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21.0 Advanced Exploration Sites, Trenches and Access Routes

Introduction

As exploration progresses to more advanced stages, the activity level at a project site and its footprint usually increases significantly. Work on advanced projects typically includes building access routes, trenching, bulk sampling, constructing drill pads and exploratory drilling – which frequently require blasting and the use of heavy equipment and may involve considerable ground disturbance. This work is usually done by contractors. Before hiring a contractor, an exploration company should carefully evaluate the contractor's safety program, incident statistics and compliance history. Generally, an exploration company geologist should be on site to monitor the contractor's work, the contractor should provide a supervisor who is responsible for compliance with the authorities having jurisdiction (AHJs), such as occupational health and safety (OHS) and Mines Acts and Regulations and environmental regulations.

Before work commences, the exploration company should inform the contractor of site hazards and environmental issues, which may require a site visit. Good communication between the company project manager and the contractor is essential in order to develop teamwork and implement site specific safe operating procedures (SOPs) and emergency response plans (ERPs). It can be challenging to get contractors and their employees to follow the exploration company SOPs, wear personal protective equipment (PPE) and attend scheduled safety meetings. Some companies advocate scheduling a regular evening safety meeting in a relaxed setting with an agenda aimed at generating discussions about various safety issues. By making these meetings as inclusive as possible and promoting active participation by all attendees, all site employees (drillers, driller helpers and camp support workers) will find it productive to attend. Also, it is a good idea for supervisors to have a safety meeting each morning to discuss the day's work and develop any necessary additional job safety analyses (JSAs). Refer to sections 2.1.2 Safety Meetings and 2.1.4 Job Safety Analyses.

Exploration companies often use their own employees when constructing access routes only requires clearing vegetation and minimal tree felling. At sites where workers are employed directly by the exploration company, the site geologist (site supervisor or project manager) is usually ultimately responsible for environmental, health and safety considerations. For information, refer to sections 5.6 Chainsaws and 11.4 Line Cutting Safety, and review the e3 Plus Environmental Stewardship Toolkit for environmental considerations at: http://pdac.ca/e3plus. The company site supervisor or geologist (and the contractor's supervisor if there is one) must be aware of all permits issued for the project and make sure the project is in compliance with them.

Note: This section of the PDAC Health and Safety Guidelines is not intended to replace heavy equipment manufacturers' operator manuals and the proper training of operators. It is intended as guidance for exploration site supervisors and geologists to help assess the safe operation of heavy equipment by trained personnel and reduce the likelihood of accidents for all workers at advanced exploration sites.

21.1 General Risks and Hazards

Severe injury or death may result from accidents when operating heavy equipment such as back hoes, excavators and dozers. Some of the risks and hazards include but are not limited to:

- Injury or death caused by improper operation of equipment due to lack of operator training and/or certification, lack of adequate supervision
- Injury or death caused by moving heavy equipment or moving parts of equipment, careless operation of equipment
- Slips, trips and falls caused by working on uneven, slippery or disturbed ground, on ice, falls into excavations
- Potential suffocation or crushing burial of workers caused by the collapse of excavations, falling debris during excavations or clearing activities
- Asphyxiation caused by toxic gas accumulations from the exhaust of gasoline and diesel motors (CO, SO_2, H_2S)
- Breathing difficulties and potential development of respiratory diseases caused by inhaling dust
- Collisions caused by poor visibility from the presence of dust, snow or whiteout conditions, heavy rains
- Hypothermia or hyperthermia caused by working in temperature extremes

21.2 Responsibilities (Due Diligence) and Advanced Exploration Sites

Exploration companies and their employees may have additional due diligence obligations at advanced exploration sites. For general information, refer to section 1.2 Due Diligence with Respect to Safety. Consider the appropriate allocation of responsibilities as guidelines.

Exploration Companies

- Protect the health and safety of employees at every work location.
- Comply with occupational health and safety (OHS) and Mines Acts and Regulations of the jurisdiction. This means that hired contractors should be held accountable for compliance with permits and regulations of the authorities having jurisdiction (AHJs).
- Develop standard operating procedures (SOPs) that address operations around heavy machinery, trenching and excavations, use of explosives, general employee safety at advanced sites and specific issues such as working alone. Include environmental precautions relevant to the site.
- Develop emergency response plans (ERPs) that address potential general and site specific emergency requirements.
- Hire competent contractors and qualified employees to carry out work. Provide the contractor with specific details of the required work so the appropriate equipment and trained and certified operators can be hired. Inform the contractor of the known health and safety risks and hazards at the site. Make sure they can provide the appropriate equipment and fulfil maintenance requirements.
- Make sure the contractor has an appropriate health and safety program or tie the contractor to the company's health and safety plan. Check that the contractor is in good standing with the jurisdictional Workers' Compensation Board.
- Make sure that the contractor has the site specific programs in place that require any daily permits as required by AHJs (e.g., confined space entry, lockout).

- Training: Verify with the contractor that employees have appropriate training by qualified personnel (trainers) to use the site equipment and that they know how to mitigate site risks and hazards. Specific training is necessary when working on ice.
- Hire supervisors who are competent and trained; check that they provide appropriate supervision of company employees on site. Exploration company supervisors should not be in the position of supervising the contractor's employees.
- Provide sufficient and appropriate equipment, including PPE as required, to enable employees to work safely.
- Establish clear roles and responsibilities for any required reporting to AHJs including accident and spill reporting.
- Carry adequate insurance (e.g., comprehensive liability, vehicle, jurisdictional Workers' Compensation Board coverage).
- Confirm that the contractor has adequate insurance coverage for both injuries and environmental damage. Establish exactly who is responsible for reporting accidents to the jurisdictional Workers' Compensation Board authority that require specific forms.
- Maintain regulatory requirements and remain in good standing with the jurisdictional Workers' Compensation Board authority in Canada or wherever work is carried out.
- See that required inspections and maintenance schedules for equipment are carried out.
- Keep appropriate records: Records should include those required by AHJs. Keep any additional records that demonstrate due diligence such as the site safety plan, contractor safety plan, safety committee and safety meetings/minutes, equipment maintenance, accidents, incidents and near misses, employee certifications and training, and inspections. Inspections of work areas should include excavations such as trenches and pits, access routes and bridges. If using ice roads for access, keep records of ice thickness and other testing procedures.

Project Supervisors

- Carry out risk assessments and job safety analyses (JSAs) at the site. Develop plans to mitigate the risks based on the outcomes of the risk assessments and JSAs.
- Develop written site specific SOPs and ERPs as required that address the risks and hazards identified in the risk assessment and JSAs. The ERPs should take into account the number of people on site and the types of emergencies that may occur. Carry out practice drills.
- Make sure employees understand and follow company and site specific SOPs and use PPE.
- Make sure employees are adequately trained for the job.
- Check that contractors carry out their jobs safely. Hold safety meetings that include all site workers including contractor employees.
- Carry out appropriate inspections and verify compliance with SOPs and safety regulations.

Employees

- Be aware of the risks and hazards associated with the site and the job.
- Follow training provided by the supervisor, follow the company SOPs and wear PPE.

- Attend and participate in safety meetings and practice drills.
- Work responsibly. Carry out daily safety checks, report unsafe conditions to supervisors and look out for the safety of co-workers.

Contractors

- Carry out work in compliance with permits issued by the AHJs.
- Provide evidence that they will supply trained and qualified employees for the required work. This includes certificates of competency, certificates or licenses to operate equipment, first aid certificates, blasting certificates etc.
- Provide proof of liability insurance coverage for injuries and environmental issues etc.
- Follow the established procedure for reporting accidents and incidents to the Company and the jurisdictional Workers' Compensation Board or equivalent using the appropriate forms.
- Keep jurisdictional Workers' Compensation Board payments up-to-date and be in good standing with the Board or equivalent.
- Have site specific procedures in place for work that requires daily permits required by AHJs (e.g., confined space entry, lockout).
- Inform their employees about the risks and hazards at the site.
- Provide qualified supervisors for employees. It is preferable for a contractor to provide their own qualified health and safety personnel (with specific experience related to heavy equipment use) in addition to the exploration company qualified health and safety person(s).
- Make sure their employees follow the exploration company's SOPs.
- Make sure their employees wear appropriate and required PPE.
- Direct their employees to attend the site induction meeting, regular safety meetings and participate in practice drills.
- Inform the exploration company staff of any site specific safety requirements regarding the equipment used on site. Only permit certified and trained employees or those under supervised training to operate heavy equipment.

21.3 Heavy Equipment

Advanced exploration work often requires the use of heavy mechanical equipment to excavate trenches, collect bulk samples, build access tracks, or construct winter and ice roads. Heavy equipment may include large drills, excavators, loaders, graders, backhoes, bulldozers, or haul trucks etc. Each type (and model) of equipment has inherent risks and hazards associated with its operation so it is very important for operators to be certified and trained to perform their jobs safely.

All employees who work around heavy equipment must remain vigilant at all times. Operators often have a restricted field of view and cannot see in all directions.

21.3.1 Specific Risks and Hazards

Risks and hazards associated with the use of heavy equipment include:

- Death or injury of workers and/or loss of equipment caused by the unsafe operation of equipment
- Death or injury of workers on foot or in small vehicles caused by the impact of equipment (run over or crushed), or when hit by falling vegetation or debris pushed by machines
- Impact or entanglement injuries caused by contact with unguarded moving parts of machinery
- Injury or equipment damage from rollover caused by unstable loads; working on unstable or steep terrain such as cliffs or swamps
- Injury or equipment damage caused by working in conditions of reduced visibility such as heavy rains, snow or near blizzard conditions or dust
- Drowning or cold water immersion hypothermia caused by equipment breaking through ice
- Hyperthermia and/or dehydration caused by working in high temperatures and/or humid conditions without adequate cooling breaks
- Hypothermia or frostbite caused by working in cold temperatures without adequate clothing, insufficient warm-up breaks
- Stranding caused by equipment breakdowns, communication breakdown
- Electrocution and/or serious burns or explosion caused by an arc flash or contact with overhead power lines, or ruptured or damaged underground cables or pipelines
- Equipment damage caused by improper operations, operating in extreme temperature conditions

23.3.2 Training

Company and contractor employees should receive training to emphasize the dangers of working around heavy equipment and why it is critically important to follow all company safety policies and procedures. Unsafe practices by equipment operators or workers on foot or in smaller vehicles can result in accidents with a high likelihood of severe injury or fatality. Training should be reinforced and augmented with discussions of work procedures around heavy equipment at safety meetings, which should include all employees (i.e., the exploration company employees, contractor's employees, equipment operators, drillers).

Training should include:

- General and site specific SOPs and ERPs regarding working around heavy equipment
- The use and maintenance of appropriate PPE
- Specific communication procedures and signals to use between heavy equipment operators and other workers. Use radio contact as appropriate. Use standardized and universally accepted hand signals that have been discussed and verified between all parties.
- Lockout procedures for hydraulic and electrical systems during equipment maintenance and repairs. Refer to section 18.4.6.2 Lockout Tag Out.

- Special training as appropriate (e.g., working near power lines, working on ice)
- Heavy equipment operators may be semi-skilled in countries where certification is lacking. Plan to train operators in safety procedures they are not familiar with.

21.3.3 Prevention and Preparation

- Operate heavy equipment according to the manufacturer's specifications. Operators should be familiar with the manufacturer's operator manual. Do not overload or over stress heavy equipment.
- Contractors' employees should attend the pre-program induction safety meeting, regular site safety meetings and daily safety briefings.
- Establish an "exclusion zone" where workers on foot may not enter. Install traffic signage or barricade work areas to designate established routes for heavy equipment. This may prevent collisions, control speed and keep small vehicles, pedestrian workers and the public out of dangerous areas.
- Place barriers to keep workers away from areas where material is ejected (e.g., drill cyclones, high pressure air hoses for RC drills, pressurized water hose releases).
- Use machinery appropriate for the job; use an excavator rather than a bulldozer for trenching.
- Use extra caution when using heavy equipment during high winds, storms, snow etc. Do not work when weather conditions are very unfavourable, especially during lightning storms and whiteout conditions. Refer to sections 9.2 Lightning and 9.3 Whiteouts.
- Only expert equipment operators should operate heavy equipment near cliffs, at high altitude, on steep slopes, or when conditions are dangerous. Assess the risks carefully and mitigate the hazards to an acceptable level; avoid operating equipment in dangerous circumstances unless it is an emergency.
- Use extreme caution and do not exceed the permissible load limits when crossing streams and river beds or using ice roads and ice bridges.
- Employees should not use the contractor's equipment without explicit permission and training and certification, as required.
- Use caution when excavating or working near possible buried utilities or pipelines and power lines. See section 21.3.4 Working Near Power Lines.

Personal protective equipment (PPE)

- Site workers should wear high visibility clothing, safety glasses, hard hats, steel toed boots, hearing protection, respiratory protection, as required. Equipment operators should wear appropriate PPE. Although in certain circumstances wearing some PPE may not be required (e.g., wearing a hard hat while riding in a pickup cab) PPE must be worn when employees leave the protection of the cab.
- Do not wear loose fitting clothing, jewelry, drawstrings on hoods or jackets that might become entangled in rotating parts of machines. Carefully confine long hair.

Safety tips for heavy equipment operators

Every operator is responsible for operating heavy equipment in a safe and reliable manner. Be vigilant and watch out for workers on foot and those driving light trucks, ATVs and snowmobiles.

- Only properly trained and certified personnel may operate heavy equipment. Operators must be authorized by the contractor and/or project manager to run the equipment.
- Carry out a circle check at the beginning of each shift and again before starting the machine when it has been left unattended to make sure there are no unknown hazards.
- Communications: Use standardized and universally accepted hand signals that have been discussed and verified between all parties involved for communication between operators and workers on the ground. Alternatively, use radio contact. When underway, operators should slow down or stop in a safe location before using radio communication for a sustained conversation. It is easy to be distracted when using radios or cell phones. It is essential to stop when using a satellite phone.
- To prevent falls, maintain a three point contact when climbing into and out of heavy equipment.
- Do not allow workers to ride on heavy equipment or accompany the operator unless there is a work related reason and the equipment is designed to carry passengers safely.

Safety tips for employees working near heavy equipment

The safety of workers on foot is the responsibility of both workers and heavy equipment operators. Stay a safe distance from heavy equipment as some operators may wear hearing protection and/or have a restricted line of sight so they may not hear or see workers on foot.

- Always be fully observant of mechanical equipment operations. In addition to observing the “exclusion zone”:
    - Stay out of the swing radius of the arm and bucket of an excavator or backhoe etc.
    - Stay out from under suspended loads.
    - Know the equipment travel patterns and avoid these areas.
    - Do not stand downhill from heavy equipment in case it rolls or knock debris downhill.
- Never approach heavy equipment unless you are absolutely certain that the operator knows where you are, what you intend to do and/or where you intend to go. Approach from the front in full view of the operator. Never approach heavy equipment from where the operator cannot see you (the blind side or blind spot). Never assume the operator knows your intentions; you must make them clear either by hand signals or two-way radio. If you cannot see the operator, the operator may not be able to see you.
- In addition to site safety guidelines, follow SOPs regarding the use of light trucks, ATVs and snowmobiles. Refer to Sections 13. Vehicles, 14. All-Terrain Vehicles and 15. Snowmobiles.

Figure 21.1: Do not stand or work downhill from heavy equipment in case it rolls or knock debris downhill. © Matt Turner

Safety devices for heavy equipment

Employees should not tamper with safety devices and equipment on any mobile equipment or vehicles. Safety equipment should meet the requirements of AHJs.

- All mobile equipment should be required to have a back-up alarm, a flashing roof light and operate with the headlights turned on at all times.
- All trucks, ATVs, utility vehicles, snowmobiles etc., that work around heavy equipment should be equipped with a flashing roof light and/or a buggy whip with a flag and light at the tip.
- Brakes: Keep the brakes in good operating condition. There should be a secondary emergency stopping system.
- Mount an easily accessible fire extinguisher near the cab to help the operator escape from a fire. A 9 kg (20 lb) ABC extinguisher is recommended.
- AHJs generally require heavy equipment to have an adequate rollover protective structure (ROPS) such as an overhead protection cab or screen on power-driven cranes, shovels, forklifts, frontend loaders and excavators. Also, an enclosed cab must have a functioning escape hatch when working on ice. Many jurisdictions require that ROPS are labelled and certified to meet standards such as those of the Society of Automotive Engineers (SAE) and the Canadian Standards Association (CSA). References for applicable standards include the publication SAE J1040 and the CSA Standard B352.0-95.

- Place a rear view mirror on machines in a position so the operator can see behind the equipment when that view is limited.
- The windshield should be made of safety glass. Keep it clean to provide unobstructed vision for the operator.
- Protect workers with guards or cages around exposed rotating or moving parts and belts (e.g., crushers, conveyer belts, rotating drill rods, drum hoists on drills). Follow guarding requirements of the AHJs. Make sure they are replaced when maintenance is completed.
- Provide heavy equipment with tow chains, towing poles, cables and/or ropes for emergencies.

Figure 21.2: Guards and cages protect employees from moving parts of this rock crusher. © Ron Breadmore

Inspections

It is advisable to develop and use checklists for heavy equipment inspections.

- Inspect all heavy equipment at the start of each shift. Do not operate the machine if it is unsafe and needs repairs.
- Check that all safety devices are in place and operational (e.g., windshield wipers, batteries, defrosters, guards).
- Check that there are no fuel or hydraulic fluid leaks.
- All brakes, gears and controls must operate correctly.
- Tires should be in good condition and properly inflated.
- All lights should work.

- Check that required equipment is present (e.g., first aid kit, survival equipment, fire extinguisher, emergency tools).
- Tag out any equipment with safety defects and report it immediately so it can be repaired.

Maintenance

Keep machinery in good mechanical condition. Note that equipment is more likely to break down in very cold and/or very hot weather.

- Follow the manufacturer's maintenance schedule and procedures and keep appropriate records. Use qualified mechanics.
- Use seasonally appropriate oil and lubricants, antifreeze agents and additives.
- Keep spare parts, hoses and appropriate tools available for emergencies.
- Do not work on equipment when components are only suspended by hydraulic pressure. Only work on equipment or components that are safely blocked or secured to prevent movement.
- Only maintenance workers or operators under the direction of a maintenance worker should move equipment into and out of a maintenance shop. Perform maintenance tasks during daylight unless a shop has very good lighting.

Parking heavy equipment

- Park equipment in a safe place, clear of other traffic and according to manufacturer's and project SOPs. Never leave heavy equipment unattended with the engine running.
- Lower the forks, bucket or blade to the ground; never leave a suspended bucket or load unattended even for a short time.
- If equipment is disabled, use flashing lights, reflectors, traffic cones or triangles etc., to warn approaching traffic.
- At night, park equipment in an area that is easy to access if inclement weather is anticipated (snow, heavy rains).

Safety tips for vehicles and heavy equipment with loads

- Establish an exclusion zone to prevent access where mechanical equipment is working with suspended loads (e.g., cranes, buckets).
- Do not pass a suspended load over workers; workers should never walk under suspended loads or lifted blades or shovels.
- In addition to endangering workers, suspended loads that are accidentally dropped can cause damage to other equipment – for example, when the heavy object is being loaded into an aircraft. Objects should only be lifted by parts and materials designed for that purpose and known to be solid.
- When loading, truck operators should remain inside the cab to prevent being hit by falling material. However, if the operator may be in danger during loading, he or she should vacate the vehicle and move away from the immediate area.
- Break large rocks into smaller pieces to increase stability during transportation. Load material to minimize spills.

- Sound the horn before moving mobile equipment or a truck and wherever visibility is poor (e.g., a blind corner, a dangerous intersection, approaching the blind crest of a hill).
- Use a spotter to direct and warn the operator when the machine must operate in reverse, where there is limited visibility, when carrying an oversized load, or when there are overhead power lines nearby.
- Cranes are the best equipment for lifting loads but some jobs can be done by excavators. Follow regulations of the AHJs when using an excavator for lifting a load and use the following precautions:
    - The operator and rigger should be qualified for the job.
    - Make sure the excavator has the rated capacity to lift the load safely. Make sure the lifting point or engineered attachment for attaching the slings is rated for the full capacity of the excavator.
    - Establish work procedures to minimize the risk to workers near the boom or bucket. Never lift, lower, or move a load if there is any possibility that a worker may be struck.
    - Follow the manufacturer's safe operation procedures and calculate the weight or make a test lift. Have applicable load charts available for the operator in the excavator cab.

21.3.4 Working Near Power Lines

Always notify the appropriate authorities well in advance when moving equipment, drilling, or commencing any planned excavations or other work where there is a risk of coming in contact with any type of power lines, underground utilities or pipelines. Contact with either overhead or underground power lines may result in severe injury or death from electrocution, explosion or fire.

Underground power lines can easily be snagged and broken during digging if one does not know *exactly* where they are buried. Overhead power lines are not insulated sufficiently to prevent shock if the equipment or person comes too close or contacts the lines. It is important to be aware that an arc flash may occur when a person, tool, or equipment does not maintain a certain distance known as the "minimum clearance distance" or the "limits of approach"[1] from the power lines. This distance depends on the voltage rating of the power lines in question. When people, tools or equipment enter within the minimum clearance distance, an electric current may arc from the wires and electrocute the person or energize the equipment. All metal, all humans and many objects are conductors that provide an easy path for electric current. If you, the ground, the machinery or tools are wet, the ability to conduct electricity and the risk of shock or electrocution is greatly increased.
Information in this section is based primarily on the following document which should be referred to for detailed information: *Working Safely Around Electricity:*
http://www.worksafebc.com/publications/health_and_safety/by_topic/assets/pdf/electricity.pdf

General safe procedures

- Perform a risk assessment of the site and identify the potential hazards before starting work. Notify the contractor and all employees of the potential risks and hazards if they must work near power lines.

[1] "Limits of approach" is a typically Canadian term and "minimum clearance distance" is used in the United States, United Kingdom, and Australia. Minimum clearance distance is used in this publication.

- Develop SOPs that address working where there are power lines and train employees appropriately. Have an ERP in place with procedures to address potential injuries including electrocution and burns caused by contact or arc flash, explosions or fires.
- Follow all regulations of the AHJs regarding notification of power companies before (1) commencing work near overhead power lines, (2) excavating near underground utilities, cables and pipelines, or (3) when it is necessary to carry out work closer than the minimum clearance distance required for overhead power lines or underground utilities, cables and pipelines.
- If it is necessary to operate within 20 m of overhead power lines, arrange a site visit with the power company and for them to barricade, de-energize or move the power lines. Obtain written confirmation of the preventive actions that will take place.
- Place warning signs in the work area so employees are warned of the presence of overhead or underground hazards.
- Only workers directly involved with work in progress should be in the area when equipment is working near power lines. Others should stay at least 10 m away.
- Stop the equipment when it is necessary for a person to approach the equipment.

Prevention and preparation regarding overhead power lines

Careful planning is required to keep employees a safe distance away when working near overhead power lines. Always maintain the minimum clearance distance from low and high voltage power lines. It is safest to always use the greatest required clearance distance for all types of power lines, as it may be difficult to distinguish between low voltage and high voltage power lines.

- The table below indicates the minimum clearance distance, which is the distance required between power lines and the worker(s) and equipment at full extension. This means the total height of equipment *plus* the height of the employees *plus* their tools when all are fully extended – for example, an employee working on a drill mast or someone standing with tools extended in a bucket truck. Extra clearance distance is advisable when moving tall equipment over rough ground or when it is windy. Uneven ground may cause machinery to sway and lurch so that the normally safe clearance distance is reduced.

Table 21.1: An example of jurisdictional minimum clearance distance requirements when working near overhead power lines

Voltage Rating of Power Lines	Minimum Clearance Distance (Limits of Approach)
Over 750 V to 75,000 V	3 m (10 ft)
Over 75,000 V to 250,000 V	4.5 m (15 ft)
Over 250,000 V to 550,000 V	6 m (20 ft)

- Verify the following <u>each time</u> it is necessary to work near overhead power lines. Power lines expand and then sag with changes in temperature and are swayed by winds.
    1. Verify the required clearance distance with the AHJs.
    2. Verify the height of the equipment, worker(s) and tools at full extension.

3. Verify the height of the power lines.

- Make sure the maximum height of a load, boom, dump box, or drill mast will not operate within the minimum clearance distance, especially when loading or unloading. Always check that the body of the boom, dump box or drill mast etc., is fully lowered before moving away from the site.
- Use a spotter to watch while equipment is operating in an area where it may enter or come close to the minimum clearance distance. It is the spotter's job to alert drivers and workers to potential dangers if the equipment approaches the minimum clearance distance. The spotter should stand at least 10 m away from the equipment or vehicle to be safe in case inadvertent contact occurs; contact will also energize the surrounding ground. (High voltage usually dissipates by 10 m from the spot on the ground where contact is made if the current is less than 60,000 V.)
- The operator should be on the vehicle or equipment while it is operating. If this is not possible, the operator should stand at least 10 m away from the machine and operate it by remote control. Then, if contact is made, the operator should be outside the zone affected by the electrical discharge.
- Employees should wear shock-resistant footwear when they work near power lines and there is any risk of contact. Boots are only resistant and do not offer complete safety.
- Do not store materials beneath power lines. If storage is unavoidable, post warning signs to prevent workers from using lifting equipment to move materials.
- Do not fell trees near power lines. Hire specialists in consultation with or through the power company to trim or remove trees near them. Secure appropriate permission before proceeding with the work.
- Maintain at least 6 m from power lines when moving heavy equipment parallel to them.
- Do not move heavy equipment at night as poor visibility increases the risk of contacting overhead power lines. If moving equipment at night is necessary, secure appropriate permission from company managers and AHJs, as required, and follow extra precautions.

If power lines are contacted:

When equipment contacts power lines, the entire machine becomes energized – all parts, all accessory equipment, all cables etc. Anyone on the ground must stay at least 10 m away and NOT touch any part of the energized equipment, including lines, cables, buckets etc. Always notify the utility company whenever contact has been made as damage to the lines may have occurred. Request them to immediately shut off the power, if necessary. The operator should attempt to move the equipment away to break contact with the power lines, if possible.

Procedures when it is impossible to break contact with the power lines and the power cannot be shut off:

1. The operator must stay inside the cab or on the machine that is energized. Other workers must stay at least 10 m away and not contact the machine or energized ground.

2. The operator must only leave the safety of the cab or machine if they are in imminent danger (e.g., an uncontrollable fire).

3. The safe method for escape: You must get off the equipment without touching both the machine and the ground at the same time. Never step down or you will be electrocuted. You must jump off a short distance, 45-60 cm (1.5-2 ft) from the equipment and land with

both feet together and touching and with your arms at your sides. Do not reach back, fall back onto, or touch the energized equipment or you will be electrocuted.

4. Once safely off the equipment, you must shuffle your feet and move along the ground for at least 10 m (30 ft) before taking steps. To shuffle: keep both feet together and touching and move one foot a few centimetres at a time so that your heel never passes your toes. Alternatively, make small hops for at least 10 m while keeping your feet together.

   Note of explanation: When your feet are in contact with each other, there is very little voltage difference between the spots where your feet contact the ground. Therefore it is unlikely that electricity will seek a path through your body. If your feet are separated or you touch the energized equipment and the ground at the same time, your body *will* provide a path for electric current to flow from a higher potential to a lower potential and you may be electrocuted. For high voltage up to about 60,000 V, the voltage usually dissipates within 10 m from the contact spot on the ground. For higher voltages, this distance may increase to as much as 32 m (105 ft).

Additional safety tips regarding overhead power lines

- If any accessory equipment is operating at the time of contact, that operator must (1) remain on the equipment and (2) not touch the ground. To be safe, the operator must follow the same procedures in #1-4 above.
- Never touch downed wires as it is difficult to determine whether they are “live”. Only rarely do they shower sparks and move about on the ground. Stay at least 10 m away. Inform the local power company about downed wires as soon as possible.
- Consider installing an alarm to indicate when heavy equipment has contacted overhead power lines. Electrocutions sometimes occur when an operator leaves the equipment to investigate a problem and is unaware that contact has been made. For information, refer to the following website: http://www.cdc.gov/niosh/mining/pubs/pdfs/henop.pdf

Safety tips for underground power lines, cables and pipelines

When working where there are underground utilities, cables or pipelines, it is essential to precisely locate them before commencing excavations, digging post holes or even driving long stakes into the ground.

- Comply with regulations of the AHJs regarding permits, notification time requirements, permitted excavation methods, blasting plan submissions, supervision by the utility company etc.
- Carry out a risk assessment and establish SOPs for employees and contractors to follow. Have an ERP in place that addresses potential electrocution, electrical burns, fire and/or explosion.
- If contact is made with underground power lines, follow the same safe procedures #1-4 as for overhead power lines (above) to prevent injury to the operator and workers. Notify the local power company immediately.
- If gas lines are jarred, pulled, or otherwise disturbed or if the smell or sound of gas is evident, immediately do the following:
    - Extinguish and remove all sources of ignition including lit cigarettes, cell phones, power tools and other equipment.
    - Move workers away and upwind if possible.

- Notify the gas company immediately and do not attempt repairs or backfill the excavation.

21.4 Access Routes to Advanced Sites

Good planning is crucial when constructing access routes to exploration sites. Well planned and well constructed access routes are (1) safer to use, (2) require less maintenance, (3) make less environmental impact, and (4) reduce the time and cost of rehabilitation. Depending on location and climate, access may be gained through year round or seasonal tracks or routes. In difficult terrain it is advisable to perform a cost evaluation, as it may be less expensive to use aircraft to access and supply a project site than build a track or road. For example, in the north it may be cost effective to move materials by helicopter and, when necessary, build a winter ice road for seasonal use. Access routes should be built to be safe and yet at the same time minimize environmental impact. Try to confine construction to the dry times of the year. Make sure all required permits are obtained before starting construction.

For detailed information, refer to the following sections and appropriate subtopics of the e3 Plus Excellence in Environmental Stewardship Toolkit: http://pdac.ca/e3plus
5.5.1 Road and Track Design
5.5.3 Bridges and Crossings
5.5.3.2 Types of Crossings
5.7 Special Terrains

21.4.1 Specific Risks and Hazards

In addition to the risks and hazards of working around heavy mechanical equipment, employees should be aware of:

- Slips, trips and falls caused by working on uneven slippery ground, steep terrain, cliffs, or slippery surfaces (e.g., sand, mud, ice and snow)
- Crush or pinch point injuries caused by moving equipment (e.g., conveyer belts, rock crushers, drill rods, winch drums, auger parts)
- Transportation related injuries or death caused by collisions, seasonal and terrain hazards, operating on uneven ground, steep slopes, near water or on ice, inadequate rider training and/or operating skills (ATVs, snowmobiles)
- Impact injuries or death caused by dangerous objects, including trees, loose rocks, unstable stumps
- Drowning or cold water immersion hypothermia caused by falling into water, falling through ice, failing to follow SOPs regarding travel on water or working on ice
- Stranding due to equipment breakdown, running out of fuel
- Equipment damage, equipment breakdown caused by road surface hazards (e.g., hidden cracks, ruts, washboards, meltwater or slush), extreme temperature conditions

21.4.2 Safety Tips for Access Routes

Construction safety tips

- Comply with permit requirements. Plan and construct access routes according to specifications of the AHJs. Exploration companies should inform the construction contractor of their environment, health and safety (EHS) standards for construction.
- Use good engineering practices to design safe trails, tracks and winter roads. This may require contracting out the design and construction to specialists familiar with the location and hazards. Whenever possible, avoid steep grades to minimize vehicle handling issues. There should be adequate pull outs (plowed in winter) and signage to indicate important information and hazards (e.g., slide areas, potential flood areas, speed limits, radio frequencies and protocols for track or road usage).
- Use appropriate heavy equipment for the job; a tracked excavator creates less environmental impact than a bulldozer. When working on ice, use the lightest possible equipment that can perform the job.
- Schedule construction when rainfall will not increase erosion and impact the safety of workers (slips and falls). Heavy rains increase the likelihood of mud and rockslides on access routes. Working in very wet terrain can stress equipment.
- Remove debris where it will impede workers (e.g., rocks, roots, stumps). Identify and mark remaining hazards and mitigate them as much as practical.
- It may be advisable to disguise the entry point to an access track to discourage use by local recreational vehicles. Where appropriate, discuss access trail construction with local communities, as they may have an interest in the trail either being rehabilitated or left for their use. Refer to appropriate sections in e3 Plus Excellence in Environmental Stewardship and Social Responsibility in Exploration Toolkits at: http://pdac.ca/e3plus
- Use permissible dust control to increase visibility and protect workers' health, as necessary.
- When clearing is required, clearly mark the route so all employees and the contractor know the location and width of access tracks. When trees must be cut, inform all employees so they know where cutting will take place and when to keep clear.
- Remove foliage and vegetation that obscures visibility around dangerous curves and at junctions, keeping in mind the objective of minimal environmental impact coupled with safe operation. When constructing access trails, bear in mind alternatives that will enhance vegetation recovery after trail use ceases.

Safety tips for employees

- Comply with company SOPs and guidelines, be trained in ERP procedures and wear appropriate PPE.
- Develop a reliable communication system. Communication is essential between heavy equipment operators and workers who are on foot, in light vehicles and at the project base.
- Road condition hazards: Be aware of road or track hazards and drive/ride safely through difficult ground such as potholes, washboard areas, washouts, temporary bridges, steep slopes and switchbacks. Be aware of weather and environmental hazards including

sudden whiteouts, high winds, heavy rains, floods, sandstorms, mud and possible mudslides.

- Training: In addition to general safety training, workers should receive additional training if they work with chainsaws, on ice, or near cold and/or deep water. Refer to sections 5.6 Chainsaws, 11.4 Line Cutting Safety, 15.10 Working on Ice, 17.12 Water Survival, and 21.4.3 Winter Access Routes (below).
- Use traffic controls (cones, barricades) to prevent access to dangerous areas (e.g., blasting, heavy traffic, cliffs).
- Take into account relevant wildlife issues such as migrating herds or dangerous animals.

21.4.3 Winter Access Routes

Winter roads provide an effective means of transportation in the north when ice is thick enough to safely bear the weight of vehicles and heavy equipment. Access to drill sites and winter drilling programs on ice are a normal part of exploration and require safe access routes for drill pad preparations before drilling operations begin. Planning programs requires accurate information regarding ice conditions. It is essential to verify that the ice is thick enough to support the intended load, whether it is a person on foot, snowmobile, vehicle, drilling equipment or an aircraft.

Employees should never be permitted to test or work on ice alone; they should never use any method of transportation on untested ice. Ice thickness should be measured at appropriate spatial distances and at regular (or appropriate) time intervals. For example, it may be necessary to make daily measurements early in the season and then less frequently as the winter progresses. However, it is essential to measure the thickness of ice whenever there may be potential changes to the thickness (e.g., after a sudden temperature change, a heavy snowfall or heavy rains). The first people who test the ice are at greatest risk because the least information about ice conditions is available.

Information in this section is based primarily on the following documents, which should be referred to for detailed information:

Best Practice for Building and Working Safely on Ice Covers in Alberta: http://employment.alberta.ca/documents/WHS/WHS-PUB_sh010.pdf
A Field Guide to Ice Construction Safety: http://www.dot.gov.nt.ca/_live/documents/documentManagerUpload/Ice%20Construction%20Field%20Guide%20web.pdf
Policy Subject: Working on Ice: www.uoguelph.ca/~wrs/OMNR.working.on.ice.policy.doc

For detailed information regarding working safely on ice on foot and with snowmobiles, refer to the following sections of these Guidelines:

15.10 Working on Ice: for ice terminology and features, hazards related to ice, equipment lists, and guidelines for initial safe ice crossings and ice testing procedures on foot and by snowmobile
15.11 Cold Water Immersion Hypothermia – Falling through Ice: for self-rescue and rescue procedures when a co-worker has fallen through ice
9.9 Cold Injuries: for recognition and treatment of hypothermia and frostbite
20. Drilling Sites: for information about drilling on ice

Ice Safety Plan

As discussed in 15.10.5 Planning and Preparation for Working on Ice, it is strongly advised that companies develop an ice safety plan that incorporates risk assessment, mitigation of hazards and a site specific emergency response plan with rescue procedures. Guidance is available specifically directed toward developing an ice safety plan and relevant emergency response procedures in:

Best Practices for Building and Working on Ice Covers in Alberta:
http://employment.alberta.ca/documents/WHS/WHS-PUB_sh010.pdf

Section 3. Ice Cover Hazard Controls
Section 4.1 Design Controls
Section 4.2 Ice Monitoring Controls
Section 5. Developing Your Ice Safety Plan
Appendix D Emergency Procedures

21.4.3.1 Specific Risks and Hazards

In addition to those associated with working in cold conditions and on slippery surfaces, the following risks and hazards are specifically related to winter access routes:

- Equipment breakthrough on ice caused by:
  - Miscalculations:
    - Using the wrong tables to calculate the load bearing capacity for ice, applying too high a risk factor when making calculations (A-value in Gold's Formula), applying inadequate hazard controls in conjunction with the A-value selected in Gold's Formula
    - Inaccurate measurement of the ice thickness, inaccurate measurement of the total weight of a vehicle, a load and/or equipment
  - Inadequate monitoring of the ice cover for ice thickness, cracks, and after temperature changes
  - Travelling at too great a speed for the ice thickness and depth of water under the ice, travelling or parking too close to the windrows where ice is thinner
  - Unrecognized variable thickness of ice, which is often due to underwater currents, temperature variations or the presence of subsurface features
  - Crossing pressure ridges, undetected cracks (covered by snow)
  - Pushing the limits: not following SOPs, going onto ice too early or too late in the season
- Ice failure caused by equipment breakdown so that a moving load becomes a stationary load
- Drowning or cold water immersion hypothermia caused by not wearing a floater snowmobile suit or PFD, lack of training in rescue procedures, inability to escape from equipment that breaks through ice

21.4.3.2 Planning and Preparation for Winter Access Routes

As a minimum, employees who work on ice should have appropriate knowledge and training to work safely. As part of the ice safety plan to assist managing and mitigating risks, employees should be trained to recognize risks and hazards, be familiar with ice characteristics, know how to

correctly measure ice thickness and how to carry out all relevant emergency response procedures. Designated employees must be trained to correctly calculate the safe load bearing capacity of ice using allowable load tables and ice bearing capacity charts.

Training

In addition to training described in section 21.3.2, employees who work on ice should receive training regarding:

- Safe operating procedures (SOPs) that include:
  - Safe testing of ice thickness on foot, when using a snowmobile, and when using heavy equipment, as appropriate
  - Required personal protective equipment (PPE): In addition to regular PPE, employees should wear a flotation snowmobile suit, a personal flotation device (PFD) or a life jacket as long as there is a risk of ice failure during the initial testing phase. Carry a hypothermia kit and know how to use the contents.
  - Never wear a seat belt while operating a vehicle or equipment on ice.
  - Required safety and survival equipment for vehicles, ATVs and snowmobiles, heavy equipment
- Emergency response rescue procedures should include as a minimum (1) self-rescue procedures, (2) procedures to rescue a crew member who has fallen through ice, (3) escape procedures when a vehicle breaks through ice, (4) escape and rescue procedures when equipment and a driver break through ice, and (5) procedures to treat cold water immersion hypothermia. See below.
- Knowledge of the physical properties and characteristics of ice so workers understand why it is essential to adhere to safe load limits and comply with safe speed limits.

Training for Emergency Response Procedures

Except for #4, the emergency response rescue procedures listed above are presented in *Hypothermia, Frostbite and Other Cold Injuries: Prevention, Survival, Rescue, and Treatment* by Dr. Gordon Giesbrecht and James A. Wilkerson. Refer to this book for comprehensive information regarding self-rescue procedures, rescue procedures for a co-worker who has fallen through ice, how to escape from a vehicle (below), and for treatment of hypothermia and cold water immersion hypothermia. Projects where employees routinely work in cold conditions or on ice should consider keeping a copy of this book on site.

If your vehicle breaks through ice:

- Try to escape as fast as possible – before it sinks. The vehicle should remain afloat for a short time – up to two minutes depending on how airtight it is.
- Exit through a side window to escape. Break them if necessary using a sharp object like a centre punch or a ResQMe tool. Many vehicles have power windows and locks that should operate for a short time under water. Open the doors *only* if the vehicle has just partially broken through the ice or the water may rush inside. As the vehicle sinks, water pressure may trap a person between the vehicle and partially opened door.
- If the side windows will not open, try to break out of the windshield or rear window. Use your feet or shoulders if there is no sharp object.
- Vehicles with the engine in front will often sink and come to rest on the roof if the water is deeper than 4.5 m (15 ft). It is very difficult to escape when submerged so get out as fast as possible.

Hypothermia and cold water immersion hypothermia

It is very important for hypothermia and cold water immersion hypothermia victims to be treated gently and receive appropriate care. For summary information, refer to sections 9.9.3 Hypothermia, 15.11 Cold Water Immersion Hypothermia – Falling Through Ice and 17.12.3 Cold Water Immersion Hypothermia.

Ice Characteristics

Many risks and hazards associated with ice are related to the physical characteristics of ice and the conditions under which it initially forms. Ice deflects (sags) under the weight of a load. When the load is moving, the depression creates a dynamic wave that travels away from the load through the ice and in the water under the ice. The faster a vehicle (load) moves, the steeper the wave becomes and if the vehicle speed is about the same as the speed of the dynamic wave, the ice is much more likely to fracture even when the load is theoretically well within the load limit the ice can bear. Ice may also rupture when a dynamic wave encounters shallow water or a subsurface feature (a shoal) or the shoreline – even when the ice is theoretically thick enough to support the load.

The load bearing capacity of ice is determined by numerous factors that include but are not limited to: ice thickness, air temperature during initial ice formation, type of water (salt or fresh), snow cover, the presence of cracks, extreme temperature changes, features – shoals, sand bars, rocks, subsurface water currents, inlets and outlets warm springs, bridge abutments and other manmade structures, and vehicle speed on the ice.

For a summary of terminology and ice features, refer to section 15.10.2 Ice Terminology and Features and the Glossary in *Best Practices for Building and Working on Ice Covers in Alberta:* http://employment.alberta.ca/documents/WHS/WHS-PUB_sh010.pdf.

Ice Thickness Records and Calculations for the Load Bearing Capacity of Ice

1. Ice Thickness Records: Local authorities (AHJs) normally require companies to keep ice thickness records in a log book. If an accident occurs, the documentation may be critical in a subsequent investigation. Record the sample site location, all ice measurements, temperature, hazards, and additional information for the duration of work on ice. Record all ice thickness measurements in terms of the "effective ice thickness" (refer to #5 in section 15.10.5.1 Guidelines for Testing and Assessing Safe Ice Thickness). Specific record keeping requirements may vary by jurisdiction. For some examples, refer to:

   Best Practice for Building and Working Safely on Ice Covers in Alberta: http://employment.alberta.ca/documents/WHS/WHS-PUB_sh010.pdf

   Section 4.1.2 Effective Ice Thickness

   Section 4.2 Ice Monitoring Controls

   Section 4.2.1 Measuring and Recording Ice Thickness

   Appendix A Table A3: Ice Cover Profile Template

   Appendix E Table E1: Ice Cover Inspection Template

   A Field Guide to Ice Construction Safety: http://www.dot.gov.nt.ca/_live/documents/documentManagerUpload/Ice%20Construction%20Field%20Guide%20web.pdf

   Section 3.3 Ice Testing

2. Load Bearing Capacity of Ice: When calculating the load bearing capacity of the ice cover, it is essential to (1) base calculations on the thinnest ice measurement in the test area and (2) use the correct allowable load tables and ice bearing capacity charts. Load bearing tables and charts for moving loads are different from those for stationary loads because ice beneath a stationary load will deform continuously until it fails. In addition, engineering expertise may be required to evaluate and compute the safe ice thickness required for stationary loads.

For moving loads: Use the correct system of units for calculations. Do not confuse *metric* and *imperial* units. Some ice bearing capacity charts for moving loads have two separate scales with different units on the same chart. Carefully note the weight specifications of the equipment. Confusion may result, especially with the term “ton or tonne”. It is easy to miscalculate: a “short ton” does not equal a “long ton” does not equal a “tonne”.

Table 21.2: Comparison of weights in different units of measurement

Units of Measurement	Ton or Tonne	Kilograms	Pounds
U.S. Customary Units	1 ton (short ton)	907.2	2,000
Imperial Units	1 ton (long ton)	1,016	2,240
International System (Metric)	1 tonne (metric ton)	1,000	2,204.6

The most stringent and conservative standards for the safe load bearing capacity of ice are recommended by the PDAC Health and Safety Guidelines. For the safety of employees, it is best to work on ice thicknesses greater than the minimum thickness recommended by charts and tables.

The following references contain tables and charts for moving and stationary loads; some include allowable time limits for loads on ice:

Best Practice for Building and Working Safely on Ice Covers in Alberta:
http://employment.alberta.ca/documents/WHS/WHS-PUB_sh010.pdf
Section 4. Ice Cover Design, Monitoring and Maintenance

A Field Guide to Ice Construction Safety:
http://www.dot.gov.nt.ca/_live/documents/documentManagerUpload/Ice%20Construction%20Field%20Guide%20web.pdf

Policy Subject: Working on Ice:
www.uoguelph.ca/~wrs/OMNR.working.on.ice.policy.doc

3. Cracks: When cracks are present, follow the guidance of best practices, the recommendations and regulations of AHJs and reduce the load accordingly. While dry cracks may not pose a problem, load reduction may be required when they are close together and of a specified width. Wet cracks usually require load reductions or special actions such as repairs or a detour because they indicate that ice has cracked entirely through to the water. When cracks are parallel to an ice road, it indicates the ice has been stressed and it is advisable to detour around them until the cracks heal. Radial cracks indicate ice is overloaded and the load should be removed. When circumferential cracks join radial cracks around a load, ice failure is imminent. For definitions and information about cracks, refer to:

Best Practice for Building and Working Safely on Ice Covers in Alberta:
http://employment.alberta.ca/documents/WHS/WHS-PUB_sh010.pdf
Section 2.3 Types of Ice Cover Cracks

Section 4.2.2 Monitoring Ice Cracks

A Field Guide to Ice Construction Safety: http://www.dot.gov.nt.ca/_live/documents/documentManagerUpload/Ice%20Construction%20Field%20Guide%20web.pdf

Figure 6 Modification of the Ice Loading and Remedial Action for Various Types of Cracks

Policy Subject: Working on Ice: www.uoguelph.ca/~wrs/OMNR.working.on.ice.policy.doc

Appendix One: Adjustments to Bearing Capacity Because of Cracks or Absence of Blue Ice

4. Temperature changes may require adjusting work schedules or the load permitted on the ice.

- An extreme drop in temperature can cause the ice to become brittle so the strength is severely compromised. The ice may not be safe to use for at least 24 hours.
- An extreme rise in temperature can cause the ice to thin unexpectedly and dramatically *even when the temperature does not rise above freezing*. Under such circumstances, it is imperative to carefully test the ice each day in order to monitor the thickness. Underwater currents may rapidly erode the lower ice surface after temperature changes.
- If the temperature rises above freezing for six of the past 24 hours, the load capacity is diminished.
- When the temperature stays above freezing for 24-48 hours, ice will rapidly lose strength and the safe ice bearing capacity charts and tables may no longer apply. The ice may no longer be safe despite the thickness.
- For additional information, refer to section 4.1.4 Effect of Sudden and Extreme Temperature Changes in *Best Practice for Building and Working Safely on Ice Covers in Alberta:* http://employment.alberta.ca/documents/WHS/WHS-PUB_sh010.pdf.

21.4.3.3 Construction of Winter Access Routes

Whenever possible, avoid constructing roads and tracks over land in the Arctic due to the environmental impact. When construction is necessary, winter roads are the best choice. Heavy equipment should be appropriate for the job. Construction methods should preserve the permafrost and make as little impact as possible on topsoils and vegetation. It is preferable to use lightweight, wide tracked, low ground pressure vehicles or tracked vehicles on snow covered tundra and frozen muskeg, as their weight is distributed over a wider area of the land. Do not count on wide tracked equipment to be safer than narrow tracked equipment for use on ice because the critical factors are the condition of the ice and the total weight of the load on the ice rather than the size of the footprint of the load.

Safety is the most important factor when designing and constructing ice roads and ice bridges. It is advisable to contract construction of winter roads to specialists. Contractors should have experience building ice roads in the same region. When possible, use ice profiling equipment that uses ground penetrating radar (GPR) to gather accurate information regarding ice thickness and general ice conditions. If a GPR ice profiler is unavailable, ice must be tested by hand.

For information about selecting routes and constructing ice roads and ice bridges, refer to:

Best Practice for Building and Working Safely on Ice Covers in Alberta: http://employment.alberta.ca/documents/WHS/WHS-PUB_sh010.pdf

Section 2.7 Contractor Capability
Section 2.8 Route and Site Conditions
Section 4.1.6 Lane Dimensions
Appendix B Guide for GPR Ice Profiling

e3 Plus Excellence in Environmental Stewardship Toolkit: http://pdac.ca/e3plus/

Sections 5.5.3.2.5 Ice Bridges
Section 5.7.1 Arctic and Alpine Terrains

Ice Bridges and Snow Fills: http://www.dfo-mpo.gc.ca/regions/central/habitat/os-eo/provinces-territories-territoires/sk/os-eo10-eng.htm
Section 15.10.5.2 Guidelines for Testing Ice Thickness on Foot in these Guidelines

Figure 21.3: Light truck with track conversion towing ground penetrating radar (GPR) ice profiling equipment
© Iain Mitchell

Figure 21.4: Wide tracked Sno-cats are used to clear ice roads and runways on ice.
© Iain Mitchell

Safety tips for operating heavy equipment on ice

- Know the total weight of the equipment when fully loaded – the Gross Vehicle Weight (GVW) + fuel + driver + equipment (gear, tools etc.). Weigh the mechanical equipment on a scale, if available. Otherwise make a best estimate of the total weight and add extra for a margin of safety. If there is any question about safety, measure the ice and use the thinnest measurement to calculate the safe load bearing capacity of the ice.
- Use extremely light tracked or amphibious vehicles when testing ice thickness early in the season. When ice is too thin for heavy equipment (a truck with a plough), it may be possible to use a machine such as a small sit-down tractor with a snow blower to clear routes. The rider should wear a flotation snowmobile suit or PFD until the ice is unquestionably thick enough to support heavier equipment.
- When using a SNO-CAT or other equipment with a closed cab, make sure there is a fully functioning escape hatch in the roof. Consider removing the hatch entirely or securing it in the open position for additional safety.
- When plowing roads and air strips on ice, plow the full width in one shift the first time the ice is cleared. After the initial clearing, plow new fallen or windblown snow out to the windrows but never plow into the windrow or across them. There is increased risk of breakthrough near windrows because the ice is usually thinner there. This is due to (1) the weight of the snow, (2) the insulation properties of snow that prevents the ice from freezing to the same thickness as ice in contact with cold air and (3) potential hidden cracks under the snow. An ice road or airstrip should become progressively narrower as plowing continues and the season advances.

- Establish a routine check-in time and maintain radio contact throughout work and/or travel on ice. This is essential in order to inform others if there is an emergency, such as a breakthrough or a whiteout.
- Clearly mark the limits of the safe route on ice once they are defined. Require equipment operators to stay within the marked boundaries.
- Do not store materials and goods on ice; do not park vehicles and machinery on ice, especially near a drill pad. The added weight may stress the ice cover to the degree that it fails.
- To prevent ice from melting, do not lay a heat source directly on ice; allow sufficient room underneath a heat source to circulate cold air.

Figure 21.5: Measure the thickness before using heavy equipment on ice, especially on frozen rivers and streams where ice thickness is always variable. © Steve Millar

Safe driving/riding procedures on ice

- Be familiar with and follow the applicable SOPs and safety guidelines including those in Sections 13. Vehicles and 15. Snowmobiles.
- Fully equip all vehicles and train all drivers and passengers. They should be able to carry out emergency rescue procedures and use the survival equipment. Stranding is always a possibility due to breakdown or adverse weather conditions. Carry extensive survival equipment and a satellite telephone where radio or cell phone contact is not dependable. Carry sufficient fuel to make a return trip with fuel to spare. Know appropriate survival skills for the terrain. Refer to sections 8. Survival and 15. Snowmobiles for equipment lists.
- Leave written details of your route and estimated time of arrival/return with the person in charge. Maintain radio contact at specified check-in times. This is essential to

inform others of your location if an emergency occurs during ice road travel. Help will be dispatched if you do not check in as required according to the ER procedures.

- Strictly adhere to rules, speed limits and weight restrictions on ice roads. If there is no posted speed limit, it will be necessary to compute a safe speed taking into account the total weight of the vehicle and load, the ice conditions, the water depth below the ice, and the bottom and shoreline configuration. Unless ice road procedures and speed limits are followed, the dynamic waves of oncoming or overtaking traffic may converge and amplify, which stresses the ice so that it may rupture. The dynamic wave of a speeding truck may cause extreme stress to the ice so that it cannot support the load that follows.
    - Never wear a seat belt while travelling on ice. Keep a window punch tool immediately available to break a window to escape and carry rescue ice picks on your person to help haul yourself up onto the ice surface.
    - Secure loads with extra restraints as ice roads and portages can be very rough and slippery.
    - Inexperienced drivers should be teamed with experienced drivers.
- Drive close to the centre of an ice road and not near the banks (windrows) where cleared snow is plowed. The ice is usually thinner and/or weaker near the windrows.
- Vehicles should travel in tandem or in convoys with adequate spacing. Park vehicles or equipment a minimum of two lengths from an equivalent piece of equipment and for *no more than two hours*. Do not park near windrows.
- Maintain a safe stopping distance that allows for rough, slippery surface conditions, blind corners, wild animal encounters etc.
- Carefully pass any oncoming traffic and overtake with caution (if permitted). Visibility may be obscured when the draft from moving vehicles creates swirling snow.
- Be alert for signs of stress and deterioration in the ice. These include the presence of cracks, water, bubbles, potholes or pressure ridges. Inform the person in charge or supervisor immediately if these features are unexpectedly encountered.
    - Pressure ridges are dangerous and can develop suddenly. Try to develop a route around them. Do not build a ramp bridge across a pressure ridge unless there is no alternative. Drive across ramps with utmost caution and do not cross them if planks are lifted or twisted out of place.
    - Watch for the presence of water (especially when approaching shore), which indicates dangerous conditions and the immediate potential for breakthrough. Try to approach the shore at 45° as it is safer than directly approaching shore at 90°.
- It is advisable to carry chains for emergency use. Chains should only be used when permitted by AHJs, as they cause severe deterioration to the ice surface.
- For additional information refer to: The Tibbitt to Contwoyto Winter Road: *Orientation 2010, Part 2. Driver Safety* on the following website: http://jvtcwinterroad.ca/

Figure 21.6: To create a thicker safer ice road, the ice is flooded to create "lifts" that freeze solidly within 12 to 24 hours. © Chris Pederson

21.5 Trenches and Pits

Trenches and pits are open excavations that pose potentially deadly risks and hazards to employees who work in or near them. Some trenches or pits are dug with hand tools (mattocks, picks, shovels), but often excavation is carried out using backhoes or excavators. Depending on the climate, weather and ground conditions, some trenches may require engineering expertise to guarantee safe and correct wall support. Trenches and pits should be designed and constructed according to AHJs to prevent the walls from collapsing and burying workers.

21.5.1 Specific Risks and Hazards

Specific risks and hazards associated with trenches and pits depend on the depth of excavation, equipment used, ground conditions, the local weather and employee behaviour. They include:

- Crushing burial, suffocation and injuries caused by wall collapse, falling debris from waste piles, and/or improperly benched or sloped walls
- Death or serious injury when struck by heavy equipment
- Injuries from hand tools caused by the lack of training, lack of or improper use of PPE, using the wrong tool for the job, working too near a co-worker
- Asphyxiation from toxic gases caused by the build-up of exhaust from generators or motors used in or near trenches or pits

- Electrocutions, burns, explosions and/or fires caused by contact with buried power cables, pipes, gas lines or overhead power lines
- Death from drowning or burial caused by flooding, water permeating or saturating the wall material causing collapse – despite shoring and benching
- Injuries caused by employees behaviour, which include not following SOPs, lack of training, not wearing PPE, lack of inspection before entry, lack of supervision of employees in excavations

21.5.2 Jurisdictional Regulations

Exploration companies should secure all required work permits and certifications for excavations in order to be in compliance with occupational health and safety (OHS) legislation and Mines Acts and Regulations of the AHJs. Require contractors to (1) check for potential buried pipelines and cables before starting an excavation and (2) acquire any required trench design certification, which may depend on the location and depth of the proposed excavation.
In places where no legislation exists, companies should develop their own safe operating procedures and safe excavation standards based on best practices elsewhere and enforce them.

Plan for compliance and safety

Adhere to or exceed the requirements of the AHJs. The following procedures reduce the risks and hazards of working in trenches and pits and should be required by AHJs.

1. Obtain all required permits, permissions and certifications.
2. Carry out a risk assessment to determine the risks and hazards including the location of overhead power lines or buried cables, pipelines etc. Remove or mitigate hazards before excavation begins.
3. Assess the soil type, which greatly influences the strength and stability of excavation walls, in order to calculate the depth, cut back, slope, and wall support requirements to prevent collapse. Consider any additional conditions that affect the stability of trenches, lithologic and soil structures, potential vibrations, potential presence of water or wet weather, and the weight of the excavated spoil and equipment present. Plan for potential shoring and benching requirements from the beginning to save time and costs before the sidewalls must be cut back (benched or battered) or adequately supported to prevent collapse.
4. Plan for the requirements for backfill, topsoil management and erosion control. Refer to section 5.4.2.1 Trenches and Pits and sections on various types of terrain and environmental zones in the e3 Plus Environmental Stewardship Toolkit for detailed information regarding the safe and correct way to (1) remove top and subsoil, (2) create drainage and (3) replace material when the trench is no longer used. Follow the excavation setback distances suggested for specific areas such as Riparian zones. Website: www.pdac.ca/e3plus
5. Carry out inspections. Inspect the excavation before each shift, before any workers enter, after a substantial rainfall, after blasting (which may affect the stability of the soils or rocks adjacent to a trench), and any time someone reports a concern or a danger sign in the walls or area surrounding the excavation. Address or eliminate all potential hazards before any workers enter.

21.5.3 Prevention and Preparation

Choose appropriate equipment for the job. Whenever possible, use excavators and backhoes to dig trenches; they can excavate a trench more accurately and cause less environmental damage than a bulldozer.

Training

- Employees must be trained to recognize the dangers of trenches and pits, especially the potential for (1) collapse and (2) confined space.
- Training should include site specific SOPs, ERPs, and rescue procedures if a trench caves in or a co-worker collapses in a trench for no apparent reason.
- Employees should be trained to use tools correctly, refer to Section 5. Field Equipment Safety.
- PPE requirements should include:
    - Safety glasses – at all times
    - High visibility vests – when working in a trench or pit and around heavy machinery
    - Hard hats should be worn at all times – even when a trench is shallow to protect from impact injuries and flying debris, especially if hand tools are used.
    - Steel toed boots should be worn when working in a trench or pit with hand tools that might cut through a boot and when sampling when rocks might be dislodged and fall onto feet.
    - Gloves help prevent cuts, blisters and infections that may result from contact with soils and sharp rocks.

General employee safety

- No employee should enter a trench if they feel the trench is unsafe for any reason. Employees have the right to refuse unsafe work.
- No employee may work alone or remain alone in a trench or pit, even for a short period of time.
- Employees may enter a trench or pit under the following circumstances:
    - The trench has been inspected and declared safe to enter.
    - There is a person on the surface at all times to monitor employees in the trench.
    - The trench walls or floor show no signs of instability.
    - If the trench is deeper than 1.2 m (4 ft), it must be in solid rock or the walls have to be widened, sloped or benched properly according to jurisdictional regulations. If there are no jurisdictional requirements, the company should develop and implement SOPs that address procedures for safe entry, supervision and rescue to protect the health and safety of workers.
- Remain vigilant at all times. Be very cautious near the edges to prevent falling in and/or being struck by excavation machinery. It is very easy to forget and step behind the moving machinery or in the path of the bucket. Never approach heavy equipment from a position where the operator cannot see you (e.g., the rear or the blind side or spot). Stay out of the “exclusion zone”, as previously described in section 21.3.3.

- Samplers should be aware of their surroundings to prevent being struck (or striking others) with tools or deflecting rock. Watch out for loose debris that might fall from above. Do not work on the benched or sloped sides above or below other employees.
- No one should be permitted to work or take samples while standing or sitting in the bucket of an excavator or backhoe. Take samples from the bucket when the bucket is resting on the ground.
- Never work underneath loads that are being lifted or transported by an excavator.

Trench configuration and safe practices

Be aware of and follow the jurisdictional requirements and environmental best practices regarding trench placement, particularly on slopes, within buffer zones, or when creating drainage to counteract erosion. Follow these tips in addition to those in section 21.5.2 Jurisdictional Regulations.

- Avoid digging deep narrow trenches; they are especially dangerous when excavated in poorly consolidated material.
- Place tools, heavy equipment and material excavated from trenches and pits (spoil) at least one metre back from the trench to help prevent cave-ins or workers being hit by falling objects. For trenches greater than one metre in depth, the excavated material should be placed as far back from the edge as the planned depth of the trench. Spoil should be piled at least 30 metres away from a lake or watercourse if no buffer zone exists, unless a different distance is specified in the permit.
- Remove or secure any trees, rocks or other objects from the edges of trenches or pits to prevent them falling onto employees.
- Access and egress: Ladders should be placed as close as possible to the work area. They should be secured and placed within 7.5 m (25 ft) of the workers and extend a minimum of 1 m (3 ft) above the top of the trench. A trench should have at least one end with a gentle slope for easy exit should a worker, an animal or other person fall in. Employees should not carry tools up and down with them when using ladders; place them in a container and hoist them.
- Inspections: Keep a record of all inspections. Develop and use checklists to cover specific and appropriate trenching requirements. Make sure various safety factors are covered on inspection forms.
- Danger signs of sloped or benched walls of trenches and pits:
    - Material bulging from the walls or sides
    - Small clumps separating from the walls or sides
    - Cracking in excavated walls
    - Ground surface tension cracks developing parallel to the trench
    - Water accumulations on the floor of the trench or behind shoring that may cause undermining and wall collapse
- Place barricades (fencing if necessary) and warning signs around open excavations. Protect workers from falls, falling loads and mechanical equipment. Open excavations also pose a hazard to the curious public, visitors, or wildlife and/or livestock. Erect barricades and post warning signs in the local language or even in graphic symbols if non literate people are likely to be at risk.

- Keep generators or combustion engines at least 10 metres away and preferably downwind and down slope from a trench – never locate them in a trench.
- Check for snakes and other wild animals before entering. Animals or venomous snakes or insects may use the trench at night or to shelter from hot sun.
- To prevent falls, fill in test pits and trenches as soon as work is completed. This is required in some jurisdictions and may be a condition of the work permit.

For additional information regarding trenches and pits, refer to the following websites:

http://www.labour.gov.sk.ca/Default.aspx?DN=d337bd61-05e6-4027-a9b3-c53ec2a159ae
http://www2.worksafebc.com/i/construction/Toolbox/pdfs/TG06-46_Sloping_shoring.pdf
http://www2.worksafebc.com/i/construction/Toolbox/pdfs/TG06-47_Trenches_excavations.pdf
http://www.csao.org/images/pfiles/27_M026.pdf
http://www.osha.gov/Publications/osha2226.pdf

Figure 21.7: Trenches should have one end with a gentle slope for easy exit. © Lorne Burden

Figure 21.8: Pile the excavated material at least one metre back from the edge of the trench. © Lorne Burden

21.6 Explosives

Explosives may be used at advanced exploration sites for building access routes, drill pads, for excavating trenches and pits, or to blast portals and exploration adits. Seismic surveys may utilize explosives. While explosives are normally handled by contractor's employees, the site supervisor should verify that all AHJ regulations regarding explosives are followed by everyone at the site and that those who use explosives are properly certified.

21.6.1 Specific Risks and Hazards

- Severe injury or death of employees or the public caused by entering a blast zone at any time as well as during blasting, inadequate training or qualifications, lack of or not following SOPs
- Unplanned detonation and fires caused by misfires, inadequate training or qualifications, lack of SOPs
- Property and or environmental damage due to poor planning, not following SOPs, poor communication procedures, inadequate training or qualifications
- Inhalation of toxic gases from blasting by-products caused by lack of planning, not following SOPs
- Potential fines or imprisonment for conviction of explosives offenses due to non-compliance with AHJs

21.6.2 Jurisdictional Regulations

Exploration companies are responsible for following jurisdictional regulations (federal, provincial, territorial, state) regarding permits, use, handling, storage and transportation of explosives.

- Only certified and licensed employees may handle and use explosives.
- Follow government regulations regarding the safe disposal of all unused, expired or deteriorating explosives. It is a criminal offence to abandon any type of explosives in Canada and the USA.
- In many jurisdictions it is very difficult to obtain and use explosives due to concerns about public security and their intended use.

When companies operate where the use of explosives is not regulated, they should develop and enforce their own safe operating procedures and requirements based on best practices elsewhere for the safe use of explosives.

21.6.3 Prevention and Preparation

- Appoint a blast supervisor with appropriate certification to be responsible for all blasting activities. It is the responsibility of the supervisor to establish the limits of the danger area, appoint guards, oversee all communication and blasting signals, including communication with the blaster, request for radio silence, warning signals, “all clear” signals and the resumption of radio communications.
- Place the correct warning signs in a blasting area to indicate the presence and use of explosives. Have a code for blasting signals in place that everyone at the area is familiar with and can hear.
- Access routes should be guarded to prevent employees or the public from inadvertently gaining access to the area while blasting is in progress. Employees must obey posted signs and guards.
- No smoking or open flames are permitted within any blasting area, magazine or within a vehicle transporting explosives. AHJs usually stipulate that no smoking or open flames are permitted within 15 m of magazines or a day box. Post “No Smoking” and “Danger Explosives” signage as appropriate.
- Blasting procedures should take into account the potential for toxic gases to develop, which may depend on the mineralization in the rock.
    - In certain circumstances blasting rock with sulphide mineralization may result in deadly levels of sulphur dioxide, carbon monoxide and other toxic gases.
    - Oxides of nitrogen are always an issue when blasting in confined areas, including trenches, pits, portals and adits.
- Do not handle explosives when an electrical storm is approaching. Require employees to leave the magazine area and move to a location where there is no danger from an unplanned explosion due to a lightning strike.
- Keep records of explosives inventory and be able to account for all explosives at all times.
- Remove all materials (explosives, wires, detonators/caps etc.) from the site after blasting activities are completed.

Transportation of explosives

Transport explosives in a vehicle that meets specifications of AHJs and in compliance with dangerous goods legislation.

- Always transport detonators and explosives in separate vehicles that are in good mechanical condition. The vehicles must travel separately.
- No smoking or open flames are permitted within 15 m of the vehicle and no combustible material, compressed gases or flammable liquids may be carried in any vehicle that is transporting explosives.
- Label the transport vehicles appropriately according to AHJs.
- Load and unload explosives with the vehicle engine turned off.

Storage of explosives – magazines

Build explosives magazines that conform to all standards and specifications of the AHJ. Magazines are subject to inspections at any time.

- Store explosives and detonators in separate magazines, unopened and in their original packaging until they are used.
- Explosives may be stored in a day box for up to 24 hours. Mark the day box conspicuously on all sides with the words “EXPLOSIVES”.
- Locate an explosives magazine at the base of a high bank in areas where severe electrical storms are a risk. It is advisable to ground the magazine as well. When a thunderstorm approaches, close the magazine and require employees to leave the immediate area.

For additional detailed information regarding explosives, refer to section 10.3 Explosives in the e3 Plus Environmental Stewardship Toolkit at www.pdac.ca/e3plus, and to the following websites:
http://www.nrcan.gc.ca/smm-mms/expl-expl/pdf/bls-sau-eng.pdf

http://www.nrcan-rncan.gc.ca/mms-smm/expl-expl/erd-dre-eng.htm

http://laws.justice.gc.ca/en/E-17

21.7 Resources

The Prospectors & Developers Association of Canada (PDAC) thanks the following for granting permission to include material from their publications.

Association for Mineral Exploration British Columbia (AME BC)
Work Safe Alberta

Their permission does not imply that they endorse the PDAC Health and Safety Guidelines. The PDAC is solely responsible for the content of the Guidelines.

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