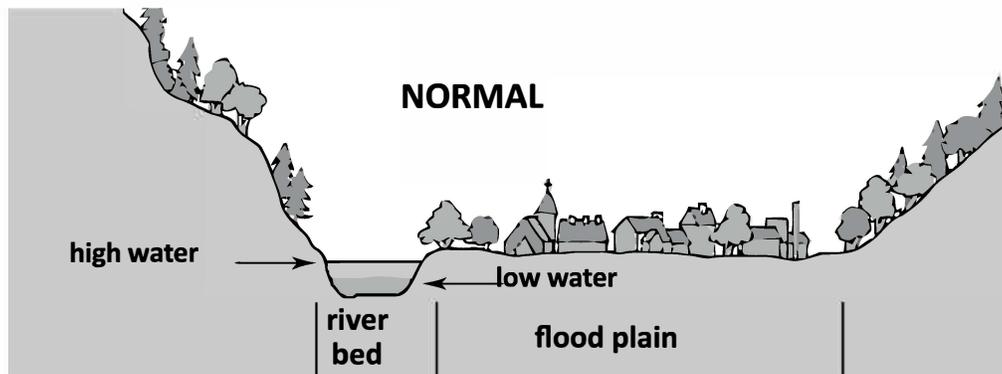


Flood theory

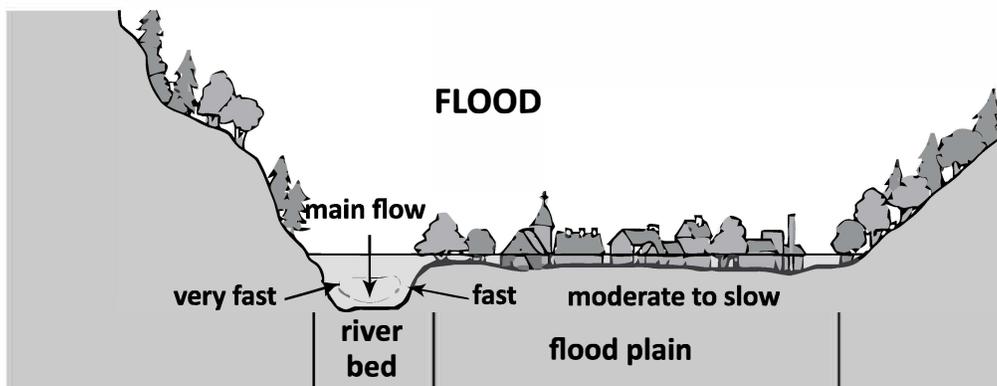
Although working in floods is essentially the same as working in any water environment, with all associated water hazards, it also has some specific issues.

River levels will vary greatly, depending upon factors such as rainfall, snowmelt, release from upstream dams etc. However, most of the time the river level will be within the river channel. Therefore, its flow and features are relatively predictable. As river levels rise, they will eventually reach a point where they are 'bankfull', so any subsequent rise will see the riverbanks overtopped and the water flowing through the adjacent low areas of land – the floodplain.



High and low water levels are normally contained within the banked channel

The increased volume of water means that most previously existing river hazards, such as lowhead dams, are probably now more powerful and dangerous, although some may actually become washed out. Additionally, there are now a range of new hazards. There may no longer be enough clearance under bridges for boats to pass. Water now flows through and around obstacles that were not designed to be in water and which create major hazards, for example parked cars, fences, hedges, gates, road signs, and park benches.



During a flood event, the water overtops the river banks and spreads onto the flood plain

Floodwater will be carrying large amounts of debris which can build up against houses and bridges and cause structural damage, as well as presenting significant risk to anyone in the water.

As water flows through the flood plain, the chance to become contaminated by hazardous materials, such as sewage, agricultural waste, and pesticides, is massively increased.

It is worth noting that once the water overflows the river banks and spreads across the flood plain, this may result in an apparent reduction in the speed of the water. However, the water flowing where the original river channel is will still be flowing at its previous rate. These all go towards making working in floods a hazardous and arduous task

The four realities of flooding

Floods, by their very nature, are:

- Multi-agency events
- Multi-jurisdictional events
- Hazmat and public health events
- Long-term events that can exhaust emergency personnel and community members emotionally, mentally, and physically

Rescue teams and emergency planners must understand that floods have their own life, and specific requirements. With effective pre-planning, specific training and appropriate equipment for these incidents, members of the public will be better protected from the effects of flooding.

At any major flood event, there will be many agencies on scene. It is essential that these agencies communicate effectively, and work together efficiently.

Floodwater does not respect any authority, boundaries or jurisdictions. As a result, rescue teams will be working with teams from other areas. By establishing common training techniques and equipment, this mutual aid process can be greatly simplified.

The public health implications of large scale flooding are clear: large numbers of people will be exposed to contaminants. The very young and the very old are most at risk. Health services in the area will be stretched to capacity.

The long-term nature of flooding cannot be overstated. Irrespective of the amount of resources available, there will always be a requirement for more. Years after the rescue response has been completed, members of the public may still be living in temporary accommodation, waiting for their homes to be rebuilt and refurbished.

The four phases of flooding

Flood incidents may be broken down into four phases. Every flood will progress through these phases, although because each flood is unique, it will progress at a different speed.

Phase 1 – Pre-flood

Flooding has not yet occurred. However, it will at some point in the future. Now is the time to develop a response plan based on an existing hazard assessment that includes historical flood data. This is also a good time to train personnel and invest in equipment. Public education during this phase can be invaluable for when the flood event occurs.

Phase 2 – Flash flood

Streams, rivers, storm drains and waste water management systems are full. Water is just beginning to escape waterways, to cover roads, and to impact property.

This phase is associated with high speed water. Most technical rescues will occur during this phase. People are caught unawares and lives are in imminent danger. During this phase rescuers will be at their greatest personal risk.

Phase 3 – Expansion

Streams and rivers are now clearly out of their banks and the water is moving laterally. Land is now being lost significantly, which means that access and egress will also be compromised. This phase is evacuation-intensive since structures, regardless of their occupancies, are now impacted. As essential infrastructure is now being compromised, hazmat issues begin to surface.

Evacuation means that people can leave under their own power – which is often not the case here. If people are being moved by rescue teams (for example by boat), then rescues are taking place. The new term is 'rescue evacuation'. This consumes resources and time.

Phase 4 – Recovery

As property owners begin to return, agencies will note an increase in accidents and injuries due to newly exposed hazards. Structures and roads should be inspected. Infrastructure restoration and hazmat issues are now the most pressing. Due to hazmat issues, public health agencies will be very busy. Search and rescue work will stop, and turn to search and recovery.

The use of rescue resources (especially inflatable boats) must be adjusted due to the decreasing water levels and emergence of new hazards. Emergency personnel should be closely monitored for fatigue, and the personal losses they may have suffered.

Flood return predictions

Floods are often referred to as the 'one in a hundred year flood'. This does not mean that they will occur every hundred years, but rather there is a 1 in 100 or 1% chance of such a flood occurring every year. A 'one in two hundred year flood' represents a 1 in 200 or 0.5% chance of the floodwaters reaching that height in any given year. It is even possible for two 'one in hundred year' floods to occur on the same river in the same year or even the same month. Looking at historic flood data and river flow measurements allows for computer models to be developed which can be used to produce flood return statistics and produce detailed flood mapping.

Flood mapping

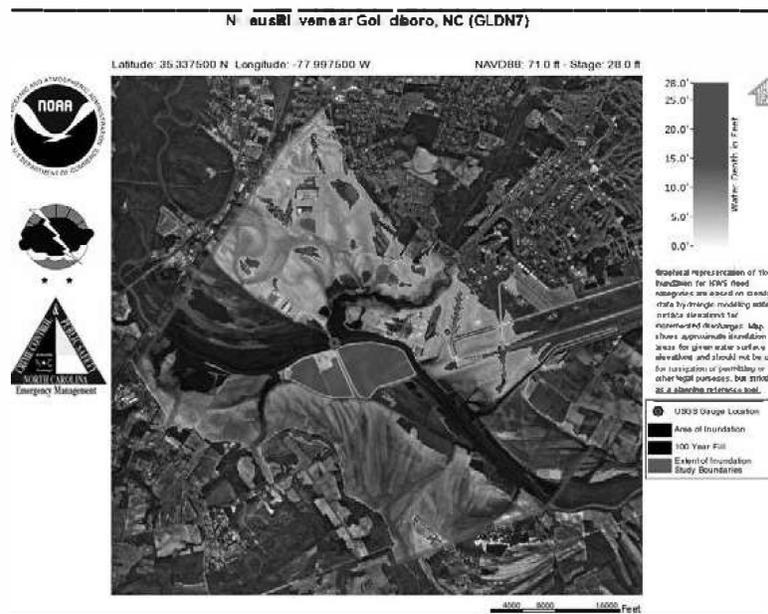
The ability to look into the future to see how many city blocks and roads might be flooded in a few days is becoming clearer with Flood Inundation Mapping. Sets of maps (referred to as libraries) are being developed which show both the extent and depth of water for various flood levels ranging from minor flooding all the way through to record flood levels. These new flood prediction tools help emergency managers and impacted citizens be better prepared to make important decisions regarding evacuations, moving property, and other mitigation efforts.

Combined with traditional forecasts and flood bulletin information, these new flood maps show the areas of likely inundation based on current conditions and future rainfall. Maps are produced using geographic information systems (GIS) and data gathered for Flood Insurance Rate Maps.

In the US, the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) and its National Ocean Service (NOS) Coastal Services Center (CSC) work in collaboration with the Federal Emergency Management Agency (FEMA) and other partners to develop inundation maps for both coastal and inland freshwater flooding.

North of the border, Environment Canada and a network of affiliates in each province provide the same service.

In the UK, flood maps are available on the Environment Agency's website². By entering a postcode, it is possible to see a map of flood areas and flood defenses. The Environment Agency maps can be viewed in up to 1:10,000 scale. The maps show levels based on 1 in 100 year events for rivers, 1 in 200 year events for coastal flooding, as well as 1 in 1,000 year events.



NOAA flood inundation map for the Nuese River, Goldboro, NC.

Flood warnings and alerts

Accurate warnings of predicted flood events are a vital tool. Warnings allow for the implementation of pre-planned responses including evacuations, placement of flood defences, initiation of road closures and pre-deployment of search and rescue resources.

In the next section we'll take a look at two systems on different continents to see how they are being put to use to keep the people in their jurisdiction safe.

European Flood Alert System

The European Flood Alert System (EFAS) provides flood alert information directly to national authorities. Their website at www.efas.eu/national-information.html provides links to national and regional authorities that publish publicly-available flood forecasts.

In the UK, for example, the Environment Agency operates a warning system called Floodline. This has a series of warning codes, which are:



FLOOD ALERT

Flood Alert means that flooding is possible and that the public should be prepared. It is used between two hours and two days in advance of forecast flooding.

- Be prepared to act upon your flood plan.
- Prepare a flood kit of essential items.
- Monitor local water levels and flood forecasts.



FLOOD WARNING

Flood Warning means that flooding is expected, and immediate action is required. It is used between half an hour and one day in advance of flooding.

- Move family, pets and valuables to a safe place.
- Turn off gas, electricity, and water supplies if safe to do so.
- Put flood protection equipment into place.



SEVERE FLOOD WARNING

Severe Flood Warning means that there is severe flooding and danger to life. It is used when flooding poses a significant threat to life.

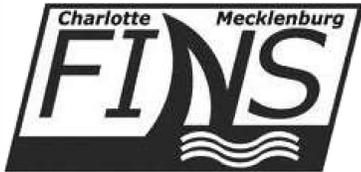
- Stay in a safe place with means of escape.
- Be ready should you need to evacuate your home.
- Co-operate with the emergency services.
- Call 999/112 if you are in immediate danger.

When no further flooding is expected, and river and sea conditions are going back to normal, there will be no warnings in force.

This information is available via a freephone telephone number (0845 988 1188) or the internet. If flood warnings are in place, this fact is often reported on TV and radio weather forecasts.

It is also possible for householders and businesses in high risk areas to register with Floodline Warnings Direct - a free service from the Environment Agency that provides flood warnings direct to you by telephone, mobile, email, SMS, and fax.

FINS



In the United States, there are some excellent examples of systems which link flood early warning systems directly to the Emergency Services. The Flood Information and Notification System (FINS) in operation in Charlotte, North Carolina is a particularly good example.

FINS is not intended to be a public warning system. It only notifies emergency responders. The National Weather Services provides Flood Watches and Flood Warnings to the news media and public.

FINS alerts local fire, police, medics, and emergency management to the threat or actual danger of flooding.

FINS is a partnership involving the City of Charlotte, Mecklenburg County and the US Geological Survey. They continually monitor rainfall and stream depth levels. Emergency responders are notified when there is a potential or actual problem.

Three levels of FINS

Alert

When rainfall is intense or streams rise rapidly, the FINS system automatically sends the alert via pager, mobile phone and email to emergency responders and Storm Water Services staff.

Investigate

If the situation gets worse, emergency personnel must personally visit the location of heavy rainfall or flooding. They will barricade streets or take other action if needed.

Emergency

The highest level. Additional precautions may be necessary, such as evacuating residents near the high-water areas.

For more information, see <http://finlive.mecklenburgcountync.gov>

Floodwater dynamics and hazards

The ability to recognize and risk assess swiftwater and flood hazards is a vital skill. Each hazard must be identified and addressed before performing a rescue. There is an enormous variety of hazards in a moving water and flood environment. A small selection is outlined below:

Utility hazards

Electricity

Clearly, electricity and water do not mix. Power lines may short out or arc. During flooding, the height between the power lines and surface is reduced - this is of particular importance during boat operations.

Substations can be flooded, leading to wide areas without electricity. Utilities companies should identify infrastructure at risk of flooding, and, ideally, a detailed response plan that provide protection for the infrastructure that will be in place.

Although power may be out in an area, some establishments have a backup or emergency system. This information should be in the agency pre-plan.

Natural gas

Gas mains can be ruptured if the earth around the pipe is eroded by floodwater. If houses are damaged then domestic piping can be ruptured, resulting in leaking gas. Clearly, this poses a significant fire hazard and an explosion hazard, particularly if operating powerboats.

LPG and oil tanks

As the contents of these tanks is lighter than water, even when they are full, they are buoyant. As tanks become immersed, they can break free of their framework and float off, venting gas or spilling oil.

Chemical and biological hazards

All waterways are polluted to some degree. Floodwater can contain significant amounts of hazardous material (hazmat). This may be industrial waste, sewage effluent, fuel, agricultural chemicals, dead animals, and much more washed into the water. These pollutants can cause serious health problems to people working near or in the water.

Personal hygiene is important while working near the water and personnel should be decontaminated following possible exposure. For more information on decontamination, see page 102.

Possible hazmat locations

Urban

- Fuel and oil from flooded vehicles
- Sewers
- Storm drains
- Fuel storage tanks
- Chemical bunds
- Household waste
- Industrial chemicals

Rural

- Pesticides
- Fertilizers
- Slurry pits
- Septic tanks
- Dead animals

Working in floods

Although a flood is a water incident and there are many similarities with dealing with a typical water rescue, there are also differences when dealing with flooding.

Early command and control needs to be established and maintained. Incident command is vital to communicate, plan, allocate, control, brief and debrief the many multi-agency teams that may be involved.

Consideration must be given to weather conditions, particularly current rainfall, predicted rainfall, tidal influences and land drainage. Clearly, these factors will all influence the water level. This continual change will affect the type of approach rescuers take to a situation. As the water level changes, so may the water speed, which could greatly affect operations.

Floodwater can be very changeable with regards to depth, flow, speed, and volume. Generally, these rates can be predicted by relevant agencies who can give an approximation of expected water levels.

Hazards

Floodwater can be flowing and moving in places it was never intended to be. Once rivers overflow their defined channels and interact with the wider environment, there is a whole new set of physical, biological and chemical hazards to deal with. Rescuers need to be constantly looking out for new hazards.

Floodwater is almost certainly contaminated. It is possible that the water has come up through the sewer system, and has been contaminated with chemicals or contains petrochemicals. Consideration should be given to such issues as testing and sampling of the water, and decontamination of personnel, equipment, and PPE. All floods should be treated as hazardous material incidents, and suitable decontamination processes should be adopted. The health of personnel exposed to floodwater should be monitored. For further information on decontamination, see page 102.

Equipment

Where personnel are committed to the water as a wading response, they should be appropriately dressed in drysuit, PFD and helmet. If waders are to be used instead of drysuits, consideration should be given to the possibility of the wearer stepping down into a deeper area of water and becoming immersed, from which it can be very difficult to recover. In addition, the skin will be contaminated with floodwater which may result in infection and illness.

All personnel operating in flooded areas should be issued with a suitable wading pole to allow them to check for underwater hazards. For more specific information, see page 114.

Tactics

Many bank-based rescue techniques can have limited applications in floods, due to the potential for wide areas of water. The effective use of both motor and paddle boats are a critical flood response asset. These require specialist training both to allow crew to operate the boat in a flowing water environment and to apply bank-based techniques such as throwbag and swimming rescues from these boats. Such training is available through the Rescue 3 Swiftwater and Flood Rescue Boat Operator (SFRBO) and Swiftwater Paddle Boat Handling (SPBH) courses.

If boats are being used, then the choice of boat type will be an issue. For more information on boat types, see page 68. When the water is deep and fast-flowing, powered inflatable boats work well. When the water becomes shallow, it may be necessary to use hard-bottomed boats. Rescuers may be able to wade in the water with boats to perform rescues. However, if the flow is too fast or the depth variable, then more advanced rescue techniques will be required, such as an aerial rope rescue or a helicopter.

Evacuation

Many people may need rescuing from a flooded area. Not all of these will be technical rescues. Incident managers need to decide who is to be rescued first and which rescue teams are best capable to deal with individual incidents – team typing is of a great help here.

Where rescuers are moving large amounts of people, consideration should be given to how they will be transported. Personal flotation devices in a full range of sizes, from small child to XXL adult, will be needed for members of the public. These should be clearly marked and a different color from those used by responders.

During an evacuation, people will need advice about what personal possessions they can realistically bring with them. Family pets can be problematic to deal with – many people refuse to leave without their pets and accommodation for pets should be available. The PETS Act authorizes FEMA to provide rescue, shelter, and essential needs for individuals with household pets and service animals, and to the household pets and animals themselves following a major flood disaster¹. People who have been rescued will need help and advice about emergency shelter and accommodation.

Search

Search is a major consideration in flood events. Not all victims will be obvious. House to house searches are required to ensure nobody is left trapped. These can be time-consuming and require many personnel to conduct them effectively. Once an area is searched, it should be marked according to international standards, and the incident management team informed, to avoid replication of work. This is usually done with spray paint on the outside of the property, on an area which will not cause undue damage, such as the door or roof.

