THE INTERISLAND LINE - RIVER RECREATION PROGRAMME

SWIFTWATER DYNAMICS

MODULE 2

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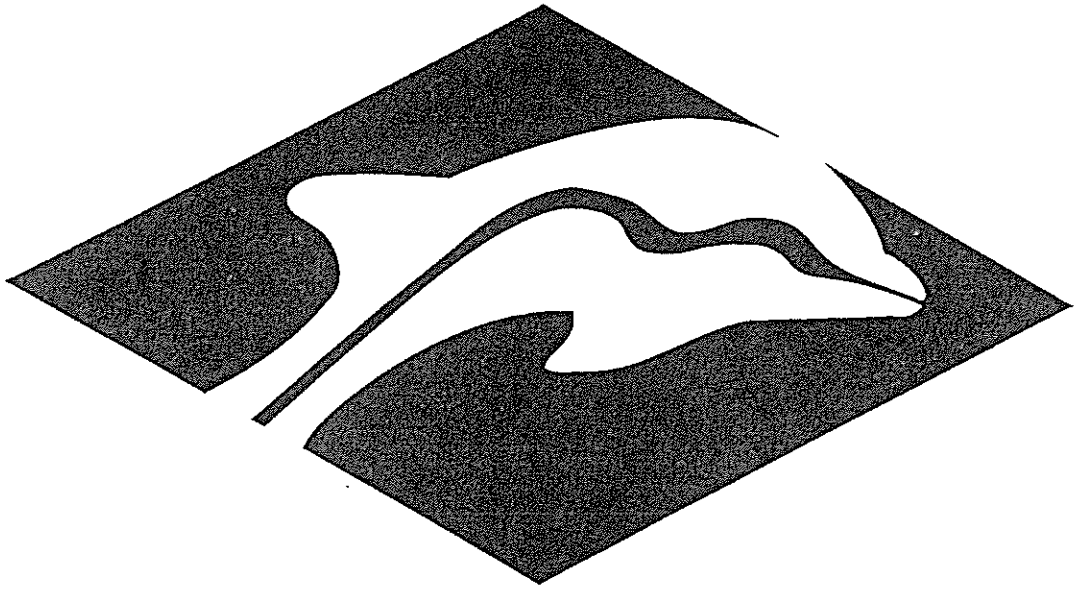

SWIFTWATER DYNAMICS

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Module 2

SWIFTWATER DYNAMICS

CONTENTS

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INTRODUCTION

Venturing onto rivers is a pastime enjoyed by many, whether it be for rafting, tubing, kayaking or recreational swimming. Associated with these enjoyable activities however is an inherent danger. A basic understanding of Swiftwater Dynamics and a healthy respect for the power of moving water can help to eliminate some of this danger.

It does not take long to learn the fundamentals of handling river craft such as kayaks and rafts, but it will take many seasons to learn how to read the river and to be able to predict or anticipate the variations in the current.

Module Two Swiftwater Dynamics is designed to give an introduction to the power of moving water and to point out some of the possible hazards associated with the moving water activities in which schools will participate.

HYDROLOGY

To understand how rivers flow we must first consider the five main factors which influence the way water behaves in the confines of a river bed.

The main factors to consider are:

1/ ELEVATION LOSS: Measured in vertical metres/kilometre. This is usually taken as an average net vertical drop between two points a kilometre apart. The elevation loss of a river section combined with the volume of flow will largely determine the difficulty of this section. A large elevation loss with a high volume of flow will usually combine to make very turbulent water.

2/ VOLUME OF FLOW: Measured in cubic metres per second (cumecs). Cumecs is the volume of water in cubic metres that passes a given point in one second.

3/ VELOCITY: Measured in metres per second and kilometres per hour, is the speed at which the water is moving. Velocity of the river is dependent upon the width and depth as the volume remains constant.

4/ GEOMORPHIC MAKE-UP OF THE RIVER BED: The make up of the river bed will largely determine the presence or absence of hazards such as holes, waves, ledges, rapids etc...

5/ HAZARDS: These come in various forms and can be broadly termed as any obstacle or condition that is capable of harming a person or craft.

CALCULATING VOLUME AND VELOCITY

The volume of flow can be calculated if the average depth, width and velocity of a river section is known.

Velocity is a little more difficult to estimate but can also be calculated by measuring a section of the river bank and observing the time it takes a float to travel this distance. This method and the following table are estimates only as other factors such as wind and water resistance on the float would have to be taken into consideration to gain an accurate value.

The table below is an example of how to calculate current speed (velocity) by using a float and 100 metre section of river bank.

Time for Float to travel 100 metres measured in sec.	Current Speed Metres/second	Current Speed Kilometres /Hr
10	10.0	36.00
20	5.0	18.00
30	3.3	11.88
40	2.5	9.00

THE FORCE OF WATER

Water in a river exerts a very powerful force against a fixed object. This force once in place remains constant unlike the ocean where the force is released with each tidal surge. The water force in a river does not increase proportionally with current speed as might be expected, but obeys a square law. This means that if the water speed doubles such as in a constricted channel the force exerted on a fixed object will increase up to four times.

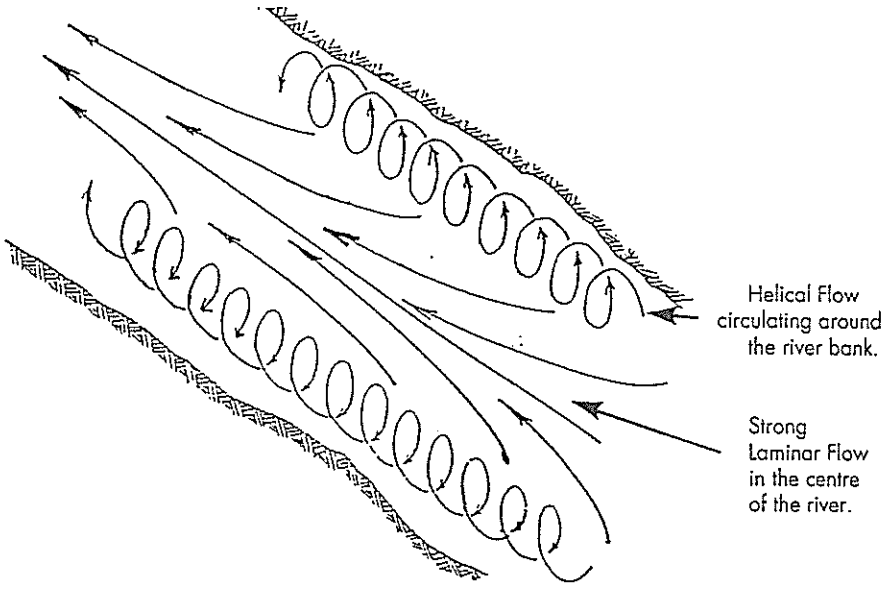
LAMINAR FLOW

As gravity causes water to flow down the river channel, friction along the edges of the river bank and river bed will slightly slow the speed of flow at these points.

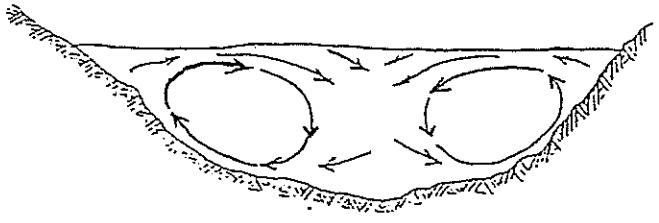
Also the water flowing near the river surface will be slowed slightly by contact with the air particularly if a strong wind is blowing upstream. The fastest current will therefore be found mid stream just below the surface. This variation of flow between various parts of the river is known as the laminar flow effect, or simply "Laminar Flow". It means that an object in midstream floating just below the surface will float faster than an object nearer the bank. (refer overheads)

Any person falling into moving water unless they have 100% buoyancy will float with their main body mass slightly below the surface in the faster moving water. When using floating rescue rope bear in mind that because of its light construction it will tend to float on the surface and if thrown upstream will not catch up to a swimmer especially if there is a upstream wind.

DIAGRAMS SHOWING LAMINAR & HELICAL FLOW.



Cross section of river.



Helical Flow moving up the bank and out towards the centre of the river.

HELICAL FLOW

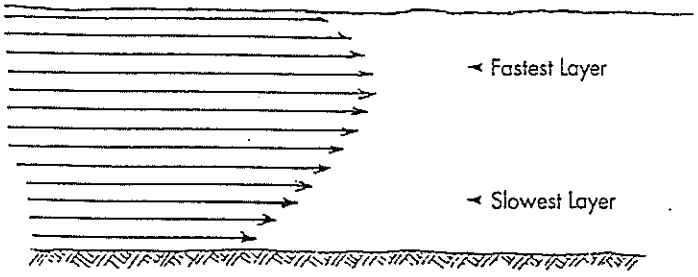
With water being affected by friction along the river bed and banks and flowing slower at these points, there is a tendency for the faster current midstream to fan out and flow into the areas of slower current. Rivers are not square boxes. River banks slope down into the river bed with the deepest part generally in midstream. Most of the force and weight of the water from the fastest laminar flow area will be pushed down towards the bed of the river then out along the river bed to the banks.

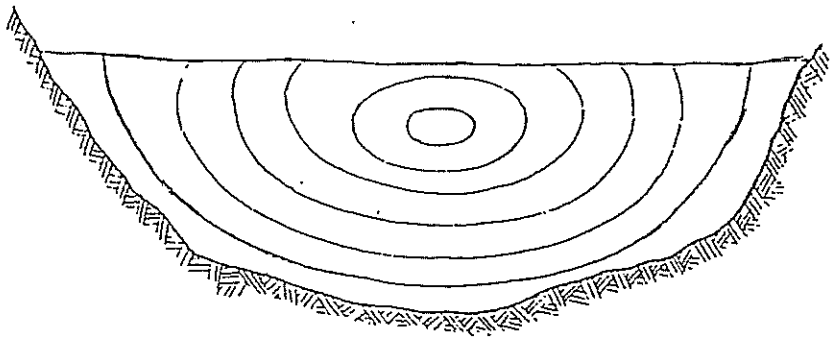
Along the river bank there is a somewhat weaker flow near the surface moving back to the middle of the river. These sub-currents set up a spiralling current known as "Helical Flow".

Helical flow has the effect of pulling floating objects away from the bank into the main current, where they will be held in the faster laminar flow and washed down stream.

The Helical Flow is especially pronounced in times of high water in rivers with steep banks.

SIDE VIEW OF RIVER SHOWING LAYERS OF WATER.





CROSS SECTION OF LAMINAR FLOW.

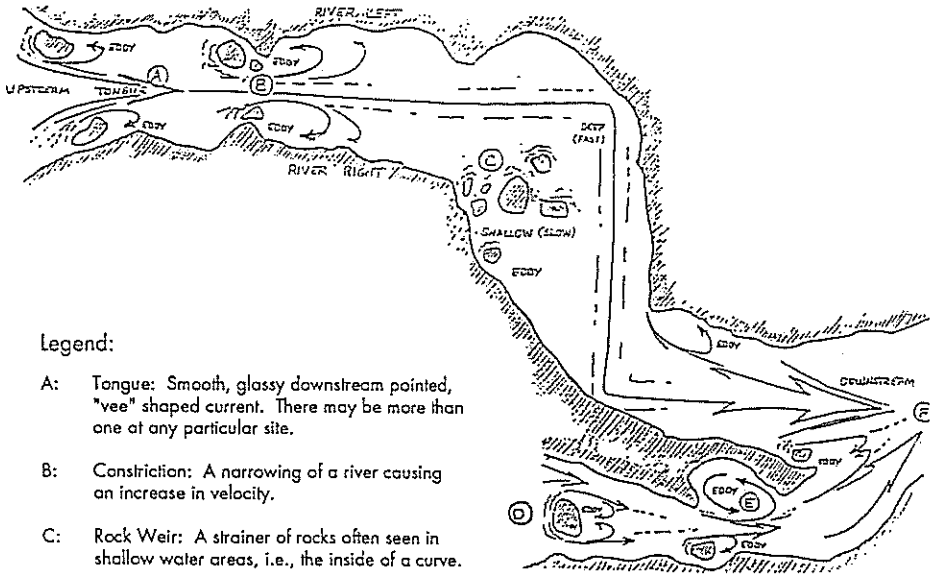
Fastest Layer in the centre of the river.
Slowest layer along the river bottom.

RIVER DYNAMICS

Water flows in a straight line, changing direction at points of high resistance. Therefore there will be a tendency for the line of greatest depth and strongest laminar flow to be on the outside of the corners.

On the outside of a corner the helical flow coming off the river bank will be compressed by the strong laminar flow so that it becomes much stronger as it is now flowing for a shorter distance. On the inside of the bend in the slower moving water the helical flow has a greater distance to flow and therefore becomes much weaker.

A person or object floating downstream will be carried by the laminar flow towards the outside bank of the corner. If a swimmer was attempting to get out of the river at this point, the combination of fast laminar flow and strong helical flow would make this very difficult.



Legend:

A: Tongue: Smooth, glassy downstream pointed, "vee" shaped current. There may be more than one at any particular site.

B: Constriction: A narrowing of a river causing an increase in velocity.

C: Rock Weir: A strainer of rocks often seen in shallow water areas, i.e., the inside of a curve.

D: Feeder Stream: These waterways add both water and debris to the river. Rapids are often found at their mouth.

E: Eddy: Vaccums of space created by an obstruction upstream. Water actually flows upstream.

F: Confluence: The meeting of two waterways.

BACKLASH/LATERAL WAVES

On sharp corners as the fast laminar flow slams into the bank, the helical flow effect will bounce water back along the surface of the river. This wave flowing off the bank is often called a backlash and has caught many a rafter and kayaker by surprise. If the backlash is strong enough it causes a "Lateral Wave" which moves diagonally out across the river.

- CLASSIFICATION OF RIVERS

Central to any river description is the system of grading the degree of difficulty. Any grading system holds true only for a set flow level. The river, when flowing higher or lower, can alter to give quite different conditions.

In New Zealand we use the international six point system ranging from Grade I (easy) to Grade VI (life threatening).

GRADE I: This includes slow moving lowland rivers, lakes and the lower parts of many wild rivers after they have lost altitude and spent their force. These bodies of moving water can have a few riffles and small waves with few or no obstructions.

GRADE II: This includes rivers showing definite movement but without any real violence. Easy rapids with regular waves in wide clear channels. Some manoeuvring may be required in a kayak or raft.

GRADE III: Rapids of Grade III appear on rivers where the current force would prevent a person from standing more than knee deep in the river. May contain rapids with high irregular waves, often capable of swamping open canoes. Some manoeuvring will be required.

GRADE IV: Usually found on rivers with a fast flow and steeper elevation loss. Long rapids with high irregular waves in constricted passages that will require precise manoeuvring in turbulent waters.

GRADE V: Long sections of confused and violent water, with extremely difficult violent rapids in highly congested routes. Careful inspection from shore will be required.

GRADE VI: Large waterfalls, very confused and violent water so difficult that navigation is virtually impossible. Unsuitable for open craft and potentially life threatening if swimming and considered unrunnable by all except a few experts.

TERMINOLOGY

Now that we know how rivers work and how they are graded, it is time to look at the specific dynamics of the river and the terminology used.

EDDIES

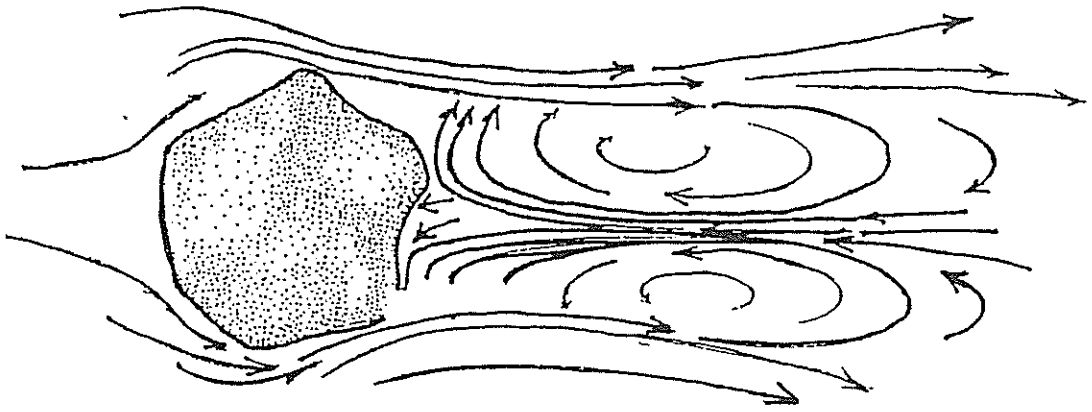
Eddies are found behind obstacles that constrict the flow, whether they be boulders midstream or projections from the bank.

As water flows around the side of an obstruction, the laminar flow is compressed and speeds up, it may also swell up to form a distinct pillow of water. Behind the obstacle (downstream) where there is no flow will be a hole the size of which will depend upon the depth of water, the size and shape of the obstacle and more importantly, the speed of the current

Water will flow from the strong laminar flow into the hole to fill it in. In order to do this it must slow, move over into the hole and flow back upstream along the bank to the obstruction. This water movement creates a back flow which then rotates out into the main current.

In the case of eddies created by boulders in the main flow the water enters the hole more or less equally from both sides. Eddies created by boulders jutting out from the shore have water coming in from one side only and build up a circular flow in the process, clockwise on the right bank and anticlockwise on the left bank.

In the tail of the eddy lies an area of quiet water slowly moving upstream which can be a safe haven even on the more wild rivers.



EDDY FORMED BEHIND ROCK IN THE RIVER WATER ENTERS FROM BOTH SIDES.

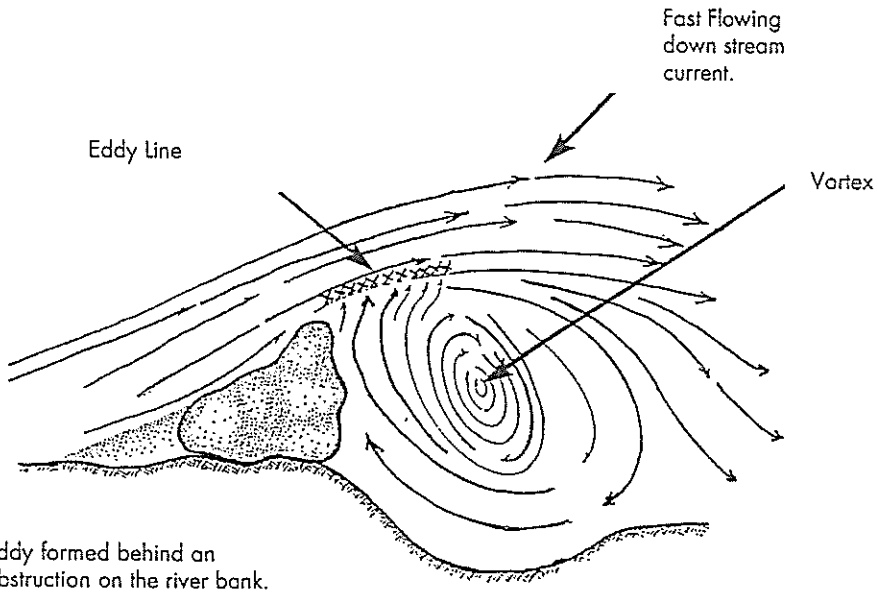
EDDY LINE

At the interface of the two currents in an eddy will be a discernible line called an " Eddy Line" where the weaker current in the eddy is being pulled under by the stronger current flowing down the river. In faster flowing rivers the eddy line can be quite pronounced with small whirlpools and confused water.

Swimmers caught in strong eddies or in the whirlpools of eddies should try to swim away from the centre across the flow rather than against the current. It is important not to fight the current at the head of the eddy where it is possible to be pulled under and held for some time as the laminar flow of the main current whisks you downstream. Rather make a break from the whirlpool into the tail of the eddy where the eddy line is not so strong. In doing this even a strong swimmer may drift around the vortex, a number of times before being flushed out.

Drownings have occurred in strong eddy lines when the currents have held people under longer than they can hold their breath.

Another place where strong eddy lines are located is where two currents join. The weaker flow will fold under the stronger flow causing considerable surge and buffeting. It may be a tributary stream joining the main stream or a part of the mainstream rejoining after being diverted from the principal channel by a boulder island or shingle bar. On bigger rivers there will also be a considerable surge and buffeting if the flow is rebounding off a bluff or wall. Care will need to be taken in these areas.



Eddy formed behind an obstruction on the river bank.

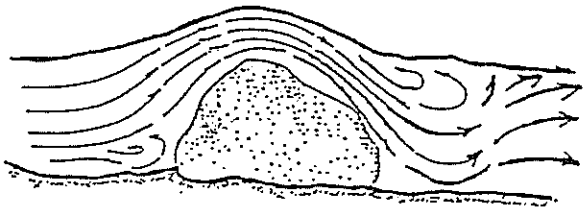
WAVES

Waves are formed by rocks or obstructions under the surface of the river causing the water to rise up and over them. The water rising up and over forms a smooth bump called a "Pillow".

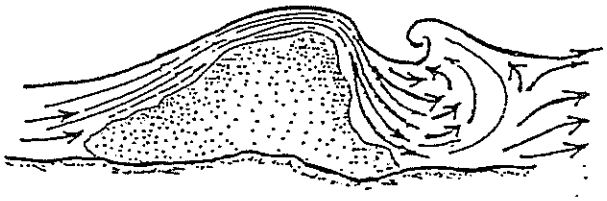
If the rock is close to the surface the water immediately after it will form a curling back wave called a " Hole" or "hydraulic," but if the rock is a little farther beneath the surface, the curling back wave gives way to a standing wave or waves.

The deeper the rock the further downstream the standing wave forms.

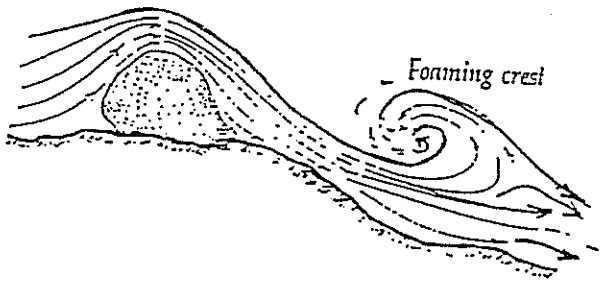
River waves differ from ocean waves in that the river water moves best the wave remains in the same position.



A surge as the water passes up and over the rocks.



A mild breaking wave.



Breaking Hole
The water passes up and over the rock then down the incline.

RAPIDS

A rapid is the turbulence created by water accelerating down an incline over obstructions on the river bed.

As the river reaches the incline, the helical flow has difficulty accelerating at the same speed as the laminar flow, and diagonal waves begin to form out from the banks and at the sides of midstream rocks. Often the approach to a rapid is generally composed of smooth surfaced accelerating water with the diagonal waves coming in from both sides forming a downstream V or tongue.

The make-up of the rapid will depend on the size and shape of the obstructions or rocks on the river bed and how close they are to the surface. Near the end of a long incline the highly energized water meets the resistance of the slower flow causing the formation of regular or near regular shaped waves called "Standing Waves" or "Haystacks"

The standing waves can vary considerably in size with the largest wave usually found at the base of the drop and each succeeding wave decreasing in size.

STRAINERS

A strainer can be termed as any obstacle in the river that allows water but not a person or craft to pass through. Trees and bushes in the river are the most common form of strainers, but undercut boulders, split rocks and bridge supports that are close together can have the same effect. These obstructions are extremely dangerous and have accounted for a number of river fatalities as the force of the water flowing through can easily pin a swimmer under the surface.

HIGH WATER

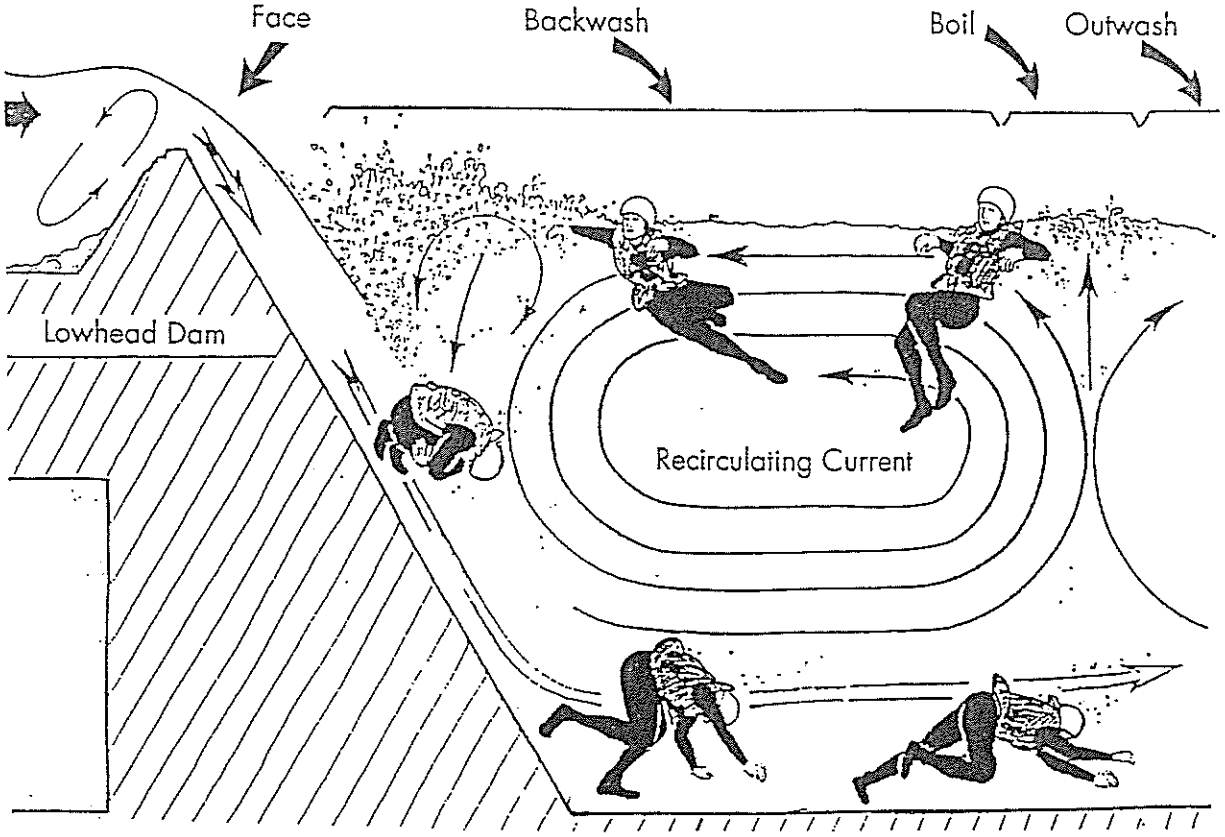
In floods and high water conditions, standing waves get bigger, eddy lines become more turbulent, eddy currents get stronger, and some holes covered by increased water volume may turn into standing waves. With even more water the hole may be completely washed out. But new holes and hazards are also formed and are generally more violent.

A river in high flow can be very dangerous as all the safe eddies will be washed out and the strong helical flows coming of the side walls and river banks will make landing a boat or swimming to shore extremely hazardous.

In flood conditions the rivers can also carry a lot of debris either washed in from the side channels or picked up as it crosses over farmland.

LEDGES AND DAMS

Ledges and dams are a major hazard on rivers and irrigation canals as they form symmetrical holes that generally extend all the way across the river. The water falls over the face of the dam and circulates around and around in the foaming area below. The danger with this type of hole is that the backwash can extend some metres downstream of the face of the drop and can be quite powerful. Generally if a swimmer is caught in this type of hole they will be unable to swim out in the conventional manner as it will be difficult to hold their breath long enough to surface in the outwash. Surfacing in the backwash will recirculate a swimmer around again. The only other option unless help is at hand is to try and swim across the backwash to the shore. From upstream, ledges and dams are easily distinguishable as there will be a definite horizon line on the river surface. Whenever a horizon line is seen or it looks as if the river is disappearing get out and have a look before running this section.



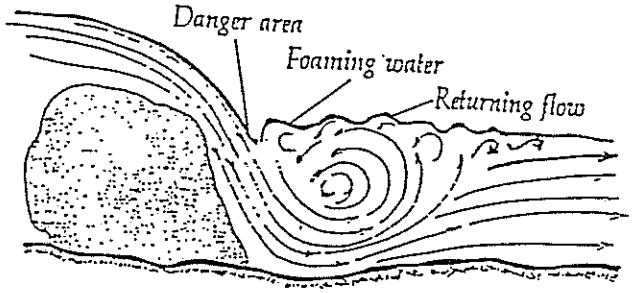
HOLES

Hole are formed by obstructions or rocks near the river surface forcing the water up and over them in a pillow wave. The water plunges over the rock down the other side where it is compressed and forced back to the surface in the form of a boil. On the upstream side of the boil the water forms a wave but because of its aerated makeup is unable to support itself and the water crashes down the face creating a recirculating foaming area of water. The steepness of the drop will determine how deep the face of the wave will be. The recirculating water upstream between the boil and the face is called the "Backwash". On the downstream side of the boil some of the water is able to escape on the surface and this is called the "Outwash". The line between boil and the outwash is called the "Boil Line."

Lying deeper underneath the surface of the hole is the main current which continues to flow downstream.

Holes need to be treated with respect and caution as they have the capability to stop and flip water craft and in some cases hold the craft in the violently churning foaming water between the backwash and the face.

If a swimmer is caught in this recirculating water the best way to get out is to swim strongly towards the face of the drop where the water will force them down to the main current flowing underneath the surface of the hole. Swimming strongly with the current will surface the swimmer in the outwash downstream of the boil.



Keeper or
recirculating hole.

CONCLUSION

Module two is an introduction to moving water and how it behaves in the confines of a river bed. Practical experience under qualified quidance is necessary before students venture out on to rivers.