State of California
The Resources Agency
Department of Water Resources

FLOOD FIGHTING METHODS

Volume II
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Division of Flood Management
Flood Operations Branch

METHOD OF FLOOD FIGHTING ON LEVEES AND ALONG RIVER BANKS

The main causes of levee failure during periods of high water are:

1. Seepage through or under the levee heavy enough to cause a "boil," and leaks through the levee caused by burrowing animals.

2. Erosion of the levee due to current or wave action; and

3. Overtopping resulting from river water-surface elevations higher than the levee.

The various emergency methods used to prevent levee failure from these causes are known as "flood fighting."

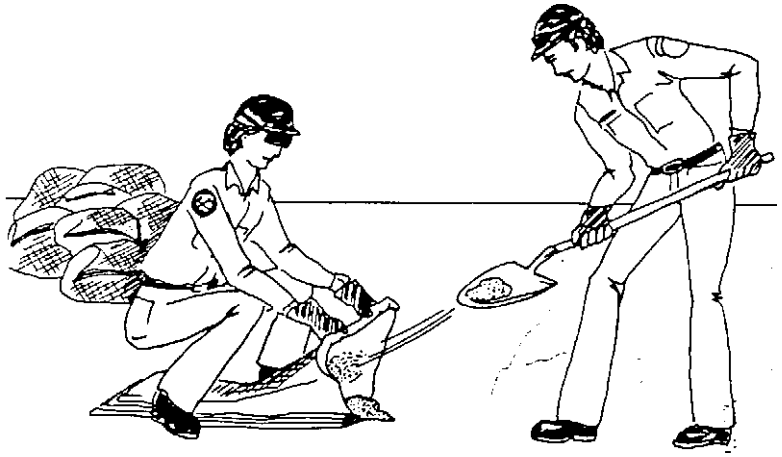
The flood fighting methods described in the following paragraphs have proved effective during many years of use by the Department and the Corps of Engineers. Structures other than levees may also require flood protection and should not be overlooked.

The various methods of treatment discussed below are illustrated in a number of sketches. However, all measures shown are temporary measures and cannot be expected to last for extended periods of time.

Filling Sandbags

When filling sandbags you should work in pairs, with one person holding the bag while the other shovels in the fill material. The first shovel of fill will be placed on the lip of the bag to help hold the bag open. The bag holder should bend at the waist until the elbows are resting on the knees while he is holding the bag open. The shoveler should use rounded scoops of fill until the bag is approximately 1/3 full. While shoveling, avoid extra **movements (turning or** twisting of the back) as this will tire you out sooner. (See Figure 1.

Figure 1



Sandbag Construction

The use of sandbags is a simple but effective method of preventing or reducing damage from flood water or debris (see Figure 2). Suggestions for constructing sandbags follow:

1. Close-weave burlap bags are recommended for all sandbag construction.

2. Fold over the empty top of the bag in a triangle to keep sand from leaking.

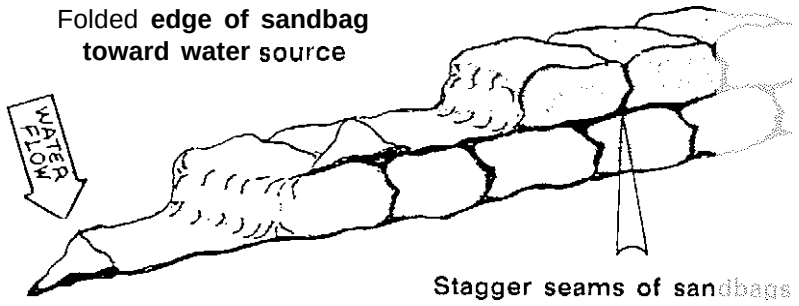
3. Place each bag over the folded top oi the preceding bag and stomp into place before placing the next layer of bags.

4. Stagger the second layer of bags, stomping each bag into place before placing the next.

5. Stomp each succeeding layer of bags.

Figure 2

Fill sandbags 113 full



Tying Sandbags

Most sandbags are used with the open end folded. In some cases, sandbags will have to be tied. Fill the bag 114 to 1/3 full of material. Grab one open comer (see Figure 3).

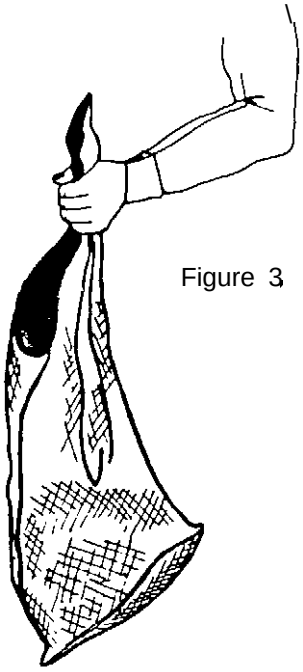


Figure 3

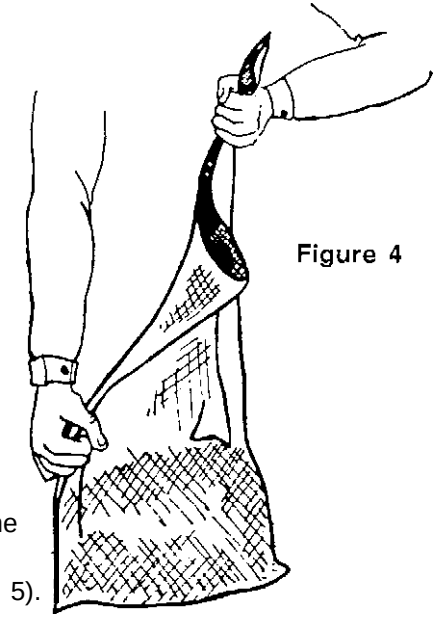


Figure 4

With your other hand grab the lower portion of the opposite side and spin it (Figures 4 & 5).

The long tail should now look like a piece of rope (see Figure 5)

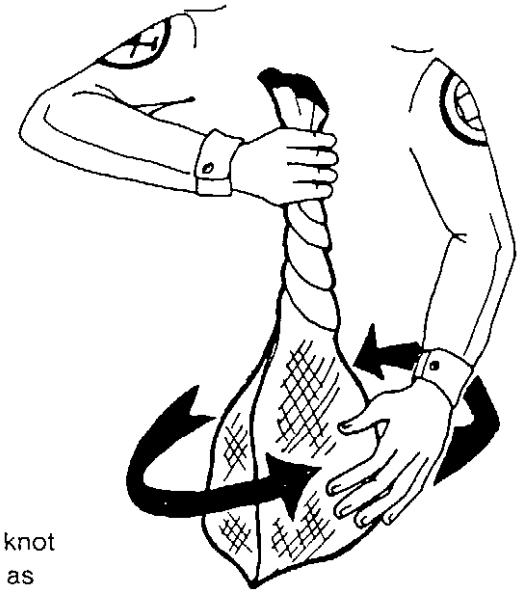


Figure 5

Now tie an overhand knot (pretzel knot) as low as possible on the bag (Fig. 6).

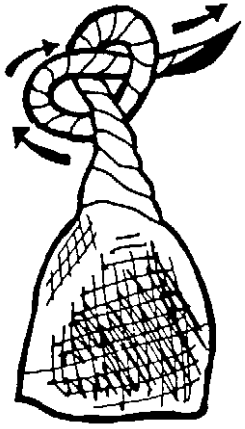


Figure 6

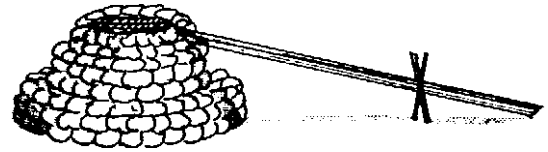
CONTROL OF BOILS
(Away from Levee)

A "boil" is a condition under which enough pressure is produced by high water to "pipe" water through or under the levee with sufficient velocity to carry earthen material to the landward side. Such danger spots are serious if sand and other materials are carried in suspension by the discharging water. If not controlled, the particles of earthen material will be eroded from within the levee at an accelerated pace, causing a local subsidence of the levee section. Continuation of the process will permit the flood waters to flow directly over the crest, causing a levee break.

The common method of controlling boils is to build up a watertight sack ring around the boil high enough to reduce the flow and prevent further discharge of earthen material from the boil (see Figures 7 and 7A). The flow of water should never be stopped completely, since this may cause the boil to "break out" in an area near the existing sack ring.

The sack ring around the boil should be large enough to effectively encompass the defective area immediately surrounding the discharge spot. If several boils of sufficient force to displace sand or earthen material are found, a sack sublevee may be constructed around the entire "nest" of boils to a height sufficient that none of the boils will discharge with enough velocity to move sand or earth from the levee foundation.

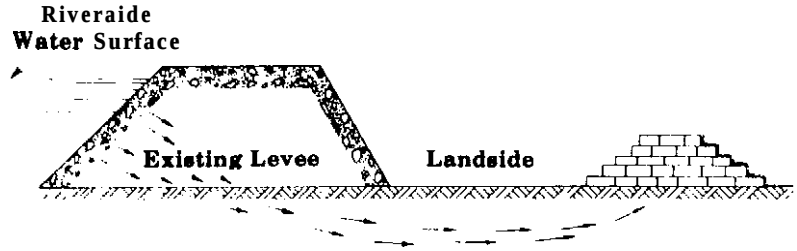
Figure 7



Bottom width should be at least 1½ times the height.

Do not sack boils not carrying material, but maintain surveillance during floods.

Figure 7A

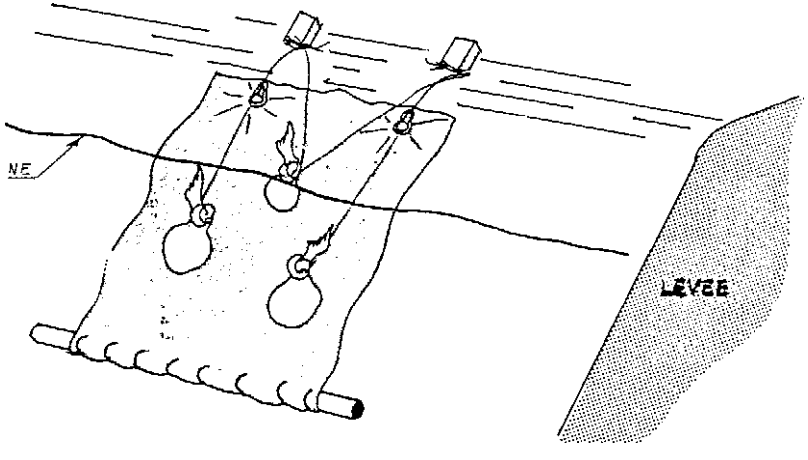


NEVER completely stop the flow from a sand boil. This may cause the boil to "break out* in an adjacent area. ALWAYS control the boil to a point where It ceases to carry material and the water runs clear.

Water running through a levee and carrying material can sometimes be stopped on the waterside, thus eliminating the building of sack rings on the waterside (see Figure 7B). A 6–foot section of 1.5– or Z-inch pipe wire to a 5-x-6 foot piece of plastic or canvas can be rolled over the inlet hole on the waterside. Secure the top of the material to two 2-x-4-x-2 foot stakes driven into the shoulder of the levee. Wire filled sandbags to the stakes and place on top of rolled-out material to hold in place.

It can be difficult to locate the inlet side of boils. Sometimes a swirl is observed at the water's edge.

Figure 7B

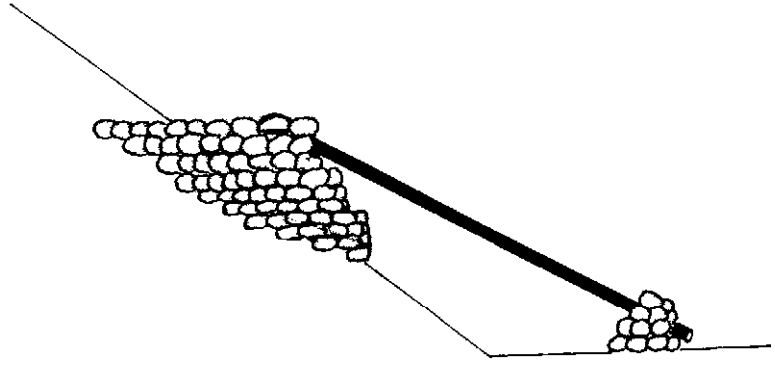


CONTROL OF SAND BOILS
(on Levee Slope)

If the boil is close to or on the levee, a U-shaped sack chimney may be built around the boil and sealed into the levee slope (see Figure 8). This method may also be used to control flow through a hole that is discharging earthen material from the levee slope. A spillway must be constructed to direct water away from all boil sites.

Various types of spillways are V-board; PVC pipe; sandbag: visquine, etc.

Figure 8



WAVEWASH PROTECTION

Wavewash

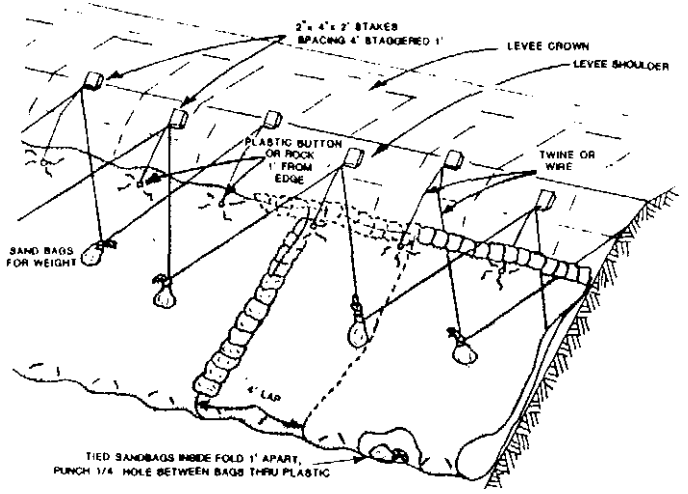
All levees adjacent to wide stretches of water should be watched during periods of high wind to detect the starting of wavewash. If the slope is well sodded, short periods of high wind should cause little damage. Still, during periods of high wind and high water, ample labor should stand by, and experienced personnel should observe where the washouts are occurring.

Visquine Wavewash Protection

When used correctly, Visquine (Polyethylene) is useful for wavewash protection. Visquine should be purchased in rolls 20-feet wide by 100-feet long by 10 mil. It comes folded and is left folded and rolled out along the lower section of the levee. This is called the envelope method (Figure 9).

Using the wide side of the 2-by-4-in. stake toward the water, pound stakes just above the levee shoulder on the side you wish to protect. Place the stakes 4 feet apart and staggered 1 foot as shown in Figure 9. Avoid driving stakes in a straight line; this tends to cause cracking and sloughing of the slope. To provide added strength and leverage, pound stakes at a slight angle facing away from the water source. Be sure the stakes are well into the ground and are secure.

Figure 9
Visquine Wavewash Protection



Roll out the Visquine

it is helpful to use a shovel or similar long-handled tool to roll the visquine out. Eight to ten people should assist in "shaking out the envelope." Be sure that both layers of visquine are held while the envelope is shaken out. Hold on tight to the visquine. Avoid being pulled down the levee by the weight of the visquine. Be especially careful in strong winds because if the wind catches the plastic it could billow out and pull you along with it,

While the crew is holding the visquine securely, toss the tied sandbag into the envelope. The tied sandbags should end up in the bottom of the envelope at l-foot intervals, The tied bags help to weigh down the visquine against the levee slope,

Ty-Downs

A ty-down button or a small stone (preferably round) is twisted into the visquine. (If a stone is used. tie a slip knot and double half-hitch to secure it.) Fasten buttons to the visquine and tie them to the stakes with these points in mind: (See Figure 9A.)

1. Fasten button at least 1 foot from the edge of the plastic.

2. Fasten buttons to both layers of visquine,

3. Fasten buttons directly below stakes (one button per stake).

4. Tie twine *low* on stake

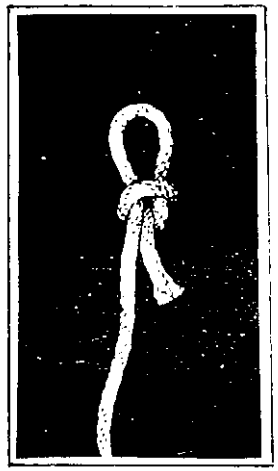
With the visquine secured to the stakes, punch a l/4-inch hole between each tied bag in the envelope. These holes should be made with a pencil. Do NOT use a knife because a slice or slit will tear and spread in the plastic. Punching the holes releases water trapped in the envelope, thus relieving the visquine of unnecessary Weight.

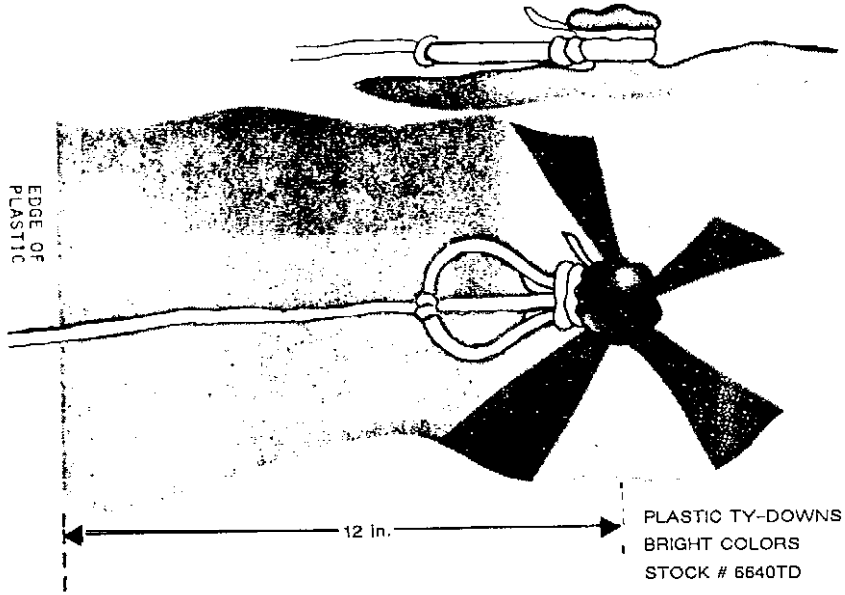
To extend another section of visquine, unroll it as before. Insert ends into existing envelope overlapping at least 4 feet. To secure overlap to stakes, button the two top layers with one button. Never fasten more than two layers of visquine into any button.

Lay a row of sandbags on the overlap seam. This is called the Seam cap. If the levee slope is too steep, some of the bags in the seam cap may be tied to the stake above the visquine with twine for support.

Figure 9A

TIE SLIP KNOT ON END OF TWINE; SLIP LOOP OVER BUTTON AND PLASTIC AND DRAW TIGHT. MAKE TWO HALF-HITCHES AROUND THROAT OF MAIN BODY. EXTEND TWINE TO LARGE END OF MAIN BODY, MAKE HALF-HITCH AROUND END, AND TIE OFF TO STAKE.





Using a continuous piece of twine, hang tied-bags from stakes in a zigzag fashion as shown in Figure 9. Tie a double half-hitch knot below the knot in each sandbag. Place each bag so that it hangs at the middle of the plastic directly below the stake between the two stakes from which it is suspended. Attach twine to every other stake with a double half-hitch. These bags are added to keep the visquine lying flat against the levee slope even in heavy winds.

Add a second row of tied bags suspended from the stakes previously skipped. If more of the slope needs protection, cover the exposed area with visquine, tying it off as explained in the preceding paragraphs. Be sure to lay the upper layer over the lower layer by at least 3 feet: then weight down the visquine with sandbags tied off by wire or twine to the edge of the visquine. This is called "capping off." To prevent slippage, make sure that the cap is half on the plastic and half on the levee as shown in Figure 9.

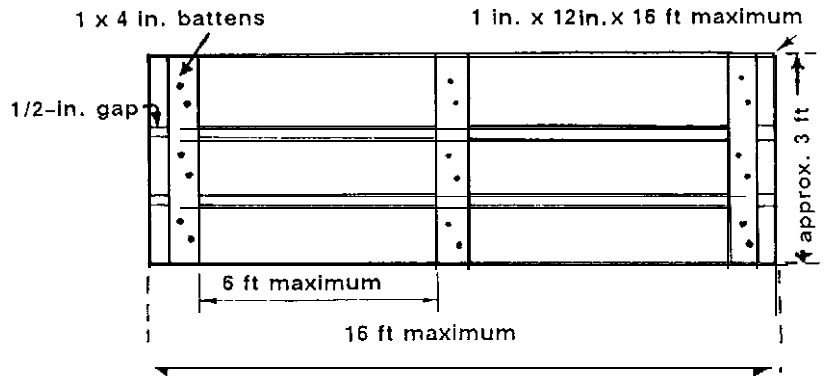
Remember, wind is your worst enemy. When using visquine, be sure all seams are secured with sandbags, and make needed repairs as soon as possible.

Wooden Panels

Many tools and materials are used in flood control efforts. A very versatile material is the wooden panel (see Figure 10). Wooden panels can be used for wavewash protection, lumber and sack toppings, and mud boxes. Wooden panels are prefabricated and brought to the work site. The panels are generally 3 feet high with a minimum length of 16 feet. They are made of boards l-inch thick and vary in width: 1 by 12's are the usual choice. The 1 by 12's are

nailed to 1 by 4's at 6-foot intervals. A 1/2-inch gap is left between each 1 by 12 in the panel.

Figure 10



Wooden Panel Wavewash Protection

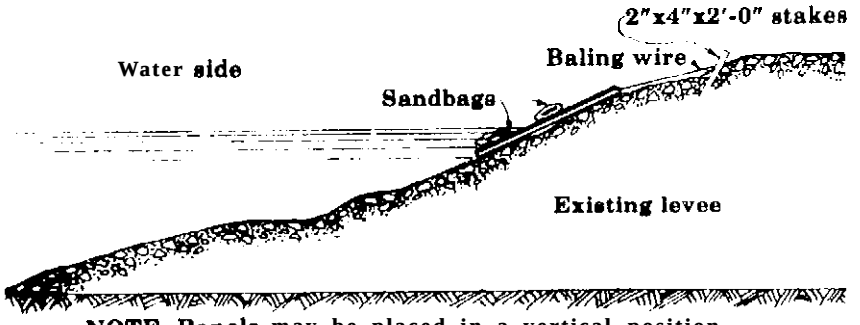
Although visquine is the preferred method of wavewash protection, wooden panels can be used (see Figure 11). When the water current is very fast or swift, wooden panels will hold up better than will plastic sheeting. Pound wooden stakes (2 in. x 4 in. x 2 ft) into the levee shoulder in the same manner as visquine (4 ft apart with a stagger of 1 ft between rows),

Bailing wire is tied to the wooden panels through the l/Z-inch gap between the 1 by 12's. The baling wire is then tied to the stakes as low as possible on the stakes. Sandbags-one-third full with the open end tied-are wired to the bottom half of the panels to weigh them down. Push the panels into the water with pike poles. Readjust the

length of the baling wire to secure the panels in the proper position. If more panels are added, the overlap area must be 1 foot and facing downstream.

One or more panels can be wired together if more than 3 feet of slope protection is needed.

Figure 11



NOTE: Panels may be placed in a vertical position. depending on existing conditions.

CONTROL OF LEVEE OVERTOPPING

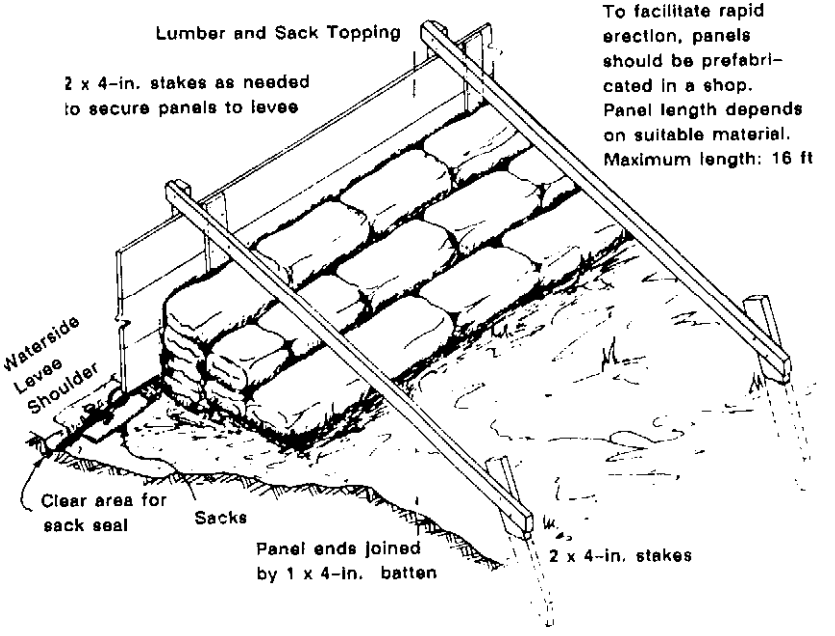
If any levee reach is lower than the anticipated high water elevation. an emergency topping should be provided to raise the levee grade to the forecast flood height. Levee topping may be required at road or stock crossings, low levee sections, or railroad crossings. The following paragraphs discuss various methods of increasing levee height.

Lumber and Sack Topping

With this method, wooden panels are used on the waterside shoulder. which has been reinforced on the landside with sandbags. The method is used to raise low reaches during emergencies (see Figure 12). Stakes 2 in. x 4 in. x 6 ft should be driven on the waterside shoulder 6 feet apart. Dig a shallow trench and line it with empty sandbags to provide a seal.

The panels are placed in the trench and nailed to the landside of the stakes. This wail should then be backed with enough sandbags to support the panels against the expected high water. In extreme cases a 3-foot topping may be provided if properly braced from behind with sacks and earth. In some cases, it may be practical to back the panels with tamped earth in lieu of sandbags. Attach 2 in. x 4 in. x 10 ft. lumber kickers to the stakes that support the panels, and drive 2 ft stakes into the levee crown. Use at least two nails at each joint to ensure rigid construction.

Figure 12



Mud Boxes

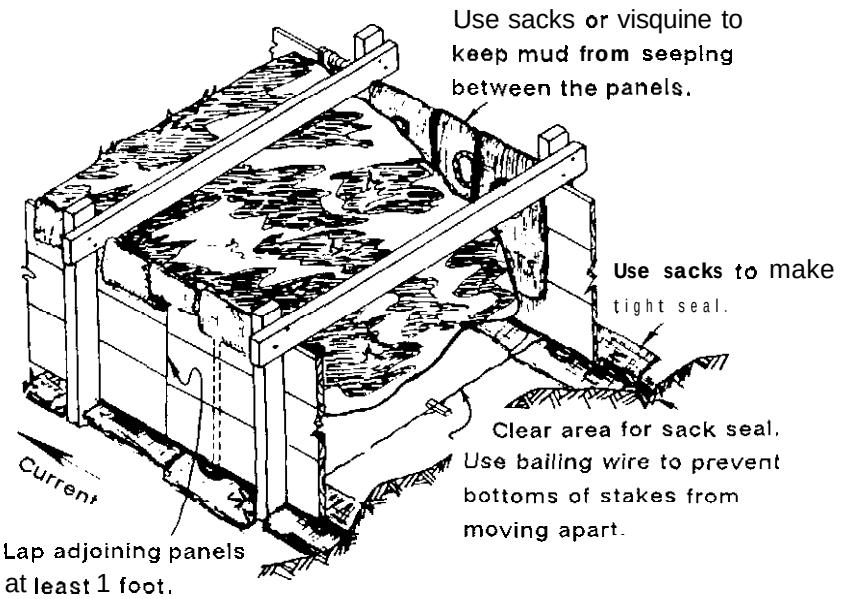
With this method, two parallel wooden walls are placed near the waterward levee shoulder and filled with available material (see Figure 13). Spacing of the walls will vary with height but should be proportional to a box 2 feet high and 3o inches wide. The method has the advantage of permitting part of the levee crown to remain as a limited roadway while the emergency topping is in place.

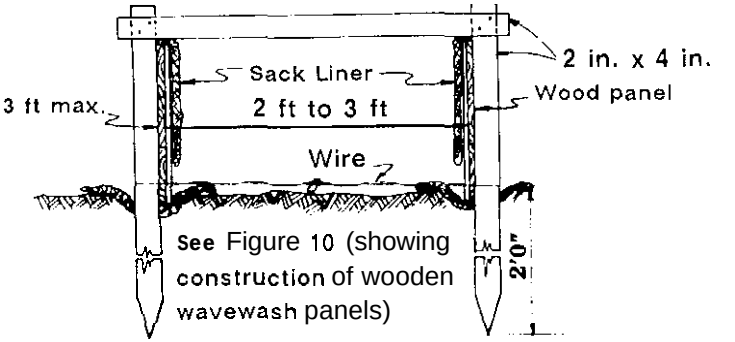
Mud boxes may be used when the fill material is "soupy, " providing the boxes are lined with canvas, visquine, or burlap. If visquine is used, "poke" pencil-size holes in the bottom of the visquine to allow water to seep out. Close the open ends of the mud box with sandbags and tie into high ground.

NOTE

Mud boxes can also be used to divert mud flows from structures. If it is used for this purpose, plywood should be nailed to the face of the mud box, thereby creating a smooth surface.

Figure 13



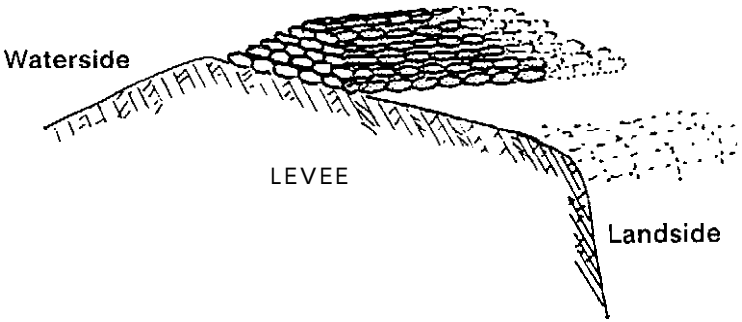


Sack Topping

The most common form of flood control work is the use of sandbags for construction of temporary walls (see Figure 14). The use of sandbag walls to increase the height of a levee section is called "sack topping." The sacks are laid " stretcherwise, " or along the levee for the first layer, crosswise for the the second layers, and so on. The sacks should be lapped at least one-third either way and stomped firmly into place. When properly sacked and tamped, one sack will provide about 3 to 4 inches of topping.

Figure 14

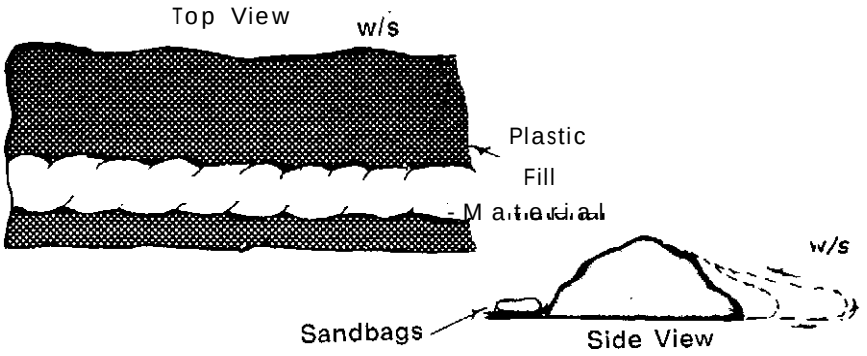
Sack Topping



Temporary Levee

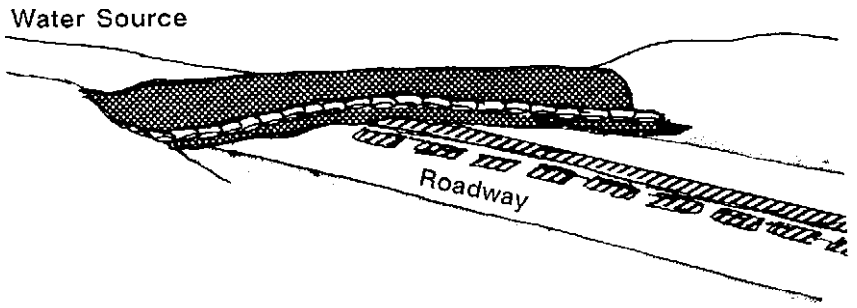
This method is used to raise low areas using visquine and fill material (sand. gravel, dirt, etc.) to prevent overtopping of levees, small earthen dams, roadways, etc. To raise low areas, unfold a 20 ft by 100 ft by 10 mil roll of visquine and lay it out flat (see Figures 15 and 15A).

Figure 15



Lay plastic flat on area to be raised. Place fill material (dirt, sand, gravel, etc.) on plastic. Fold plastic back over fill material and lay a solid row of sandbags on lip of plastic.

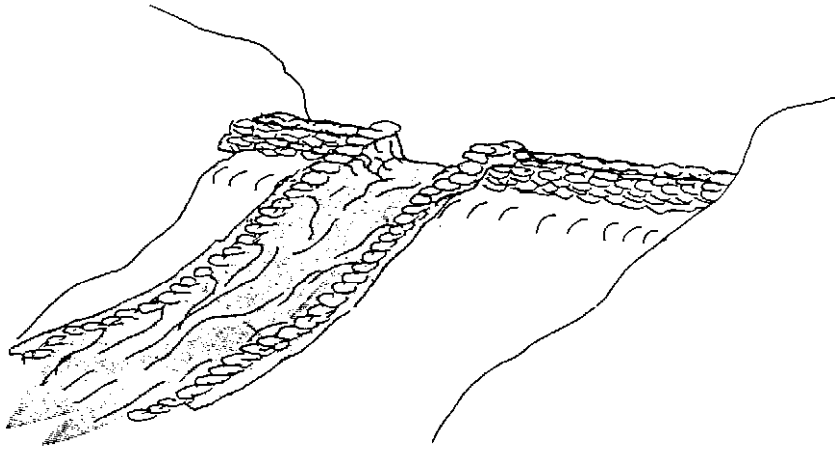
Figure 15A



Place **fill material (sand, dirt, gravel, etc.) on** the visquine by hand labor or with equipment. Next, fold the visquine over the material from the waterside toward the landside. Finish by placing one solid row of sandbags on the edge of the visquine following procedures for sandbag construction in Figure 2. When used in overtopping of small earthen dams. a spillway must be constructed.

Figure 16

Emergency Spillway Using Visquine and Sandbags



METHODS OF FLOOD FIGHTING AROUND STRUCTURES

The main causes of damage to homes and property during heavy rains or flood flows are:

1. Flood water from street gutters or drains, particularly on sloping streets, flood flows onto property through driveway openings, and low spots in curbs

2. Debris flow from hillsides that have been denuded by fire or real estate development.

The flood-fighting methods described in the following paragraphs have proved effective in combating flood waters and flood flows. If the exposed area producing mud flows is not too large, covering it with visquine can help reduce the movement of additional material from future rainstorms.

Protection of Slopes

The "raincoat" method is used to prevent further saturation of levee or hillside slopes. Visquine is laid out flat on the slope, and stakes are driven into the ground just above the area to be protected. The stakes are 4 feet apart with a i-foot stagger. The visquine is secured to the stakes with ty-down buttons or small round rocks (see Figure 9).

Use a crisscross method of placing the sandbags (Figure 9) or substitute tires for the sandbags. Place a solid row of sandbags on all edges of the visquine (half on ground, half on the visquine).

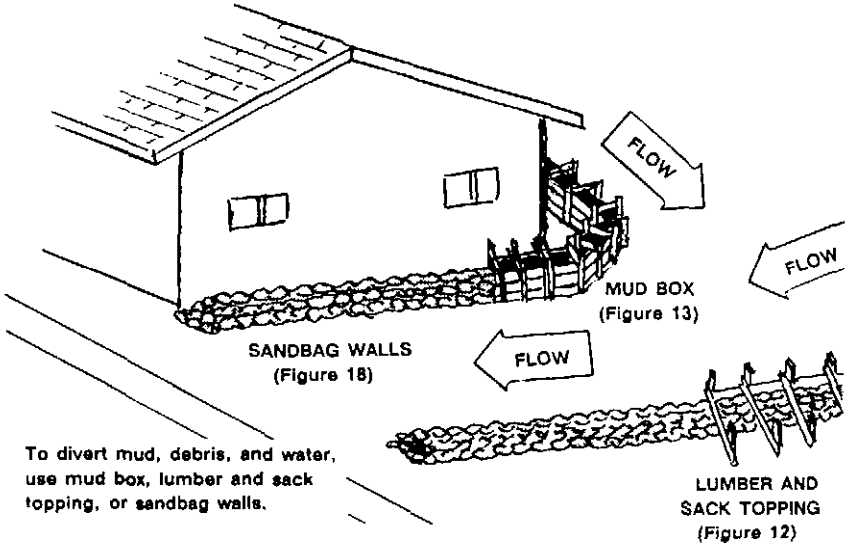
Diverting Water Away from Homes

Homes may often be protected from flood water by redirecting the water flow as shown in Figure 17. The barriers will divert the water flow away from the structure. The sandbags or wooden barriers must be placed at an angle and must be long enough to divert the flowing water into the street gutter.

To prevent or reduce property damage, the methods

shown in Figure 17 may be helpful. Walls made of lumber or sandbags are constructed to channel the mud and debris away from any improvements.

Figure 17

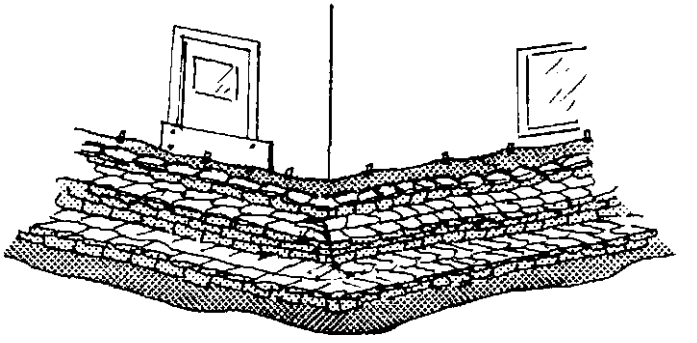


Protection of Home or Structure

The following method is used for protection of buildings and other structures along lake shores and in similar situations where water is rising with little or no current.

Lay visquine on the ground and up the building walls to a point at least 1 foot above the predicted water elevation. and far enough out on the ground to form a half pyramid of sandbags (see Figures 14 and 18). Secure plywood over doors and vents. Overlap visquine and sandbags at corners of buildings.

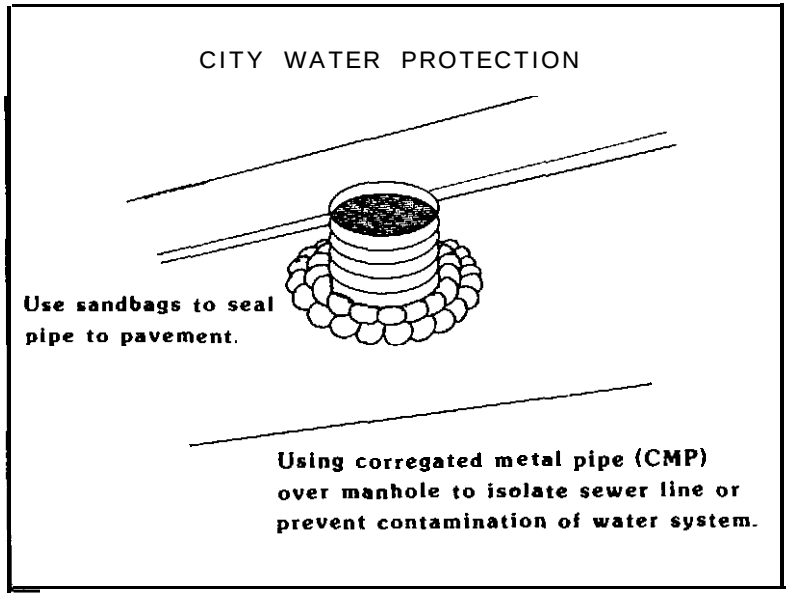
Figure 18



Protection of Water or Sewer System

Water or sewer systems can be protected by placing corrugated metal pipe (CMP) over the manhole (see Figure 19). Lay visquine up the walls of the CMP and place sandbags in the form of a half pyramid around the CMP to seal it to the pavement. In a nonpaved area, concrete can be placed in a shallow trench. CMP is then set in the concrete. Visquine and sandbags are placed around the CMP. This method will prevent mud and debris from entering the system and also act act as a surge chamber.

Figure 19



Levee Patrol

When water levels reach a predetermined height, mobile patrols should be assigned areas for observation. The patrols should look for wavewash. boils, seepage, cracks, or sluffs on slopes, water spouts, and toppled trees. The patrols should maintain radio contact with headquarters to report problem areas too large or time-consuming to repair with the minimal amount of flood-fight equipment and materials carried in patrol vehicles.

Safe Work Habits

When working on floods, observe all safety precautions, When moving materials or personnel by boat, all personnel must wear flotation devices. When working around or in water, lifelines and personal flotation devices must be used.

Above all, don't panic!