CALIFORNIA DEPARTMENT OF WATER RESOURCES

FLOOD FIGHTING METHODS

2024

Division of Flood Operations
Flood Project Inspection
and Assessment Section

STATE OF CALIFORNIA
CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

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With assistance from

DWR Graphic Services

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Foreword

The California Department of Water Resources (DWR), Division of Flood Operations has been tasked to prevent, reduce, and mitigate the risk of damages associated with flooding. DWR is the lead state agency responsible for responding to flooding. Our mission is to prevent loss of life, damage to property, infrastructure, and the environment.

Working together, State, federal, and local agencies manage California's Flood Control System of reservoirs, levees, weirs, bypasses, and debris retention basins.

This statewide system is managed with support from technologies such as weather and hydrologic forecasting, coordination of reservoir releases, a network of rain and stream gages, and snow pack monitoring. The information gathered is extremely important to emergency responders and the public.

The 'Flood Fighting Methods' outlined in this booklet have proven effective during many years of use by DWR, United States Army Corps of Engineers, and local agencies on flood-related emergencies. This handbook is published by the DWR State-Federal Flood Operations Center and is designed to be used with the Flood Fighting Methods class.

Levee and Embankment Threats

The main causes of levee failure or flood related problems due to high water are:

- Seepage through or under the levee heavy enough to move material.
- Erosion of the levee or embankment due to swift moving water or wave action.
- Overtopping resulting from water-surface elevations higher than the levee or embankment.

Patrolling

The best defense against flood related issues and/or levee failure is to identify problems early and repair them immediately. Levee inspections and effective patrolling make this possible. The following suggestions will help in organizing patrol teams for this work.

- Read and carry a copy of the Levee Threat Monitoring Guidelines.
- Operate under the Standardized Emergency Management System and Incident Command System and report to the appropriate section coordinator.
- Provide a sufficient number of personnel to safely patrol the levee.
- Provide each personnel with a copy of this 'Flood Fighting Methods' handbook.
- Assign two people to each mobile patrol.
- Assign each mobile patrol vehicle an area no larger than can be inspected at least every 2 hours, with more frequent patrols as conditions warrant. Foot patrols may offer a more thorough inspection.

- Items recommend for patrol vehicles are located on Page 42, Flood Fight Material/Equipment List.
- Identify potential problems: boils, seepage, erosion, cracks, sloughing, etc.
- Know what danger signs to watch for, and how to signal for help.
- Instruct each patrol team on the correct filling and placement of sandbags.
- Vehicles should remain on high ground in threatened areas, oriented in the direction of the escape route. Always have escape routes and make them known to all responders.
- Instruct each leader to check with their team members frequently. Investigate all reported problems.
- Be aware of the locations of stockpiled flood fighting materials, tools, and equipment.
- Be prepared to request additional resources on short notice.
- Advise and coordinate with district officials or emergency response agencies in the area. If necessary, request their help, i.e. local Office of Emergency Services (OES).
- If additional support is needed, contact the State-Federal Flood Operations Center at 916-574-2619.

Filling Sandbags

When filling sandbags, work in pairs; one person holds the bag while the other shovels the material. The bag holder should find the most comfortable position while holding the bag open (Figure 1). The first shovel of material should be placed on the lip of the bag to help hold the bag open. The shoveler should use rounded scoops of material **until the bag is approximately 1/3 full**. Avoid extra movements (turning or twisting of the back) to prevent injury and reduce fatigue. **The most common mistake is overfilling bags.**

Filling Sandbags

Figure 1: Proper sandbag filling

Passing sandbags

Passing Sandbags

To minimize injury risk and maximize efficiency, flood fighters should be organized into a sandbag-passing line or 'chain'.

- The line is formed by standing facing the next person and slightly offset, shoulder to shoulder.
- The bags are passed down the center of the chain.
- If a bag gets dropped do not pick it up.
- Communication is key for an effective chain.

CAL FIRE crew passing sandbags

Sandbag structure

Sandbag Placement

The use of sandbags is a simple but effective method of preventing or reducing damage from floodwater and debris (Figure 2). Burlap bags are recommended for all sandbag structures when available. The sandbag structures described in this book are based upon the proper placement of bags to form a stretcher row:

- Mark the limits and location of the first stretcher row, using lath, stakes, or marking paint.
- Place the 1/3 full bag on the ground, with the open top facing downstream.
- Fold the empty top of the bag at a 45° angle, away from the water to keep sand from leaching out.
- Place the next bag over the folded top of the preceding bag, forming the stretcher row.
- The last sandbag in the stretcher row is referred to as a Key Sack. The bag is folded in half, with the empty top folded underneath.

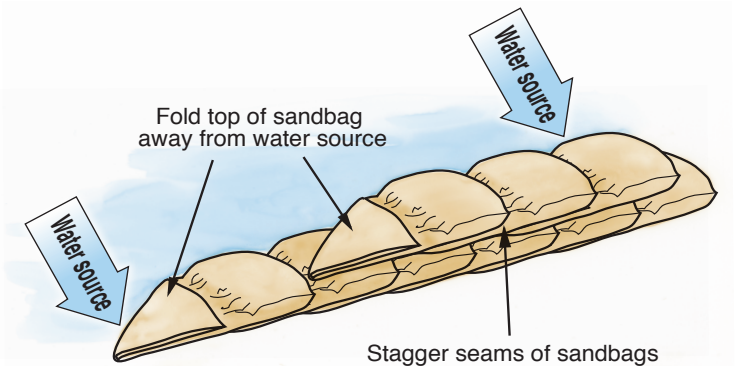


Figure 2: Proper sandbag placement

- Stomp all bags to form a tight seal.
- If additional rows are placed on top, stagger each layer over the seams of the layer below.

For estimating purposes, a single sandbag placed in this manner covers one square foot, approximately 3" high.

Mitigate Overtopping

If a levee or stream bank is lower than the anticipated high water elevation, an emergency sack topping should be Implemented to provide mitigation above the forecast flood elevation. Sack Topping may be required at road or livestock crossings, low levee sections, or railroad crossings. The following sections discuss various methods for increasing levee and bank elevations.

Sack Topping – "Full Pyramid"

The most common form of flood control work is the use of sandbags for construction of temporary walls. The use of sandbag walls to increase the height of a levee section is called "sack topping" (Figure 3). The sandbags are laid as stretcher rows.

Stretcher rows are placed adjacent and on top of each other to create a "full pyramid" shape. The base of the structure should be 1-1/2 times the height. When properly filled, placed, and compacted, each sandbag layer will provide about 2" to 3" of height.

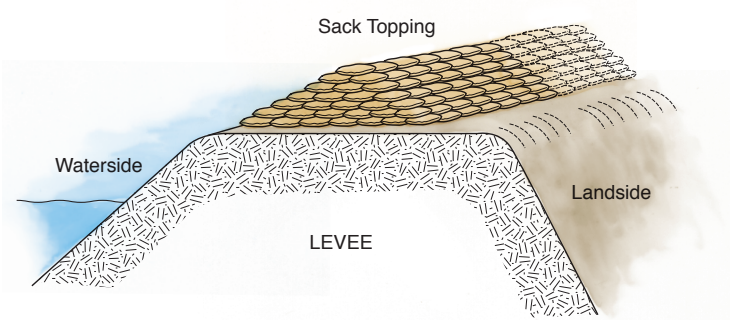


Figure 3: Sack Topping on a levee

Full Pyramid

Diversion Wall

Diversion Wall – "Half Pyramid"

Stretcher rows are placed adjacent and on top of each other to create a "half pyramid" shape. The vertical wall of the structure is placed closest to the water. When properly filled, placed, and compacted, each sandbag layer will provide about 2" to 3" of height.

Temporary Levee

This method is used to raise low areas during high water periods to prevent overtopping of levees, streams, and riverbanks, small earthen dams, roadways, etc. To raise low areas using a Temporary Levee:

- Unfold a 20'x100'x10 mil roll of plastic sheeting and lay out flat on area to be raised (Figure 4), with excess plastic towards the waterside.
- Place fill material on plastic.
- Fill material can be placed using bottom dump or dump bed trucks, front-end loader or manually.
- Fold plastic over material.
- Lay a single row of sandbags on the backside lip of plastic and on all seams.

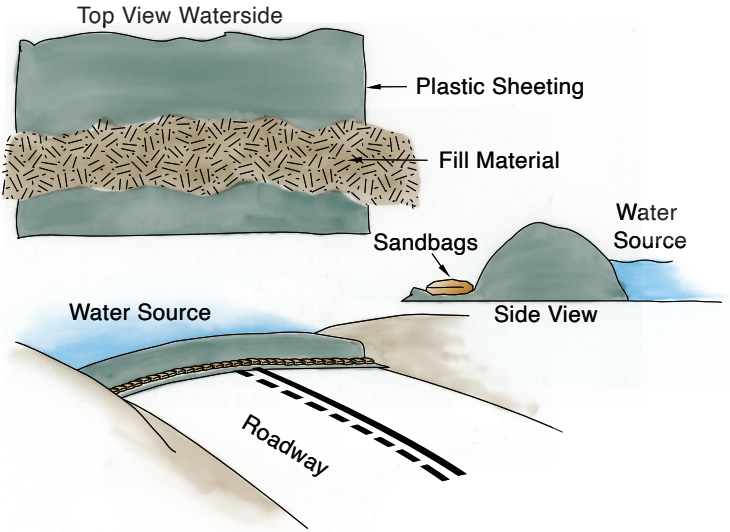


Figure 4: Temporary Levee

Temporary Levee

Muscle Wall®

Muscle Wall®

Portable flood control barriers, such as Muscle Wall®, can be used to mitigate overtopping. To deploy Muscle Wall®:

- Unfold a 20'x100'x10 mil roll of plastic sheeting and lay out flat on area to be raised with excess plastic toward the water side.
- Place sections of Muscle Wall® on the plastic with the toe toward the water, interlocking the ends.
- Use ratchet straps to tie the sections together for added stability.
- Fill each section of Muscle Wall® at least 3/4 full with water.
- Roll the plastic over the top and secure on the landside with a stretcher row of sandbags.
- Place a knotted or key folded sandbag with 1' spacing on the toe of the Muscle Wall®.

Muscle Wall® should not be used on rocky or unstable terrain. Sandbags laid as stretcher rows can be used to create a stable foundation and fill low spots in the area where the Muscle Wall® is being deployed.

When placing Muscle Wall® on paved surfaces, use manufacturers recommendations to prevent sliding.

Always refer to the manufacturer's recommendations to ensure proper deployment.

Boils

A boil is a condition that occurs when water is "piped" through or under a levee and resurfaces on the landside. These weak points are generally caused by burrowing rodents or decomposed tree roots. High water velocity can begin to erode the interior of the levee and weaken the structure. Levee material will deposit around the exit point as the water discharges on the landside. If the boil is determined to be carrying material then corrective action is required to control the situation.

If left unattended the material that makes up the levee can be eroded at an accelerated pace, causing subsidence and overtopping of the levee. This could result in a levee break.

Sack Ring

The common method for controlling a boil is to build a sack ring. The sandbag structure should be high enough to slow the velocity of the water and prevent further discharge of material from the boil

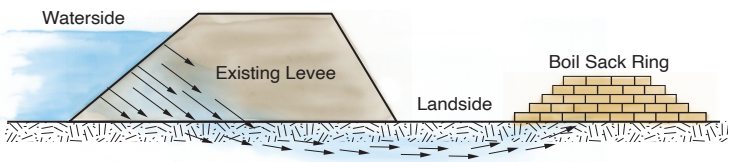


Figure 5: Flow of water through a levee

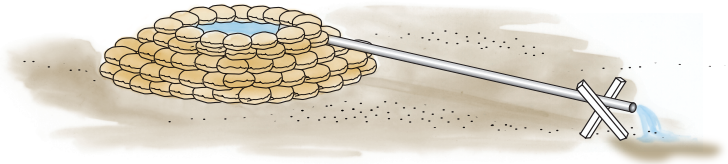


Figure 6: Boil Sack Ring

(Figures 5 & 6). The flow of water should never be stopped completely, this may cause a new boil to form in an area near the existing sack ring. A spillway must be constructed to direct water away from all boil sites. Monitor the sack ring and adjust the spillway as necessary to ensure the flow of water is not stopped or in the event that the boil begins to move material again

Do not place sack rings around boils that are not carrying material, but continue to monitor. Boils can begin to carry material after first located.

Boil Sack Ring under construction

Boil Sack Ring

The sack ring should only be large enough to enclose the area immediately surrounding the discharge point (3′ to 4′ diameter).

U-Shaped Sack Ring

If the boil is close to or on the levee slope, a U-shaped sack ring may be built around the boil and keyed into the slope. Construction of this method can be difficult and requires substantial shoring up of the U-shaped sack ring structure.

A spillway must be constructed to direct water away from all boil sites (Figure 7).

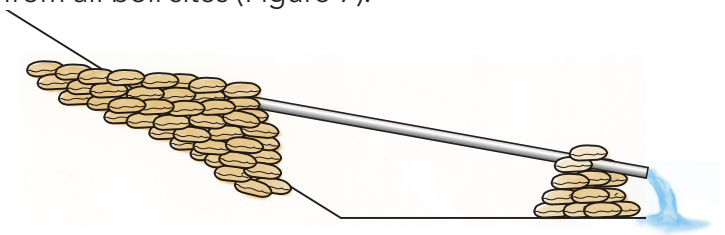


Figure 7: Spillways can be constructed by nailing two 2″x 6″ boards together to form a V notch, PVC pipe, two parallel sandbag rows, visqueen, etc.

U-Shaped Sack Ring (looking from the levee crown towards the landside toe)

NEVER completely stop the flow of water from a boil. This may cause a new boil to form in an adjacent area. **ALWAYS** control the boil to a point where it ceases to carry material and the water runs clear by raising or lowering the height of the sack ring.

Waterside Boil Inlet Detection

Water running through a levee and carrying material can sometimes be stopped on the waterside, thus eliminating the need for sack rings on the landside (Figure 8). A 6′ long section of 2″ diameter metal pipe secured to a 5′x 6′ piece of plastic or canvas can be rolled over the inlet hole on the waterside. Drive 1″x 2″x 2′ stakes into the shoulder of the levee. Suspend half-filled sandbags on top of rolled-out material with twine and tie off to stakes (Figure 8). It can be difficult to locate the waterside inlet of boils. Sometimes a swirl is observed at the water's edge.

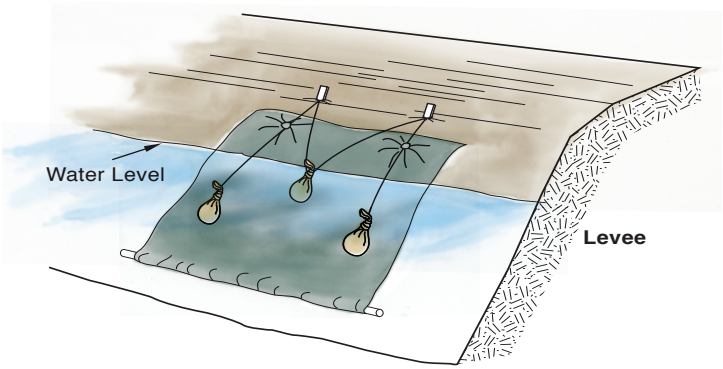


Figure 8: Waterside boil protection

Wavewash Protection

All levees adjacent to wide stretches of water should be monitored during periods of high water and strong wind to detect the early stages of wavewash erosion.

During sustained periods of strong wind and high water, experienced personnel should observe and monitor the affected areas.

When used correctly, plastic sheeting is useful for wavewash protection. Plastic sheeting should be purchased in 10 mil rolls, 20′ wide by 100′ long.

Envelope Method

Plastic sheeting folded in half to create an envelope may be used to protect against wavewash. The sheeting is affixed to the slope using knotted sandbags, stakes, and twine. The method of construction is:

Team 1: Wooden 1″x2″x2′ stakes are driven into the ground just above the levee shoulder on the side you wish to protect.

- Place the stakes 4′ apart and stagger vertically by 1′ as shown in Figure 9.

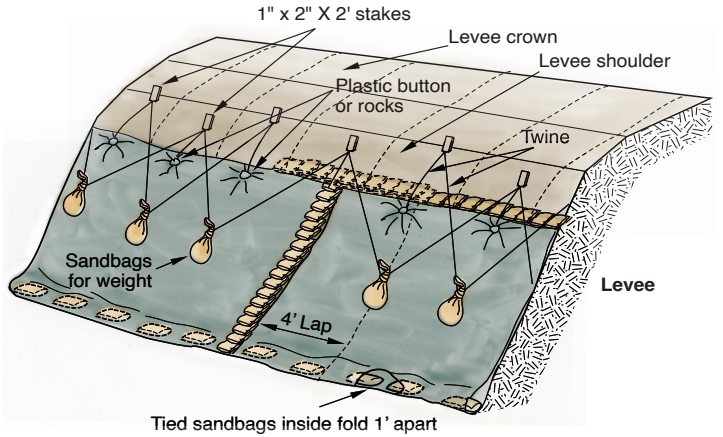


Figure 9: Wavewash Protection

Avoid driving stakes in a straight line; this can cause cracking and sloughing of the slope.

- To provide added strength and leverage, drive stakes at a 35-45 degree angle away from the plastic with the wide (2") side facing the plastic. Be sure the stakes are driven well into the ground and are secure.

Wavewash Protection

- If using grommets, attach twine to the wooden stakes using a slip knot with enough length to later secure to the plastic.
- Stage four knotted sandbags at each stake.

Team 2: Roll out the plastic sheeting along the protected side shoulder.

- Ensure that both edges of the plastic are held while the envelope is shaken out. Hold on tight! Use caution in strong winds. If wind catches the plastic it could billow out and pull you along with it. It is recommended to pre-position sandbags to temporarily secure the plastic down on the slope.
- While flood personnel hold the plastic envelope securely open, toss tied sandbags into the envelope. The tied sandbags (Figure 11) are thrown into the bottom of the envelope with a 1' gap between bags. The tied bags provide weight to hold the plastic against the levee slope.
- If another sheet of plastic will be used to continue the envelope, do not place any bags in the last 4' of the envelope. The new sheet of plastic will be placed inside the upstream envelope, overlapping 4'.

Team 3: Use grommets or tie-down buttons and twine to secure the plastic to the slope at each stake. Twine should be a minimum of 250 lb. tensile strength. **(See Figure 10 on how to secure tie-down button to plastic)**.

A small stone can be used in place of tie-down button, (preferably round) the stone is secured through both layers of plastic. If a stone is used, tie a slip knot and double half-hitch to secure it.

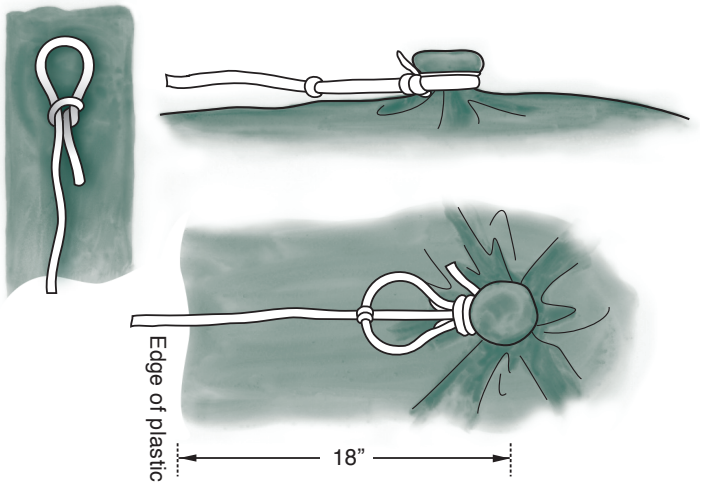


Figure 10: Plastic Tie-Down Buttons

If the envelope is to be extended downstream, do not place grommets or buttons in the last 4’ until the next sheet of plastic has been placed.

- Position button directly below stakes (one button per stake).
- Place button at least 18” from the edge of the plastic.
- Place button under both layers of plastic.
- To secure buttons to the plastic envelope, place the large opening of the button frame over the button and pull toward the small end.
- Tie a slipknot loop on the end of the twine, then place slipknot loop over button and plastic and draw tight.
- Tie two half-hitch knots around the narrow section of the button frame.

- Extend twine through bottom of large end of frame, tie a half-hitch knot around the end, and secure twine to stake (Figure 10).
- Tie twine low on stake for strength and to reduce tripping hazard.

Creating an eyelet using a grommet

When using grommets to secure the plastic to the slope, fold the top of the plastic over at least twice so that the grommet has a minimum of 6 layers of plastic to go through. Once the eyelet has been created, tie a piece of twine from the top stake- down to the plastic-and then halfway back up the slope. With the twine through the eyelet, create a trucker's hitch directly above to tighten the twine while making sure you don't rip out your newly created eyelet. Secure the trucker's hitch with a knot.

Team 4: Using a continuous piece of twine, hang tied bags from stakes in a criss-crossed fashion or "V" fashion as shown in Figure 9.

- Secure the sandbags to the twine using an adjustable knot, i.e., girth hitch.
- Place each bag so that it hangs at the middle of the plastic directly below the next stake.
- Attach twine to every other stake with a girth hitch.
- Add a second row of tied bags suspended from the stakes previously skipped forming a criss cross pattern. These bags will keep the plastic lying flat against the levee slope in windy conditions.

Team 5: Place a stretcher row along all seams to prevent wind and water from entering the envelope.

- Place the sandbags half on the plastic and half on the levee as shown in Figure 9.
- If the levee slope is too steep, knotted bags may be tied off with twine to the stake above the envelope for support.
- If the water is anticipated to repeatedly rise and recede, a small hole may be punched between each tied bag in the envelope, (a pencil works well).

If further slope protection is necessary

If the upper portion of the slope needs protection, use an additional envelope.

- Overlap the upper layer over the lower layer 2′ to 3′.
- To extend plastic, insert an additional envelope into the adjacent upstream layer of wavewash protection, overlapping at least 4′.

- To secure the overlap to the stakes, attach the two top layers with two buttons and the two bottom layers with another two buttons. The buttons line up with the stakes that are 4' apart. There should be four buttons securing the two envelopes. Grommets may be placed through all layers of plastic.

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

Tying Sandbags

Most sandbags are used with the open end folded. In some cases, sandbags will have to be tied (Figures 11A-11D). At minimum, 75 knotted sandbags will be needed for each 100' section of wavewash protection.

Tying a sandbag

Figure 11A: Sandbag filled 1/4 to 1/3 full

Figure 11B: Grasp bag at top corner and spin

Figure 11C: The long tail should be twisted tightly and look like a piece of rope.

Figure 11D: Tie an overhand knot (pretzel knot) as low as possible on the bag.

Erosion Control Fencing (EvoGuard®)

In areas where erosion has not yet occurred and there is adequate access on stable ground, erosion control fencing is useful for wavewash protection as a wave energy dissipater. Fencing comes in 100′ long by 3′ tall sections. Also needed to install fencing are 6′ tall t-posts, t-post drivers or sledge hammers, and zip ties.

- Unroll the fence along the levee slope. The containment toe extends towards the water approximately 6″ from the base of the fence.
- Slide the t-posts through the integrated sleeves that are set every 6′.
- Use UV stable zip ties to fasten the bottom of the fence 2′ above the bottom of the post. Secure the top of the fence once the post has been driven in. This prevents the fence from sliding up or down when driving in the post.

  - Typically t-posts have holes or notches. If using a standard wooden stake, drill holes or create a notch to prevent zip ties from sliding.
- Set the first post and pull each post as tight as possible before putting them into the ground. Use the t-post driver or sledge hammer to drive the post 2' deep into the soil.
  - The post should press the bottom rope channel tight to the ground, making positive contact to prevent undermining.
  - If teams are working in areas with loose uncompacted soil, longer posts may be required to drive deeper into the ground.
- Once the fence has been fully set up, place the securing pins in the containment toe.
  - Approximately 3 pins per 6' section.
  - Dirt, fill material, or sand bags may also be added on the toe if needed.

Always refer to the manufacturer's recommendations to ensure proper deployment.

CCC members installing erosion control fencing on the waterside berm

Installed erosion control fencing on the waterside berm

Raincoat Method

The raincoat method is used to prevent further saturation of levee or hillside slopes. Plastic sheeting is laid out flat on the slope, and sandbags are placed around the perimeter with additional bags evenly spaced for weight. If the slope is steep, wooden stakes can be driven into the ground just above the area to be protected. The stakes are 4′ apart with a 1′ stagger. The plastic is secured to the stakes with grommets, buttons, or small round rocks (Figure 12).

Use a crisscross method of placing the sandbags (Figure 12) on the plastic. Place a solid row of sandbags on all edges of the plastic (half on the ground, half on the plastic).

Raincoat Method

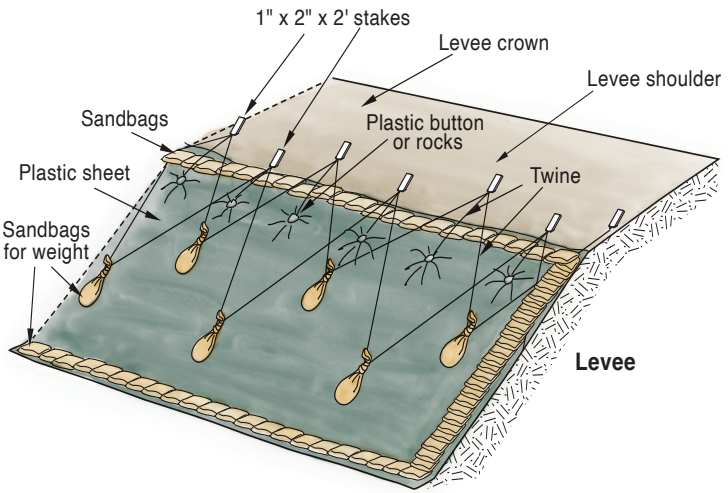


Figure 12: Raincoat Method

Emergency Spillway

To prevent damage to the levee slope due to overtopping, an emergency spillway (Figure 13) can be constructed at a known low spot or where overtopping has occurred in the past.

- Place plastic sheeting over area to be used for spillway.
- Line all sides with at least a single row of sandbags.
- Use additional tied sandbags on plastic for weight if needed.
- Extend spillway beyond the levee toe.

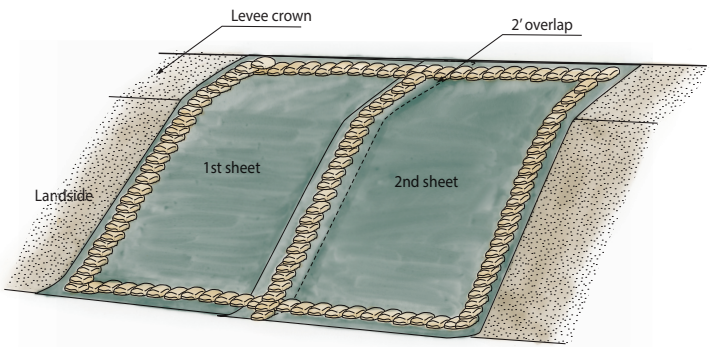


Figure 13: Emergency Spillway using plastic sheeting and sandbags

Emergency Spillway

Structure Protection/Diversion

The main causes of damage to structures, homes, and property during heavy rains or flooding are:

- Floodwater from overwhelmed storm drains and urban diversions, particularly on sloping streets.
- Flood flows onto property through driveway openings and low spots in curbs.
- Minor debris flow from hillsides that have been cleared of vegetation by fire or development.

The flood fighting methods described in the following sections have proved effective in combating floodwaters and debris flows.

Diverting Water or Debris Flows Away from Structures

Homes and structures can be protected from floodwater or minor debris flows by redirecting the flow as shown in Figure 14. Barriers must be long enough to divert the flows away from all structures. Barriers constructed of sandbags, Muscle Wall®, or lumber can also be used to channel mud and debris away from infrastructure.

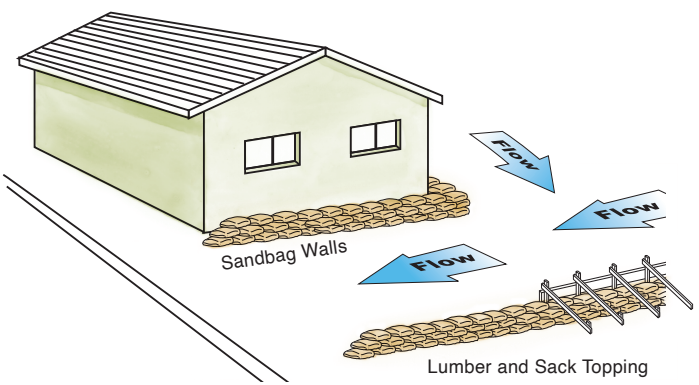


Figure 14: To divert mud, debris, and water, use sandbag walls or lumber and sack topping

Structure Protection

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.

- Secure plywood over doors and vents.
- Lay plastic sheeting on the ground and up the building walls to a point at least 1′ above the predicted water elevation.
- Place sandbags on the plastic sheeting in the form of a half pyramid against the structure (Figure 15).
- Overlap plastic sheeting and sandbags at corners of buildings.

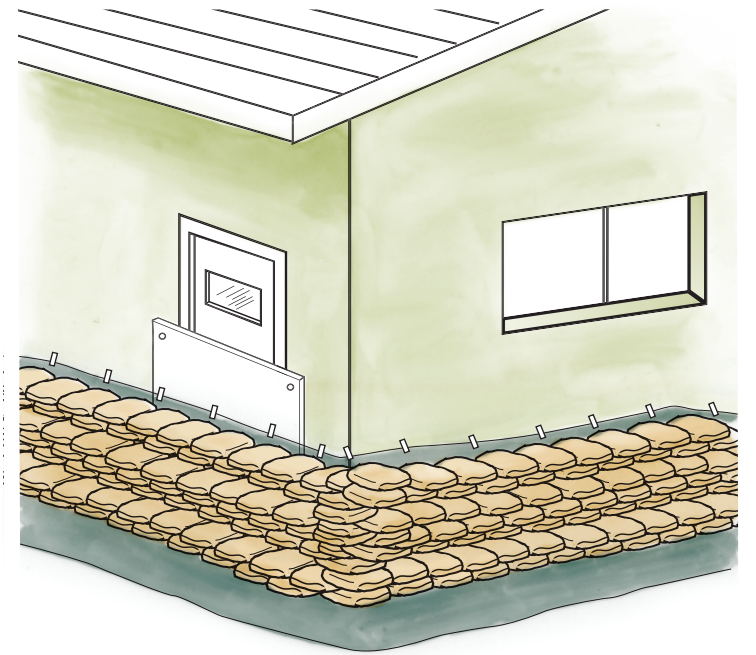


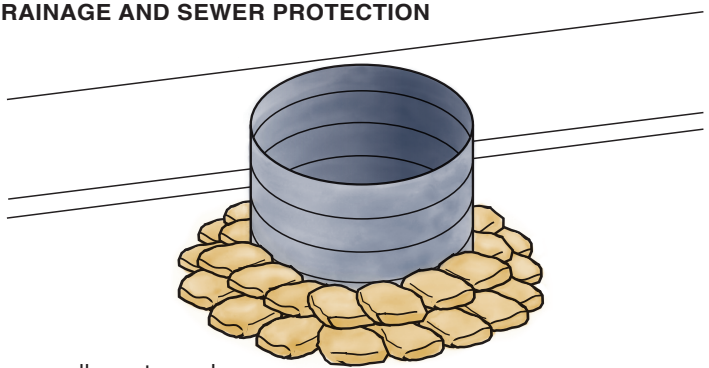
Figure 15: Structure Protection

Structure Protection

Drainage and Sewer Drain Maintenance Hole Protection

Drainage or sewer systems can be protected by placing corrugated metal pipe (CMP) over the utility hole (Figure 16). Place sandbags in the form of a half pyramid around the CMP to seal it to the pavement. If no CMP is available, a boil sack ring without a spillway may be constructed This method will prevent mud and debris from entering the system and act as a surge chamber.

DRAINAGE AND SEWER PROTECTION



Use sandbags to seal pipe to pavement.

Using corregated metal pipe (CMP) over utility hole to isolate sewer line or prevent contamination of storm drain system.

Figure 16: Sewer/storm drain protection

Flood Fight Safety

Numerous potential hazards exist during flood events. These hazards are manageable if identification and communication occur on an ongoing basis. Personal safety requires a conscious effort that every flood fighter must consider in their various duties and activities.

Changing Weather Patterns: This occurrence can affect existing conditions and create more serious situations. Always know the forecast and how it affects vulnerable areas, personnel and the public.

Changing Water Elevations: The rise and fall of water can occur gradually or very quickly. Knowledge of high water and how it relates to levees, communities, and personnel is essential. Continuous monitoring and communication of water level influences (i.e. reservoir releases, tides, and drainage inflow) are very important. Always know your area and the flood history around you.

Swift Water: High velocities of water are common during flooding events. Extreme caution should be used when anyone is exposed to high water. Personnel should have flotation devices, throw ropes, and lifelines in the immediate area. Swift water rescue teams may be available. Use common sense and sound judgement around swift water. Know your resources and how to activate them prior to the event.

Temperature Related Illness: During a flood fight, weather patterns can change constantly. Changes in temperature present the potential for hypothermia and heat exhaustion/stroke. Flood fighters should know the signs of distress for these types of illnesses and how to treat them. During cold, wet weather it is recommended that personnel layer clothing to

stay warm and dry. A dry blanket and warm clear fluids should be on the work site for emergency use. In warm or hot weather, lightweight clothing is recommended. If skin is exposed, a sun block agent may need to be applied. Plenty of drinking water should be on site and consumed regularly. Headgear is recommended in both hot and cold situations.

Insect/Animal Exposure: Flooded areas force a variety of animals to evacuate to high ground. Personnel in these areas should be aware of these animals and not handle them. If animal removal is needed, contact a local professional. Stinging and biting insects are prominent in certain flood-prone areas. Chemical repellents can be useful as a deterrent. A complete first aid kit should be on site.

Vegetation: Noxious plants such as star thistle, stinging nettle, and poison oak are commonly found along rivers, streams, and levees. Avoid direct contact with this type of vegetation to prevent itching and rash. Consult medical personnel if symptoms persist.

Sandpile Safety: When shovels are used for filling bags, a safe distance between personnel is essential. Sandbags and sand may contain contaminates. Have disinfectant available. Safety glasses or goggles are recommended for protection from blowing sand particles.

Contamination: Flooded areas can potentially carry high levels of contaminants. Common contaminants include fuel, sewage, and pesticides. Local Haz-Mat teams should be contacted if needed. Always wear protective clothing to help limit contact with water. Carry antibiotic hand soap and wash thoroughly after working around floodwater.

Exhaustion: Stress combined with long, physically demanding hours can have an adverse effect on personnel. It is very important to recognize exhaustion or sleep deprivation and treat them immediately. Operation of vehicles, machinery, or equipment should be avoided. A shift rotation of personnel will help eliminate fatigue factors.

Body Mechanics: Proper body mechanics while fighting floods is very important. The body is expected to work long, physical hours during the event. Each individual must make a conscious effort to use safe lifting and weight distribution techniques. Watch your footing; surfaces can be slippery and cluttered with tripping hazards.

Construction Equipment: There are times when equipment and people will occupy the same work area. Personnel should wear reflective vests and hard hats and be aware of their surroundings. Safety warning devices (i.e. backup alarms and lights) should be installed and properly operating on all equipment. Communication and alertness are vital! All operators must be certified for their equipment.

Boat Travel: Materials and/or personnel will sometimes need to be transported to work sites by boat. Operators of the watercraft must be certified. Personal Flotation Device must be available for every passenger. Extreme care should be taken while loading and off-loading.

Vehicle Placement: Vehicles in work areas along the levee should remain parked on high ground, typically the levee crown. This is usually the crown roadway. Vehicles should be parked facing their escape route. An escape plan should be communicated to all personnel. Vehicles should not be parked over areas with seepage, slumping, sloughing, erosion, and boils.

Structure Considerations: When working around structures, be aware of downed power lines, natural gas or propane leaks, and unstable structure supports. Communicate with the structure owner if possible.

Safety Gear: Rain gear, warm clothing, handheld lights, gloves, goggles, hardhat, boots, first aid kit, ropes, personal flotation devices (PFD), hip waders.

Heavy equipment being used during an advance flood fight

Flood Fighting Terminology

Boil	Also known as 'Sand Boil', is caused by water piping through or under a levee, possibly carrying eroded levee material, and surfacing on the landside of the levee.
Button	A plastic tie down device used to anchor plastic sheeting.
Diversion Wall	A sandbag wall with a half pyramid shape used to prevent overtopping or divert flow. (Page 10)
Emergency Spillway	Plastic sheeting and sandbags used to allow water to flow over a levee, protecting it from erosion. (Page 29)
Envelope Method	Plastic sheeting, sandbags, twine, stakes, and buttons used to prevent erosion of levee slopes and embankments. (Page 17)
Flood Fighting	An effort made to prevent or mitigate the effects of flood waters.
Grommet	A metal eyelet that is fastened to plastic sheeting to provide an attachment point.
Home Protection	Plastic sheeting and sandbags placed around individual homes to protect from low current flood waters. (Page 31)
Lath	Long, narrow wooden stakes (4' long by 1 ½" wide) used to mark problem areas during high water patrolling. A brief description of the problem along with the date, time, and patroller's initials are written on the lath with a permanent ink marker. Brightly colored survey ribbon is attached to the lath for easy identification.

Levee	An earthen structure that parallels a river or stream designed to prevent high water flows from inundating urban and/or agricultural land.
Levee Break	A point in the levee system that has failed to perform its designed function, has eroded away and is allowing water to inundate land.
Overtopping	When water has risen higher than the banks of a waterway or the top of a levee.
Plastic sheeting	Made of polyethylene, these 100'x20'x10 mil rolls are sometimes referred to as visqueen and are used for erosion control.
Raincoat	A single layer of plastic sheeting and sandbags used to protect slopes from further rain saturation. (Page 27)
Relief Cut	Intentionally-removed section of levee to relieve hydraulic pressure upstream and downstream of the levee section.
Sack Ring	Multiple sandbags used to encircle a boil, slow the flow of water, and mitigate the erosion of levee material. (Page 13)
Sack Topping	A sandbag wall designed to prevent overtopping. (Page 8)
Sandbag	An 18"x30" bag (burlap or plastic) filled with sand or other appropriate material intended for use as a temporary flood fighting measure.

Sloughing	Soil movement or slides often caused by over saturated levee or hillside slopes.
Structure Protection	Sandbags, wooden panels, or other materials used to divert water, mud, and minor debris flows away from buildings, homes, and other structures. (Page 30)
Temporary Levee	Use of plastic sheeting, fill material and sandbags to raise a low area on a levee or embankment. (Page 10)
Twine	250lb tensile strength polypropylene tying twine.
"U" Shaped Sack Ring	A sandbag structure used on levee slopes to mitigate boils. (Page 15)
Wooden Panels	Wooden planks or plywood sheets used in conjunction with other flood fighting materials to prevent overtopping of levees or embankments and divert water.
Wavewash	Wind-generated waves breaking against a levee or embankment and possibly causing erosion.

Reference Guide

DWR Division of Flood Management
water.ca.gov/Programs/flood-management

California Data Exchange Center (CDEC) National Weather Service
https://cdec.water.ca.gov

California Governor's Office of Emergency Services
www.caloes.ca.gov

National Weather Service
www.weather.gov

California Nevada River Forecast Center (CNFRC)
www.cnrfc.noaa.gov

How-to flood fighting videos can be found on California DWR's YouTube channel.

To request a copy of the Directory of Flood Officials or Flood Emergency Phone Card, contact the DWR Flood Operations Center at (916) 574-2619.

Flooded road

Flood Fight Material/Equipment List

- Fill/Repair material (Sand, Rock, Road Base)
  - Approximately 1 cubic yard of sand for every 100 sandbags
- Sandbags (18" width x 30" length)
- Plastic Sheeting (100'x20'x10 mil rolls)
- Wooden Stakes (1"x2"x24")
- Bailing Twine (250lb tensile strength)
- Grommets (3/8" inside diameter) and compatible grommet gun
- Tie Down Buttons

Patrolling

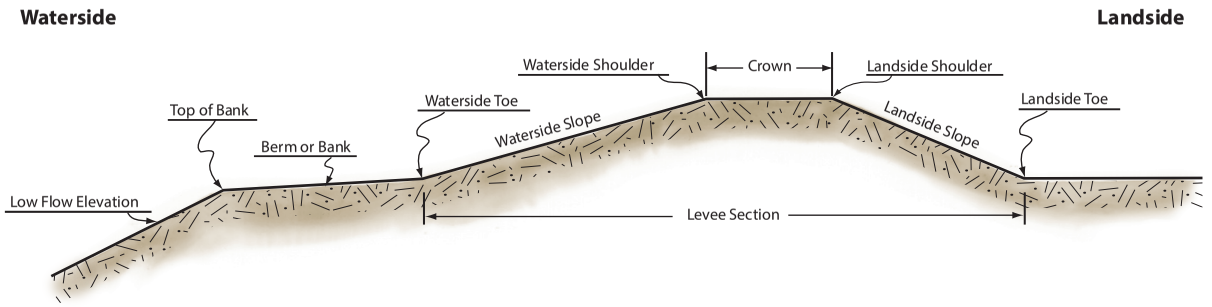
- Patrol Vehicle (4WD)
- Communication Devices (Radio, Cell Phone, Laptop Computer (e-mail))
- Global Positioning Satellite Handheld Device (GPS)
- Digital Camera
- Lighting (Flashlight, Flood Light)
- Batteries
- Marking Paint
- Lath (Bundle of 50)
- Survey Ribbon (Bright Colors)
- Permanent Ink Markers
- Patrol Log (Writing Pad and Pencil)
- Measuring Tape (100')

Tools

- Shovels, Long Handle (#2 Mud Shovel)
- Sledge Hammer (10lb)
- Multi Purpose Lineman Pliers
- Pulaski
- McLeod
- Loppers

Safety

- Rain Gear
- Rubber Boots
- Hard Hat
- Safety Glasses
- Gloves
- Boots
- Throw Rope
- Relevant Emergency Contacts
- Personal Flotation Device (PFD)
- Personal Safety Light
- Warm Clothing
- First Aid Kit/Reference Guide



Levee Cross Section

State of California
Department of Water Resources
Division of Flood Operations
Flood Project Inspection and Assessment Section

For all flood training information, emergencies, questions, or for additional information, please contact:

State-Federal Flood Operations Center
(916) 574-2619
flood_center@water.ca.gov