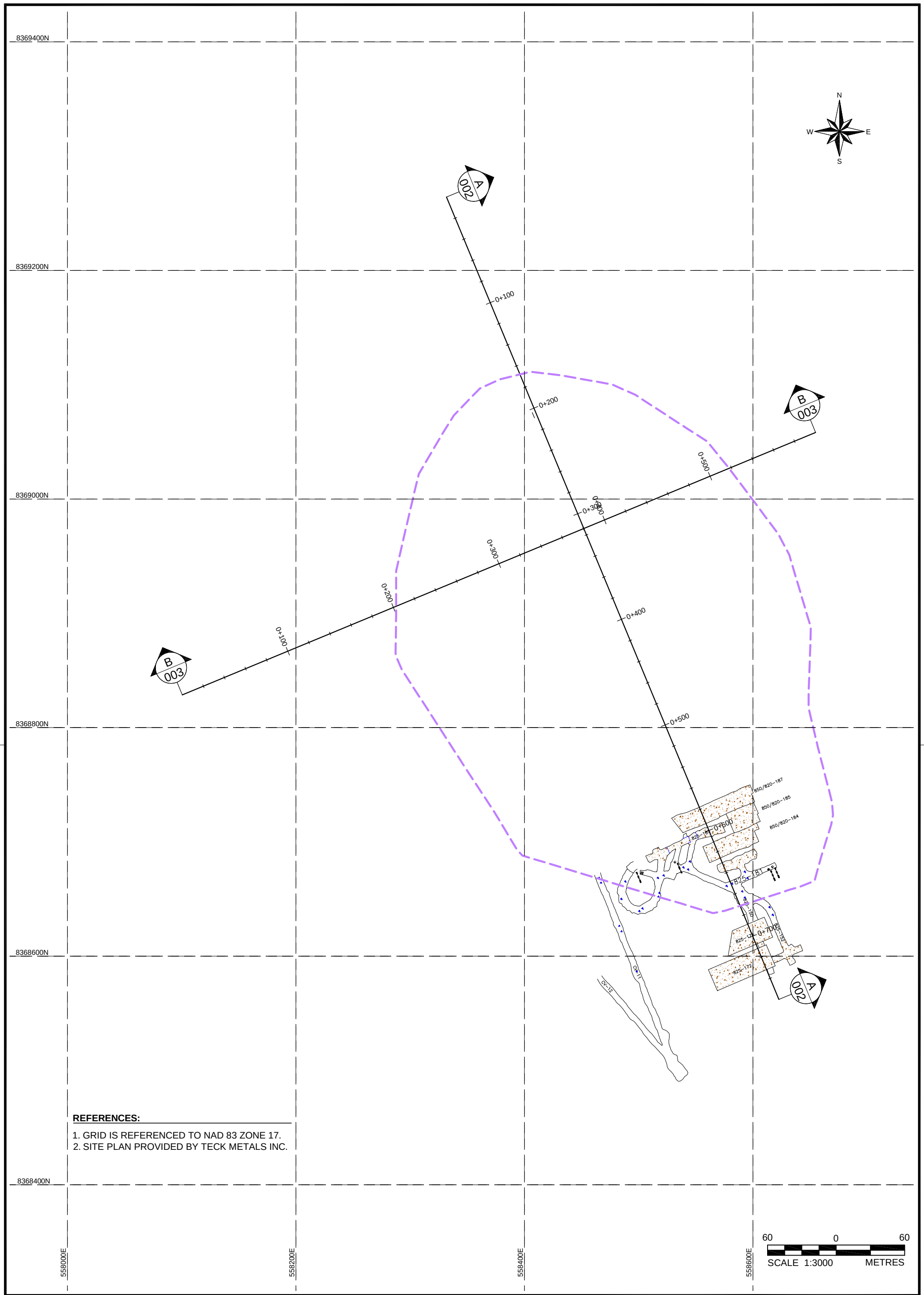
TITLE

LEVEL 820 PLAN VIEW

TECK METALS - SUBSIDENCE ASSESSMENT

FIGURE **A-6**

PLOT DATE: November 19, 2012
FILENAME: T:\Projects\2012\12-1118-0022 (TECH RESOURCES, Resolute)\-AC-\1211180022AC00A1-15.dwg



REFERENCES:

1. GRID IS REFERENCED TO NAD 83 ZONE 17.
2. SITE PLAN PROVIDED BY TECK METALS INC.

Golder Associates
Mississauga, Ontario, Canada

SCALE	AS SHOWN
DATE	Nov. 19, 2012
DESIGN	EPT
CAD	MY
CHECK	DCJ
REVIEW	RH

FILE No. 1211180022AC00A1-15.dwg
PROJECT No. 12-1118-0022 REV.

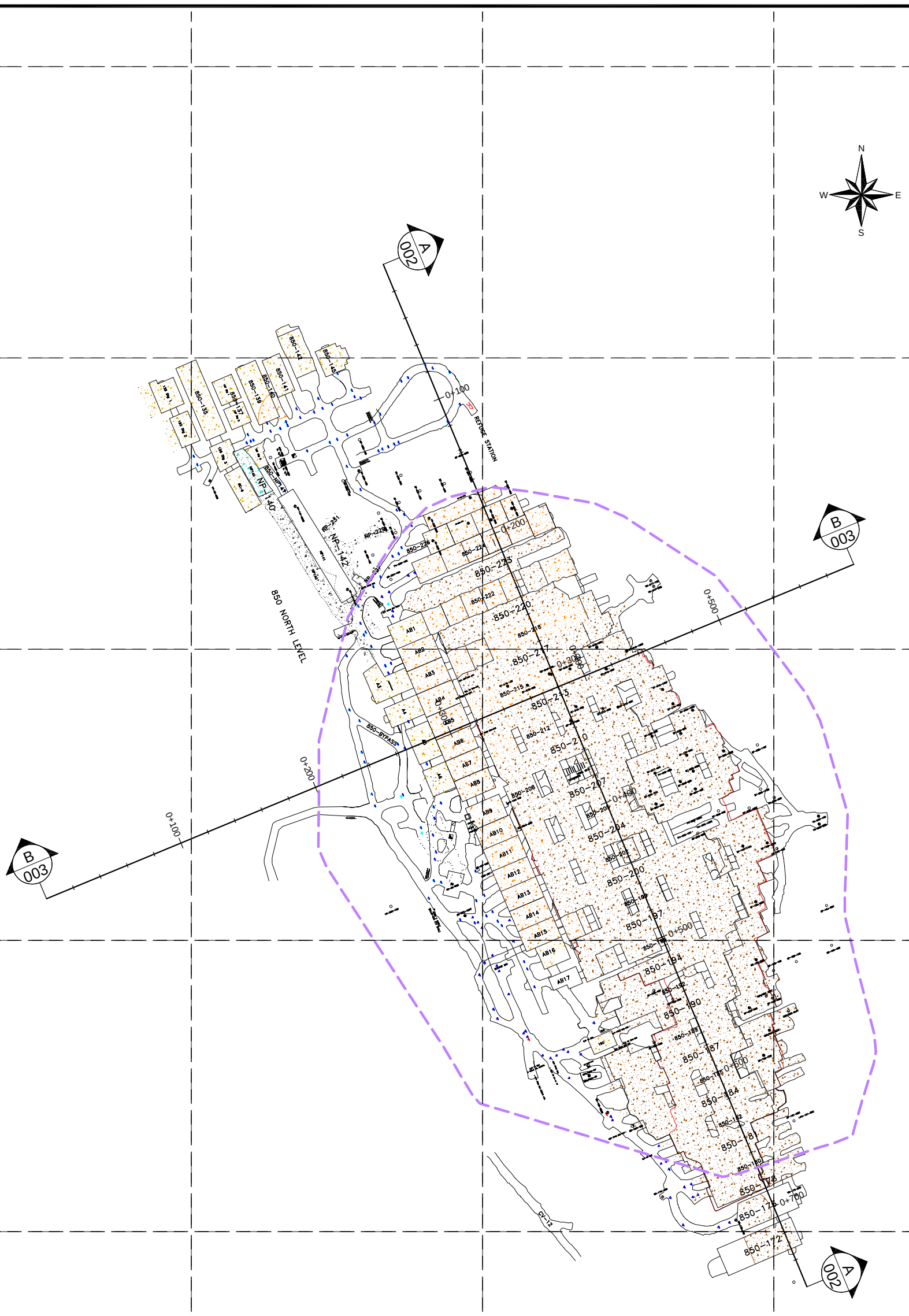
TITLE

LEVEL 825 PLAN VIEW

TECK METALS - SUBSIDENCE ASSESSMENT

FIGURE
A-7

PLOT DATE: November 19, 2012
FILENAME: T:\Projects\2012\12-1118-0022 (TECH RESOURCES, Resolute)\-AC-\1211180022AC00A1-15.dwg



REFERENCES:

1. GRID IS REFERENCED TO NAD 83 ZONE 17.
2. SITE PLAN PROVIDED BY TECK METALS INC.

Golder Associates
Mississauga, Ontario, Canada

SCALE	AS SHOWN
DATE	Nov. 19, 2012
DESIGN	EPT
CAD	MY
CHECK	DCJ
REVIEW	RH

FILE No. 1211180022AC00A1-15.dwg
PROJECT No. 12-1118-0022 REV.

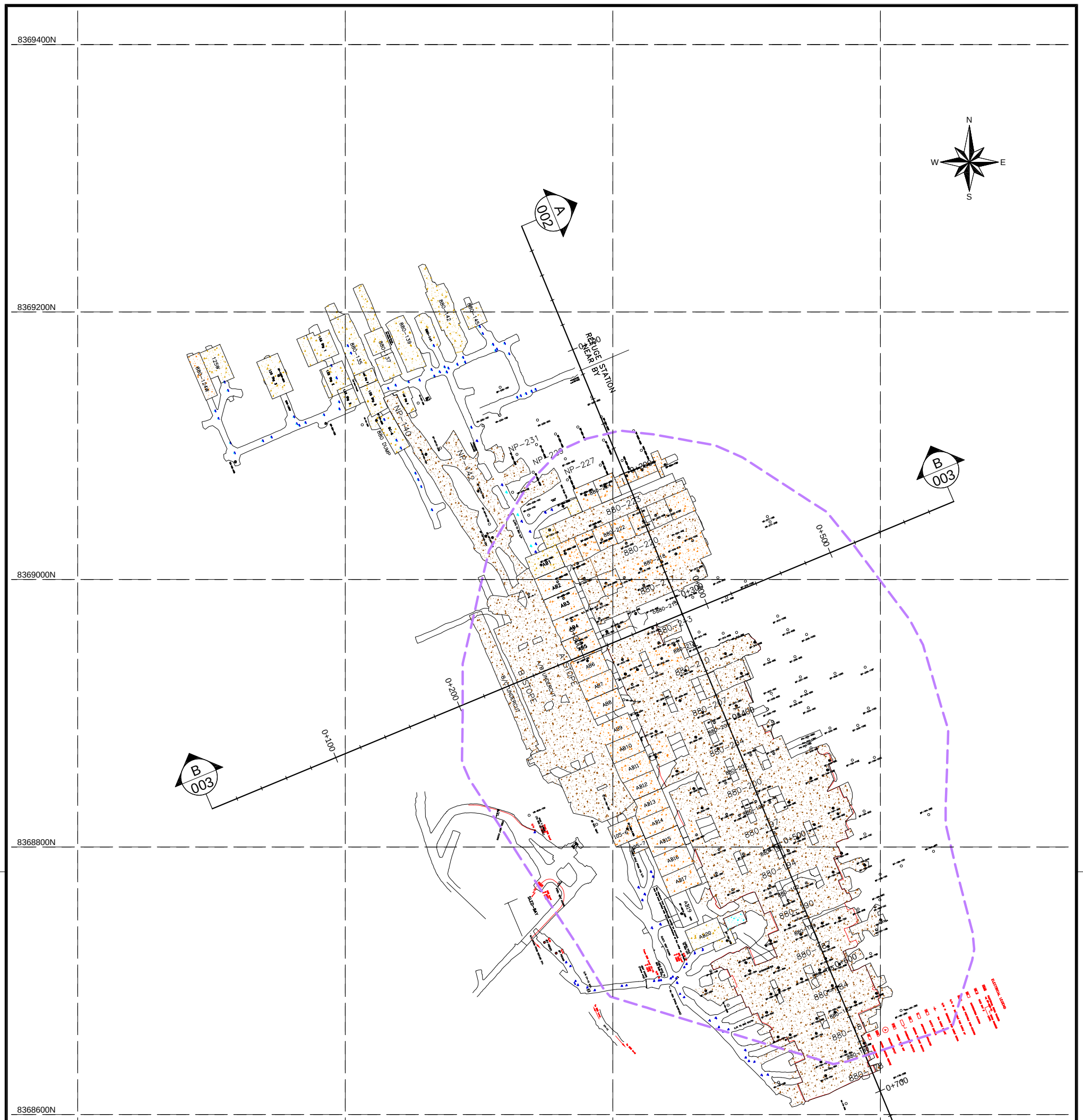
TITLE

LEVEL 850 PLAN VIEW

TECK METALS - SUBSIDENCE ASSESSMENT

FIGURE
A-8

PLOT DATE: November 19, 2012
FILENAME: T:\Projects\2012\12-1118-0022 (TECH RESOURCES, Resolute)\-AC-\1211180022AC00A1-15.dwg



REFERENCES:

1. GRID IS REFERENCED TO NAD 83 ZONE 17.
2. SITE PLAN PROVIDED BY TECK METALS INC.

Golder Associates
Mississauga, Ontario, Canada

SCALE	AS SHOWN
DATE	Nov. 19, 2012
DESIGN	EPT
CAD	MY
CHECK	DCJ
REVIEW	RH

TITLE

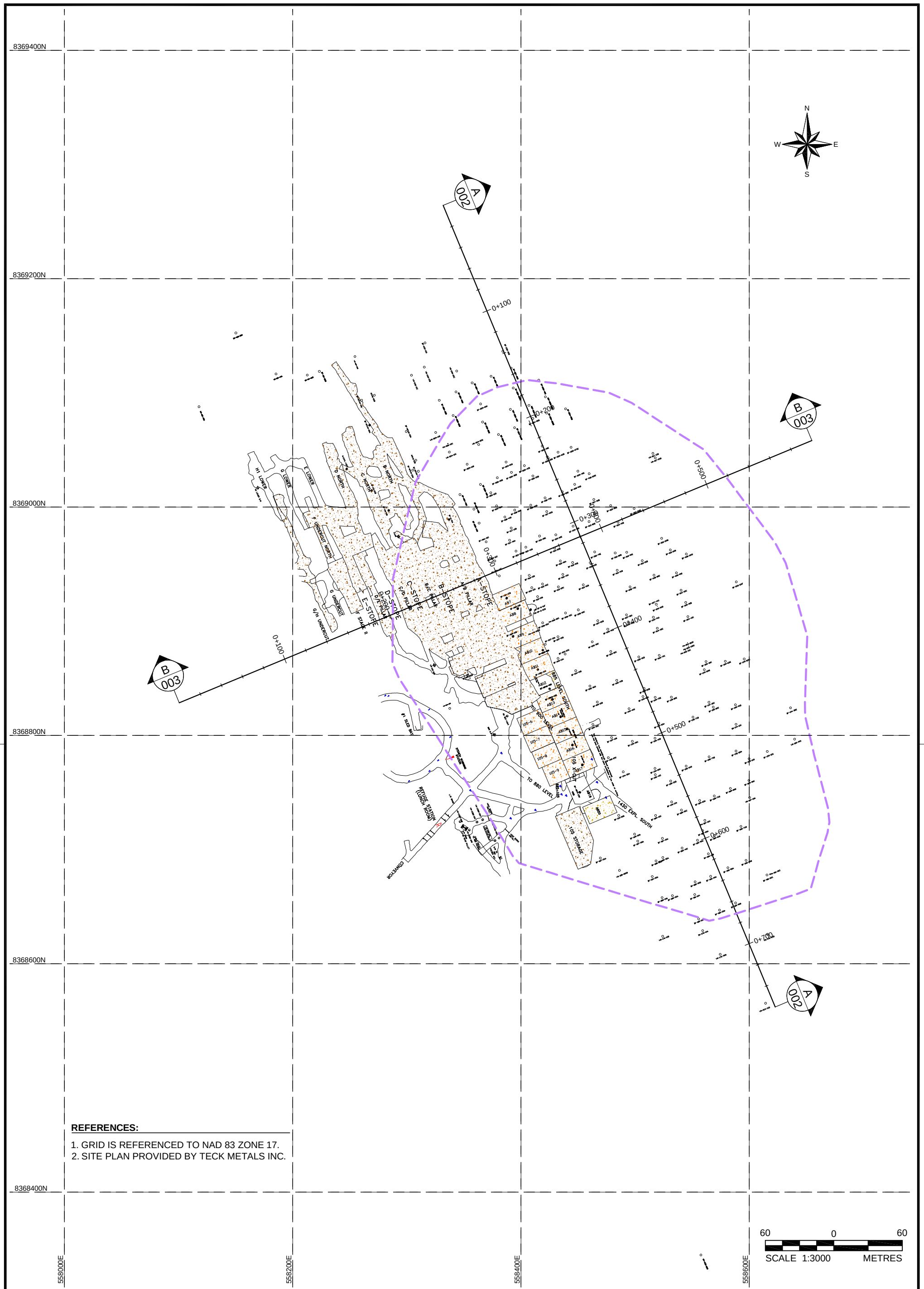
LEVEL 880 PLAN VIEW

FILE No. 1211180022AC00A1-15.dwg
PROJECT No. 12-1118-0022 REV.

TECK METALS - SUBSIDENCE ASSESSMENT

FIGURE
A-9

PLOT DATE: November 19, 2012
FILENAME: T:\Projects\2012\12-1118-0022 (TECH RESOURCES, Resolute)\-AC-\1211180022AC00A1-15.dwg



REFERENCES:

1. GRID IS REFERENCED TO NAD 83 ZONE 17.
2. SITE PLAN PROVIDED BY TECK METALS INC.

Golder Associates
Mississauga, Ontario, Canada

SCALE	AS SHOWN
DATE	Nov. 19, 2012
DESIGN	EPT
CAD	MY
CHECK	DCJ
REVIEW	RH

FILE No. 1211180022AC00A1-15.dwg
PROJECT No. 12-1118-0022 REV.

TITLE

LEVEL 885 PLAN VIEW

TECK METALS - SUBSIDENCE ASSESSMENT

FIGURE
A-10

PLOT DATE: November 19, 2012
FILENAME: T:\Projects\2012\12-1118-0022 (TECH RESOURCES, Resolute)\-AC-\1211180022AC00A1-15.dwg

8369400N
8369200N
8369000N
8368800N
8368600N
8368400N

558000E
558200E
558400E
558600E

N
W
E
S

A 002
B 003
B 003
A 002

0+100
0+200
0+500
0+300
0+400
10+300
0+100
0+500
0+600
0+700

REFUSE STATION NEXT RIGHT
REFUSE STATION NEXT LEFT
NOP-1
NOP-2
231-6
229-
800-1
CV12-2
CV12-3
KEY-2

V(273)
V(179)
V(243)
V(301)
V(150)

800 N RAMP
800-15E
800-15W
800-15F
800-12W
800-12E
800-12W ACC
800 CD
800 DE
800 CDR
E LOWER
G LOWER
H LOWER
F RAMP V/E
115 K/C
115 CROSS CUT
E STOPE
D STOPE
C STOPE
B STOPE
A STOPE
F PILLAR
G PILLAR
D/E PILLAR
B/C PILLAR
A PILLAR
CDR PILLAR
F RAMP BYPASS
105 CROSS CUT
800 CDR
MAIN DECLINE
105 X.C. BYPASS
105 X.C. BYPASS EXT.
105 STORAGE
#2 SLED-WAY
105 X-CUT
A520
CV-11 HEAD PULLEY

60 0 60
SCALE 1:3000 METRES

REFERENCES:

1. GRID IS REFERENCED TO NAD 83 ZONE 17.
2. SITE PLAN PROVIDED BY TECK METALS INC.

Golder Associates
Mississauga, Ontario, Canada

SCALE	AS SHOWN
DATE	Nov. 19, 2012
DESIGN	EPT
CAD	MY
CHECK	DCJ
REVIEW	RH

FILE No. 1211180022AC00A1-15.dwg
PROJECT No. 12-1118-0022 REV.

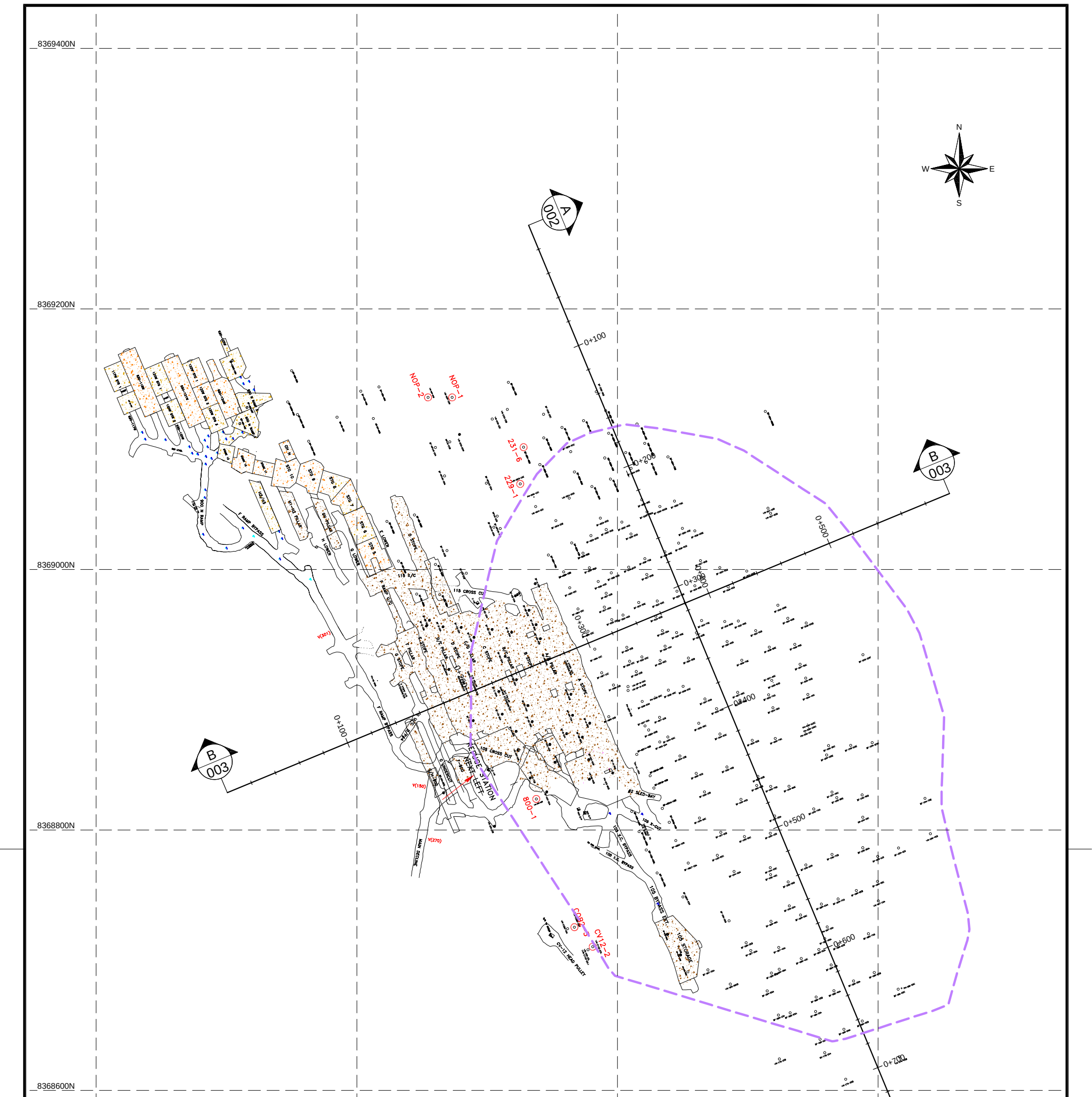
TITLE

LEVEL 900 PLAN VIEW

TECK METALS - SUBSIDENCE ASSESSMENT

FIGURE
A-11

PLOT DATE: November 19, 2012
FILENAME: T:\Projects\2012\12-1118-0022 (TECH RESOURCES, Resolute)\-AC-\1211180022AC00A1-15.dwg



REFERENCES:

1. GRID IS REFERENCED TO NAD 83 ZONE 17.
2. SITE PLAN PROVIDED BY TECK METALS INC.

Golder Associates
Mississauga, Ontario, Canada

SCALE	AS SHOWN
DATE	Nov. 19, 2012
DESIGN	EPT
CAD	MY
CHECK	DCJ
REVIEW	RH

FILE No. 1211180022AC00A1-15.dwg
PROJECT No. 12-1118-0022 REV.

TITLE

LEVEL 930 PLAN VIEW

TECK METALS - SUBSIDENCE ASSESSMENT

FIGURE
A-12

PLOT DATE: November 19, 2012
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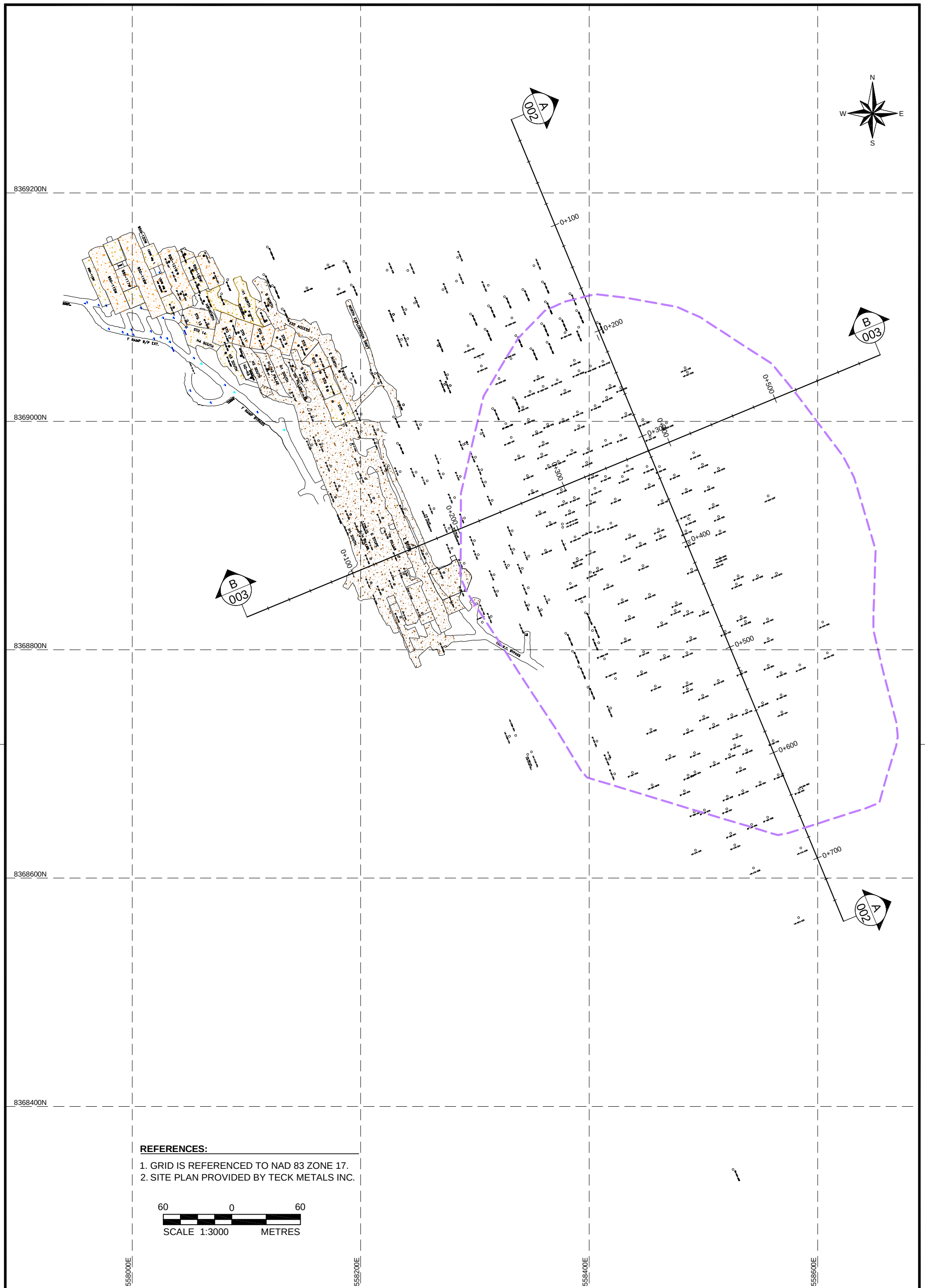


REFERENCES:

1. GRID IS REFERENCED TO NAD 83 ZONE 17.
2. SITE PLAN PROVIDED BY TECK METALS INC.

60 0 60
SCALE 1:3000 METRES

Golder Associates
Mississauga, Ontario, Canada

SCALE	AS SHOWN
DATE	Nov. 19, 2012
DESIGN	EPT
CAD	MY
CHECK	DCJ
REVIEW	RH

FILE No. 1211180022AC00A1-15.dwg
PROJECT No. 12-1118-0022 REV.

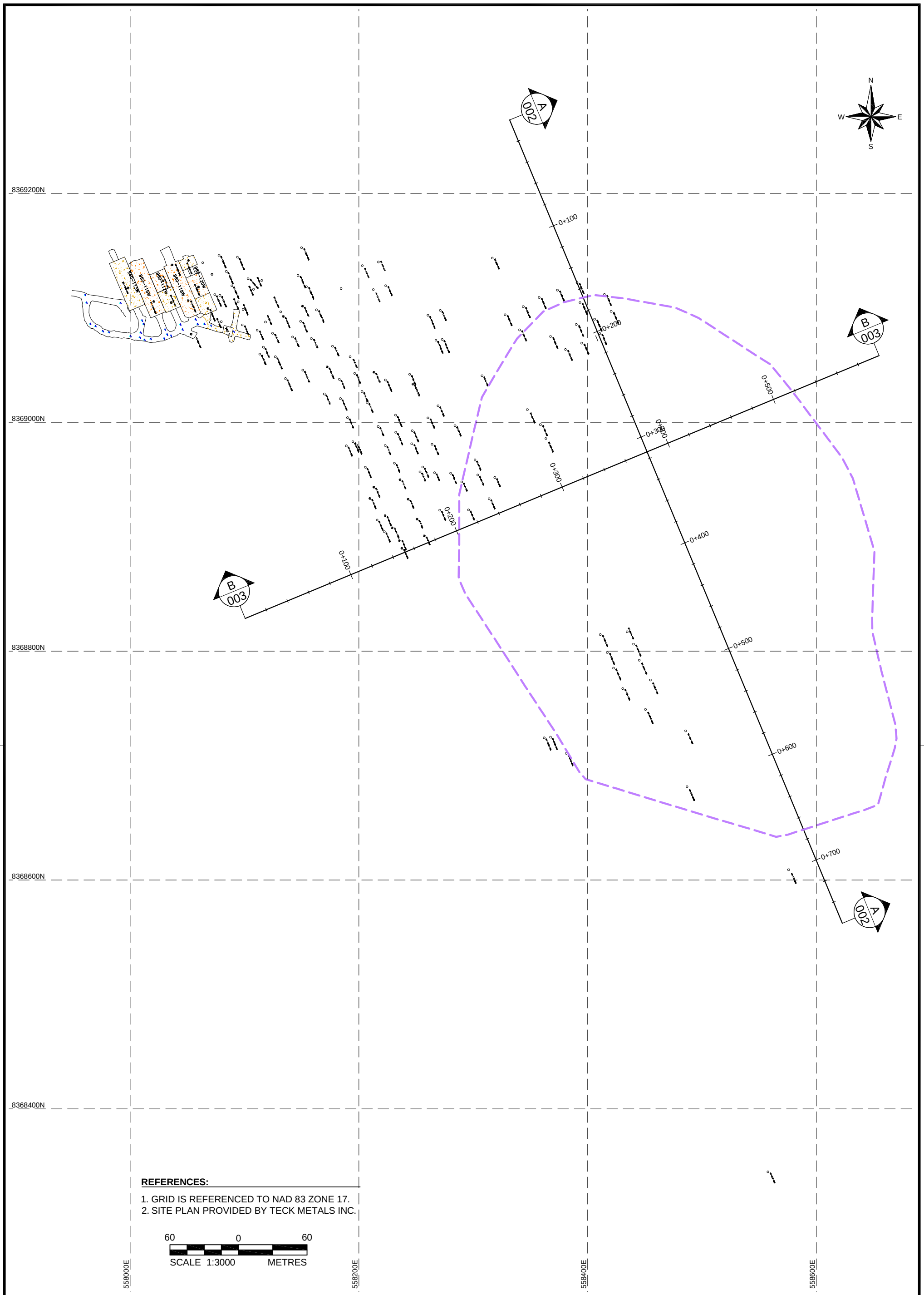
TITLE

LEVEL 950 PLAN VIEW

TECK METALS - SUBSIDENCE ASSESSMENT

FIGURE
A-13

PLOT DATE: November 19, 2012
FILENAME: T:\Projects\2012\12-1118-0022 (TECH RESOURCES, Resolute)\-AC-\1211180022AC00A1-15.dwg



REFERENCES:

1. GRID IS REFERENCED TO NAD 83 ZONE 17.
2. SITE PLAN PROVIDED BY TECK METALS INC.

60 0 60
SCALE 1:3000 METRES

Golder Associates
Mississauga, Ontario, Canada

SCALE	AS SHOWN
DATE	Nov. 19, 2012
DESIGN	EPT
CAD	MY
CHECK	DCJ
REVIEW	RH

FILE No. 1211180022AC00A1-15.dwg
PROJECT No. 12-1118-0022 REV.

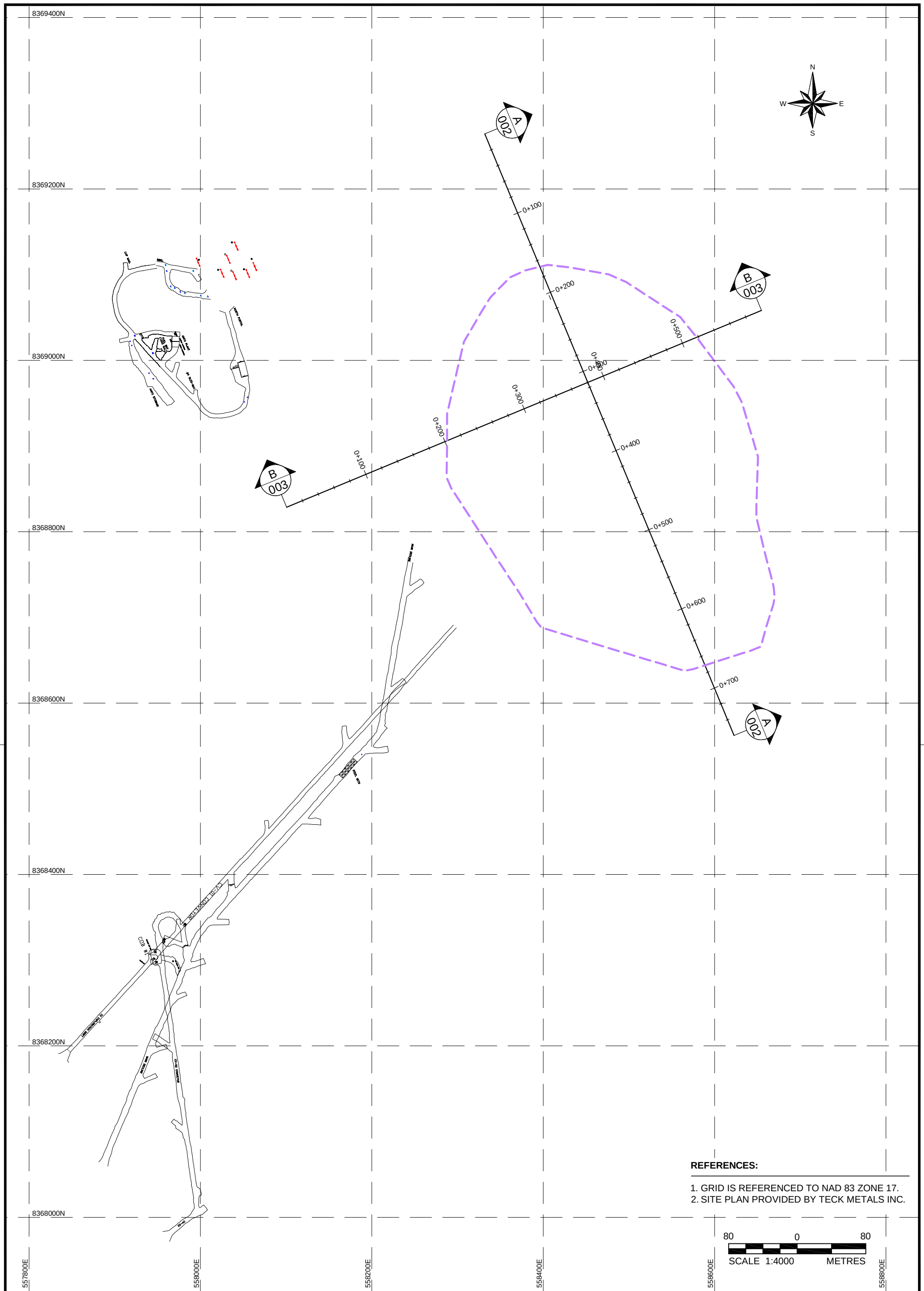
TITLE

LEVEL 960 PLAN VIEW

TECK METALS - SUBSIDENCE ASSESSMENT

FIGURE
A-14

PLOT DATE: November 19, 2012
FILENAME: T:\Projects\2012\12-1118-0022 (TECH RESOURCES, Resolute)\-AC-\1211180022AC00A1-15.dwg



REFERENCES:

1. GRID IS REFERENCED TO NAD 83 ZONE 17.
2. SITE PLAN PROVIDED BY TECK METALS INC.

80 0 80
SCALE 1:4000 METRES

Golder Associates
Mississauga, Ontario, Canada

SCALE	AS SHOWN
DATE	Nov. 19, 2012
DESIGN	EPT
CAD	MY
CHECK	DCJ
REVIEW	RH

FILE No. 1211180022AC00A1-15.dwg
PROJECT No. 12-1118-0022 REV.

TITLE

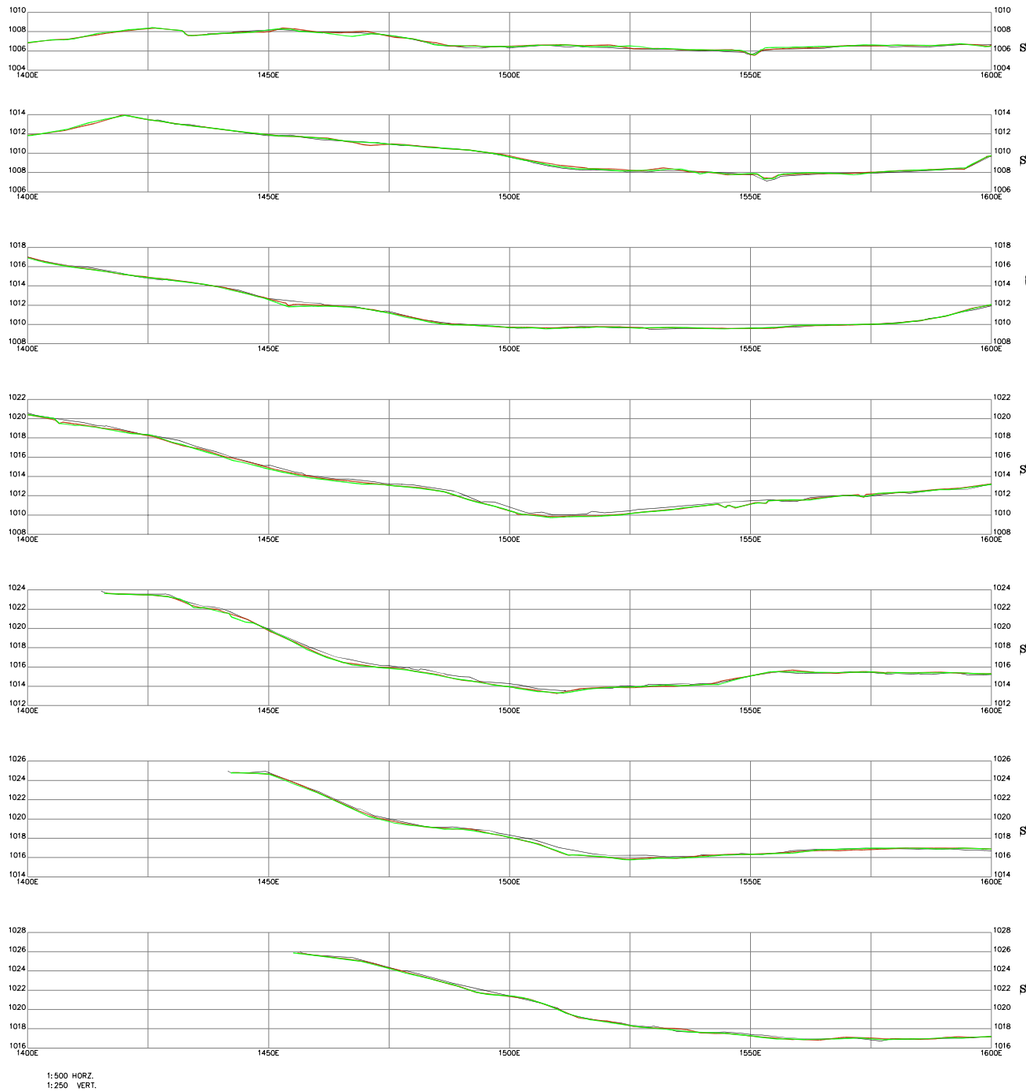
LEVEL 980 PLAN VIEW

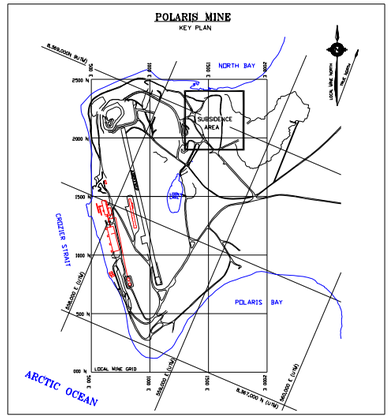
TECK METALS - SUBSIDENCE ASSESSMENT

FIGURE
A-15

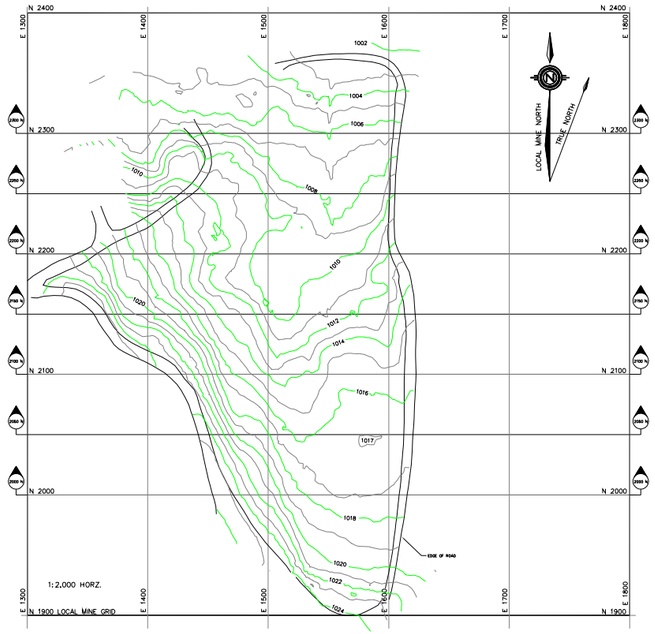
APPENDIX B

2011 Survey Results of Ground Surface over Underground Mine Workings





POLARIS MINE
AREA 8



NOTES:
1. DATA COLLECTED JULY, 2011 BY FOCUS ENGINEERING.
2. SECTION CO-ORDINATES AND ELEVATIONS REFER TO LOCAL MINE DATUM.
3. CONTOUR INTERVALS = 1meter
4. SECTIONS HAVE A 2:1 VERTICAL EXAGGERATION.

LEGEND:
- DENOTES 2011 SURFACE.
- DENOTES 2010 SURFACE.
- DENOTES 2005 SURFACE.

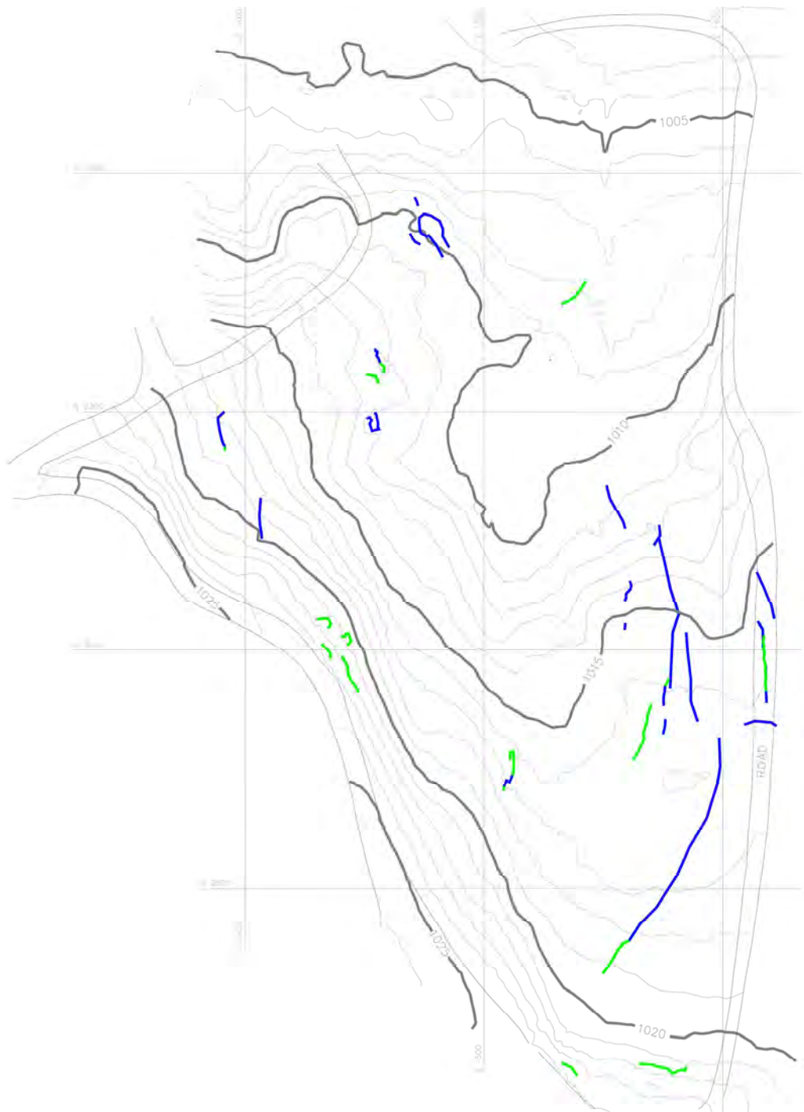
PROJECT:
POLARIS MINE POST CLOSURE
2011 ANNUAL SITE INSPECTION

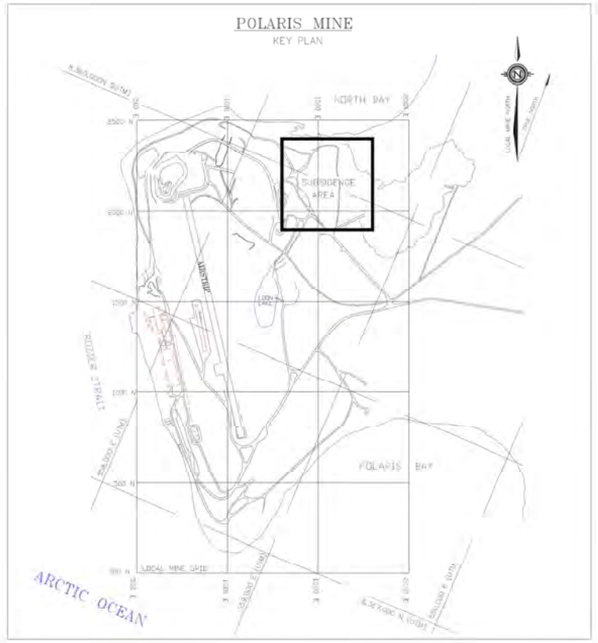
DRAWING:
PLAN & SECTION VIEWS
SUBSIDENCE – AREA 8

DRAWN BY: T. M. TECH SERVICES		CLIENT: Teck	
10-542			
DATE: AUGUST 3, 2011		SCALE: 1:1250 HORZ. 1:625 VERT.	
FIGURE No.			SHEET:
PM	2011	AREA 8	1 of 2

Golder Associates

FILE No. 1211180022AC00B1.dwg		SCALE AS SHOWN	TITLE 2011 SUBSIDENCE AREA SURVEY PLAN AND SECTION
PROJECT No. 12-1118-0022	REV.	DATE Nov. 19, 2012	
		DESIGN EPT	
		CAD MY	TECK METALS - SUBSIDENCE ASSESSMENT
		CHECK DCJ	FIGURE B-1
		REVIEW RH	





POLARIS MINE
AREA 8

NOTES:
1. DATA COLLECTED JULY, 2011 BY FOCUS ENGINEERING.
2. ELEVATIONS REFER TO LOCAL MINE DATUM.
3. CONTOUR INTERVAL 5 metre.

LEGEND:
DENOTES CRACKS LOCATED IN 2011 NOT PREVIOUSLY IDENTIFIED
DENOTES CRACKS IDENTIFIED IN PREVIOUS YEARS
CONTOURS FROM JULY 2011 SURVEY

PROJECT:
POLARIS MINE POST CLOSURE
2011 ANNUAL SITE INSPECTION

DRAWING:
ANNUAL SURVEY REVIEW
SUBSIDENCE CRACKS – AREA 8

DRAWN BY: T. M. TECH SERVICES
CLIENT: Teck
DATE: AUGUST 4, 2011
SCALE: 1:2500
FIGURE No.: PM 2011 AREA 8
SHEET: 2-2

Golder Associates
Mississauga, Ontario, Canada

FILE No.	1211180022AC00B2.dwg
PROJECT No.	12-1118-0022
REV.	
SCALE	1:2500
DATE	Nov. 19, 2012
DESIGN	EPT
CAD	MY
CHECK	DCJ
REVIEW	RH

TITLE
2011 SUBSIDENCE AREA SURVEY OBSERVED SURFACE CRACKS

TECK METALS - SUBSIDENCE ASSESSMENT

FIGURE
B-2

PLOT DATE: November 19, 2012
FILENAME: T:\Projects\2012\12-1118-0022 (TECH RESOURCES, Resolute)\-AC-\1211180022AC00B2.dwg

APPENDIX C

Geotechnical Cost Calculations

TABLE C-1
GEOTECHNICAL INSPECTION COST ESTIMATE
Polaris Long-Term Geotechnical Monitoring

Geotechnical Inspection Cost (per event in 2012 dollars)

Description		Quantity	Unit	Unit Cost	Total
Disbursements	Flight (round trip Ottawa/Resolute)	1	$	$5,625	$5,625
	Flight (round trip Resolute/site)	1	$	$3,616	$3,616
	Room & Board (in Resolute)	5	$/day	$170	$850
	Equipment rental	1	$/day	$500	$500
Labour	Geotechnical Engineer (including travel)	40	$/hr	$180	$7,200
	Inuit Wildlife Monitoring	12	$/hr	$25	$300
	Local contracted labour	12	$/hr	$90	$1,080
	Inspection Report Preparation	1	lump sum	$10,000	$10,000
Miscellaneous	30% total (15% tax and 15% contingency)				$8,751
				Total Cost	$37,922

TABLE C-2
FENCING INSTALLATION AND REPAIR COST ESTIMATES
Polaris Long-Term Geotechnical Monitoring

Fence Installation Cost Around Full Underground Mine Area (every 40 years)

Description		Quantity	Unit	Unit Cost	Total
Fence Installation (1360 m)	Supply and Installation of Fencing (materials, labour and supervision)	1	lump sum	$280,000	$280,000
	Purchase of Installation Equipment	1	lump sum	$250,000	$250,000
Transporting Supplies	Ship From Montreal to Site (40 tonnes)	1	lump sum	$100,000	$100,000
Travel	Flights (round trip Ottawa/Resolute)	7	round trip	$6,000	$42,000
	Flights (round trip Resolute/site)	10	round trip	$2,500	$25,000
	Temporary Camp (Room & Board)	20	days	$2,000	$40,000
Additional Labour	Inuit Wildlife Monitor	240	hours	$50	$12,000
	Local Contracted Labourer	240	hours	$50	$12,000
	Mechanic	240	hours	$100	$24,000
Miscellaneous	ATV	2	lump sum	$5,000	$10,000
	Fuel	1	lump sum	$10,000	$10,000
	30% total (15% tax and 15% contingency)				$241,500
				Total Cost	$1,046,500

Major Fence Repair Cost (every 20 years)

Description		Quantity	Unit	Unit Cost	Total
Repair (400 m)	Supply and Installation of Fencing (materials, labour and supervision)	1	lump sum	$100,000	$100,000
Transporting Supplies	Ship From Montreal to Resolute (6 tonnes)	1	lump sum	$10,000	$10,000
	Chartered Flights From Resolute to Site	30	round trip	$2,500	$75,000
Travel	Flights (round trip Ottawa/Resolute)	6	round trip	$6,000	$36,000
	Flights (round trip Resolute/site)	1	round trip	$2,500	$2,500
	Temporary Camp (Room & Board)	7	days	$2,000	$14,000
Additional Labour	Inuit Wildlife Monitor	84	hours	$50	$4,200
	Local Contracted Labourer	84	hours	$50	$4,200
	Mechanic	84	hours	$100	$8,400
Miscellaneous	30% total (15% tax and 15% contingency)				$76,290
				Total Cost	$330,590

Notes: Assumes 6 labourers required for fence installation and repair.
Assumes 20 days for fence installation or replacement (every 40 years).
Assumes 7 days for major fence repair (every 20 years).

APPENDIX D

Author Resumes

Education

M.Sc. (Eng.) Geotechnical/Environmental Engineering, Queen's University, 1998

B.Sc. Civil Engineering, Queen's University, 1996

Certifications

Xstrata Stage Gate Training, December 2011

Joint Health and Safety Committee Certified Member, Gowlings, February 2008

Manager of Landfill Operations (MOLO) Technical Associate, SWANA, November 2007

Towards Sustainable Mining (TSM) Auditor, Mining Association of Canada, December 2006

Languages

English – Fluent

Golder Associates Ltd. – Mississauga

Senior Geotechnical Engineer

Mr. Johnson is a Senior Geotechnical Engineer with over 15 years of experience in mining environmental management and waste facility design. He is a registered Professional Engineer in Ontario, British Columbia, Nunavut, Northwest Territories and Yukon. Mr. Johnson has carried out geotechnical and hydrogeological site investigations, dam design and slope stability assessments, mine closure plans and financial assurance calculations, and design of landfills and mine tailings areas across Canada and around the world. His project experience includes very remote mine sites and permafrost settings. Recently Darrin participated in Xstrata Stage Gate training and he will be leading preparation of Stage Gate deliverables for this project.

Mr. Johnson has been involved with all project lifecycle phases including greenfield site development, feasibility studies, detailed engineering design, approvals, contract tendering, construction, optimization and expansion of existing operations, and closure planning. Darrin has significant experience with dynamic slope stability analysis, liquefaction analysis and design of seismic ground improvement. In addition, Mr. Johnson has been responsible for contract administration and construction monitoring of large multi-disciplinary environmental management projects.

He has contributed to the preparation and review of environmental assessment reports for several new mine and infrastructure projects. Darrin has experience assisting First Nations with solid waste management and review of proposed mining projects on behalf of First Nations. Mr. Johnson has also provided geotechnical engineering expertise for public hearings and assisted with the review of water licence applications for proposed and operating mines.

Employment History

Golder Associates Ltd. – Mississauga, Ontario
Senior Geotechnical Engineer (2010 to Present)

Project Manager for mine site development, tailings impoundment design and solid waste landfill projects. Responsible for planning and supervision of geotechnical field investigations, technical analyses, engineering design, construction monitoring and reporting.

AECOM (formerly Gartner Lee Limited) – Guelph, Ontario
Senior Geotechnical/Environmental Engineer (2007 to 2010)

Responsible for geotechnical engineering design, review and project management of multidisciplinary mining, contaminated site remediation and solid waste management projects. Post-closure geotechnical inspection of decommissioned mines, landfills and remote arctic military sites.

Gartner Lee Limited – Burnaby, British Columbia
Senior Geotechnical Engineer (2005 to 2007)

Geotechnical engineering for mine and solid waste management facility site

development. Planning and implementation of specialized geotechnical and hydrogeological investigations at remote arctic sites. Environmental assessment of new mine and infrastructure projects.

Gartner Lee Limited – Markham, Ontario
Geotechnical/Environmental Engineer (2003 to 2005)

Design and operations planning for landfills, solid waste transfer stations, organics composting facilities and material recovery facilities (MRFs). Environmental site assessment and contaminated site remediation. Contract administration and construction monitoring.

Golder Associates Ltd. – Mississauga, Ontario
Geotechnical/Environmental Engineer (1995 to 2003)

Site investigation for mine site development, tailings facility design and contaminated site remediation. Engineering design and construction monitoring of mine tailings dams and mine closure earthworks. Environmental site assessment and remedial system design. Static and dynamic slope stability analyses and liquefaction analysis for design and closure of mine tailings dams.

Golder Associates Ltd. – Sudbury, Ontario
Geotechnical Engineer-in-Training (1995 to 1998)

Field investigation, groundwater sampling, laboratory soils testing and reporting.

Trow Consulting Engineers Ltd. – Sudbury, Ontario
Summer Student (1994 to 1994)

Field and laboratory testing of soil and concrete.

PROJECT EXPERIENCE – MINE WASTE MANAGEMENT

Cliffs Natural Resources Inc. James Bay Lowlands, Ontario, Canada	Project manager for geotechnical investigation supporting a Pre-Feasibility Study (PFS) of a proposed open pit chromite mine and surface infrastructure facilities.
Osisko Hammond Reef Gold Ltd. Atikokan, Ontario, Canada	Assessment of tailings siting options and geotechnical investigation to prepare a project description in support of Canadian Environmental Assessment Act (CEAA) approval for a proposed open pit gold mine.
Agrium Inc. (Phosphate Mine) Kapuskasing, Ontario, Canada	Planned and carried out geotechnical and hydrogeological investigations for environmental assessment and design of a new open pit phosphate mine and tailings disposal area. Recent project work included geotechnical design of waste material and ore stockpiles.
Barrick Gold Corporation (Bicroft Mine Inspection) Bancroft, Ontario, Canada	Project Manager for annual inspection and monitoring program for the closed uranium mine tailings area. Facilities inspected include 6 water retaining dams and 3 spillway structures.
Constance Lake First Nation (Proposed Phoscan Phosphate Mine) Martison, Ontario, Canada	Coordinated a multi-disciplinary technical review of the Preliminary Feasibility Study to identify potential socio-economic and environmental impacts to assist the First Nation with negotiating an Impact Benefit Agreement. Identified operating and post-closure environmental issues and recommended potential mitigation measures.
Xstrata Nickel (Smelter Closure) Falconbridge, Ontario, Canada	Assisted with various aspects of preparing a closure plan for a base metal smelter property where mining, milling, and smelting had been carried out for over 50 years. Involvement included geotechnical investigation, groundwater monitoring, slope stability analyses and closure design for tailings and granulated slag areas.
Compania Minera Antamina, S.A. Peru	Supervised geotechnical and hydrogeological field investigations for design of a tailings impoundment and process water reservoir in the Andes Mountains of Peru.
INCO Ltd. (WD16 Open Pit Mine) Sudbury, Ontario, Canada	Collected background hydrological field data for a new open pit mine development including stream water flow measurements, lake and groundwater levels and water chemistry sample collection during regular site visits.
St. Lawrence Cement (Mosport Gravel Pit) Orono, Ontario, Canada	Carried out slope stability analyses and design of a rehabilitated slope at an active gravel pit.
Rio Algom Limited Elliot Lake, Ontario, Canada	Prepared a long-term care, maintenance and monitoring manual for tailings areas at several uranium mines. Developed a risk-based model for calculation of care and maintenance costs.

Xstrata Nickel (Tailings and Waste Rock Storage Area Closure) Onaping, Ontario, Canada	Conceptual design of three zoned earth dams for flooded closure of the Strathcona tailings area. Supervised construction of the West Morgan Lake tailings containment dam. Prepared a conceptual design and cost estimate for submerged closure of potentially acid generating (PAG) waste rock.
Barrick Gold Corporation (East Malartic and Barnat-Sladen Tailings Areas) Malartic, QC,, Canada	Geotechnical investigation and collection of tailings and groundwater samples for tailings area closure design.
Caribou Mine Bathurst, N.B., Canada	Stability analysis and design of an upstream dam raise on tailings to support subaqueous deposition of sulphide tailings.

PROJECT EXPERIENCE – PERMAFROST ENGINEERING

Teck-Cominco Metals Ltd. (Former Polaris Mine) Nunavut, Canada	Responsible for annual geotechnical inspection of the closed mine site and landfills constructed on continuous permafrost in the high arctic.
Public Works and Government Services Canada (Discovery Mine Landfill) Northwest Territories, Canada	Involved with construction monitoring and as-built reporting of a landfill designed for disposal of demolition and remediation wastes generated during mine closure in an area with discontinuous permafrost.
Yukon Zinc Corporation (Wolverine Mine) Yukon, Canada	Carried out a baseline hydrogeology investigation and installed vibrating wire piezometers to monitor the influence of dewatering during a test mining program and assess potential environmental impacts in an area with discontinuous permafrost.
Wolfden Resources (High Lake Mine) NU, Canada	Planned and implemented a baseline hydrogeology characterization program north of the Arctic Circle. Vibrating wire piezometers were installed in exploration boreholes beneath almost 500 m of permafrost to collect groundwater pressure data in support of an environmental assessment for the proposed mine.
Attawapiskat First Nation (Victor Mine) Attawapiskat, Ontario, Canada	Responsible for review of geotechnical and engineering aspects for the Victor Diamond Mine Project Comprehensive Study Environmental Assessment developed in an area with discontinuous permafrost.
Rankin Inlet (Landfill Closure) Nunavut, Canada	Project Manager for development of a closure plan for the Rankin Inlet Municipal solid waste landfill.
Defence Construction Canada Cambridge Bay, Nunavut, Canada	Project Manager for monitoring and geotechnical inspection of several remediated DEW Line sites with continuous permafrost in the Canadian Arctic.

PROJECT EXPERIENCE – LANDFILL AND SOLID WASTE MANAGEMENT

Chippewas of Rama First Nation (Landfill) Rama, Ontario, Canada	Project manager for estimating landfill closure costs, annual groundwater monitoring, estimating remaining landfill capacity, and providing operations guidance and recommendations for filling remaining landfill airspace.
Greater Vancouver Regional District (Coquitlam Landfill) Coquitlam, B.C., Canada	Project Manager for development of an updated closure plan for the Coquitlam landfill. Assessment and upgrades to an existing landfill gas collection system.
Landfill Design Brunei Darussalam, Azerbaijan, Kolkata (India) and Abu Dhabi (United Arab Emirates)	Design Lead or team member for several large regional municipal solid waste management facilities and landfills. Calculation of landfill gas equivalent carbon greenhouse gas credits.
Closed Landfill Redevelopment Toronto, Ontario, Canada	Geotechnical design, landfill gas modelling and Certificate of Approval air application to support redevelopment of a closed landfill for use as a paved vehicle training facility.
Village of Cache Creek British Columbia, Canada	Site inspection and review of the annual report for a large regional landfill that receives approximately 500,000 tonnes of municipal solid waste per annum.
ESCO Limited (Landfill Cell Design) Port Coquitlam, B.C., Canada	Design Lead for an HDPE geomembrane lined landfill cell for disposal of foundry waste materials.
Regional District of Bulkley-Nechako Vanderhoof, B.C., Canada	Design Lead of a new municipal solid waste landfill and final construction inspection.
British Columbia Environmental Assessment Office Victoria, B.C., Canada	Evaluation of the performance of a composite HDPE and GCL landfill liner for a proposed regional landfill.
Columbia Shuswap Regional District Sicamous, B.C., Canada	Preparation of an updated Design and Operations Plan for a small rural municipal solid waste landfill and specification of heavy equipment for earthworks and waste compaction.
Squamish Lillooet Regional District Pemberton, B.C., Canada	Preparation of a closure plan and final cover design for the Pemberton Landfill.
District of Kitimat Kitimat, B.C., Canada	Preparation of an updated Design and Operations Plan for a small rural municipal solid waste landfill.
City of Guelph Guelph, Ontario, Canada	Preparation of an operations manual for an organic waste processing facility.

Regional Municipality of Niagara Niagara Falls, Ontario, Canada	Construction administration of the Niagara Enviro Centre Material Recovery Facility (MRF).
Regional Municipality of Niagara Port Colborne, Ontario, Canada	Resident Engineer responsible for QA/QC monitoring of a clay barrier liner for an upgraded landfill leachate collection system at the Elm Street landfill.
Ontario Power Generation Thunder Bay, Ontario, Canada	Final cover design and closure cost estimates for a fly ash landfill.

PROJECT EXPERIENCE – CONTAMINATED SITE REMEDIATION

GE Canada Toronto, Ontario , Canada	Health and Safety Manager for several contaminated sites with active remediation programs.
Squamish Nation North Vancouver, B.C., Canada	Project Manager for a soil remediation contract involving excavation and disposal of over 2,700 tonnes of creosote impacted soil.
Ontario Power Generation Toronto, Ontario, Canada	Technical Lead for soil and groundwater investigation to characterize historic hydrocarbon contamination and design of a remedial groundwater extraction trench at the decommissioned Hearn coal generating plant.
Canadian National Railway Concord, Ontario, Canada	Project Manager for investigation of hydrocarbon impacted soil, groundwater and surface water at a large railway yard and identification of remedial options
Ministry of Environment Hamilton, Ontario, Canada	Project Manager for the remediation of a large plastics fire at the former Plastimet site.
Various Clients and Locations	Project Manager for Phase II Environmental Site Assessment (ESA) of sites contaminated with heavy metals, hydrocarbons, PCBs, and explosives and development of remedial options and cost estimates.

TRAINING

Xstrata Stage Gate Training, *Xstrata, Montreal, Quebec, December 2011*

Facilitation, *Golder Associates, Calgary, Alberta, January 2011*

Project Management, *Golder Associates, Mississauga, Ontario, May 2010*

Environmental Regulation and Compliance Seminar, *Envirogate, Toronoto, Ontario, November 2008*

Emerging Technologies in Mine Waste Management Seminar
APEGBC, Vancouver, B.C., April 2007

Canadian Environmental Assessment Act (CEAA) for Mining Projects
Ontario Mining Association (OMA), Toronto, Ontario, October 2004

Mentoring Skills for Leaders, *SkillPath, Markham, Ontario, September 2004*

Air Photo Interpretation, *John Gartner, Markham, Ontario, March 2004*

40 Hour Hazardous Waste Operations and Emergency Response Training, *Mississauga, February 2001*

PROFESSIONAL AFFILIATIONS

Professional Engineer, Professional Engineers Ontario (PEO)

Assoc. of Professional Engineers and Geoscientists of British Columbia

Assoc. of Professional Engineers, Geologists and Geophysicists of NWT and Nunavut

Association of Professional Engineers of Yukon

Member, Canadian Geotechnical Society (CGS)

PUBLICATIONS AND PRESENTATIONS

Conference Proceedings

Johnson, D. 2011. *Use of Engineered Landfills for Arctic Mine Site Reclamation.* Mine Closure Conference 2011, September, Lake Louise, AB, Canada.

Johnson, D. 2006. *Baseline Hydrogeological Testing and Instrumentation of Deep Exploration Boreholes for Mine Environmental Assessment.* Canadian Geotechnical Society Conference, October, Vancouver, BC, Canada.

Johnson, D. 2004. *Environmental Issues Associated with Dewatering Mine Excavations*. Canadian Geotechnical Society and International Association of Hydrogeologists Conference, October, Quebec City, Canada.

Presentations

"*Mine Waste Management and Geotechnical Engineering"*. Queen's University and Royal Military College GeoEngineering Graduate Students, January 2012, Ontario, Canada.

"Geotechnical Slope Stability Considerations at Pits and Quarries". Ontario Sand Stone and Gravel Association (OSSGA) Rehabilitation Tour, September 2009, Bowmanville, Ontario, Canada.

"Geotechnical and Geoenvironmental Engineering Case Studies". Queen's University and Royal Military College GeoEngineering Graduate Students, November 2004, Ontario, Canada.

"Liquefaction and Dynamic Stability Analysis of Earth Structures and Slopes". Golder Associates Short Course, March 2003, Mississauga, Ontario, Canada.

Education

D.I.C., University of London, 1976

Ph.D. Rock Mechanics, James Cook University, North Queensland, Australia, 1976

M.Eng.Sc. Geomechanics, James Cook University,, North Queensland, Australia, 1972

B.E. Civil Engineering, James Cook University, North Queensland, Australia, 1970

Golder Associates Ltd. – Burnaby

Employment History

Golder Associates Ltd. – Burnaby, BC

Senior Engineer, Specialist Engineer, Associate, and then Principal (from 1983) (1975 to Present)

Providing consulting services on mining, civil engineering, and petroleum engineering projects.

PROJECT RELATED EXPERIENCE – UNDERGROUND MINES

Perseverance Mine Western Australia	Conducted due diligence audit of the geotechnical aspects of the Feasibility Study of the deepening of the Perseverance Mine and continuing caving and long hole open stope mining for Western Mining Corporation Ltd. (2002)
Diavik Mine Northwest Territories, Canada	Reviewed assessments of proposed underground mining for Diavik Diamond Mines Inc. (2002 – 2006)
Musselwhite Mine Ontario, Canada	Conducted a review of geotechnical, stability and support, mining method, mine design, sequencing, and backfill aspects of the Musselwhite Mine for Placer Dome Inc. (2001 - 2002)
Britannia Mine British Columbia, Canada	Undertook detailed assessments of historical underground workings in preparation for the abandoned historical mine to become a balancing reservoir for water entering the mine prior to being treated for the removal of dissolved minerals by a water treatment plant. Also reviewed stability of portals and shafts on surface, and developed closure plans, as well as supervised construction of closure structures. (2001 – to date)
Agua de la Falda Mine Chile	Conducted a detailed assessment of pillar mining activities for Homestake Mining Company. (2001)
Golden Giant Mine Ontario, Canada	Participated in detailed review and assessment of planned extraction of shaft pillar at the Golden Giant Mine for Newmont Corporation. (2001)
Cigar Lake Mine Saskatchewan, Canada	Carried out detailed assessment of stability and hydrogeological aspects of inflow to the Cigar Lake Mine as part of an insurance claim for Micon International Ltd. (2001)
Ekati Mine Northwest Territories, Canada	Provided input on geotechnical, stability and support, mine design, mining method, backfill, and pit/underground interaction aspects of scoping study of BHP Diamonds Inc.'s Panda and Koala diamond pipes, conducted by MRDI. (2000 - 2001)
Pogo Mine Alaska, USA	Provided input on geotechnical, stability and support, mine design, mining method, and backfill aspects to the feasibility study of the Pogo Mine, undertaken by MRDI for Teck Corporation. (2000 - 2001)
Unicalce Lime Mine Italy	Conducted review of geotechnical, mining method, and blasting of Limestone Mine for Unicalce S.p.A. (2000 - 2002)
Cigar Lake Mine Saskatchewan, Canada	Carried out on-going assessments and reviews of the geotechnical, hydrogeological, stability and support, mining methods, and freezing aspects of the Cigar Lake Mine for the Cigar Lake Mining Corporation and then Cameco Corporation. (2000 - 2006)
Hudson Bay Mining and Smelting Mines Manitoba, Canada	Carried out assessments and on-going reviews of geotechnical, hydrogeological, and mining aspects of Callinan, Trout Lake, Chisel, Snow Lake, Ruttan, 777, and Konuto Mines for Hudson Bay Mining and Smelting Co. Ltd. (2000 – 2005)
Myra Falls Mines British Columbia, Canada	Carried out review of mining methods, current backfill practices, and alternative systems to optimize future backfill production and placement (including paste backfill), at the Myra Falls Mines for Outukompu. (2000)

Eskay Creek Mine British Columbia, Canada	Carried out assessments of geotechnical, hydrogeological, mining, and backfill aspects of the Eskay Creek Mine for Homestake Mining Company. (2000)
Williams and David Bell Mines Ontario, Canada	Carried out detailed review of geotechnical, mining, backfill, and rock burst aspects of Williams and David Bell Mines for Homestake Mining Company. (2000)
Snap Lake Project Northwest Territories, Canada	Carried out assessments of geotechnical, hydrogeological, stability and support, blasting, mining methods, backfill, and mining/environmental aspects of the proposed Snap Lake Mine, initially for Windspear Resources and subsequently for de Beers. (2000 - 2002)
Stillwater Mine Montana, USA	Carried out detailed review of geotechnical, hydrogeological, and mining aspects of Stillwater Mine for MRDI and then Stillwater Mining Company for the Nye and East Boulder operations. (2000 - 2001)
Cigar Lake Mine Saskatchewan, Canada	Conducted detailed review of geotechnical, hydrogeological, mining method, and freezing aspects of the feasibility study, undertaken by Cigar Lake Mining Corporation, of the proposed Cigar Lake Mine for Cameco Corporation. (1999)
Midwest Project Saskatchewan, Canada	Carried out assessments of geotechnical, hydrogeological, and mining aspects of the proposed Midwest project for Cogema Resources and Denison Mines Corporation. (1999 - 2002)
Aguas Tenidas Mine Spain	Carried out review of geotechnical and stability aspects of the Aguas Tenidas Mine for Golder Associated UK, who was providing design and review services to the owner of the mine. (1999)
Vipiteno Mine Italy	Carried out review of geotechnical, stability, mining method, and mine design of theVipiteno Mine for Omya S.p.A. (1999 - 2002)
South Deep Mine South Africa	Carried out review of geotechnical, stability, mining method, mining sequence, and rock-burst control aspects of the South Deep Mine for Kilborn Consultants, who were working for the owners at the time of the merger with Placer Dome. (1999)
Lisheen Mine Ireland	Carried out review of the mine design, stability, mining method, and proposed mining sequence of the Lisheen Mine, for Anglo American plc. (1999 - 2000)
Bougrine Mine Tunisia	Carried out detailed review of geotechnical, stability, and mining aspects of the Bougrine Mine for Breakwater Resources. (1999 - 2000)
Deep Post Mine Nevada, USA	Conducted on-going reviews and assessments of geotechnical, hydrogeological, mining, and backfill aspects of the Deep Post Mine for Barrick Gold Corporation and then Newmont Corporation. (1999 to date)
Campbell Red Lake Mine Ontario, Canada	Carried out detailed review of geotechnical, stability, and mining aspects of the Campbell Red Lake Mine for Placer Dome. (1999 - 2000)
Rodeo and Meikle Mines Nevada, USA	Carried out on-going reviews and assessments of geotechnical, hydrogeological, mining, backfill, and blasting aspects of the Rodeo Mine, from initial project feasibility to current sustained production, for Barrick Gold Corporation. Subsequently provided similar review and assessments for Meilke Mine as well. (1999 to date)

Deep Post Mine Nevada, USA	Assessed potential interaction between proposed underground mining of Deep Post Mine and the stability of the Betze-Post Open Pit for Barrick Gold Corporation. (1998)
Getchell And Turquoise Ridge Mines Nevada, USA	Carried out on-going review and assessment of geotechnical, hydrogelogical, and mining aspects of the expansion, and subsequent production mining of, Getchell and Turquoise Ridge Mines for Placer Dome. (1998 to date).
Bullion Project Nevada, USA	Carried out a review of geotechnical, hydrogeological, and mining aspects for proposed acquisition by Placer Dome. (1998).
Dome Mine Ontario, Canada	Carried out review of stability aspects of underground mining operations, including stability of hydraulic backfill and interaction of underground workings, and further open pit development, for Placer Dome. (1998).
McLean Lake and Midwest Projects Saskatchewan, Canada	Carried out assessments of geotechnical, hydrogeological, and mining aspects of the proposed McLean Lake and Midwest projects for Cogema Resources. (1998 - 1999)
Bissett Mine Manitoba, Canada	Conducted review of the Bissett Mine underground mining operations for Harmony Gold. (1998 - 2000)
Cigar Lake Mine Saskatchewan, Canada	Conducted review of proposed future mining of Cigar Lake Mine for Cogema Resources. (1998)
Deep Post Mine Nevada, USA	Assessed potential interaction between proposed underground mining of Deep Post Mine, and the stability of the Betze-Post Open Pit, for Barrick Gold Corporation. (1998)
Cobriza Mine Peru	Conducted geotechnical, stability, mining, and backfilling assessments of underground mining operations at the Doe Run's Cobriza Mine, Peru. (1998 to date)
Cresson Project Colorado, USA	Assessed the historical mining activities, and developed remediation plans to stabilize the material above the extensive old mine workings and provide for stable foundations for the valley leach facilities for Cripple Creek and Victor Gold Mining Company, Colorado, USA. (1998 - 1999)
El Indio Mine Chile	Provided assessments of the closure strategy for the underground and open pit workings and the hydrogeological (mine inflow) aspects of the El Indio and Tambo mining complexes as part of the development of a conceptual closure plan study for Barrick Gold's El Indio Mine in Chile. (1998)
Chelopech Mine Bulgaria	Developed mining methods and approaches for the proposed expansion of the Chelopech Mine in Bulgaria, and for Navan Resources of Ireland and Homestake Mining Co. of USA. (1997 - 1998)
Clover Hill Mine New Brunswick, Canada	Reviewed the factors leading to the development of the leak, assessed the cause of the leak, and reviewed the attempts made to remediate the major inflow to Potacan's Clover Hill potash mine for the Department of Natural Resources and Energy of the Government of New Brunswick, Canada. (1997 - 1999)

Greymouth Coal Project New Zealand	Reviewed mine design, ground control, excavation sequence, and hydrogeological aspects of feasibility study undertaken by Greymouth Coal Operating Ltd of hydraulic mining and room and pillar mining of coal property owned by Greymouth Coal Ltd., New Zealand. The assessment was undertaken as part of a broader review by MRDI, Calgary, Canada. (1997)
Battle Mountain Mining Complex Nevada, USA	Developed and assessed concepts for underground drainage tunnel system beneath open pits to enhance the quality of pit drainage water during operations and at closure for Battle Mountain Gold Company, Nevada, USA. (1997)
Tara Mine Ireland	Undertook a review of mining approaches for proposed pillar extraction activities at shallow depth with significant subsidence restraints for Outokumpu's Tara Mine, Ireland. (1997)
Clover Hill Mine New Brunswick, Canada	Conducted assessment of flooding problem and remediation activities of Potacan's Clover Hill potash mine, New Brunswick, Canada, and advised Alexander Holburn Beaudin & Lang, Vancouver, Canada, on technical aspects of insurance claim. (1997)
Cobriza Mine Peru	Conducted review of interaction of underground mining and major surface landslide, and general assessment of underground mining and backfilling operations at Centromin's Cobriza Mine, Peru. (1997)
Ulu Mine Northwest Territories, Canada	Carrying out ongoing rock mechanics, ground control, and excavation support assessments for Echo Bay Mines' Ulu Mine, Northwest Territories, Canada. (1996 to 1997)
San Juan Ridge Mine California, USA	Performed assessment of support requirements and ground control aspects of Siskon Gold's San Juan Ridge Mine, California, USA. (1996)
El Indio Mine Chile	Carrying out review of mining, ground control, blasting, excavation support, and backfilling aspects of Barrick Gold's El Indio Mine in Chile. (1996 to 1997)
Confidential Client Canada	Performed risk assessment of underground mining at very great depths. (1996)
Diavik Diamond Project Northwest Territories, Canada	Acting as technical Director for mining, geohydrology, waste rock, tailings, hydrology, and environmental coordination studies for diamond mining project in the Canadian Arctic for Diavik Diamond Mines Inc. in the Northwest Territories, Canada. (1996 to 1997)
Udon Thani Project Thailand	Provided input to various aspects of feasibility study for the development of the Udon Thani potash deposit in Thailand for Asia Pacific including development of mining and backfilling concepts. (1995 - 1999)
McArthur River Mine Saskatchewan, Canada	Conducted on-going reviews of geotechnical, hydrogeological, mining and backfill aspects of Cameco's McArthur River Mine. (1995 - 2005)
Asse Mine Germany	Conducted review of stability and potential inflow problems to salt mine. (1995)
Texas Mine Maryland, USA	Carried out review of stability and proposed backfilling of abandoned mine to provide for long-term stability of the overlying property at Genstar's site. (1995)
Cluff Mining Operations Saskatchewan, Canada	Performed review of proposed mining of high grade pods beneath lake at the extremity of DJ Extension to Cluff Mining's uranium operations. (1995)

Contact Lake Mine Saskatchewan, Canada	Performed assessment of hangingwall stability problems and associated impact on ore dilution at Cameco's Contact Lake Mine in Saskatchewan, Canada. (1995)
Lupin Mine Northwest Territories, Canada	Carried out detailed investigation of the possibility of placing paste backfill without cement or with minimum cement at Echo Bay's Lupin Mine in the Northwest Territories, Canada. (1995)
Solvay Mine Wyoming, USA	Reviewed major pillar collapse of room and pillar trona mine owned by Solvay Minerals Inc. for Commercial Union Insurance in Wyoming, USA. (1995)
Pea Ridge Mine Missouri, USA	Carried out detailed review of Pea Ridge iron ore mine prior to possible acquisition by Sheffield Steel in Missouri, USA. (1995)
Cresson Project Colorado, USA	Conducted assessment of potential impact of old mine workings beneath proposed heap leach pads and remediation requirements of the foundations prior to constructing pad lining in Colorado, USA. (1995 – 1996)
McArthur River Uranium Mine Project Saskatchewan, Canada	Responsible for development of mining method, and detailed assessment of ground control, groundwater, blasting, and backfill aspects of Cameco's McArthur River Project for feasibility study and permit application requirements in Saskatchewan, Canada. (1994 - 1995)
HW Mine British Columbia, Canada	Conducted assessment of proposed development excavation in cemented backfill for Westmin's HW Mine in British Columbia, Canada. (1994)
Akzo Salt Mine New York, USA	Continuing to review pillar collapse and mine flooding of Akzo Salt Mine for Commonwealth Insurance of Vancouver, Canada. (1994 to date)
ZCCM Copper Mines Zambia	Carried out general mining, ground control, rock mechanics, blasting, and backfill consulting for Konkola Mine, Chingola B Mine, Nchanga Mine, and Baluba Mine for ZCCM, Zambia. (1994 – 1997)
Mufulira Mine Zambia	Performed detailed review of mining plans, assessment and design of revised mining methods, and review of implementation plans for ZCCM's Mufulira Mine, Zambia. (1994 – 1996)
Chambishi Mine Zambia	Performed review of detailed feasibility study in preparation for privatization of ZCCM's Chambishi Mine, Zambia. (1994)
Cluff Mining Operations Saskatchewan, Canada	Carried out review of geotechnical and mining aspects of the proposed underground mining of the DJ Extension to Cluff Mining's uranium operations in Saskatchewan, Canada. (1994)
Galmoy Mine Ireland	Provided design studies of room and pillar mine, including backfill and groundwater inflow and dewatering aspects, and assistance with and participation in public hearings for permit application for Arcon International, Ireland. Continuing with on-going reviews of the underground mining, ground control, and backfilling activities for production and permitting activities. (1993-2002)
Asarco's Mine Tennessee, US	Conducted review of room and pillar mining of Asarco's mine in Tennessee, USA. (1993)
Macassa Mine Ontario, Canada	Performed analysis of energy release mechanisms in seismically active mine for Lac Minerals in Ontario, Canada. (1992 – 1993)

Vanscoy Potash Mine Saskatchewan, Canada	Carried out assessment of groundwater inflow into Cominco's Vanscoy Mine, Saskatchewan, Canada. (1992)
Cassiar Mine British Columbia, Canada	Conducted review of mining practices of asbestos mine for Black Swan Mining Co., British Columbia, Canada. (1992)
Westray Coal Mine Nova Scotia, Canada	Conducted review of ground control practices and mine design for Curragh Resources, Nova Scotia, Canada. (1991)
Kidd Creek Mine Ontario, Canada	Performed review of options and design considerations for placing paste backfill in some areas of Kidd Creek Mine to tight fill mined voids, Ontario, Canada. (1991)
Stillwater Mine Montana, USA	Conducted review of mining practices at platinum mine, including assessments of the mining method and the ground control, blasting, and backfill practices, Montana, USA. (1991)
McArthur River Project Northern Territories, Australia	Provided design of room and pillar mine based on computer stress analysis of pillar loads and prevention of domino pillar collapse, and ongoing review of McArthur River mining activities for MIM, Australia. (1991 – 1996)
Missouri Leadbelt Mines Missouri, USA	Carried out review of proposed boundary mining between The Doe Run Co.'s mines and Asarco's mine, Missouri, USA. (1990-1997)
Fraser Mine Ontario, Canada	Carried out review of rock mechanics and ground control aspects of future cut-and-fill mining of Falconbridge's Fraser Mine, Ontario, Canada. (1990)
McArthur River Project Northern Territories, Australia	Carried out review of proposed shaft location and potential subsidence for Mt. Isa Mine's McArthur River Project, Northern Territories, Australia. (1990)
Doyon Mine Quebec, Canada	Performed field monitoring study and general review of blasting at Lac Mineral's Doyon Mine, Quebec, Canada. (1990)
Moinho Mine Portugal	Performed computer stress analyses and stability assessment of proposed extension to Pirites Alentejanas's Moinho Mine and subsequent mining reviews including assessments of mining method, underground support, mining layout, backfill, and blasting practices, Portugal. (1990 – 1994)
Eskay Creek Mine British Columbia, Canada	Carried out assessment of stability of access decline for Corona's Eskay Creek Mine, British Columbia, Canada. (1990)
Estrades Mine Quebec, Canada	Conducted assessment and review of mining method, ground control aspects, and backfill design for Breakwater Resources' Estrades Mine, Québec, Canada. (1990 – 1991)
Highland Valley Copper Mine British Columbia, Canada	Carried out assessment of blasting practices and detailed blast monitoring for diagnostic and optimization studies for the Highland Valley Copper Mine, British Columbia, Canada. (1990)
Quirke and Panel Mines Ontario, Canada	Carried out detailed assessment of mine stability, subsidence, and impact from proposed close-out and flooding of Rio Algom's Quirke and Panel Mines, Ontario, Canada. (1990)
Elliot Lake Mines Ontario, Canada	Provided expert assessment related to boundary dispute between two mines in Elliot Lake, Ontario, Canada. (1990 – 1992)

Homestake Mine South Dakota, USA	Carried out review of shaft stability problems for the Homestake Mine, South Dakota, USA. (1989 – 1990)
The Doe Run Co. Missouri, USA	Performed detailed review and rock mechanics assessment of proposed pillar mining following placement of cemented backfill for the Doe Run Co.'s mines, Missouri, USA. (1989 to date)
Gaspe Mine Quebec, Canada	Conducted review of ground control problems, mine design, excavation sequence, and backfill for Noranda's Gaspe Mine, Québec, Canada. (1989)
Thompson Mine Manitoba, Canada	Participant in on-going review committee assessment of ground control, mine design, mining method, backfill practice, blasting practice, research programs, and research requirement for Inco's Thompson Mine, Thompson, Manitoba. (1989 – 1991)
CANMET Study Ontario, Canada	Carried out review of general assessment by Golder Associates of the stability of surface crown pillars of underground mines for CANMET, Ontario, Canada. (1989)
Nickel Plate Mine British Columbia, Canada	Performing on-going review of the interaction of old underground workings and current open pit mining of Corona's Nickel Plate Mine, British Columbia, Canada. (1989 – 1990)
Lupin Mine Northwest Territories, Canada	Carried out review of blasting practice and monitoring for diagnostic studies and optimization of blasting procedures for Echo Bay's Lupin Mine, Northwest Territories, Canada. (1989 – 1990)
Strathcona Mine Ontario, Canada	Carried out review of future mining and the application of stiff backfill to reduce stability and rockburst problems in the Deep Copper Zone of Falconbridge's Strathcona Mine, Ontario, Canada. (1989)
Caribou Mine New Brunswick, Canada	Performed review of rock mechanics, ground control, mining method, and mine design for East-West Caribou's (then Breakwater Resources') Caribou Mine, New Brunswick, Canada. (1988 – 1990)
Con Mine Northwest Territories, Canada	Responsible for design and review of in situ stress measurement program for NERCO's Con Mine, Northwest Territories, Canada. (1988)
Con Mine Northwest Territories, Canada	Carrying out assessment of rock mechanics and ground control aspects of mining in highly stressed rock at NERCO's (then Miramar's) Con Mine, Northwest Territories, Canada. (1988 to date)
Page Williams and Golden Giant Mines Ontario, Canada	Performed assessment of uncontrolled caving of sill pillar separating two mines for Lac Minerals Ltd., Ontario, Canada. (1988)
Campbell Red Lake Mine Ontario, Canada	Carried out audit of rock mechanics and ground control aspects of Placer Dome's Campbell Red Lake Mine, Ontario, Canada. (1988)
San Manuel Mine Arizona, USA	Performed assessment of blasting practice based on sophisticated blast monitoring for Magma Copper Co.'s San Manuel Mine, Arizona, USA. (1988)
Sulphurets Project British Columbia, Canada	Reviewed rock mechanics and related mine planning aspects of Northair Group's Sulphurets underground mining project, British Columbia, Canada. (1988)
Neves Corvo Mine Portugal	Reviewed rock mechanics and related mine planning aspects of Somincor's Neves Corvo Mine. (1988 – 1992)

Moinho Mine Portugal	Reviewed rock mechanics and ground control aspects for Wright Engineers, Canada, of proposed change of mining method of Pirites Alentejanas's Moinho Mine. (1988)
Black Angel Mine Greenland	Carried out detailed analysis and assessment of potential pillar collapse for Boliden Mineral, Sweden, as part of overall pillar mining study of Black Angel Mine. (1988)
Buick and No. 28 Mines Missouri, USA	Carried out detailed assessment and computer simulation of rock mechanics and ground control aspects of Doe Run Co.'s Buick and No. 28 Mines, Missouri, USA. (1988)
Missouri Lead Belt Mines Missouri, USA	Carried out independent review and development of boundary mining agreements for Cominco's Ltd.'s and Doe Run Co's adjoining underground mines in Missouri, USA. (1988)
Cannon Mine Washington, USA	Performed assessment of blasting practice based on sophisticated blast monitoring including optimization of underground blast design and minimization of surface vibrations in adjacent residential areas for Asamera's Cannon Mine, Washington, USA. (1987 – 1988)
AECL's URL Manitoba, Canada	Performed review of stress measurement program for AECL's underground research laboratory in Manitoba, Canada. (1987 – 1988)
Belle Isle Salt Mine Louisiana, USA	Reviewed problems related to the stability and flooding of salt mine in Louisiana, USA. (1987 – 1988)
Namew Lake Mine Manitoba, Canada	Reviewed rock mechanics and mine planning aspects of Hudson Bay Mining and Smelting Co.'s Namew Lake Mine, Manitoba, Canada. (1987 – 1988)
Ruttan Mine Manitoba, Canada	Conducted assessment of blasting practice based on sophisticated blast monitoring for Hudson Bay Mining and Smelting Co.'s Ruttan Mine, Manitoba, Canada. (1987)
Thompson Mine Manitoba, Canada	Conducted assessment of blasting practice based on sophisticated blast monitoring for INCO's Thompson Mine, Manitoba, Canada. (1987)
Detour Lake Mine Ontario, Canada	Reviewed proposed backfill design and placement procedures for Detour Lake Mine, Ontario, Canada. (1987)
Tennessee Chemical Co's Mine Tennessee, USA	Acted as expert witness for litigation related to mine accident caused by instabilities in underground mine in Tennessee, USA. (1987)
AOSTRA's UTF Alberta, Canada	Carried out numerical analysis simulations and assessment of underground and surface monitoring results of formation response to steam injection for recovery of bitumen at AOSTRA's UTF near Fort McMurray, Alberta, Canada. (1987 - 1990)
AOSTRA's UTF Alberta, Canada	Responsible for design, installation, and data assessment of geotechnical monitoring program for underground test facility to inject steam and recover bitumen from oil sand for AOSTRA's UTF near Fort McMurray, Alberta, Canada. (1987 – 1990)
Troya Mine Spain	Conducted review of rock mechanics and ground control aspects of Exminesa's Troya Mine, Spain, for Cominco Ltd. (1987 – 1992)

Clover Hill Mine New Brunswick, Canada	Responsible for on-going review of rock mechanics and ground control aspects of Denison Potacan Potash Co.'s Clover Hill Mine, New Brunswick, Canada. (1987 – 1990)
PCA's Potash Mine Saskatchewan, Canada	Reviewed flood problem and assessed of bulkhead design in PCA's potash mine, Saskatchewan, Canada. (1987)
Seabright Resources Nova Scotia, Canada	Reviewed ground control aspects of Seabright Resources' underground mines, Nova Scotia, Canada. (1987)
Sullivan Mine British Columbia, Canada	Carried out review of ground control aspects and computer stress analysis of Cominco's Sullivan Mine, British Columbia, Canada. (1986 to 2000)
Magmont Mine Missouri, USA	Performed ground control studies of extensive pillar collapse and future mining strategy for Cominco's Magmont Mine, Missouri, USA. (1986 – 1990)
K-2 Mine Saskatchewan, Canada	Acted as chairman of review panel regarding investigation of IMC's K-2 underground potash mine flood problem and provided technical advice on insurance matters to Alexander Holburn Beuadin & Lang, Vancouver, Canada. (1986 – 1993)
David Bell Mine Ontario, Canada	Conducted rock mechanics studies of Teck-Corona's David Bell Mine, Ontario, Canada. (1986 – 1987)
David Bell And Golden Giant Mines Ontario, Canada	Carried out assessment of stability and reviewed mining sequence adjacent to boundary pillar between Teck-Corona's David Bell Mine and Noranda's Golden Giant Mine, Ontario, Canada. (1986 – 1988)
Flin Flon Mine Manitoba, Canada	Carried out ground control studies for Hudson Bay Mining and Smelting's Flin Flon Mine, Manitoba, Canada. (1986)
Kinsenda Mine Zaire	Carried out review of ground control aspects of Kinsenda Mine in Zaire for Phillips Barratt Kaiser, Vancouver, Canada. (1986)
Suncor's Coal Mine Nova Scotia, Canada	Reviewed geotechnical studies of Suncor's proposed underground coal mine, Nova Scotia, Canada. (1985 – 1986)
Falconbridge's Sudbury Basin Mines Ontario, Canada	Conducted rock mechanics course for operating engineering staff of Falconbridge's Sudbury operations, Ontario, Canada. (1985)
Campbell Red Lake Mine Ontario, Canada	Responsible for development of computer model and training program for Campbell Red Lake Mines Ltd.'s underground gold mine, Ontario, Canada. (1985)
Cluff Lake Mine Saskatchewan, Canada	Carried out review of stability aspects, fill design, and stress analyses of Amok Ltd.'s under-cut-and-fill mining operation, Saskatchewan, Canada. (1985)
Cigar Lake Mine Saskatchewan, Canada	Performed detailed design and stability assessments of Cigar Lake Mining Corporation's proposed underground uranium mine in very weak rock, Saskatchewan, Canada. (1985 – 1991)
Key Lake Mine Saskatchewan, Canada	Conducted preliminary assessment and reviewed stability aspects of Key Lake Mining Corporation's proposed underground uranium mine, Saskatchewan, Canada. (1985 – 1987)
Elliot Lake Uranium Mines Ontario, Canada	Carried out regional stress analysis related to rock burst problems at Rio Algom's Quirke Mine and Denison's underground uranium mines, Elliot Lake, Ontario, Canada. (1985)

Ontario Government Provincial Enquiry Ontario, Canada	Reviewed international mining practice as part of Provincial Enquiry into Ground Control and Emergency Preparedness in Ontario Mines for Ontario Ministry of Labour, Canada. (1985)
Rocanville Mine Saskatchewan, Canada	Performed review of research and development studies of total extraction mining system at Potash Corporation of Saskatchewan's Rocanville Mine, Saskatchewan, Canada. (1984)
Golden Giant Mine Ontario, Canada	Provided rock mechanics and ground control consulting including stress analysis, backfill testing, and design for Noranda's Golden Giant Mine, Hemlo, Ontario. (1984 – 1988)
Falconbridge's Sudbury Basin Mines Ontario, Canada	Responsible for development of computer stress analysis system and training program for Falconbridge's underground mines, Sudbury, Ontario. (1984)
Pine Point Mine Northwest Territories, Canada	Conducted rock mechanics review of underground room and pillar operation for Cominco's Pine Point Mine, Northwest Territories, Canada. (1984)
Proposed Hydraulic Underground Coal Mine Alberta, Canada	Carried out review of ground control aspects of proposed hydraulic underground coal mine for Luscar Ltd., Alberta, Canada. (1984)
CANMET Study Ontario, Canada	Performed review of geotechnical problems associated with mining potash throughout the world using different mining methods for CANMET, Ottawa, Canada. (1984)
Health Steel Mine New Brunswick, Canada	Reviewed rock mechanics and ground control aspects of the Heath Steel Mine, New Brunswick, Canada. (1984)
Polaris Mine Northwest Territories, Canada	Assessed pillar and hangingwall stability and analyzed behaviour of frozen shale backfill for Cominco Ltd.'s Polaris Mine, Northwest Territories, Canada. (1983 – 1993)
Salmita Mine Northwest Territories, Canada	Provided rock mechanics and ground control consulting for Giant Yellowknife Mines Ltd.'s Salmita Mine, Northwest Territories, Canada. (1983 – 1986)
Millstream Potash Property New Brunswick, Canada	Performed preliminary geotechnical and ground water review for shaft construction and initial mine design of B.P. Canada's Millstream potash property, New Brunswick, Canada. (1983)
Proposed Dominique-Peter Underground Mine Saskatchewan, Canada	Performed preliminary assessment of ground control problems and support methods for Amok's proposed Dominique-Peter underground mine, Saskatchewan, Canada. (1983)
Black Angel Mine Greenland	Conducted assessment of stability and ground control problems, and carried out investigation of potential rock mechanics problems associated with mining pillars at Greenex's Black Angel Mine, Greenland. (1983 – 1985)
Lupin Mine Northwest Territories, Canada	Providing ongoing rock mechanics, ground control, blasting, and backfill consulting studies for Echo Bay Mines' Lupin Mine, Northwest Territories, Canada. (1983 - 2002)
Stall Lake Mine Manitoba, Canada	Performed review of in situ stress measurement results and assessed ground control problems using computer stress analyses for Hudson Bay Mining and Smelting's Stall Lake Mine, Manitoba, Canada. (1983)

Balmer South Mine British Columbia, Canada	Conducted assessment of caving action of hangingwall of thick seam, underground, hydraulic coal mine and responsible for ongoing review of subsidence monitoring program of Westar Mining Ltd.'s Balmer South Mine, British Columbia, Canada. 1983 – 1984)
Selebi Phikwe Mines Botswana	Performed stress analysis and assessment of pillar stability for BCL's Selebi Phikwe Mines, Botswana. (1982 – 1984)
Copperhill Mines Tennessee, USA	Carried out stress analyses and investigation of pillar instabilities for Tennessee Chemical Company's Copperhill Mines, Tennessee, USA. (1982 – 1985)
Goldstream Mine British Columbia, Canada	Performed rock mechanics and ground control studies for Noranda's Goldstream Mine, British Columbia, Canada. (1982 – 1985)
Wesfrob Mine British Columbia, Canada	Carried out stability assessment of proposed pillar mining of Falconbridge's Wesfrob Mine, British Columbia, Canada. (1982)
Mines in Elliot Lake Ontario, Canada	Carried out detailed stress analysis and investigation of rock burst and ground control problems for Rio Algom's mines in Elliot Lake, including Quirke and Stanleigh Mines, Ontario, Canada. (1982 to date)
Con Mine Northwest Territories, Canada	Conducted rock mechanics and ground control studies for Cominco's Con Mine, Northwest Territories, Canada. (1982 – 1987)
Gaspe Copper Mine Quebec, Canada	Conducted rock mechanics and ground control studies for Noranda's Gaspé Copper Mine, Québec, Canada. (1981)
Cirque ProjectBritish Columbia, Canada	Responsible for geotechnical site investigation, design studies, and preparation of contract documents for proposed exploration adit for Cyprus Anvil Mining Corporation's Cirque property in British Columbia, Canada. (1981)
CANMET Study Ontario, Canada	Participated in development of prediction methods to determine stable excavation spans for deep mines in hard rock for CANMET, Ottawa, Canada. (1980)
AOSTRA Surmont In Situ Oil Sands Project Alberta, Canada	Carried out detailed geotechnical design study of shaft in weak uncemented sediments and tunnels in clay, oil sand, shale, and limestone horizons for Gulf-AOSTRA Surmont In Situ Oil Sands Project, Alberta, Canada. (1980)
Proposed Midwest Lake Uranium Mine Saskatchewan, Canada	Responsible for development of geotechnical model from field data for Esso Resources' proposed Midwest Lake uranium mine, Saskatchewan, Canada. (1979)
Brunswick Mining and Smelting New Brunswick, Canada	Carrying out in situ stress measurements, stress analyses, stability assessments, detailed mining studies, backfill assessments, support assessments, and blasting assessments for Brunswick Mining and Smelting's No. 12 Mine, New Brunswick, Canada. (1979 1998)
Eldorado Mine Saskatchewan, Canada	Performed initial in situ stress measurement and stability analyses for Eldorado uranium mine, Saskatchewan, Canada. (1979)
U.S. Strategic Petroleum Reserve Program Louisiana, USA	Conducted stability study of relocation of underground room and pillar salt mine to horizon above proposed oil storage facility for U.S. Strategic Petroleum Reserve Program, Louisiana, USA. (1977)
Oil Shale Mines Colorado, USA	Conducted stability design studies for proposed in situ retorting oil shale mine, Colorado, USA. (1977)

Copper Mines Zambia	Conducted stability studies of underground copper mines and hangingwall caving mechanisms, Zambia. (1975)

PROJECT RELATED EXPERIENCE – UNDERGROUND EXCAVATIONS FOR CIVIL ENGINEERING AND ENERGY PROJECTS

Upper Mamquam Hydroelectric Project British Columbia, Canada	Provided input on tunnel stability and support, hydrogeology, slope stability, bulkhead design and construction aspects for Canadian Hydro Developers' Upper Mamquam Hydroelectric Project for the designers and project managers Canadian Projects Limited (2002 – 2003).
Cayoosh Creek Diversion Tunnel British Columbia	Conducted a review and assessment of the long term stability and integrity of the Cayoose Creek Diversion Tunnel for Stl'atl'imx Nation Hydro in response to reports prepared by BC Hydro. (2001)
Desert Crossing Project Arizona, USA	Directed detailed project studies for the site investigation, design, drilling, solution mining, stability, water supply, construction, operation, and cost estimation aspects of a feasibility study of a multi-cavern natural gas storage project forming part of the Desert Crossing gas storage and transportation system for Skipping Stone Consultants. (2001 – 2002)
Pingston Hydroelectric Project British Columbia	Provided input on tunnel and shaft stability and support, hydrogeology, slope stability, bulkhead design and construction, watering-up and drawdown plans, and monitoring programs for Canadian Hydro Developers' Pingston Hydroelectric Project for the designers and project managers Canadian Projects Limited (2001 – 2007).
Machupicchu Hydroelectric Project Peru	Carried out review of underground power station and tail race tunnel that had flooded because natural damming of the river just downstream as a result of a major landslide and debris flow (1999).
UK Nirex Ltd. United Kingdom	Carried out review of precedent experience in permanent and temporary (non-entry) excavations in mines and civil engineering facilities in Canada and Zambia. Undertaken for Geo-Engineering on behalf of UK Nirex Ltd. as part of UK nuclear waste program. (1994 – 1996)
Short Course in Rock Mechanics Indiana, USA	Conducted five-day short course in rock mechanics for civil engineering and mining at Purdue University, Indiana, USA. (1990)
Harlan Diversion Tunnels Tennessee, USA	Conducted one-week rock mechanics and blasting course and development of rock mechanics and blasting training program for underground hydroelectric projects in India for United Nations Development Program, New Delhi, India. (1987)
Rock Mechanics and Blasting Course New Delhi, India	Conducted one-week rock mechanics and blasting course and development of rock mechanics and blasting training program for underground hydroelectric projects in India for United Nations Development Program, New Delhi, India. (1987)
Natural Gas USA	Performed preliminary assessment of geotechnical aspects related to the development of underground facilities and barriers to store natural gas in aquifers, USA. (1986)
Dam Foundation Montana, USA	Carried out review of stress analyses to assess stability and deformations in foundation of dam in Arizona for Morrison Maierle, Montana, USA. (1986)

UNDP Rock Mechanics Course New Delhi, India	Offered one-week rock mechanics course and development of rock mechanics training program for underground hydroelectric projects in India for United Nations Development Program, New Delhi, India. (1986)
Bhumibol Hydroelectric Project British Columbia, Canada	Carried out review of insitu stress measurement program conducted at Bhumibol hydroelectric project site in Thailand for Crippen Consultants Ltd., British Columbia, Canada. (1986)
Kiambere Underground Hydroelectric Kenya	Carried out review of insitu stress measurement program conducted at Kiambere underground hydroelectric project site for Foundation Skanska Joint Venture, Kenya. (1984 – 1985)
Vancouver Rapid Transit System British Columbia, Canada	Conducted review of design aspects and performed regular inspections of underground excavations for Vancouver rapid transit system for Hatch Associates Ltd., British Columbia, Canada. (1984)
Nuclear Waste Program USA	Carried out geotechnical studies related to underground excavation and design of monitoring systems for shafts and tunnels in salt and tuff formations for nuclear waste program, USA. (1984)
Guavio Underground Hydroelectric Colombia	Performed review of insitu stress measurement program conducted at Guavio underground hydroelectric project site for Ingetec, Colombia. (1984 – 1985)
Rogers Pass Rail Tunnel British Columbia, Canada	Responsible for design studies and assessment of stability of CP Rails Rogers Pass Rail Tunnel through a section of the Rocky Mountains, British Columbia, Canada. (1984)
Proposed Cordon del Plato Hydroelectric Project Argentina	Acted as consultant to Agua y Energia on geotechnical aspects of the proposed Cordon del Plato hydroelectric project in Argentina. (1980)
Rio Grande Hydroelectric Pump Storage Scheme Argentina	Was Site Engineer responsible for design and construction supervision of caverns, tunnels, and shafts for Rio Grande Hydroelectric Pump Storage Scheme, Argentina. (1979)
U.S. Strategic Petroleum Reserve Program Louisiana, USA	Carried out study of solution-mined underground caverns in salt domes to assess stability of facilities to store crude oil for U.S. Strategic Petroleum Reserve Program, Louisiana, USA. (1978)
Colombo Plan Scheme Himalaya Mountains	Acted as expert under Colombo Plan Scheme for U.K. Overseas Development Ministry to provide assistance and to educate engineers in India in the geotechnical design of hydroelectric power stations in the Himalaya Mountains. (1977)
U.S. Strategic Petroleum Reserve Program Louisiana, USA	Carried out study of underground room and pillar salt mine to determine suitability for storage of crude oil for U.S. Strategic Petroleum Reserve Program, Louisiana, USA. (1977)

PROJECT RELATED EXPERIENCE – SLOPE STABILITY

Kumtor Mine Kurgistan	Provided input to an assessment of the sudden failure of the pit wall in permafrost at Kumtor Mine for Cameco Corporation. (2002)
Cobriza Mine Peru	Carried out review of interaction of underground mining and major surface landslide at Centromin's Cobriza Mine, Peru. (1997)

Colombo Plan Scheme India	Conducted study and back-analysis of large rockslide on Sutlej River, India, adjacent to an abutment of a partially completed dam sponsored by U.K. Overseas Development Ministry, Colombo Plan Scheme, India. (1978)
Island Copper Mine British Columbia	Responsible for stability study of pit walls separating open pit mine from adjacent tidal inlet for Utah Mine's Island Copper Mine, British Columbia, Canada. (1976)
Proposed South Haystack Open Pit Coal Mine Wyoming, USA	Performed stability study of pit walls for Rocky Mountain Energy Co.'s proposed South Haystack open pit coal mine, Wyoming, USA. (1976)
Proposed Open Pit Copper Mine Arizona, USA	Responsible for strength assessment and design of pit walls in sheared and weathered rock for Conoco's proposed open pit copper mine, Arizona, USA. (1976)
Twin Buttes Open Pit Copper Mine Arizona, USA	Performed stability study of pit walls for Twin Buttes open pit copper mine, Arizona, USA. (1975)

PROJECT RELATED EXPERIENCE – HYDROGEOLOGY

Galmoy Mine Ireland	Carried out groundwater inflow and dewatering studies of Galmoy Mine and providing assistance with and participating in public hearings for permit application for Arcon International, Ireland. (1993 to date)
McArthur River Uranium Mine Project, Saskatchewan, Canada	Performed assessment of groundwater control measures, including grouting and freezing, for Cameco's McArthur River Project for feasibility study and permit application for uranium mine, Saskatchewan, Canada. (1994 to date).
Akzo Salt Mine, New York USA	Reviewed pillar collapse and mine flooding of Akzo Salt Mine for Commonwealth Insurance, Vancouver, Canada. (1994 to date)
Vanscoy Potash Mine Saskatchewan, Canada	Performed assessment of groundwater inflow into Cominco's Vanscoy Mine, Saskatchewan, Canada. (1992)
PCA's Potash Mine Saskatchewan, Canada	Reviewed flood problem and assessed of bulkhead design in PCA's potash mine, Saskatchewan, Canada. (1987)
K-2 Mine Saskatchewan, Canada	Acted as chairman of review panel regarding investigation of IMC's K-2 underground potash mine flood problem and on-going review of remedial measures for Alexander Holburn, Saskatchewan, Canada. (1986 – 1993)
Gulf-AOSTRA Surmont In Situ Oil Sands Project Alberta	Conducted groundwater hydrology studies required for engineering design of proposed shaft in weak, uncemented sediments, and tunnels in limestone for Gulf-AOSTRA Surmont In Situ Oil Sands Project, Alberta, Canada. (1980)
Proposed North Butte Underground Uranium Mine Wyoming, USA	Carried out studies of mine inflow, mine depressurization, and environmental impact on groundwater hydrology for Cleveland Cliffs Iron Co.'s proposed North Butte underground uranium mine in Wyoming, USA. (1979)
Proposed Pumpkin Buttes Uranium Mining Development Wyoming, USA	Conducted baseline surface and groundwater hydrology studies for 400 sq. mile area for Cleveland Cliffs Iron Co.'s proposed Pumpkin Buttes uranium mining development in Wyoming, USA. (1978)

South Haystack Open Pit Coal Mine
Wyoming, USA

Performed surface and groundwater hydrology study for environmental and engineering purposes for Rocky Mountain Energy Co.'s proposed South Haystack open pit coal mine, Wyoming, USA. (1976)

Proposed Underground Oil Shale Mine
Colorado, USA

Carried out groundwater hydrology study and mine inflow prediction for proposed underground oil shale mine, Colorado, USA. (1975)

PROJECT RELATED EXPERIENCE – SURFACE MINING AND MINING ENVIRONMENTAL STUDIES

Ruttan Mine
Manitoba, Canada

Conducted studies of the stability and potential for subsidence and caving of the Ruttan Mine, and provided input into the closure plan, for Hudson Bay Mining and Smelting. (2002)

Britannia Mine
British Columbia, Canada

Provided input on underground mining, hydrology, hydrogeology, mine inflow, tunnel stability and support, bulkhead design, reservoir operation, pressure and flow monitoring of underground reservoir, permitting, contaminated waste rock disposal, and water treatment plant sludge disposal aspects of environmental clean up and construction and operation of water treatment plant at the Britannia Mine site. (2001 – to date)

Antimina Mine
Peru

Carried out assessment and design of bulkhead, in drainage tunnel, at the base of tailings dam, for Bechtel Corporation. (1999)

PROJECT RELATED EXPERIENCE – GEOTECHNICAL/THERMODYNAMICS

AOSTRA's UTF
Alberta, Canada

Performing analyses of coupled heat flow, pore fluid flow, and stress-stain response of oil sands and underlying limestone to assess impact of injecting steam into oil sands to extract bitumen as part of AOSTRA's UTF project, Alberta, Canada. (1987 to date)

Echo Bay Mines
Northwest Territories, Canada

Conducted assessment of methods and practicality of backfilling mine with ice, and reviewed potential for ice to flow down stopes under gravity for Echo Bay Mines, Northwest Territories, Canada. (1983)

Atomic Energy of Canada Ltd.
Alberta, Canada

Carried out study of potential novel problems which may arise from constructing a nuclear power plant adjacent to an in situ steam injection facility for Atomic Energy of Canada Ltd., in Alberta, Canada. (1982)

Gulf-AOSTRA Surmont In Situ Oil Sands Project
Alberta, Canada

Performed assessment of potential impact on shaft and tunnels of proposed high pressure and high temperature steam injection in adjacent oil sands for Gulf-AOSTRA Surmont In Situ Oil Sands Project, Alberta, Canada. (1980)

PROFESSIONAL AFFILIATIONS

Registered Professional Engineer, British Columbia

Member, Canadian Institute of Mining, Metallurgy and Petroleum

Member, Canadian Geotechnical Society

LECTURES

Sixth Canadian Geotechnical Colloquium Speaker. Lecture titled "Designs Philosophies for Underground Excavations in Rock for Civil Engineering Projects". Montreal, 1982.

PUBLICATIONS

Robertson, P.K., Sasitharan, S., Cunning, J.C., and Sego, D.C. "Shear-Wave Velocity to Evaluate In Situ State of Ottawa Sand," Journal of Geotechnical Engineering, 1995, ASCE, 121(3): 262-273.

Burman, B.C. and Hammett, R.D., 1975. "Design of Foundations in Jointed Rock Masses." Proc. 2nd Australia-New Zealand Conference on Geomechanics, Brisbane, pp. 83-88.

Hammett, R.D. and Hoek, E., 1981. "Design of Large Underground Caverns for Hydro-Electric Projects, with Particular Reference to Structurally Controlled Failure Mechanisms". Recent Developments in Geotechnical Engineering for Hydro Projects. Proc. ASCE International Convention, New York, pp. 192-205.

Mathews, K.E., Hammett, R.D., and Stewart, B.S., 1982. "Case Examples of Underground Mine Stability Investigations. Proc. 1st International Conference on Stability in Underground Mining, Vancouver, Aug. 1982.

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