# STRUCTURAL FLOOD CONTROL OPTIONS

# CHAPTER 05

## Floodwater Damage to Structures

The extent of damage to structures that come in contact with floodwaters depends on the depth of the water in and around the structure, the length of time of inundation, the toxic extent of contaminants in floodwaters, and how rapidly the water is moving. Both static (little or no water movement) and dynamic (rapidly flowing water) forces are often at play.

In a *static environment*, water attacks and compromises the integrity of every part of a structure, particularly the wood foundation pilings, structural beams, carpets, wood floors, cabinetry, mechanical systems, utilities, and walls. Most damage to homes is sustained in the first four feet above the first floor. Within this space are located the above structural components and household furnishings. Floods that rise and recede quickly because less damage than water that sits for long periods. In these types of floods, the carpets, floors and drywall can be replaced, other components dried out, and the remainder of the structure is likely sound.

Floodwaters that fill homes and other structures for weeks typically result in totally ruining interiors, i.e., replacing all of the components listed in the above paragraph. The economic decision is whether to demolish the structure and start over or repair what remains.

The dynamic forces of rapidly moving floodwater add to the above scenario. As stated earlier, water flowing around and within a structure can exert great pressure on structural surfaces (e.g., water flowing at ***10 mph*** exerts the same pressure as wind gusts of ***270 mph***), often causing further damage, even failure.

## Structural Alternatives for Flood Control/Proofing

Structural alternatives for ***flood control/proofing*** include physical changes to the river environment and adjacent surroundings. For ease of discussion, the flood control/proofing of structures is divided between those in the floodplain, the floodway, and river channel.

# 1 Flood Control/Proofing Of Structures for FLOODPLAIN

The floodplain encompasses all the land at or below the **100-year** flood elevation, but exclusive of the floodway and river channel. Structural alternatives for the floodplain may appear to be remote from the river, but are subject to floodwaters on occasion.

## 1.1 Flood Proofing Alternatives

Flood-proofing may involve changes to the structures themselves or changes to the surroundings while leaving the structures alone. Structural changes include relocation, elevation, and encapsulation/waterproofing. Changes to the surroundings may include flow diversion and the construction of dikes or levees.

### ♣ Relocate / Move to higher ground

***Structural Measure***

**Relocation** involves either physically moving the structure in the floodplain to ground with an elevation above the 100-year flood level, or demolishing the structure and rebuilding a similar structure above the 100-year flood level. Moving a structure requires that the structure be in sound condition to be jacked up and transported to higher ground. This is a very expensive alternative and one not used very often.

***Impact on Flood Control***

Since the alternative removes an obstruction to flood flow in the floodplain during the flooding event, the impact has either negligible impact or a positive impact, depending on the footprint of the structure removed. It also means there is no longer a structure in the flood plain needing protection, so other flood or erosion control measures such as levees or riprap may also be removed. This in turn may allow the river greater latitude during floods and may reduce flood hazard up and down the river.

***Impact on River Process***

**Relocation of structures** out of the floodplain would benefit river processes. River channel dynamics require the ability of systems to remain connected with the floodplain, an area that receives the floodwaters of the river at high flows. In the Dungeness River, the majority of sediment is transported during flood flows (***Bountry et al 2002***). Levees that have been constructed to protect structures constrict the flow of the river, and do not allow connection to the floodplain or to side channels that convey floodwaters. By removing human made structures from the floodplain, including the levees and other structures that are intended to protect human property from flooding, uninhibited use of these areas would be re-established and the natural migration of the river would be more likely to occur in the channel migration zone. River bends can and do migrate across the floodplain over time (***Bountry et al 2002***). The removal of structures from the floodplain would allow natural river processes to occur without causing damage, or risk of damage to human made structures.

### *Impact on Fish Habitat*

Removing structures from the floodplain would result in many indirect effects on fish habitat. In a general sense, the protection measures used to prevent damage to human-made structures in the floodplain often restrict the natural migration of the river, reduce the ability of the river to handle flood flows, and disrupt the natural sediment transport processes that occur within a river system.

The effect of bank hardening structures and levees used to protect property usually results in higher velocities in channels and lower levels of habitat complexity for fish and other aquatic species.

These structures can also affect riparian vegetation development, spawning substrate, and pool frequency. Relocation of structures out of the floodplain, and the removal of hardened protection measures for those structures, would allow the natural development and use of the floodplain, and allow a more natural distribution of sediment throughout the river system, and would improve fish habitat.

## ♣ Elevation of Existing Structure

The structure can be elevated onto ***either a new pad foundation or onto piles.***

### *Structural Measures*

#### PAD FOUNDATION

- Elevating a structure onto a pad foundation can be done by building the pad adjacent to the structure and relocating the structure (jack-up and transport) to the pad, or jacking up structure and filling in under the elevated structure.

#### PILE FOUNDATION

- Elevating a structure onto piles can be done by installing the piles adjacent to the structure and relocating the structure (jack-up and transport) to the piles, or jacking up structure and drilling piles under the elevated structure, then lowering the structure onto the piles.

### *Impact on Flood Control*

The *impact of the flood control* depends on the size of the pad relative to the original foundation of the structure. If the pad is similar in size to the original foundation of the structure, the pad will not change the impacts on flood control. If the pad is larger than the original structure foundation, the pad may *restrict flood* flow some small percentage and negatively impact flood control by elevating the flood elevation upstream. Elevating a structure onto piles can be done by installing the piles adjacent to the structure and relocating the structure (jack-up and transport) to the piles, or jacking up structure and drilling piles under the elevated structure, then lowering the structure onto the piles.

### *Impact on River Process*

Elevating structures above the floodplain would have mixed effects on river processes depending on the structural approach used. An elevated pad foundation would not offer direct improvement to river processes because the structure would still disrupt the natural use of the floodplain. The removal of levees that may occur with the elevation of structures would offer some improvement to river process function. An elevated pile foundation would allow for some improvement to river process function in that the floodwaters would be able to flow through and around the piles, which would cause less overall disturbance to natural floodplain processes.

The indirect effects of this alternative measure would be the same as those for the pile foundation. If protection measures such as levees could be removed as a result of the elevation of the structure, than natural river process function would likely improve.

### *Impact on Fish Habitat*

Elevation of structures above the floodplain is unlikely to have direct effects on fish habitat. However, if flood protection measures, such as levees, can be removed as an indirect result of structure elevation, the similar benefits to fish habitat could occur as those described in Section 1.1. However, since the structure will remain in the floodplain, it is unlikely that the complete removal of levees would be possible to the extent that would occur if the structures were removed from the floodplain.

## ♣ Encapsulate/Waterproof below Flood Level

### *Structural Measure*

This alternative involves either installing watertight doors and windows in the structure below the ***100-year flood*** elevation or strengthening and wrapping that portion of the structure in waterproof film.

### *Impact on Flood Control*

Waterproofing structures within the floodplain will have no direct effects on the frequency or duration of flooding. This measure will decrease the risk of potential damage to property. The impact depends on the size of the encapsulation material relative to the original foundation of the structure. If the structure is just wrapped in a waterproof film material and results in a section similar in size to the original foundation of the structure, this alternative will not change the impacts on flood control. If the encapsulation results in a section larger than the original structure foundation, it may restrict flood flow some small percentage and negatively impact flood control by elevating the flood waters upstream

### *Impact on River Process*

Waterproofing structures below the flood level would have no direct improvements on river processes. The structures would remain in the floodplain, and there would be no increase in the ability of the floodplain to dissipate floodwaters. The protection provided to structures from waterproofing measures is unlikely to allow complete removal of protection measures such as levees. If the levees and other flood protection measures remain in place, the indirect benefits to river process function from waterproofing structures are likely to be less than the potential indirect benefits from structure elevation, and much less than those from the removal of structures from the floodplain.

### *Impact on Fish Habitat*

There would be no effects on fish habitat from waterproofing existing structures within the floodplain.

## ♣ 1.2 Levee/Floodwall/Berm/Dike around Foundation

### *Structural Measure*

This alternative involves constructing a levee or floodwall around the foundation of the structure. The protection can be either temporary or permanent and typically extend up to the 100-year flood elevation.

*A **levee** typically consists of a **trapezoidal-shaped section** of earth-material with a plant, concrete-block, or riprap scour protection facing.*

*A **floodwall** is typically a vertical wall constructed of man-made material. A levee or floodwall is usually with a few feet of the structure foundation.*

### *Impact on Flood Control*

Levees, floodwalls, berms, and dikes all provide flood control to structures inside the barriers by raising the height to which the water has to rise before spilling into the structure area. These measures provide protection to one structure or set of structures, but may be increasing the risk to other structures by occupying space on the floodplain. The barriers also may increase the potential damage to the very structures they are protecting if the barrier should fail. In the event that one of the barriers fails, the resultant flood waters inundate the surrounding area to a much greater extent than would have occurred without the water height provided by the barrier holding back the water.

### *Impact on River Process*

Levees, floodwalls, berms, and dikes all have similar impacts on river processes. These structures would be used to surround a structure on the floodplain and prevent floodwaters from damaging the structure. However, additional floodplain space would be occupied by the levees or other protection structures, so the ability of the floodplain to process floodwater would be reduced. The disconnection of the river from a larger part of the floodplain would have a negative effect on the development of natural river processes.

### *Impact on Fish Habitat*

The construction of levees, floodwalls, berms, and dikes generally has a negative effect on fish habitat. The occupation of the floodplain by structures and protective levees does not allow for natural migration of the channel across the floodplain. The need to protect these structures leads to channelization of the river to try to “control” the flow and keep the channel in one place. Channelization tends to increase water velocity, remove backwater habitat, reduce recruitment, and reduce habitat complexity.

## 1.3 Divert Flow: Off-stream Detention Pond

### *Structural Measure*

This alternative involves constructing a detention pond on the floodplain or beyond, but away from the floodway, and cutting a channel to it. Flood flow is channeled to the detention pond when the flood level reaches a specified elevation, but less than the 100-year flood.

### *Impact on Flood Control*

During a flood, floodwaters are diverted to the detention pond and impacts downstream are improved. The detention pond stores some of the flood water lessens the amount water the river system has to carry.

### *Impact on River Process*

Creation of an artificial off-stream detention pond could alter river processes by reducing the level of flow downstream from the pond. Reduction of flows would reduce the sediment transport capacity in downstream reaches. Reduction of sediment transport could lead to channel aggradation in downstream reaches, and deposition of fine sediment. Additionally, diversion of flow into an off-stream detention pond includes the risk of more river flow than anticipated entering the pond, and the potential for river channel avulsion.

### *Impact on Fish Habitat*

Creation of an off-stream detention pond could provide temporary off-channel habitat for salmonids during peak flows. Over wintering habitat has been shown to have benefits on growth to maturity for coho salmon and other salmonids. Those juvenile fish that overwinter in off-channel habitat achieve greater size-at-age than those fish that overwinter in the mainstem channels. However, the connection between the off-channel pond and the mainstem would need to be carefully constructed to maintain connection in order to prevent stranding of juvenile fish.

## Abandoned channel restoration / split channel

### *Structural Measure*

This alternative involves constructing a channel from the existing river channel to an abandoned or less-used river channel. This alternative is available only in meandering and braided sections of the river. It may require some further excavation/dredging of the previously abandoned channel to accommodate flood volumes.

### *Impact on Flood Control*

During a flood, floodwaters are diverted to the abandoned channel and impacts downstream are improved. The abandoned channel stores some of the flood water and lessens the amount of water the river system has to carry. In effect, this diversion would increase the flood conveyance of the main stem, and allow flood waters to recede gradually as they returned from side channels or abandoned channels to the main channel, or percolated into the groundwater.

### *Impact on River Process*

Reconnecting an abandoned channel to the mainstem channel could have various effects on river process, depending on the current status of the mainstem channel. If the mainstem channel has been extensively affected by human efforts to channelize the river through diking and bank hardening techniques such as riprap, reconnection with an abandoned channel may allow the river system to regain more of its natural sinuosity and allow the dissipation of excess energy that had been created by channelization. Identifying areas with existing human-made barriers would be beneficial in selecting sites for reconnection with abandoned channels and other off-channel habitats.

Diversion of flow into a side channel, abandoned channel, or newly created channel can have a variety of effects on river processes. Naturally, new river channels are often created by avulsions or meander bend cut-offs. The incorporation of deflectors or wood structures to divert flows at high water may increase the rate of creation of new channels that would have occurred naturally, only at a slower pace. LWD often plays a role in channel avulsions and diversion of flows to side channels during peak events. If there is a lack of LWD in the river system, artificial placement of log jams or other structures may be necessary to maintain channel diversity. However, the artificial diversion of high flows could alter the channel forming processes that occur during high flow events be reducing the amount of flow in the main channel. The main work of sediment transport occurs during high flow events, and if those flows are diverted into other channels, sediment may begin to aggrade in the main channel.

### *Impact on Fish Habitat*

Reconnection of the main stem with abandoned channels, or side channels, could provide important rearing habitat for coho and Chinook salmon and for other salmonids. Off-channel habitats can provide refuge from high flows in winter as well as thermal refuge in summer, as long as they remain connected to the main channel. Overwintering in off-channel areas can increase the growth to maturity for salmonids such as coho and chinook. Those juvenile fish that overwinter in off channel habitat achieve greater size-at-age than those fish that overwinter in the mainstem channels.

# 2 Flood Control/Proofing Of Structures for FLOOD WAY

The floodway includes the active channel and the river banks up to the level of bank full flow. The floodway is the portion of the land adjacent to the river that enables flood waters to pass without increasing flood depths upstream, but is exclusive of the river channel. A floodway usually has a small bank either cut by previous floods or a natural levee deposited by overflow of previous floodwaters.

## ♣ 2.1 Reduce Bank Slope

### *Structural Measure*

Bank reduction involves excavating or cutting the bank back at a gentler slope than currently exists. The process usually includes replanting or surfacing the bare bank slope with some form of scour protection.

### *Impact on Flood Control*

Reducing bank slopes may increase the flood conveyance of the channel by increasing the bankfull width of the channel. The reduced bank slope will increase the surface area of the bankfull channel and therefore, the volume of the channel at bankfull flow. If banks with reduced slopes have time to revegetate, bank stability will likely increase and natural channel containment will occur. Water velocity will decrease in areas that have vegetation, which increases channel roughness. Reduced water velocities will further reduce the erosive force of the water, but may also reduce the capacity of the channel to convey high flows without over topping its banks. However, bank vegetation is likely to trap sediment from high flows, and banks may build up further as a result of floods. The long-term effectiveness of reducing bank slopes is a site-specific issue that is difficult to generally predict.

### *Impact on River Process*

Reduction of bank slopes will reduce the potential for erosion of river banks. This reduction in erosion potential will have several effects including: reducing delivery of sediment to the channel, reducing recruitment of large woody debris, and reducing channel migration. If the channel is experiencing excessive erosion and bank failure, reducing bank slopes may help to stabilize the banks to allow them to re-vegetate. However, the natural process of erosion is vital to the dynamic balance of river systems, and reducing bank slopes affects this process. Bank erosion is the primary driver behind the delivery of LWD to river channels, and without natural erosion, in-channel levels of LWD will decrease, reducing channel complexity.

### *Impact on Fish Habitat*

The reduction of bank slopes may have mixed effects on fish habitat. If a stream is out of dynamic equilibrium and there is excessive erosion and sedimentation of spawning gravel, a reduction in bank slopes may help to decrease the level of fine sediment in the channel and benefit spawning habitat. However, undercut banks are a primary source of cover for juvenile fish, including salmonids. These fish generally hide under cover during the day to escape predation and feed mostly after dark. Removing steep banks would eliminate this important cover habitat.

## ♣ 2.2 Reinforce Bank

***Bank reinforcement*** *involves adding material to the bank face to increase the bank stability, protect the bank from river scour, or both.*

## *Bioengineering*

**Bioengineering** refers to the use of plants or planting to stabilize the bank and increase its ability to resist scour by river and flood flows.

## *Structural Measures*

***Hydro seed:*** Hydro seeding includes various methods of applying a liquid mixture of water, fertilizer, and plant seeds to the bank. Over time, the plants grow and establish a mature root system. The plants provide a surface roughness to slow flood flow. The plant roots entangle with the soil and increase the soil mass resistance to scour.

***Hand plant:*** Hand planting involves the insertion (planting) of saplings or mature plants into the riverbank. An advantage of hand planting is that the plants are immediately available to provide flow reduction and scour protection. Also, a variety of plant sizes can be introduced at the same time.

***Plant mats:*** Plant mats are blankets or meshes of natural or synthetic material containing fertilizer and plant seeds. The mats are rolled onto the riverbank and then anchored or stapled into the bank. Water can be sprayed onto the mats to start the growing process or fluctuation in the river level can be used to start the growth

## *Impact on Flood Control*

Bioengineering in not likely to reduce the frequency or duration of flooding, but may help prevent banks from failing and accelerated channel migration. These measures are designed to stabilize banks without drastically increasing water velocity, which could lead to channel down cutting or excessive erosion. Bank stabilization will not control floods, but may help reduce property damage and loss.

## *Impact on River Process*

Bioengineering allows failing banks to be reinforced in a manner that is more reflective of natural processes than traditional "hard" engineering practices. The incorporation of organic materials into the design, as well as the use of vegetation to increasingly stabilize the banks through time, provides a longer lasting, more natural treatment that requires less long-term maintenance. The organic materials mimic the natural inputs of the riparian environment, such as LWD. Vegetation used to stabilize banks will increase in root strength over time, and flood adapted species are likely to thrive in high flows. As vegetation increases, channel roughness may increase and water velocity may decrease. This effect is similar to the long-term effects from reduction in bank slope discussed in

### *Impact on Fish Habitat*

Bioengineering is intended to stabilize banks while also providing benefits to fish. The materials used in bioengineering are generally the same materials, such as LWD, that would naturally enter the river from the riparian corridor. LWD provides cover and food resources, as discussed earlier, while also providing backwater habitat to salmonids and other fish. Bioengineering techniques can serve the dual purpose of stabilizing banks to protect property along rivers and improving fish habitat.

## ♣ Gabions

### *Structural Measure*

Gabions are wire-mesh baskets filled with locally available stones, usually in the 2-inch to 6-inch range. The baskets come in block or mattress (flat) form. The former can be stacked to form a stepped wall. The latter can be laid on gentler slopes to form a surface covering of scour protection.

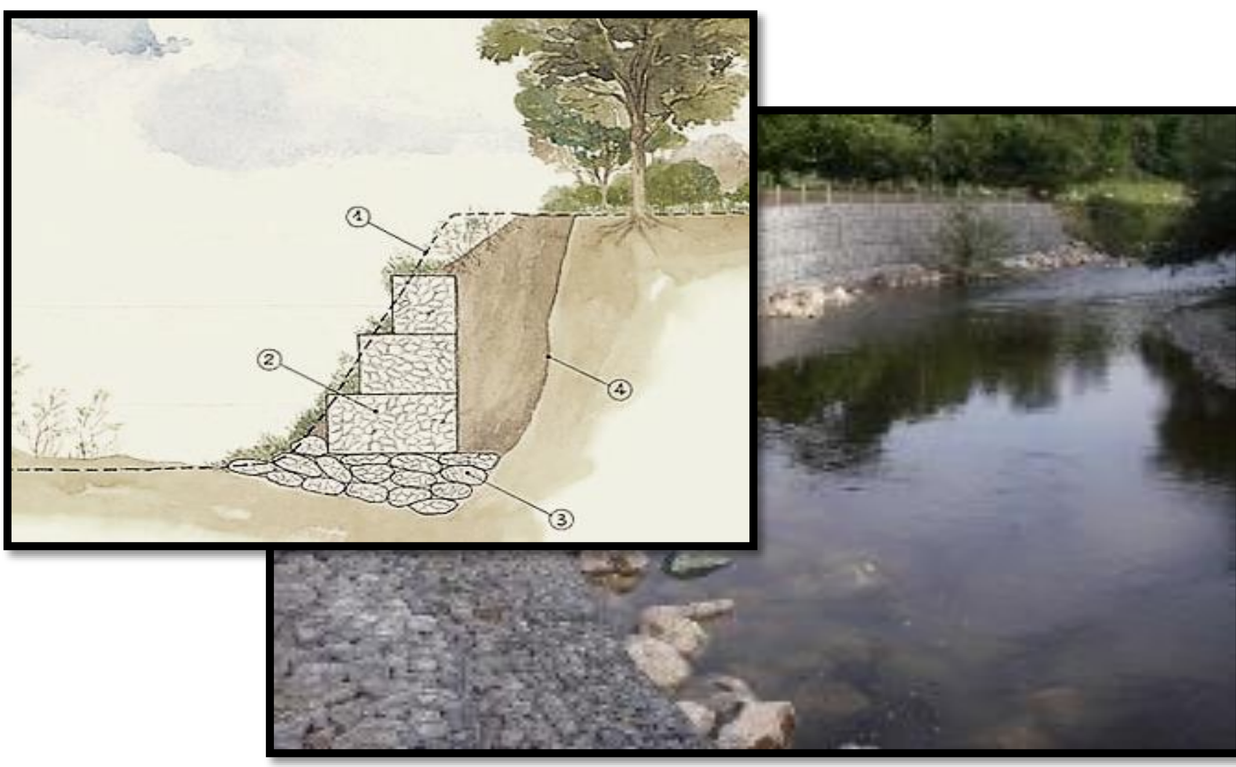



**Fig.: Gabions for Protection Against Flood.**

### *Impact on Flood Control*

Like bioengineering, gabions will not affect the frequency or duration of flooding, but may provide protection to streamside property and prevent bank erosion. However, unless combined with vegetation to re-enforce the strength of the structure, these rock filled baskets will deteriorate over time, and will need to be replaced to maintain their level of function.

### *Impact on River Process*

Gabions are often used to protect banks in areas where erosion and channel migration are excessive, or to protect property on the river banks. These hard structures can prevent erosion and decrease the delivery of fine sediment to downstream habitat. Gabions are designed to deflect river flow and provide an erosion resistant armor for banks. The deflection of flow may redirect erosion to other areas in the river channel. Gabions, like berms and dikes, may also increase the velocity water flow and decrease backwater habitat available for fish.

### *Impact on Fish Habitat*

Gabion structures do not provide direct benefits for fish habitat, but may serve as a source for spawning gravel if designed to do so. There is little usable cover provided by most gabion structures, and although invertebrates may colonize the rocks, the access to these invertebrates is limited for most fish species. If combined with bioengineering practices, the use of gabions may provide eventual benefits for fish habitat in the form of spawning gravels released as the gabion fails through time.

## Concrete-block Mattresses

### *Structural Measure*

Concrete-block mattresses consist of concrete blocks about 12 inches by 12 inches by 9 inches laced together with synthetic or steel rope. The blocks are interlaced to for a flexible pad or mat of blocks that resist erosive flood forces. The blocks come in closed and open (holes through them) form.

The latter form allows soil to be placed in the openings and plants to be grown in the soil, thereby providing for a softer visual impact. The mattresses are placed on sloping banks and anchored into the underlying soil.

### *Impact on Flood Control*

The concrete-block mattresses armor the floodway bank and prevent erosion of the floodway bank or surface.

### *Impact on River Processes*

Bank hardening structures, such as concrete-block mattresses would affect river processes by restricting the natural migration of the channel. This restriction would reduce the overall sinuosity of the channel over time and prevent the creation of meander bends and additional off-channel habitat. The mattresses would channelize the flow and could increase velocity by decreasing bank roughness. At the location of the structures, bank erosion would be decreased or eliminated, but further downstream, increases in flow velocity may increase downstream erosion. Localized decreases in bank erosion may decrease sediment and LWD levels downstream. However, if there are downstream increases in flow velocity, sediment and would input could increase in those areas.

### *Impact on Fish Habitat*

Concrete-block mattresses would have a negative effect on fish habitat. Hardening of the bank would remove the capacity for under-cut banks, which provide cover for fish species. Concrete block mattresses do not provide cover for fish species, and remove the potential for additional LWD recruitment through bank erosion at the site of the treatment. The reduction in roughness at the bank is likely to increase local velocities which would remove feeding and resting opportunities for juvenile fish, and increase the difficulty of upstream migration for adult salmon.

## ♣ Riprap/Geotextiles

### *Structural Measure*

**Riprap** is an exposed layer of well graded stone or rock placed on a sloping bank face to resist erosive flood waters. A ***synthetic geotextile*** is usually placed between the riprap and underlying soil to act as a filter, thereby preventing the piping of soil through the rock and relieving hydrostatic pressure

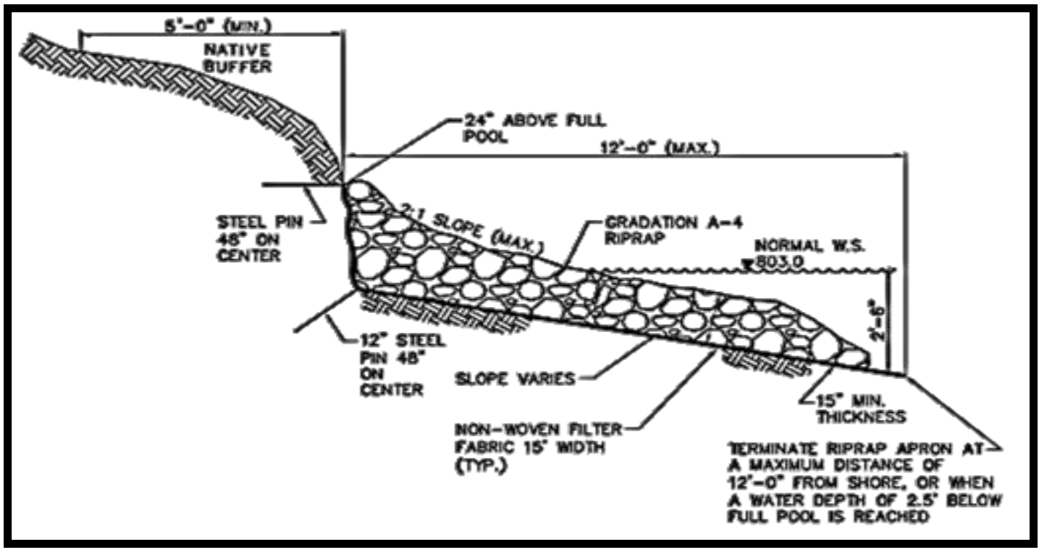



**Fig. :** *Riprap for Protection Against Flood.*

## *Impact on Flood Control*

Riprap has been commonly used to protect roads and other structures from erosion and channel migration. These measures do not alter the frequency or duration of flooding, but provide longer-term protection to structures or property on river banks. Riprap may also increase channel conveyance if water velocity or bank heights are increased.

## *Impact on River Process*

Riprap has similar effects on river processes as gabions, however, riprap is likely to affect river processes for a longer time period, and will not provide spawning size gravel to downstream fish habitat. Riprap may also increase the channel velocity more than gabions depending on the design and channel roughness. Increased channel velocities, as discussed earlier are likely to cause increased erosion downstream and may cause channel down cutting. Riprap re-enforced banks are highly unlikely to deliver LWD to channels or allow for natural channel migration. The artificial constriction of the river is likely to cause changes in the dynamic equilibrium downstream.

## *Impact on Fish Habitat*

The reduction in quality fish habitat due to the use of riprap has been documented. The Washington Department of Fish and Wildlife limits the installation of riprap in areas where the objective is to improve fish habitat. There is little habitat value in the use of large boulders as riprap alone, but these measures can be combined with bioengineering techniques to provide habitat elements that are beneficial to fish species.

## 2.4 Levee and Dike Setback

### *Structural Measure*

Some levees have been placed at the edge of the river's bankfull zone, cutting off side channels and reducing the river's floodway to a narrow zone. Levees and dikes can be set back to some higher point, perhaps as far back as the prehistoric floodplain line, or can at least be set back to allow a wider river meander and channel zone within the flood plain.

### *Impact on Flood Control*

Moving these levees back into the floodplain allows the river more room to meander and more volume capacity during high flows. Setting back levees leaves the lands between the new levee location and the old one fully susceptible to flooding, but does a better job of protecting structures behind the levee because the river is less likely to overtop the levee, even in very large flood events.

### *Impact on River Process*

Levee setback is one of the most effective ways to restore river process. It allows the river more of its historic channel and floodway, often allows access to side channels during both high and lower flows, and allows the river its natural meander zone. All these measures improve the river's ability to carry large volumes of water during flood events and to re-establish a more natural riparian community.

### *Impact on Fish Habitat*

Especially where levee setback includes renewed access to side channels, fish habitat is markedly improved by the measure. Since the river can spread out more during floods, there is less scouring in areas of high velocity and less aggradation upriver of artificially narrowed areas. Natural channel migration allows the creation of meanders that may contain lateral scour pools, and may eventually form oxbows or other backwater habitat that is used for rearing of juvenile salmonids such as chinook and coho salmon.

# 3 RIVER CHANNEL

## 3.1 Detention Pond/Reservoirs

### *Structural Measure*

***A detention pond*** is created by constructing a weir or low dam across the river thereby impounding a portion of the floodwaters, and possibly excavating the river bank to widen the river immediately upstream of the weir or dam. Flood flow is regulated by the height of the weir or dam, and the width and elevation of the outlet.

### *Impact on Flood Control*

Detention structures in river channels have been used in flood control nationwide. These structures can effectively ameliorate high flows and release water slowly downstream after flood events.

Impacts may include reduction in river flow downstream, slowing of the river flow velocities in the detention pond, and inundation of more of the river valley upstream.

### *Impact on River Process*

Detention ponds or reservoirs disrupt the natural flow of rivers through the channel. The dam structure used to create the pond prevents the downstream movement of water, sediment, and wood, as would occur in a natural river system. The effects of dams on river process are extensive and well documented. The disruption of river flow creates imbalance in the dynamic equilibrium of the system and significantly alters the hydraulic processes of erosion and deposition, which changes the sediment transport regime. Water flow below the detention pond or reservoir is likely to be much lower than above the dam, as water is held back behind the dam. Dams used for flood control eliminate the natural high flows that help to create the features of a natural channel. Changes in water temperature can also be significant if water is released from the bottom of the dam. The reservoir upstream of the dam will generally have little to no current, and will collect all of the sediment and LWD that the river carries from higher in the watershed. The channel below the dam will consequently be sediment and wood starved, which could lead to higher rates of bank erosion downstream.

### *Impact on Fish Habitat*

The creation of in-channel detention ponds or reservoirs can have serious adverse effects on fish habitat. The disruption of river flow drastically alters the habitat both upstream and downstream of the structure. Upstream of the structure, lack of current, slow water, and warmer water temperatures may make the reservoir marginal habitat for many fish species that are adapted to river systems. Negotiating the detention structure may be difficult or impossible for many fish species, depending on the level of fish passage. Downstream of the detention structure, water velocities may be higher and erosion may increase due to changes in river processes. There may be fewer pools available if the flow below the structure is reduced. Channel forming high flows will be restricted, and the channel is likely to lose habitat complexity through time. Additionally, the structure will likely block LWD transport, which could lead to low levels of wood in downstream reaches. Lower levels of LWD would reduce the amount of available cover, channel complexity, and the available food resources for juvenile fish.

## 3.2 Sediment Trap/Mining

### *Structural Measure*

A sediment trap is constructed by excavating or dredging a depression in the bottom of the river. The dimensions of the sediment trap are optimized by a careful assessment of the sediment load in the river during a flood. The trap will need to be mined (sediment removed) after each major flood event to be efficient. The latter usually requires the construction of haul roads and an excavator pad adjacent to the trap for cleaning out the trap.

### *Impact on Flood Control*

In-channel sediment traps or gravel mining can be used to reduce the amount of sediment in the channel and increase the channel volume and flood conveyance. The removal of sediment may improve flood conveyance in the short-term, but sediment transport processes will continue to bring sediment downstream, and repeating the sediment removal is likely to be required.

### *Impact on River Process*

Gravel mining within the river channel would significantly alter natural river processes. The active removal of sediment from the channel will change channel morphology, which will affect the interaction of water flow with the bed of the channel. Removal of sediment from the river may cause a change in channel gradient, which would cause further changes in gradient upstream and downstream. If gradient is increased in one location, a "nick point" could form at which the sudden increase in gradient causes the channel to re-adjust by head ward erosion in the bottom of the channel. At the nick point, the water flow erodes at the channel bed to a point upstream where the gradient stabilizes, or where the substrate is resistant to erosion, such as a bedrock channel bottom.

***Impact on Fish Habitat***

Sediment traps or gravel mining can affect fish habitat in a variety of ways. If large amounts of fine sediment are present in the channel due to an acute event (versus a long-term process) than the removal of sediment may reduce the level of fine sediment in the channel, and may improve spawning habitat for many fish species. If the gravel mining removes spawning gravel from the river channel, the effects on fish habitat are likely to be negative, as there will be a reduction in available spawning habitat.

## 3.3 Anchor Logs

***Structural Measure***

Logs, with all limbs removed except the root wad, are placed at various angles across the bottom of the river. Logs can even overlap. Each log is held in place by a cable or chain wrapped around or through the log, and the cable or chain is attached to an anchor buried under the log

***Impact on Flood Control***

Anchor logs will not prevent flooding, but may provide protection to eroding banks or other sensitive areas that need protection from erosion. If the logs do slow the water velocity significantly the total flood conveyance at the location of the logs may be reduced. Anchored logs can create quiet pools in the river channels. They can trap sediment which modifies the configuration of the river channel(s).

***Impact on River Process***

Anchor logs place in the channel would likely have many of the same effects on river processes as those placed along the banks. These measures would generally increase the roughness of the channel, slow water velocity in local areas, and may cause a scour pool to be formed where the flow interacts with the log.

***Impact on Flood Control***

Anchor logs will not prevent flooding, but may provide protection to eroding banks or other sensitive areas that need protection from erosion. If the logs do slow the water velocity significantly the total flood conveyance at the location of the logs may be reduced. – Anchored logs can create quiet pools in the river channels. They can trap sediment which modifies the
Configuration of the river channel(s).

### *Impact on Fish Habitat*

The effects of in-channel anchor logs on fish habitat are likely to be positive as these structures are generally intended to mimic the natural function of wood in streams. Anchor logs that extend out into the current mimic the function of LWD that has fallen into the channel and extends out into the current. These structures are likely to create scour pools where they contact the channel bed, and may provide important cover elements and feeding areas for fish.

## ♣3.4 Deflector Structures

Deflector structures are constructed to reroute water flow in the river.

### *Structural Measures*

#### VANES

Vanes are vertical panels placed in the river channel to divert flow in a prescribed direction. The panels are typically made of steel or concrete. They are held in place by piles or by having the lower half of the panel buried in the river bottom.

#### SPUR DIKES

Spur dikes are built to extend from the river bank into the river channel, usually at an angle to the river flow. Spur dikes are usually constructed of rock; but steel sheet-piles, concrete panels, and lines of closely spaced timber piles have been used.

### *Impact on Flood Control*

Spur dikes and vanes serve to redirect river flow, but do not change the frequency, severity, or duration of floods. These structures can provide protection to river side structures and property that could be at risk of flood damage, or failure due to bank erosion.

### *Impact on River Process*

Deflector structures such as vanes and spur dikes provide erosion protection to banks and divert flow away from sensitive areas. The structures extend out into the current and force the water flow away from the bank. There may be additional downstream affects from this flow redirection that could affect river processes. Whenever water is redirected, the force of that water affects other areas within the channel. The redirection of flow by spur dikes is unlikely to dissipate the flow energy of the current. The re-directed flow may come into contact with banks downstream, and the remaining energy may increase downstream erosion rates. Vanes may allow more of the water to pass through the structure and are likely to allow more energy to dissipate. The potential for downstream erosion problems with vanes is less than that for spur dikes.

### *Impact on Fish Habitat*

Spur dikes and vanes are unlikely to have significant benefits to fish habitat. Spur dikes will redirect flow which may create scour pools on the opposite bank, however, these pools may not be stable over time, and there may be negative effects from sediment that is scoured and transported downstream. Vanes may allow the creation of scour pools below the structure and may provide some backwater habitat for fish, but over time, they are not likely to provide additional cover or nutrient input due to the lack of vegetation associated with the structures.

## ♣3.5 Channel/Bed Dredging

### *Structural Measure*

Channel bed dredging involves dredging existing river channels to a deeper elevation.

### *Impact on Flood Control*

Channel dredging would increase the channel capacity and thereby, increase the flood conveyance of the channel. This increase in capacity would likely reduce the frequency, duration, and severity of flooding.

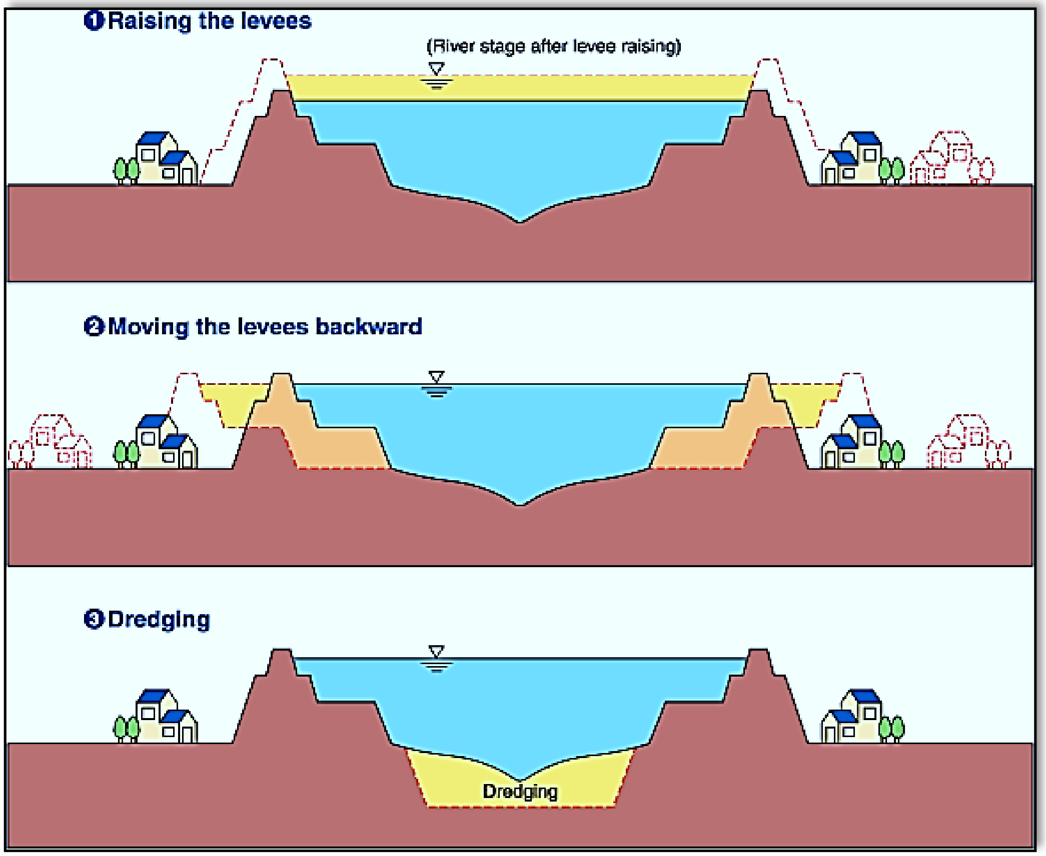
### *Impact on River Process*

Removal of sediment from the channel bed is likely to alter the sediment transport regime of the river.

### *Impact on Fish Habitat*

***Channel/bed dredging*** is likely to have negative effects on fish habitat due to the severe disturbance to the channel bottom. Natural habitat features would be destroyed, spawning gravels could be removed, and invertebrate communities would be disturbed.

### *Methods of Increasing the Cross-sectional Area of the River*




## PRESENT EMERGING TECHNOLOGIES

### ♣ Temporary Flood barriers

In recent years the *Environment Agency of U.K* has used a range of temporary or "*demountable*" flood barriers to provide additional protection to flood-prone areas.

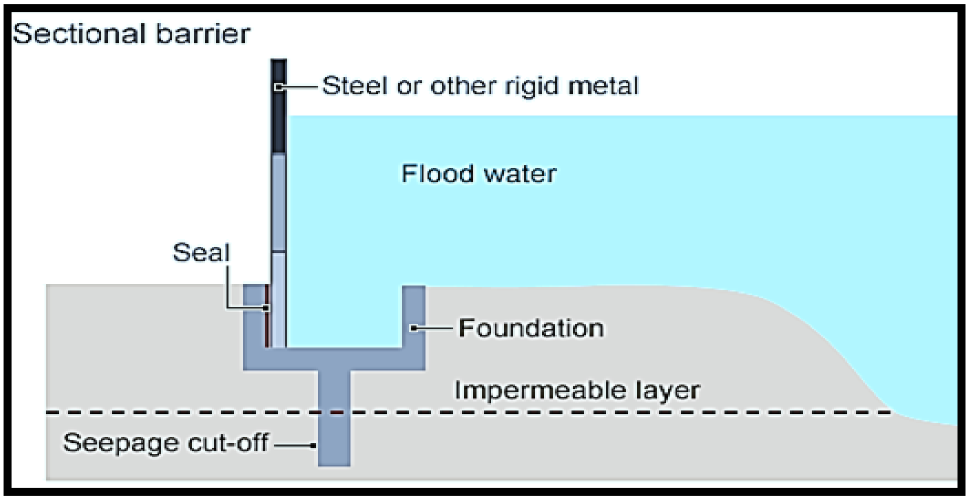
Lightweight sectional metal barriers are relatively inexpensive and can be placed in various configurations and removed completely when waters recede.

Frame barriers consist of rigid frames holding an impermeable membrane and use the weight of the floodwater itself to hold the barrier in place.

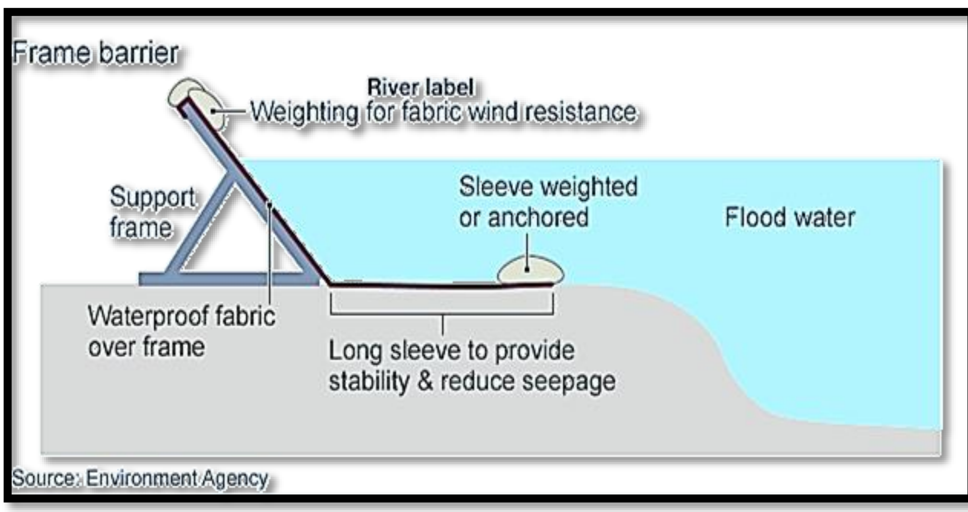
***Types:***

Two types of temporary flood barriers has been introduced recently. They are:

i. *Sectional Barrier*
ii. *Frame Barrier*




**(i)**




**(ii)**

**Fig. *(i)* Sectional Type Flood Barriers & *(ii)* Frame Type Flood Barriers**