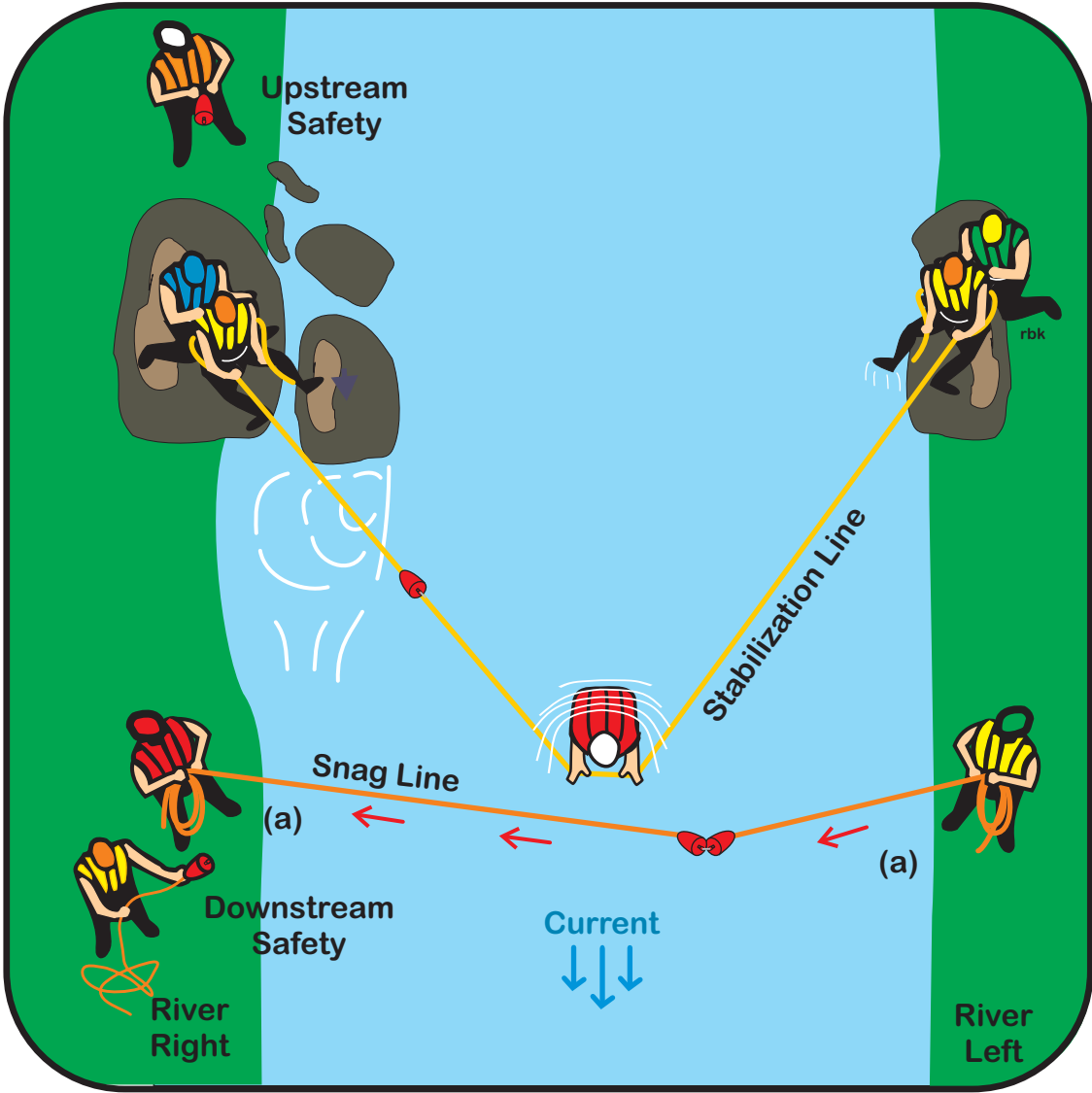


Swiftwater Rescue Course Manual

Fall 2018



Forward

The contents of this manual reflects the swiftwater course taught in the Adventuresports program at Garrett College. The materials contained in this manual follow closely the content of the course and represents the evolution of the course over the years. The materials in this manual represent over twenty-five years of instruction.

The manual presents some new information. For example, there is a primer on the experience and the search component as applied to a swiftwater rescue situation. Although it occurs infrequently, it may be necessary to find the victim. The manual provides a primer on search techniques as applied to swiftwater rescue situations. On a smaller scale there are new innovative techniques such as the pendulum effect. The anatomy of an eddy is one of my favorite additions. It precisely delineates the parts of an eddy. Most publications draw the currents in an eddy incorrectly, if at all. Also, under river hazards, a new addition is a diagram of an undercut rock.

A unique and valuable contribution of this manual is that it provides diagrams of most of the on-river exercises. There are over 90 original diagrams. The strainer and throw bag drills are two examples. The diagrams present the basic setup for the activities conducted as part of the course. Most traditional materials focus on rescue situations. Few materials focus on course exercises and materials.

Organizationally, I believe the materials presented in the manual have a good flow. In Chapter 2, it breaks the materials into wading, swimming, and crossings. Chapter 3 covers throw bags and then covers shore based rope rescues, swimming based rope rescues, and cinches. The chapters on knots and mechanical advantage are modules that I have used elsewhere. The chapter on river dynamics is an outgrowth of materials developed for the ACA book on *Canoeing* and *Kayaking*.

As with any publication, it involves other people. I would like to thank Terry Peterson who has co-taught the course and who has provided considerable input into the materials developed including the basic structure of the course. Also, I would like to thank Mike Logsdon who has provided support for the course over the years. Also, we have worked with countless co-instructors and students on an interim basis. I would like to thank Steve Storck with whom I taught the course many years ago. Last, I would like to thank Charlie Walbridge. He is referenced in many of the chapters and his pioneering book on swiftwater rescue provided a contextual backdrop for much of the materials presented in this manual.

Robert B. Kauffman, Ph.D.

Swiftwater Rescue Course Manual

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Swiftwater Rescue Skills Sheet

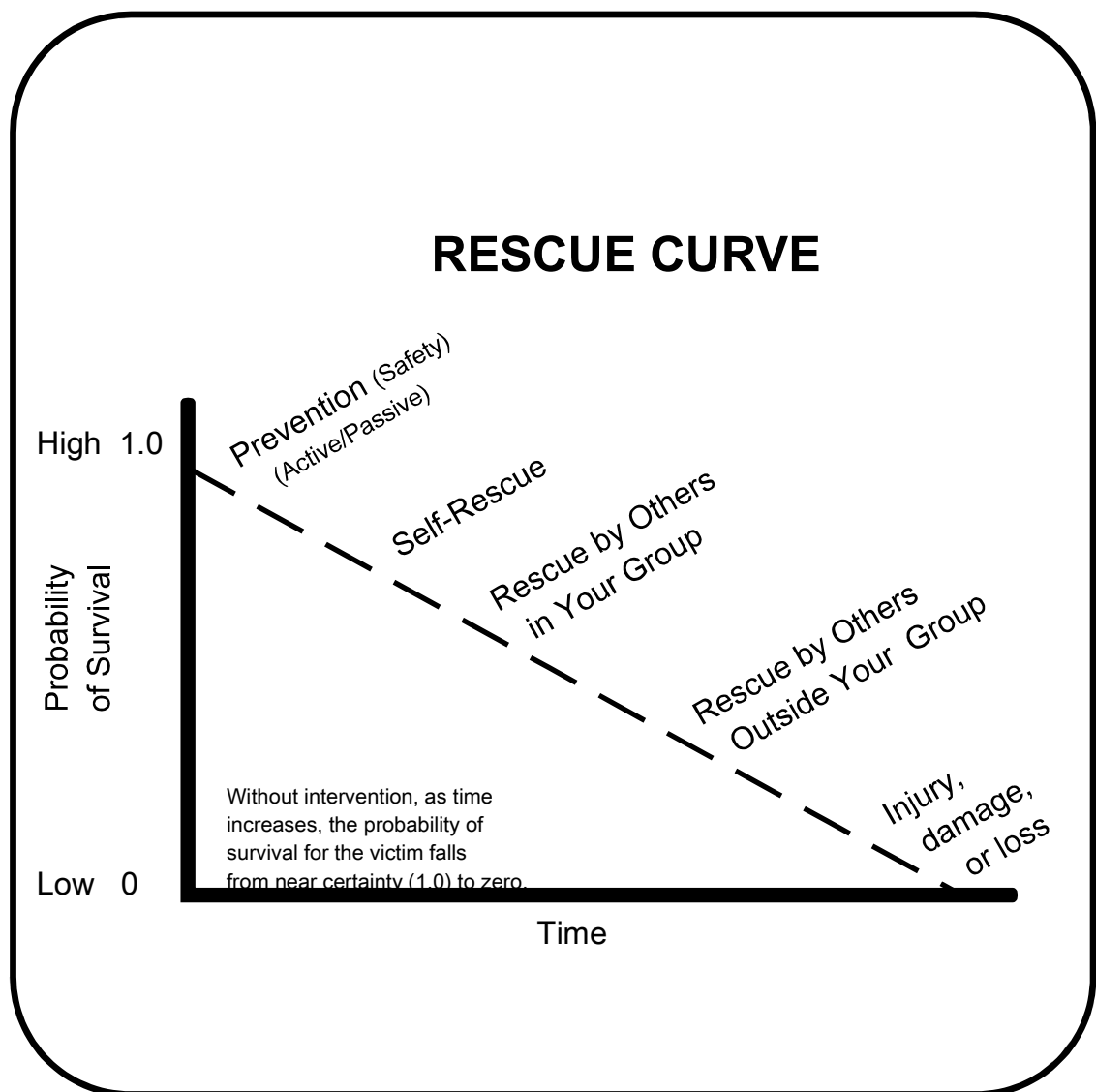
Student: _____ Address: _____

Date and Location of Course: _____

Instructions: Check off the completed skills as you complete the skills listed in the table. If the instructor has any questions regarding the completion of the skill, he/she will note so in the remarks column. Any remarks will be discussed with the student.

Skill	Remarks:	Date-Observed (O) Performed (P)	Student Initials
Swiftwater entry (p.xx)			
Defensive swimming (p.2.5)			
Aggressive swimming (p.2.5)			
Barrel Roll (p.2.5)			
Strainer Drill (p.2.9)			
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Diagonal Traverse (p.2.11)			
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V-Lower (p.3.10)			
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Knots (p.5.0)			
Anchor systems (p.5.16)			
Mechanical advantage systems (p.6.0)			
Universal River Signals (p.xx)			

Chapter 1: Concepts and Philosophy of Rescue



Chapter 1: Concepts and Philosophy of Rescue ¹

This section is a potpourri of principles and concepts. The first section focuses on the principles of rescue with a list of key points to consider. The second focus is on the rescue curve. It frames rescue in philosophical terms for both the participant and the swiftwater rescuer. The third section focuses on the experience. The adventure sports programmer needs to consider the experience they are creating for their participants. Although this is really true for creating paddling experiences, it is also true for creating swiftwater rescue experiences for participants. The last section focuses on search techniques. Usually, the location of the victim(s) is known. However, this is not always the case and on occasion the victim needs to be found before they can be rescued.

Principles of Rescue

The following are sixteen principles of rescue. They are good thumb rules for practice. The original reference is unsure. The author believes the principles came from Charlie Walbridge's instructor materials. This author has added a couple of principles to the original list.

- 1) **A sign of a novice is that they begin their rescue efforts with rescue by others (i.e. the rescue squad).** In contrast, experienced boaters emphasize safety and self-rescue as their first line of defense. This is an application of the Rescue Curve discussed later in this section (see 911 Syndrome). If your first line of defense in rescue is rescue by the rescue squad, your next option is a major injury or body recovery. In a sense, you have squandered away most of your options. Experienced paddlers increase their options of survival and enjoyment by focusing on safety, prevention and self-rescue as their first lines of defense.
- 2) **Eliminate the accident/incident before it happens.** Think good trip planning. Recognize fatigue, hazards, insufficient skills, lack of experience, etc. before it leads to a life threatening situation. Choose a trip that is commensurate with the skills and abilities of the participants. Remember, no accident; no rescue. Isn't this what everyone wants? All, this is under the rubric of good trip planning.
- 3) **Always wear a life jacket (PFD).** Anyone within 10 feet of the water should be appropriately dressed for being in the water, including wearing a life jacket.
- 4) **"Caution" is always the sign of a good rescue.** There are several themes here. The first is the affect of adrenalin. It narrows a person's focus. It reduces cognitive thought in the frontal lobes. This is why training is important. It counter acts the loss of cognitive thought. It can lead to a rescuer entering the scene without adequately surveying the scene for the mechanism of injury (MOI). It can lead to a second victim. Most manuals recommend that the first step is to ***"survey the scene."*** Practice **STOP**. When you first come upon scene, **stop, think, observe/options, and plan** (Figure 1.2).

¹ This chapter was written by Robert B. Kauffman who is solely responsible for its content. This chapter is copyrighted © Robert B. Kauffman, 2016.

5) **Never make the situation worse.**

If a rescuer becomes a victim while performing a rescue, you have made the situation worse. You now have two victims. If you dislodge the victim without someone to pull the victim out downstream, you have made the situation worse.

6) **Never tie a rope around the rescuer.**

If you are tied in, then you are no longer in control of yourself. Also, don't confuse this point with a self-release system on a rescue harness. With a rescue harness, you have control and can release the belt.

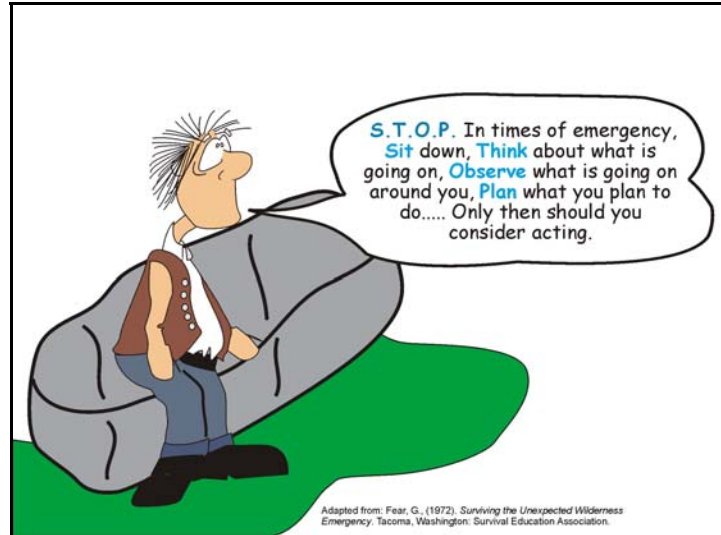


Figure 1.1: STOP - Survey the scene and stop, think, observe and plan.
Source: Author – [file: \FA-STOP2.cdr]

7) **KISS.** Keep it simple and safe. Utilize the lowest risk methods first. Set up the next higher risk method as the next alternative. To a degree, this principle reflects the underlying changes in swiftwater rescue philosophy. It reflects a change in the 1970s when swiftwater rescue morphed many of the more complex climbing rescues (e.g. Tefler lower). Also, it reflects the amount of equipment swiftwater rescuers have to effect a rescue. Usually, this is a throw rope and two to three carabiners.

8) **Think multiple systems.** If one rescue system fails, you should have an alternative approach in the works. Always use the lowest risk method first. If you have the personnel, use them. Also, think more than one way of rescue. Note: Examine the cover of this manual. The diagram has both a snagline and four person rescue performing rescues simultaneously.

9) **Deploy upstream spotters.** You don't need recreational paddlers or rafters interfering with your rescue. In addition, you want to spot debris before it interferes with the rescue. Normally, this would read always deploy upstream spotters. A typical group of four or five paddlers may not have the luxury of having a designated spotter. If not, designate someone to assume this role. Note: Most of the diagrams this manual depict an upstream and downstream spotter.

10) **Deploy downstream backup rescuers.** If the victim becomes dislodged from the original site, you need someone to pull the victim into shore. This may require one or more rescuers. Also, if there is a lack of manpower to disperse a downstream backup rescuer, this makes a case for using some of the cinches.

11) **Rescuers first, victims second.** This is axiomatic. When a rescuer becomes a victim, you have two victims and one less rescuer. You have made the situation worse in two ways.

12) **What you bring with you is what you have for the rescue.** This point dovetails with one of the continuing themes regarding the difference between “rescue by others in your group,” and “rescue by others outside your group (i.e. rescue squad).” The equipment which you bring with you may be all the equipment you have for the rescue. Typically, boaters will usually have

several throw bags, prusicks, and carabiners available to effect a rescue. In contrast, a rescue squad can bring all the equipment they like.

- 13) **When you are focusing on what you are doing, you are not focusing on what the group is doing.** Actually, this is a really good thumb rule for leaders. If you are tying a knot in a system, you are not focusing on what everyone else is doing. However, if you are supervising the setup of a rescue system and tying a knot, you are supervising the overall system. Everyone focuses on what they are doing. However, if this becomes continuous, this may be a sign that the rescue is out-of-control. If as the trip leader, you are focusing on how cold you are, you are not focusing on what the group is doing. You may no longer be in control of your group. It may be time to STOP (see Item #4 and Figure 1.1).
- 14) **Rescues are dynamic, not static.** Things are always changing during a rescue. The victim may come loose. A raft may paddle into the incident scene. The rescue scene is dynamic and it is always changing. The rescuer must prepare for the change, anticipate it and plan for it.
- 15) **Play the "what if" game.** You need to plan ahead and anticipate what might happen both before and during a rescue. What if I turn over. Can I roll? What if someone gets hypothermia? Can we extricate them without completing the trip? What if it begins to rain, or the weather gets colder? Did I bring extra equipment? What if the victim comes loose? Is there a downstream rescuer positioned to rescue the victim.
- 16) **There is a difference between the ACA Swiftwater Rescue and Rescue 3's Swiftwater Technician programs.** This used to be more of a concern when there was a lot of overlap between the two programs and which groups they addressed. In essence, it acknowledges the differences between “rescue by others in your group” and “rescue by the rescue squad” (see Rescue Curve and Figure 1.2). Some of the differences between the two programs may be explained in terms of time, personnel, and equipment. **Time** since the boaters in your group are generally the first rescuers on the scene (i.e. the rescue curve). Rescue squads arrive later to the scene. A rescue squad has lots of **personnel** to help in the rescue; a boating trip has those member on the trip less the victim. Rescue squads have loads of **equipment** or "toys." Generally, boaters have less equipment to effect a rescue. The ACA's program focuses on prevention, self-rescue and rescue by others in your group. The Swiftwater Technician program focuses on rescue by other outside your group (i.e. rescue squads).

Rescue Curve²

The rescue curve describes rescue in terms of who does what when and what will happen if those attempts fail. The rescue curve states that once an incident occurs, “***without intervention, the probability of survival or avoiding injury, damage, or loss increase with time.***” The rescue curve has been refined several times since it was first developed by Kauffman and Carlson (1992) (Figure 1.2). Although the model was originally developed in the context of outdoor activities, it has been generalized to non-outdoor activities (Kauffman, 2003).

² This section on the rescue cure is excerpted from the textbook: Kauffman, R., and Moiseichik, Merry., (2013). *Integrated Risk Management for Leisure Services*. Champaign, ILL: Human Kinetics. p. 200-202.

Safety and Prevention – According to the rescue curve, the first line of defense is safety and prevention. These include the active and passive measures that the participant should take to avoid a rescue situation or, if a rescue situation occurs, to better help survive the situation. *Active measures* are measures a participant takes to help prevent an incident from occurring. The participant uses their knowledge, skills, and abilities to avoid a situation in which a rescue is necessary. A climber’s climbing ability, a paddler’s paddling ability, or a driver’s driving ability are examples of active safety measures. *Passive measures* are measures that normally do not help prevent the initial incident from occurring but that do help during the rescue phase. For example, a climber uses climbing ropes and protective gear as protection against a fall, but ropes and protection do not aid in the actual climb. A paddler’s life jacket aids the paddler only if she comes out of her boat. A spare tire has little value to a driver unless the car has a flat tire. On a playground, surfacing, fall zones, and equipment design are examples of passive measures.

Once an incident occurs, injury, damage, or loss normally occurs unless there is intervention. Intervention is defined as self-rescue, rescue by others in your group, and rescue by others outside your group. Occasionally, intervention will occur naturally. A person falls from the rock face, lands in a tree, the branches cushion the fall, and the person lands relatively unharmed on the ground. A child falls off a climbing apparatus on the playground, and hits the pea gravel surfacing underneath the apparatus. The pea gravel breaks the fall (intervenes) and the child continues to play, uninjured.

Self-rescue – The first level of defense after an incident occurs is self-rescue, or what the victim can do to rescue himself. For example, a climber who falls several feet as a rope suspends his weight

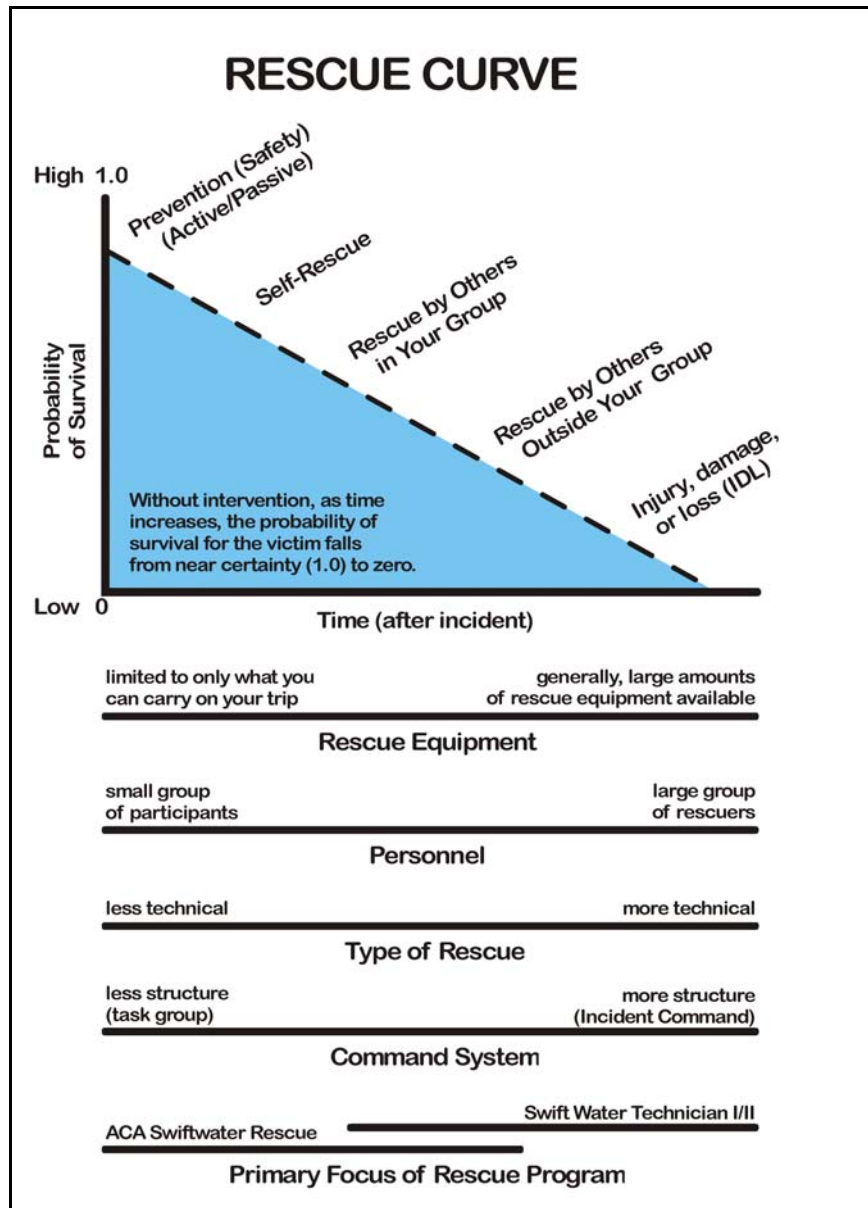


Figure 1.2: The Rescue Curve – The rescue curve suggests that once an incident occurs, without intervention the probability of survival decreases as time increases. The four stages of the rescue curve are prevention and safety, self-rescue, rescue by others in the group, and rescue by others outside the group. The differences in rescue equipment, personnel, type of rescue, and command structure are addressed with the curve. Source: Kauffman and Carlson, 1992, Kauffman 2003.

can grab hold of the rock face and continue climbing. The paddler can Eskimo roll or swim with her boat to the shore. The driver can remove the flat tire and put on the spare tire. On a playground, a child slips on a climbing apparatus, catches herself, and continues climbing. The child self-rescued.

Rescue by Others in Your Group – The third line of defense is rescue by others in the victim’s group is the next line of defense. If the climber is belayed, the belayer may lower the climber to a safe area. If the paddler comes out of her boat, a member of her group may paddle over, extend the stern and grab loop to her, and paddle her to shore. The passenger in the car may help change the tire or assist by directing traffic. On the playground, the child climbs to the top of the climbing apparatus, looks around, gets scared, freezes, and starts crying. Her mother rushes over and with outstretched arms lifts her daughter off the climbing apparatus. The daughter is rescued by others in her group. Anyone participating in the activity alone bypasses this phase and directly enters the next.

Rescue by Others Outside the Victim’s Group – The next line of defense, rescue by others outside the victim’s group, includes the rescue efforts of people passing by or the rescue squad. If the climber is injured in a fall or the rescue escalates beyond the capabilities of the other climbers, a rescue squad with specialized training is summoned. The same is true for the paddler. On the playground, the child is crying atop the climbing apparatus, and the mother is standing there not knowing what to do. A passerby rushes over and lifts the child off the apparatus. The passerby performs a rescue by someone outside of the group. Or, in the same situation, the passerby calls 911, and the park sends the fire department and the fireman lifts the child off the apparatus. Again, it is a rescue by someone outside of the group, in this case the rescue squad.

Injury, Damage, or Loss – If no one rescues the victim, additional injury, damage, or loss usually occurs. Even if the climber is not injured by the initial fall, he will experience additional injury or even death without intervention. The paddler who is not rescued may eventually flush through the rapids and naturally wash up on the shore. If no one rescues the driver, he may be stranded in a desolate area. On the playground, it is difficult to envision someone not eventually coming to the rescue. Most likely the child will eventually stop crying and attempt to climb down the apparatus (self-rescue). The child will most likely successfully climb down and go home. Or the child will fall and injure herself and need treatment. Or, the mother will come to her senses, and help the child off the apparatus (rescue by others in the group). This example illustrates the principle that the previous stages can be re-entered again.

Available Resources and the Rescue Curve (see Figure 1.2) – The rescue curve is useful in helping to explain the resources available to or influencing the rescuers. The rescue squad is in the business of performing rescues. As a general rule, the rescue squad has lots of personnel and equipment at their disposal to perform a rescue. In addition, they have trained extensively in rescue procedures. In contrast, people participating in the recreational activity are interested in performing the activity. Rescue is what happens when something goes wrong performing the activity. It is not that they are interested in rescue. They are. However, they are more interested in performing the activity. Often they think in terms of how they can adapt the equipment used in performing the activity to a rescue situation, or they will bring along with them simple devices as long as these items don’t interfere with the performance of doing their activity. In terms of personnel, they are limited by who is in their group unless, of course, they are doing the activity alone. In that case, they bypass this phase for the next phase. The following examples illustrate the difference in resources between participants in the activity interested in rescue, and the rescue squad who is prepared to rescue others. In terms of personnel, a group of climbers might consist of 2 instructors and 10 youths. Although the group comprises 12 people, only 2 are well trained (1 if the victim is an instructor). In a paddling group of 5 people, 4 people must conduct the rescue assuming that 1 person in the group is the victim; this is a small group for a whitewater rescue. In contrast, a rescue squad

could have 20 to 30 trained rescuers available to them for a rescue (see Scenes #3 and #4 in Figure 1.4).

Regarding equipment, climbers usually do not bring rescue pulleys and a Stokes litter with them; the rescue squad does. The paddler group might have two carabiners per person and several rescue bags. This makes any rescue involving a lot of carabiners or several hundred feet of rope difficult. In contrast, the rescue squad usually arrives with large amounts of specialized rescue equipment.-

The difference between equipment and personnel in terms of the rescue curve is illustrated by the child stuck atop of the climbing apparatus. If the children become stuck on a bouldering rock (climbing apparatus), it is not expected that the mother supervising the children will have brought a ladder along with her in case she needed to rescue the children. However, if the fire department is called, they would bring a ladder. In this case, the rescue squad (rescue by others outside your group) would have the equipment and personnel necessary to perform the rescue in contrast to the children (self-rescue) or the mother (rescue by others in your group) who wouldn't.

911 Syndrome (Figure 1.3) – The 911 syndrome focuses on the difference between inexperienced and experienced participants. More experienced, specialized participants tend to begin their rescue efforts with safety and prevention. They focus on their equipment and on developing their skills and rescue techniques. They know that if a potential incident occurs, their first line of defense is self-rescue. If self-rescue does not occur, they can move very quickly through the stages of the rescue curve and run out of options. Experienced participants tend to front-load their activity with safety and prevention because they know their survival depends on it.

In contrast, inexperienced or “activity for a day” participants usually do not have the necessary skill, knowledge, or training to perform a rescue, and they most likely do not possess or know how to use rescue equipment. They tend to quickly skip over the first three phases of rescue (i.e., safety and prevention, self-rescue, and rescue by others in the group) and immediately go to the fourth phase—rescue by others outside the group. They call 911 and hope that someone comes to rescue them. Usually, they believe that it is the responsibility of someone else to rescue them (Kauffman, 1992; Kauffman et al., 1991, and rely almost completely on the resource manager or the rescue squad for their survival.

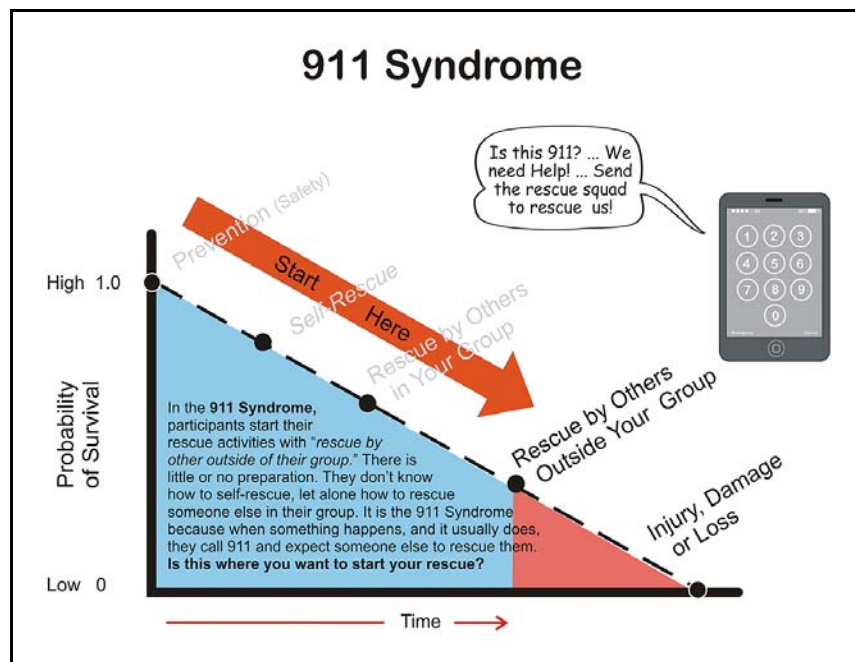


Figure 1.3: 911 Syndrome – In the 911 syndrome, participants begin their rescue efforts by calling the rescue squad (i.e. rescue by others outside your group). Source: Author – [file: \RK-911Syndrome.cdr].

Rescue Curve and Swiftwater Rescue (Figure 1.4 and Figure 1.5) – The availability of resources section discusses the differences in resources available between the ACA swiftwater rescue type courses and Rescue 3 courses (see Figure 1.2). It is the difference between rescue by others in your group and the rescue squad. The focus of the ACA swiftwater rescue courses is on a group of paddlers on a trip. They will have less equipment resources with them. They will have with them what they bring with them. This does not preclude using many of their techniques by the rescue squad or in response to a formal rescue. Typically in terms of the rescue curve, a paddling group represents rescue by others in your group (see Scenes #3 and #4 in Figure 1.4).

In contrast, the rescue squad is generally called to the scene after an incident occurs. Unless, they are camping out at known sites, there is often substantial time between when incident occurs and when they arrive. Usually, they bring lots of equipment and personnel with them. Typically, the rescue squad represents rescue by others outside your group.

Second, passage from one phase to the next can occur innocuously and with seemingly simple decisions. One such example is illustrated in Scene #2 in Figure 1.4 and in Figure 1.5. A swimmer is thrown a throw rope from the shore. Prior to the throw rope, the swimmer is *self-rescuing*. By accepting the rope, the swimmer has seamlessly passed to the next phase of *rescue by someone in your group*. This is not a bad thing. It is done all the time. However, the swimmer is still responsible for himself. He must pay attention to the situation. If the rescuer is going to swing the swimmer into a hazard, the swimmer needs to take responsibility and let go of the throw rope and assume *self-rescue* again. In technical terms, the swimmer passes from the self-rescue phase to rescue by others in your group phase and then back to the self-rescue phase.

Third, many of the wading and swimming exercises including the strainer drill familiarize swiftwater rescue students with moving water. These exercises aid in self-rescue.

Fourth, and moving to the safety and prevention phase, it goes without saying that the knowledge, skills, and abilities learned by the swiftwater rescuer aids the rescuer in their preparation. It is the reverse of the 911 Syndrome. Knowing what can happen leads to better preparation. In terms of knowledge, knowing how to negotiate a strainer can save one's life. Knowing the parts of an eddy aids in identifying them on the river. Knowing the parts of hydraulics aids in identifying them on the river.

Knowledge complements skills. Skill is the ability to do or perform. Having performed the strainer drill takes an intellectual exercise and transforms it into a skill. Eddies are like people. Physiologically everyone is pretty much the same, but their personalities are quite different. The ability to recognize the differences in eddies and what they can do to you comes with experience. The same is true for hydraulics. Frowning and smiling holes are a simple example of being able to differentiate between a hydraulic which can be played and one which will play with the paddler. Having the tactile feel of the attitude of the boat underneath the paddler can determine whether the paddler remains a rescuer or becomes a victim also when approaching the victim in the backwash or downstream portion of a hydraulic.

Ability is the actual ability to perform the previously mentioned skills. Prior knowledge, skills and ability make river users safer. They know what to avoid and can more easily avoid what needs to be avoided.

Rescue Curve Examples Involving Swiftwater Rescue

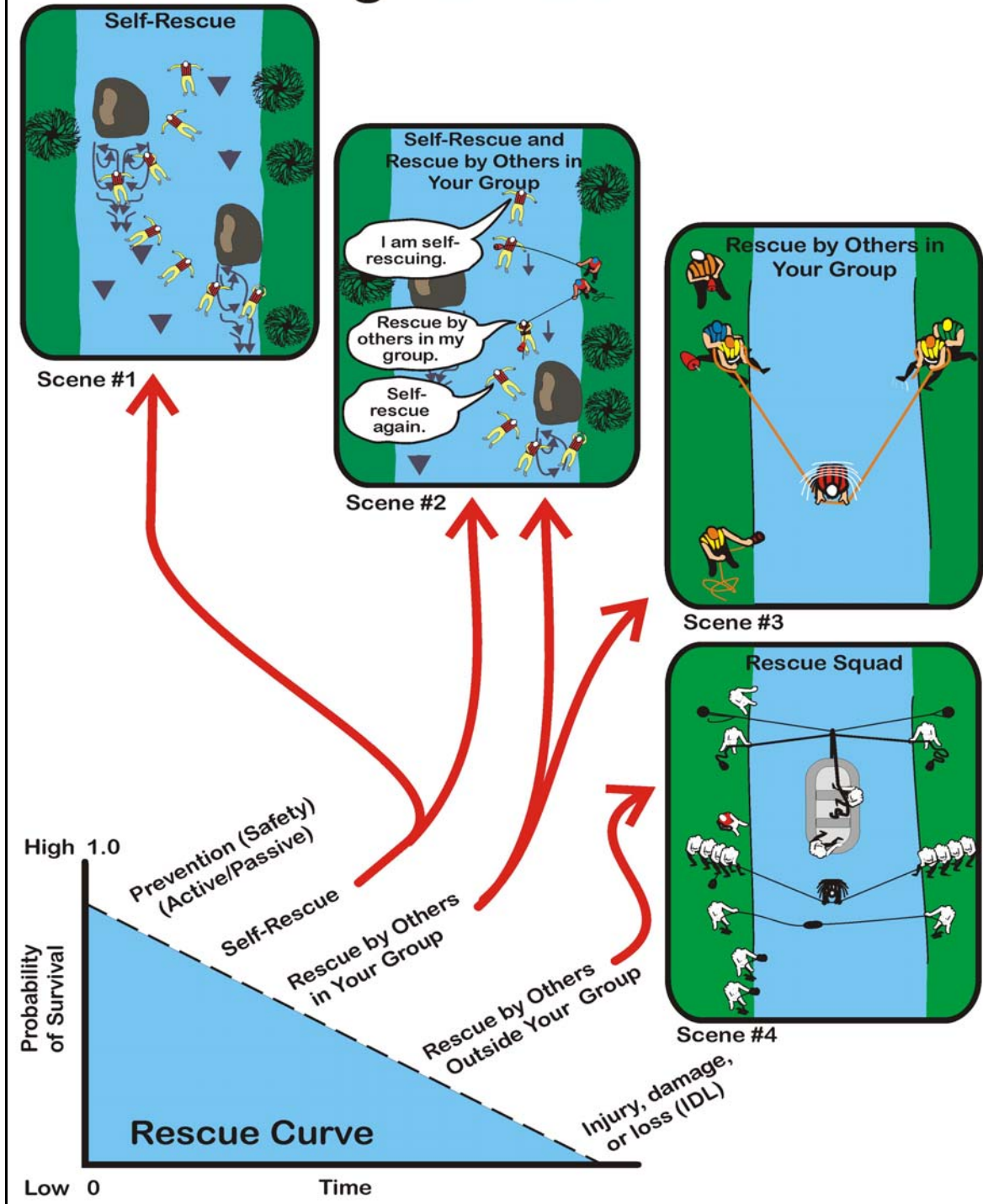


Figure 1.4: Rescue Curve Examples Involving Swiftwater Rescue – Four different scenes depicting swiftwater rescue examples are presented for three of the rescue curve phases. Source: author – [file:\PHIL-RescueCurve_v4.cdr]

A Swiftwater Example of Moving from One Rescue Curve Phase to Another

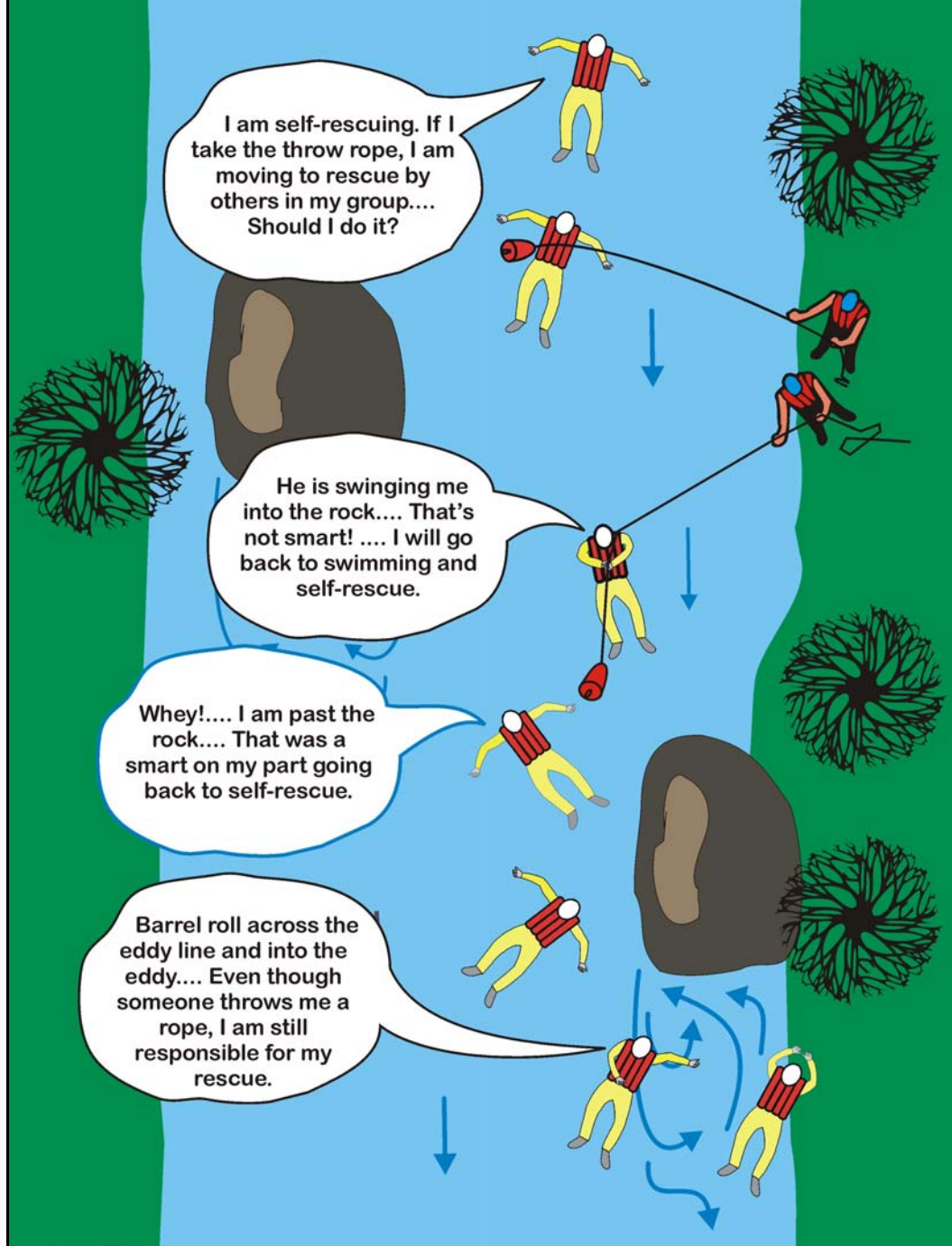


Figure 1.5: Moving from One Phase to Another – This scene shows how easily a swimmer can move from self-rescue to rescue by other in your group and then back to self-rescue. Source: author – [file:\PHIL-RescueCurve_v3.cdr]

The Experience

There are two distinctly different approaches toward creating the experience for participants. Interestingly, both approaches have their roots in the same research. The discussion begins with the flow model and “*seeking mastery*.” With the introduction of perceived risks and a leader or guide who provides considerable knowledge, skills and experience to the activity, the second “*roller coaster experience*” approach emerges.

Seeking Mastery – A boater or for that matter anyone seeking mastery, attempts to bring all of their knowledge, skills and experiences to match the challenges present (Figure 1.6). Conceptually, the flow model suggests the relationship between the challenges present and the skill of the individual. Although Csikszentmihalyi didn’t focus on perceived risks in discussing the flow experience, a person seeking mastery seeks to minimize perceived risks because perceive risks diminish the matching process of the skills to the challenges. This should become apparent in the next section on the Adventure Experience Paradigm.

Typically, surfing a wave, making a precise eddy turn, or making another maneuver is an art form where the boater matches the challenge of the maneuver with their ability to perform the maneuver. Mastery is the ability to find the find line between challenges and skills. In terms of the flow model, flow can occur when this happens. Flow may not occur, only that it can occur. The boater knows when this occurs because according to flow methodology, typical symptoms of a flow experience include a merging of the activity and experience, a loss of external reality, and a oneness with the experience. A classic symptom of not being in the flow experience is consciously thinking about and analyzing what he or she is doing. In this situation, the boater is viewing the activity externally and the flow experience is not occurring.

Athletes and boaters seeking mastery require, knowledge, skill and experience. Practice and experience provides the boater with the ability and skill to be able to find the edge and to place the boat and boater in a kinesthetic dance with the moving water. Over time, the athlete or boater increases their skills and the ratchets up the challenges to correspond with the new skills developed. It is a process of skill development and seeking mastery of the activity.

It is worth noting the other position in the flow model. If the challenges greatly exceed the skills, anxiety occurs and if they mildly exceed the skills, worry occurs. On the bottom of the graph, if skills greatly exceed the challenges, anxiety will occur and if they mildly exceed the challenges, boredom occurs.

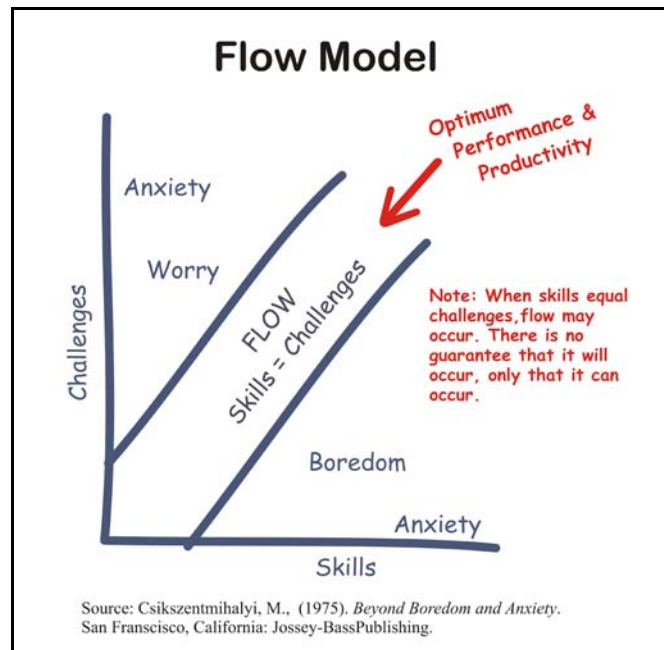


Figure 1.6: Flow Model – In the flow model, the participant seeks to match their skills with the challenges present. Their knowledge, skills and experience help them to create this match. Source: Csikszentmihalyi – [file:RK-Flow.cdr]

Adventure Experience Paradigm (AEP) – Developed by Priest and Gass (1997), the Adventure Experience Paradigm incorporates a generic flow model embedded in the paradigm (Figure 1.7). From a programming perspective, the paradigm is foundational. There are two significant differences from the flow model. The flow model focuses on the individual. The AEP introduces a leader or programmer who facilitates the experience. Second is the introduction of perceived risks and perceived competencies.

As in the flow model, the programmer seeks to match the challenges and risks present in the activity with the skills and competencies of the participants. A peak adventure occurs when the two are matched or are in equilibrium. A misadventure and devastation and disaster occur when the risks and challenges greatly exceed the competencies and expectations of the participants. Providing activities in this range can easily lead to participant dissatisfaction and can eventually in being sued. If the competencies and skills exceed the challenges an adventure and exploration and experimentation can occur.

Since the leader or programmer brings considerable knowledge, skills and experience to the activity, their ability can easily compensate for the lack thereof on the part of the participant. Or with the introduction of perceived risks and challenges, the leader or programmer can create a peak adventure while at the same time reduce actual risks (Figure 1.8). This makes the activity safer. Hence, the roller coaster experience discussed in the next section.

In the case of raft or similar guides, the guide increases perceived risks while reducing or managing actual risks. Choosing the designated or standard route through a rapids is an example of reducing actual risks. Making it an exciting run increases the perceived risks and challenges. It is the application of the roller coaster experience to create the desired experience while making

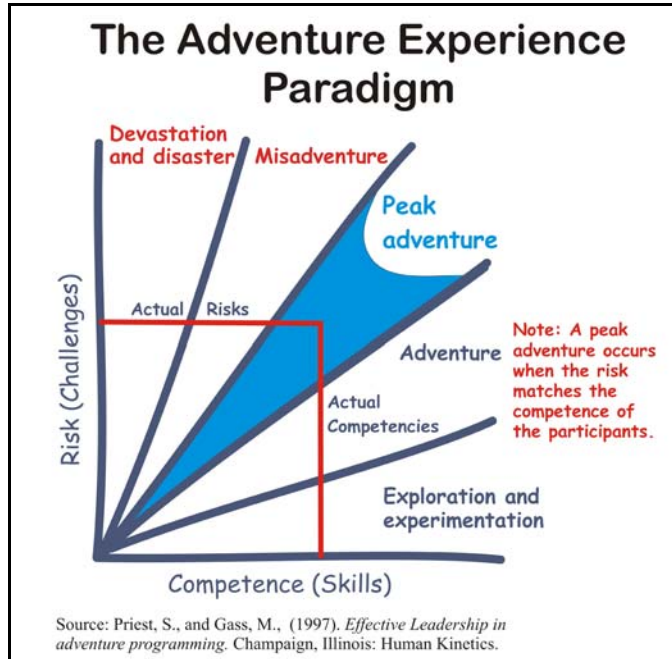


Figure 1.7: Adventure Experience Paradigm(AEP) – Caption: The AEP embeds the flow model into it to create a peak adventure where the risks and challenges match the competencies and skills of the participants. Source: Priest and Gass – [file:\RK-AdvenExperParadigm.cdr].

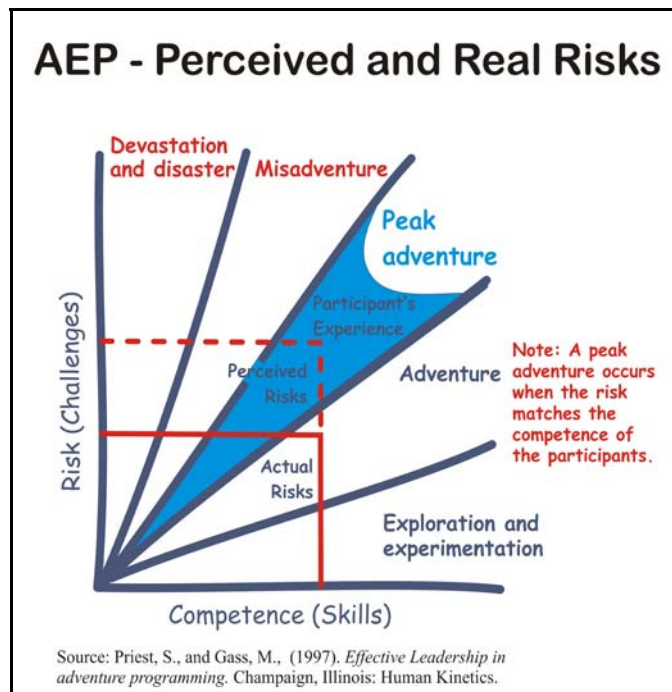


Figure 1.8: AEP - Perceived Risks – Caption: Instead of matching actual risks and challenges to provide a peak experience, perceived risks and challenges are provided to create a peak adventure. It returns to a variation of the roller coaster. Source: Priest and Gass – [file:\RK-AdvenExperParadigm3.cdr].

the activity safer also.

As a sidebar to this discussion, the participant can have perceived competence or perceived skills. Since the participants are relying upon the knowledge, skills and experience of the leader or programmer, they may believe that they have more skill than they actually have. In the rafting example, a participant may believe they have the ability to maneuver the raft (i.e. skill) when they really don't have the ability. For those familiar with Hersey's (1984) *Situational Leadership* model, this situation is called a "pseudo-4" (Kauffman, 2011) where the follower believes they have the ability when they don't.

Roller Coaster Experience (Figure 1.9) – Perceived risks and challenges and the reliance upon a leader or programmer for participant skills are the factors behind the roller coaster experience. Quite simply in terms of the AEP, the leader or programmer seeks to enhance the experience by increasing perceived risk while at the same time reducing and managing actual risks. It provides a peak experience that is safer at the same time.

Consider the roller coaster. It is high on perceived risk and low (hopefully low) on actual risk. The roller coaster is inspected daily. The probability of a person getting on a roller coaster having a successful ride is fairly high. The roller coaster rides on a track. There are safety devices to keep people safely within the coaster. The ride is designed to minimize actual risk. When was the last time a roller coaster came off the track? It is designed to create high perceived risks with low actual risks.

As a matter of practice, an adventure sports programmer wants to create a roller coaster type experience by decreasing actual risks and increasing perceived risk. Yes, there are risks in running rivers. Nevertheless, the guide seeks to reduce the actual risks while maximizing perceived risks.

For the raft guide or adventure sport's programmer, the roller coaster is a good model to utilize. Although the actual risks can't be minimize to the extent of an actual roller coaster, they can be minimized. The guide takes the designated route. It is as if the boat is on a set of rails, much like a roller coaster. Taking a designated or standard route consistently reduces risks. In addition, the trip avoids high water levels. At the same time the guide can increase perceived risks. This can be done verbally or by purposely brushing against rocks to create the perception of greater risks by the participants. It is the roller coaster experience which minimizes actual risks while increasing perceived risks.

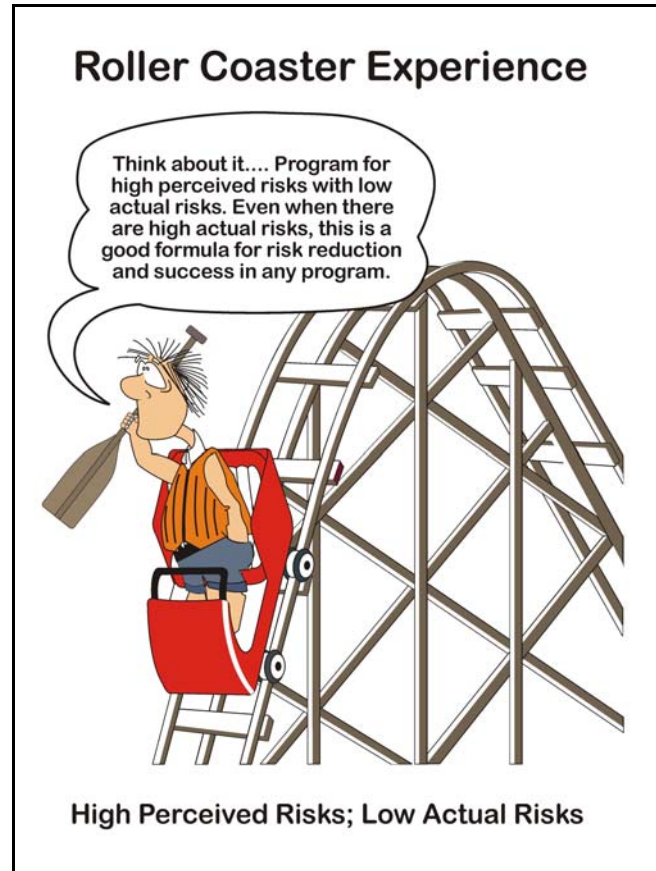


Figure 1.9: The Roller Coaster – When designing an experience, think of a roller coaster. It minimizes actual risks and increases perceived risks. Source: author – [file:PHIL-RollerCoaster.cdr]

SWR Experience – Returning to the SWR course and experience, swiftwater rescue courses utilize primarily the mastery model. The goal is to develop SWR skills among the participants. Rapids and river experiences (i.e. challenges and risks) are chosen to match the skill levels of the participants. Doing so will most likely result in a good experience by participants. In addition, a minimum level of challenges and skills may be prescribed for the course also.

Search Techniques for Swiftwater Rescue

Very often in swiftwater rescue incidents, the location of the victim is apparent and in practice, the rescue quickly enters the rescue phase without the need to search for the victim. However, in some cases, the location of the victim is not readily known and a search must be conducted for the victim. The purpose of this section is to provide a primer on swiftwater search techniques for swiftwater rescuers.

This discussion is delimited in its focus to groups already on the river such as private boaters and commercial rafters and not to rescue squads who usually arrive later. In terms of the rescue curve, its focus is “*rescue by others in your group.*” It does not include extended searches by rescue squads. The section draws upon three sources: (Kauffman and Moiseichik, 2013, Ch.10; Setnicka, T., 1980; Stoffel, R., 2001). To a certain extent, the materials used are adapted from land base techniques. The example used is based on an actual incident on the Arkansas River (Durkee. 2018). The incident site is accurate as is the general position of the rafts. The type of raft and their passengers are not accurately depicted.

Search and Rescue Phases (Figure 1.10) – In a normal search and rescue operation there are five phases. They are the search, rescue, first aid (medical), evacuation and management Kauffman and Moiseichik, 2013, Ch.10). Except for the management phase, the phases are generally sequential. This means that before performing the rescue phase, the victim needs to be found. Before performing first aid, the victim needs to be removed from the MOI (Mechanism of Injury). This reduces the likelihood of a second victim. And, before evacuation, the victim needs to be stabilized and prepared for transportation (i.e. first aid).

Search Phase – The search phase is the first phase. The purpose of the search phase is to locate the victim. Usually, but not always, the search phase is fairly easy because the victim is easily located. However, this is not always the case and it is important to prepare for situations where a search needs to be conducted. The search phase will be addressed in greater depth regarding swiftwater rescue in the next section.

Rescue Phase – The purpose of the rescue phase is to remove the person from the source of harm or MOI (i.e. Mechanism of Injury). This is the primary focus of most swiftwater

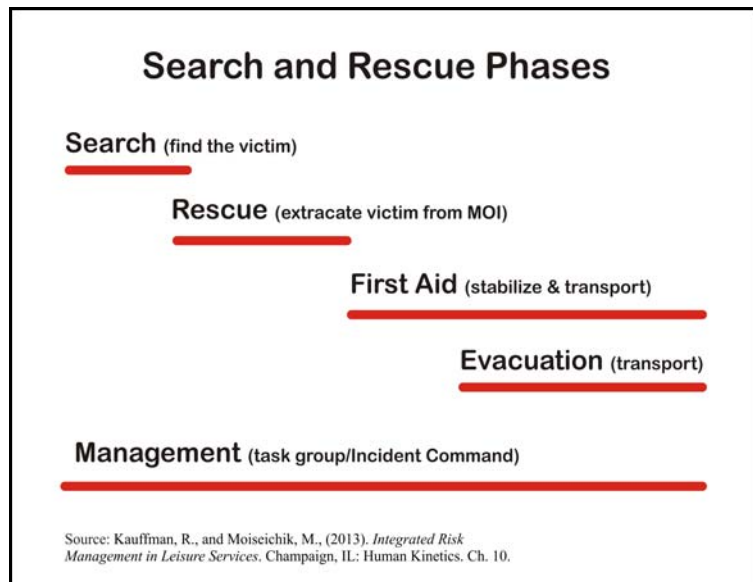


Figure 1.10: Search and Rescue Phases – Caption: In general, the four phases are sequential. Before extrication, the victim must be found (search). Before rendering first aid, the victim needs to be extricated (rescue), Before evacuation, the victim need to be stabilized and prepared to transport (First Aid). Source: Author – [file:\PHIL-S&RPhases.cdr]

rescue skill instruction. It is the focus of this book and subsequent chapters.

First Aid (Medical) Phase – The purpose of the first aid or medical phase is to stabilize the victim and prepare them for evacuation or transport. Conceptually, this phase follows the rescue phase. First aid skills are generally covered in Wilderness First Responder and similar courses. First aid techniques are not included here.

Evacuation Phase – The purpose of the evacuation phase is to transport the victim to a location where they can be transported to the hospital or appropriate facility. Usually, this phase receives passing consideration or everyone assumes the helicopter will simply lift the victim out of the incident site. Unfortunately, not every site is accessible by helicopter nor is a helicopter always available. Anyone who has done a mock evacuation carrying a loaded stokes litter understands the difficulty and energy consumption of the evacuation process. Although more consideration should be given to evacuation, it too receives limited discussion in this section.

Management Phase – The purpose of the management phase is to provide the administrative support to a search and rescue operation. In most search and rescue operations associated with private boaters and commercial rafters, the management structure tends toward a task group in contrast to the incident command structure associated with larger and more formal SAR efforts.

The incident command structure was outgrowth of efforts to fight wildfires in the 1970s. It divides the administrative structure into operations, planning, logistics, and finance and administration. The incident command structure is mentioned because it is usually associated with rescue squads and larger groups. In contrast, swiftwater rescue situations associated with private boaters and commercial rafters tend to involve a smaller group of rescuers, and they are not extended multi-day efforts. For this reason, they tend to use a task group structure where one of the rescuers takes on the leadership role.

Search Phase for SWR – As noted in the beginning of this section, there may be times when it is necessary to search for the victim. For this reason, it is appropriate to integrate some of the search principles into swiftwater rescue training. In a river situation, the objective is to locate the victim as quickly as possible. Usually, time is of the essence. Pre-incident activities are important because the first step is to recognize that someone is missing. This is not always as easy as it may sound. Next, determine the Point Last Seen (PLS) for the victim. This along with the river current and hazards determines the search areas and where the hasty search is conducted.

Pre-Incident – Pre-incident behavior and procedures followed by the group is important. This is the first line of defense because when an incident occurs, everything seems to unravel. This is the nature of incidents. There are two important objectives of any group on the river. First, boaters need to keep track of the people in their boat and when possible other boats also. Know the count. Be sure to keep track of the other boats on the trip. Follow normal river running procedures and protocols. Second, when one or more people fall into the water, it is important to keep track of the swimmers. Doing so minimizes the need for a search. Key to the process is that once an incident occurs, people can easily become dispersed and it is important to account for everyone so that a search can begin if someone is missing.

Point Last Seen (PLS) – The Point Last Seen (PLS) is the location where a witness last saw the victim. Determining the PLS is important because it helps determine the search area. It is one of the first tasks of the rescuers to determine. Be sure to ask other people on the trip including passengers on commercial trips. In Figure 1.11, the PLS was identified at the bend of the river. Area (a) is the logical area to begin the search.

Last Known Position (LKP)

– Some of the safety literature mentions the Last Known Position (LKP) also. This is the last place where the victim was known to be based on physical evidence. In a swiftwater rescue situation, it determines the upper limit of the search area. In Figure 1.11, the LKP is where the victim falls out of the raft in the large breaking wave. As a practical matter, the LKP and PLS are often the same location. It is mentioned, but as a matter of practicality, most rescuers will refer to and use the PLS.

Determining the Search Area

– Once the PLS is determined, determine the search area and prepare to conduct a search. A ***hasty search*** is a quick search of likely areas where the victim might be found. In river situations, consider the following in determining the search area. It is unlikely that the victim will be found upstream of the PLS. It is likely that the victim's location will be affected by river dynamics and currents.

It is more likely that the victim will be found on the outside of a bend in the river where the current is stronger than on the inside of the bend where it is shallower and the current is less strong. Known hazards such as strainers and undercut rocks are likely collectors of victims and are a likely place to search.

Using Figure 1.11 as an example, a raft dumps two passengers in a large breaking wave at the top of the rapids (LKP). The one passenger drifts downstream toward river left and is picked up by another raft on the inside of the bend at the bottom of the rapids. The other passenger drifts downstream with the current. The PLS was determined by one of the passengers in another raft who thought he saw the victim above the tight bend in the river. The importance of determining the PLS is that it focuses the search on the most likely place to begin the search.

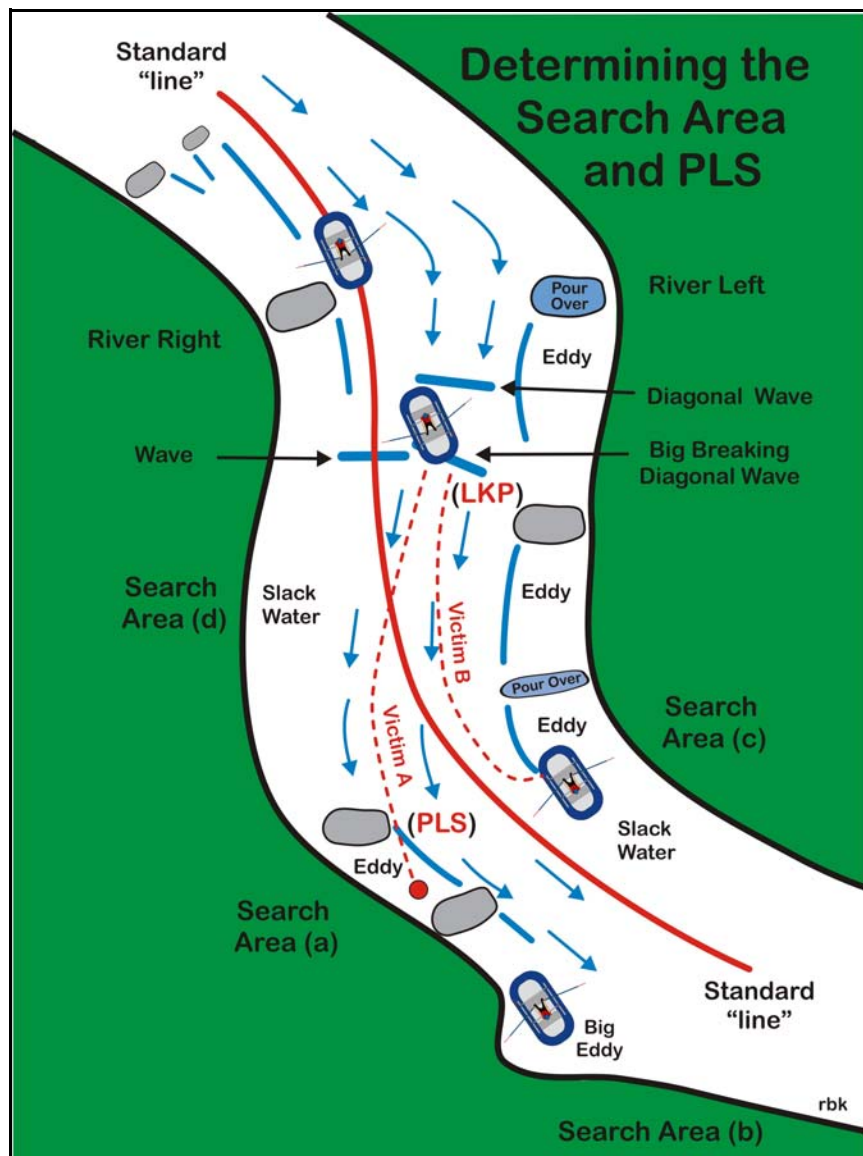


Figure 1.11 – Determining the Search Area and PLS – Big Drop on the Arkansas River. Source: Author – [file:\PHIL-PLS.cdr]

Based on the PLS, the first area to be searched is area (a). Based on the river currents and known hazards present, a hasty search discussed in the next section can be conducted immediately. A second area in which to conduct a search is area (b). This assumes the victim was swept through the rapids and further downstream. Also, remember that the victim would float past the raft situated in the eddy on river right without being noticed. After a search of area (a) and (b), area [c] and (d) may also be included. Area [c] is on the inside of the bend where it is shallower and where the current tends to be moving toward river right than river left. Area (d) is above the PLS site and less likely to have the victim. It depends on the strength of the those who determined the PLS. If it is weak, this area may be included earlier in the search.

Hasty Search – As the name implies, the purpose of a hasty search is to perform a quick search in the most likely area where the victim is most likely to be found. Its emphasis is on speed. If personnel are available, it may be conducted simultaneously with determining the PLS. Searchers should use the buddy system where the buddies are in close visual contact with each other. In a swiftwater rescue situation, the hasty search is influenced by river dynamics, known hazards and if readily determined, by the PLS.

Returning to Figure 1.11, the main current plows into the river bend at the bottom of the rapids before exiting river left. Also, there is a known hazard of undercut rocks on the bend. A drifting passenger is very likely to become entangled in the undercut rocks on the bend. Even without identifying the PLS, area (a) would be a logical location to search for the victim since the river current would normally sweep a person into the eddies and undercut rocks located on the bend of the river. If the water is deep, paddles or sticks could be used to locate an underwater victim.

Take Care of Non-searchers – If there are passengers on a commercial trip or people in a private boating group who are not involved in the search, make sure they are in a safe and secure area. If needed, have someone supervise them. You don't want a second victim.

Search Techniques Summary – This section addresses a niche in swiftwater rescue. Often, but not always the victim is readily found and the rescue can begin. However, there are instances where the victim needs to be found first before the rescue can be performed. This section adapts basic search techniques and protocols to swiftwater rescue situations.

Summary

This section focuses on the concepts and philosophy of rescue. The first section provides sixteen principles of rescue. They are a potpourri of suggestions. Many of these principles filter into the second section on the rescue curve. Philosophically, the rescue curve suggests individual responsibility. Conceptually, it frames rescues in terms of surviving and time after an incident occurs. Like any paradigm, it intuitively makes sense. The first line of defense is safety and prevention. Once an incident occurs, the second line of defense is self-rescue. Then it is rescue by others in your group. The fourth line of defense is rescue by others outside your group, including the rescue squad. If none of these intervene, injury, damage or loss can occur.

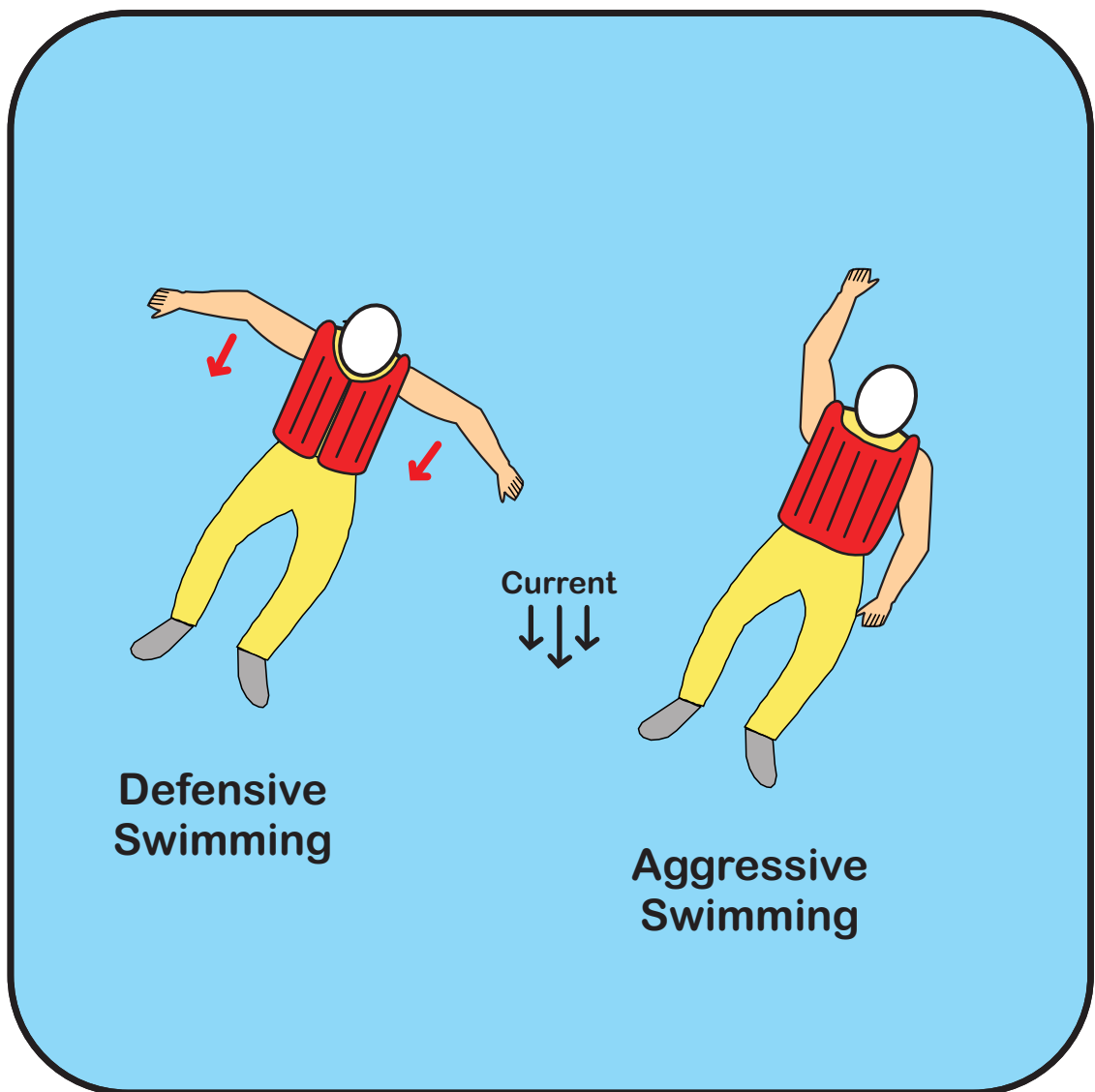
Don't forget the search function. On occasion, the victim(s) will need to be found first. This requires search techniques. Adapted from land based search principles, the section on search principles provide a primer on search principles adapted to swiftwater situations. In terms of the rescue curve, these techniques are applicable to *rescue by others in your group*.

The next to last section introduces the concept of programming for risks. It introduces the roller coaster experience and programming for high perceived risks while reducing actual risks. This is a formula for providing safe and enjoyable experiences. This includes swiftwater rescue courses also.

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Chapter 2: Wading, Swimming & Crossings



Chapter 2: Wading, Swimming, and Crossings ¹

Rescuers have a need to move around in the water to effect rescues. They can wade in the water, swim, or use crossing techniques. This section covers several of these techniques. A secondary benefit of wading and swimming is that they increase the comfort level of rescuers in the water.

Wading Techniques

One way to reach the victim, move rescuers into position, to cross the river, and to alter river dynamics is through the use of wading techniques. Some of the commonly used wading techniques include solo wading with a paddle, two-person wading, four-person wading, pyramid, and in-line crossing. Generally, these wading techniques are differentiated from rope crossings since they are performed without the use of a rope.

Solo Wading with a Paddle (Figure 2.1) – The river bottom is rocky and uneven. A three-legged stool is very stable, even on an uneven floor. The three legs create triangulation and the stool easily adjusts to the unevenness. Solo wading with a paddle creates the same type of stable triangulation using the paddle and the two legs of the wader. Triangulating with a paddle can create the stability provided by a three-legged stool on an uneven river bottom.

To move in the water using this technique, place the tip of the blade on the river bottom. The current will force the blade downward which helps to keep the blade fixed to the river bottom. This makes the paddle very stable. Using the paddle for stability, the wader can move laterally in the water. Avoid crossing the feet since this reduces stability. When the feet are stable, reposition the paddle.

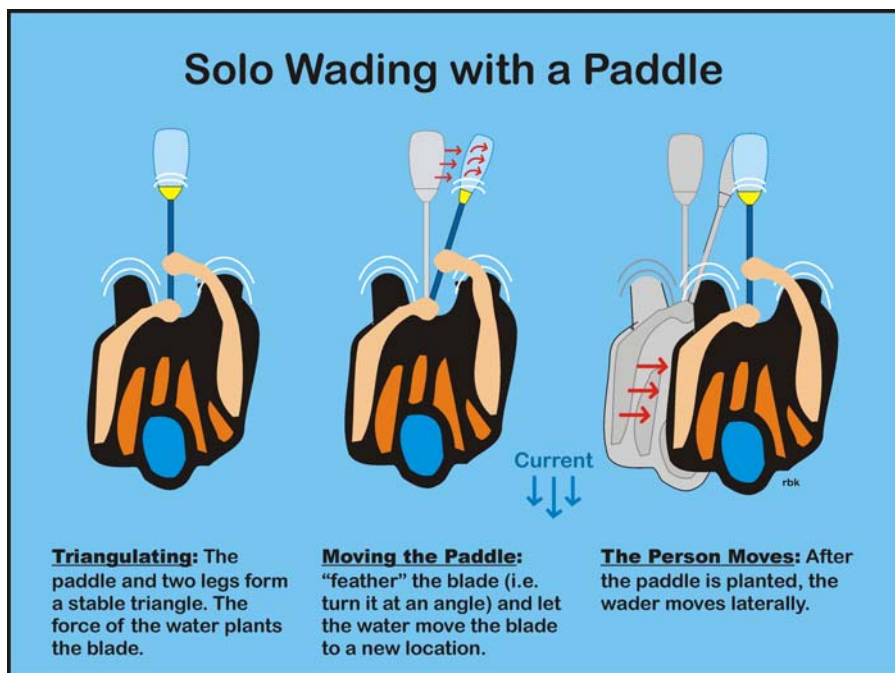


Figure 2.1: Solo Wading with a Paddle The paddle and two legs of the wader triangulate and create a stable base in the water. Source: author – [file:\SWM-WadeSolo.cdr]

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Repositioning the paddle can be done two ways. The paddle can simply be lifted out of the water and replaced where it is wanted. This works well in shallow water, but becomes cumbersome in waist deep water. Also, this can lead to instability since the third leg of the triangle is removed, if only briefly.

The second method is to feather the blade of the paddle and use the force of the current to move the paddle in repositioning it (see Figure 2.1). This approach works better in deeper water and maintains stability because it lessens the time the blade isn't in contact with the bottom. Feathering the paddle is turning the blade so that it is parallel with the current. This minimizes the force of the

current on the blade. Angle the blade slightly and the force of the current will move the blade in the direction that the top of the blade is pointing. Reverse the angle of the blade and the force of the current moves the paddle the other direction. Quickly turn the blade to the current and the force of the current repositions it on the bottom.

Two-Person Wading (Figure 2.2) – Where the solo wading with a paddle uses a paddle to provide stability, the second person in this technique provides stability. In the two-person wading, the upstream person faces downstream and the downstream person faces upstream. Each person grasps the corresponding shoulder straps of the other person's life jacket. Moving in the water is simple. While one person remains stationary, the other person moves and repositions herself. This simple process is repeated as they move through the water.

Four-Person "Huddle" (Figure 2.3) – The four-person huddle is an expanded version of the two-person crossing. It is also called the pinwheel or crab crawl because the group tends to rotate or pinwheel as it repositions itself. The four-person circle can easily be done with three or five people (not shown).

Each person grasps the shoulder straps of the life jacket of the person next to them. The group moves one of several ways. As with the two-person wading, two people remain stationary as the other two people reposition themselves. Or, one person remains stationary as the other three people reposition themselves. This tends to result in the group rotating or pinwheeling around the stationary person. Or, everyone in the group rotates or pinwheels at the same time. Depending on the depth and speed of the water the approaches can be used interchangeably to meet changing circumstances.

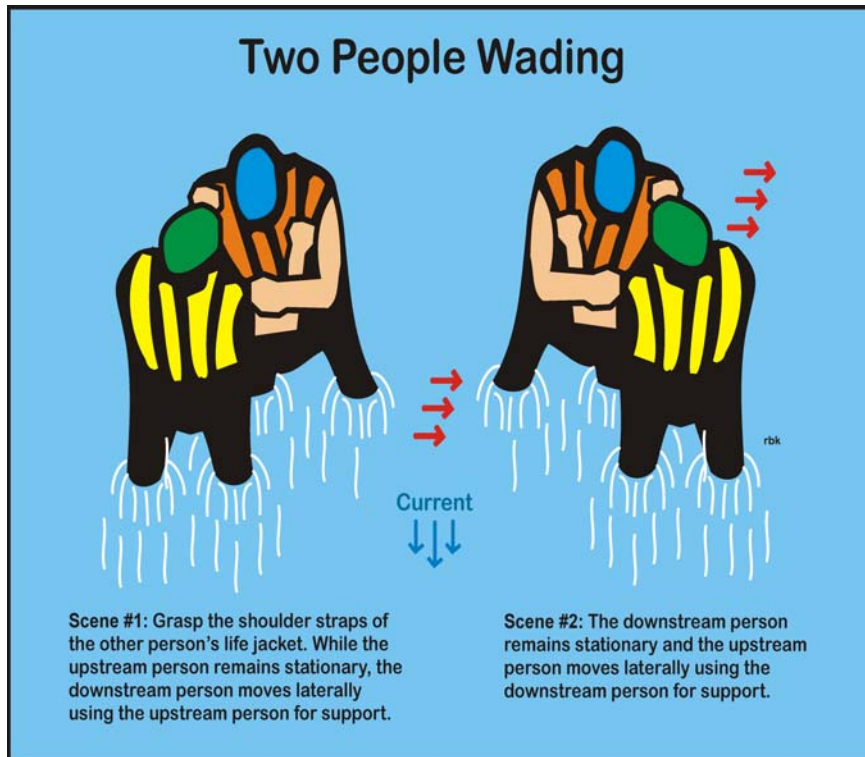


Figure 2.2: Two-Person Wading – The other person provides the stable base. Source: author – [file:\SWM-WadeTwoPeople.cdr]

Pyramid (Figure 2.4) – The pyramid can be used to move a group of people through swiftwater. It can be used to transport a rescued victim, and it can be used to alter the flow of the current upstream of a victim. Generally, it requires six or more people.

The point person in the pyramid is a solo wader with a paddle (see Figure 2.1). Usually, one of the larger people is chosen for the point. The point person maneuvers as if he is a solo wader with a paddle. The second row has two people. The person behind the point person on the river right side grasps the back left shoulder strap of the life jacket with her left hand and the back right shoulder strap of the life jacket with her right hand. The person behind the point person on the river left side grasps the back left shoulder strap of the point person's life jacket with his left hand and the back right shoulder strap of the life jacket with his right hand.

The third row has three people. The person on the river right side grasps the left shoulder strap of the person in front of them with her left hand and the right hand on the right shoulder strap of the same person in front of him. The person on the right does the same. The person in the middle grasps the back of rear right shoulder strap of the person on his left in front of him, and grasps the back left rear shoulder strap of the person on his right in front of him. Additional rows align themselves in a similar manner.

To work, the pyramid requires good communications. Usually, someone toward the rear calls out the commands. Being in the rear, they have a good overview of the scene. In contrast, the point person cannot see what is occurring behind them, and when they speak, it is hard to hear them because they are speaking away from the group. Although the point person is not a good command person, there needs to be

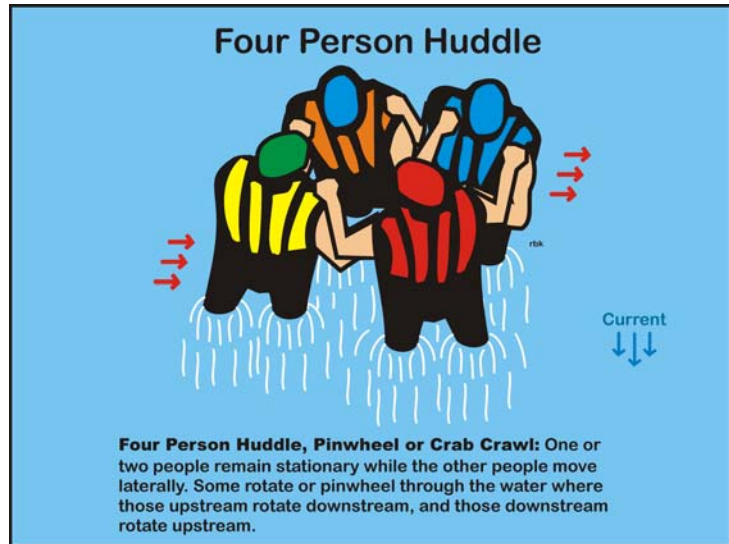


Figure 2.3: Four Person Huddle – Also called the pinwheel or crab crawl, the four-person huddle is a more stable version of the two person wade. Source: author – [file:\SWM-WadeFourPeople.cdr]

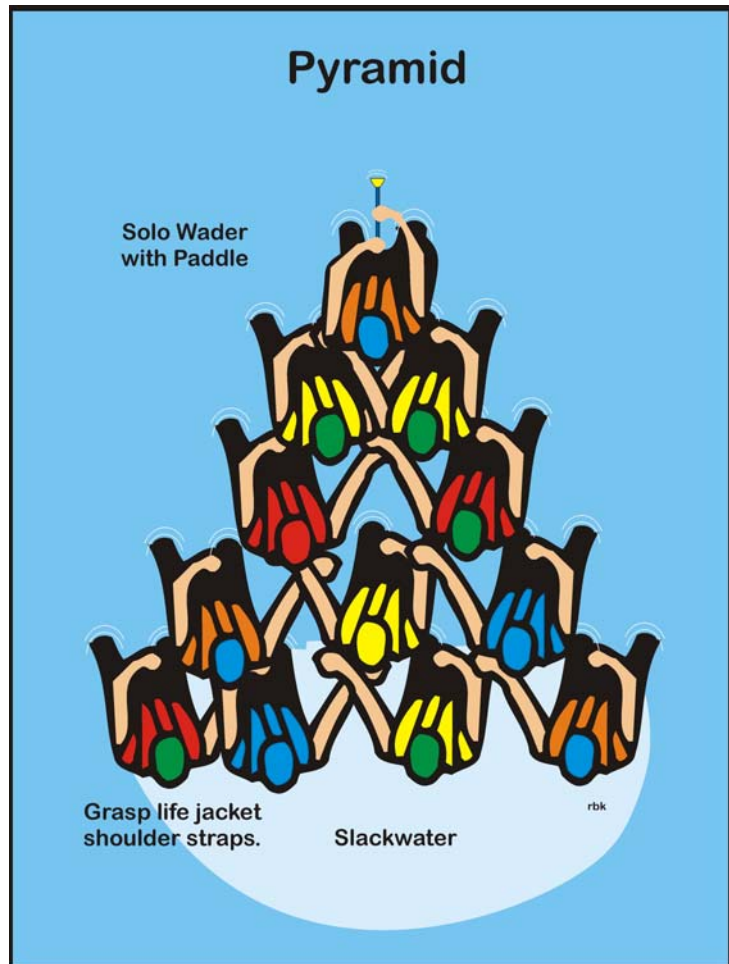


Figure 2.4: Pyramid – The pyramid can move a lot of people in the water and it can be used to alter the river dynamics. Source: author – [file:\SWM-Pyramid.cdr]

communication between this person and the person calling out the commands.

In-line Crossing (Figure 2.5) – The in-line crossing is derived from Rescue 3 International. It is useful for moving large numbers of inexperienced people through moving flood waters knee deep or less. It can easily be applied to river rescue situations.

The first person enters the water facing upstream (Scene #1). The next person enters the water behind the first person. They use the person in the line for stability and take a position next to the first person. They lock arms (Scene #2). More than one person can move along the line at a time. Making it easier to move in the water, a series of eddies or slackwater behind each of the people inline is created by the line. After everyone in the group assumes their position on the line, the first person who entered the water moves on down the line and assumes a position at the end (Scene #3). The second person follows, and then the third. The line moves toward the other shore. To speed up the process and depending on circumstances, more than one person can move down the line at a time. When the line encounters the other shore, people rotate onto the shore (Scene #4) until everyone is on the shore (Scene #5).

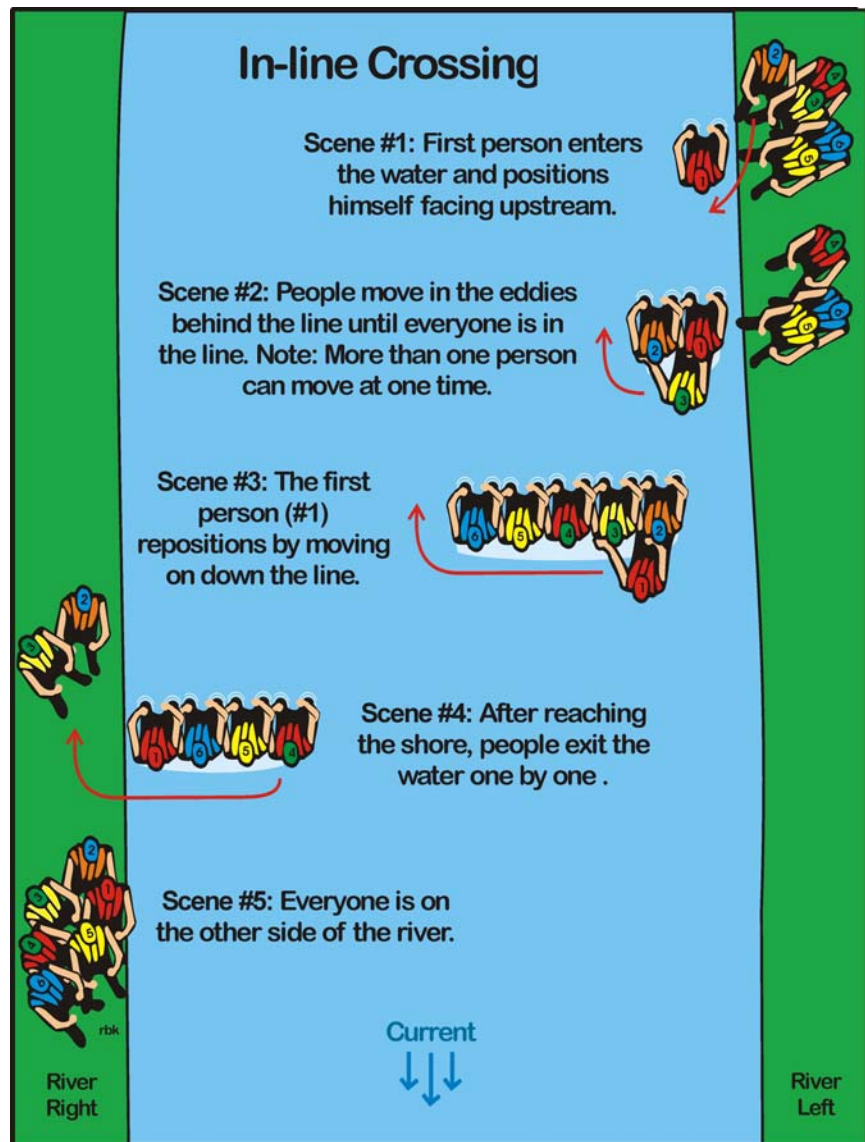


Figure 2.5: In-line Crossing – From Rescue 3 International, the In-line Crossing is a useful tool for moving large groups quickly through shallow moving water such as often found in floods. Source: author – [file:\SWM-LineWalk.cdr]

Swiftwater Swimming Techniques

There are two swimming modes: *defensive swimming* and *aggressive swimming*. Rescuers should be familiar with both methods. They can be used interchangeably. In addition, there is the barrel roll into eddies, back ferry and strainer drill which emphasize swiftwater swimming techniques.

Defensive Swimming (Figure 2.6) – In defensive swimming, the swimmer floats on her back with her feet on the surface and pointing downstream. If the swimmer wants to move laterally or across the current, she rotates her body so that is no longer parallel with the current and uses her arms to back paddle. Back paddling at an angle against the current executes the basic back ferry. Also, it slows the downstream movement of the swimmer. Both are good outcomes.

Aggressive Swimming (Figure 2.6) – Aggressive swimming is the crawl stroke with the head up out of the water as much as possible so that the swimmer can see where she is swimming. When swimming, the emphasis is on pulling the swimmer through the water with the arms. Excessive kicking uses more energy than the propulsion it provides.

As might be expected, there is often a controversy regarding which method is better, which method is faster, or which method is safer. Generally, defensive swimming uses less energy, and the swimmer moves slower in the water. The butt absorbs hits and

often there is a tendency for the butt to hang down in the water because of the sitting position. Also with defensive swimming, the swimmer has a broader view of the waterscape. However, if the swimmer wants to get from one point to another quickly, aggressive swimming will do it. Also, when using the swiftwater entry, the swimmer enters the water in position for aggressive swimming. For these reasons, the two swimming methods are used interchangeably as a changing situation demands.

Barrel Rolls (Figure 2.7) – The barrel roll is a technique used to help a swimmer break the eddy line and enter the eddy. For the purposes of discussion the barrel roll is broken into three phases.

Entry – As the swimmer approaches the eddy, the swimmer in defensive swimmer mode reaches over into the eddy with his right arm and plants the hand into the upstream moving water in the eddy.

Barrel Roll – Scoop the eddy water with the right hand and barrel roll over the arm. This tends to move or rotate the body laterally into the eddy. The swimmer scoops the water and begins the rotation in



Figure 2.6: Defensive and Aggressive Swimming – Defensive and aggressive swimming can be used interchangeably. Source: author – [file:\SWM-DefensiveAggressiveSwimming.cdr]

the entry phase. In a continuous rolling motion the swimmer rotates over on his stomach into what would be considered an aggressive swimming position.

Recovery – In a continuous motion, the swimmer continues the role until there is one full rotation. The swimmer is on his back in the defensive swimming mode. If needed, barrel roll again. It may be necessary to cover more distance to actually make it into the eddy. The barrel roll can end in either the defensive swimming mode (shown) or the aggressive swimming mode (not shown). Barrel roll as many times as needed to enter the eddy.

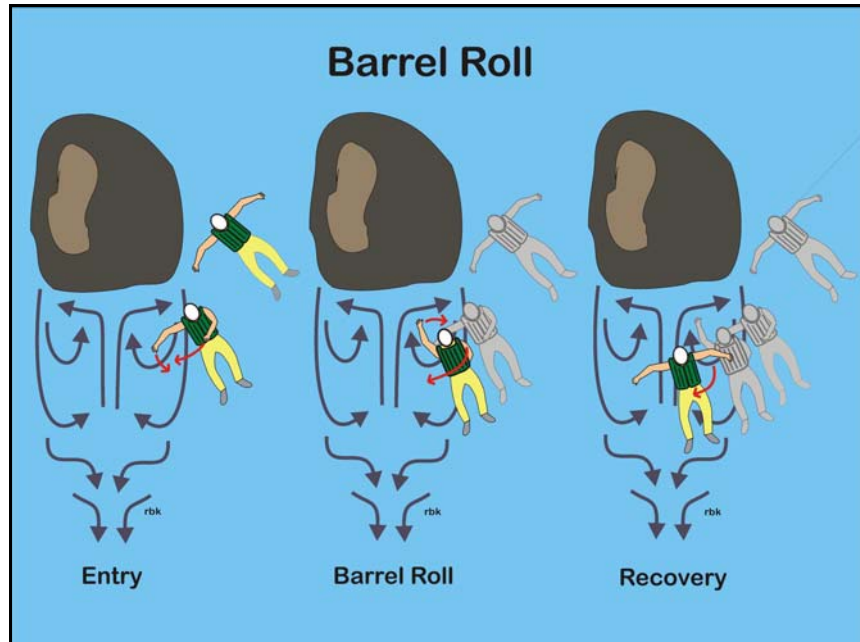


Figure 2.7: Barrel Roll – The barrel roll is a useful technique for crossing over the eddy line in an eddy. Source: author – [file:\SWM-BarrelRoll.cdr]

Back Ferrying (Figure 2.8) – The back ferry is a fundamental technique used to maneuver a swimmer or boat in moving water. In fact, most swimmers in the defensive swimming mode intuitively perform the back ferry. In a canoe, kayak or raft, the back ferry occurs with the bow of the boat pointing downstream and with the boater facing downstream. This differentiates it from the forward ferry where the bow is pointed upstream. Similarly, for the defensive swimmer, the feet or bow is pointing downstream and the defensive swimmer is facing downstream also. Also, the back paddling of the swimmer has the same effect as reverse strokes used in a canoe, kayak or raft. Hence, the defensive swimmer in defensive swimming mode is back ferrying. Also, it is why this section is titled back ferrying.

To perform a back ferry, the swimmer must do two things. First, the swimmer points her head toward the shore where she wants to go. This creates an angle with the main current. Her body is no longer parallel with the current. Second, the defensive swimmer back paddles with her arms. Back paddling at an angle against the current creates both a horizontal and vertical force. The vertical force slows the swimmer in the current and the horizontal component moves the swimmer toward the shore to which the head is pointing. This method of moving laterally or across the current is a back ferry.

For defensive swimmers, factors influencing the back ferry include the speed of the current, the amount of back paddling effort, and the angle of the swimmer in the current. As a practical matter, swimmers should experiment in moving water to determine what works well and what doesn't. On the same stretch of moving water (i.e. constant speed of the current), experiment with different body angles and the amount of back paddling required to move the swimmer laterally or horizontally in the water.

Figure 2.8 illustrates the typical back ferry for a defensive swimmer. Scene #1 shows the swimmer without a ferry angle. Unless there is back paddling, the paddler will float at the same speed of the current and will travel with the current. In Scene #2, the swimmer has pointed his head in the direction that he

wants to travel. He now has an angle with the current. In order to maintain the ferry, he needs to back paddle. In Scene #3, the swimmer increases his angle with the current and needs to increase the back paddling effort to prevent drifting downstream. In Scene #4, the swimmer is swimming parallel with the current and with strong back paddling, he remains stationary in the rapids.

In scene #5, the swimmer has drifted downstream and ferries back to river right. The swimmer points his head toward the river right shore to create a ferry angle (Scene #6) and ferries back to the river right shore (Scene #7).

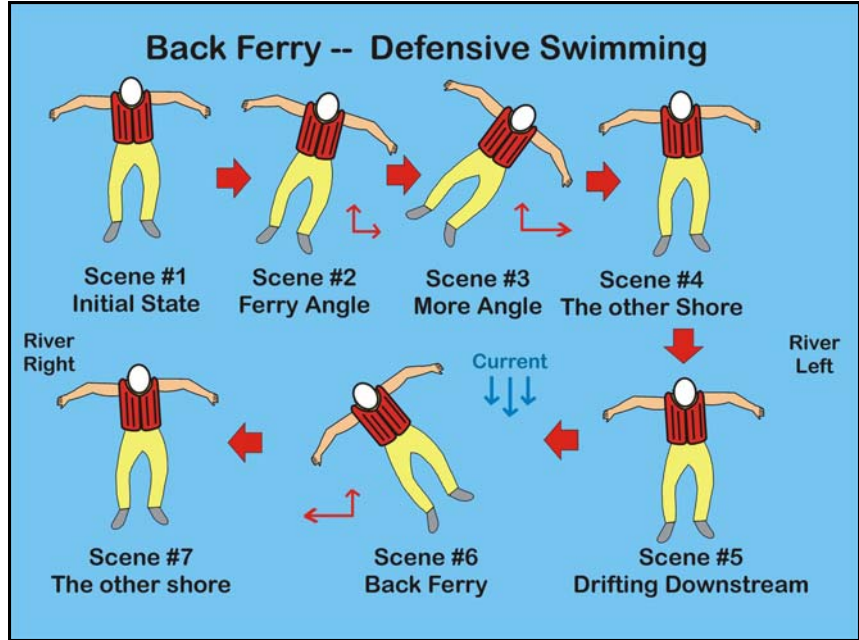


Figure 2.8: Back Ferry – Defensive Swimming – Back paddling at an angle against the current executes the basic back ferry. Source: author – [file:\SWM-BackFerry.cdr]

Using Defensive and Aggressive Swimming to Swim a Rapids (Figure 2.9) – Figure 2.9 depicts a typical river scene and a swimmer using defensive swimming to maneuver through the river. The numbers and captions correspond to the subheadings in the figure.

Scene #1: Defensive Swimming Position – The swimmer is in the main current in the defensive swimming position. Feet are up and pointing downstream. The swimmer maybe floating or back paddling slowly. Initially, the swimmer is going with the flow.

Scene #2: Back Ferry to Eddy – The swimmer decides to swim to the eddy. The swimmer assumes a ferry position and points his body toward the shore (i.e. eddy) to which he want to back ferry. The swimmer’s body is no longer parallel with the current. Generally, the greater the angle the greater the back paddling effort that is required. For the back ferry to work, the swimmer must be back paddling against the current. The swimmer back ferries with aggressive back paddling toward the eddy.

Scene #3: Barrel Roll into the Eddy – The barrel roll helps the swimmer break the eddy line and move laterally into the eddy. The swimmer reaches the eddy line. He barrel rolls into the eddy by reaching into the eddy with his right arm and rolling over the eddy line into the eddy (see Figure 2.7 for a more detailed barrel roll). More than one roll may be needed.

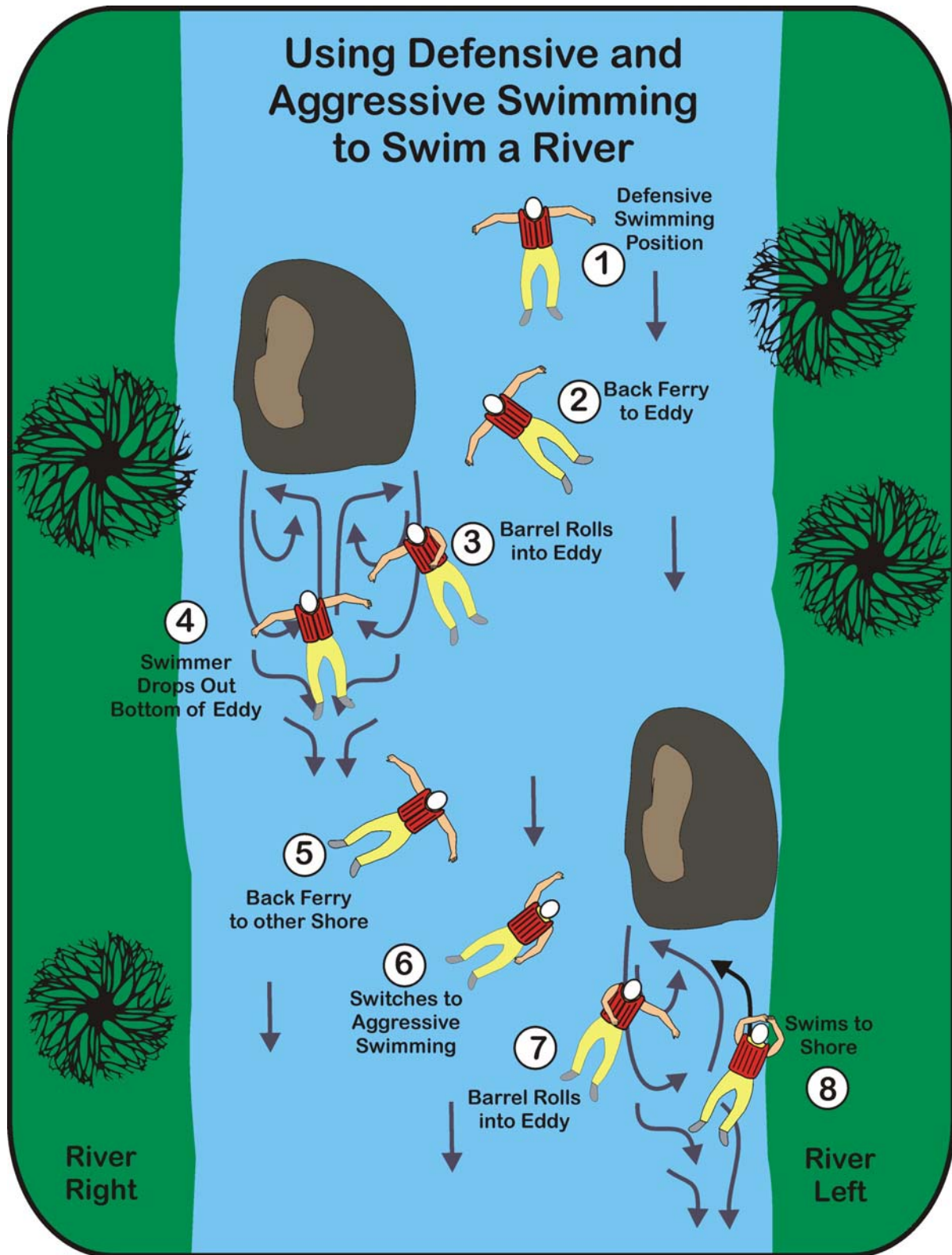


Figure 2.9 – Using Defensive Swimming to Swim a River – This scene depicts a typical swimming scenario using defensive swimming. Source: author – [file:\SWM-DefensiveSwimming.cdr]

Scene #4: Swimmer Drops Out Bottom of Eddy – Depending on what the swimmer wants to do, he can swim back upstream to the rock, hang-out in the neutral portion of the eddy, or drop out the bottom of the eddy in the slower moving downstream current. The swimmer decides to drop out the bottom of the eddy and back ferry to the eddy on the river left shore.

Scene #5: Back Ferry to the other Shore – Still in the defensive swimming position, the swimmer positions himself to back ferry. As the strength of the current increases, the swimmer will need to back paddle harder to reach the other shore. The swimmer may even need to switch over to aggressive swimming to maintain sufficient force to maintain the ferry angle.

Scene #6: Switches to Aggressive Swimming – The swimmer decides that he needs to flip over and aggressively swim (i.e. crawl stroke) to reach the eddy on river left. He maintains his ferry angle.

Scene #7: Barrel Roll into Eddy – The swimmer barrel rolls into the eddy on river left using a barrel roll. In this case, the swimmer reaches into the eddy with his left arm and barrel rolls into the eddy.

Scene #8: Swims to Shore – Using the eddy current, the swimmer decides to swim to shore in the aggressive swimming mode.

Strainers and the Strainer Drill

(Figure 2.10) – Avoid strainers, they are killers. If possible identify them early and use defensive or aggressive swimming to do whatever it takes to avoid them. This is the best strategy. In Figure 2.10, a downed tree in the bend of a river is shown to create the strainer. Strainers can be created by undercut rocks or loose rocks that allow the water to easily pass through them. Strainers and the strainer drill are included in this section because it uses both defensive and aggressive swimming modes.

The strainer drill is designed to simulate a strainer and how to approach them if a swimmer is inadvertently swept into one (Figure 2.10). Usually, the strainer is a four or six inch PVC pipe held firmly by two people in the swiftwater. Lowering the strainer in the water makes it easier to go over. Raising the strainer makes it more difficult to go over.

The swimmer begins in the defensive swimming mode. Roughly, 15-20

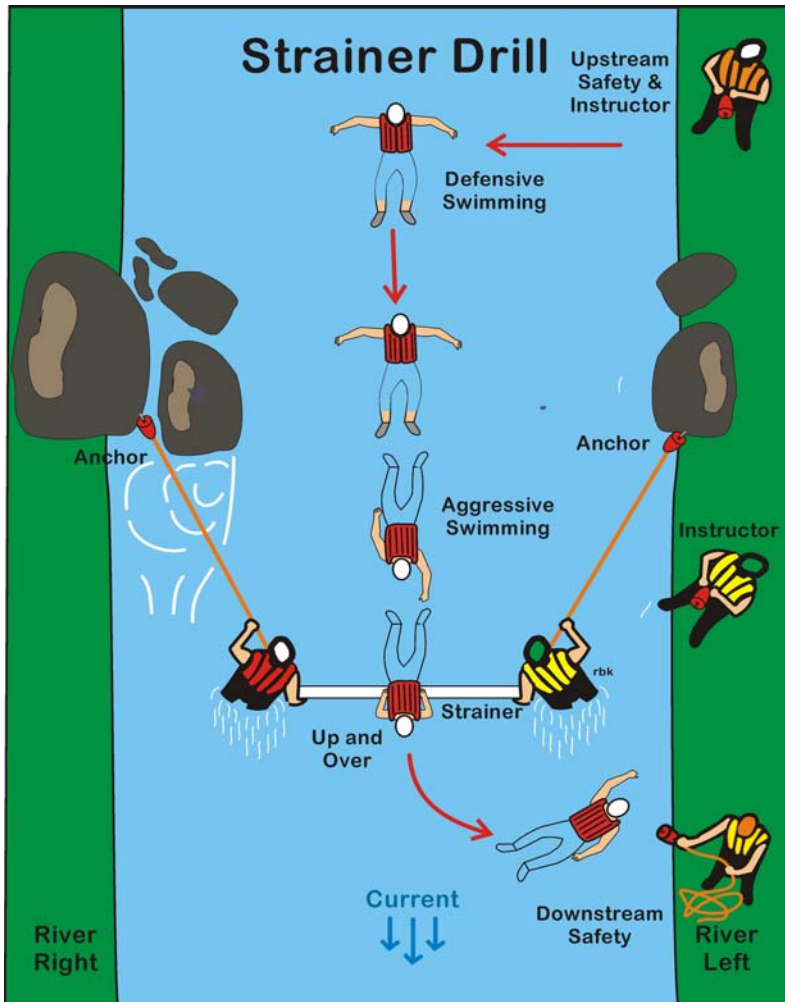


Figure 2.10: Strainer Drill – A PVC pipe is used to simulate a strainer. Source: author – [file:\SWM-StrainersDrill.cdr]

yards before the strainer, the swimmer flips over to aggressive swimming mode. With a good kick, the swimmer lunges up and attempts to swim over the strainer. Usually, if the swimmer's hips encounter the strainer, they will make it safely over the strainer. If their stomach encounters the strainer, the swimmer will usually flush underneath the strainer.

The difference between the strainer drill and a real strainer is that in the drill, the swimmer safely swims over the strainer or safely flushes under the strainer. With a real strainer, the best the victim can usually hope for is that they can lunge high enough on the strainer so that when they impale themselves, it is high enough that their head is above water and they don't drown. The strainer drill is fun. Real strainers aren't.

Crossing Techniques

In addition to wading or swimming to cross moving water, a line crossing and diagonal traverse can be used also. Both use a line or throwbag.

Line Crossing (Figure 2.11) – A static line is stretched across the moving water. It is tied off to a tree or rock on either or both sides. If belayers are used, a sitting belay should be used. Normally, the belayer is backed up. The backup emphasizes pushing down on the belayer to prevent them from sliding into the water. It is not uncommon to tie or carabiner two throw bags together to reach across the moving water.

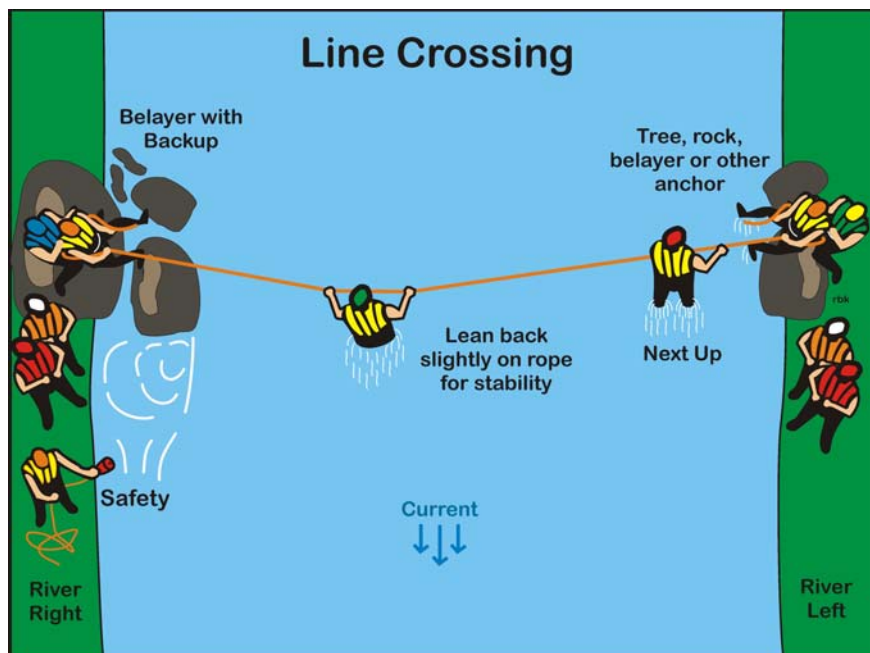


Figure 2.11: Line Crossing – The line crossing can be used to move rescuers across a river. Source: author – [file:\SWM-LineCrossing.cdr]

The purpose of the rope is to provide stability. In a sense, it provides triangulation between the rope and the wader's two feet. The trick for the wader is to provide

moderate tension on the line. No tension results in instability. As with the other wading techniques avoid crossing the legs when moving. Move the right foot close to the left foot. Move the left foot and then move the right foot close to the left foot again.

Diagonal Traverse (Figure 2.12) – In contrast to the line crossing, the diagonal traverse is designed to place the line across a stretch of river at a sufficient angle to the current to allow the current to vector or move the swimmer across the moving water. It utilizes the same principle as ferrying.

To setup, a line is stretched across a stretch of moving water at an angle. The rope can be tied off to a tree or rock. If a belayer is used, use the same procedures used in the line crossing including a backup. As a footnote, the diagonal traverse can easily consume more than one throwbag length. Clipping throwbags together is not an option since it impedes the carabiner from sliding along the line. The exception is that a throwbag can be clipped into either end of the line to extend it. However, it needs to be clipped in before where the swimmer clips into the line. On the takeout side it can extend the line as long as it doesn't impede the swimmer taking out.

To use, the swimmer clips in her carabiner on the rescue vest tether to the line. If done properly, the current will ferry the swimmer over to the other side. The swimmer can maintain a ferry angle which can aid in the ferry. Point your head to the shore to which you are traveling.

Setting Up of Line – It is necessary to get the line across the river. It can be thrown. A swimmer can swim it across, or boater can tow it across.

Throw – The first approach to setting up a line across moving water is to throw the rope to someone on the other side. As a general rule, the higher the thrower's elevation, the further the throwbag can be thrown. A paddle can be used to extend the reach of the person catching the incoming throwbag. If the bag doesn't reach the other shore it may be necessary to extend the line across the river with a swimmer or boat.

Swimming (Figure 2.13) – This is the live bait rescue without the victim where

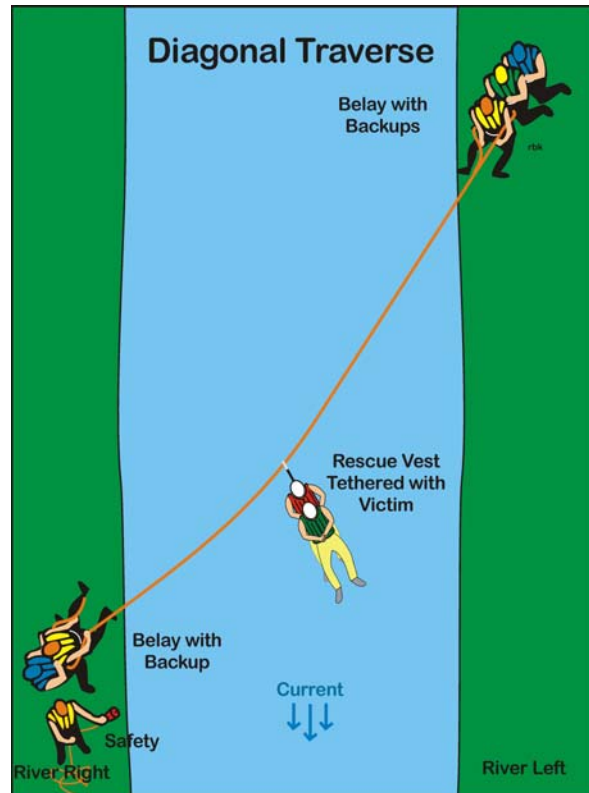


Figure 2.12: Diagonal Traverse – The diagonal traverse can be used to move rescuers across the river. – [file:\SWM-DiagonalTraverse.cdr]

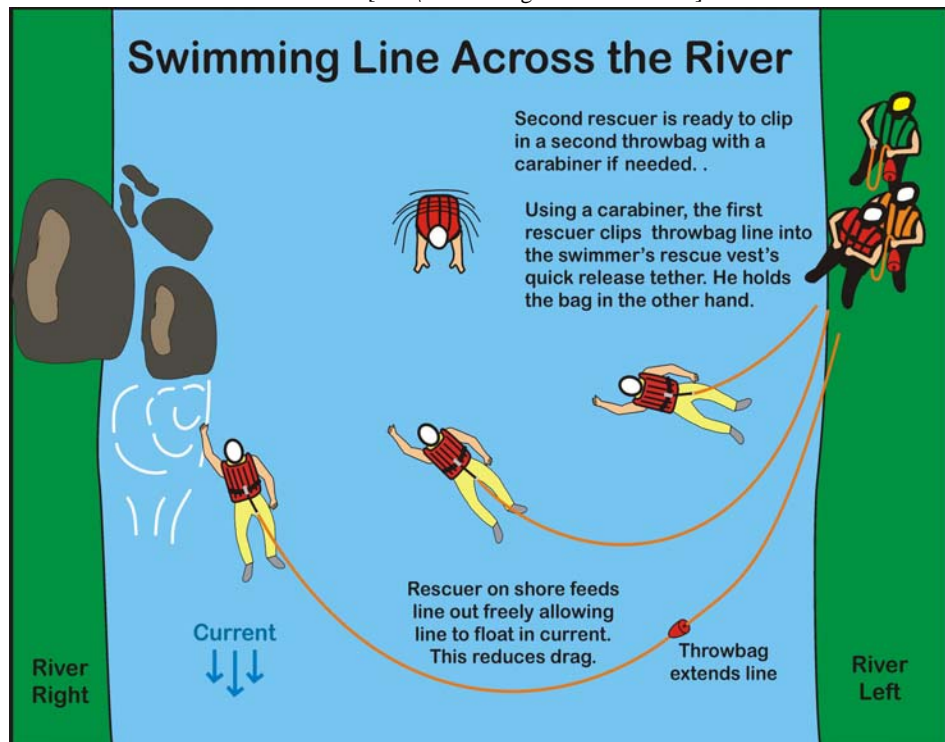


Figure 2.13: Swimming the Line Across the River – If needed, a swimmer can swim the line across the river. – [file:\SWM-SwimLineAcross.cdr]

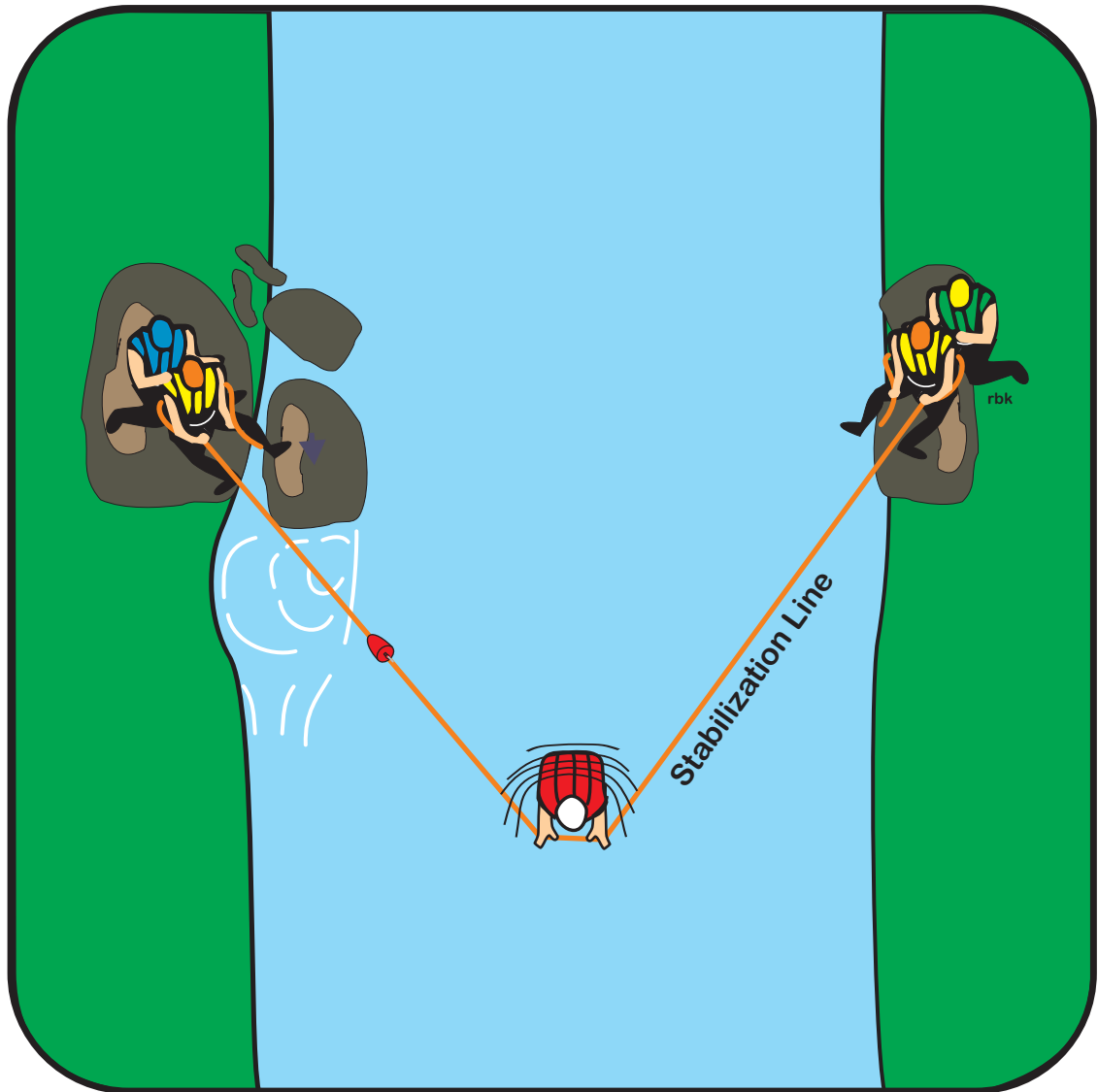
a swimmer swims the line across the river. The line is clipped into the rescue vest's quick release tether with a carabiner. Again, do not tie the line directly to the swimmer. The swimmer enters the water with a rescue dive (i.e. a belly flop with hands guarding the face). Using aggressive swimming, the swimmer aggressively swims to the other shore. An important tip for the person feeding out the line is to let the line drift in the current. This reduces drag on the swimmer. Slack can be removed from the line once the swimmer is on the other side. Clipping another throwbag into the line extends the line.

Boat – A boater can ferry the line across the moving water. The same principles used for the swimmer apply to the boater. Do not tie the line to either paddler or boat. Use the detachable tether on the rescue vest.

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Chapter 3: Rope Rescues



Chapter 3: Rope Rescues ¹

Rope rescues rely on ropes and throw bags as an integral part of the swiftwater rescue. These rescues are divided into throw bag, shore based rope rescues, swimming based rope rescues, and cinches. Some of the rescues are fairly simple and other can be quite complex in their setup.

Swiftwater rope rescues have evolved considerably since the 1970s. Initially, they cloned climbing techniques such as the Tefler Lower which was used to lower rescuers and/or litter to a rescue site. Many of these techniques were equipment and personnel intensive. They were oriented to a rescue squad rather than group of paddlers paddling down a river. Paddlers tend to be minimalists who travel mean and lean. Typically, a paddler will carry a throw bag, two or three carabiners, a knife, and perhaps a carabiner pulley. On a trip of five people, multiply the above items by four, assuming one of the paddlers is the victim. It supports the following dictum. *“All the resources you bring with you are all the resources you will have for a rescue.”*

Throw Bags

Throw Bags come in many sizes and shapes. One of the main determinants for selecting a throw bag is to ask yourself the following question. *“Will you take it with you at all times.”* If you don’t have it with you, you can’t use it.

Packing the Throw Bag – There are numerous ways to re-stuff a throw bag. What works works. The criteria for successfully re-packing a throw bag is that the rope is **randomly** stuffed into the bag. The operative term is “randomly.” When the rope is randomly stuffed, it comes out without becoming entangled when thrown. As a footnote, many graphic artists incorrectly draw a neatly coiled rope in the throw bag. This is incorrect.

The recommended method of restuffing a throw bag is as follows. This method is the what an employee for a throw bag manufacturer who stuffed throw bag commercially for resale used. First, open the end of the throw bag. Second, hold the bag open using the third, fourth and fifth fingers of each hand. This frees up the first finger and thumb to stuff the rope. Place the rope over the shoulder. The life jacket prevents the rope from slipping off the shoulder. If done correctly, there may be a slight rope burn over the shoulder. Grasp the rope with the thumb and first finger and stuff hand over hand the rope into the bag.

First Throw of a Throw Bag – There are three approaches to throwing a throw bag. These are the underhand, sidearm or overhand approaches. All can be use effectively. Generally, the farthest throws occur underhand. When standing in knee deep or deeper water, the underhand throw becomes impractical and a side arm or overhand throw needs to be used. Practice all three methods and determine which works best in different situations.

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Second Throw (Figure 3.1) – The rescuer throws the throw bag. Perhaps it misses or another victim is floating past the rescuer on the first throw. Time to the second throw is important. Retrieving the bag, stuffing it, or even filling the retrieved bag with water is not really an option if the rescuer is in a hurry.

For the second throw, start coiling the throw bag rope end on shore (Figure 3.1). Let the bag float downstream if necessary. Count the coils. The length of each coil will depend on the person coiling. Figure three to four feet per coil. Counting the coils is important because if the victim is fifteen feet away, there needs to be at least five coils or fifteen feet of rope to reach the victim. If not, the second throw will fall short.

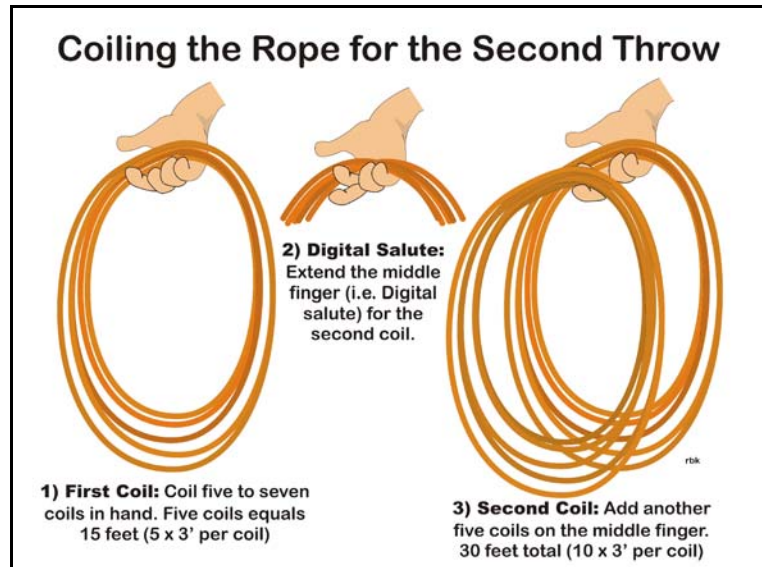


Figure 3.1: Coiling the Rope for the Second Throw – When coiling the rope, try making two coils which when released are less likely to be come entangled. Source: author – [file:\BAG-SecondThrow.cdr]

Coil five to seven coils in the throwing hand (Figure 3.1; Scene #1). The number of coils can vary according to what is comfortable for the rescuer. Practice and determine what is a comfortable throw for each rescuer. Figuratively speaking, extend the middle finger as if giving the digital salute (Scene #2). It is not really the digital salute but the use of the middle finger to make a second coil independent of the first coil. Again five to seven coils or what feels comfortable to the rescuer. Practice will determine the comfort level regarding the number of coils and throws (Scene #3).

To make the second throw, take the second coil and hold it in the non-throwing hand. Step on the line. This prevents the line from slinking away from the rescuer into the river. With the first coil in the throwing hand, throw it to the victim. At the same time gently release the second coil in a manner that doesn't place a drag on the first coil thrown. This takes practice to perfect and most rescuers practice this skill in between rescue drills to perfect their proficiency at this skill.

As an epitaph, many rescuers use the second throw approach as their first throw. It is a pain to constantly repack the throw bag and using this approach initially reduces the amount of rope that has to be repacked into the throw bag. Setting up for a potential rescue situation, the rescuer drops the bag on the rock and coils the rope using the loose end to the throw bag. Step on the throw bag or throw bag end of the rope and throw the coiled rope to the victim as previously depicted. When performing as a safety rescuer stationed below an exercise, this author uses this approach frequently.

Throw Bag Drill (Figure 3.2) – Actually the throw bag drill is both a defensive swimming and throw bag throwing drill. It provides participants in a swiftwater rescue class the opportunity to swim defensively as well as practice using the throw bag to rescue swimmers. The exercise has found itself being used in summer camps and other non-swiftwater class settings. It is really two activities in one. It is an excellent activity to familiarize participants with moving water and its potential dangers. Also, it is fun. Some of the following discussion may be more detailed than necessary since it has been influenced by litigation cases.

Instructors – Normally, this activity is done with two instructors. The instructor should inspect the site for hazards such as strainers and undercut rocks. If they are present, they need to be identified to participants, or the activity should be moved to another site. Also, the instructor should swim the site prior to conducting the activity.

One instructor is upstream with the swimmer group and the other instructor is with the rescuers (i.e. throw bag throwers). The upstream instructor supervises and instructs participants on the following key points. The first key is the entry into water. Depending on the site, the entry may involve wading or a swiftwater entry dive. Next, swimmers may need to be prompted to swim to an appropriate distance away from shore. Third, swimmers are reminded to keep their feet up and to use the defensive swimming position. If properly instructed, a student or participant can assume the instructor's role at this station.

The second instructor supervises the throw bag throwers. This involves the throwing of throw bags and hauling the swimmer into shore. Normally, the instructor has a throw bag in hand in case it is needed on missed throws. In addition, there needs to be good communication between the instructors in coordinating the swimmers and rescuers.

Downstream Safety – One or more downstream safeties should be located downstream to rescue any swimmers not rescued by the throw bag rescuers. Remember, swimmers can always swim to shore if the rescuers miss them. Students or participants can be used for this function.

Scene #1: Swimmer Enters the Water – Depending on the site, swimmers can enter the water by wading or using a swiftwater entry dive. The swiftwater entry dive is not really a dive, but a belly-flop with hands held outward to protect the face. The instructor coordinates the entry with the other instructor and monitors the key points to swimmers.

Scene #2: Throwing the Throw Bag – Holding the throw bag in the throwing hand and grasping the loop in the other hand, the rescuer throws the throw bag to the victim. Two keys to a good throw are the throw bag should be thrown over or past the swimmer, and the line should land over the chest of the victim. There is a lot of discussion on whether the line should be thrown upstream, downstream, or at the victim. Best result is when it is thrown over the victim and the rope lays across the victim's chest.

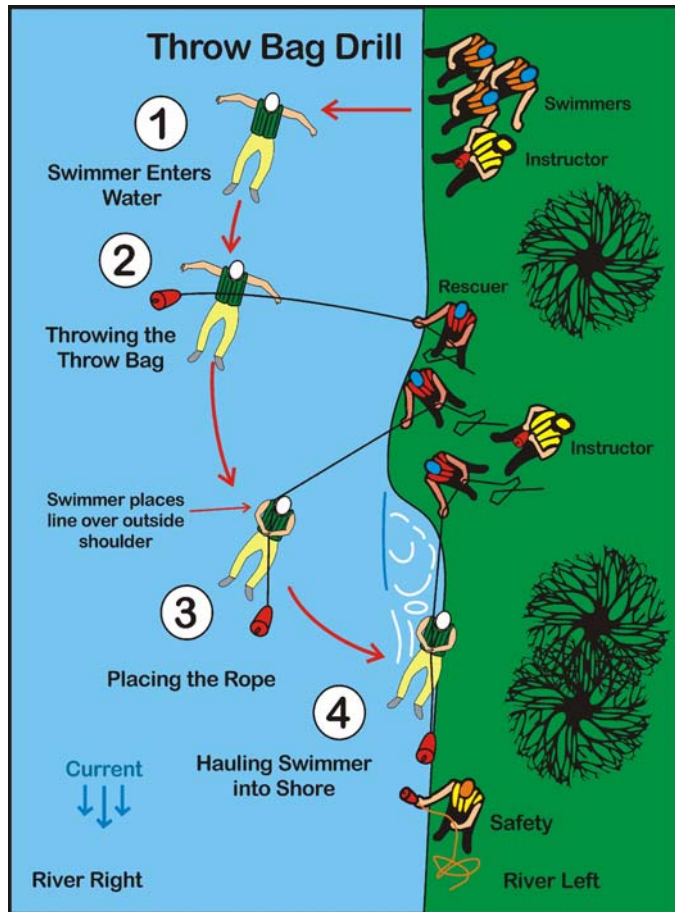


Figure 3.2: Throw Bag Drill – The throw bag drill is a two activities in one. It is both a defensive swimming and throw bag throwing exercise. Source: author – [file:\BAG-ThrowRopeDrill.cdr]

There are numerous variations to this drill. There can be multiple swimmers and rescuers. The swimmer can purposely miss the first throw requiring a second throw. The rescuer can practice using a second throw as their first throw.

Scene #3: *Placing the Rope* – The swimmer grabs hold of the line and places it over the shoulder facing away from the rescuer. The swimmers head is pointing toward the shore and the rescuer. This creates a good ferry angle for the swimmer that aids in swinging the swimmer to shore. The force of the water at an angle on the swimmer creates a ferry angle.

Some people find the placement of the rope over their outside shoulder objectionable since it can bite into their neck. They may prefer using the shoulder facing the shore. This is one of those instances where it most likely doesn't matter. Either shoulder will normally work. However, placing the rope over the outside shoulder is technically correct.

Scene #4: *Hauling Swimmer to Shore* – The rescuer hauls in the victim to shore. Ideally, there is a large eddy to haul the swimmer into. Depending on circumstances, the rescuer can move laterally or inward on shore which increases the pendulum effect (see Figure 3.4). The different belays can be practiced, and if needed a backup belayer can be used. Participants can be rotated through the different stations including downstream safety.

Belays – In a belay, the rope is bent around an object which transfers all or part of the load to the belay object. Although the focus is on the rescuer's hip belays, rocks and trees can be used as belays. The rope can be wrapped around a rock or tree. Be sure the rock or tree is substantial. If needed, the rescuer can add a hip belay to a partial belay around a rock or tree.

In a hip belay, the rope goes around the butt of the rescuer. As a rule, the line extending to the victim is downstream and the unloaded end is on the upstream side of the rescuer. This reduces the likelihood of the rescuer becoming entangled in the line if they have to let go of the victim. If the rescuer needs to increase resistance on the belay, he pushes the line over and down the leg in the crouch area with the upstream hand.

Standing Belay (Figure 3.3) – In a standing belay, the rescuer belays the rope around the upper portion of her butt while standing. The advantage of a standing belay is that it allows mobility. The rescuer can move to a new location which can reduce the load and pendulum the swimmer to shore more easily (see Figure 3.4). Another rescuer can backup the standing belayer if needed. The backup belayer holds onto the life jacket shoulder straps of the belayer. The backup belayer emphasizes pulling down rather than pulling backwards. If more belaying is needed, the standup belayer can reposition herself in a sitting belay.

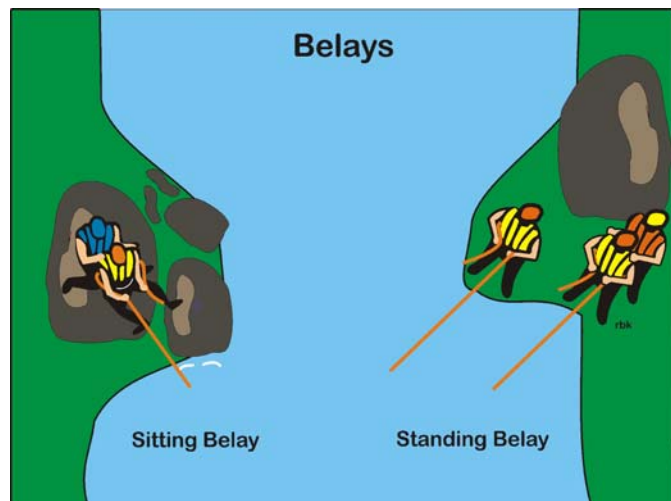


Figure 3.3: Belays – In both the standing and sitting belays, the line passes around the upper portion of the butt. The backup belayer holds the shoulder straps of the belayer's life jacket and pulls down. Source: author – [file:\ROPE-Belays.cdr]

Sitting Belay (Figure 3.3) – In a sitting belay, the rescuer belays the rope around the upper portion of her butt while in a sitting position. The advantage of a sitting belay is that it offers more resistance with the ground and in general, it can carry more load. Also, the belayer can use rocks and other objects to brace her feet. The disadvantage is that the rescuer lacks mobility. As with the standing belay, a backup belayer grasps the shoulder straps of the life jacket and emphasizes pulling downward.

Increasing Pendulum Effect (Figure 3.4) – Many rescue sites have sufficient room to allow the rescuer to take several steps backward toward the shore. Taking several steps backward or laterally offers the rescuer several benefits. First, it increases the ability of the rescuer to pendulum the victim to shore. In Scene #2 the line is parallel with the current and there is no pendulum effect left. The victim is left dangling in the current. In Scene #3, the rescuer is able to pendulum the victim to shore. Note, there is still an angle in the system if needed.

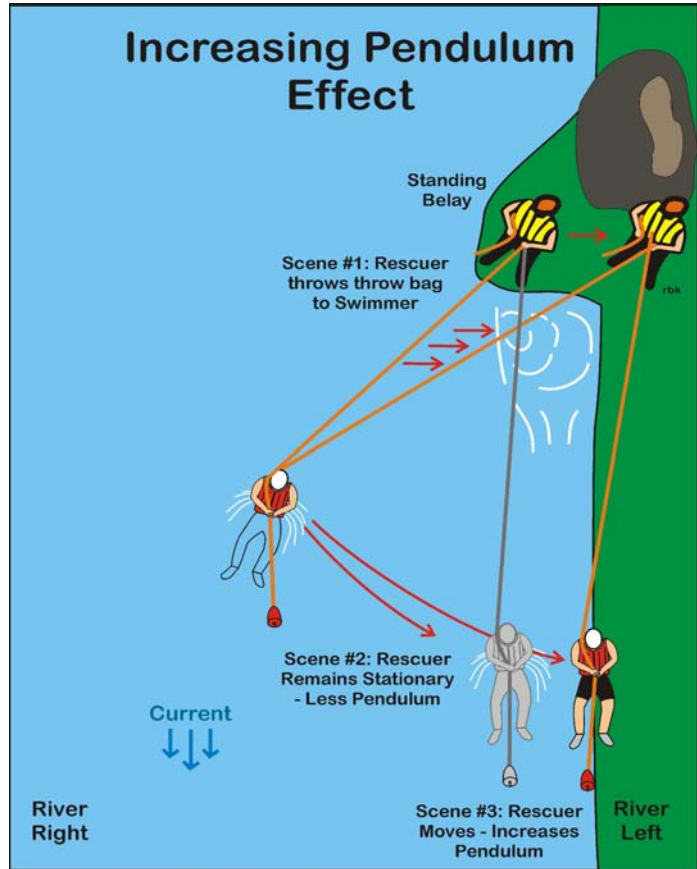


Figure 3.4: Increasing Pendulum Effect – After throwing the rope, the rescuer takes several steps inward which makes swinging the swimmer into shore easier. Source: author – [file:\ROPE-Pendulum.cdr]

Second, taking several steps backward, reduces the load on the rescuer. In Scene #2, the total weight of the victim including the force of the water is borne by the rescuer. Often this requires the rescuer to go into a sitting belay to counteract the weight of the victim. By taking several steps backward on the shore, there is a greater angle between the line and the current which reduces the weight or force borne by the rescuer. In many rescues, the reduced weight or force on the rescuer allows the rescuer to remain in a standing belay. It may avoid having to use a belay at all, and it allows the rescuer to simply haul the swimmer into shore.

The following is a tip for those using this technique. The rope is thrown to the victim in Scene #1. Because of the angle, there is little weight on the rescuer as the rescuer moves on the shore. Also, the rescuer can let out several feet of line as they reposition themselves. When repositioned, the rescuer pulls the rope taught and pendulums the victim to shore. In other words, in most cases a little extra drift is without consequence.

Shore Based Rope Rescues

In shore based rope rescues, the primary activity of the rescuers is from the shore. Shore base rescues can include rocks in the channel or other structures. Stated another way, these rescues do not normally utilize swimmers or wading as part of the rescue. Technically, the inverted paddle rescue involves wading, but since it is a variation or extension of the snag line, it is included here. The shore based rope rescues in the section include the stabilization line, snag line, and inverted paddle snag line.

Stabilization Line (Figure 3.5) – The purpose of a stabilization line is to provide support with which the victim can raise his head above the water to breath, particularly in a heads-down foot entrapment. It provides enough support for the victim to brace themselves against the line with their hands and arms.

The pressure on the belayers is considerable. Also, the stabilization line can be fatiguing when the time frame becomes extended. Hip belays are recommended. Also, consider the 120° rule where if the angle between the victim and the two belayers is 120°, the force is equal on the victim and the two belayers. If there is 100 lbs of force on the victim, there is 100 lbs of force on each belayers. Although it is not always possible, the belayers want to minimize the angle between them and the victim to reduce the force on the belayers. When possible, the belayers should be backed up. Holding onto the shoulder straps of the life jacket, the backup pulls downward on the belayer to prevent them sliding off the rock.

Position both upstream and downstream safeties. When there is a stabilization line or any line across the river, use an upstream safety. The purpose of the upstream safety is to redirect or stop anyone coming down the river. One or more downstream safeties should be provided. The downstream safeties provide two services. If one of the rescuers becomes a swimmer, they can rescue the rescuer. When a conscious or unconscious victim is extricated, they will need to be rescued or they will continue to float downstream. As a graphic note, to save space, not all the diagrams have the upstream and downstream safeties pictured. If there is any question, post them.

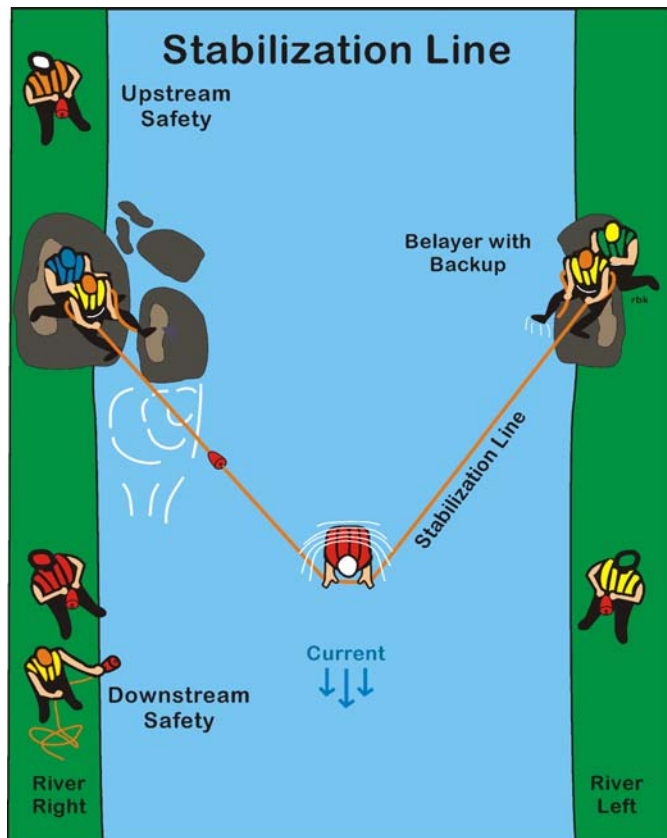


Figure 3.5: Stabilization Lines – The purpose of the stabilization line is to provide sufficient support to the victim so that they can breath. Source: author – [file:\ROPE-StabilizationLine.cdr]

Snag Line (Figure 3.6) – The purpose of the snag line is to position the snag line low enough on the victim to extricate them. Traditionally, two throw bags filled with river rocks are used to lower the snag in the water and snag the victim loose (see also the next section on the inverted paddle snag line). Normally, the snag line is used in conjunction with a stabilization line.

Construct a snag line as follows. Rescuer (a) on river right throws a line to rescuer (b) on river left (not shown). Using a carabiner, rescuer (b) fastens the two throw bags together, and fills the bags with rocks to weigh them down in the water (not shown). Rescuer (a) on river right pulls on the line while rescuer (b) on river left lets out line. The bags are positioned downstream of the victim.

Both rescuers move upstream to a point where they can pull the entrapped victim off the obstruction. Remember the 120° rule. The further upstream the two rescuers can move, the more leverage they have to pull the victim off the obstruction. Also, when crossing over the stabilization line, it is important to go **under** the stabilization line.

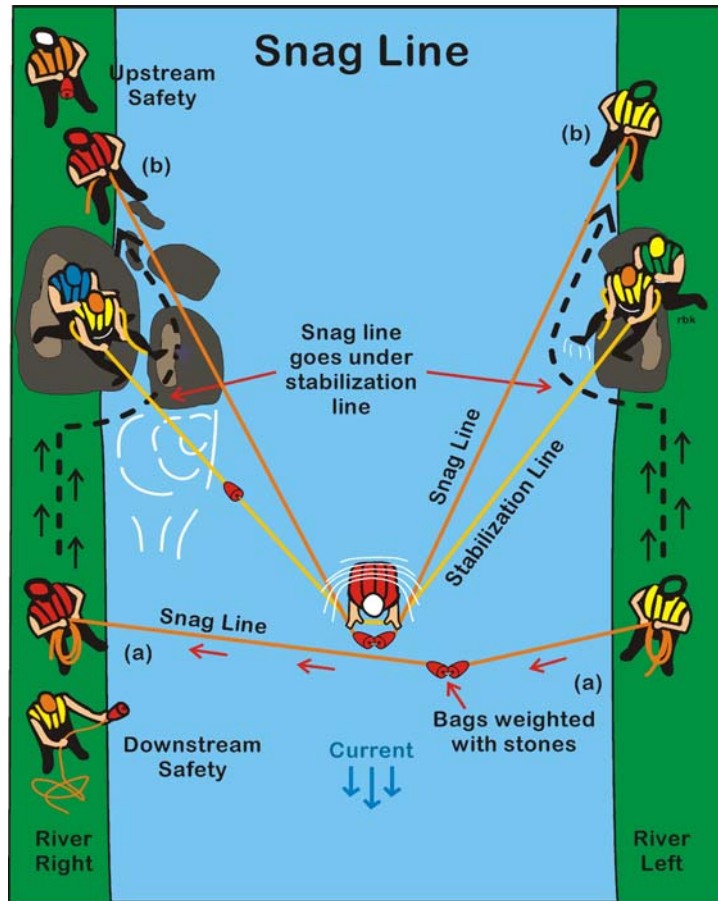
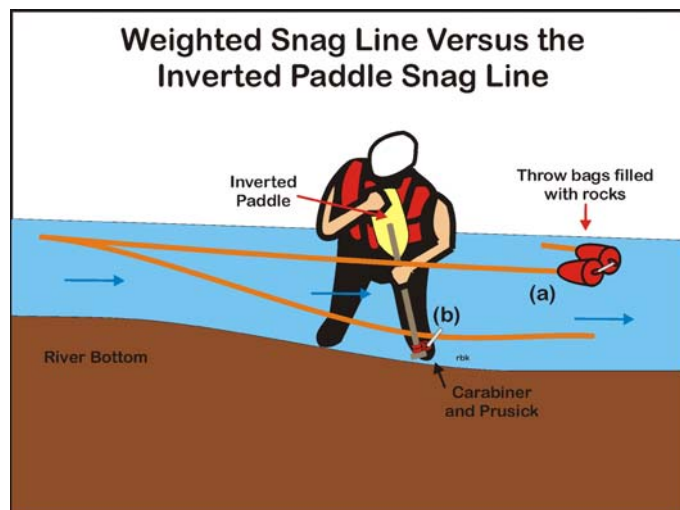


Figure 3.6: Snag Line – The purpose of the snag line is reach down under the victim to extricate them from the obstruction. Source: author – [file:\ROPE-SnagLine.cdr]

Inverted Paddle Snag Line (Figure 3.7) – The inverted paddle snag line is a variation of the snag line. The swift current keeps the snag line on the surface. This technique lowers the snag line on the victim where it can snag the victim and extricate the victim from the entrapment. The problem with the snag line is that even when the throw bags are weighted with rocks, the current tends to make it difficult to move the snag line lower on the victim. Essentially, the inverted paddle snag line uses paddles to lower the snag line on the victim. It is one of those techniques to include in your repertoire if needed.



Swimming Based Rope Rescues

Swimming based rope rescues involve situations where the rescuer is wading or swimming to actively rescue the victim. In this section, swimming based rope rescues include the simple rope tether, tethered swimmer or live bait, and V-lower

Simple Rope Tether (Figure 3.8) – The simple rope tether illustrates that often simple techniques can be done quickly and efficiently to effect a rescue. This technique illustrates a technique that can be setup quickly and with little fanfare. In the simple rope tether, the rescuer uses a belayed line for stability. In the solo rescue with a paddle, the paddle provides the same stability. In the two person rescue, the second person provides this stability. In this rescue, the belayer on the shore provides this stability. A belayer is shown in Figure 3.8. However, a rock, tree, or other object can just as easily provide the belay point for the rescuer to pendulum out to the victim using the belayed line for stability.

Tethered Swimmer or Live Bait Rescue (Figure 3.9) – The live bait rescue is useful in rescuing an unconscious victim or equipment floating downstream in the current (Figure 3.9). It is useful in rescuing boaters who come out of their boats in whitewater above a major hazard. The following text corresponds with the figure and explains the live bait rescue drill.

Scene #1: Victim Enters Water – Using a swiftwater entry, the victim enters the water upstream. A swiftwater entry is hands in front of the face with a shallow belly flop dive. The victim swims out into the main current and floats downstream. Normally, they are simulating an unconscious victim. As noted, it can also be equipment floating downstream or anything that cannot self-rescue.

Scene #2: Rescuer Enters Water – First, the rescue bag is clipped into the tether of the rescuer's rescue vest. This allows the rescuer the ability to eject herself from the line if needed. The line and not the bag is clipped into the rescuer. This enables only the needed line to be used. Clipping the bag end into the tether results in all the rope in the bag coming out. Using a swiftwater entry, the rescuer enters the water and swims toward the victim. On shore, the assistant feeds the line out of the throw bag. It is important for the belayer on shore to feed out the line with as little resistance as possible. Also, to reduce drag on the swimmer, the assistant can allow the rope to float downstream if necessary.

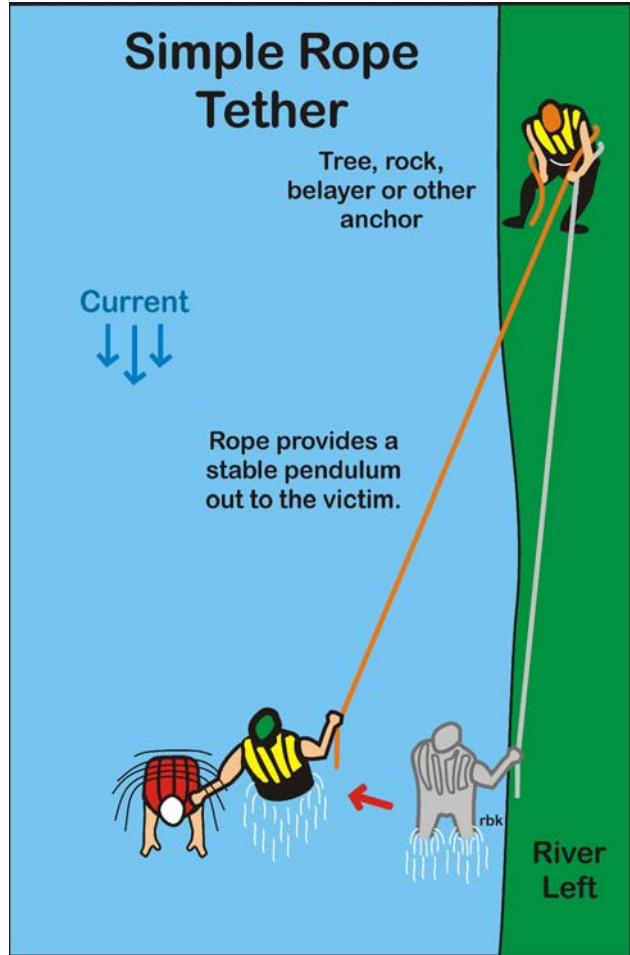


Figure 3.8: Simple Rope Tether – The simple rope tether illustrates that sometimes keeping it simple can create an effective rescue. The rescuer uses the belayed rope for stability as she wades out to the victim. Source: author – [file:\ROPE-SimpleRopeTether.cdr]

Scene #3: Grasping the Victim – The rescuer grasps the victim by the shoulder straps of the life jacket with both hands. If the victim is conscious, some recommend splashing water into the victim’s face. This temporarily disorients the victim which allows for the rescuer to grab a hold of the victim. With the victim in her grasp, the shore based assistant or rescuer can haul in and pendulum the rescuer and victim to shore.

Scene #4: Hauling into Shore – Both the rescuer and the victim are hauled to shore by the rescue assistants on the shore. If possible the rescuers on shore can step laterally or horizontally back on the shore prior to going into a sitting belay. This increases the pendulum effect and makes hauling the swimmer into shore much easier (not shown). If necessary, the rescuer on shore may need to go into a standing belay or a sitting belay. If needed, the belayer can be backed up with another rescuer. Remember, the force on the victim is equal to the force on the belayer. Reducing the force on the belayer with a good pendulum reduces the force on the rescuer and victim and makes hauling to shore easier.

V-Lower (Figure 3.10) – The V-Lower lowers a rescuer in moving water to effect a rescue of a trapped victim. With one or more belayers on each side of the river, one or more lines are connected and extended across the river. Also, two rocks in the river can be used by the belayers to lower the rescuer in a channel of the river. If possible, setup of the belayers and rescuer should consider the 120° rule to reduce the load on the belayers.

Next the line is connected to the tether of the rescue vest (Figure 3.11). Avoid situations that potentially side load one of the carabiners when under load. The use of locking carabiners is preferred. Several methods can be used. On the line, tie an inline figure eight on a bite or a simple figure 8 on a bite. If two lines are connected together with one or two carabiners, fasten the carabiner from the tether to the loop in the throw bag rather than clipping it into one of the carabiners. Clipping it into one of the carabiners tends to side load the carabiner under load and should be avoided. Clipping it into the loop provides flexibility and avoids side loading. Some rescue vests have an O-ring rather than a tether to fasten the rescuer to the line. The same principles apply.

Only a rescue vest with a detachable O-ring or tether. This allows the rescuer to free himself if needed. Again, a line should not be tied or carabinered directly to the rescuer.

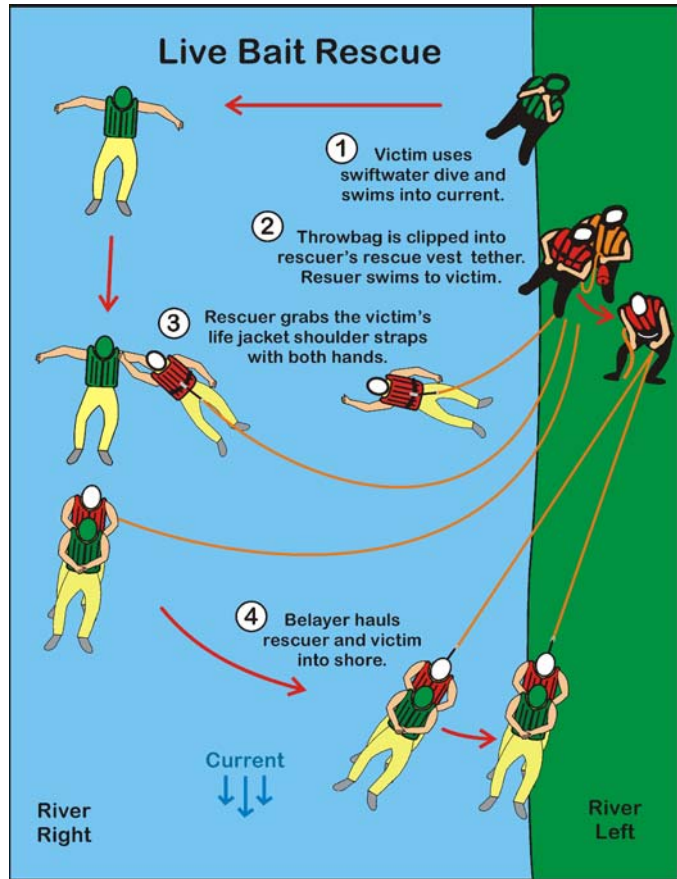


Figure 3.9: Live Bait Rescue – The tethered swimmer “live bait swimmer” swims out rescues the unconscious swimmer or equipment and hauled back to shore. Source: author – [file:\ROPE-LiveBaitRescue.cdr]

Simple hand signals can be used by the rescuer. If the rescuer point toward river right, the river right belayer pulls in line and the river left belayer lets out line. If the rescuer points downstream, both belayers let out line and if the rescuer points upstream, both belayers take in line.

When doing the V-Lower exercise, the rescuer will normally want to move left and right, and move upstream and downstream also. Also, the rescuer should ball-up and arch his back. Balling-up tends to sink the rescuer in the current. In contrast, arching the back tends to raise the body out of the water in a planing action. This is a good exercise to experience these experiences. When done, release the rescue belt and swim to shore. The tether remains attached to the line.

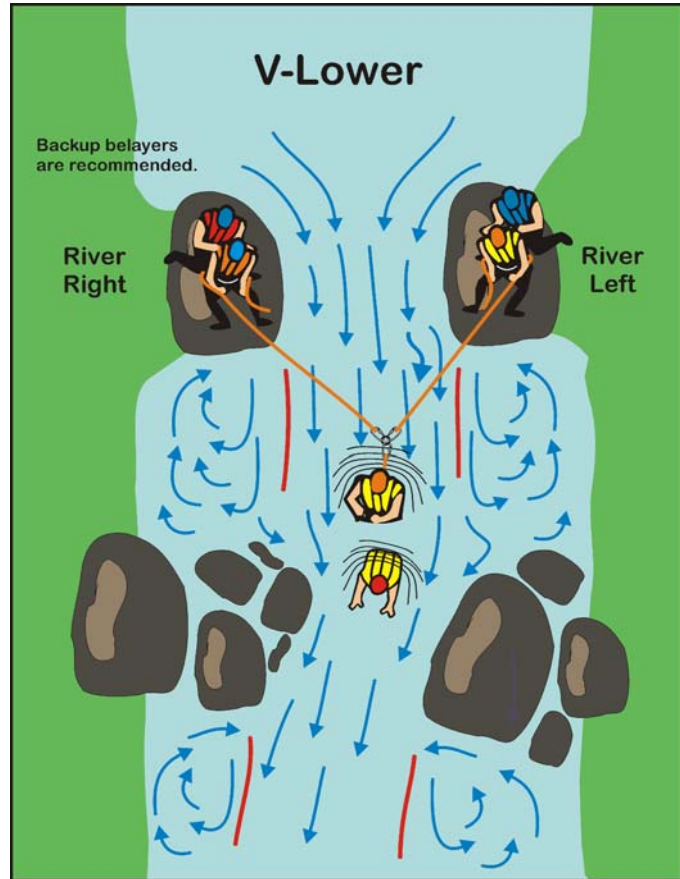


Figure 3.10: V-Lower – The V-Lower lowers a rescuer in the current. Use only with a rescue vest. Source: author – [file:\ROPE-V-Lower.cdr]

Cinches

As the term suggests, cinches use ropes to grip the victim firmly during the extrication. There are numerous cinches available. Three cinches are presented in this section. The first is the simple cinch. It was chosen because it can easily be morphed from a stabilization line. The Kwi cinch is a same shore rescue. The Carlson cinch is a true cinch where the victim will not slip out of the cinch.

Simple Cinch (Figure 3.12) – The simple cinch converts a stabilization line into a simple cinch. It shows how one system can easily be converted into another. The steps listed for creating a simple cinch are listed below.

Step #1: Throw the Rope –

A stabilization line has been established on the victim. The first step is to stretch a line across the river. This rope will create the cinch. The rescuer on river left throws a

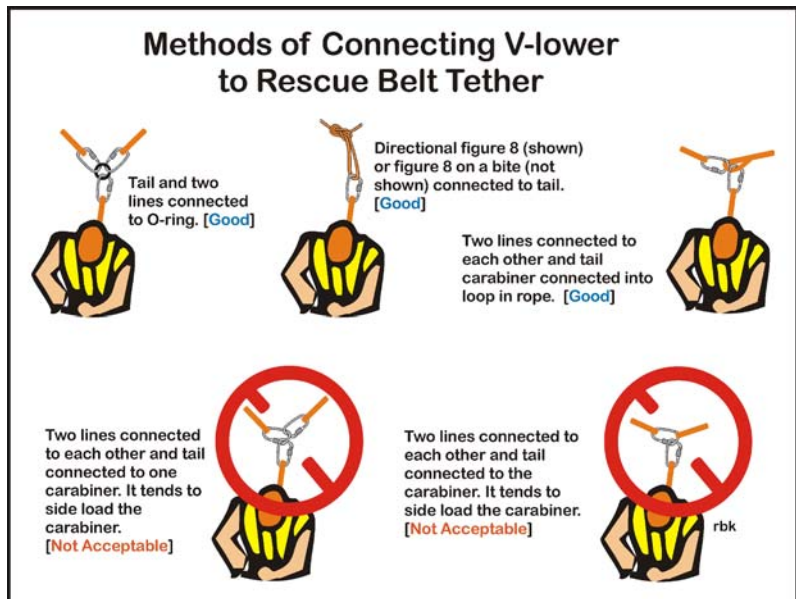


Figure 3.11: Methods of Connecting V-lower to Rescue Belt Tether – When connecting the line to the tether on the rescue vest, avoid situations that can side load a carabiner. Source: author – [file:\ROPE-V-LowerTetherHookup.cdr]

throw bag to the rescuer on river right.

Step #2: Clip In – The rescuer on river left clips the throw bag line into the stabilization line. Usually, it is the non-bag end of the throw bag.

Step #3: Cinch – The river right rescuer works the cinch. He moves downstream and pulls the rope down the stabilization line until it cinches snugly around the victim. To extricate the victim, the belayers on the river right side pull on the victim at an angle.

Step #4: Swing to Shore – When the victim comes loose, the river right belayers pendulum the victim to shore. The river left belayers give slack but maintain a snug cinch. The rescuer working the cinch can also haul the victim toward shore.

Kwi Cinch (Figure 3.13) – The Kwi Cinch is a same shore based cinch to extricate a victim who is reasonably close to shore. The steps for the Kwi cinch are listed below.

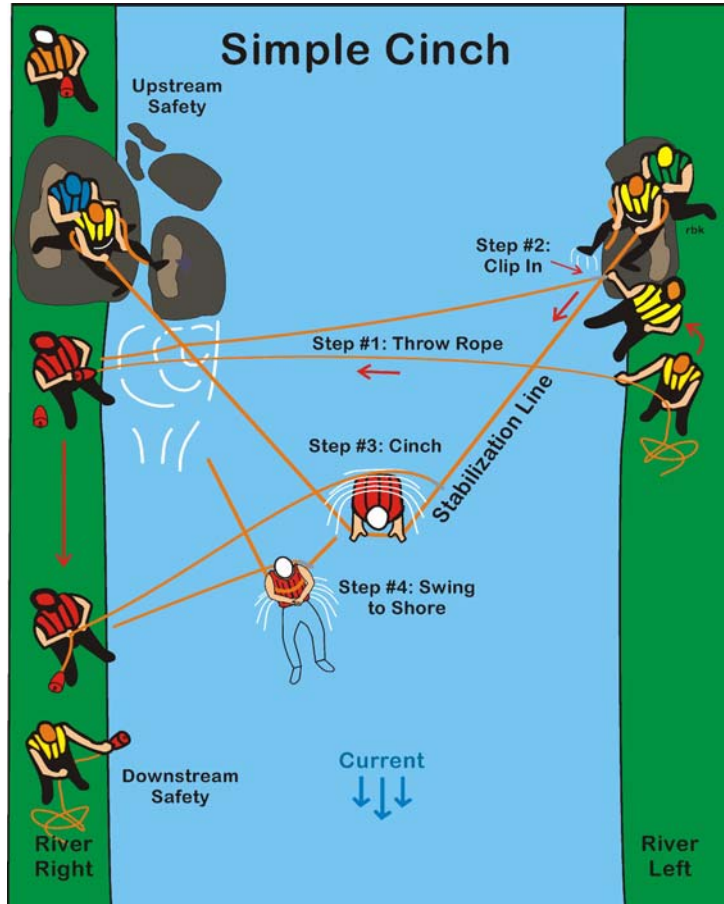


Figure 3.12: Simple Cinch – The simple cinch can morph quickly from a stabilization line. Source: author – [file:\CNCH-SimpleCinch.cdr]

Step #1: Find the Center of the

Rope – In Step #2, the two rescuers are going to simultaneously throw their end over the victim. Hence, the two rescuers need to find the middle of the throw bag line. Their half of the line will form the line they throw around the victim.

Step #2: Coil the Ropes and Simultaneously Throw Both Ropes – Each rescuer coils his end of the rope using a butterfly coil or a simple coil. They simultaneously throw their coils together. This requires coordination between the two rescuers. The upstream rescuer throws his coil with his right hand. The downstream rescuer throws his coil with the left hand. Remember to hold the end of the line with the other hand.

Step #3: Over and Under – The crux move is the over and under. In order to create the cinch, the two rescuers exchange places. The upstream rescuer goes over the line of the downstream rescuer and the downstream rescuer goes under the line of the upstream rescuer. This creates the cinch.

Step #4: Cinch and Extricate – The two rescuers tighten the cinch around the victim. They extricate the victim by pulling on the upstream portion of the cinch and swing the victim to shore.

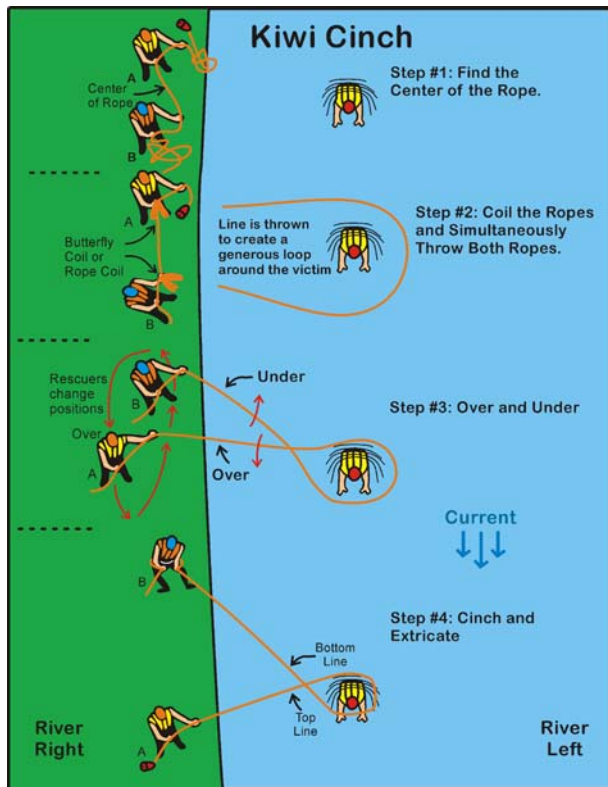


Figure 3.13: Kiwi Cinch – The Kiwi cinch is a same side cinch where the victim is reasonably close to the shore. Source: author – [file:\CNCH-KiwiCinch.cdr]

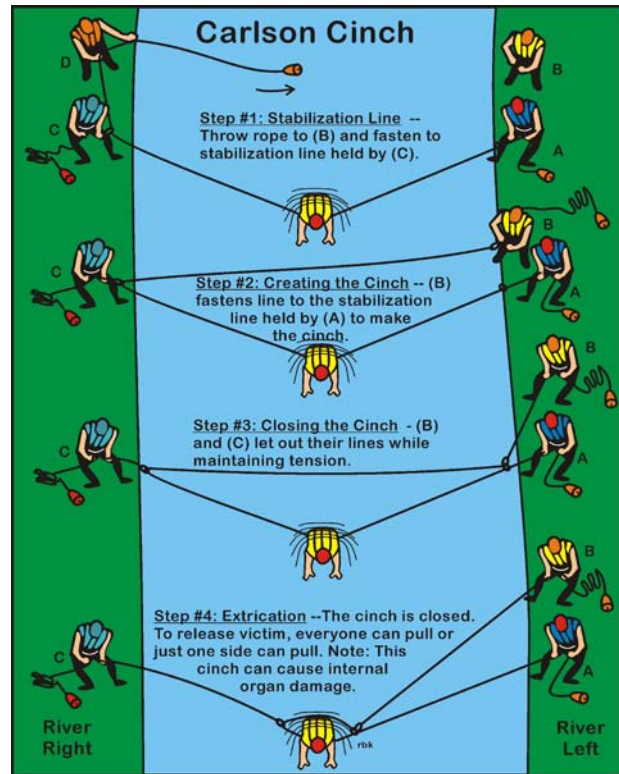


Figure 3.14: Carlson Cinch – A true cinch, the Carlson cinch should only be use where it is a life and death situation or body recovery. It can cause internal organ damage. Source: author – [file:\CNCH-CarlsonCinch.cdr]

Carlson Cinch (Figure 3.14) – The Carlson cinch is a true cinch where once the victim is cinched, the victim is not going to become uncinched. Although an experienced rescue team can moderate the tightness of the cinch, the Carlson cinch tends to cinch even tighter when the rescuers pull the victim free. This can cause damage to internal organs. For this reason, the Carlson cinch is used when it is a life or death situation for the victim or in body recoveries.

Step #1: Stabilization Line – A stabilization line has been established on the victim. The Carlson cinch will convert the stabilization line into a cinch to remove the victim. In this step the river right rescuer throws a throw bag over to the river left side and fastens his end to the end of the stabilization line on the river right side with a carabiner.

Step #2: Creating the Cinch – With a carabiner, the river right rescuer fastens another line to static line connected with the attached throw bag. This act converts the static line into a cinch. On the river left side, the throw bag from the other side is connected to the static line so that it can move freely along the static line. Another line is hooked into the carabiner also.

Step #3: Closing the Cinch – The lines attached to what was formerly the static line or stabilization line on both the river right and left sides work in opposition to each other as the cinch is closed by the river right rescuer. Rescuer (a) pulls on the line which closes the cinch.

Step #4: Extrication – The cinch is closed. If both rescuers B and C pull on their ropes, they can counteract the cinch and reduce its effect. This is easier said than done. Extrication can occur one of two ways. Both sides can pull the cinched victim off the entrapment, or the river left rescuers can pull the victim off the extrication. Usually, this is the extrication method.

Summary

The trend in swiftwater rescue is toward rescues that don't require lots of equipment and resources. For paddlers, several carabiners and throw bags are the norm. The throw bag forms the basic tool used in most rescues.

First, stabilize the victim. A stabilization line can accomplish this. However, don't overlook other methods. A rescuer on a rope tether may keep the victim's head above water. Also, think multiple systems. For example, while the rescuer is holding the victim's head above the water, other rescuers can set up a stabilization line or snag line.

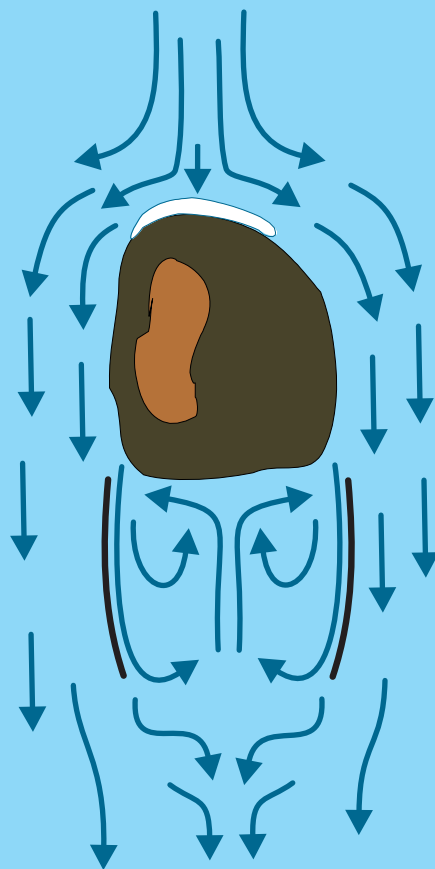
Next, extricate the victim. A snag line or cinch can be used to pull the victim. Many of the systems can easily be morphed into another rescue. For example, the stabilization line can easily be converted into a simple cinch or Carlson cinch, if needed.

References

- Kauffman, R. (2015). *Swiftwater Rescue Packet*. McHenry, Maryland: Garrett College. Unpublished packet.
- Walbridge, C., and Sundmacher, W., (1995). *Whitewater Rescue Manual – New Techniques for Canoeists, Kayakers, and Rafters*. Camden, Maine: Ragged Mountain Press.

Chapter 4: River Dynamics

Anatomy of an Eddy



Chapter 4: River Dynamics ¹

Moving water has power. A swiftwater rescuer needs to understand moving water. This section covers river dynamics which provide the foundation for river reading. The dynamics of moving water covered in this section includes river currents, river obstacles, and river hazards.

River Currents

River Right and River Left – River right and river left are an orientation used by river users. The orientation is noted on many of the diagrams. Looking downstream, river right is the right shore and river left is the left shore. Looking upstream, river right is the left shore (if looking downstream), and river left is the right shore (if looking downstream). Looking upstream, what is on the right is really on the left, and what is on the left is really on the right.

Primary Current (Figure 4.1) – The primary current refers to the general direction in which the river is flowing. It is the current found in an unobstructed main channel. In Figure 4.1, the primary flow is represented by the laminar flow. The slowest moving water is next to the bottom and each successive layer of water toward the surface flows faster than the layer below it. The fastest moving water is found just below the surface. This is because the air next to the surface creates friction which slows the surface water slightly.

A way to conceptualize this principle is to imagine sheets of plywood stacked on the floor with wooden dowels between each of the sheets of plywood. Push the stack of plywood. The next higher sheet of plywood on the stack will travel at the speed of the lower sheet plus its own speed. Hence, the higher the stack of plywood, the greater the speed that the plywood. The last sheet of plywood representing the surface of the water travels slightly slower than the sheet below it because of friction with the air above it.

The major implication of this principle for a rescue swimmer is when swimming in the defensive swimming mode. Often, it is difficult to keep the feet on the surface of the water since

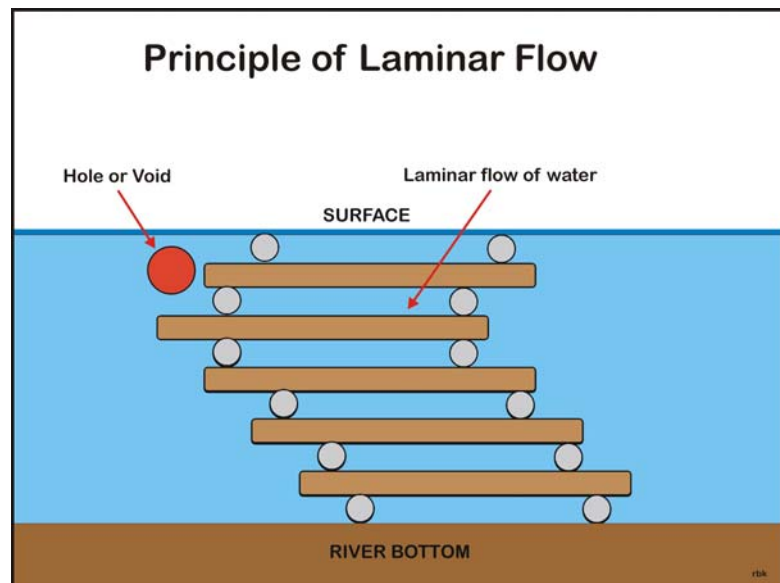


Figure 4.1: Laminar Flow – Laminar flow is like a series of sheets of plywood where each layer travels at the speed of the sheet below it plus its own speed. Source: author – [file:\RIDY-LaminarFlow.cdr]

¹ This chapter was written by Robert B. Kauffman who is solely responsible for its content. The source material for this section was adapted from a draft of Building Your Canoe Basics (Chapter 6) in *Outdoor Adventures: Canoeing*. American Canoe Association (eds), Human Kinetics, March, 2008. This chapter is copyrighted © Robert B. Kauffman, 2016.

the slower current below the surface tends to pull the feet downward.

The laminar flow is a function of the depth of the river. Since the channel is normally deeper in the middle and decreases in depth to the shore, the current in the center or deepest part of the channel is faster than current close to the shore. The difference in the speed of the current on the surface of an unobstructed channel is represented in Figure 4.2. Again, this represents a normal river channel which gets shallower toward the shore. As a footnote, canals, bridge abutments, and similar walled channels are similar to taking the center out of the channel all the way to the canal wall, bridge abutment, or similar walled channel. In these situations, there is little current differentiation from the center of the river to the channel wall. Rocks and other obstructions can affect this flow. Submerged rocks in deep channels can force vertical currents that reach the surface as boils.

Downstream and Upstream “Vs” (Figure 4.3 and Figure 4.4) – Two rocks or other objects can create a restriction in the water where the water flows between the rocks to form a small chute. The rocks form an upstream V and the chute between the rocks forms a downstream V. There is a difference in vertical height between the upstream and downstream Vs. The water piles up against the rock creating an increase in the vertical height of the water. Also, it creates a cushion of water against the rock. Conversely, the water drops off quickly in between the two rocks forming a chute and a downstream V. Also, it is lower in elevation. Boaters and swimmers look for this difference in height as they look for downstream Vs and avoid upstream Vs. Figure 4.3 shows a typical stretch of river with its upstream and downstream Vs. Figure 4.4 provides a view from a swimmer’s perspective of the change in elevation and the upstream and

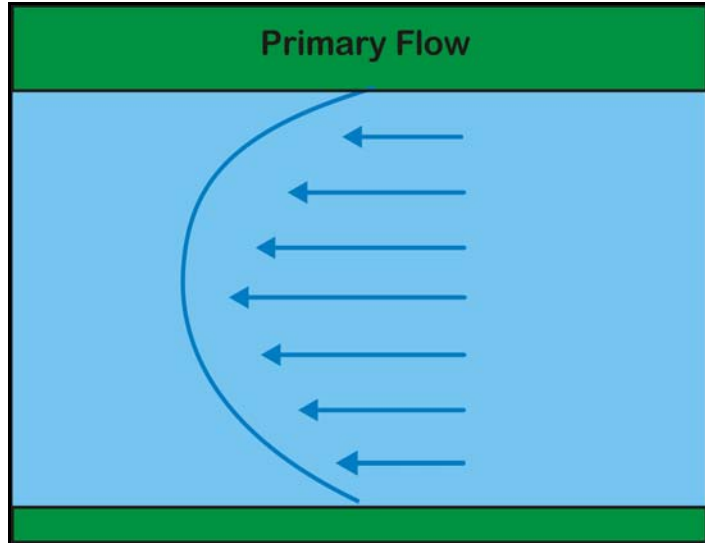


Figure 4.2: Primary Flow – The shores are shallow and the center of the river is deeper. This normal contour results in faster current in the center of the river and slower currents toward the shore. Source: author

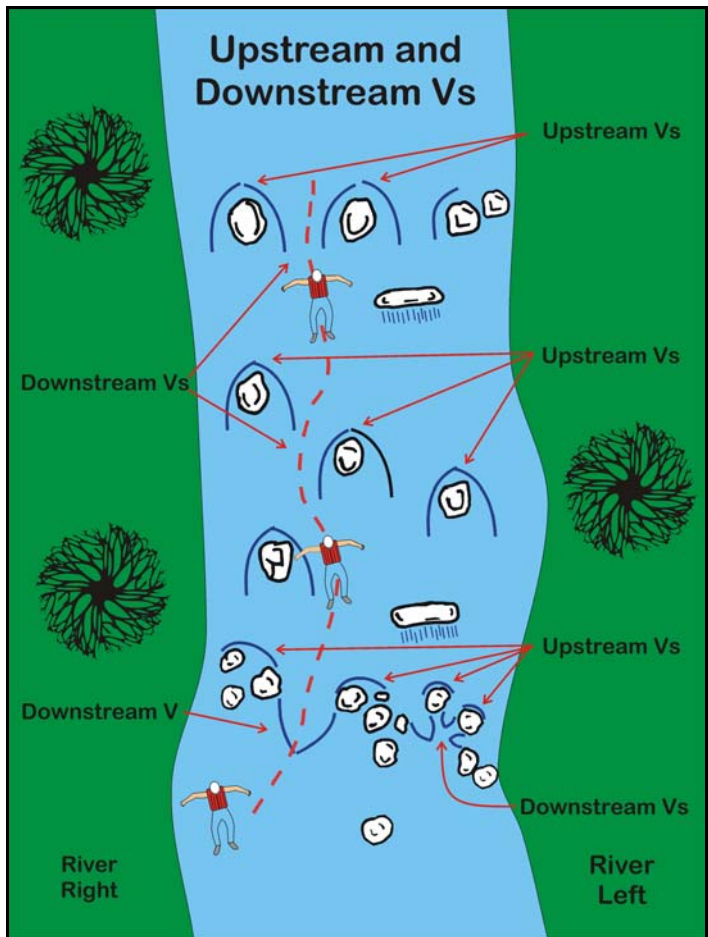


Figure 4.3: Upstream and Downstream Vs – This scene is a typical stretch of river where the swimmer looks for the downstream Vs and to avoid the upstream Vs. Source: author – [file:\RIDY-Vs.cdr]

downstream Vs. The height differential may be slightly exaggerated for emphasis. This is the view the swimmer would have running the stretch of river in Figure 4.3.

Bends (Figure 4.5) – Rivers tend to meander. When the river bends, inertia forces the main current toward the outside of the bend. As the deeper, faster and the more powerful current reaches the outside of the bend, it turns downward and creates a spiraling effect off the bottom of the river that leaves more room for surface water on the outside of the bend. The force of the water tends to erode the outside of the bend where trees and other debris fall into the river where they can form strainers. In contrast, the slower, shallower and less powerful current is usually found on the inside of the bend.

When swimming around a bend, the swimmer normally hugs the inside of the bend where the current is slower. Moving to the outside of the bend, the swimmer encounters the faster water which tends to push the swimmer into the outside bank where the swimmer is likely to encounter a strainer or other obstruction. Second, when swimming a bend, the swimmer sets a slight ferry angle with the head pointing toward the inside of the bend. Since the current is going faster on the outside of the bend, if the swimmer remains parallel with the current, she will be turned around by the current. This is because the head and shoulders are moving faster than the feet.

Chutes and Waves

(Figure 4.6) – A narrow constriction in the water forces the water to increase its speed through the constriction. This water usually forms a smooth tongue of water. After the water passes through the

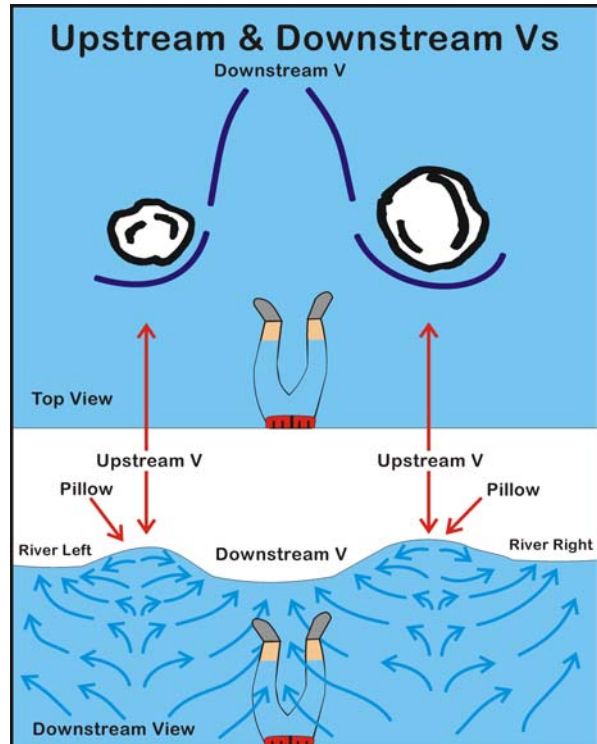


Figure 4.4: Upstream and Downstream Vs – This is the view from the swimmer’s perspective. Note the subtlety in height between the upstream Vs (high) and downstream Vs (low). Source: author – [file:\RIDY-Vs&Tongues.cdr]

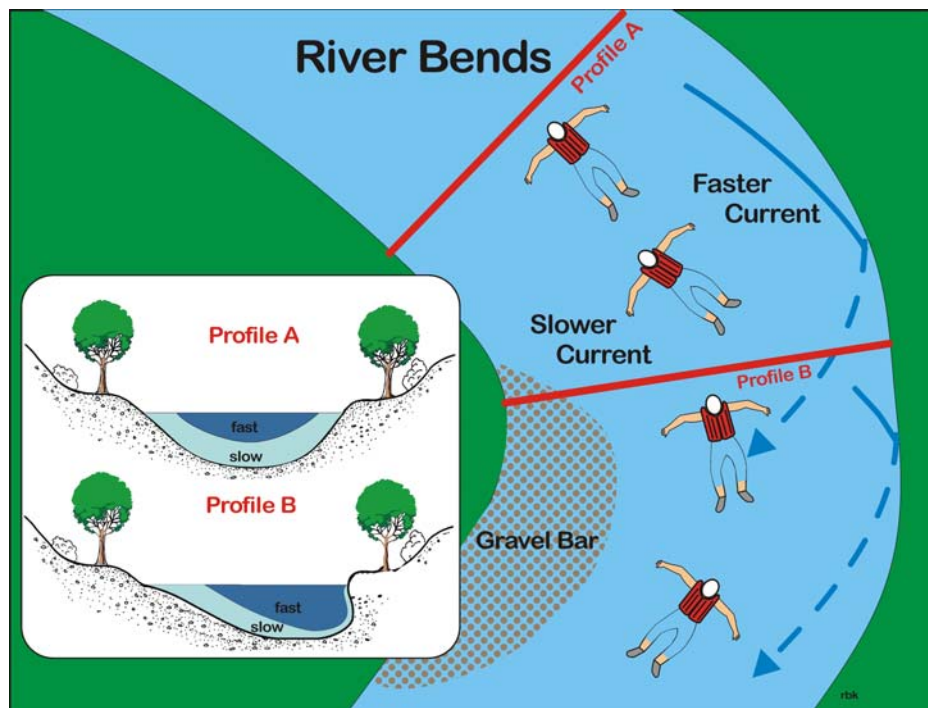


Figure 4.5: Bends – When swimming in a bend in the river the swimmer “sets” or points their head toward the inside of the bend to avoid being turned around by the current. Source: author – [file:\RIDY-Vs.cdr]

constriction, its deceleration into a deeper and slower water results in a series of uniformly spaced scalloped shaped standing waves. The constriction can vary several feet in width to a river wide constriction. The former creates a simple drop with small waves. The latter river wide constriction can create large standing waves several feet in height from the trough to top of the wave. An important consideration for the swimmer is to coordinate her breathing so that she breaths in between the waves and not as she goes through the wave.

River Features

Rocks are the main obstacles found in a river. The depth of the rock in the water and its size are key factors in determining the effect of the rock on river dynamics. Pillows, holes and eddies are closely related. A totally submerged rock may have little or no effect on the surface current. As the rock gets closer to the surface, it will force the water passing over it upward to the surface creating a small wave or *pillow* downstream of the rock. As the rock or obstruction widens, water from the side cannot fill in behind the rock. This results in a depression or void behind the rock. Now the water flowing over the rock attempts to fill the void creating a *hole* or *hydraulic* behind the rock. As the rock becomes exposed, the water can no longer flow over the rock and can only fill the void behind the rock from the sides. *Eddies* are created by the water filling in the void from the sides behind an exposed rock.

Eddies (Figure 4.7) – Eddies are formed behind rocks or other obstructions in the river. Water flows past the obstruction creating a void behind the object which the water attempts to fill. There are three distinct parts of an eddy which are created by the water attempting to fill the void.

The first part of the eddy is where the water in the main current rushes by the rock so fast that in order to fill the void the water has to flow back upstream (see #1 in Figure 4.7). This creates a very strong current differential between the main current and the current in the eddy. The interface between the downstream current and the upstream current creates an eddy line or even an eddy wall. As the current increases dramatically, the eddy line becomes an eddy wall. An eddy wall is the vertical height difference between the downstream current and the current in the eddy attempting to fill the void behind the rock. If there is an eddy wall, there is a noticeable downhill current inside the eddy also. For a rescue swimmer, this powerful of an eddy can be problematic and the rescue swimmer can find the eddy unfriendly. However, most eddies will have an eddy line where there is little or no vertical difference between the main current and the upstream current in the eddy.

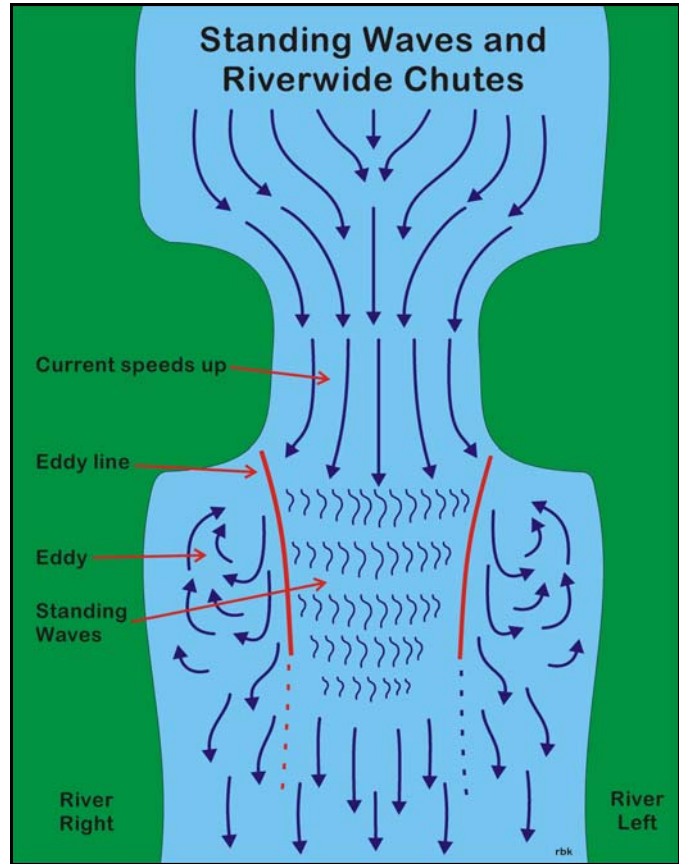


Figure 4.6: Chutes and Waves – Water speeds up in a constriction of the channel and then it is dissipated as it drops. This creates a series of standing waves. Source: author – [file:\RIDY-Chutes.cdr]

The third part of an eddy is where the water in the main current enters the void behind the rock so far downstream that it continues on downstream but at a slower rate than the main current (see #3 in Figure 4.7). This area of an eddy can be problematic for rescue swimmers because rescue swimmers may think that they are in the upstream current in the eddy when they are really moving downstream, and quickly falling out of the eddy (see Figure 4.7). In addition, since the current is moving downstream in the eddy, there is no real eddy line present in this portion of the eddy. Many beginning rescue swimmers will prefer entering an eddy in this area because there is no current differential and there is less risk of having to cross the eddy line. This is okay but remember to swim upstream into the eddy.

The second part of the eddy is the interface between the current moving upstream and downstream in the eddy. The current here is neutral. In a strong eddy, this is often the ideal location for a rescue swimmer to remain stationary. They aren't being plastered against the backside of the rock by the upstream current where it is difficult to exit the eddy, and they aren't falling downstream either.

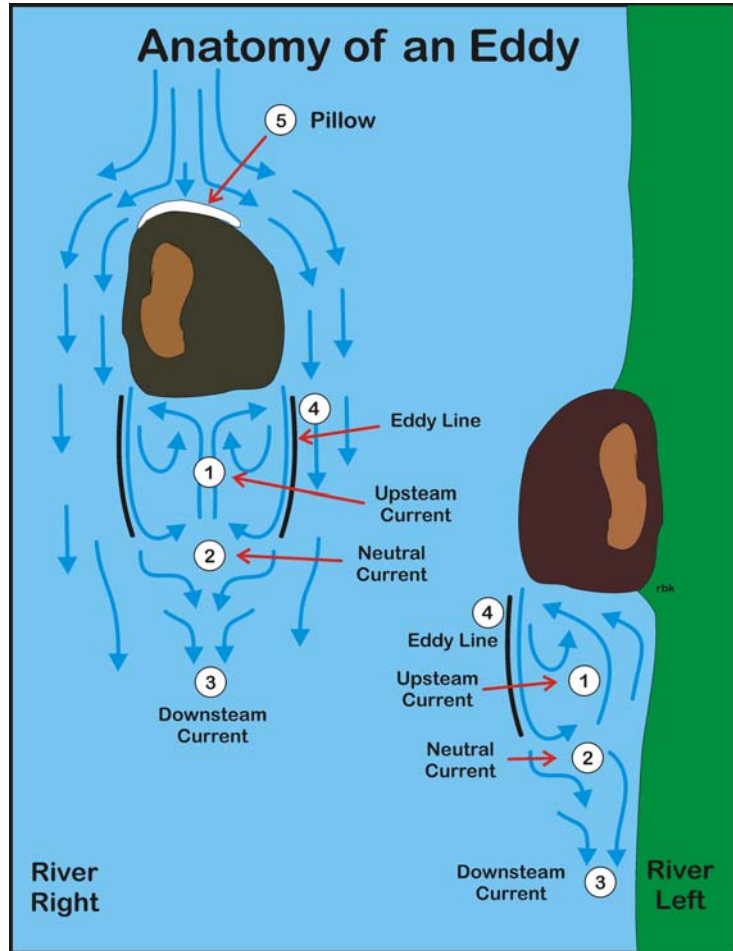


Figure 4.7: Anatomy of an Eddy – In the anatomy of an eddy, there are three parts. There is the water moving back upstream. The eddy line occurs in this section. There is a neutral area, and there is a downstream moving area. Source: author – [file:\RIDY-EddyAnatomy.cdr]

Conceptually, the three parts of an eddy have many of the same characteristics as a hole or hydraulic. Both are caused by the river attempting to fill a void. In a sense, an eddy is a hole rotated on its side. Most eddies are friendly and rescue swimmers will use them extensively as they eddy hop down a river. However, remember that some eddies can be violent and very unfriendly also.

Hydraulics and Holes (Figure 4.8) – A hole occurs in the river when a rock or other obstruction of sufficient width to prevent the water from filling in the obstruction from the side forces the water flowing over the rock to fill the void or depression behind the rock. As the water flows over the rock, it plunges down to the bottom of the river and races downstream. As it races downstream, the water shoots back up to the surface where it moves in one of three directions. A portion of the water re-circulates back upstream to fill the void behind the rock (1). Further downstream, some of the water comes up to the surface and continues on downstream (3). This water travels at a slower rate than the general flow of the river and quickly picks up speed as it moves downriver. In between or at the interface of the upstream and downstream flow, the flow is neutral in that it is not really flowing downstream or upstream (2). This neutral area is called the “boil.”

The shape of the hole affects how friendly it is. In a *smiling hole* the center of the hole is further upstream than the sides. This creates the impression that the hole is smiling when looking at the hole from the upstream side. It tends to be more friendly to a swimmer or paddler since they will find it easier to maneuver to the side of the hole where they can exit the hole.

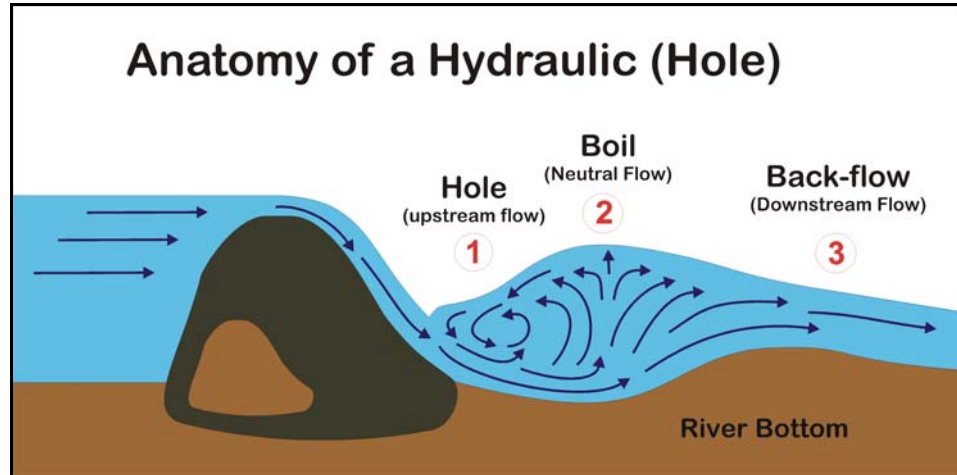


Figure 4.8: Anatomy of a Hydraulic – In the anatomy of an eddy, there are three parts. There is the water moving back upstream attempting to fill the hole. There is the neutral area or boil, and the downstream flow. Source: author – [file:\RIDY-HydraulicTypical.cdr]

In contrast, in a *frowning hole*, the middle of the hole is downstream of the sides. From the upstream side of the hole, it looks like it is frowning. Since the middle of the hole is downstream, the force of the hole tends to move the swimmer or paddler to the center of the hole where it is strongest and most powerful. These holes are often called *keepers* because they keep a person stuck in the hole. They are difficult to exit because the swimmer or paddler has to literally paddle uphill to reach the side of the hole where they can extricate themselves from the hole.

If you are paddling a canoe or kayak you can easily feel where you are in the hole. If you are on the upstream side of the boil, you can feel the pull of the current pulling the canoe upstream and into the hole. Conversely, if you are on the downstream side of the boil, you can feel the boat slipping downstream and dropping out of the hole. If you are sitting on the shore and watching the paddler you can play a little mental game where you look closely at the attitude of the canoe and tell where the canoe is in the hole. Look at the trim of the boat. If the stern is lower than the bow, then the canoe is in the downstream portion. Unless they paddle hard, they are out of the hole, and they might as well ferry to the shore and try again. If the bow is lower than the stern, the canoe will move upstream and into the hole.

Understanding these currents on an experiential level can be of benefit to the swiftwater rescuer. The rescuer can approach the victim in the downstream current behind a low head dam or keeper hole and throw a rope to the victim trapped in the hole. This area is perfectly safe for the rescuer, but the rescuer needs to know exactly where they are in terms of these three currents. Once the rescuer crosses the boil, it is all downhill and they too can become a victim. This is not an uncommon situation. This author has reviewed more than one case where the rescuer crossed the boil and died. It is important to know where you are in terms of the currents pictured in Figure 4.8.

Pillows (Figure 4.9 and Figure 4.10) – As the rock approaches the surface, it will force the water passing over it upward to the surface creating a small rounded wave or pillow downstream of the rock. The further underneath the water that the rock is in the water, the further downstream the pillow. And, as the rock moves closer to the surface, the pillow moves closer to the rock until it is directly over it. It takes experience for a swiftwater rescuer to recognize which pillows are close to the surface and need to be avoided and which ones are deep enough not to pose a problem.

When the rock finally emerges out of the water, the pillow becomes a cushion of water that flows up against the rock forming a *cushion*. A boater floating up on a well developed cushion can use the cushion to avoid broach on the rock. Regardless, it requires quick thinking and a quick reaction to avoid broaching. In addition, if the current is powerful enough, the rock may actually form a series of compression waves upstream of the obstacle (Figure 4.10).

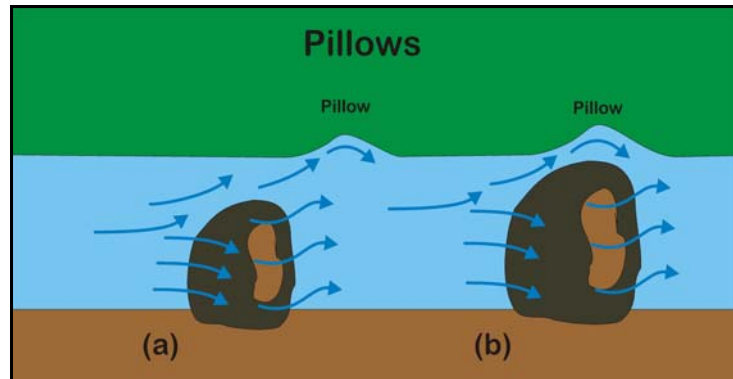


Figure 4.9: Pillows – The water hits the top of the rock forcing it to the surface creating a downstream bubble or pillow on the surface. Source: author – [file:\RIDY-Pillows.cdr]

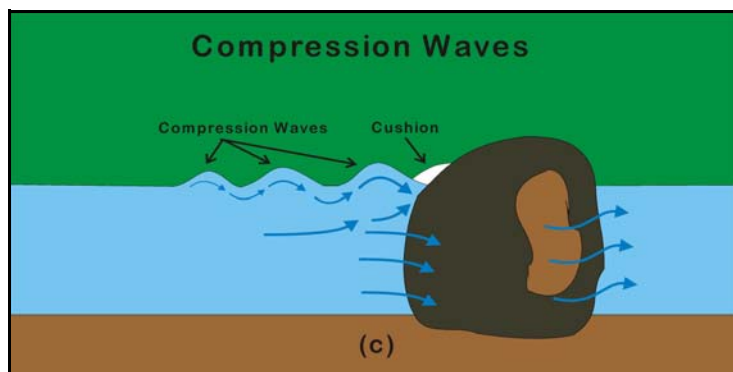


Figure 4.10: Compression Waves – The water hits the front of an exposed rock and creates a cushion because it has no where to go. Source: author – [file:\RIDY-CompressionWaves.cdr]

River Hazards

Strainers (Figure 4.11) – Strainers are formed when water flows through an obstacle. Much like spaghetti in a colander, water flows through the strainer leaving the victim trapped helplessly. Strainers are most commonly formed by trees and rocks. STRAINERS ARE KILLERS. They are extremely dangerous and river users should always avoid them.

Trees are the most commonly encountered form of strainers found on a river. As a river continues to carve out a bend in the river, trees along the bend will fall into the river channel as the river current undermines the foundation underneath the tree. Also, a strainer on the bend of a river is particularly dangerous since the current is faster there and the rescue swimmer who is flowing with the current is more likely to be swept into the strainer.

Rocks can also cause strainers. Usually, the rocks are positioned on the bottom in such a way that water will flow thru them to create a strainer. Often, these strainers are referred to as undercut rocks. Water boiling up from the bottom in an eddy or an eddy without an eddy line is often a good indication of an undercut rock.

The strainer drill helps to prepare students for handling strainers. Again, avoidance is the primary strategy. If there is no avoiding the strainer, swim aggressively toward it and try to get as high up onto it to avoid drowning.

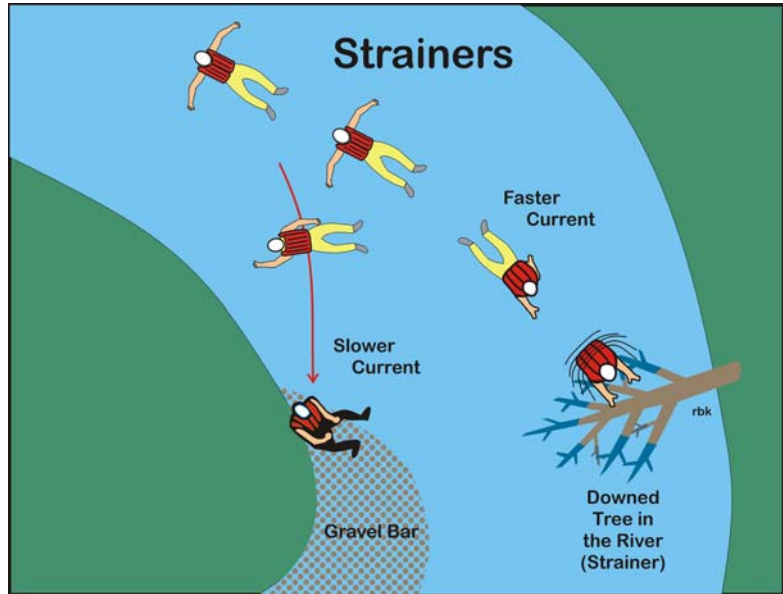


Figure 4.11: Strainers – A strainer allows the water to pass through but holds the swimmer. They are killers and should be avoided. Source: author – [file:\RIDY-Strainers.cdr]

Undercut rocks – Most undercut rocks are a form of strainers. The main attribute of an undercut rock is that the water flows underneath rather than around the rock. Depending on its size, the current can sweep a victim underneath the rock and impale the victim in the orifice of the undercut rock (strainer).

For most boaters, a good indication of an undercut rock is that normal river features like an eddy don't behave as they normally do. They seem weird or different and they act weird because the currents are different. The eddy pictured in Figure 4.12 is modeled after an undercut rock on the Lower Youghiogheny River.

Typically, there are several symptoms or characteristics to help spot an undercut rock. First, the pillow or cushion on the upstream side of the rock is missing. This is because the current is flowing through and not piling up against the rock. Second, the current flowing through the orifice creates a boil with its outflow. The boil and outflow significantly changes the river feature. The eddy pictured does not behave as an eddy normally behaves (see Figure 4.7). Next, there

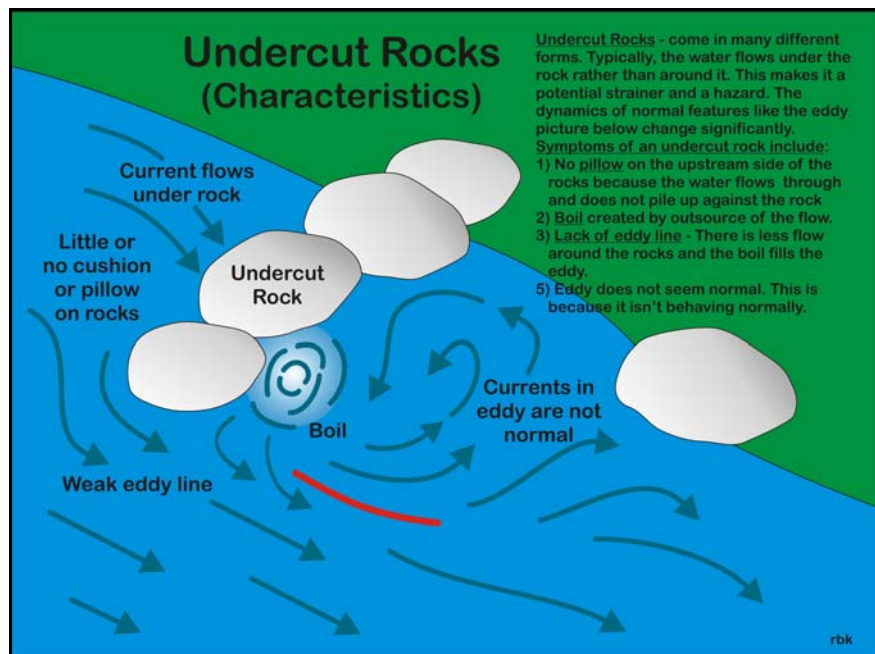


Figure 4.12: Anatomy of an Undercut Rock – To the trained eye, the undercut rock seems very different than a normal river feature. Source: author – [file:\RIDY-UndercutRocks.cdr]

is less current flowing around the rock. The eddy line may be weak or missing. The outflow current may reduce the current differential and eddy line. A boater entering this eddy would immediately experience the lack of an eddy line to cross and the force of the outflow current. Last, because of the outflow and boil, the current in the eddy is different than normal.

Low-head Dams (Figure 4.13) – A low-head dam and a hydraulic are essentially the same with some important differences (see Figure 4.8). Examination of Figure 4.8 and Figure 4.13 suggests that they are essentially the same diagrams. However, there are some important differences. The hydraulic behind a low-head dam is a “perfect” hydraulic. It goes from one river abutment to the other. The only exit may be to dive down and catch the water moving downstream. In contrast, naturally formed hydraulics are imperfectly formed and can usually be escaped. A low-head dam is designed to disperse the kinetic energy of the falling water upward rendering it harmless. Unfortunately, hydraulic is perfectly formed and extends from one abutment to the other abutment. This is why they are called the drowning machine.

A *horizon line* is the usual indicator of a river wide obstacle like a waterfall or low-head dam. Actually, this is a variation of the differential heights created by upstream and downstream Vs (see Figure 4.3), except there is no height differential. Hence, the horizon line. As you look downstream, there will often be a section of calm or smooth-looking water followed by a line across the river where the water drops out of sight. Trees on your side of the horizon line will look normal. However, the trees just downstream from the horizon line often look as if someone cut a section out of their trunks. If the horizon line is formed by a low-head dam there are usually abutments on each side of the dam which are a clear indication of the dam.

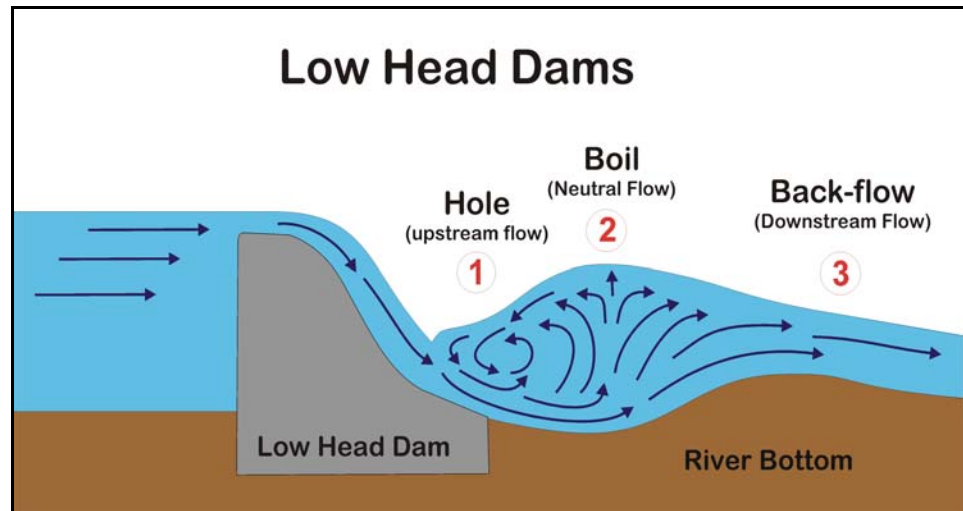


Figure 4.13: Low Head Dams – Low head dams are perfect hydraulics from abutment to abutment. They are killers and should be avoided. Source: author – [file:\RIDY-HydraulicLowHeadDam.cdr]

There are several approaches to rescuing a victim caught in the hydraulic of a low head dam. Several of these are in the province of the rescue squad and their specialized equipment. The first rule for any rescue attempt is to understand that the hydraulic behind a low head dam is a drowning machine. This applies to rescuers also. An untethered rescuer trapped in the hydraulic becomes another victim. There are cases where a bystander with full knowledge of the dangers of low head dams attempted a rescue and drowned in his rescue attempt to rescue two victims. One victim recycled out of the hydraulic and survived. The other victim along with the rescuer drowned.

The following are some rescue methods. The first requires the specialized equipment of a rescue squad. A fire hose is capped with a special cap and inflated with air. The hose is extended to victim trapped in the hydraulic. It works but requires the specialized caps. A Teflon lower can be used. This requires considerable setup time. Third, a power boat can maneuver in the slowly moving downstream current behind the hydraulic and throw a throw bag to the victim. A grappling hook can be used in place of the throwbag. A tethered victim can enter the hydraulic and effect a rescue. However, this can endanger the rescuer and should be used as a last resort, if at all. Maneuvering in the slackwater behind a hydraulic by rescuers requires an empirical understanding of the parts of hydraulic. This point cannot be emphasized enough.

Old Man-made Structures (no figure) – Most rivers contain man-made structures such as old dams or bridge abutments that have fallen in disuse. Sometimes these structures are potentially a fun place to play with a canoe or kayak. Always use caution around these structures. Rip-rap may contain large spikes. Old dams and bridge abutments may contain reinforcing rods or sharp rocks that can create nasty injuries. Check the site at low water for hazards and if there is any doubt, find another place to play.

Drowning Trap Flows (Figure 4.14, Figure 4.15, and Figure 4.16) – Any water level on the river can be hazardous. Ask people when the river is dangerous. Most people associate flood-like conditions with danger like muddy water, water flowing over the banks, water in the trees, floating debris and big waves. Floods and high water are dangerous and most people recognize the danger and stay off the river (Figure 4.14).

On many rivers, recreational fatalities tend to occur at moderate water levels when the river is well within its banks and the river looks perfectly normal (i.e. It is not flooding). The normal cycle of flows for rivers is that during the summer when most people visit the river, the water level drops to where the moving water is no longer a contributing factor in the fatalities. However, if the water level rises, the river can become very dangerous (Figure 4.15).

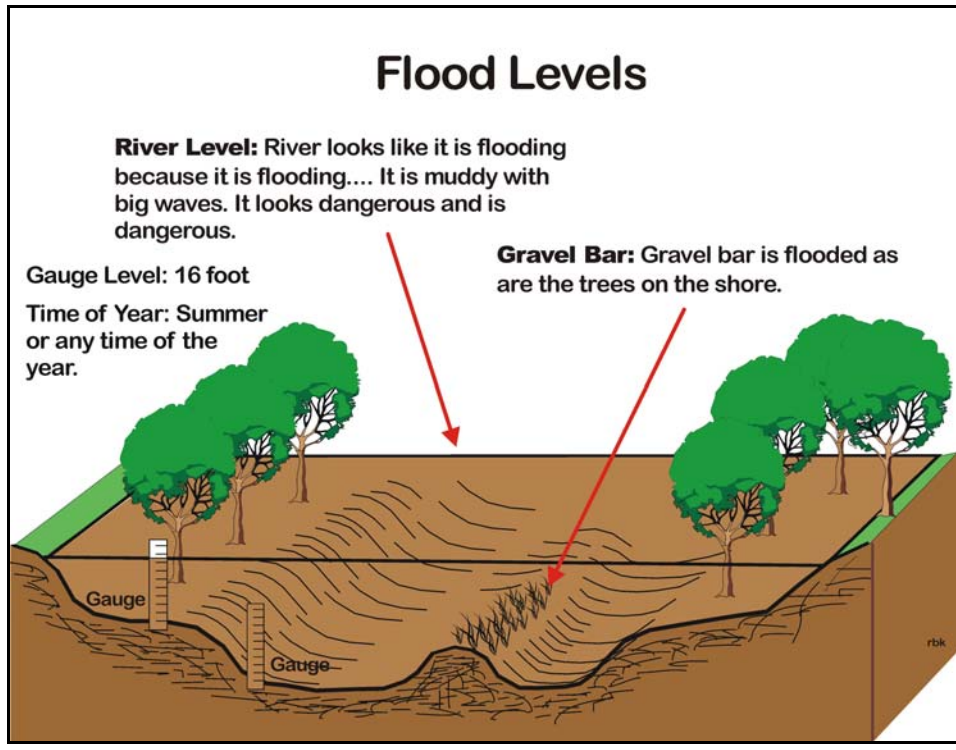


Figure 4.14: Flood Levels – Intuitively, most people recognize rivers flooding and the dangers associated with them. They avoid flooding rivers. Source: author – [file:\RIDY-DrowningTrapFlood.cdr]

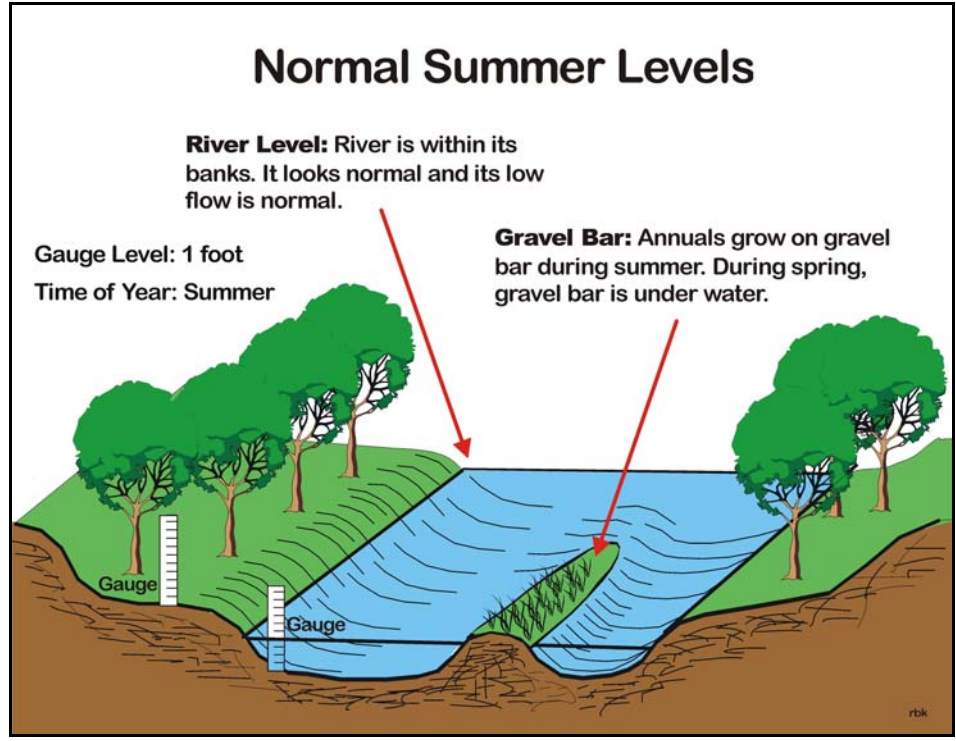


Figure 4.15: Drowning Trap – Normal Summer Flows – In the summer when most people visit rivers, the river is at low flow where it tends to lose its power as a contributing factor in accidents. Source: author – [file:\RIDY-DrowningTrapNormal.cdr]

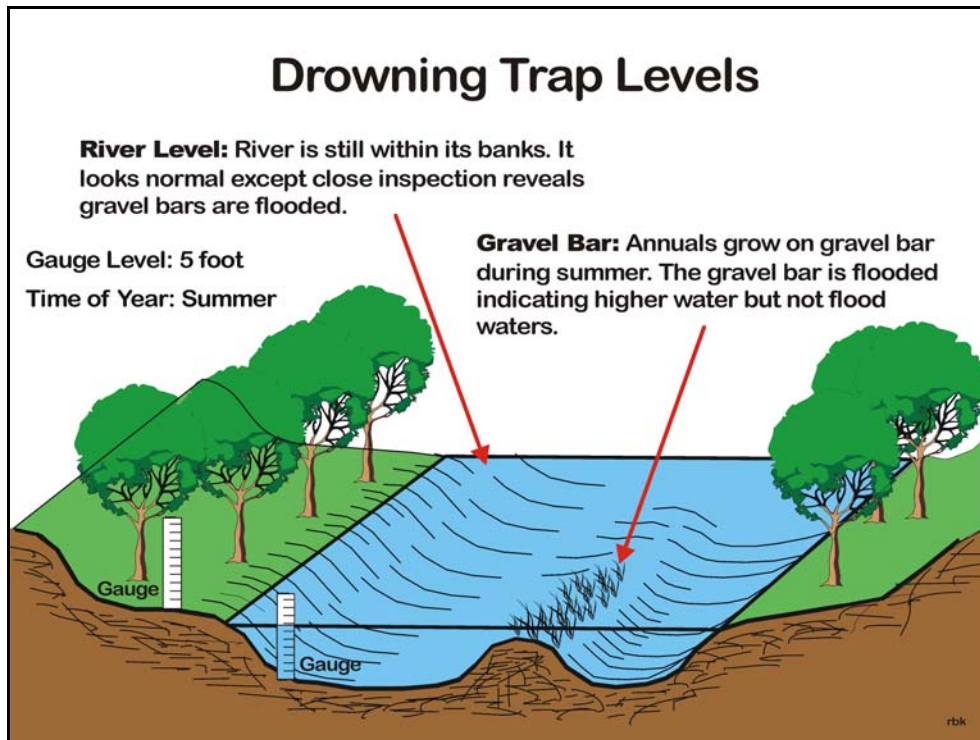


Figure 4.16: Drowning Trap – Drowning Trap Flows – When high flows occur during summer, the river current has the power to become a contributing factor in drownings. Since the river is within its banks, people don't perceive it being dangerous because there aren't flood conditions. Source: author – [file:\RIDY-DrowningTrapNormal.cdr]

Depth, velocity and deceptiveness define the drowning trap (Figure 4.16). At these moderate flows the river has the power (depth and velocity) to drown, yet it is deceptive since people tend to associate flood conditions with danger rather than moderate flows. The cross-sectional profile of a typical eastern river illustrates the relationship between moderate drowning trap flows, summer low flows and flood levels which people normally perceive as being dangerous.

The depth of the water is a key determinant of its velocity and its power. Imagine standing in moving water about waist deep. With some deliberate care you can brace yourself against the current and stand in the water. Add another foot of water so that the water is above your waist. Now the river current can easily move you. Perhaps it may knock you off your feet and sweep you downstream. When the river's speed reaches that of person walking fast, it begins to have the power to move you, knock you over and depending on circumstances, drown you.

A good indicator of drowning trap levels is when annual vegetation on gravel bars are inundated during the summer months. Look for those areas which were under water during the spring runoff. When this vegetation becomes either partially or fully under water, the river is higher than normal and may be in the drowning trap flows.

The third component of the drowning trap is deceptiveness. When asked, most people correctly associate flood-like conditions as being dangerous. And they are dangerous. However, in the Drowning Trap flows the river is well within its banks and to the casual visitor, the river looks perfectly normal. A study on the

Potomac River in Maryland found that three fourths of the river visitors visited two or less times to the river. Hence, most visitors have no reference point to determine what is the normal summer flow of the river. The river is not flooding and it looks normal because it is well within its banks. However, it has the depth and velocity to contribute to an accident. In this way it is deceptive because people don't readily recognize the danger for what it really is.

Summary

Having an understanding of river dynamics is important for the rescue swimmers. First, it helps the rescue swimmer not to become a second victim. This was evident in rescues behind a low head dam. Second, understanding and having familiarity with river dynamics is important as the rescuer moves in the river. It helps to facilitate a rescue, and again, it helps the rescuer in not becoming a second victim during the rescue. Third, understanding river dynamics goes hand-in-hand with river rescue. Last, wading and swimming rapids helps the rescuer to become familiar with the medium with which they are working. This familiarity is always a good thing.

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Chapter 5: Knots, Hitches, & Bends

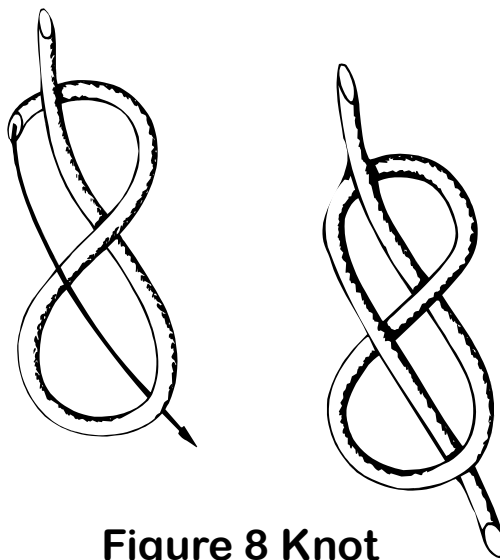


Figure 8 Knot

Chapter 5

Knots, Hitches, Bends and Anchors ¹

The term knot is used generically to cover knots, hitches, and bends. It is done so here. Technically, knots, hitches and bends are structurally different and serve different purposes. In addition, the three types of knots indicate three basic knot tying situations. The rope needs an object or another rope to maintain its internal integrity (i.e. hitch). It is fasten two ropes together (i.e. bend). Or it is a self-supporting knot in the rope that creates a loop or serves some other function. Along with principles and definitions, the three types of knots are used as the organizational structure and headings in this section.

Principles and Definitions

Knot – The critical element in determining a knot is that when it is tied, it is self-contained and self-supporting. It does not need another object or rope to maintain the integrity of the knot (e.g. a hitch does). And, it does not tie two ropes together (i.e. bend).

Also, it should be noted that the term knot is often the generic term used for hitches and bends much like Xerox ® is synonymous with copying and used interchangeably with all copying. Similarly, Kleenex ® is synonymous with tissue paper and used interchangeably with it. So generic is the use of knot as part of the nomenclature, obvious bends such as the water knot, grapevine knot, or barrel knot are actually called knots. This section recognizes the difference between knots, hitches, and bends. It is structured along these distinctions. However, the term knot is used generically and interchangeably with hitch and bends.

Hitch – A hitch needs an object or another rope to tie it. Without the object or other rope, it will fall apart. The other object or rope assists in maintaining its structure. Without a tent peg or tree limb, a clove hitch will fall apart. Without another rope, the Prusik will fall apart. Both need an object or another rope to maintain its structure and integrity.

Bends – Bends are used to tie two ropes together. The water knot is used to tie the two ends of webbing together to create a sling. Also, the water knot and double fisherman’s knot are really bends.

Families – Examination of knots reveals that their internal structure tends to repeat itself in other knots. This suggests that knots can be grouped into families. Also, this helps when visually examining knots because the configurations are the same. The figure eight family of knots is probably the largest family of knots and the it is really a variation of the overhand knot. The same configuration can be found in knots, hitches, and bends. The bowline and sheetbend have identical configurations. Two half-hitches and the clove hitch have the same configurations. Two half-hitches are tied around an object. A clove hitch is tied around an object. The fisherman knots are two interlocking overhand knots.

Families can be extended to include similar configurations but where the number of loops or other element is varied in the knot. The single, double, and triple fishermen knots (bends) have the same configuration except for the number of internal loops. The double sheetbend is similar to the sheetbend, except that it has a second internal loop. The barrel or triple fisherman has three internal loops.

¹ This chapter was written by Robert B. Kauffman who is solely responsible for its content. This chapter is copyrighted © Robert B. Kauffman, 2018.

Perhaps the most common knot group is the overhand knot (Figure 5.1). Add one more half turn and it becomes the all familiar figure eight knot. Add a third half-turn and the knot becomes the figure nine knot. So in a very real sense, the figure eight knot is really a variation of the overhand knot. The conclusion is that there are a few basic knots with many variations.

Parts of a Rope (Figure 5.2) – The following are some commonly used rope terms. It is useful in orientating and describing the parts of a rope as well as working with a rope. Some of the terminology seemingly overlaps with other terms, such as the difference between a bight and loop. The purpose of labeling the parts is that it helps orient the reader when describing how to tie the knots.

Bight – A bight is a bend in the rope where the line comes back on itself but doesn't cross over itself. It is a loop where the rope doesn't cross over itself. It is usually taken out of the center of the rope.

Loop – In contrast with a bight, a loop is a turn in the rope where the lines cross over each other. When tying a bowline, the first step is to make a loop. The line crosses over each other and held between the thumb and second finger. The first step in tying a trucker's hitch shown in Figure 5.2 is to create a loop (i.e. actually multiple turns). The second step is to create a bend that is pulled through the loop.

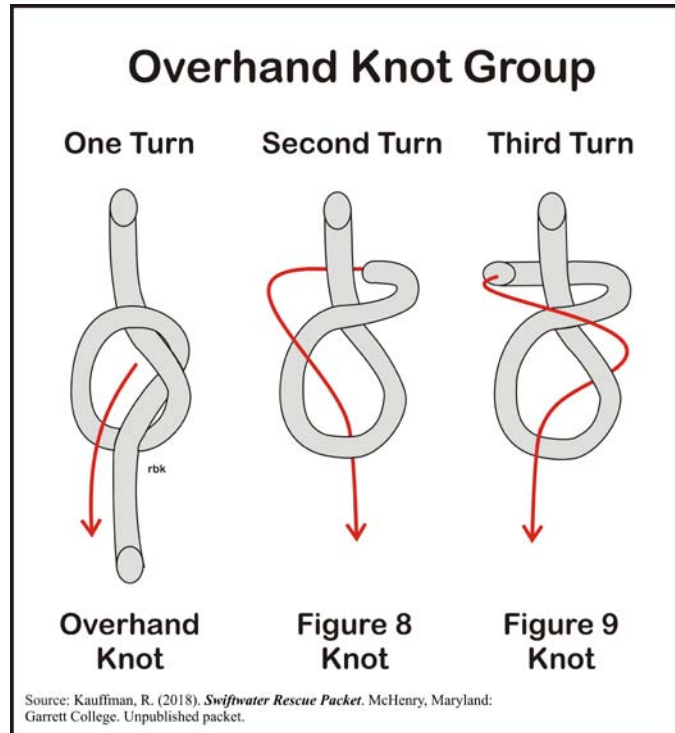
Working End – The working end is attached to the item being rigged or hauled. Think of it as the end of the rope working or currently occupied.

Standing End – The standing part of a rope includes all the rope excluding the working end.

Running End – The running end is the free end of the rope. Sometimes it is called the *free end*. It is part of the standing end of the rope and it is the section of the rope used to tie a knot, hitch or something else.

Tying Considerations – Some knots are selected because of their strength (e.g. figure-8). Some are chosen because a life might depend on the knot being “bombproof” (e.g. figure-8 on a bight). Some knots are selected because they can be tied quickly and untied easily (e.g. bowline). Others have a specific purpose or functions (e.g. double fisherman, Prusik, water knot).

Function – Many knots are designed for specific uses and functions. A sheetbend and double fisherman are designed to tie two ropes together. A water knot is designed to tie two pieces of webbing together but not two ropes. A bowline is designed to tie a loop in the rope. A clove hitch is designed to tie a rope to a branch or peg.



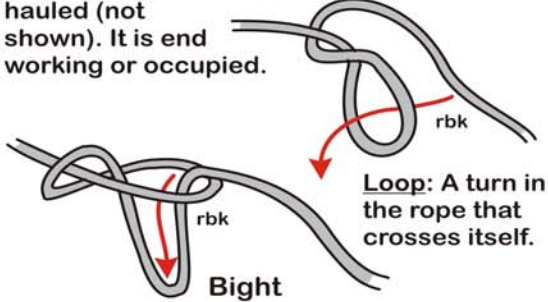
Source: Kauffman, R. (2018). *Swiftwater Rescue Packet*. McHenry, Maryland: Garrett College. Unpublished packet.
Figure 5.1 – Overhand Knot Group – Source: Author – [file:\-KN-OverhandGroup.cdr]

Parts of a Rope

Figure 5.2

Working End: The end tied off to object being hauled (not shown). It is end working or occupied.

Standing End: All the rope not fasten to the object being hauled.



Loop: A turn in the rope that crosses itself.

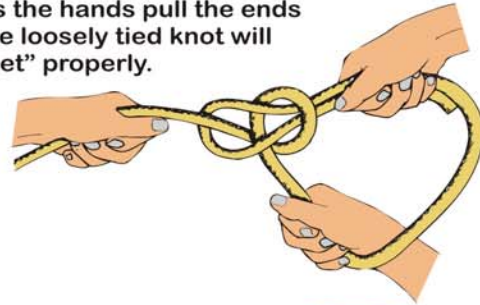
Bight: A loop that does not cross over itself, usually taken from the center of the rope.

Running End: The end of the rope not tied off and free to use.

Setting and Dressed

Figure 5.4

As the hands pull the ends the loosely tied knot will "set" properly.



This knot is not "dressed" properly. Note the kink or unwanted twist in the webbing.



Relative Strength of Knots

Figure 5.3

100%	No Knot
75%-80%	Figure 8
70%-80%	Bowline

65%-70%	Double Fisherman's
60%-70%	Water Knot

60%-65%	Fisherman's
60%-65%	Clove Hitch
60%-65%	Overhand Knot
60%-65%	Two Half-hitches

43%-47%	Square Knot

Types of Rope

Figure 5.6

Laid Rope



Solid Braid



Dynamic Kernmantle



A braided sheath is woven over the twisted-core which acts as a shock absorber.

Static Kernmantle



A protective sheath is woven tightly over the load-bearing parallel-fibers in the core.

Patterns and Running Ends

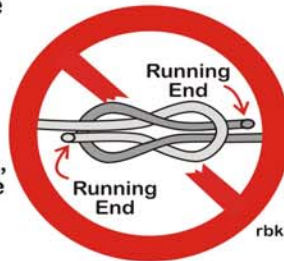
Figure 5.5

Square Knot



"Killer" Square

Except for the running ends, both knots look identical. The "killer" square will come undone, even under a little tension.



Source: rbk

Source: Smith, B., and Padgett, A.,(1996). *On Rope - North American Vertical Rope Techniques*.Huntsville, AL: National Speleological Society, Inc.

Strength (Figure 5.3) – Tie a knot in a rope and it will immediately lose 1/4 to 1/2 of its strength. A figure eight retains roughly 75% – 80% of its original strength. In contrast, a square knot retains only 43% – 47% of the rope’s original strength (Figure 5.3). The knot creates a stress point where the fibers on the outside of the bend are stretched more and those on the inside of the bend are stretched less. On the inside of the bend, the strands may even become compressed. The differential in stresses can lead to rope failure at this point. A good rule to remember is that when the object around which a rope is bent is at least four times the diameter of the rope (e.g. pulley, branch, a knot, etc), the bend in the rope will be unstressed as a practical matter..

Ease to Tie/Untie – A knot should be relatively easy to tie. When tying a line around a post or object, the bowline is easier and quicker to tie than a figure-8 follow-through.

Often overlooked is the ability to easily untie a knot (see Figure 5.12c). A bowline is easy to untie even after heavy loading. Just bend the “horse collar” section of the knot over the working end of the rope and the knot will fall apart. In contrast, once under load, a double fisherman can be virtually impossible to untie. It derives this attribute from its lineage to the overhand knot.

Setting and Dressed (Figure 5.4) – In tying a knot, the knot is tied loosely. *Setting* is the process of tightening the knot so that it becomes dressed. A knot is *dressed* when it is configured properly. All the parts of the knot are in their proper location and the knot looks as it is pictured in the textbook. This is important because, a properly dressed knot makes for easier inspection and an improperly dressed knot can lose up to 50% of its strength.

Inspection (Figure 5.5)– It is important to determine that a knot is tied properly and is safe. A properly dressed knot makes it easier to determine if the knot is configured correctly. A figure-8 knot has a unique and distinct configuration. It looks like the figure eight. In a figure-8 follow-through the second rope runs parallel to the first rope within the knot. This creates a distinctive pattern. Also, it relates to the knot being properly dressed. Next, there may be a key element of the knot that needs to be checked. In the square knot, the two running ends are on the same side of the knot (Figure 5.5). In the “killer square” the running ends are on opposite sides of the knot. Except for this feature, both knots look identical. Unfortunately, the killer square knot will literally fall apart under tension.

Amount of Rope Used – Some knots consume more rope than others. A figure eight on a bight consumes 36% more rope than a bowline. Yet both knots create loops in the end of a rope. A simple experiment was conducted with 8mm cord. With a 2.5" loop, a bowline consumed 11.5 inches of cord. In contrast, a figure eight on a bight consumed 18 inches of cord or 36% more cord than a bowline. This is not insignificant, and at some point, the amount of rope consumed in tying the knot can affect its use.

With its three loops, a triple fisherman’s knot consumes more rope than a double fisherman or a single fisherman. Leaving a 1" tail, half of a single fisherman consumed 4.25 inches of the 8mm cord. Half of the double fisherman consumed 5.75 inches or 26% more cord for the additional loop. With three turns, half of the barrel or triple fisherman consumed 8.25 inches or 30% more cord than the double fisherman. Since not much strength is gained using a triple fisherman over the double fisherman, the double fisherman can save some rope.

Types of a Rope (Figure 5.6) – Several of the common rope types are presented in Figure 5.6. These are laid, braided and kernmantle. In a laid rope, the strands are usually twisted to be in opposition to each

other. This encourages the rope from becoming unraveled. A major disadvantage of the laid rope is that abrasion cuts the outside strands which weaken the rope when that strand move inward and becomes a supporting strand.

Kenmantle is comprised of the *kern* and the *mantle*. The mantle is a woven outer sheathing that protects the kern. Kenmantle ropes are either *dynamic* or *static*. The kern in a dynamic rope consists of twisted strands of fibers. Dynamic ropes are used in climbing and are designed to stretch. Specifically, they are designed to absorb the fall of a climber. The kern in a static rope consists of parallel unidirectional strands of fibers. The design minimizes stretch. They are used in rescue situations and not in lead climbing or in situations designed to absorb falls.

Ropes are constructed out of nylon, spectra, and polypropylene as well as natural and other materials. Nylon is one of the more common materials. It is strong, flexible, and doesn't float in water. Spectra is much stronger than nylon which is reflected in its cost. Also, it floats. Polypropylene has less strength than nylon. It is inexpensive and it floats in water. In whitewater situations, spectra is often the rope of choice because it is strong and floats.

Knots

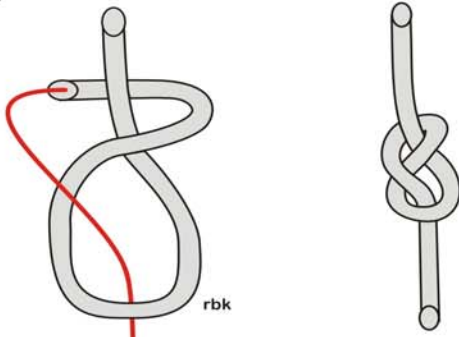
When tied, a knot is self-contained and self-supporting. It doesn't need an object or another rope to maintain its integrity (e.g. hitch). This may be a fine distinction, but a distinction non-the-less. Traditionally, the term knot is used to include both hitches and bends. To make matters more confusing, many hitches and bends actually incorporate the term knot in their name. The double fisherman's knot and water knot are actually bends. Two families of knots are emphasized in this section, the figure eight and bowline.

Figure Eight Family (Figure 5.7) – Consider the figure eight knot as the basic knot in this group. Actually, it could be argued that it is really an extension of the overhand knot with one additional turn (see Figure 1). By itself, the figure eight is a stopper knot that is tied at the end of a rope to stop someone who is repelling from dropping off the line at the bottom of the rope. Other than this, the figure eight by itself has little utility. Other than demonstrating how to tie the knot, this author can't remember ever using the figure eight by itself. Having said this, the figure eight knot is foundational or a base knot for a whole family of knots. The figure eight on a bight, figure eight follow through, or in-line figure eight have utility and considerable usage along with other derivations of the figure eight not noted here.

Figure -8 – Figure-eight on a Bight (Figure 5.8) – The figure eight on a bight provides a loop in the end of the rope. The running end of the rope is made into a bight and the bight is tied as if were a simple figure eight. If the person is creating a loop and then clipping it (i.e. carabiner) into something else, this knot is quick to tie and efficient to use. In contrast, if trying to tie a loop around a person or some other fixed object, the figure eight on a bight becomes less practical to use.

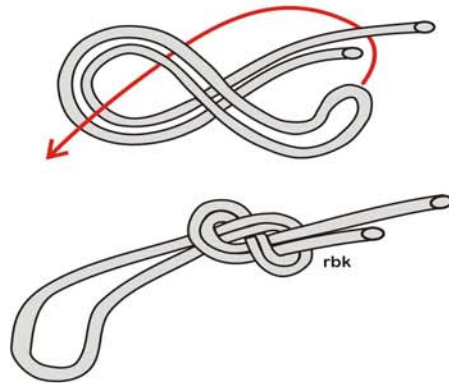
Figure-eight Follow-through (Figure 5.9) – For climbers, this is the knot used to tie into the harness. It is "bullet proof" in that it won't come undone and it provides maximum protection. It is designed to create a loop in the rope connected to the harness or around the person or other object that is secure and provides maximum protection. It is a staple of climbers. The disadvantage of this knot is that it does take time to tie. Under normal circumstances this is not a problem. In an emergency situation and when time is of the essence, this can become more problematic.

Figure eight
Figure 5.7



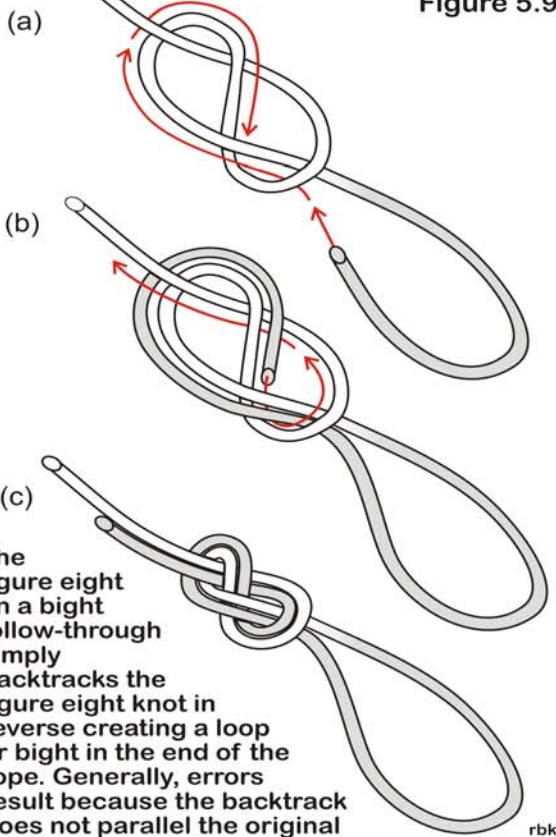
The Figure 8 knot is one of the strongest knots. It can be used as a stopper knot, to tie two ropes together, or to tie a loop in the end of a rope.

Figure eight on a bight
Figure 5.8



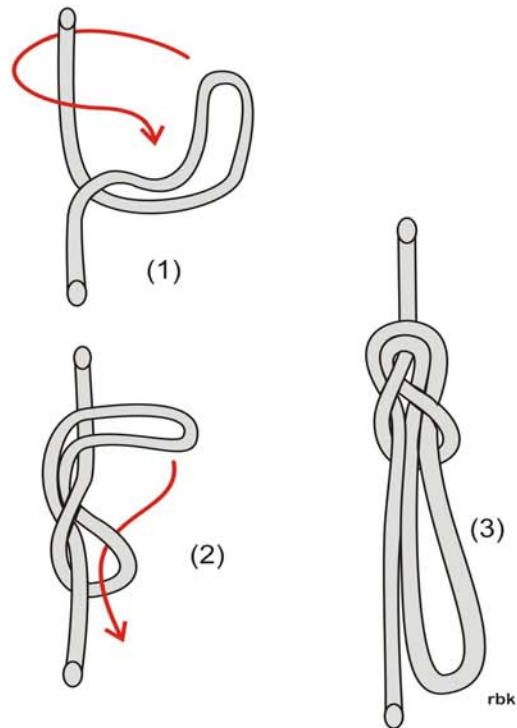
Fold the rope back on itself. Tie a Figure 8 knot with the two strands as you would the Figure 8 pictured above.

Figure eight on a bight follow through
Figure 5.9



The figure eight on a bight follow-through simply backtracks the figure eight knot in reverse creating a loop or bight in the end of the rope. Generally, errors result because the backtrack does not parallel the original configuration.

In-line figure eight
Figure 5.10

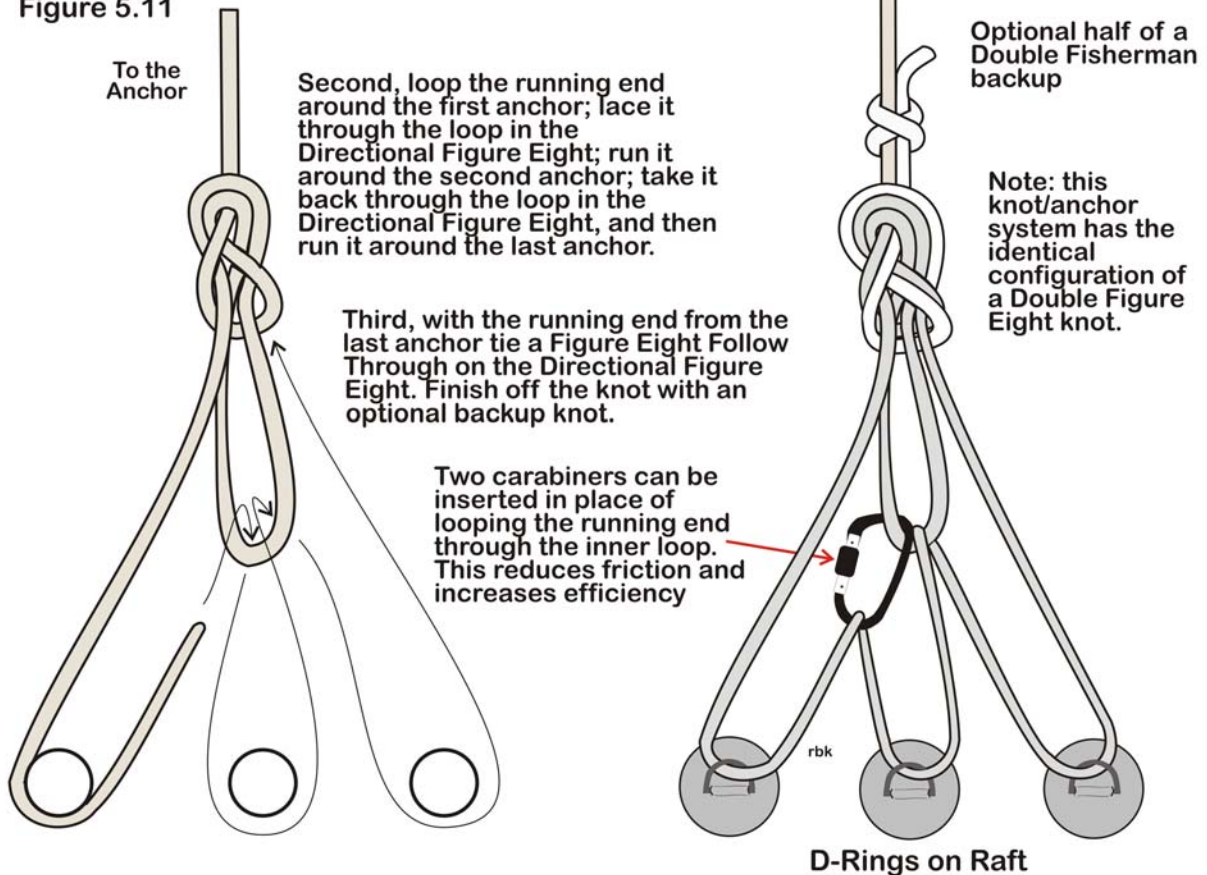


Make an overhand loop on the rope (1). Go around the back of the rope, and through the loop (2). Seat Knot (3).

Source: Smith, B., and Padgett, A.,(1996). *On Rope - North American Vertical Rope Techniques*.Huntsville, AL: National Speleological Society, Inc.

Self-Equalizing Anchor Using a In-line figure eight follow-through

Figure 5.11



Source: Developed by Bill Matney of Rescue 3 International.

In-line Figure Eight (Figure 5.10) – The in-line figure eight is a figure eight tied onto the middle of the main line. It is a specialized knot. It is not difficult to tie and it is relatively easy to untie. It is superior to tying a overhand knot on a bight which is virtually impossible to untie once loaded. It forms the base knot in creating a self-equalizing anchor (see next item).

Directional Figure Eight Follow-through (Figure 5.11) – The running end of the in-line figure eight is worked back through the loop and then retraced the knot as diagramed. The setup is a self-equalizing anchor system where the pull on each anchor is the same. The system can easily incorporate multiple anchor points with the addition of another loop. If there is an abundance of carabiners, they can be used to clip the loops around the anchors to the loop at the bottom of the figure eight.

The system has been used in river rescue and to a lesser extent in climbing. The system can be hooked to multiple D-rings on a raft to extricate it from a pinning. Or it could be used to anchor a haul line to multiple trees used as anchors where no one tree would serve as a suitable anchor. Actually, it should be

used more in climbing since it is truly self-equalizing, particularly when used with carabiners.

Bowline (Figure 5.12) – The bowline is used to tie a loop in the end of a rope. The advantage of using the bowline is that it can be tied quickly and easily. Also, it consumes less rope to tie than a figure eight follow-through. The knot maintains its integrity under tension. However, it can loosen when placed in continuous tension and compression situations. In the climbing community the bowline has fallen into disfavor for this reason. When a climber falls, they tend to bounce which can loosen the knot. If there is any doubt that the bowline could be placed in a tension and compression situation, back it up.

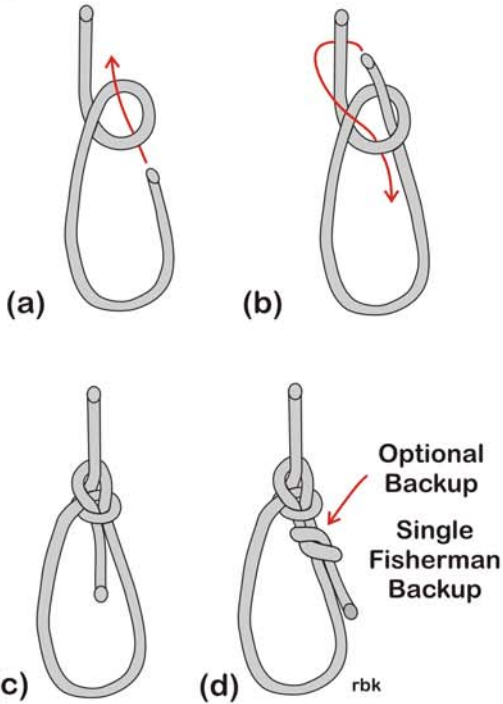
Untying the Bowline (Figure 5.13) – Even after being placed under extreme tension, the bowline is easily untied. Bend the working end or “neck” forward. This frees the horse collar which can be flipped over the bent working end (i.e. “neck of the horse”). The knot will easily fall apart.

Yosemite Tie-off (Figure 5.14) – If there is a need for a secure bowline, back it off. The Yosemite tie-off is one of several acceptable methods. When tied correctly, the Yosemite tie-off has a figure eight knot look to it.

Other knots can be used to back off the bowline. Half a double fisherman’s knot can be used (not shown). Half a single fisherman can be used in a pinch, but it may need to be tightened periodically since it tends to be a loose knot (see Figure 5.12d).

Bowline

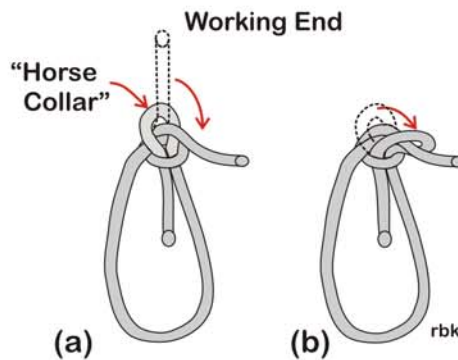
Figure 5.12



Source: Smith, B., and Padgett, A.,(1996). *On Rope - North American Vertical Rope Techniques*.Huntsville, AL: National Speleological Society, Inc.

Untying the Bowline

Figure 5.13



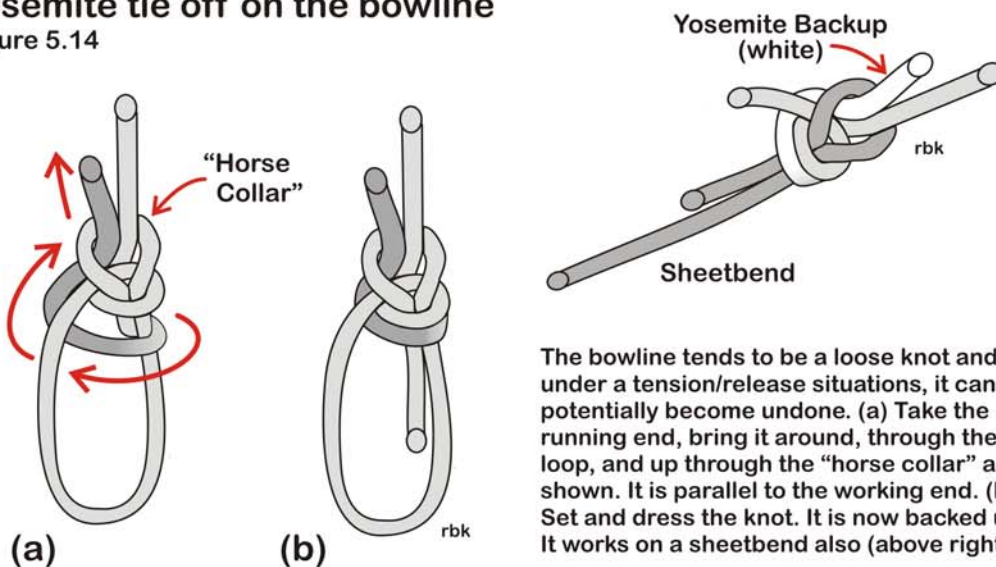
Bend the working end of the rope over the knot (a). This frees the horse collar to be flipped over the working end (b). The knot will become loose and easy to untie.

Source: rbk

A Knot Tying Story: The rabbit comes out of his hole (a); goes around the tree and seeing the fox goes back down into his hole (b). The rabbit grabs his tail and the fox grabs the tree (don't ask me why, but you need to do so to make the knot work). They both pull (c) Then they both go bowling (pun intended).

Yosemite tie off on the bowline

Figure 5.14



The bowline tends to be a loose knot and under a tension/release situations, it can potentially become undone. (a) Take the running end, bring it around, through the loop, and up through the "horse collar" as shown. It is parallel to the working end. (b) Set and dress the knot. It is now backed up. It works on a sheetbend also (above right).

Source: Smith, B., and Padgett, A.,(1996). *On Rope - North American Vertical Rope Techniques*.Huntsville, AL: National Speleological Society, Inc.

Hitches

A hitch requires an object or another rope to maintain its integrity and structure. Without the object or other rope the hitch will simply fall apart. Several hitches are covered in this section, two half-hitches, clove hitch, Prusik, trucker's hitch, double fisherman's, tensionless anchors, and munter hitch.

Two Half-hitches (Figure 5.15) – Two half-hitches are commonly used to tie a loop around an object or another line. It is useful in tying off the running end in a trucker's knot where it cinches down on the loop (see Figure 5.18). Technically, when tied correctly, the knot has the same configuration as a clove hitch (Figure 5.16a). A common variation is where the loop is looped back against itself (Figure 5.16b). Most people are unaware of the variations and simply tie one or more hitches. This author is unaware of any difference in strength or holding power between either tying approach. Tying a third or more half-hitch is a common practice and tends to enhance its holding power (Figure 5.16c&d). In addition, tying multiple half-hitches is useful for reducing excess rope.

Clove Hitch (Figure 5.16) – The clove hitch is used to tie a line to a post or tent peg. The knot has the same configuration as two half-hitches. The difference is that the clove hitch fastens the running end around a fixed object (e.g. peg, posts), and two half-hitches fasten the line around another line. The clove hitch is a loose knot and in tension and compression situations, it tends to become loose and undone. This author usually backs up the clove hitch with two half-hitches to maintain its internal integrity (see Figure 5.16c).

Prusik (Figure 5.17) – The Prusik is a multi-purpose hitch. It is used in climbing as an ascender and in rescue on hauling systems. In many circles, it is preferred over mechanical devices because it slips at around 900 lbs of tension. This protects the system from fatiguing elsewhere. The Prusik is a hitch because without the main line to maintain its integrity, the knot will fall apart.

The Prusik is designed to cinch down on the rope and to kink the rope at an angle to increase its hold. In theory, the Prusik works best when the diameter of the Prusik is significantly smaller than the main line. In rescue work, this author has used Prusiks with diameters that are close to the main line with little adverse effect. In swiftwater rescue, most mechanical advantage systems use Prusiks in both the hauling system and self-equalizing brake.

The first step in making a Prusik is to make a sling. Tie the two ends of the rope together using a double fisherman's knot. Next, loop the loop around the main line and through itself as pictured in Figure 5.17.

Third is the issue of where the double fisherman knot is located. There are three options. First, the double fisherman can be positioned over the Prusick as pictured in Figure 5.17. In theory, this minimizes the loss of tensile strength due to a knot in the system and in theory, the tensile strength of the Prusik approaches that of the rope without a knot. In practice, it may not make that much difference. The Prusik has two supporting lines. If the rope has a tensile strength of 900 lbs, it has an effective tensile strength of 1,800 lbs. It should be noted that some people find it easier to tie the Prusik by positioning the double fisherman over the knot. In addition, some people find it easier to tie the Prusik by latching onto the knot and passing it through the loops. There is a method to this approach and it works well.

The second option is to have the double fisherman located on the side of the sling. As a practical matter, this approach is satisfactory also. Remember, if the Prusik fails (i.e. slips on the rope) at 900 lbs, two 1,800 lb tensile strength cords are not going to fail at the knot even if the knot reduces the strength of the

Prusik cord by 50%.

The third option is to locate the double fisherman where the carabiner fastens into the Prusik. This should be avoided since it places undue stress on the system. Often, when tying the knot, the double fisherman is grasped and looped through and around the main line. It is convenient. This approach will tend to line up the knot where the carabiner clips into the sling.

For a Prusik to be effective, it needs to be loosened easily and readjusted along the main line. This is a three-step process of loosening the knot, moving it and re-cinching it. It is important to loosen the knot first or it will be difficult to move a cinched Prusik. To loosen or untie the Prusik, pull the “horse collar” over itself. Using the first method, this is the double fisherman. Conceptually, this process is similar to loosening the bowline. Prusiks can easily cinch down on the main line making them difficult to move and readjust.

Trucker’s (Rigger’s) Hitch (Figure 5.18) – The trucker’s hitch is used to fasten boats, construction materials, and other items to roof racks on a car, or to fasten lines to tent pegs that are easily adjustable. Close inspection of the rig reveals that the hitch is the same configuration as a Z-rig and offers a theoretical 3:1 mechanical advantage. This mechanical advantage makes the trucker’s hitch an attractive rig for when the line needs to be taught or when the tension on the line needs to be adjusted. The adjustable lines to the tent pegs are an example of this re-adjustment. The other feature of the trucker’s hitch is that it is easy to untie and when untied, the hitch simply falls apart. A key to having it fall apart easily is to put several twists (i.e. 3-4) in the initial loop.

In situations where the tension needs to be monitored or adjusted, or where there needs to be micro adjustments made in hauling line, the trucker’s hitch is ideal for these situations. The author uses it as a staple tool to set up and adjust lines in river rescue including the strainer drill.

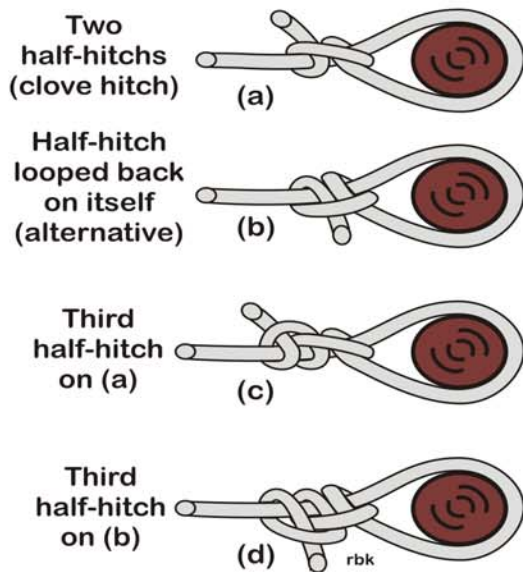
Two half-hitches are used to finish off and lock the trucker’s hitch into place (see Figure 5.15). If there is any doubt regarding the two half-hitches, use three half-hitches. The half-hitches need to be snug against the loop or it will slide down the line until it becomes snug. If it is anticipated that the system will be readjusted, tie the half-hitches using a bight in the rope. Pulling on the one side of the bight unties the half-hitches. In addition, extra line can be daisy chained (not shown).

Tensionless Anchor (Figure 5.19) – Traditionally, the tensionless anchor has been used to anchor ropes around trees. This author has used the tensionless anchor to fasten boats, construction items and other items to be hauled to the roof racks on his car. It has replaced the trucker’s hitch in this use. It works by the rope creating friction around the anchor. It is a hitch because it uses the tree or roof rack to maintain its integrity and structure. In contrast, the anchors depicted in the anchor section use slings to create the anchor. At some point there is considerable overlap between a hitch which requires an object for it to wrap around and an anchor. In the end, it may be a fine distinction.

In Figure 5.19, the tensionless anchor is drawn with the rope neatly coiled around the anchor. This need not be the case. Only the first two coils should be neatly looped around the anchor and free of crossovers. This aids when finishing off the knot. Feel free to coil the remainder of the rope around the anchor with numerous crossovers.

Two half-hitches

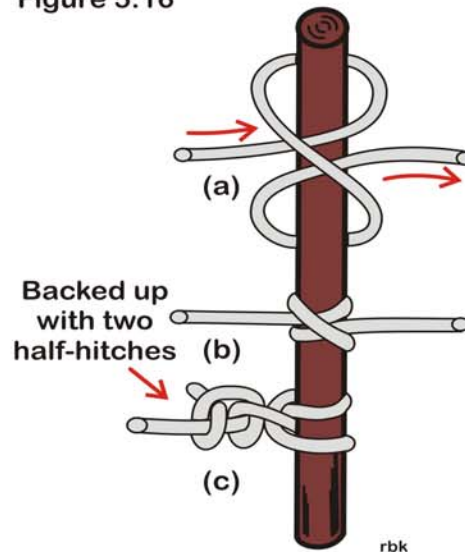
Figure 5.15



The technically correct version is pictured in (a). It looks like a clove hitch. A common alternative is to loop back on itself (b). There is no evidence of a loss in effectiveness. If there are any questions add a third half-hitch (c&d).

Clove hitch

Figure 5.16

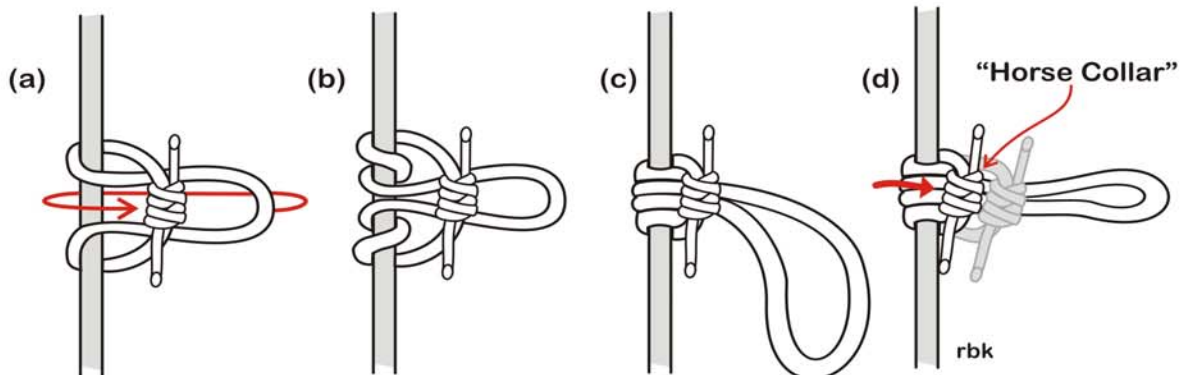


Careful inspection reveals that the clove hitch and two half-hitches are identical knot configurations.

Usually, the author ties the clove hitch off with two half-hitches since the clove hitch tends to loosen and easily falls apart (c).

Prusik

Figure 5.17

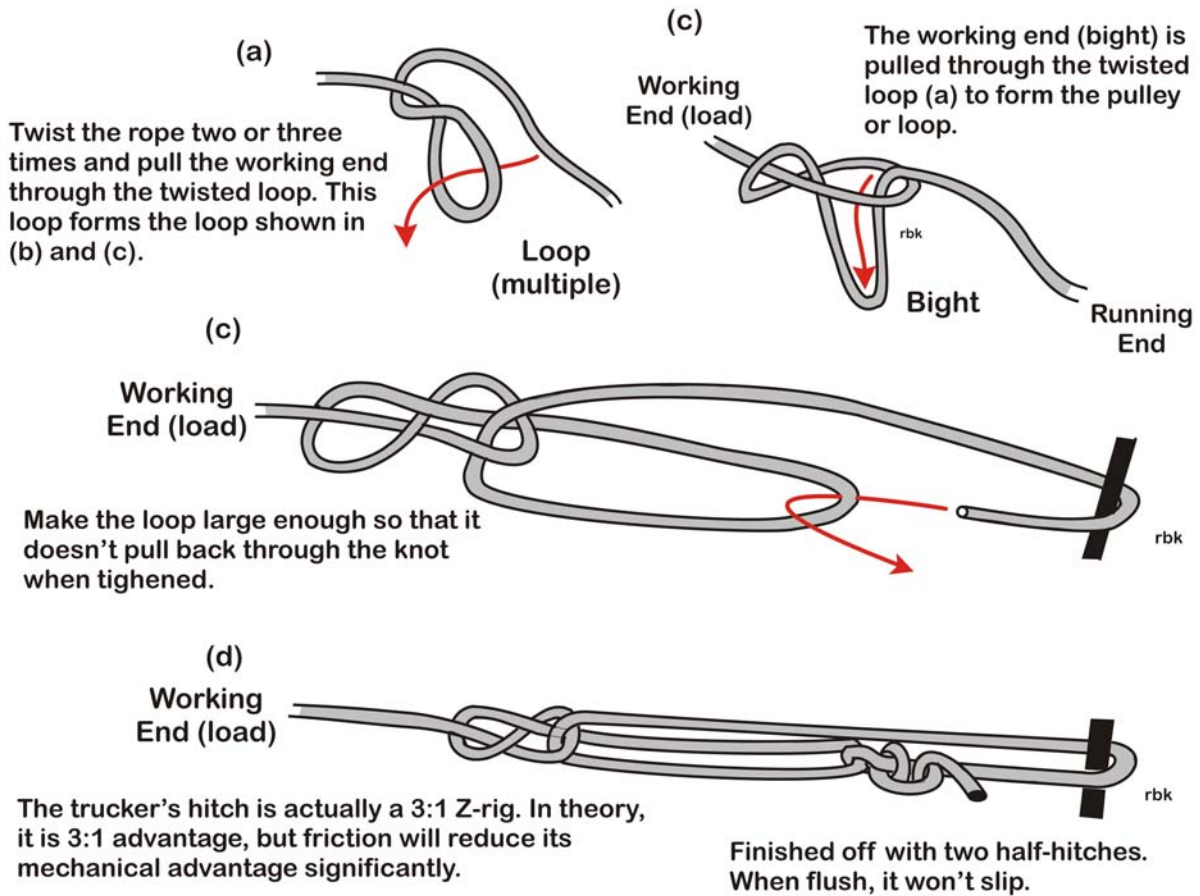


- 1) Tie two ends of the cord using a double fisherman's knot (not shown).
- 2) Hold the double fisherman's knot in the one hand and loop two to three times around the main rope (a) & (b). A third loop is often added for extra bight (not shown). Make sure the loops are parallel with each other (c).
- 3) To untie a tight prusik, flip the double fisherman's knot (i.e. horse collar) back over the loop (a) and push the loop through the horse collar (d). This will loosen the knot allowing it to be easily readjusted.

Source: Smith, B., and Padgett, A., (1996). *On Rope - North American Vertical Rope Techniques*. Huntsville, AL: National Speleological Society, Inc.

Trucker's (Rigger's) Hitch

Figure 5.18



Source: Kauffman, R. (2015). *Swiftwater Rescue Packet*. McHenry, Maryland: Garrett College. Unpublished packet.

Tensionless Anchor

Figure 5.19

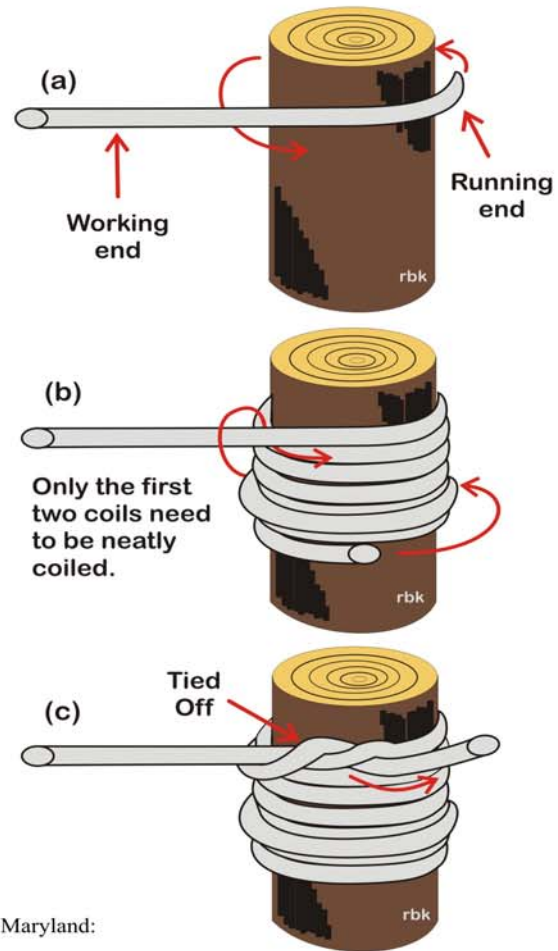
A tensionless anchor utilizes the friction created by the rope wrapped around a tree, car roof rack, or other object to prevent slippage of the standing end of the rope.

Many texts depict a tensionless anchor with the running end not tied off or just hanging (b). The problem is that the system will tend to loosen and begin to unwind particularly, if the system is placed under cycles of tension and slack.

A good way to tie off the anchor is shown in (c). The free end is simply looped around the working end and pulled taught. It locks the rope and maintains the integrity of the system. This author has used this system to fasten boats to a car roof rack for years. It is quick and easy to tie and untie also.

Some people will tie the free end to the working end using two half-hitches (not shown). It works, but in the estimation of this author, it is not as efficient as the method shown in (c).

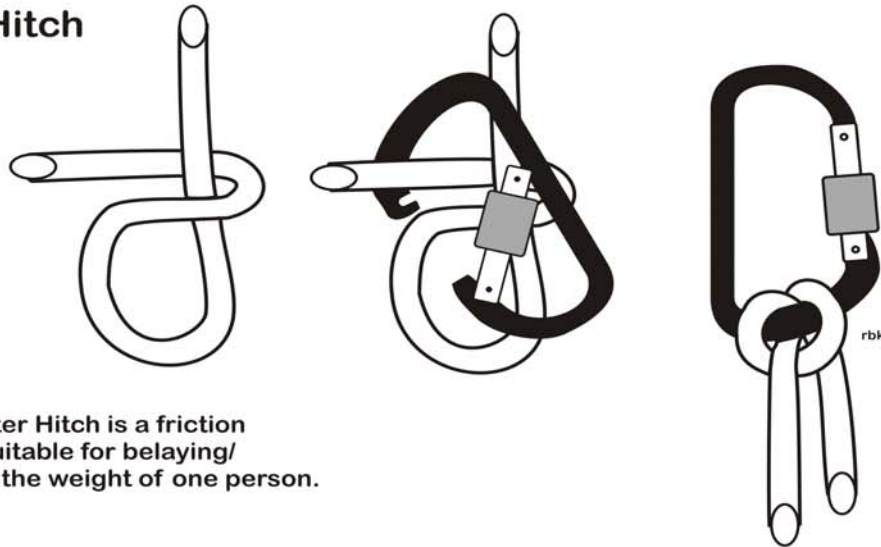
Only the first two loops need to be neatly coiled. This is for the tying off. The remaining coils can be wrapped crossing over each other without ill effect.



Source: Kauffman, R. (2015). *Swiftwater Rescue Packet*. McHenry, Maryland: Garrett College. Unpublished packet.

Munter Hitch

Figure 5.20



The Munter Hitch is a friction device suitable for belaying/ lowering the weight of one person.

Source: Kauffman, R. (2015). *Swiftwater Rescue Packet*. McHenry, Maryland: Garrett College. Unpublished packet.

The literature shows several ways to finish off the tensionless anchor. The first is to let the free end hang loose (not pictured). This is not recommended. If the tensionless anchor is only under tension, the system will tend to maintain its integrity and not loosen. Regardless, this author doesn't like loose ends and prefers a tie off method. However, if the system is under repeated tension and slack, the anchor will loosen and system will begin to fall apart.

The second method of finishing off the tensionless anchor is tie a figure eight on a bight and fasten the knot to the main line with a carabiner (not shown). This approach is slightly better than using no tie off. It does provide fail safe protection where if the system loosens and begins to unwind, it will eventually lock down on itself.

The third approach brings the loose free end around the main line on the first coil and cinching it off as shown in Figure 5.19. This is why it is important to neatly coil the first two coils. After the first two coils, the rope can be wrapped in any fashion that is convenient and crossing over itself does not affect the integrity of the anchor.

The author has used this version of the tensionless anchor for years to fasten boats and other items to the roof racks on his car. It replaced the use of the trucker's hitch for tying down boats on roof racks. It is easy to tie and untie. It works equally well on metal roof racks. Also, the system tends to maintain its integrity when experiencing repeated tension and compression situations. However, if there are known situations with extreme repeated tension and compression situations, the author will normally revert to the trucker's hitch which will maintain its integrity regardless.

Munter Hitch (Figure 5.20) – The munter hitch is a friction device that can be used in place of a rappelling device. The author uses it in place of a clove hitch on a carabiner tied off with two half-hitches (not shown). Either way works. The advantage of using either a tied off munter hitch or clove hitch is that it prevents the carabiner from rotating.

Bends

Bends tie two ropes together. Three bends are covered, the sheetbend, water knot and double fisherman's knot. A figure eight follow through is not included. However, it can easily be inferred (see Figure 5.9 and Figure 5.11).

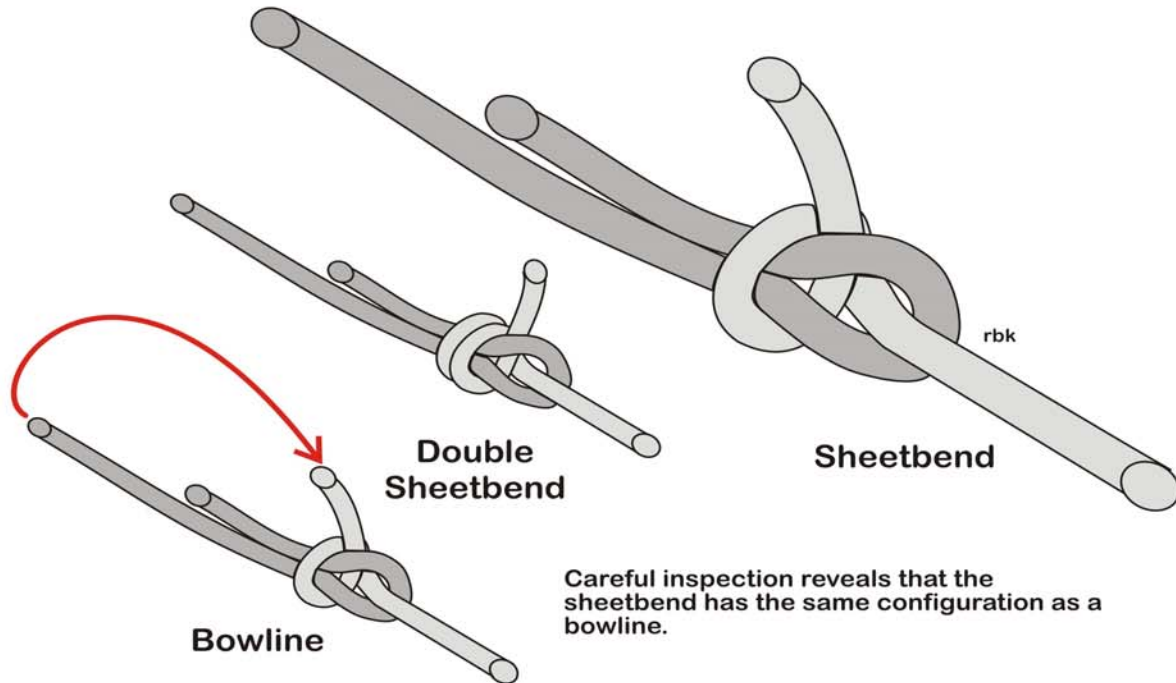
Sheetbend (Figure 5.21) – The sheetbend is used to tie two ropes together. Careful inspection of the knot reveals that it has the same configuration as a bowline (see also Figure 5.12). Hence, the sheetbend has most of the same attributes as a bowline. It tends to be a loose knot. Under tension and slack, it will tend to become loose and come apart. Like the bowline, it is easy to untie. Simply, break the "horse collar" and the knot falls apart. For additional strength, consider a double sheetbend with two internal loops.

Water Knot (Figure 5.22) – The water knot is used to tie two pieces of webbing together to form a sling. This is the primary purpose of the knot and no other knot excels like the water knot in this capacity. It is such a stable and strong knot, it does not need to be backed up. Normally, it is not used to tie two ropes together. A sheetbend or figure eight follow through would be preferred.

Sheetbend

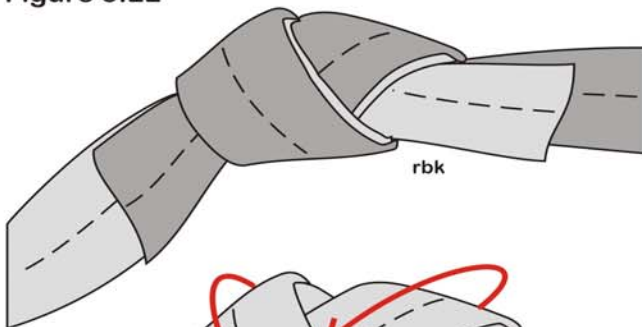
Figure 5.21

Use the sheetbend for tying two ropes together even if they are of different diameters. A double sheetbend is better.



Water Knot (Bend)

Figure 5.22



TOP: The water knot is a follow-through overhand knot. It is the preferred knot for tying two pieces of webbing together.

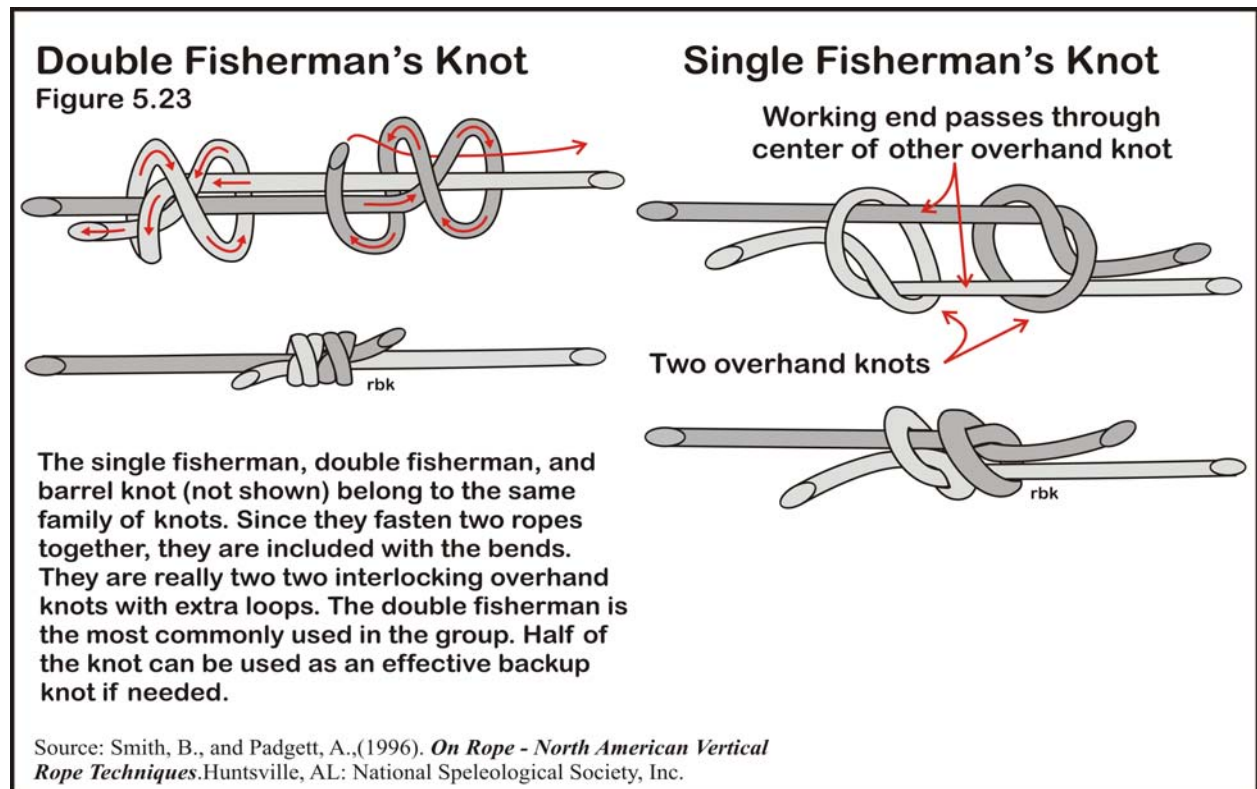
BOTTOM: Tie an overhand knot in the one piece of webbing (right). With the other piece of webbing, trace it back through the original overhand knot following every bend. It creates a parallel knot that mirrors the original knot. It is stable and need not be backed up.

Source: Smith, B., and Padgett, A.,(1996). *On Rope - North American Vertical Rope Techniques*. Huntsville, AL: National Speleological Society, Inc.

Literally, the knot is tied as a follow-through overhand knot. Tie an overhand knot loosely in the webbing. With the other end, follow through the knot in reverse. Seat and dress the knot. Avoid kinks. The follow through webbing should parallel the original knot. No backup is needed. The knot maintains its tightness under stress and compression.

Double Fisherman (Figure 5.23) – Normally, the double fisherman is used to fasten two ends of a rope together to form a loop or sling. Sometimes, it is called the grapevine knot. It is an integral component in creating a sling and tying the Prusik. Half of the knot is often used as a backup knot for other knots. The knot cinches on itself making it extremely difficult if not virtually impossible to untie after being loaded. For this reason, it is used in situations where it won't be untied. When tying together two separate lines that will eventually be untied, other knots such as the sheetbend or figure-8 follow-through would be preferred.

The configuration of the single, double, and triple fisherman are essentially the same except for the number of wraps around the rope. The configuration of the single fisherman is that of an overhand knot with the other end of the rope passing through the center of the other overhand knot. A single fisherman's knot has one loop. A double fisherman's knot has two loops and the barrel or triple fisherman's knot has three loops. A single fisherman's knot tends to be a loose knot and in backup situations, half a double fisherman is generally preferred. In terms of strength, there is not much difference between a double fisherman's knot and the triple fisherman. However, the triple fisherman's knot consumes more rope. In most situations, the double fisherman is more than adequate in terms of strength and in maintaining its integrity.



Cams Straps

Currently, cam straps have not become a staple in the swiftwater rescue community (Figure 5.24). However, they are a staple in the rafting and boating communities. They are used to fasten everything to the raft in both paddle craft and oar rigs. For this reason they may be available to use in rescue situations where there are limited resources available. The traditional cam trap is a 1" polypropylene strap with a tensile strength of roughly 1,500 lbs. They come in a variety of lengths ranging from one foot to 20 feet in length.

Cam straps are easy to use and relatively foolproof. Thread the strap into the cam. Pull it taut. The cam is designed to lock down on the strap. To release, simply press the button on the back of the cam.

Pull it taut. The cam is designed to lock down on the strap. To release, simply press the button on the back of the cam.

There are several methods used to store cam straps. Coiling the straps is one of those methods (Figure 5.25). The advantage of coiling the straps is that they store easily and compactly with other gear. There are no loose ends. They are easy to uncoil. They can be easily tossed to someone who needs a strap. The big disadvantage is that it takes time to coil the straps.

Coiling the straps is not initially intuitive. Two tips to the method include the following. First, thread the webbing behind the cam lever and where the other end of the webbing is attached to the frame (Step 1, see Figure 5.24 for parts). Second, allow sufficient length of the free end so that it can be cinched down later. This may require some trial and error. Next, the strap should hang down (Step 2). Coil the webbing back on itself upward. Coil it toward the cam opening in the frame. When coiled, wrap the free end around the coil and through the cam (Step 3). Cinch it down until it is snug. Store it in the gear bag (Step 4). It is ready for use.

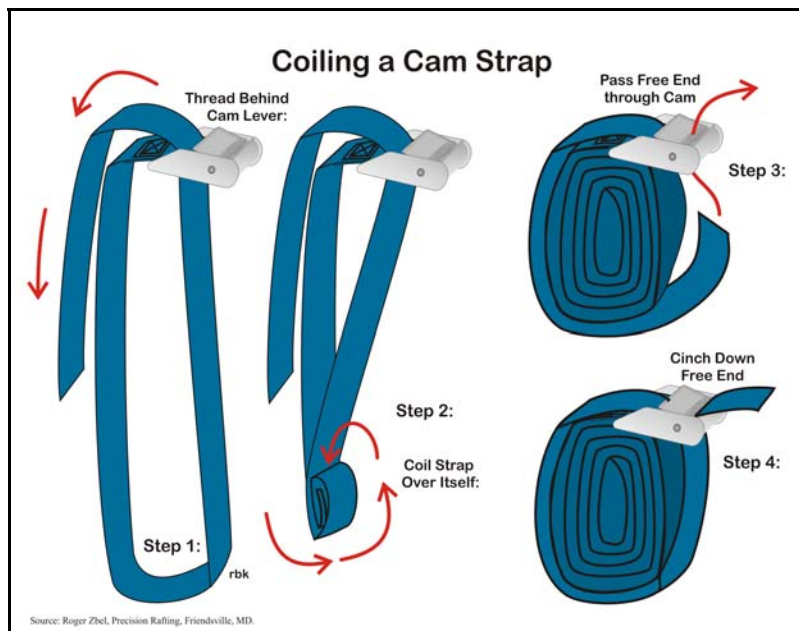


Figure 5.24: Anatomy of a Cam Strap – The NRS ® straps or generic cam straps are a staple on the river used to fasten everything to the raft. Source: Author – [file:\EQUIP_NRSstrap.cdr]

Figure 5.25: Coiling a Cam Strap – Source: Author

Anchors

In general, an anchor is a rock, tree or other object to which a line can be firmly attached. A belayer can be considered an anchor. The tensionless anchor discussed in the hitch section is also used as an anchor (see Figure 5.19). The figure-8 follow through makes an excellent self-equalizing anchor (Figure 5.10 and Figure 5.11). Usually, webbing is used to wrap around the anchor. Three anchors are discussed in this section. They are the simple or single loop, the 3-bight, and the girth hitch.

Simple or Single Loop (Figure 5.26) – One of two situations occurs. The end result is the same. The webbing is looped around an object or anchor and the water knot is tied connecting the two ends of the webbing together to make a loop. The downside of this approach is having to tie a water knot when tying the sling around the object. It takes time. Second, a pre-tied sling can be slipped or looped around an anchor which is much quicker. Often, when going around a rock, the extra length of webbing is needed to get around the rock.

The big disadvantage of the single loop is that it can slip down the anchor. This is particularly true on tree trunks and other vertical objects. It is less of a problem going around a rock anchor. The big advantage of the single loop is that it has twice the length of webbing than in the 3-bight approach which can be useful in going around a large rock. .

The second version of the simple anchor is much more practical. It can be used on rocks but not trees. Most rescuers will take the sling and loop it around the anchor. This is particularly applicable to wrapping the webbing around a rock or similar anchor. If this doesn't work, the rescuer will often move to the 3-bight approach. It doesn't require retying the sling. It reorients the sling.

3 Bight (Figure 5.26) – A water knot is pre-tied in the webbing making a sling. The sling is looped around the anchor and the two ends connected with a carabiner. An advantage of this system is that it is quick and easy to construct. Another advantage of this anchor is that it reduces the load on each of the webbing strands by a fourth of the total load. It is divided by four supporting lines. As with the simple anchor, a disadvantage of this setup is that it can slip down vertical anchors such as tree trunks. As noted, a disadvantage is that it takes twice the amount of webbing to go around the

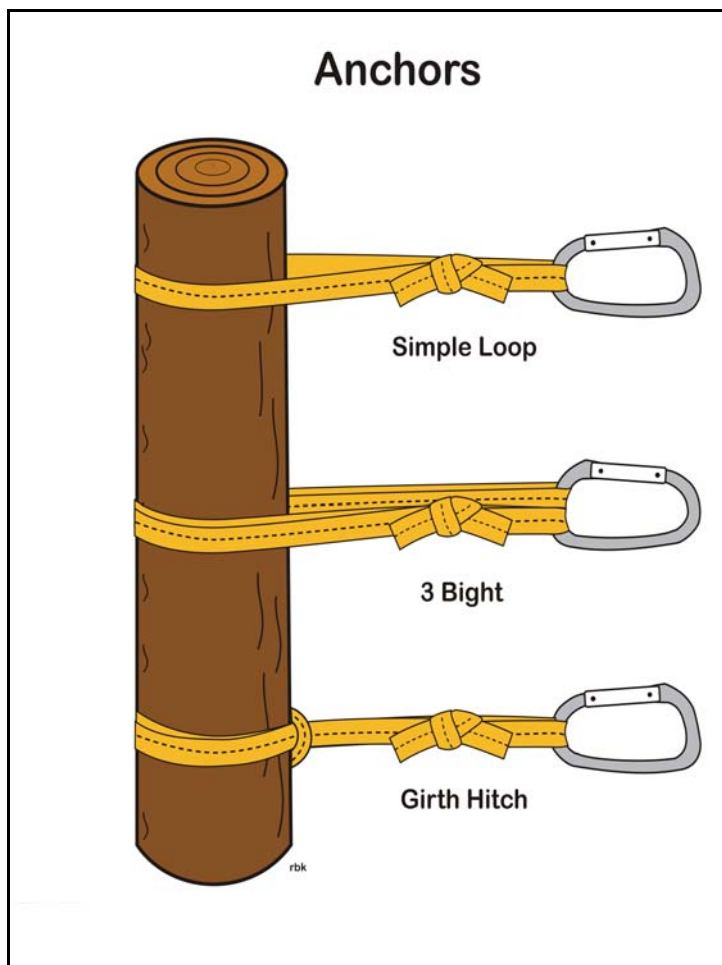


Figure 5.26: Anchors – Three types of anchors are presented. Source: author – [file:\ROPE-Anchors.cdr]

same anchor as the simple anchor.

Girth Hitch (Figure 5.26) – In practice, the girth hitch is a practical anchor. It cinches down on the anchor. It can be tied quickly and easily. It is intuitive and simple to use.

A pre-tied sling is looped around the anchor and then the two loose ends are passed through the loop. An advantage of the girth hitch is that it cinches down on the anchor, making the anchor more effective. A disadvantage of the girth hitch is that because it cinches down on the anchor, it creates a stress point at the hitch. Although this is technically true, it rarely presents an actual problem or system failure.

Carabiners

Carabiners are a staple of swiftwater rescue. They are used to connect ropes to other ropes or webbing. They are used in rescue vests to connect the tether to a line in several of the rescues. Carabiners come in all types of shapes and forms. Choose a type of carabiner that you will carry with you. Locking carabiners are recommended. However, if you choose to bring non-locking carabiners with you, they are better than not having any carabiners at all.

The parts of a carabiner are presented in an anatomy of a carabiner (Figure 5.27). A locking gate is shown. The purpose of the gate is to maintain the structural integrity of the carabiner under load. It is important for the gate to remain closed under load. A locking gate screws up the gate to cover the nose. This prevents the gate from opening. Providing a visual check, a red anodized section of the gate is often provided on the gate. When it is no longer visible the gate is closed.

A second approach is the self-locking gate where the locking mechanism is spring loaded to keep the gate closed unless actively opened. In theory, the spring loaded gate should be susceptible to sand and other river grime found in the river environment. This author has used two self-locking carabiners for years in a hostile river environment without ill effect. In fact, they have worked perfectly and in many respects better than the screw versions that can tend to become a little gritty to operate. However, there are different versions of self-locking gates and other versions may work less satisfactorily than the version used by this author.

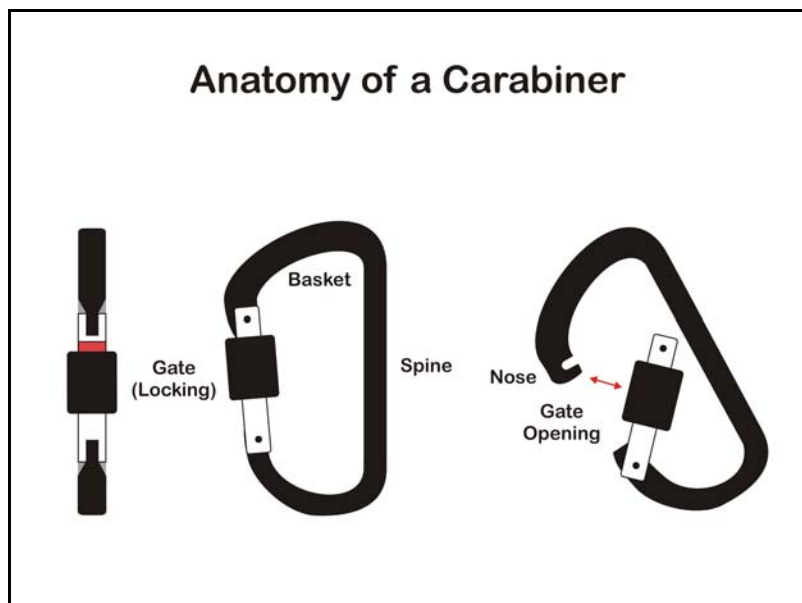


Figure 5.27: Anatomy of a Carabiner – Source: Author

When locking the gate, do not screw the gate tightly onto the nose. This can result in the gate becoming truly locked and difficult to unlock after being placed on load. To help prevent this, it is recommended to close the gate and then back off a quarter of a turn. If the gate becomes stuck, reload the carabiner and back off the locking mechanism.

On a “D” shaped carabiner, the basket is larger of the two ends. The gate opens into the basket. The spine is self-explanatory and carries the load placed on both ends of the carabiner. Also, of consideration is the gate opening. It limits what can be inserted into the carabiner.

It is important not to side load a carabiner. This is where a force is applied on the gate or spine of the carabiner. In swiftwater rescues this is not difficult to do. For example, in the V-lower the tether is hooked to a line. The tether is at a right angle to the carabiners connecting the lines. If not done correctly, it is easy to side load one of the carabiners.

Many paddlers like to clip two carabiners into the shoulder strap of their life jacket. It looks sexy, but it can be potentially dangerous. The carabiners become a potential items to ensnare a victim. Consider carrying the carabiners in a pouch or fastened them with velcro or a similar device that will disconnect easily if snared.

In swiftwater applications, locking carabiners are recommended (Figure 5.28 and Figure 5.29). Two carabiners fastened together or a carabiner fastened to a “D” ring in a boat can easily become unfastened by the agitation of moving water. Figure 5.28 and Figure 5.29 show two ways that unlocked carabiners can easily become

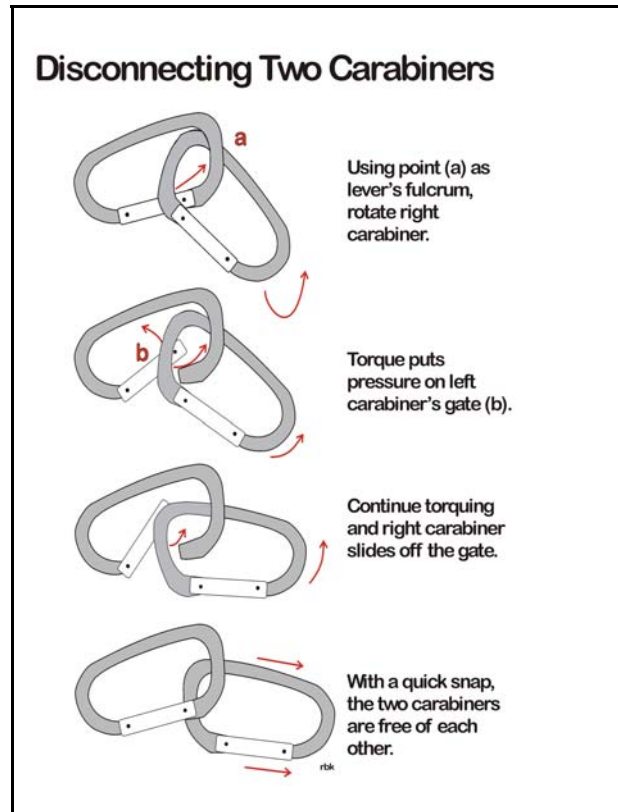


Figure 5.28: Disconnecting Two Carabiners –In swiftwater situations, two carabiners can easily become disconnected. Source: Author.

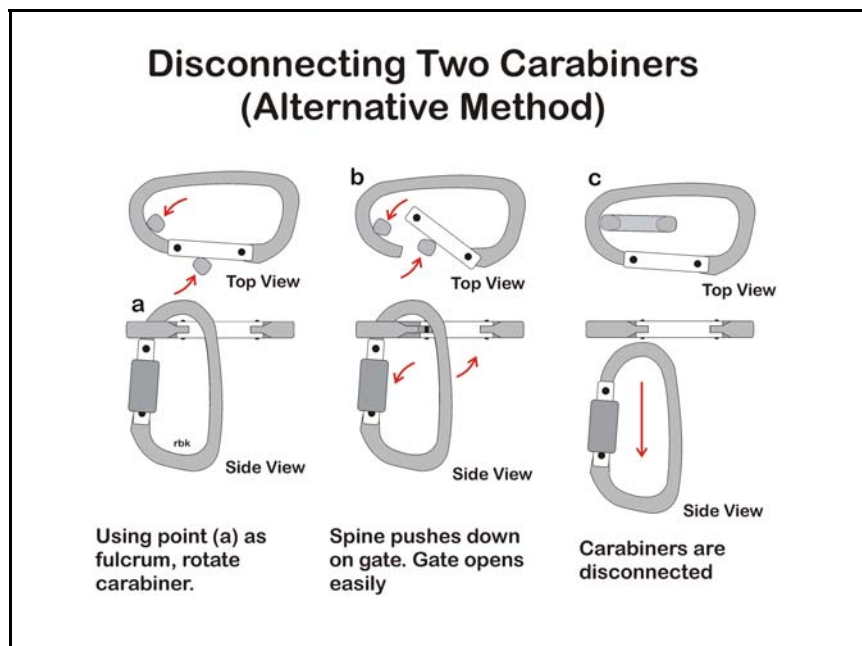


Figure 5.29: Disconnecting Two Carabiners (Alternative Approach) –In swiftwater situations, two carabiners can easily become disconnected. Source: Author.

disconnected from each other.

Summary

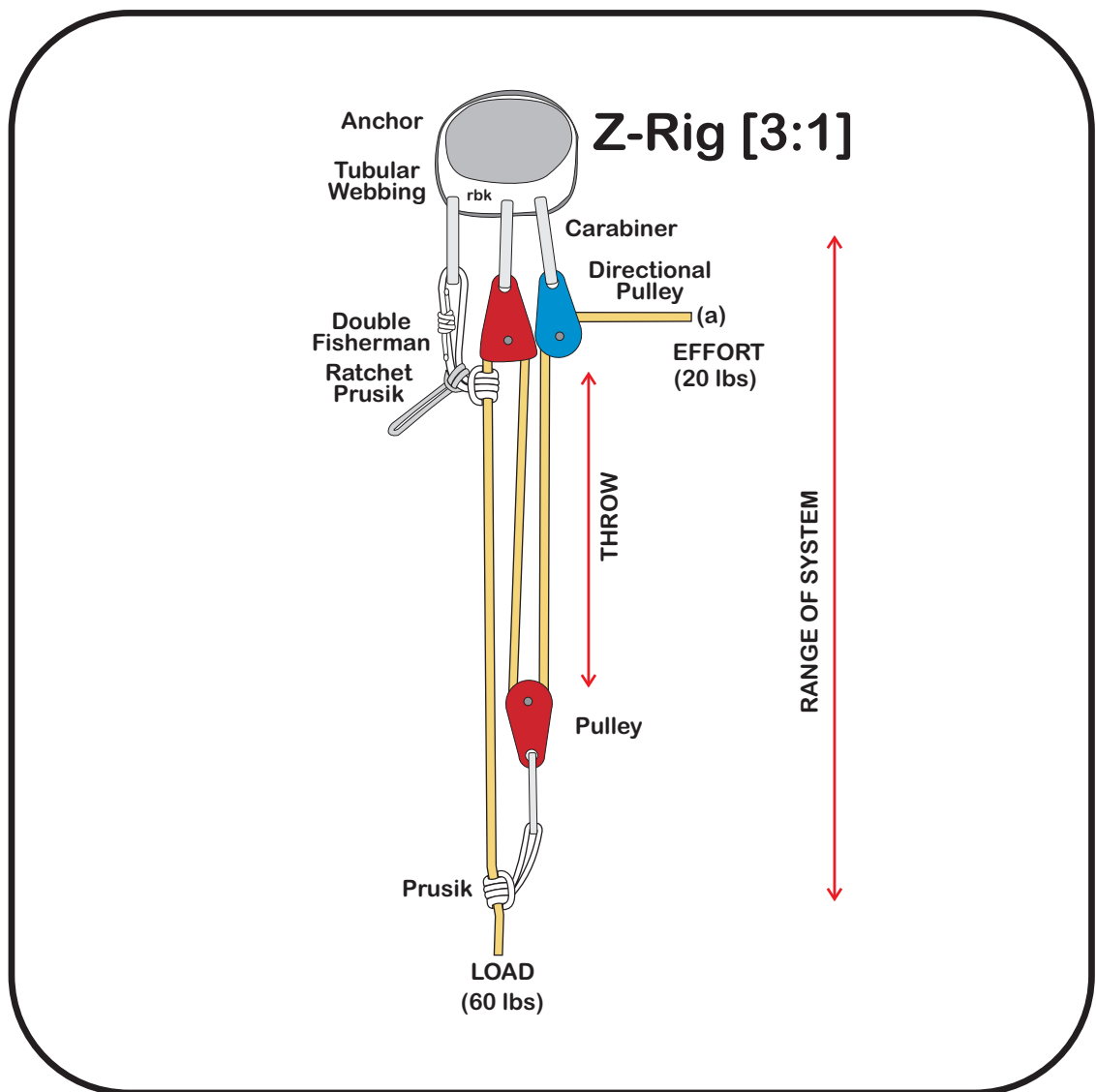
The term knot is used generically to cover knots, hitches, and bends. Although the differentiation was used here, it may not make that much difference in practice. The three types of knots indicate three basic knot tying situations. The rope needs another rope or object for it to maintain its internal integrity (i.e. hitch). It fasten two ropes together (i.e. bend). Or it is a self-supporting knot in the rope that creates a loop or serves some other function. Although not a staple in the rescue community cam straps were introduced. In addition, anchors and carabiners were discussed.

Consider knowing how to tie one knot in each of these three situations. The corollary is that sometimes less is more. Consider being able to tie these three knots blindfolded, backwards, or forwards. The point is that knowing how to tie a few knots well is better than trying to tie multiple knots with overlapping functions poorly or with uncertainty.

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Chapter 6: Mechanical Advantage



Chapter 6: Mechanical Advantage Systems ¹

Pulley systems utilize mechanical advantage to pull weighted loads. In swiftwater rescue, hauling systems may be used to extricate a raft or canoe. Or they may be used as an integral part of a rescue system (e.g. Teflon lower). In climbing, hauling systems are used to haul gear on multi-pitched climbs and in rescue to raise or lower a litter. The major advantage of the rescue pulley systems described in this section over traditional pulley systems is that they are adjustable meaning that they can be moved along the length of the haul line.

Principles and Definitions

There are three basic pulley systems. They are the 2:1, the Z-rig, and block and tackle (Figure 6.1; see also Figure 6.7, Figure 6.8, and Figure 6.12). Most systems described in this section are configurations that use combinations of the 2:1 or 3:1 Z-drag. Principles and definitions sections include mechanical advantage, compound pulley systems, the concept of throw, self-adjusting brakes, range of system, throw, internal versus external pulling systems, and the 120° rule.

Mechanical Advantage – The primary purpose of a hauling system is to gain mechanical advantage. There are several ways to calculate mechanical advantage. A scale can be attached to the effort and the load. Dividing the weight of the load by the weight on the effort line provides the mechanical advantage. Second, measure how far the effort line moves in terms of how far the load moves. If the effort line moves nine feet for a corresponding movement of one foot on the load, there is a nine to one mechanical advantage. Some people will count the number of lines supporting the load. This method may work on some systems, but with many of the complex systems it is inaccurate. For example, the double Z-rig has five supporting lines and a mechanical advantage of 9:1 (see Figure 6.11).

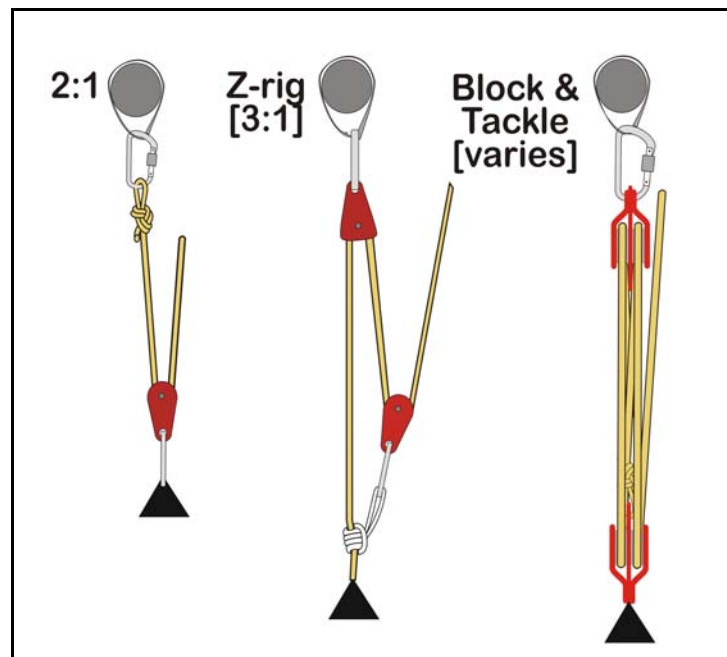


Figure 6.1: The Three Basic Hauling Systems – Source: rbk

Compound Pulley Systems – These are pulley systems where one pulley system is pulling on the effort of another system. The 4:1 piggy-back is a 2:1 pulling on a 2:1 system (see Figure 6.9). The 5:1 is a 3:1 Z-drag and 2:1 system hooked together in parallel (see Figure 6.10). The double Z-rig is a 3:1 Z-rig

¹ This chapter was written by Robert B. Kauffman who is solely responsible for its content. This chapter is copyrighted © Robert B. Kauffman, 2016.

pulling on another 3:1 Z-rig. (see Figure 6.11) are examples of compound systems. One technique for determining mechanical advantage is to count the supporting lines. As noted, this doesn't necessarily work for complex systems. The 9:1 double Z-rig has five supporting lines, not nine (see Figure 6.11).

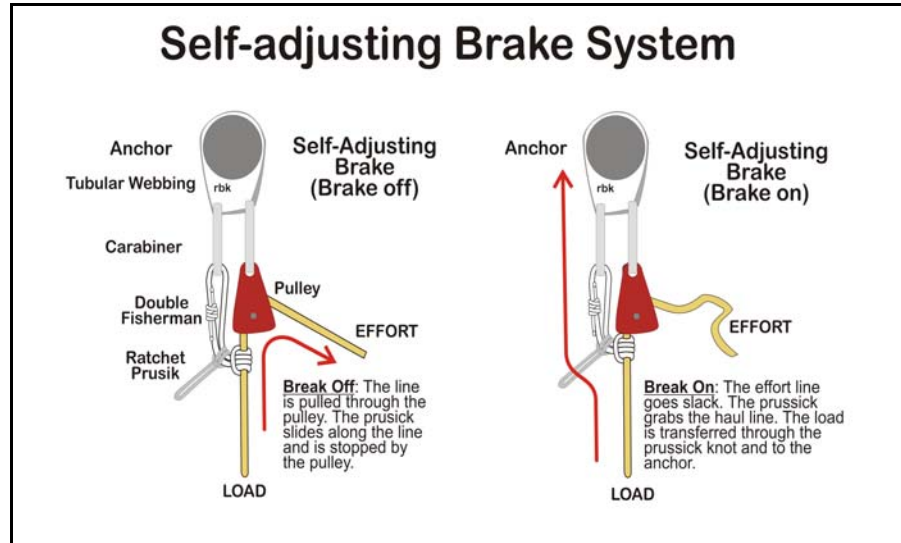


Figure 6.2: Self-adjusting Brake. Source: rbk

Self-adjusting Brake

(Figure 6.2) – The self-adjusting brake is a prusik knot fastened to the haul line that maintains tension on the haul line as the hauling system is readjusted for a new pull. In addition, the brake provides a safety on the haul line in case for some unknown reason someone lets go of the rope.

In general, the use of a prusik is preferred over mechanical devices (e.g. ascenders). In contrast to mechanical devices which tend to dig into the rope, the use of a prusik will begin to slip at around 900 lbs of pressure releasing tension on the haul line well before the braking point of the haul line. In tests where the system was pulled until it fatigued, the pressure of nylon on nylon burnt through the mantle (i.e. the braided protective sheath) and the prusik slid down the kern (i.e. center core of kernmantle rope). This occurred at around 900 lbs of pressure. Often the prusik would slide on the haul line before the rope broke creating a built in safety factor.

Range of System (Figure 6.3) – The *range of the system* is defined as the length of the hauling system. It can be as long as desired. However, there are practical limitations. As a general rule, the longer the hauling system becomes, the more cumbersome the hauling system becomes to manage. Often the range is limited by obstacles or features in the landscape.

Also, the longer the hauling system becomes, it multiplies the amount of rope needed to configure the system. Increase the range of a 5:1 system by one foot, and an additional five feet of rope is needed within the hauling system to gain that one foot increase in range.

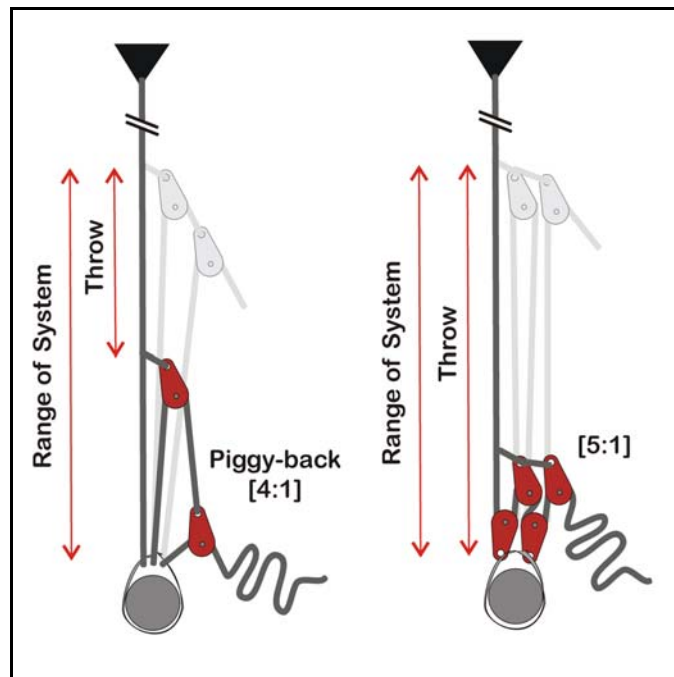


Figure 6.3: Range of System and Throw for Piggy-back and 5:1 Systems – The throw for the piggy-back is half that of the 5:1 system. It needs to be readjusted twice as much as the 5:1.

For the purposes of discussion, the range of the system is held constant in the discussion and in the drawings.

Throw (Figure 6.3) – *Throw* is defined as the distance the hauling system moves before it needs readjustment. Throw and range of the system are interrelated. The concept of throw is demonstrated with the piggy-back [4:1] and 5:1 systems in Figure 6.3. The piggy-back is a 2:1 system pulling on another 2:1 system. When the system is exhausted or pulled to its limit at the anchor, the second or top pulley moves half the distance of the “range of the system.” This distance is “throw.” This requires the piggy-back system to be adjusted twice as often as the 3:1 Z-rig or 5:1 system which have a throw equal to the range of the system. Lack of throw makes the piggy-back a more cumbersome system to use since it needs constant readjustment.

An advantage of the 5:1 system is that it has both good mechanical advantage (5:1) and the same throw as a 2:1 system or a 3:1 Z-rig (Figure 6.4). This means that the 5:1 system moves the same distance as the 2:1 or 3:1 systems before it needs to be readjusted. In contrast, a 4:1 piggy-back system has half the throw as the 5:1 system. The throw for the different pulley systems discussed in this section are summarized in Figure 6.4.

Figure 6.4: Summary Table of Throw for Pulley Systems				
Pulley System and Mechanical Advantage	Range of System ¹ [feet]	Throw ² [feet]	Throw as a % of Range of System ³	Notes:
2:1	10	10	100%	Figure 6.7
3:1 Z-Rig	10	10	100%	Figure 6.8
4:1 Piggy-back	10	5	50%	Figure 6.9
5:1	10	10	100%	Figure 6.10
8:1 Double Piggy-back	10	2	20%	Not diagramed
9:1 Double Z-rig	10	3.3	33%	Figure 6.11
Block and Tackle ⁴	10	10	100%	Figure 6.12

¹ **Range of the system** – The *range of the system* is the length of the hauling system. See discussion within the text. For purposes of this table, the range of the system is held constant at ten feet.

² **“Throw”** – Throw is defined as how far the hauling system moves before it needs to be readjusted. The greater the throw the less times the system needs to be readjusted. Note: The length of the pulleys and prusicks were not included in the calculation of throw.

³ Calculation: [Throw] / [Range of System] x 100 = [% Throw is of Range of System] The length of the pulleys and prusicks were not included in the calculations.

⁴ Mechanical advantage is determined by the number of lines supporting the load. Since the pulleys are all located next to each other, throw remains relatively unaffected and is the same as the range of the system.

Internal Versus External Hauling Systems

– In an *internal system*, the hauling system and hauling line are one and the same. The Z-rig is a classic example of the internal hauling system (see Figure 6.8). In the *external system*, the hauling system acts independently of the haul line. The Piggy-back is a classic example of an external system (see Figure 6.9). The piggy-back system is designed to be rigged as an external system and not as an internal system. However, the Z-rig can be rigged as either an internal or external system.

120° Rule and Directional Pulleys

(Figure 6.5 and Figure 6.6) – Derived from the climbing literature, when the angle between two anchors is roughly 120 degrees, the force on each anchor equals the weight of the load (Figure 6.5). It is a 1:1:1 ratio between the two anchors and load. In pulley systems, when the angle between the anchor and the effort is 120 degrees, the force on the anchor, effort and load are all the same (Figure 6.5). The result is that there is no mechanical advantage.

Intuitively, when using a 2:1 pulley system, the effort should be half of the load. A 20 lb effort should exert a 40 lb effort on the load or twice the effort (Figure 6.6). However, this is not the case when the angle is 120 degrees. It is a 1:1:1 ratio between the load, anchor and effort. Any potential mechanical advantage is lost. As the angle between the anchor and effort decreases, the mechanical advantage approaches the theoretical 2:1 ratio. A directional pulley minimizes the angle (i.e. zero angle) and maximizes the mechanical advantage (i.e. 2:1). In addition, the use of a directional pulley provides safety for the haulers since it allows them to safely stand off to the side of the hauling system in case the system fails.

Types of Systems

There are three basic pulley configurations: 2:1 Pulley System, the 3:1 Z-rig and the block and tackle. Although the block and tackle receives a minor role, it should be given more consideration as an external hauling system, particularly in search and rescue situations. For the purposes of this discussion, all of the pulley systems are a combination of the 2:1 and Z-rig systems. The block and tackle system is treated separately.

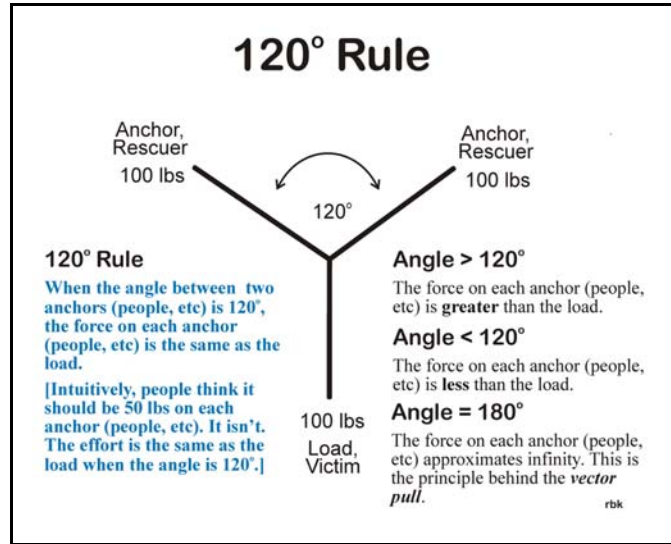


Figure 6.5: 120 degree Rule. Source rbk

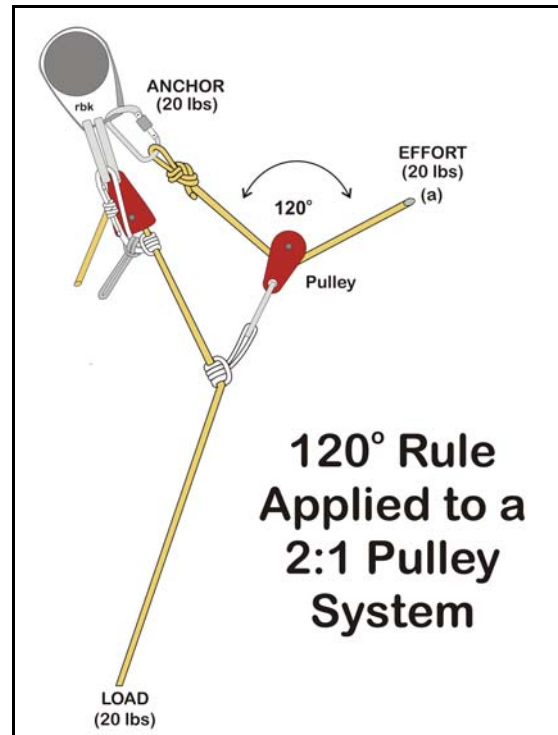


Figure 6.6: 120 degree Rule. Source: rbk.

2:1 Pulley System – The 2:1 pulley system is one of the two basic systems (Figure 6.7). Normally, it is configured as an external hauling system. It doesn't lend itself as an internal hauling system because it can't be readjusted. Not including a directional pulley, the system can be constructed with one pulley and a prusik. The self-adjusting brake adds another prusik and pulley to the system. Throw is the same as the range of the system. As a practical matter and because of its low mechanical advantage, there is little benefit of using a 2:1 pulley system by itself. It is usually used in combination with itself in the piggy-back (4:1) or in concert with other systems such as in the 5:1 system.

Z-rig (3:1) – The 3:1 Z-rig is the second basic system (Figure 6.8). Not including a directional

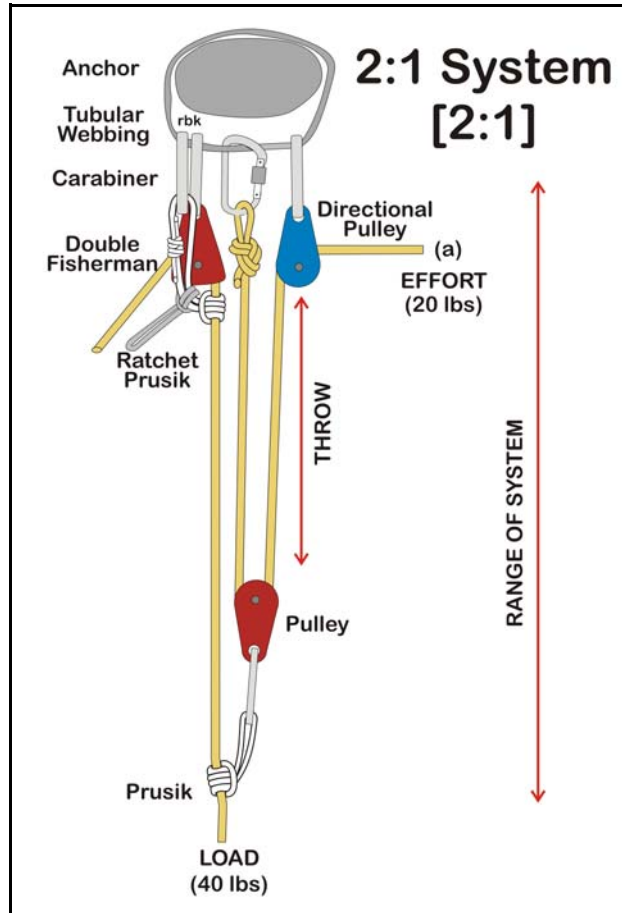


Figure 6.7

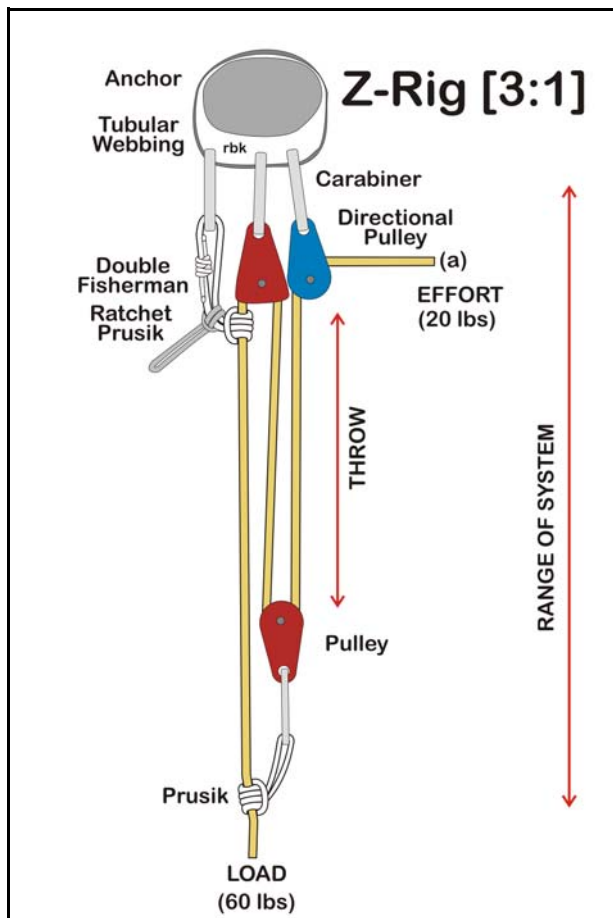


Figure 6.8

pulley, the system can be constructed with two pulleys and a prusik. The self-adjusting brake adds another prusik to the system. A directional pulley adds a third pulley. Normally, the Z-rig is used as an internal system where the haul line is used as part of the hauling system. The Z-rig has a throw equal to the range of the system. The Z-rig can also be configured as an external hauling system. It can be used in more complex systems like the 5:1 pulley system or the double Z-rig. In some circles, the Z-rig has fallen into disfavor because with the inherent inefficiencies and friction found in any of these system. In practice, the system is closer to a 2:1 mechanical advantage. For this reason, if mechanical advantage is needed, consider the 5:1 system.

Piggy-back (4:1) – The 4:1 piggy-back system is literally a 2:1 pulley system pulling on another 2:1 pulley system (Figure 6.9). It is normally rigged as an external system. Not including the directional pulley, it requires two pulleys and a separate haul line. Obtaining a 4:1 mechanical advantage with only two pulleys can be considered an advantage of the system. The self-adjusting brake adds another prusik and pulley to the system however. As a practical matter, most 4:1 systems utilize three pulleys. Although two separate lines are shown in Figure 6.9, a Figure 6.8 on a bight is often tied in the middle of a rope and the two running ends of the rope become the two haul lines. As demonstrated in Figure 6.3 and Figure 6.4, the system has poor throw or half the range of the system. Often users tend to compensate for the lack of throw by increasing the range of the system. However, that can be problematic also.

Consider several of the following notes regarding the use of a piggy-back system. Figure 6.9 shows two separate systems. A figure-eight on a bight can be tied on the effort line of the first pulley and used as the hauling system for the second pulley system.

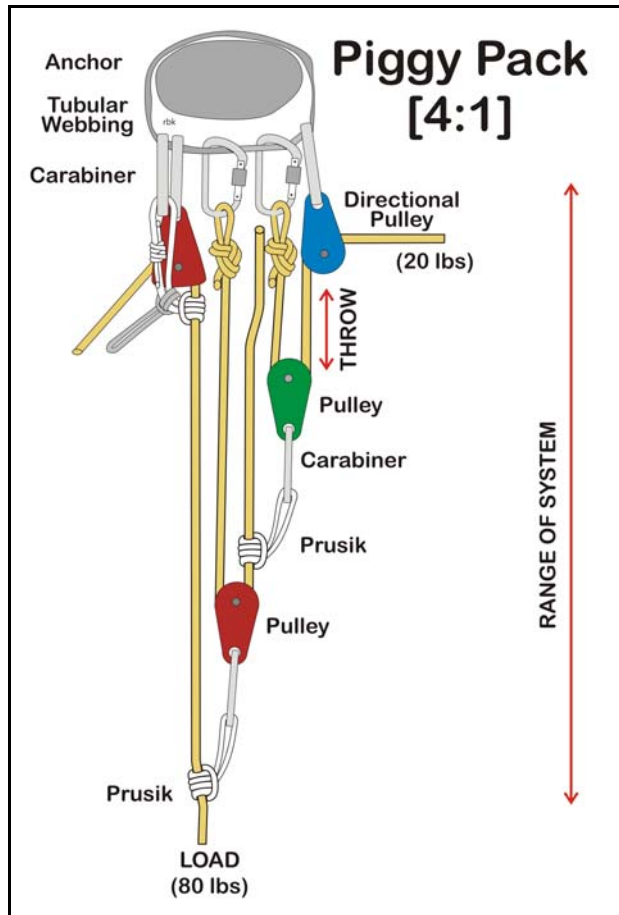


Figure 6.9

Building on a theme of maximizing mechanical advantage while using a minimum of pulleys, multiple piggy-backs begin to come into their own. In multiple piggy-back systems, mechanical advantage increases exponentially. Add another 2:1 pulley and the 4:1 piggy-back has a mechanical advantage of 8:1. Add a fourth pulley to create a double piggy-back, and a mechanical advantage of 16:1 is obtained. However, a major disadvantage of multiple piggy-back systems is that the systems require multiple lines to construct and throw is sacrificed forcing constant readjustment of the hauling system. Comparatively, a double Z-rig requires a minimum of four pulleys for a 9:1 mechanical advantage. With an 8:1 mechanical advantage, a multiple piggy-back system requires three pulleys, one less pulley than the double Z-rig. In terms of mechanical advantage, a double piggy-back system comes into its own using four pulleys to provide a 16:1 mechanical advantage. However, the mechanical advantage is obtained at the expense of throw and there is a tendency to extend the range of the system in order to obtain a reasonable throw.

5:1 System – The 5:1 system is a 2:1 pulley system pulling on 3:1 Z-rig (Figure 6.10). It requires four pulleys and if used, a directional pulley is the fifth pulley. The self-adjusting brake adds another Prusik to the system, but not another pulley. Since the base system is a 3:1 Z-rig, the 5:1 system is usually configured as an internal system. However, it can be configured as an external system if desired. A significant advantage of the 5:1 system is that it has a throw equal to the range of the system. It has the same throw as a 2:1 system or Z-rig, yet it has a mechanical advantage of 5:1. The 5:1 system has sufficient mechanical advantage to more than compensate for the practical losses of mechanical advantage resulting from the inefficiencies and friction associated with a simple 2:1 or Z-rig. This makes it an excellent alternative to these and the piggy-back systems.

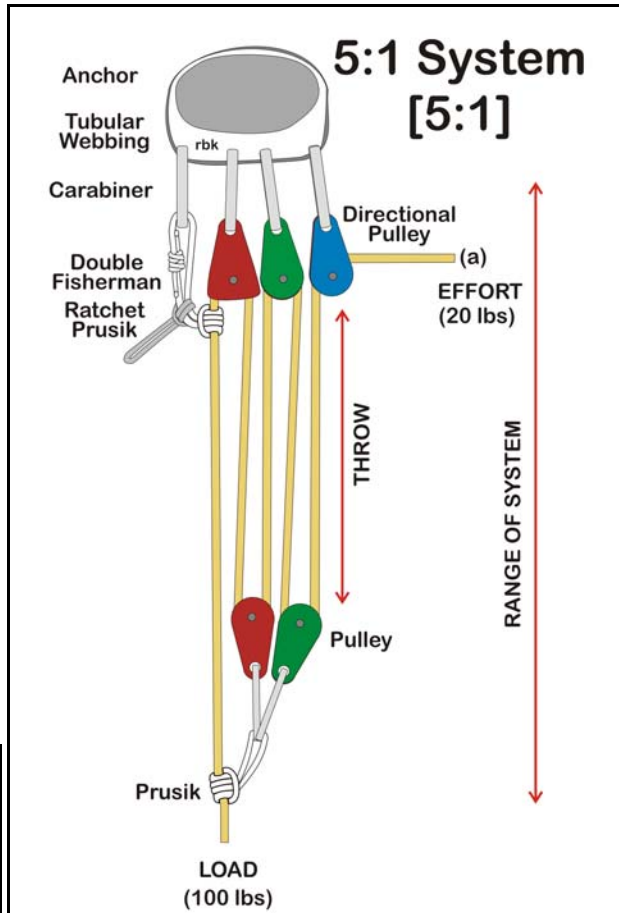


Figure 6.10

If needed, the 5:1 system can easily be converted into a double Z-rig, and conversely, the double Z-rig can easily be converted into a 5:1 system. To create a double Z-rig, simply unhook the 2:1 system (green pulleys) and fasten it with a prusik to the effort line of the Z-rig.

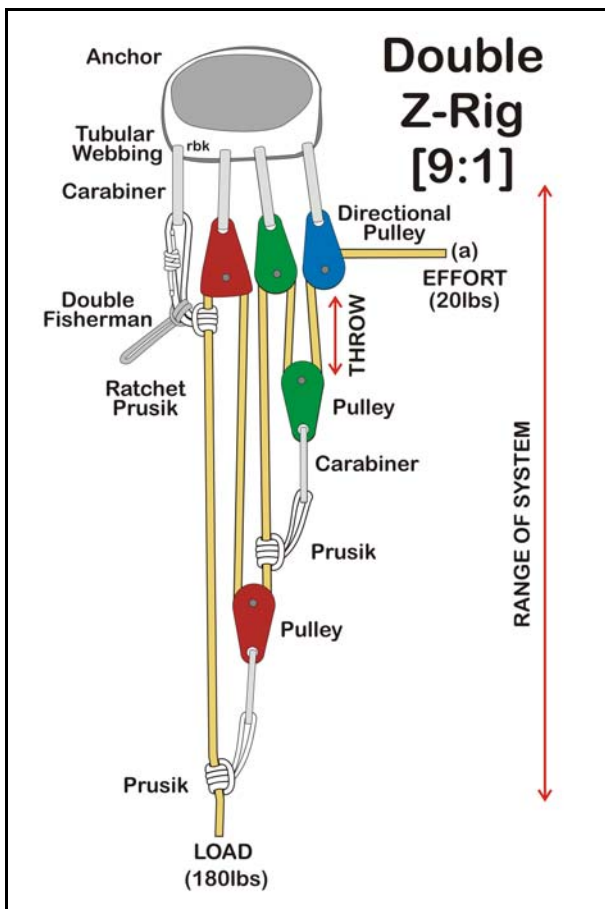


Figure 6.11

Double Z-rig (9:1) – The 9:1 double Z-rig system is a 3:1 Z-rig pulling on another 3:1 Z-rig (Figure 6.11). It requires four pulleys or the same number of pulleys as in the 5:1 system. A directional pulley is the fifth pulley. The self-adjusting brake adds another prusik to the system. Although it is usually used as an internal system, it can be configured as an external system if needed. In contrast to the 5:1 system, the double Z-rig maximizes mechanical advantage at the expense of throw (see Figure 6.4). Comparatively, it has poor throw, roughly one-

third of the range of the system.

As previously noted, the 5:1 system can easily be converted into a double Z-rig and the double Z-rig can easily be converted into a 5:1 system. To create a 5:1 system, simply unhook the green Z-rig and fasten it to the prusik on the main haul line with a carabiner.

Normally, the double Z-rig system is rigged as internal system. This means that the main haul line is used to configure the pulley system and no additional lines are necessary to configure the hauling system. If desired, the double Z-rig can be rigged as an external system.

Block and Tackle – A block and tackle system consists of two or more pulleys pulling in opposition to each other (Figure 6.12). Usually, there are two or more pulleys housed within each of the two blocks or housings. When configured as an internal system, lifting is finished when the two pulleys are drawn together and the system cannot be readjusted. As an internal system, the block and tackle system is relatively impractical except for lifting heavy loads short distances.

However, when configured as an external system, a block and tackle system becomes a practical and efficient hauling system. In this configuration, it is configured similar to a piggy-back or any other external system except the block and tackle is substituted for the piggy-back system. The system can be rigged with a self-adjusting brake and the system can easily be repositioned along the haul line.

Throw is the same as the range of the system. Also, because the pulleys are positioned next to each other, the system has better practical throw compared with systems where pulleys are pulling on other pulleys (e.g. double Z-rig). As pictured in Figure 6.11, the system provides a 5:1 mechanical advantage (Note: There are five lines supporting the load). Additional pulleys can be added increasing the mechanical advantage without sacrificing throw. This makes this system particularly advantageous in rescue situations. The biggest disadvantage of this system is bulk and weight making it more suitable for search and rescue teams than general recreation users. Regardless, the use of a block and tackle system as an external system has all the advantages of an external system, and in SAR situations, it can often supercede most of the systems discussed on this section.

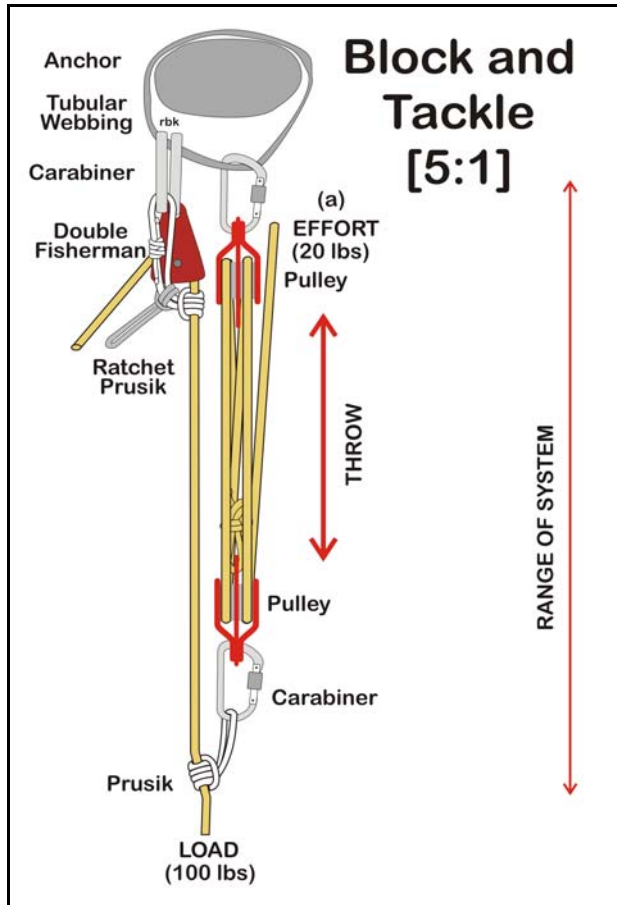


Figure 6.12

Summary

This chapter is a comprehensive and thorough discussion of mechanical advantage systems. It simplifies the discussion into its basic components and moves toward a recommendation regarding which is the optimum system. The best all around system is the 5:1 system.

The mechanical advantage systems can be condensed into three basic systems, a 2:1, 3:1 Z-rig, and block and tackle systems. All compound systems are composed from the 2:1 and 3:1 Z-rig. The 5:1 system is literally composed of the 3:1 Z-rig and 2:1 system hooked in parallel. In addition, haul systems are either internal (e.g. Z-rig) or external (e.g. piggy back). Some like the piggy back are external systems only. Others like the Z-rig are normally an internal system but can be rigged as an external system if desired. Throw or how far the hauling system can operate before it needs to be readjusted is another consideration.

The need for mechanical advantage is determined, in part, by the number of people present. In the field, one of two situations is generally present. There are a lot of people present and the “arm strong” method works quite well. Ten people pulling on a line can exert considerable force on a hauling system. Or, if there are few people available, there is a need for mechanical advantage to compensate for the lack of people. Couple this with the inefficiencies resulting from the 120 degree rule or simple friction within the system and a 3:1 Z-rig sounds good but in reality it is closer to delivering a 2:1 mechanical advantage. As a practical matter, there is usually a need for more mechanical advantage to compensate for these inefficiencies.

In conclusion, if there is one system to know, it is the recommendation of this author that it is the 5:1 system. It has both good mechanical advantage and throw. With efficiency losses, it will still deliver at least a 4:1 mechanical advantage. In addition, if more mechanical advantage is needed, it can very easily be converted into a 9:1 Z-rig with a simple adjustment. Conversely, if less mechanical advantage is needed, the 2:1 can be unhooked and the simple Z-rig used. In summary, if one system is emphasized, it should be the 5:1 system.

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Chapter 7: Study Questions



Swiftwater Rescue Course

EXAMINATION QUESTIONS

1. The following are multiple choice questions. Please write the correct response on the blank in front of the question. (1.25 pts each)

- _____ 1) As a rule always wear a life jacket (PFD) within 10 feet of the water. (p: 1.1)
a) true
b) false
- _____ 2) It is okay to loop the rope around your wrist to increase your grip on the rope. (p: 1.2)
a) true
b) false
- _____ 3) Deploying upstream spotters is necessary. However, deploying downstream rescuers is not necessary. (p: 1.2)
a) true
b) false
- _____ 4) What you bring with you is what you have for the rescue. (p: 1.2)
a) true
b) false
- _____ 5) “Rescuers first, victims second” means that the safety of the rescuer comes first. If a rescuer becomes a victim, you now have two victims to deal with. (p: 1.2)
a) true
b) false
- _____ 6) Coming onto the scene of an incident, paddlers in a recreational group have several important differences from a rescue squad. All items listed below are true regarding this difference except one. Which is it? (p: 1.3)
a) Generally, paddlers have fewer *people* to assist in the rescue than the rescue squad.
b) Generally, paddlers have less *rescue equipment* on hand to effect a rescue than a rescue squad.
c) Generally, paddlers reach the incident site before the rescue squad (*time*).
d) In a heads down rescue, paddlers generally have the best opportunity to effect the rescue (*type of rescue*).
e) All of the above items are true.
- _____ 7) The Swiftwater Rescue Technician (SRT I/II) course by Rescue 3 (*rescue squads*) is designed for rescuers operating in which phase of the rescue curve? (p: 1.3)
a) prevention/safety
b) self-rescue
c) rescue by others in your group
d) rescue by others outside your group
- _____ 8) According to the rescue curve, your first line of defense is which of the following? (p: 1.1)
a) prevention/safety
b) self-rescue
c) rescue by others in your group
d) rescue by others outside your group
e) injury, damage or loss

- _____ 9) In terms of the rescue curve, a victim swims to shore unaided is an example of which of the following? (p: 1.1)
- a) prevention/safety
 - b) self-rescue
 - c) rescue by others in your group
 - d) rescue by others outside your group
 - e) injury, damage or loss
- _____ 10) A rescuer on your trip throws a rope to the victim. The victim grabs a hold of the rope. In terms of the rescue curve, the victim is now in which phase? (p: 1.1)
- a) prevention/safety
 - b) self-rescue
 - c) rescue by others in your group
 - d) rescue by others outside your group
 - e) injury, damage or loss
- _____ 11) There is no relationship between a roller coaster and providing the experience to the participant. (p: 1.9)
- a) true
 - b) false
- _____ 12) An adventure sports programmer seeks to increase actual risks and reduce perceived risks. (p: 1.9)
- a) true
 - b) false
- _____ 13) The *solo wading with a paddle* technique doesn't work very well on rocky and uneven bottoms. (p: 2.1)
- a) true
 - b) false
- _____ 14) The heart of the two person wading technique is the use of the paddle to stabilize the waders. (p: 2.2)
- a) true
 - b) false
- _____ 15) The huddle is really a variation of the solo wading with a paddle wading technique except with multiple people. (p: 2.2)
- a) true
 - b) false
- _____ 16) The pyramid can be used to alter the current above a victim. (p: 2.3)
- a) true
 - b) false
- _____ 17) The pyramid uses the solo wading with a paddle technique for the point person. (p: 2.3)
- a) true
 - b) false
- _____ 18) The text suggests the point person in the pyramid should be the leader and call out the commands. (p: 2.3)
- a) true
 - b) false
- _____ 19) The in-line crossing is designed to move a small group through deep water. (p: 2.4)
- a) true
 - b) false

- _____ 20) Aggressive swimming is essentially the same thing as the crawl stroke. (p: 2.5)
a) true
b) false
- _____ 21) The barrel roll is used by a swimmer to exit an eddy. (p: 2.5)
a) true
b) false
- _____ 22) Aggressive swimming is a technique that uses the extensive use of the back ferry. (p: 2.6)
a) true
b) false
- _____ 23) When packing the rope into the throw bag, the rope should be neatly coiled in the bag so that it comes out easily. (p: 3.1)
a) true
b) false
- _____ 24) When coiling the rope for the second throw, count the number of coils you make so that you can estimate the amount of rope you have to throw. (p: 3.2)
a) true
b) false
- _____ 25) The victim should place the throw rope over which shoulder to help ferry (move) the victim over to the shore. Which shoulder should it go over. (p: 3.3)
a) Place the rope over the shoulder **away from** the shore you want to go toward. This points the head to the shore where you want to go.
b) Place the rope over the shoulder **nearest** to the shore you want to go toward. This points the head away from the shore where you want to go.
- _____ 26) When entering the water, the rescuer does a shallow water dive with his hands over his chest to protect the chest. (p: 3.3)
a) true
b) false
- _____ 27) After throwing the bag, the text recommends that the belayer immediately go into a sitting belay. (p: 3.5)
a) true
b) false
- _____ 28) The 120 degree rule has little or no applicability to how you set up a stabilization line. (p: 3.6)
a) true
b) false
- _____ 29) The purpose of the stabilization line is to cinch and extricate the victim. (p: 3.6)
a) true
b) false
- _____ 30) When backing up a belay, the backup pulls backwards but not downward. (p: 3.7)
a) true
b) false
- _____ 31) The Inverted Paddle Snag Line is used to rescue paddles and equipment. . (p: 3.7)
a) true
b) false

- _____ 32) In the *simple rope tether*, the rescuer uses a belayed line for stability. (p: 3.8)
a) true
b) false
- _____ 33) In the tethered swimmer rescue, clip the line with a carabiner into the back of the rescuer's shoulder strap. (p: 3.8)
a) true
b) false
- _____ 34) In the tethered swimmer rescue, the rescuer grabs the shoulder straps of the victim's life jacket. (p: 3.9)
a) true
b) false
- _____ 35) (p: 3.9) In the V-lower, the rescuer pendulums outward on a line belayed from the shore.
a) true
b) false
- _____ 36) Turbulent water can often disconnect two locking carabiners fastened together that are left unlocked. (p: 3.9)
a) true
b) false
- _____ 37) A simple cinch converts a stabilization line into a cinch. (p: 3.10)
a) true
b) false
- _____ 38) The Kiwi Cinch requires a minimum of four people to implement the cinch. (p: 3.12)
a) true
b) false
- _____ 39) The Carlson Cinch can damage the internal organs of the victim. (p: 3.12)
a) true
b) false
- _____ 40) When looking upstream, river right is on the right shore. (p: 4.1)
a) true
b) false
- _____ 41) The principle of laminar flow is that the deeper the water the faster the water near the surface flows. (p: 4.1)
a) true
b) false
- _____ 42) A rock or other obstruction causes the upstream-V. (p: 4.2)
a) true
b) false
- _____ 43) There is no vertical height differences between the upstream and downstream-Vs? (p: 4.2)
a) true
b) false
- _____ 44) The chute formed between two rocks forms an "upstream-V." (p: 4.2)
a) true
b) false
- _____ 45) The water travels faster on the inside of a bend. (p: 4.3)
a) true
b) false

- _____ 46) A pillow is created by a rock underneath the water. (p: 4.4)
a) true
b) false
- _____ 47) Which of the following is **not** part of an eddy. (p: 4.4)
a) An area where the water is flowing back upstream
b) A current differential
c) An eddy line
d) A downstream current that moves more slowly than the main current.
e) All of the above are part of an eddy
- _____ 48) Which of the following is not part of a *hole or hydraulic*. (p: 4.5)
a) A backwash where the water is flowing back upstream to fill the hole
b) A boil
c) An eddy line
d) A downstream current that moves more slowly than the main current.
- _____ 49) Conceptually, a hydraulic is an eddy turned on its side. (p: 4.5)
a) true
b) false
- _____ 50) Which of the following is part of a “*smiling*” hole. (p: 4.6)
a) The center of the hole is downstream of the sides.
b) The energy of the hole tends to force things to the center of the hole.
c) Generally, they are to be avoided. It is a superficial smile.
- _____ 51) A downed tree in the river current where the water flows through the tree is an example of a *pillow*. (p: 4.7)
a) true
b) false
- _____ 52) A **knot** is a group of wraps in the rope that require an external object for the knot to maintain its structural integrity. (p: 5.2)
a) true
b) false
- _____ 53) A **hitch** is a group of wraps in the rope where the wraps themselves maintains its structural integrity (p: 5.2)
a) true
b) false
- _____ 54) The “**running end**” of the rope is the end of the rope that is used to rig with or tie off to something. (p: 5.2)
a) true
b) false
- _____ 55) The “**working end**” of the rope is the free end or the end of the rope that is not rigged. (p: 5.2)
a) true
b) false
- _____ 56) A “**bight**” is a double back section of a rope somewhere in the center of the rope that does not cross over itself. (p: 5.2)
a) true
b) false
- _____ 57) In general, a bowline is a relative easy knot to untie after being placed on load. (p: 5.2)
a) true
b) false

- _____ 58) When tying a knot it is important to “set” the knot where all the parts of the knot are tighten together to maintain the knot’s configuration. (p: 5.4)
a) true
b) false
- _____ 59) *Dynamic kernmantle rope* rather than *static kernmantle rope* should be used in rescue work. (p: 5.4)
a) true
b) false
- _____ 60) The double fishermans knot is part of the figure-8 family of knots. (p: 5.5)
a) true
b) false
- _____ 61) The *directional figure-8 follow through knot* can also be used as a self-equalizing anchor. (p: 5.5)
a) true
b) false
- _____ 62) A prusik knot slips at between 900 to 1,200 lbs of tension. Hence, using a prusik knot used in a hauling system provides a built-in safety check since the system will slip before the rope breaks. (p: 5.9)
a) true
b) false
- _____ 63) A rigger’s knot (i.e. trucker’s knot) is really a Z-rig. (p: 5.10)
a) true
b) false
- _____ 64) The double fisherman’s knot is really a hitch. (p: 5.10)
a) true
b) false
- _____ 65) The double fisherman is chosen because it is an easy knot to untie after being under load. (p: 5.10)
a) true
b) false
- _____ 66) A bend is used to tie two ropes together. (p: 5.13)
a) true
b) false
- _____ 67) There are three basic pulley systems. These are the block and tackle, 4:1, and 3:1 systems. (p: 6.1)
a) true
b) false
- _____ 68) Counting the number of supporting lines in a pulley system will always indicate the mechanical advantage of the system. (p: 6.1)
a) true
b) false
- _____ 69) The range of the pulley system is the length of the hauling system before it needs to be readjusted. (p: 6.2)
a) true
b) false
- _____ 70) The concept of throw is synonymous with the mechanical advantage of the system. (p: 6.3)
a) true
b) false

- _____ 71) A 2:1 pulley system pulled at an angle of 120 degrees essentially has a practical or actual mechanical advantage of 1:1. (p: 6.4)
- a) true
 - b) false
- _____ 72) The 120 degree rule has little or no impact on how you tie a double fisherman knot. (p: 6.4)
- a) true
 - b) false
- _____ 73) One of the following statements is false regarding why you would put a *directional pulley* on a mechanical hauling system. Which is it?
- a) It helps to optimize the mechanical advantage of the system.
 - b) It minimizes or reduces the impact of the 120 degree rule.
 - c) It provides a degree of safety for the rescuer in case the system breaks.
 - d) It adds considerable friction to the system and should be avoided.
- _____ 74) Under the right conditions, a 9:1 Z-drag can lead to the failure of the system including the ropes.
- a) true
 - b) false
- _____ 75) All of the following can be used as anchors except one? Which one is it?
- a) You can loop webbing around the horn or protrusion on a submerged rock.
 - b) You can use the water knot on a loop of webbing as a chock wedged into a small crack in the rocks.
 - c) You can girth hitch a piece of webbing around a small rock and "chock" or wedge it into a crack.
 - d) You can wrap the webbing around the spot where two rocks join or press together.
 - e) All of the above can be used as anchors.
- _____ 76) Which of the mechanical advantage systems is incorrect or doesn't exist in the packet?
- a) C-rig; 7:1
 - b) Z-drag; 3:1
 - c) piggy-back; 4:1
 - d) double Z-drag; 9:1
- _____ 77) When using a haul system (e.g. piggy-back, Z-drag), all of the following items except one is recommended to increase the safety of the haulers.
- a) hang an object on the line to absorb and redirect kickback if the line breaks
 - b) redirect the line so the haul team is out of the way
 - c) stand behind the anchor (e.g. rock or tree) for protection while pulling
 - d) have someone off to the side to check your progress and forewarn you of problems
 - e) All of the above may be done to increase safety.
- _____ 78) A 5:1 system is really two Z-rigs pulling on each other. (p: 6.7)
- a) true
 - b) false
- _____ 79) Compared with a Z-rig, the piggy-back system has much better throw. (p: 6.3)
- a) true
 - b) false
- _____ 80) The 5:1 system can easily be converted to a 9:1 system if needed. (p: 6.7)
- a) true
 - b) false