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Working Safely on River Ice

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Collecting data for river ice studies often involves venturing onto a river ice cover. Whether it be to conduct measurements of ice thickness or flow velocity, or to collect ice samples for lab analysis, working on a river ice cover can be highly dangerous and warrants careful planning and appropriate safety precautions. In this paper we present our experiences in developing a safe work plan for ice covered rivers. These include guidance and details such as communicating proactively with local authorities, selecting appropriate personal protective equipment and using it effectively, and planning a safe work zone.

1. Introduction

Collecting data for river ice studies often involves venturing onto a river ice cover. Whether it be to conduct measurements of ice thickness or flow velocity, to collect ice samples for lab analysis, or simply to travel to and from a study area by snowmobile or other means, working on a river ice cover can be highly dangerous and warrants careful planning and appropriate safety precautions. Lifesaving Society (2015) correctly emphasizes the risk to the general public of venturing onto any river ice cover and advises against it. However, it is commonplace in many parts of Northern Canada for rivers and lakes to be part of the winter transportation network, with rivers such as the Hay River at Hay River, the Athabasca near Fort McMurray, and Lake Athabasca (to name but a few) being vital to snowmobile (and sometimes vehicle) traffic. However, factors such as the need to collect data across large areas or complete river transects combined with limited local or traditional knowledge can increase the risk exposure for river ice field workers. Therefore, it is important to recognize our own tendency toward complacency.

Jasek and Lavalley (2003) provide information on ice safety training operations and safe data collection experience related to BC Hydro's activities on the Peace River. In this paper we present our experiences in developing a safe work plan for ice covered rivers to complement previous work by Jasek and Lavalley (2003) and other resources that can be found elsewhere. We will discuss details such as communicating proactively with local authorities, selecting appropriate personal protective equipment and using it effectively, and planning a safe work zone. The intent of this paper is not to provide a comprehensive safety plan for others to follow, but rather to present a basic outline of things one might consider when planning their own fieldwork programs on river ice. As such, we offer no guarantees or warranties as to the suitability of any particular approach for others conducting such work. There are commercial ice safety training courses available, and all persons working on an ice cover (and their employers) should consider the advantages and benefits of formal ice safety training as part of their safety program. Some jurisdictions and agencies may also require specific training, and both workers and their employers should be sure they are familiar with all local requirements and workplace safety regulations.

Finally, as with all field work it is important to ensure that a responsible colleague who is not in the field with you (usually your manager or supervisor) is aware of the details of your field work plan and arrangements have been made to check in with them periodically throughout the day; especially once your work is complete and you are safely done for the day.

2. Preparation and Planning

Before conducting any field work on river ice covers, it is essential to do two things. First, it is important to obtain as much direct knowledge of the stream characteristics at the site as possible; second, it is important to communicate with local authorities of when and where you will be working on the ice cover. This is particularly important in urban areas where the general public may mistake you and your team for people in distress and activate emergency services. In some special situations it may also be necessary to obtain special permits or permissions from local agencies responsible for emergency management (e.g. during times of breakup when flood risk is high and local officials are engaged in evacuation of high risk areas).

It is always important to contact the local authorities in advance of the field work in case permit or permission takes some time to arrange. It is also a good idea to contact them again on the day the field work starts to remind them of your plans to go out on the river ice. If you will be working in view of the general public, consider posting a sign briefly explaining the nature of your work and that the public should not go on the ice.

The most significant risks to field personnel related to ice conditions are drowning and hypothermia, and an effective safety plan should not overlook these risks regardless of the perceived improbability of occurrence. Any individual breaking through an ice cover will be exposed to an extreme risk of drowning (at worst) or hypothermia (at best). These risks can be managed through various preparation and planning activities. Government of Alberta (2013) is a useful document that describes risk mitigation procedures and best practices for determining safe working loads on ice covers in Alberta, including design considerations for heavy equipment crossing river ice covers.

In our experience, having an idea of the expected water depths and flow velocities in your work area are important for ensuring a safe and effective field program. In particular, the ice cover is often thinner in the deeper, fast flowing sections of the river and, as a consequence, it is highly desirable to avoid such zones as much as possible. Knowledge of the flow depths expected under the ice cover will also aid in a qualitative assessment of the danger associated with breaking through.

Estimates of flow depths and expected velocities may be available from earlier measurements at the site – either under open water or ice covered conditions. Ideally, field teams should observe and document a river study area under open water conditions or fly the reach prior to freeze-up to gain experience and appreciation for local conditions such the location and configuration of islands, side channels and bars as well as the location of tributaries. If hydraulic modeling will be conducted as part of your study, bathymetry data collected may be used to estimate depth and velocity conditions and it is very useful therefore to collect bathymetry during open water conditions in advance of a winter survey program. One-dimensional (1-D) models are convenient for estimating flow depths; however, 2-D models are needed to estimate the transverse variations of velocities.

A plan to manage hypothermia in the event a field team member breaks through the ice is essential. Generally speaking, this plan should include means of communication with the nearest hospital and emergency responders, having access to a nearby pre-warmed vehicle or shelter, and dry blankets and clothes for each team member that are stored at a safe distance from work areas on the ice cover. Time will be of the essence in warming someone who is immersed in river water whether fully or partially exposed.

The risk of drowning may be mitigated through a combination of training in self-rescue techniques, tethering using ropes, ice anchors and sometimes pulleys, and maintaining separation between team members until the safety of the ice cover is established by probing and measuring the thickness. Perhaps most importantly, field workers should discuss their safety plan thoroughly and watch each other for signs of complacency. Some expectation that the ice cover can fail while you are working on it is reasonable and encourages teams to work more safely. Also, recognize that conditions can change daily. A safe working ice cover one day does not guarantee that it will also be safe the next; each day the conditions should be assessed and re-assessed throughout a field program to avoid complacency.

3. Ice Safety Equipment

3.1 Personal Protective Equipment

The first line of defense is always personal protective equipment. As a minimum, when working on an ice cover teams should have the following on your person:

- warm clothing and insulated waterproof boots (and a change of clothing kept separately nearby in case you become immersed in water);
- personal floatation device (PFD) with strong D-ring;
- climbing helmet that fits comfortably over a helmet liner or warm hat;
- floating throw rope and bag;
- ice awls (ice picks); and
- cleats for ice (as needed).

Examples of some of these are illustrated in Figure 1.

Figure 1. Examples of climbing helmet, PFD with D-Ring, and throw rope in bag (Throw bag photo source: Force 6).

It is important to wear a helmet even if the ice is snow covered, as it is also possible to slip and fall when climbing up and down steep river banks. Some people may choose to wear an insulated floatation suit, as well; however, a PFD is still essential.

3.2 Tethering and Ice Anchoring Systems

Ice anchoring systems (Figure 2) may be used to tether team members to solid ice until a safe work zone has been mapped out or in any instances where the safety of the ice cover may be in question and measurements must be obtained. This includes the use of ice screw anchors, climbing carabiners, and climbing ropes and webbing.

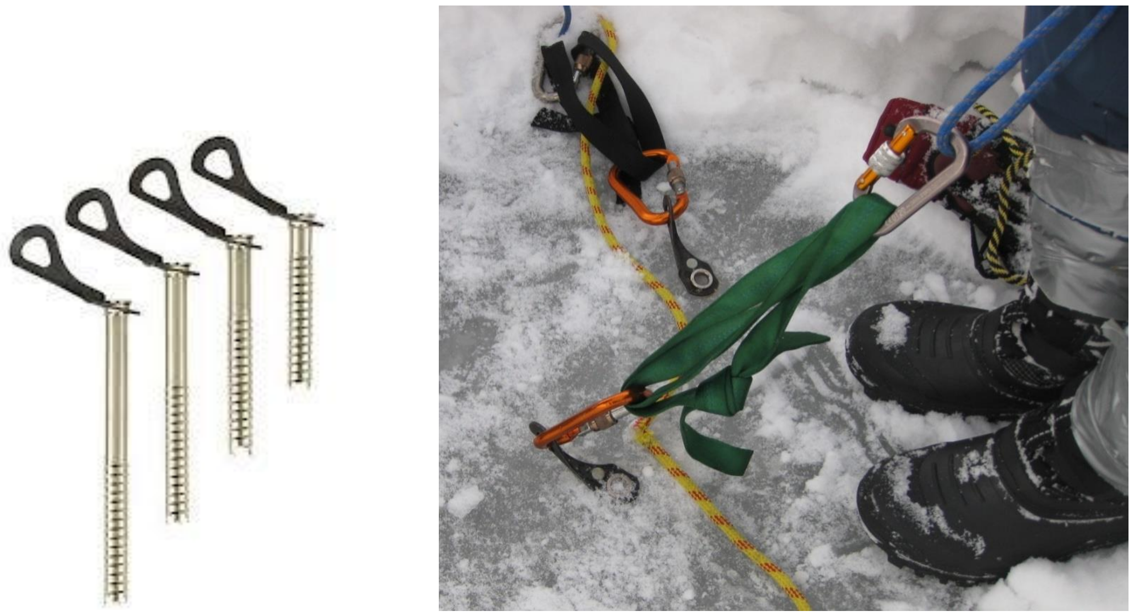

Figure 2. Examples of ice screw anchors (left), and carabiners, ropes and webbing (right).

As shown in Figure 2, the ice anchors are screwed into solid ice and then carabiners are used between the anchors and webbing, between the webbing and ropes, and between the rope and the PFD (see Figure 1). It is vitally important to make sure that all equipment is in good shape and proper working order before going to the field. In particular: ice screws should be sharp and the clip ring secure; carabiners should operate smoothly and stay closed once engaged, and; ropes and webbing should not be frayed or worn. Never tether yourself to an anchor point you cannot release yourself from if you become trapped. PFDs should have a quick-release for the D-ring and anchor belt for this purpose.

3.3 Other Equipment

Survey flags or stakes may be used to delineate a safe work zone on the ice cover. In addition, either an ice auger or Ground Penetrating Radar (GPR) is needed to assess ice thickness when mapping the safe work zone. In some jurisdictions, there are professional practice guidelines (e.g. APEGA, 2008) applicable to use of GPR for ice thickness mapping by qualified geophysicists that should be considered. Therefore, the most efficient means of assessing ice cover thickness might be direct measurement using and ice auger and measuring tape.

4. Working on the Ice Cover

4.1 General Approach for Establishing the Safe Work Zone

When establishing a safe work zone, one member of the team may be tethered with ice anchors and ropes, as illustrated in Figures 2 and 3. It is also possible to use a dynamic belay technique with another team member feeding rope around their waist and acting as an unsecured anchor point. An ice chisel is used to test ice integrity ahead as they walk out onto the ice cover. The ice thickness should be checked directly every 5 to 10 m using a small bore ice coring bit (5 cm diameter) as shown in Figure 3. The perimeter of the safe working zone can then be marked with survey flags or stakes (Figure 4) and other field team members can then go out onto the ice cover as long as they stay within the safe work zone.

Figure 3. Team member secured and checking ice integrity (left), checking ice thickness directly using a 5 cm drill bit (right).

Figure 4. Team member unsecured while working in a delineated safe zone.

4.2 Rope Rescue

Where ice conditions are unknown or the possibility of breaking through the ice is not remote, advance preparation of a rope rescue system can mitigate those risks. A rope system will provide a means of support for a person's own self-rescue, prevent them from being swept under the ice cover by the river current, and allow fellow team members to more readily pull them out of the water. Such a system must be set-up before going onto the ice with the rope attached to the person's PFD and an anchor point in order to be fully effective and allow quick response to an emergency.

For the initial setup, a length of climbing rope is attached to a carabiner using a secure knot (e.g. a *figure 8 on a bight*: http://www.animatedknots.com/fig8follow/) and clipped to the D-ring on the PFD (Figure 2). The PFD is checked to make sure it is securely buckled and the carabiner is checked to assure it is securely closed. The length of rope used is only about as long as needed for the distance to be covered. A *figure 8* knot is put in the rope approximately 1/3 to 1/2 of the way from the free end leaving a small loop (Figure 5). The free end of this line must be secured to an anchor point in competent ice away from the work area (Figure 6).

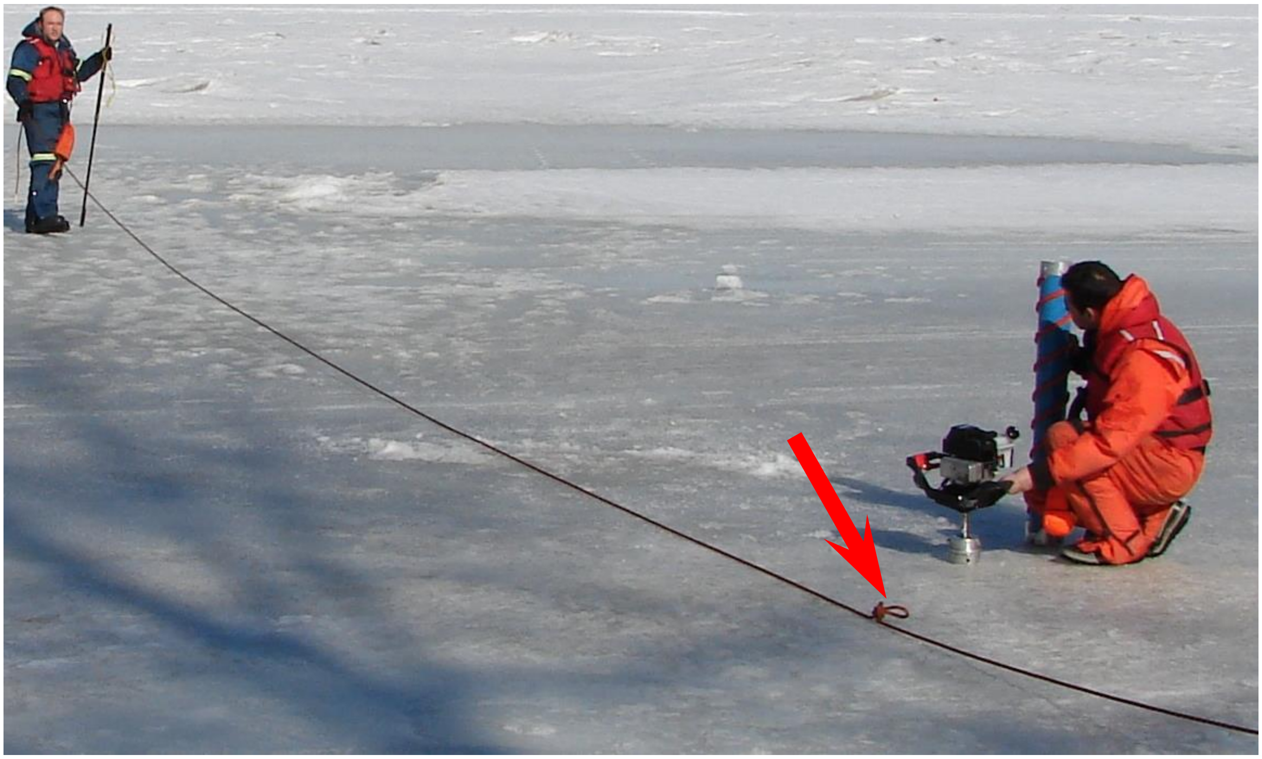

Figure 5. Figure 8 knot (on a bight) in tether rope approximately 1/3 to 1/2 of the way from the free end.

a)  b) 

Figure 6. Use of ice anchors to secure rope lines a) Rope fixed to anchor with a *figure 8* knot, b) rope passed through carabiner to use as a belay or part of a pulley system. (Note: carabiners can be used in place of pulleys as in b); however, there will be less friction resistance if a true pulley is used.)

As a first course of action in an emergency, a fellow team member can attempt to assist in rescuing their partner by pulling on the rope line from a point near the middle as shown in Figure 7 using a technique sometimes referred to as "vectoring". This technique can be surprisingly effective, particularly if the person in the water is able to assist in their own rescue, the amount of force that can be delivered through the rope is often sufficient to pull the person safely back onto the ice.

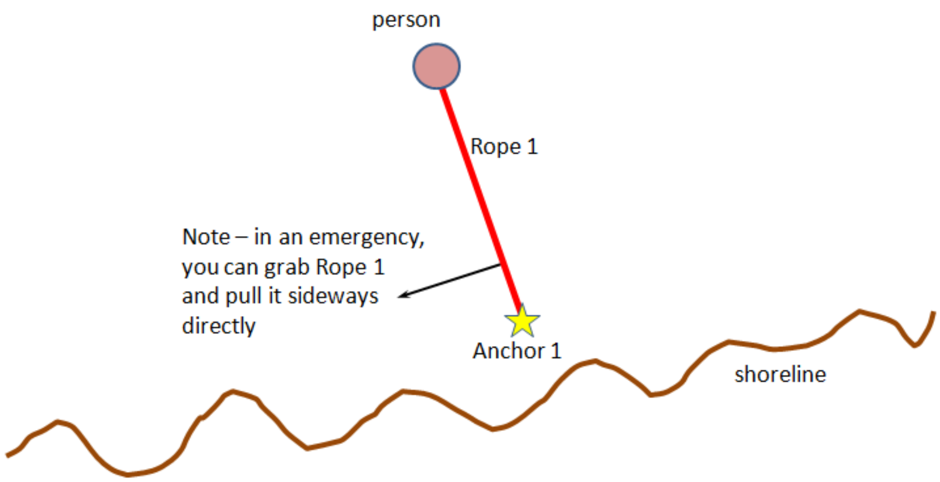

Figure 7. Rope rescue by vectoring to assist a person that has broken through a river ice cover. (Note: it takes much less force to pull the person out by applying a perpendicular force on the rope line.)

If vectoring is not effective, then a second rope line can be attached to the loop placed near the middle of the first rope line in various configurations to provide a greater mechanical advantage and deliver greater force towards pulling the person out of the water. The fastest and most straightforward means would be to attach a carabiner or pulley to the loop on the first rope line and running a line anchored to the ice cover at one end through it. Pulling on the free end of this line delivers a 3:1 mechanical advantage which should provide sufficient force to pull the person out of the water to safety.

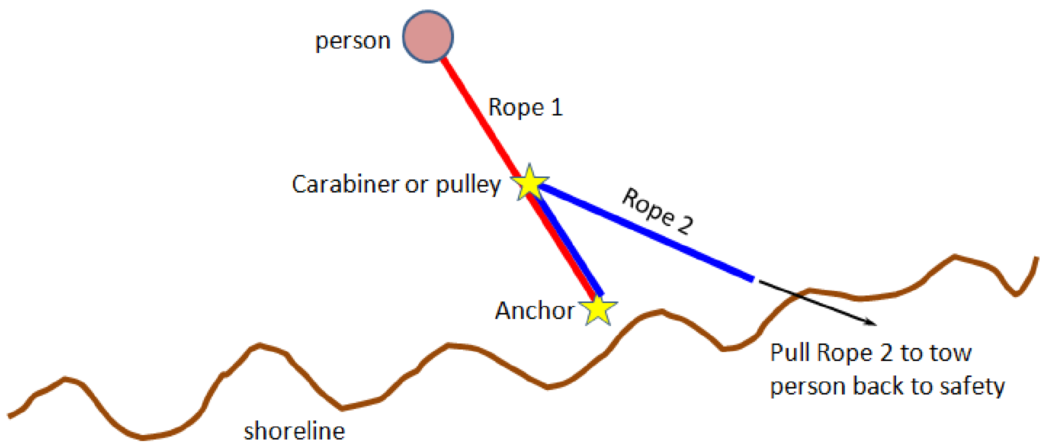

Figure 8. Use of a secondary rope to quickly deliver a 3:1 mechanical advantage to assist in rope rescue of a person that has broken through a river ice cover.

5. Summary

This paper describes in general terms various considerations for planning and executing work on a river ice cover safely. While there are risks associated with this type of work, they can be mitigated effectively with appropriate personal protective equipment, planning, site-specific knowledge of the river and local conditions, and where appropriate formal ice safety training for field team members. Most importantly, all persons working on a river ice cover should do so with a mindset that an ice cover can fail and appropriate plans should be in place to deal with emergencies such as hypothermia and potential for drowning.

Some basic techniques for delineating a safe working area and executing a rope rescue are provided in this paper for illustrative purposes only and to demonstrate that such measures do not need to be complex or so cumbersome as to interfere with work activities. In our experience, tethering and anchoring systems can be quickly deployed and used to assist in rescuing someone from the river if they fall through the ice. A variety of other rescue techniques exist and a safety plan that is specific to the nature of work being done and the study site should be developed, with full consideration to any local authority requirements and both employer and client safety policies.

6. References

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