



**National Water
Safety Management
Programme**

Level 2: River Module



Safeguarding lives in, on and near water

This resource is the approved material for the RLSS UK's National Water Safety Management Programme and has been specifically designed to support your learning as you develop your water safety awareness competencies.

Level 2: River Module



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Introduction

When we consider flowing water, we usually mean brooks, streams and rivers. However, flood and estuarial waters are also classed as moving waters. In this module, we will examine the unique and significant hazards presented by moving water (which have their own dynamic characteristics). This module will consider these hazards individually, including investigating their combined effects and exploring methods

to ensure that groups can enjoy these environments through safe management systems. This module will also provide the basis for lone workers to understand and manage the hazards they are exposed to. Tidal currents are considered separately in the Beach Module.

Water naturally flows from high to low ground under the influence of gravity. Whilst there are a number of standard natural features that affect normal flow, objects located in the water channel can also create localised effects. The speed of a current is affected by four factors:

- Size of the water channel (width/depth)
- Gradient of the water channel (how steep the water bed is)
- The volume of water (rainfall/flood)
- Riverbed composition

The speed of the current will increase if the water channel gets smaller, if the channel gradient increases or if the volume of water increases. This means that water speed can be variable even within the same channel of water.

For further reading, consult the RLSS UK/ ROSPA booklet 'Safety at Inland Water Sites'.

Learning Outcomes

The learning outcomes of this module are:

- To provide a group leader with the knowledge and appropriate skills to develop safety plans to manage groups effectively whilst in and near moving water (utilising simulated exercises)
- To improve individual's awareness of personal safety when around moving water environments
- To greater understand the need to manage risk in moving water environments
- To develop effective use of rescue equipment

Rivers and Estuaries



Large River with Highest Velocity of Water in Middle Section

Rivers are natural channels of water normally flowing towards the sea or other bodies of water such as lakes or reservoirs. Tributaries, which are supply channels to rivers, are smaller flows of water created from rainfall, surface run-off and ground water. There are a number of names given to tributary water flow, including streams, brooks and creeks.

Estuaries are the tidal mouths of rivers (where rivers meet the sea) and these can create complex and dangerous currents. The often-murky water of estuaries is influenced by fresh river water, saline sea water and coastal conditions, including tide and wave motion. These influences contribute to one of the most prominent characteristic of estuaries, which is sedimentation of the water bed. At low tide, the thick sediment is exposed. Estuaries can also flow against incoming waves at the estuarial mouth, causing a rip current (or in other words, a current travelling out to sea).

Generally speaking, where rivers flow in a straight line, the flow is at its greatest in the middle of the river and weakest near the banks (primarily due to friction on the riverbed). Despite reduced flow near the banks, a spiralling effect called 'Helical Flow' can occur, which can direct someone who has fallen from a bank into the river towards the centre of the river channel.

As the water flows close to the river banks and river bed, friction is generated between the water and edges of the river. The effect of the friction is to reduce the speed of water close to the river banks and bed. The fastest flow of water is found furthest from the banks and river bed in a layer just below the surface of the water. The speed of the water on the surface layer is slowed due to friction experienced through contact with the air.

As water flows around bends, the main flow will be on or near the outside of the bend. It is here that the water will also be at its deepest. Conversely, the slowest and shallowest water can be found on the inside of the bend. As the river continues to erode the riverbank, undercutting may develop, exposing tree roots beneath the water surface and destabilising the bank.

Rivers and Estuaries



Meandering River, Water Flows Fastest on Outer Bends

Hazards and Risks

- Rivers and streams, especially in highland areas, are generally very cold
- Slip, trip and fall hazard from uneven water bed
- Currents can carry you into deep water
- Rip currents can form where estuaries flow into the sea



Cold River Water, North Wales

Water Force

The force that water exerts on an object or person is often underestimated. Most people can be easily knocked off their feet, even in shallow and slow moving water. It is important to understand that the force of the water does not increase at the same rate as its speed.

The force of the water actually increases by the square of the increase in speed. If the speed of the water doubles, the force of the water quadruples. This means that a small increase in the water speed produces a much larger increase in the water force. The table below shows how the water force on a person's legs can increase with a relatively small increase in water speed.

WATER SPEED	EQUIVALENT SPEED (APPROX)	WATER FORCE LEGS
1m/s (2.2mph)	Slow walk	40N (4kg)
2m/s (4.5mph)	Fast walk	160N (16.3kg)
3m/s (6.7mph)	Jog	360N (36.7kg)

(Speed - metres per second [m/s], miles per hour [mph]. Mass - kilograms [kg]. Force - Newtons [N]. 10 newtons applies the same amount of force to the legs as 1kg resting against them).

Hazards and Risks

Casualties can be:

- knocked off their feet or unable to get their footing, causing injury
- swept downstream, away from safety
- unable to escape from the water flow due to water force, making rescue difficult

Specific Moving Water Hazards

Eddies

Eddies are caused when water flows around an obstacle (for example, a rock) and then swirls and flows back towards the downstream side of the obstacle (against the current). In most situations, eddies don't present a high level of danger and, commonly, the calm water behind the obstacle is a safe place to shelter from the current. In rare cases with very powerful currents, eddies may present a holding effect, similar to a hydraulic (also commonly known as a stopper).



Illustration of Eddy Currents



Eddy Current Downstream of the Obstacle

Hazards and Risks

- In very powerful currents, eddies may develop a slight holding effect (similar to a stopper/hydraulic) that can be difficult to escape from
- Powerful currents can lead to boats flipping over as they enter an eddy

Specific Moving Water Hazards

Cushion/Pillow Waves

Cushion or pillow waves form where high volumes of water flow meet a large obstruction (for example, a rock or riverbank), causing the water to 'pile up' in front of it. The waves will often push small watercraft away from the obstruction, but the impact and compression of the water can create undercut rocks and banks.

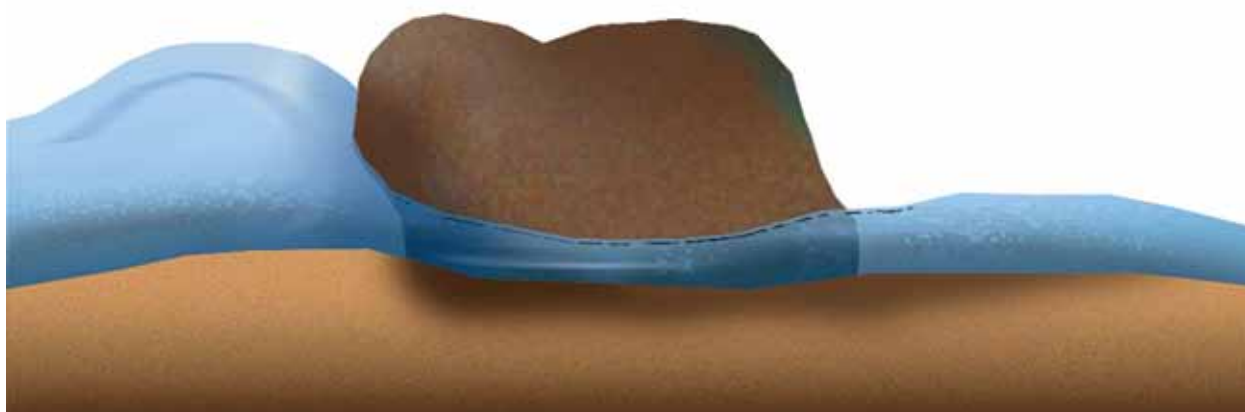


Illustration of Cushion Pillow



Cushion Wave in Front of the Rock

Hazards and Risks

- Cushion waves generally push small watercraft around obstacles but some configurations can cause them to flip over
- Undercuts created by cushion waves can cause unstable landforms, which can lead to falling into the water unintentionally, collision with falling debris and entrapment

Specific Moving Water Hazards

Hydraulics/Stoppers

Hydraulics/stoppers are caused when water flows over an obstacle (for example, a rock or weir) and then forms a rapid and aggressive re-circulating flowing motion back towards the obstacle (like a vertical eddy).



River Hydraulic/Stopper at the base of the weir



Natural Stopper

Hazards and Risks

- Re-circulating current can hold casualties inside the hydraulic/stopper, disorientating the casualty and making survival and rescue extremely difficult
- Some of the most powerful and dangerous hydraulics/stoppers form on the downstream side of weirs

Specific Moving Water Hazards

Strainers

Strainers are partial blockages in the water column that allow water to flow through but block larger objects. They can be formed by fallen trees, bars at the entrance of storm drains and even by normal road drains during flooding.



Illustration of Strainer

Hazards and Risks

- Holding effect – Even during low flow rates, the force of the water can hold the casualty against the strainer. Once a casualty is stuck against a strainer, due to the force of the water, the likelihood of rescue and survival is very low (unless the water subsides).

Specific Moving Water Hazards

Undercut Rocks and Banks

Undercut rocks and banks form through the process of water erosion underneath the surface of the water. During periods of low flow rate, undercuts can become more visible. Rocks that are undercut beneath the surface are very hazardous. Undercut banks can become unstable, which can lead to the bank 'giving way', and are more common in sedimentary rocks that are sand based. Unstable and eroded banks can collapse, with falling debris being a hazard to anyone underneath.



Undercut River Bank

Hazards and Risks

- Entrapment hazard – Undercut rocks and banks, exposing tree roots, can entrap water users, causing a build up of water which may hold the casualty and prevent them from breaking free (making rescue extremely difficult)
- Unstable bank edges, leading to either an unexpected fall or collision from falling material

Specific Moving Water Hazards

Weirs

Weirs are man-made, overflow style dams used commonly in rivers and canals to control the water level and flow, often to make the waterway deep enough for boats to pass through or to reduce erosion. Weirs partially obstruct the flow of the water, forcing it to either flow over the top of the weir, or through sluice gates, creating hydraulics/stoppers.

Weir hydraulics/stoppers can be extremely dangerous, due to both their powerful re-circulating motion and the fact that they often have walled, uniform edges, presenting no escape route.

The features of weirs that indicate a powerful and dangerous hydraulic/stopper are:

- The height of the drop over the weir
- The steepness of the weir face
- Floating debris (stuck in the hydraulic/stopper)
- Walled in edges to the weir
- Flow rate over the weir



Uniform Weir

Hazards and Risks

- Weirs create very stable and powerful hydraulics/stoppers
- Weirs with uniform edges create uniform hydraulics/stoppers which have uniform force across the weir and therefore do not offer any egress routes with lower force (which you can sometime find with natural hydraulic/stopper systems). This type of weir makes rescue extremely difficult
- Slips, trips and fall hazards (for people walking across weirs)

Flooding

Flooding is a very special form of moving water and contains unique hazards which are beyond the scope of this module. However, a brief overview of the hazards are presented. Leaders should not manage group activities near flooded waters or where there is a high risk of flood.

Flooding is an overflow of water onto an area of land, normally a floodplain, usually caused by excessive rainfall or a burst waterway. Floodwater is commonly murky and opaque which can make it difficult to identify the specific hazards that it contains.

Floodwater is extremely hazardous and entry into the water should always be avoided.



Flood in Urban Area

Hazards and Risks

Pollution and debris

- Sewage and storm water discharge.
- Chemicals and toxic waste.
- Industrial waste.
- Debris (floating and submerged).
- Agricultural waste and run-off.
- Vehicle discharge (oil, battery acid, petrol and diesel).

Micro-organisms

- Pathogenic micro-organisms (including bacteria).
- Parasites.

Water hazards

- Highly irregular water bed
 - paths, roads, sunken debris and sudden drops.
- Strainers
 - created by drains and debris
- Irregular and fast flowing currents
 - rapidly changing depth and sudden wave surges.

Suggested Controls for River Water

Key hazards created by open moving water are presented previously in this module, although this is not an exhaustive list. The hazards vary in severity but all must be treated with caution as immersion in even low to moderately flowing water can quickly develop into a serious incident. As the water flow increases, so the danger increases.

General controls listed here are provided as a guide for planning activities on rivers. These are only suggested controls, are not an exhaustive list and other arrangements may be necessary.

General Controls

- Observe all warning signs
- Where multiple activities are occurring on the same site, zoning must be considered
- If you are the designated safety cover, ensure you hold a current lifesaving qualification and can deal with life support and basic casualty care
- Those operating around the river, keep a safe distance from the edge of steep drops, to avoid inadvertently falling in (beware of undercut and edge erosion)
- Ensure the leader(s) is equipped with a rescue aid (e.g. throw line, buoyant aid) and lone workers are also equipped with appropriate rescue provision
- Plan activities away from identified hazards
- Ensure there are a number of suitable access and egress points
- Be aware of the weather forecast and be vigilant of changing weather conditions
- Make sure all those operating around the river wear appropriate clothing to cope with hot and cold conditions and, where appropriate, wear personal protective equipment and personal floatation devices
- Put time limits in place for water activities to avoid hypothermia
- Ensure plenty of fluid is available to avoid dehydration
- Follow the slip, slop, slap rule, applying clothing, hat and sun cream to avoid sun burn
- Create behavioural framework for river activity

Specific Controls for Group Management

- Clear instructions to be communicated to groups
- Groups should be allowed in low flow, shallow river water where there is ease of access and egress and where the activity is programmed
- Select a site that is within the capability of the group
- Leaders to maintain contact and observation of the group at all times.
- ALWAYS have a plan B to switch activities



Moving Water Hazards Summary

FEATURES	HAZARDS AND INFORMATION
Water Beds: Composition	<ul style="list-style-type: none"> • Slip, trip and fall hazard • Entrapment hazard • Entanglement hazard
Water Beds: Depth	<ul style="list-style-type: none"> • Gently shelving – Low hazard • Steeply shelving – Moderate hazard • Sudden drop offs – High hazard • Irregular surface – High hazard
Estuaries	<ul style="list-style-type: none"> • Rip currents can form where an estuary flows into the sea, usually stronger when the tide is low
Silt, Mudflats and Quicksand	<ul style="list-style-type: none"> • Soft sediment layer • Entrapment hazard • Drowning hazard (from incoming water)
Banks and Freeboards	<ul style="list-style-type: none"> • Slip, trip and fall hazard • Self rescue difficulty • Bank collapse hazard
Water Quality and Pollution and Pathogens (Open Water)	<ul style="list-style-type: none"> • Naturally occurring hazards (micro-organisms, parasites) • Pollution and debris • Weil's disease, poisoning, infections, injury
Deep and Cold Water	<ul style="list-style-type: none"> • Sea temperatures 4°C to 21°C (inland waters drop below 0°C) • Cold Water Immersion (Stages 1-3)
Water Speed and Force	<ul style="list-style-type: none"> • Speed – Channel size, gradient, water volume • Force – Increases by the square of the increase in speed • Casualties knocked off their feet • Casualties swept downstream
Eddies	<ul style="list-style-type: none"> • Water flow against the current behind an obstacle • Commonly, a safe place to shelter from the current • Rarely, a slight holding effect • Rarely, can flip boats
Pillows/Cushion Waves	<ul style="list-style-type: none"> • Water 'piles up' in front of an obstruction • Push watercraft away but may flip them • Can create undercut rocks
Undercut Rocks	<ul style="list-style-type: none"> • Form through water erosion • Entrapment hazard
Hydraulics	<ul style="list-style-type: none"> • Aggressive re-circulating current after passing over an obstacle • Holding and re-circulating hazard
Strainers	<ul style="list-style-type: none"> • Partial blockage to water flow • Holding effect

Flooding Summary	
FEATURES	HAZARDS AND INFORMATION
Water Quality and Debris	<ul style="list-style-type: none"> • Sewage and storm water discharge • Industrial waste • Agricultural waste and animal run-off • Chemical and toxic waste • Debris • Vehicle discharge • Pathogenic micro-organisms
Water hazards	<ul style="list-style-type: none"> • Highly irregular water bed • Strainers • Irregular and fast flowing currents
Water Beds: Composition	<ul style="list-style-type: none"> • Slip, trip and fall hazard • Entrapment hazard • Entanglement hazard
Water Speed and Force	<ul style="list-style-type: none"> • Speed – Channel size, gradient, water volume • Force – Increases by the square of the increase in speed • Casualties knocked off their feet • Casualties swept downstream