1. Sandbag Size and Fill Materials

Bags must be filled and placed properly to give the best protection. Any available material can be used to fill sandbags, but sand is easiest to handle. Silt and clay will form a good dike but are more difficult to work with. Different size bags are available, but bags are easier to handle if weight is limited to between 35 and 40 pounds. This weight limit is particularly important when teenagers or older persons will be handling the bags and assisting with emergency operations and dike construction.

Typically sandbags are filled approximately half full. It is desired that the sandbags lay flat when placed. Overfilled bags reduce the dike's effectiveness by leaving gaps between the bags, allowing water to seep through. Tying is not required for a correctly filled sandbag. Although tied sandbags are generally easier to handle and stockpile, untied sandbags are recommended for most situations, because untied bags make a better seal when they're stacked. Since the bags aren't more than 2/3 full, they can be transported almost as easily whether they're tied or untied. Tied sandbags should be used only for special situations when the bags need to be pre-filled and stockpiled, or for specific purposes such as filling holes or for holding objects in position.

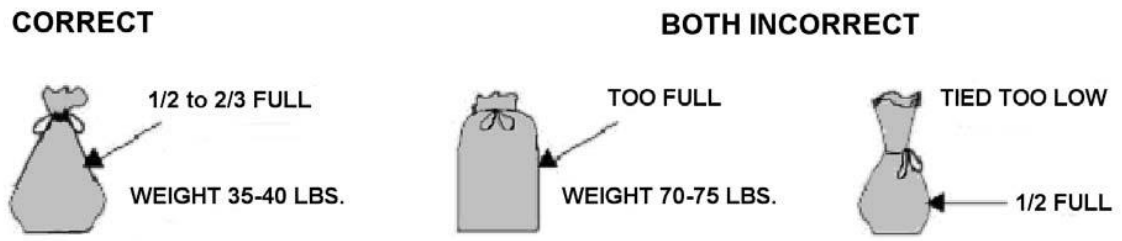


Figure 1 – Correct and incorrect sandbag preparation.

Ordinarily, filling sandbags is a two or three-person operation. One member of the team should place the bottom of the empty bag on the ground slightly in front of wide-spread feet with arms extended. This person may also want to kneel or sit to avoid back strain from bending. The throat of the bag is folded outward about 1-1/2 inches to form a collar and held in that position to allow a second team member to empty a shovelful of material into the open end, until the bag is ½ to 2/3 full. The third team member stacks and stockpiles the filled sandbags. Gloves should be used to avoid injury, and safety goggles are desirable during dry and windy days. For larger operations, bag-holding racks and funnels on the back of dump trucks, and other power loading equipment can be used to expedite the filling operation.

1.2 Site Selection and Preparation

When selecting the location for a dike, consider the ground elevation, ground condition, obstructions, and alignment. For stability, the dike should be kept as short and low as possible. Avoid any obstructions that would weaken the dike, and do not build the dike against a building wall unless the wall has been designed to retain floodwaters.

If possible, plan to leave at least 8 feet between the landward toe / base of the dike and any building or obstructions to allow for future dike raises, dike monitoring, construction equipment and vehicles, and to prevent damage to building walls and foundations.

Remove all ice and snow from a strip of land at least as wide as the base of the dike. If the dike will be more than 2 - 3 feet high, remove a strip of sod to create a bonding trench along the center line of the alignment to better anchor the dike in place, as shown in ***Figure 2.***

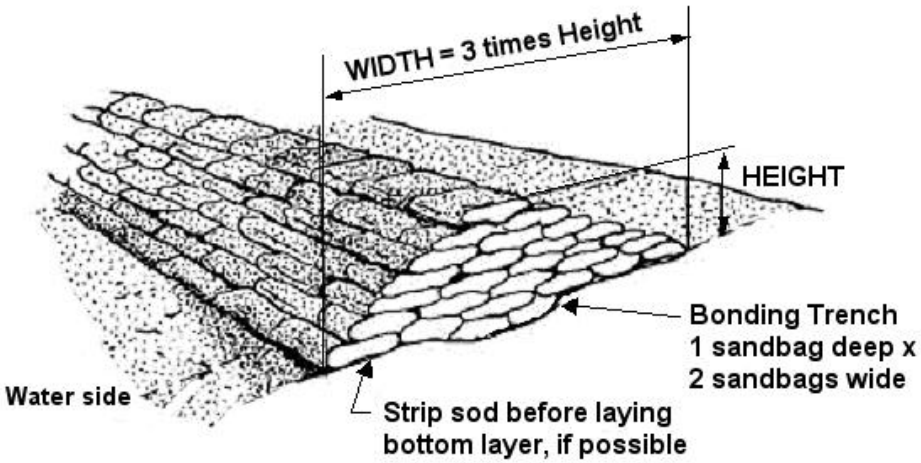
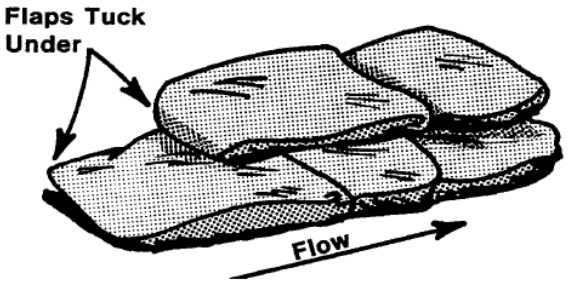


Figure 2 – Proportions of sandbag dike showing bonding trench at base.

1.3 Sandbag Placement

When laying the sandbags, the open end of the unfilled portion of the bag is folded over to form a triangle. If tied bags are used, flatten or flare the tied end. Place the partially filled bags lengthwise and parallel to the direction of flow, so the bottom of the bag faces downstream and the folded end faces upstream. (This positioning reduces the chance that floating debris will snag on the tucks and open the bags.)



Tuck the flaps under, keeping the unfilled portion under the weight of the sack. Overlap the next bag slightly over the one before it, so that the top of that sandbag layer can be flattened without leaving any gaps between the bags. Once a bag is placed, it's very important that you then walk over it, stomp on it, or maul it into place to eliminate voids and form a tight seal. When succeeding layers are added, stagger the bags like bricks, so that each one is placed over the gap between the two below it.

This ensures that each seam is interlocked between bags and strengthens the structure. (There should never be less than 1/3 the length of a bag overlapping with the ones beneath it.) When placed properly, each bag should raise the elevation of the structure by 4 inches.

1.4 Stacking Sandbags to Form a Dike

Overlap the sandbags as shown in ***Figure 3***, placing the first layer of bags lengthwise along the dike and lapping the bags so the filled portion of one bag lies on the unfilled portion of the previous bag.

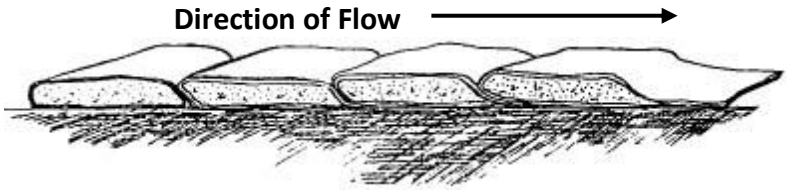


Figure 3 – Overlap sandbags lengthwise and parallel to river flow.

The bags should be placed lengthwise and overlapped parallel to the direction of the river flow. The bonding trench shown on ***Figure 2*** should be filled with a layer that is two sandbags wide by one sandbag high; the first full layer is then placed over this bonding trench. The base of the dike should be three times as wide as the dike is high.

The second layer of bags should be staggered perpendicular to the first layer and placed over the seams of the previous layer, with additional layers laid in alternating directions to the top of the dike, as shown in the "Correct" example in ***Figure 4***. By alternating placement directions, the gaps and seams along the edges and corners in each layer below will be covered and filled in by a sandbag in the next overlying layer.

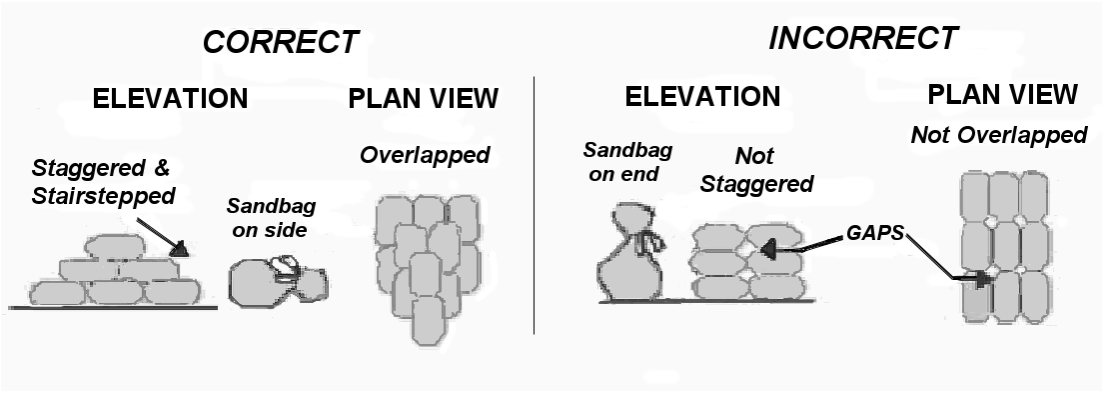


Figure 4 – Correct and incorrect placement of staggered sandbag layers.

1.5 Sealing the Dike with Polyethylene Plastic Sheeting

The finished dike can be sealed with a sheet of polyethylene plastic (poly) to improve water tightness. The poly sheeting should be about 6 mils thick, and is generally available in 20 foot-wide by 100-foot-long rolls from construction supply firms, lumberyards, and farm stores. The poly must always be anchored at the bottom edge and weighted along the top and slope to be effective.

Three methods are recommended to anchor the poly on the riverward face of a sandbag dike. The most successful is shown in ***Figure 5*** and described as follows: (1) Poly is placed flat on the ground surface extending away from the bottom row of sandbags, and one or more rows of sandbags are placed over the flap. The poly is then unrolled over the anchoring row of sandbags, anchored again, and then up the slope and over the top of the sandbag dike, far enough to allow for anchoring with additional sandbags.

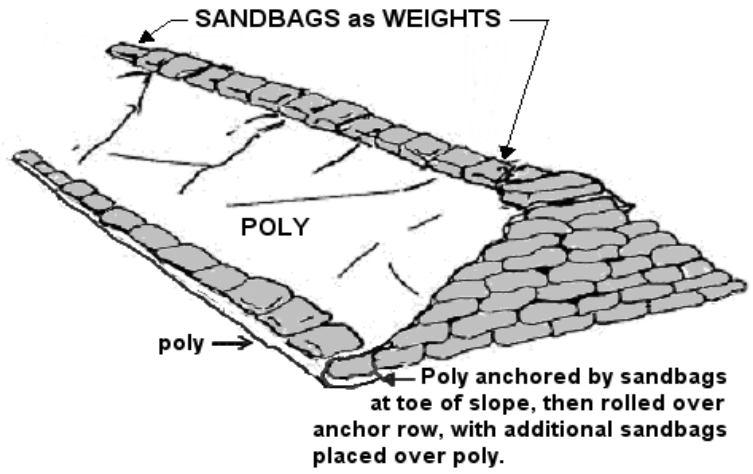


Figure 5 – Preferred method of tucking under and anchoring poly with two rows of sandbags.

Other methods available include: (2) At the base of the dike along the water side, spread a layer of dirt or sand one inch deep and about one foot wide along the bottom of the dike, to create a uniform surface to anchor the poly. Lay the poly sheeting so the bottom edge extends one to two feet beyond the bottom edge of the sandbags over the loose dirt. Place sandbags over the edge of the poly to anchor (***Figure 6)***.

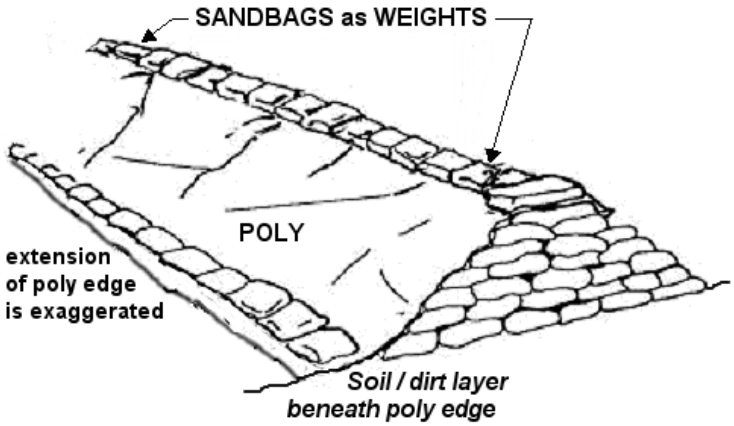


Figure 6 – Poly edge placed over dirt and anchored with a row of sandbags.

A third method to anchor the poly is: (3) Excavate a 6-inch or deeper trench along the toe of the levee, place poly in the trench, and backfill the trench, compacting the backfill material or placing a row of

sandbags over the trench to prevent loss of the backfill material (***Figure 7***). This method will be unsuitable if water levels have reached the sandbags at the toe of the dike. In all cases the poly is unrolled up the slope and over the top, and anchored along the top with additional sandbags.

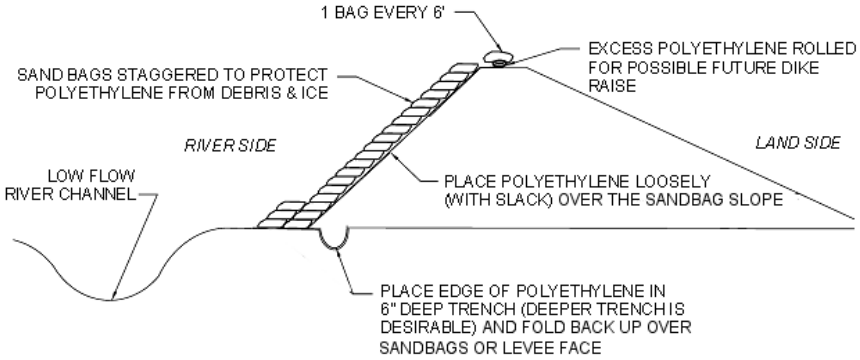


Figure 7 – Poly anchored within a trench – placed under dry conditions.

Poly should be placed from downstream to upstream along the slopes and the next sheet upstream overlapped by at least 3 feet, as shown on ***Figure 8.*** Overlapping in this direction prevents the current from flowing under the overlap and tearing the poly loose. Lay the poly sheeting down very loosely, as the pressure of the water will make the poly conform easily to the sandbag surface if the poly is loose. If the poly is stretched too tightly the force of the water against the poly and sandbags could puncture the poly. Once the poly is placed, additional sandbags, boards, and/or loose dirt placed over the poly are needed to anchor the poly in place and prevent the wind or river current from disturbing it. These anchors are not shown on the illustration. Avoid puncturing the poly with sharp objects or by walking on it.

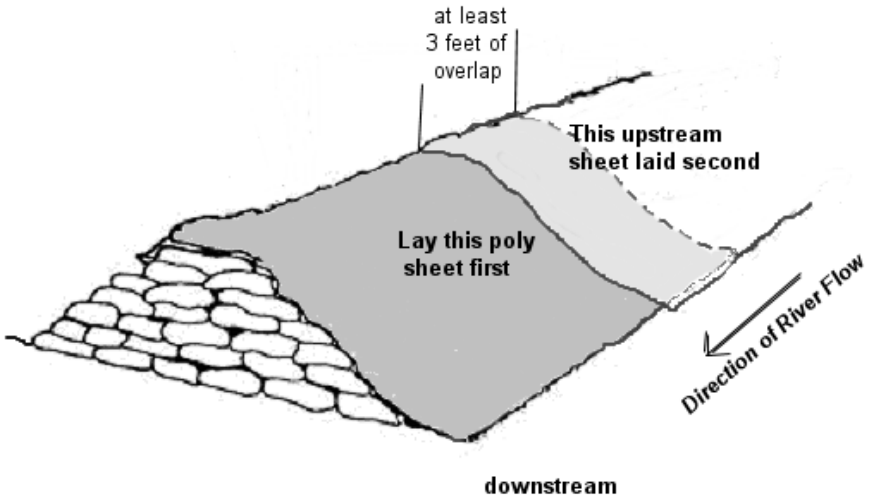


Figure 8 – Poly placement from downstream to upstream with overlap shown.

1.6 Treatment of Sandboils

The most common and accepted method of treating sandboils that are displacing soil is to construct a ring of sandbags around the boil(s) as illustrated in the Figure 9.

The purpose of the ring is to raise a head of water over the boil to counterbalance the upward pressure of the seepage flow. The height of the water column is adjusted so that the water exiting the boil runs clear and no longer removes soil from the levee foundation. It's extremely important that the flow of water is never stopped completely, as this may cause additional boils to break out nearby. Treated areas should be kept under constant surveillance until the water recedes.

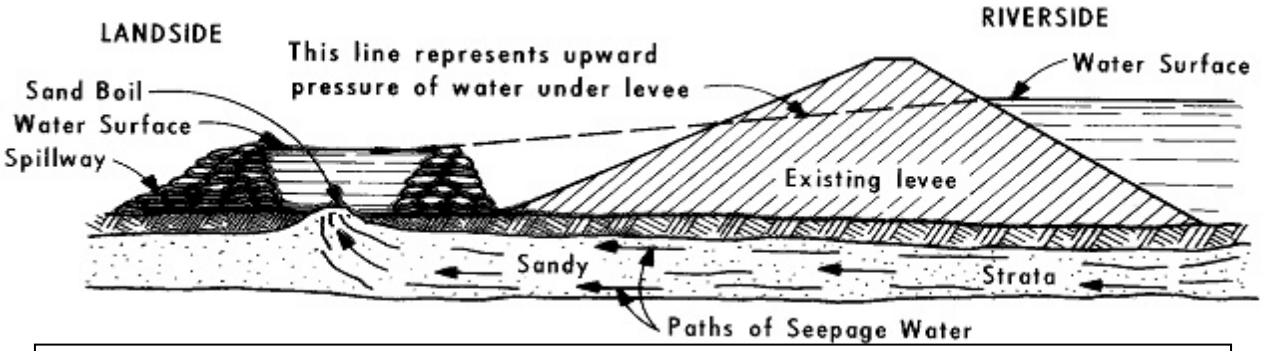


Figure 9 - To treat the sandboil, the pressure of the seepage water is counterbalanced by hydrostatic pressure from the column of water in the ring levee.

The diameter and height of the ring will depend on the actual conditions at each sandboil. The base width should be at least 1½ times the contemplated height, and the inner ring of sandbags should begin between one and three feet from outer edge of the sandboil. "Weak" or "quick" ground near a boil should be included within the sack ring to prevent these areas from developing into new boils when the active boil is treated.

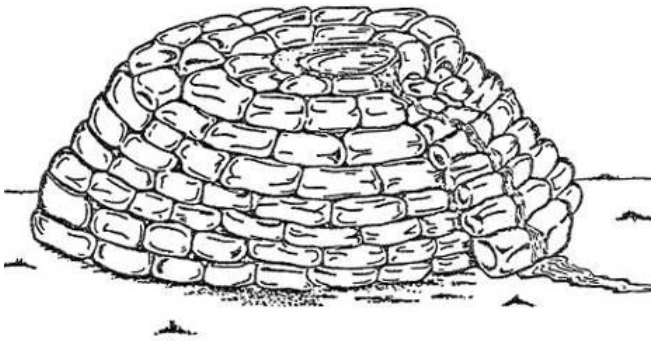


Figure 10 -Sketch of a typical ring levee with spillway.

Where several sandboils develop in a localized area, a ring levee of sandbags should be constructed around the entire area. The ring should ideally be of sufficient diameter to permit sacking operations to keep ahead of the flow of water. When a sandboil is located near the levee toe, the sandbag ring may be tied into the landside slope of the levee, as shown to the right.

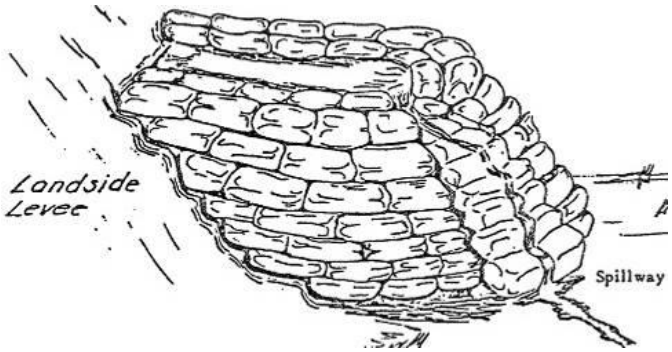


Figure 11 - Sketch of a ring levee tied to a levee slope, with spillway.

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The base or foundation for the sack ring should be cleared of debris and scarified to provide a reasonably watertight bond between the ground surface and the sandbags. The ring is constructed with sacks filled approximately two-thirds (2/3) full of sand, and tamped firmly into place.

Do not tie the ends of the sacks. When adding subsequent layers, the joints should be staggered for stability and water tightness. The untied ends of sandbags should be laid towards the inside of the ring and folded under. The height of the sack ring should be only sufficient to slow the flow until the water exiting the boil runs clean. Never place sandbags directly over the sandboil or attempt to completely stop the flow through the boils, as this may result in other boils developing nearby.

A spillway or exit channel should be constructed on the top of the sack ring so that the level of the water in the ring levee can be adjusted, and the overflow water can be carried a safe distance from the boil, away from the direction of the levee. Because the height of the water is the critical factor in adjusting the rate of flow through the boil, the spillway will require constant monitoring and adjustment once the sandbag ring levee is filled with water. This spillway is normally constructed of sandbags, but alternately, a V-shaped drain can be constructed of two boards; or PVC pipe, plastic sheeting, or other materials may be helpful in building the spillway.

1.7 Number of Sandbags Needed

The following information in ***Table 1*** indicates the approximate number of sandbags that are needed for dikes of various heights and lengths. Note that 5 feet high is the practical limit of sandbag dike. If a higher sandbag dike is needed, alternative means of construction should be considered. The preferred height limit is 3 feet.

Estimated Number Of Sandbags Per Linear Foot Of Dike	
Height in Feet	Bags Required
1	5
2	10
3	21
4	36
5	55

DIKE HEIGHT	Number Of Sandbags Required For Length Of Dike									
	50 FT	100 FT	175 FT	200 FT	250 FT	300 FT	350 FT	400 FT	450 FT	500 FT
1 Foot	250	500	750	1,000	1,250	1,500	1,750	2,000	2,250	2,500
2 Feet	850	1700	2,550	3,400	4,250	5,100	5,950	6,800	7,650	8,500
3 Feet	1,800	3,600	5,400	7,200	9,000	10,800	12,600	14,400	16,200	18,000
4 Feet	3,100	6,200	9,300	12,400	15,500	18,600	21,700	24,800	27,900	31,000

Table 1 - ***Estimated number of sandbags needed per foot of length and height of dike.***

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Material, Tools, and Labor Requirements for Sandbag Levee

Listed below are the materials, tools, and labor required to construct 100 linear feet of sandbag levee, two feet high, with a haul distance of 1 mile round trip.

- **Materials and Tools**
  1,800 Sandbags
  10 Shovels
  27 Flash lights
  10 Tons sand (approx)
  2 Emergency light sets
  2 Radios or cell phones (one at filling site; one at laying site)
  6 Pickup trucks
- **Labor Requirements:**
  10 Filling sandbags
  5 Loading
  6 Hauling
  5 Laying
  2 Foremen (1 at sandbag filling site, 1 at work site)
  28 People required, total
- **Time Requirements:** With given resources, the time for completion is estimated at 2 ½ hours, from start to finish.

Sources: *Information in the following section is modified from several sources, in particular: 1) the North Dakota State University, Extension Service, Coping With Floods website, 2) the Dane County, Wisconsin, Department of Emergency Management website, and 3) employees of the St. Paul District U.S. Army Corps of Engineer (USACE-MVP), (4) Flood-Fight Handbook - Preparing for a Flood 2009 Edition (CEMVP Feb 2009), and (5) the USACE Levee Owner's Manual for Non-Federal Flood Control Works, March 2006.*

This document is intended as a guidance document only, and should be used as such. For technical questions, please contact the US Army Corps of Engineers, and/or the abundant resources available on the Internet.

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