Reusability

Once removed, the RDFW units were inspected for damage. Some damage to the units was identified (Figure 3-144). The most damage was to the top row, bottom row, and the end units. Some individual panels of these units could be saved with the damaged pieces being replaced. Once the damaged pieces are replaced, the unit is reusable. Each RDFW unit consists of 14 pieces. Geocell Systems conducts a replacement procedure that they term "cannibalize" the units. This procedure includes the removal and replacement of damaged pieces within a unit with undamaged pieces to make the unit reusable. While minor damage was sustained during testing from the units shifting against the weight of the water, most of the damage to the RDFW units occurred during removal. Damage to the bottom units was attributed to the use of heavy machinery. By approximate field estimates, approximately 90 percent of the units were reusable.

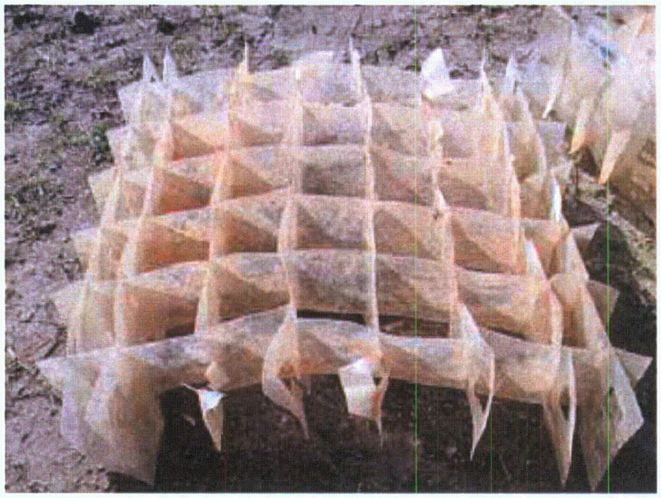


Figure 3-144. Damaged RDFW unit

The units can be cleaned by washing the sand, mud, and debris off with a garden hose. However, they were not cleaned during this project. The used units that were not damaged or could be repaired (cannibalized) were folded flat and returned to the wooden crates. The units damaged beyond repair were disposed of.

Summary

For the field testing, various construction, removal, and performance parameters were evaluated. Table 3-8 provides a summary for the field-testing of the Rapid Deployment Flood Wall (RDFW) structure.

Even if a product performs well, the flood-fighting community is not likely to use the product unless it is cost-effective. In order to make a fair comparison of costs, each product vendor was asked to submit the cost of constructing and removing 1,000 lft of their product, 3 ft high in Vicksburg, MS. This cost included the purchase of the product plus fill material, labor, and equipment based on Vicksburg rates. The cost for shipping the products were not provided. For this cost determination, sand fill delivered to the site was estimated at $8 per cu yd. Labor rates were $8/hr for laborers and $12/hr for equipment operators. Table 3-9 provides a summary of the costs furnished by Geocell Systems (RDFW). The costs provided for RDFW are based on its first time use. At the time that the costs were provided, Geocell Systems guaranteed the RDFW product for three uses. Therefore, RDFW also provided the expected costs for two subsequent uses.

Since the RDFW product was reusable, the second and third uses did not include any cost for purchase of the product. However, Geocell Systems did include a recertification fee after each of the first two uses that equals 10 percent of the initial purchase price. This fee provided for Geocell Systems to inspect and certify that each unit is reusable. All unusable pieces were replaced at no additional cost. Since the quoted purchase price for 1,000 ft of RDFW, 3 ft high was $137,750 the recertification fee to inspect and replace damaged pieces prior to the second and third uses would be $13,775 per use. Since that time, Geocell Systems has decided to no longer guarantee the RDFW product for reuse. Geocell Systems has no control over the amount of care in the installation and removal and over the type fill material used. Extremely rough handling of the product during installation and removal or the extraction of fill material other than sand can lead to excessive damage. However, Geocell Systems continues to claim that with proper care in the installation and removal process, the RDFW product is reusable. The field test tends to verify this claim with over 90 percent of the product used for this test certified as reusable.

Table 3-8
RDFW Field Testing Summary

Item	RDFW
ROW Used (ft)	22
Footprint Width (ft)	6 (4-ft wide units + 2- ft wide half units)
Structure Length (ft) Riverward Face East Tieback West Tieback	 101 42 45.5
Ease of Construction Time (hr) Effort (man-hours) Manpower (no. men) Equipment	 7.5 48.4 7 Shovels 2 Bobcat Loaders
Fill (cu yd)	85
Durability	The RDFW structure stayed in the field for 2 months and was subjected to hot, wet weather. The structure showed no signs of deterioration.
Varying Terrain	The field test site was relatively flat with a mild slope from the protected side of the RDFW structure to the riverward side.
Ease of Removal Time (hr) Effort (man-hours) Manpower (no. men) Equipment	 17.3 113.4 Up to 10 Hand Held Vacuums Air Compressor Shovels Pumps with Fire Hoses Vacuum Truck Track Hoe Front End Loader Forklift
Seepage (gal/hr) For 100 sq ft Wetted Area For 200 sq ft Wetted Area For 300 sq ft Wetted Area For 400 sq ft Wetted Area For 500 sq ft Wetted Area	 50 200 700 900 1,500
Repairs	All Minor – Structural Integrity Not Threatened Added Sand Fill After Initial Sand Fill Settled
Reusability (percent)	Greater than 90

Table 3-9
Costs For RDFW

Item	RDFW
Product	1,450 4 ft by 4 ft by 8 in. units at $95/unit = $137,750 290 4 ft by 2 ft by 8 in ½ units at $47.50/unit. = $13,775 Total product cost = $151,525
Shipping	No $ Provided
Installation Laborers Operators Equipment Fill	 50 man-hours = $400 9 man-hours = $108 2 loader days = $650 548 cu yd = $4,383
Removal Laborers Operators Equipment	 100 man-hours = $800 18 man-hours = $216 4 loader days = $1,300 Hand tools = $200
Training by vendor for installation and removal	For initial installations only = $10,433 No training required for subsequent installations
Technical support during installation and removal	Per installation = $23,987

Based on the field testing, strengths and weaknesses of each product were observed. RDFW's strengths include ease of construction including time and manpower. The RDFW structure was constructed quickly and with limited effort, had low seepage rates, had a high degree of reusability, and a RDFW structure can be raised as needed by placing additional rows of units on top an existing structure. Also, the RDFW unit has the most height flexibility since the RDFW units are 8 in. high. For example, if a quantity of RDFW product was purchased to construct a wall 4 ft high and in a given flood event, only a 2-ft-high wall was required, then sufficient product would be on hand to construct a barrier twice as long as could be constructed to a height of 4 ft. For the field testing, the RDFW structure was constructed much quicker and with a much smaller labor force than the sandbag structure. The RDFW units were inspected after the field testing was completed with over 90 percent of the pieces being certified as reusable. A RDFW unit consists of 14 separate pieces. If a piece is damaged, that piece can be replaced resulting in the entire unit being reusable. RDFW's weaknesses include additional right of way required due to the placement of granular fill perpendicular to the structure by heavy machinery. Also, RDFW has a high initial cost due to the purchase price of the RDFW units ($95 per unit). The RDFW structure was labor intensive and time consuming to remove due to the extraction of the fill sand from the 7 in. x 7 in. openings in the grid. For the field testing, the Geocell Systems representatives tried several methods for extracting the sand fill from the structure. These included hand-held vacuum devices, water hoses, compressed air, rented vacuum truck, and small garden shovels. Since the field testing was completed, Geocell Systems has been working to develop a more efficient method for removing the RDFW units after use. They have conducted tests at their office with the use of a trailer-mounted suction device. Geocell Systems has also developed a "grappler" lifting device. This device consists of a pipe frame that supports a series of standard pallet pullers. The pallet pullers are attached to the frame and the grappler is lifted with a front-end loader. This lifting device allows for the removal of two grid units in a single lift. Geocell Systems plans to make the grappler lifting device available to RDFW users to assist in the removal process.

Field Installation and Performance of Portadam Barrier

Introduction

Portadam is manufactured in the United States by Portadam, Inc. of Williamstown, NJ. Portadam describes its flood-fighting product as "a steel-supporting structure with a continuous reinforced vinyl liner membrane." The structure is free standing due to the design of the support frame that transfers the hydraulic loading to near vertical. The supporting frames are available in 3-ft, 5-ft, 7-ft, and 10-ft heights. The steel frame is assembled onsite with furnished hardware (clamps, bolts, and connecting rods). Once the frame is constructed, the impermeable liner membrane is pulled onto the steel frame and tied into place. Portadam has primarily been used for both water diversion (cofferdams) and temporary holding basins.

Field construction

For the Vicksburg Harbor field test, a 5-ft-high steel-supporting frame was used. For typical applications, Portadam pulls the liner to the top of the frame. However, the field testing protocol required each structure first to be built high enough to hold back 3 ft of water and then raised 1 ft. This requirement meant that Portadam had to manufacture a special liner for the field test. The liner consisted of a typical liner with eyelets at the top to tie it to the frame. For the field test application, Portadam attached a second, much smaller liner to the standard liner just below the eyelets to accomplish the required structure raise. This additional liner was left dangling for the initial construction to hold back 3 ft of water. For the raise, the additional liner was pulled up and tied to the top of the frame. This technique is not a standard installation practice. Portadam typically pulls the liner to the top of the frame and secures it at that height for a normal installation. This means that for a typical installation, the Portadam structure cannot be raised.

The Portadam product was delivered to the Vicksburg Harbor with two liner sections, both rolled and tied; supporting-frame members banded together in groups of approximately 20; and hardware (clamps, link bars, and bolts) in three drums (Figure 3-145). Prior to installation, the Portadam product was prepositioned adjacent to the construction site. Also, at the request of the Portadam representative, 450 sandbags were filled and delivered to the Portadam site. Portadam typically places a row of sandbags along the leading edge of their liner membrane to help provide a seal between the liner and the ground. Also, at the time the Portadam structure was constructed, the river was falling. The testing could be conducted only when the river rose to appropriate levels. Therefore, the Portadam structure had the potential of sitting in the field for an extended period of time before the river rose high enough for testing. The Portadam representative was concerned about the impacts of wind during the time when the structure would be sitting in the field with no water against it. Therefore, he requested sandbags to add weight to the structure.

Construction of the Portadam structure began during the early afternoon on 12 May in constant rain with mild temperatures. The construction crew consisted of a Portadam representative and four government laborers. None of the government laborers had any prior knowledge of the Portadam product. The Portadam representative conducted a 5-min training session on the installation process.

Figure 3-145. Portadam as delivered to Vicksburg

Once the training session was complete, the laborers began assembling the steel supporting frame along the desired alignment. Each of the 5-ft frame members weighs approximately 28 lb. Therefore, the members were easily lifted and carried by the laborers from the staging area to the assembly location. The frame is assembled by alternately bolting the adjacent members together at the bottom and clamping the next adjacent member at the top (Figure 3-146). Also, link bars are placed in the tops of adjacent members to further strengthen the frame. This procedure creates a continuous supporting frame. In accordance with the construction protocol, about half of the site was graded to bare ground while the other half was left undisturbed with the natural grass and weeds (Figure 3-147).

Figure 3-146. Supporting frame with, bolts, clamps, and link bars (hardware)

Figure 3-147. Structure frame constructed on graded and undisturbed ground

The entire supporting frame was assembled prior to installing the liner membrane. Construction of the frame began at the free end of the east tie-back section and continued around the structure to the free end of the west tie-back section. Because the supporting frame is a continuous structure, two 90-deg turns (Figure 3-148) were required to form the u-shaped structure. The Portadam structure as constructed included a riverward face of 103 ft with the east tie-back of approximately 41 ft and the west tie-back of about 43 ft.

Figure 3-148. Making a 90-degree turn

After the frame was assembled, the two sections of liner membrane were unrolled (Figure 3-149). One section was unrolled starting from the free end of the east tie-back and the other section was unrolled from the free end of the west tie-back. The sections were connected along the riverward face of the structure with a pin-and-liner flap system (Figure 3-150). The liner membrane was then pulled by hand onto the supporting frame and tied at the 3-ft-high level (Figure 3-151). The next phase of the construction process included excavating an 8-in-deep trench around the structure along the leading edge of the liner membrane. A rented Ditch Witch was used to excavate the trench (Figure 3-152). The leading edge of the liner was placed in the trench (Figure 3-153) and buried with the soil that had been excavated from the trench (Figure 3-154). Once buried, a row of sandbags was placed along the buried edge of the liner (Figure 3-155). Burying the liner edge helps reduce the potential for seepage under the liner membrane. After the sandbags were placed, the Portadam representative inspected the structure and certified that construction of the structure to hold back 3 ft of water was completed. This construction took the Portadam representative and the four government laborers 4.5 hr (25.6 man-hours) to complete. The construction time included 0.5 hr (6.4 man-hours) to fill the sandbags used for the structure. The equipment used to construct the structure included a ratchet and socket, shovels, and the rented Ditch Witch. The only fill material needed for the Portadam structure was the sand used in the sandbags.

Figure 3-149. Unrolling liner membrane

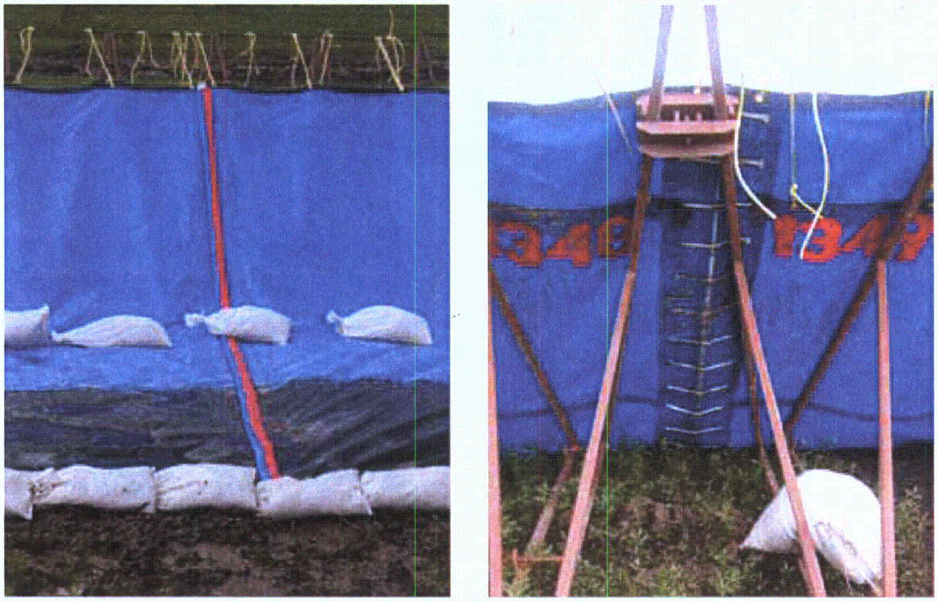


Figure 3-150. Seam between liner membrane sections

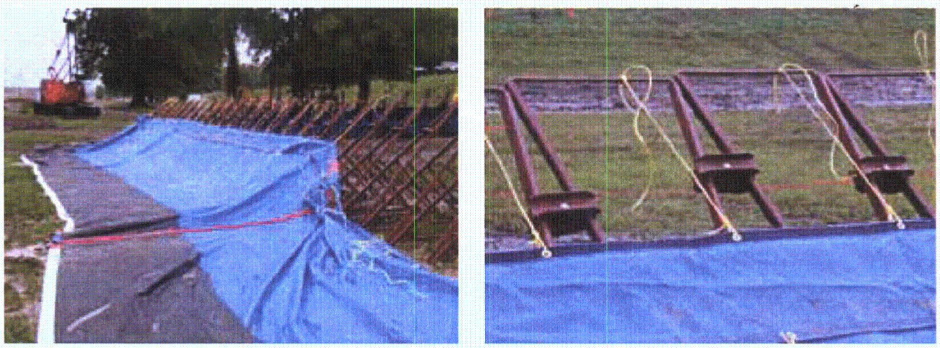


Figure 3-151. Liner membrane tied to support frame

Figure 3-152. Excavating trench for liner leading edge

Figure 3-153. Liner leading edge placed in trench

Figure 3-154. Burying liner leading edge

Figure 3-155. Placing sandbags on liner leading edge

On the morning of 13 May, work began on the required raise to hold back 4 ft of water. The weather that morning was sunny and humid. Since the raise only included pulling up the additional liner and tying it to the frame (Figure 3-156), the Portadam representative conducted the raise without the help of any of the government laborers. The Portadam representative completed the raise in 0.6 hr (0.6 man-hours). No equipment was used to make the raise. The total time (initial structure plus the 1-ft raise) to construct the Portadam structure was 5.1 hr (26.2 man-hours).

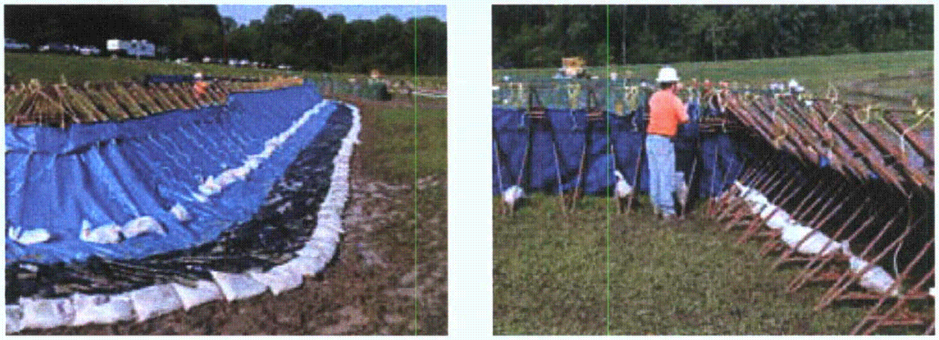


Figure 3-156. Required Portadam raise

The 5-ft Portadam frames have a 6-ft footprint. The liner membrane for the Vicksburg Harbor test extended approximately 9 ft beyond the frame for a total footprint of 15 ft. Approximately 5 ft of additional right of way beyond the 15-ft footprint was needed to construct the structure. Total right of way required was 20 ft. If constructed on top of a levee, approximately 10 ft of right of way would be needed since the supporting frame would be constructed on the levee crown and the liner membrane would be placed down the levee slope. Figure 3-157 shows the completed Portadam structure. In accordance with the construction protocol, the Portadam representative signed a certification that the structure was constructed according to his onsite directions and according to Portadam's installation specifications.

a. Riverward face

b. Protected side

Figure 3-157. Completed Portadam structure

Testing

The Portadam structure was constructed during May 2004 during a time when the river was receding. The river began to rise in early June, and by the morning of 5 June approximately 0.3 ft of water was standing against the Portadam structure. Figures 3-158 through 3-165 are a series of daily photos of the Portadam structure during the field testing. As the river continued to rise, the structure was subjected to greater static loadings. Daily water levels against the structures are given in figure captions. These water levels were determined from the 8 a.m. readings for the Mississippi River at the Vicksburg gage. Testing of the Portadam structure ended early on the morning of 11 June when the structure overtopped and flow over the structure exceeded the pump capacity on the protected side.

Figure 3-158. 4 June 2004, no water against structure

Figure 3-159. 5 June 2004, 0.3 ft of water against structure

Figure 3-160. 6 June 2004, 1.3 ft of water against structure

Figure 3-161. 7 June 2004, 2.1 ft of water against structure

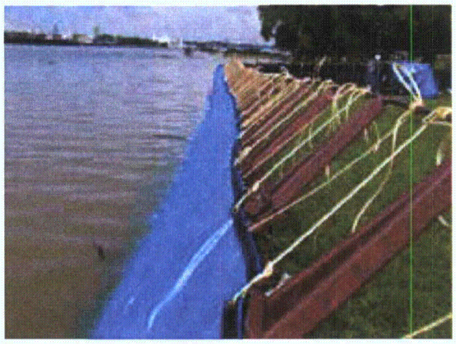


Figure 3-162. 8 June 2004, 2.7 ft of water against structure

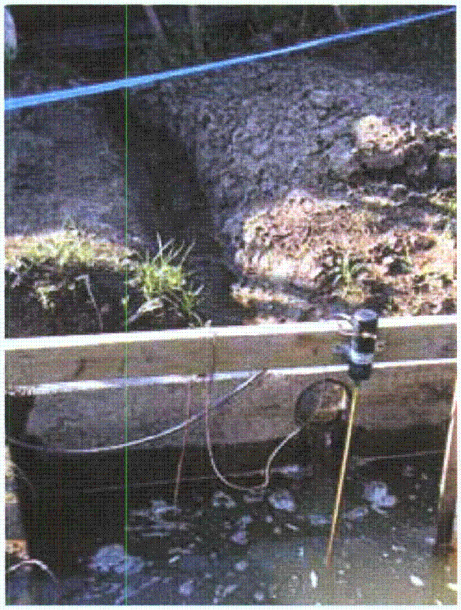
Figure 3-163. 9 June 2004, 3.1 ft of water against structure

Figure 3-164. 10 June 2004, 3.5 ft of water against structure

Figure 3-165. 11 June 2004, structure overtopped

During the field test, seepage was collected in a buried concrete tank. Seepage rates were determined by computing the change in volume in the tank over a specific time. Seepage began as soon as the river rose high enough to put water against the structure. As the water levels continued to rise, the structure experienced only limited increases in seepage. Figure 3-166 shows the Portadam structure seepage tank. The first photo was taken on 6 June 2004 with less than 1.5 ft of water against the structure. The second photo was taken on 10 June 2004with over 3.5 ft of water against the structure. These photographs indicate that the seepage was not significantly greater on 10 June than it was on 6 June. Table 3-10 shows the seepage rate for the Portadam structure, which only gradually increased as the water levels against the structure increased. At the time that the Portadam structure overtopped, its seepage rate was the lowest of the four structures.

a. 6 June 2004



b. 10 June 2004

Figure 3-166. Portadam seepage collection tank

Table 3-10 Field Test Seepage Rates – Portadam	
Wetted Surface Area of Structure (sq ft)	**Seepage Rate (gal/ hr)**
100	200
200	300
300	500
400	550
500	600
600	600

During testing, no major repairs were required to the Portadam structure. However, two minor repairs and one standard preparation for overtopping were made. The minor repairs consisted of removing slack in the top of the liner membrane where the membrane was sagging. At these two locations, water began to flow over the top of the liner membrane on 10 June 2004 (Figure 3-167). The first repair included folding the top of the liner over on top of itself and holding it in place with a pair of vice grip pliers (Figure 3-168). The second repair included clamping off in the northeast 90-degree turn a section of liner with two pieces of a wooden survey stake and two c clamps (Figure 3-169). These repairs allowed for a more uniform overtopping of the structure. At the request of the Portadam representative, government laborers made the typical overtopping preparation, which consisted of placing plastic sheeting on the ground along the overtopping impact zone. This sheeting reduces the potential for erosion around the supporting frame. Figure 3-170 is a photograph of the installed plastic sheeting.

Figure 3-167. Sagging liner

Figure 3-168. Sagging liner repair (repair 1)

Figure 3-169. Sagging liner repair (repair 2)

Figure 3-170. Typical preparation for overtopping (plastic sheeting)

As the river rose, the ground around the riverward face of the supporting frame became saturated. The weight of the water on the structure pushed the supporting frame into the saturated soil approximately 4 in. (Figure 3-171). The sinking of the supporting frame increased structural stability by reducing the potential of sliding but also reduced the height of the structure. Reducing the structure height resulted in a decreased level of protection. The weight of the water also applied a significant load on the liner, especially around the corners where excess liner is located and at the connection between the two sections of liner. Though stressed, no damage to the liner was observed. Figure 3-172 shows the excess liner sagging between the supporting frame members. Figure 3-173 shows the stress on the liner seam.

a. Unsunk frame along east tieback b. Sunk frame along riverward face

Figure 3-171. Reduced protection due to sinking of supporting frame

Figure 3-172. Sagging of liner between supporting frame members

Figure 3-173. Stressed liner seam

Early in the morning hours of 11 June 2004, the Portadam structure overtopped. By 5 a.m., the structure was overtopped at nine separate locations along the riverward face (Figure 3-174). Shortly thereafter, the pump capacity on the protected side of the structure was exceeded. At that point, the pump was removed and testing ended (Figure 3-175). Figure 3-176 is a photograph of the Portadam structure after the field testing had ended and the protected side had filled with water.

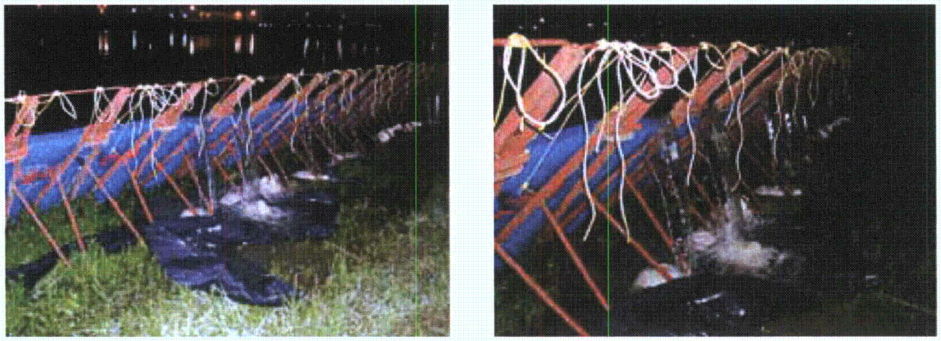


Figure 3-174. Overtopping of Portadam structure

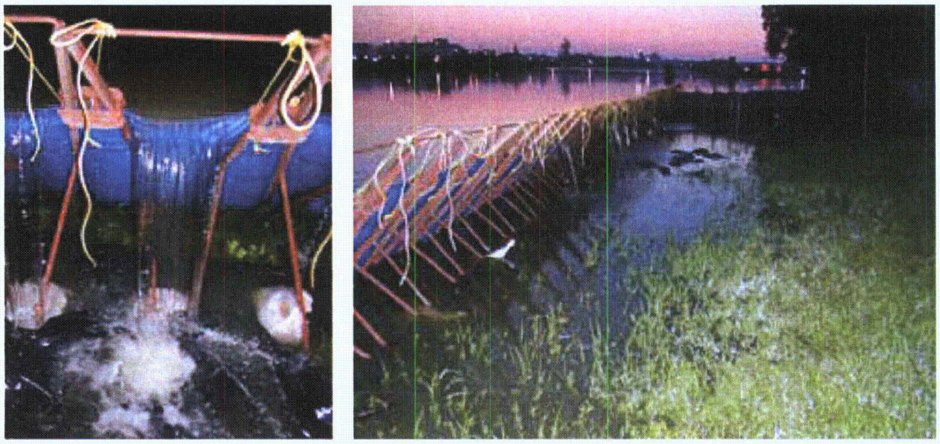


Figure 3-175. Testing complete

Figure 3-176. Portadam structure after protected side filled with water

Removal

The crew began removing the Portadam structure on the afternoon of 19 July 2004. The weather was hot and humid with a high heat index. Due to the extreme heat, the work crew took frequent breaks. Only the time that the crew was physically working to remove the structure was included in the removal time (the clock stopped during breaks). The removal was conducted by a representative from Portadam and six government laborers. However, only four of the six government laborers worked at any one time, to allow frequent breaks and avoid heat stress.

Figure 3-177 shows the Portadam structure after the highwater receded and prior to initiating removal. The liner membrane was untied from the supporting frame and the liner was pulled off the frame (Figure 3-178). Frame disassembly (Figure 3-179 and Figure 3-180) included using a ratchet and socket to remove the clamps and bolts that held the frame members together and removing the link bars from adjacent members. The hardware (bolts, clamps, and link bars) and the frame members were hand-carried (Figure 3-181) to the staging area where the hardware was placed in drums and the frame members were wire-banded together in groups of approximately 20 members (Figure 3-182). Once the frame was disassembled, the two sections of liner were disconnected (Figure 3-183). Sandbags were removed from the liner and liner sections were pulled from the excavated trench. The liner was initially used to pull the liner from the trench by the laborers (Figure 3-184). However, since the forklift was onsite to load the product onto the trailer for transport offsite, a rope was tied around the liner and used to pull the liner from the trench with the forklift (Figure 3-185). Once removed from the trench, the liner was folded (Figure 3-186), rolled (Figure 3-187), and placed on wooden pallets (Figure 3-188). The frame members, hardware drums, and liner were loaded by the forklift onto a trailer for transport offsite (Figure 3-189). By the end of the work day (19 July), the Portadam structure had been removed (Figure 3-190). On the morning of 20 July, the sandbags were removed from the site with a front-end loader and disposed. Figure 3-191 is a photograph of the Portadam site after removal was completed. The entire removal of the Portadam structure including discarding of the sandbags required only 2.9 hr (12.6 man-hours). The tools and equipment required to remove the Portadam structure included a ratchet and socket, wire banding tool, forklift, and a front-end loader. Once the structure was removed, the Portadam representative signed a certification that the structure was removed according to his direction and in accordance with Portadam's removal specifications.

Figure 3-177. Portadam structure prior to removal

Figure 3-178. Removing liner membrane from supporting frame

Figure 3-179. Disassembling supporting frame (bolts and clamps)

Figure 3-180. Disassembling supporting frame (members)

Figure 3-181. Carrying frame members to staging area

Figure 3-182. Removal staging area

Reusability

During the removal process, the hardware, supporting frame members, and the liner membrane were inspected for damage. No visible damage was observed. Therefore, the Portadam structure used for the field testing was certified as 100 percent reusable. In fact, Portadam has historically been a rental procuct. They typically reuse the supporting frame members, hardware, and the liner membrane many times. However, for expedient flood-fighting, Portadam does sell their product. The field testing results indicate that the Portadam product is durable and could be reasonably expected to be reused many times. The only cleaning required for the Portadam structure includes scraping the mud off the frame members and washing the liner membrane with fresh water to remove mud, dirt, and debris. Prior to storage, the liner should be allowed to completely dry. Should the liner be ripped or torn during use, Portadam does not have a patch that can be placed in the wet. Portadam recommends repairs in the wet include placing a sheet of plywood between the torn liner and the frame on the protected side and hanging sandbags from the frame down the river face of the liner to cover the holes. Once the water has receded and the liner has dried, Portadam has two different patches for holes. One patch is glued over holes in the portion of the impermeable liner that is in contact with the frame. The other patch is attached over holes in the fabric that is in contact with the ground beyond the frame. This patch is attached by needle and thread.

Figure 3-183. Disconnecting two sections of liner

Figure 3-184. Laborers removing liner from excavated trench

Figure 3-185. Forklift removing liner from excavated trench

Figure 3-186. Folding liner

Figure 3-187. Rolling folded liner

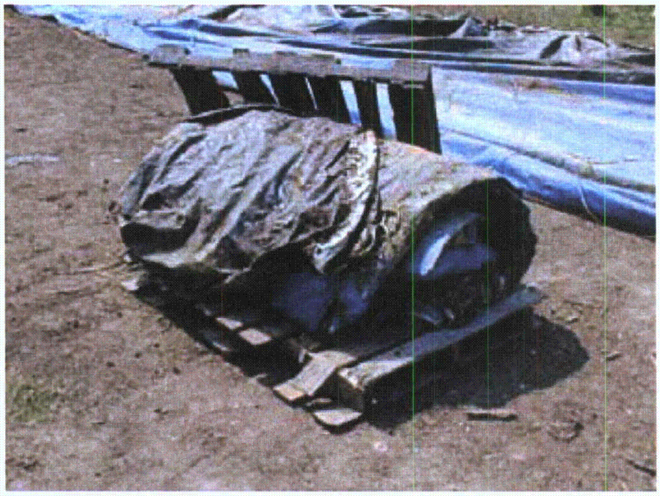


Figure 3-188. Liner placed on pallet

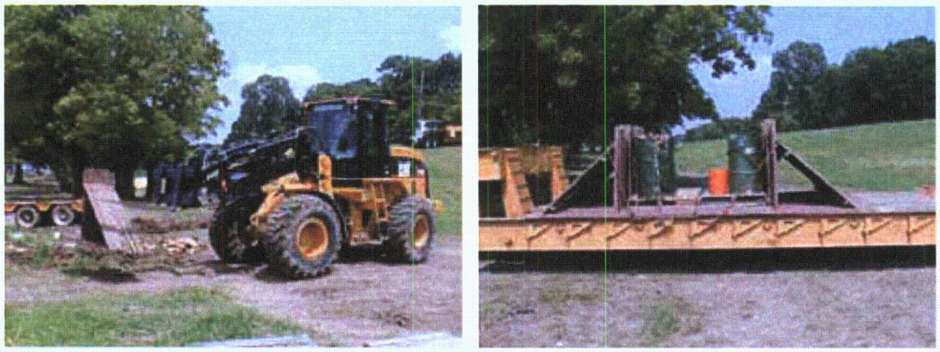


Figure 3-189. Loading Portadam frame members and hardware onto trailer

Figure 3-190. Portadam site with only sandbags remaining

Figure 3-191. Portadam site after removal complete

Summary

For the field testing, various construction, removal, and performance parameters were evaluated. Table 3-11 provides a summary for the field testing of the Portadam structure.

Even if a product performs well, the flood-fighting community is not likely to use the product unless it is cost-effective. In order to make a fair comparison of costs, each product vendor was asked to submit the cost of constructing and removing 1,000 lft of their product, 3 ft high in Vicksburg, MS. This cost included the purchase of the product plus fill material, labor, and equipment based on Vicksburg rates. The cost for shipping the products were not provided. For this cost determination, sand fill delivered to the site was estimated at $8 per cu yd. Labor rates were $8/hr for laborers and $12/hr for equipment operators. Table 3-12 provides a summary of the costs furnished by Portadam. Since Portadam includes a steel frame, its cost varies with changing steel prices. The cost contained in Table 3-12 is based on November 2004 steel prices. The Portadam units are reusable. However, Portadam does not provide a guarantee that would provide for no cost replacement of damaged product.

Table 3-11
Portadam Field Testing Summary

Item	Portadam
ROW Used (ft)	20
Footprint Width (ft)	15
Structure Length (ft) Riverward Face East Tieback West Tieback	 103 41 43
Ease of Construction Time (hr) Effort (man-hours) Manpower (no. men) Equipment	 5.1 26.2 5 Ratchet and socket Shovels Ditch witch
Fill (cu yd)	450 sandbags
Durability	The Portadam structure stayed in the field for 2 months and was subjected to hot, wet weather. The structure showed no signs of deterioration.
Varying Terrain	The field test site was relatively flat with a mild slope from the protected side of the Portadam structure to the riverward side.
Ease of Removal Time (hr) Effort (man-hours) Manpower (no. men) Equipment	 2.9 12.6 5 Ratchet and socket Banding tool Front end loader Forklift
Seepage (gal/hr) For 100 sq ft Wetted Area For 200 sq ft Wetted Area For 300 sq ft Wetted Area For 400 sq ft Wetted Area For 500 sq ft Wetted Area For 600 sq ft Wetted Area	 200 300 500 550 600 600
Repairs	All Minor – Structural integrity not threatened Raised sags in the liner
Reusability (percent)	100

Table 3-12
Costs For Portadam

Item	Portadam
Product	$71.30 per lft = $71,300
Shipping	No $ provided
Installation Laborers Operators Equipment Fill	 8 men for 8 hr = $512 None required Forklift and trenching machine Some sandbags
Removal Laborers Operators Equipment	 8 men for 8 hr = $512 None required Forklift
Training by vendor for installation and removal	No cost provided
Technical support during installation and removal	No cost provided

Based on the field testing, strengths and weaknesses of each product were observed. Portadam's strengths include ease of construction and removal (time, manpower, and equipment). The Portadam structure was installed much quicker and with a much smaller work force than the sandbag structure. Also, the Portadam structure was installed without the use of heavy machinery. For this field testing, the Portadam structure had low seepage rates. Being an impermeable liner with a supporting frame, Portadam required no fill except for sandbags used to help seal the leading edge of the liner and for added weight to limit wind impacts. The Portadam structure proved to have a high degree of reusability. After the field testing was completed, the Portadam structure was inspected and certified as 100 percent reusable. In fact, Portadam typically rents its product. As a rental product, the Portadam product is reused many times. Since no heavy machinery is required to construct a Portadam structure, only limited right of way is required. The weaknesses of the Portadam structure include that for a typical application, a Portadam structure cannot be raised. For the field testing, Portadam manufactured a special liner that could be tied off at 3 ft of protection and then a second flap could be pulled up and tied off for the required raise. In a typical Portadam application, the liner is pulled to the top of the supporting frame and secured there. Also, the Portadam product is not applicable for high wind use unless the structure will soon after construction have floodwater on it. A Portadam structure can also be anchored or additional weight can be applied to the structure as was the case for the field test. Sandbags were placed on the portion of the liner that extended beyond the frame and on the frame members to limit wind impacts.

4 Summary and Conclusions

Summary

Congress has recognized the need for expedient, temporary barrier type flood-fighting technologies. During 2004, Congress directed the Corps to devise real-world testing procedures for Rapid Deployment Flood Wall (RDFW) and other promising alternative flood-fighting technologies. In response, ERDC developed a comprehensive laboratory and field-testing program for the scientific evaluation of RDFW and two other alternative flood-fighting technologies. The alternative technologies, Portadam and Hesco Bastion Concertainers, were selected through a competitive process based on technical merit. A sandbag structure was also tested in both the laboratory and the field to provide a baseline by which the other products could be evaluated.

The Flood-Fighting Structures Demonstration and Evaluation Program (FFSDEP), leveraged with GI R&D research programs, provided for the modification of an existing wave test basin into a world-class test facility for the evaluation of flood-fighting products at prototype scale. A standardized protocol was developed to allow temporary flood-fighting barriers to be evaluated under a set of carefully controlled, repeatable conditions that simulate real-world conditions. During the spring and summer of 2004, the four structures were tested consecutively under identical conditions. Each product was subjected to hydrostatic testing, hydrodynamic testing with waves and overtopping, and structural debris impact testing. Also laboratory setting operational parameters including time, manpower, and equipment to construct and disassemble, suitability for construction and disassembly by unskilled labor, fill requirements, ability to construct around corners, disposal of fill material, damage, repair, reusability, and performance on a finished concrete surface were evaluated.

During May–July 2004, the field-testing was conducted in Vicksburg, MS, at the Vicksburg Harbor. The selected field site offered several advantages. The site is impacted by backwater from the Mississippi River and therefore, had a good chance of being exposed to high water during the spring and early summer. The site was located on property owned by the Vicksburg District which made the site secure with no public access. Also, the site was located adjacent to the Vicksburg District's Mat Sinking Unit and Dredge Jadwin, which provided the required work force and heavy machinery. Protocols were developed for the field tests to include construction, testing, and removal. The protocol for the field testing included performance parameters including hydrostatic testing and hydrodynamic testing (overtopping). The field testing also included the same operational parameters that were evaluated for the laboratory testing but also included footprint and right of way requirements, durability, adaptability to varying terrain, performance on various surfaces including freshly graded and natural vegetation (grass and weeds) and ability to be raised.

Laboratory and field testing summary

For the lab and field testing, various construction, removal, and performance parameters were evaluated. Table 4-1 provides a summary of the laboratory testing. Table 4-2 provides a summary for the field testing.

Costs

Even if a product performs well, the flood-fighting community is not likely to use the product unless it is cost-effective. In order to make a fair comparison of costs, each product vendor was asked to submit the cost of constructing and removing 1,000 lft of their product, 3 ft high in Vicksburg, MS. This cost includes the purchase of the product plus fill material, labor, and equipment based on Vicksburg rates. The cost for shipping the products were not provided. For this cost determination, sand fill delivered to the site was estimated at $8/cu yd. Labor rates were $8/hr for laborers and $12/hr for equipment operators. Table 4-3 provides a summary of the costs. As shown in Table 4-3, the cost for purchase of the product is far and away the primary cost in using the products. The fill material, labor, and equipment rental costs are small compared to the purchase cost of the products.

The costs contained in Table 4-3 for the sandbag structure were based on several assumptions. Those assumptions include a structure section that is 13 bags wide at the base and 2 bags wide at the crest, each sandbag adds 3 in. of height and 9 in. of length to the structure, the cost of each sandbag is $0.25, the required volume of sand was increased by 20 percent to account for waste and spillage during filling, and the sandbag structure would be built by volunteer labor (no labor cost for construction). Since a sandbag structure is labor intensive, the cost of constructing a sandbag structure would be greatly increased if cost was included for construction of the structure.

The cost for the Portadam product varies with changing steel prices. The cost contained in Table 4-3 is based on the November 2004 steel prices for a 3-ft-high frame. While both Portadam and Hesco Bastion products have proved to be reusable, neither company provides a guarantee that would provide for no cost replacement of damaged product.

The costs provided in Table 4-3 for RDFW are based on its first time use. At the time we asked the vendors for price quotes, Geocell guaranteed the RDFW product for three uses. Therefore, Geocell also provided the expected costs for two subsequent uses. Since the product is reusable, the second and third uses did not include any cost for purchase of the product. However, Geocell Systems did include a recertification fee that was equal to 10 percent of the initial purchase price. This fee provided for Geocell to inspect and certify that each unit was reusable. All unusable pieces were replaced at no additional cost. Since the purchase price for the RDFW full size units was $137,750, Geocell Systems would have charged $13,775 to inspect and replace damaged pieces prior to the second and third uses. Since that time, Geocell no longer guarantees the RDFW product for reuse. Geocell has no control over the amount of care in the installation and removal and over the type fill material used. Therefore, Geocell has decided to no longer guarantee the product for reuse. However, Geocell continues to claim and the laboratory and field testing prove that with proper care in the installation and removal, much of the product can be reused at least once.

During January 2005, the Corps purchased approximately 5,000 lft of each of the three tested products. These quantities were distributed to three host Districts. Those Districts were Philadelphia, Omaha, and Sacramento. This product was used for additional field testing (pilot testing) with the remainder being stored for use during real floods by any Corps District in the host Districts' geographical region that chooses to use the products. The product costs as provided in Table 4-3 were for 3-ft-high structures. The products purchased in 2005 were for 4-ft-high structures. Furnished here is the cost for the purchased products. Three hundred thirty-six of the 4-ft-high Hesco Bastion units were purchased. Each unit was 4 ft high x 3 ft wide x 15 ft long and costs $488. The total cost of the Hesco Bastion product was $163,968 or $32.53 per lft as compared to the $26.27 vendor furnished cost for the 3-ft-high units. For Portadam, 4-ft-high frames, liner, and hardware were purchased at a total cost of $473,595. The cost per lft was $94.72 as compared to the vendor furnished cost of $71.30 for the 3-ft high frames. For the RDFW, 8,700 units were purchased at a cost of $95 per unit. The total cost of the RDFW was $826,500 or $162.86 per lft for a 4-ft-high structure as compared to the vendor furnished cost of $135.71 for a 3-ft-high structure.

Table 4-1
Laboratory Test Summary

Item	Portadam	Hesco Bastion	Sandbags	RDFW
ROW used (ft) Restricted by the facility size only	n/a	n/a	n/a	n/a
Footprint Width (ft)	6 (frame)	3	10	6
Apron Width (ft)	17	n/a	n/a	n/a
Structure Length (ft)				
Center-line Length	68.5	71.5	80.8	73.4
Ease of Construction				
Time (hr)	4.8	3.5	11.5	5.5
Effort (man-hours)	24.4	20.8	205.1	32.8
Manpower (no. men)	5 to 6	6	17 + 2 part time	6
Equipment	Ratchet and Socket Shovels	Shovels 916 Cat© Front End Loader	Sandbagger Shovels Bobcat	Shovels 2 Bobcat Loaders
Sand Fill (cu yd)	250 sandbags	25	52.3	35
Durability	All products stayed in the laboratory during construction and testing with no direct sunlight and subjected only to the ambient temperature of the steel building. No deterioration was noted.			
Varying Terrain	The laboratory test products were all built on a flat surface (finished concrete floor) along the entire length of the structures.			
Ease of Removal				
Time (hr)	1.1	2.7	4.5	7
Effort (man-hours)	4.4	13.4	9	42
Manpower (no. men)	4	5	2	6
Equipment	Ratchet and Socket Banding Tool Forklift	Shovels Brooms Pin Removal Bar 916 Cat© Front-end Loader	916 Cat© Front End Loader Broom and Shovel	2 Shop Vacuums 2 Sharp Shooter Shovels 3 Small Folding Shovels Bobcat
Seepage-Static Head Test	Seepage (Gallons per Minute per Foot of Structure)			
1-ft water elevation	.095	.390	.047	.021
2-ft water elevation	.135	.935	.230	.076
90 and 95 percent structure height	.140	1.81	.535	.096
Seepage - Dynamic Tests 66 percent Structure height water elevation	Seepage (Gallons per Minute per Foot of Structure)			
2-in. wave height	.087	.820	.260	.038
7-in. wave height	.090	.775	.275	.042
11-in. wave height	.36	.98	3.09	.360

(Continued)

Table 4-1 (Concluded)				
Item	**Portadam**	**Hesco Bastion**	**Sandbags**	**RDFW**
Seepage - Dynamic Tests 80 percent Structure height water elevation	Seepage (Gallons per Minute per Foot of Structure)			
2-in. wave height	.124	1.04	.390	.043
7-in. wave height	10.72	1.07	7.42	4.48
11-in. wave height	20.43	3.14	17.52	8.85
Overtopping	Maximum Flow Over Structure + Seepage (Gallons / Minute)			
	Undulating elevation along structure 5500	~ Constant elevation along structure 2500	Undulating elevation along structure 7760	~ Constant elevation along structure 2400
Damage - Overtopping	No damage Tested 1 hour	No damage Tested 1 hour	Failed > 5 min. into test	No damage Tested 1 hour
Damage - Log Impact	Vinyl Tarp Puncture	No Damage	No Damage	No Damage
Structural Damage During Installation, Testing, and Removal	-Impermeable liner torn during debris impact	-Minor sand settling & washout -Some wire bending during debris impact	-Repeatedly damaged by waves -Failed during overtopping	-Minor sand settling - Significant washout along edges and toe -Toe damage during large waves or overtopping -10% of structure broken
Material Hazard	None	None	None	None
Repairs Minor (M) Not Threatened Failure Concern (FC) Structural Integrity	M Raise Liner bags	M Add Sandbags Place cover over the top	FC Add and Restack Sandbags	M Add Sand
Reusability (percent)	>99	> 99	0 – All Disposed	90

Table 4-2
Field Test Summary

Item	Portadam	Hesco Bastion	Sandbags	RDFW
ROW Used (ft)	20	25	25	22
Footprint Width (ft)	15 (frame + liner)	4 (bulge in 3-foot-wide units)	12	6 (4-foot- wide units + 2-ft-wide half units)
Structure Length (ft)				
Riverward Face	103	98	101	101
East Tieback	41	48	32	42
West Tieback	43	48	30	46
Ease of Construction				
Time (hr)	5.1	8.9	30.5	7.5
Effort (man-hours)	26.2	57.5	453.1	48.4
Manpower (no. men)	5	7	Up to 20 (fill) Up to 27 (place)	7
Equipment	Ratchet and Socket Shovels Ditch Witch	Shovels 2 Bobcat Loaders	Sandbagger Shovels Bulldozer Flat Bed Trailer	Shovels 2 Bobcat Loaders
Fill (cu yd)	450 sandbags	91	132	85
Durability	All products stayed in the field for 2 months and subjected to hot, wet weather. Only the sandbag structure showed any deterioration (bags not to specs).			
Varying Terrain	The field test site was relatively flat with a mild slope from the protected side of each structure to the riverward side.			
Ease of Removal				
Time (hr)	2.9	8.7	2.6	17.3
Effort (man-hours)	12.6	36.3	3.5	113.4
Manpower (no. men)	5	6	2	Up to 10
Equipment	Ratchet and Socket Banding Tool Front- End Loader Forklift	Shovels Pin Removal Bar Front-End Loader Forklift	Front-End Loader Bulldozer	Hand-Held Vacuums Air Compressor Shovels Pumps with fire hose Vacuum Truck Track Hoe Front-End Loader Forklift
Seepage (gal/hr)				
For 100 sq ft Wetted Area	200	300	0	50
For 200 sq ft Wetted Area	300	2,300	0	200
For 300 sq ft Wetted Area	500	3,900	50	700
For 400 sq ft Wetted Area	550	6,000	300	900
For 500 sq ft Wetted Area	600	---	800	1,500
For 600 sq ft Wetted Area	600	---	3,200	---
Repairs	All Minor – Structural Integrity Not Threatened			
	Raise Liner Sags	Seal Joints	Add Plastic Sheeting	Add Sand
Reusability (percent)	100	> 95	0 – All Disposed	> 90

Table 4-3 **Cost for Flood-Fighting Products**				
Item	**Portadam**	**Hesco Bastion**	**Sandbags**	**RDFW**
Product	$71.30 per linear foot for 3' high frames, liner, and hardware = $71,300	67 3'x3'x15' units at $394 / unit = $26,398	$0.25 per bag for 120,000 bags = $30,000	1450 4'x4'x8" units at $95/unit = $137,750 290 4'x2'x8" units at $47.50/unit = $13,775
Total Product	$71,300	$26,398	$30,000	$151,525
		Installation		
Shipping	No $ Provided	No $ Provided		No $ Provided
Laborers	8 men for 8 hr = $512	6 men for 20 hr = $960	Built by volunteer labor = $0	50 man- hours = $400
Operators	None required	2 men for 20 hr = $480	1 man for 40 hr = $480	9 man-hours = $108
Equipment	Forklift and Trenching Machine	2 loaders for 2 days = $1,300	Sandbagger provided by COE	2 loader days = $650
Fill	Some sandbags	425 cu yd = $3,400	800 cu yd = $6,400	548 cu yd = $4,384
		Removal		
Laborers	8 men for 8 hr = $512	6 men for 20 hr = $960	None required	100 man-hours = $800
Operators		2 men for 20 hr = $480	3 men for 8 hr = $288	18 man-hours = $216
Equipment	Forklift	2 loaders for 2 days = $1,300	2 loaders for 1 day = $650 2 dump trucks for 1 day = $650	4 loader days = $1,300 Hand tools - $200
		Training and Technical Support		
Training by vendor for installation and removal	No $ Provided	No charge for initial installation	By COE or Local Sponsor Volunteers	For initial installation only = $10,433
Technical support during installation and removal	No $ Provided	No charge for initial installation	By COE or Local Sponsor Volunteers	Per Installation = $23,987

Conclusions

Based on the laboratory and field testing, strengths and weaknesses of each product relative to the sandbag structure and each other were observed. The strengths of a sandbag structure include low product cost. Sandbags also conform well to varying terrain. In both the laboratory and field tests, the sandbag structure had low seepage rates. Also, sandbag structures can be raised if needed by simply placing additional sandbags. The weaknesses of a sandbag structure are that they are labor intensive and time consuming to construct. Also, sandbags are not reusable. During the laboratory testing, the sandbag structure was damaged during the wave impact tests and failed during the overtopping tests. The sandbags began to deteriorate during the field tests.

Portadam's strengths include ease of construction and removal (time, manpower, and equipment). The Portadam structures were constructed in less time and with a much smaller labor force than the sandbag structures. Also, the Portadam structure was constructed without the use of heavy machinery. The Portadam structure proved easy to remove. The Portadam structure had low seepage rates in both the laboratory and field tests. Portadam structures require no fill except for some sandbags that are used to help seal the leading edge of the membrane liner and to add weight to prevent wind damage. Portadam structures have a high degree of reusability. For the field test, the Portadam structure was 100 percent reusable. Since no heavy machinery is required to construct a Portadam structure, only limited right of way is required. However, Portadam does have the largest footprint of the products tested. Portadam's weaknesses include that the membrane liner punctured during the laboratory debris impact tests, a Portadam structure can't be raised in a typical application, and a Portadam structure may not be applicable for high wind use unless the structure is anchored or weighted with sandbags.

Hesco Bastion's strengths include ease of construction and removal for both time and manpower. The Hesco Bastion structures were constructed much faster and with much less labor force than the sandbag structures. The Hesco Bastion product is low cost, and a Hesco Bastion structure can be raised if required by placing a second row of units to the top of the structure. Stability can become an issue for increased height due to the narrow width of the Hesco units. If stability is an issue, a pyramid structure (two units wide on bottom row topped with a single row of units) should be constructed. Hesco Bastion units proved to have a high degree of reusability. During the laboratory and field testing, the Hesco Bastion structures suffered only minimal damage. The weaknesses of the Hesco Bastion product include the need for significant right of way due to the addition of granular fill with machinery perpendicular to the structure and high seepage rates. Since completion of the testing, Hesco Bastion has evaluated their high seepage rates. Their evaluation concluded that in both the laboratory and field testing, the Hesco Bastion units were installed incorrectly. If installed correctly, the seepage rates for a Hesco Bastion structure would be expected to be reduced.

RDFW's strengths include ease of construction for both time and manpower. In both the laboratory and field testing, the RDFW structures were constructed much faster and with a much smaller labor force than the sandbag structures. Additional strengths of the RDFW structures included low seepage rates, high degree of reusability, a RDFW structure can be raised as needed by placing additional rows of units to an existing structure, and since the RDFW units are 8 in. high, an RDFW structure provides various height options. For instance, if a user purchased a quantity of RDFW to construct a 4-ft high flood-fighting structure 1,000 ft long and in a particular flood only needed a 2-ft-high structure, then this user would have sufficient product to construct a 2,000-ft-long structure. RDFW's weaknesses include significant right of way required due to the placement of granular fill with machinery perpendicular to the structure, high cost of the product, and in both the laboratory and field testing, the RDFW structures were difficult and time consuming to remove. Since the laboratory and field testing were completed, Geocell Systems has been working to develop more efficient methods of removing the units. They have conducted tests at their office with the use of a suction trailer for extracting sand. Also, Geocell Systems has developed a "grappler" lifting device to assist with the removal of the units. This grappler consists of standard pallet pullers attached to a pipe frame. The grappler is connected to two adjacent RDFW units and is lifted with a bucket on a front-end loader. If the grappler lifting devices prove effective, Geocell Systems plans to make these devices available to RDFW users to assist in the removal process.

Both the laboratory and field testing show conclusively that a Portadam, Hesco Bastion, and RDFW structure can be constructed much faster and with much less labor force than a comparable sandbag structure. All three products performed well for most all of the testing parameters. A potential user should closely evaluate the laboratory and field testing data to determine which product or products will best meet his temporary, barrier style flood-fighting needs. The laboratory and field testing information has been placed on a publicly accessible Web site. That Web site address is http://chl.erdc.usace.army.mil/ffs.

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Appendix A
Congressional Mandate and Appropriation

MAKING APPROPRIATIONS FOR ENERGY AND WATER DEVELOPMENT FOR THE FISCAL YEAR ENDING SEPTEMBER 30, 2004, AND FOR OTHER PURPOSES

CONFERENCE REPORT

TITLE I

DEPARTMENT OF DEFENSE—CIVIL
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS—CIVIL

FLOOD CONTROL AND COASTAL EMERGENCIES

In light of the recent replenishment of the Flood Control and Coastal Emergencies reserve fund, the conferees have provided no additional funds for this account. The recent depletion of this account, however, calls attention to two areas of concern about how this account is funded and administered. First, the drawing down of funds which could have been used to respond to actual emergency events to meet routine administrative and readiness expenses suggests that the Nation would be better served if response and readiness funds were provided and administered separately.

Second, justification provided by the Corps of Engineers suggests that those administrative and readiness expenses have grown to unacceptable levels. The Secretary is directed to consider changes in the separate management of these funds, and to report to the Appropriations Committees of the House and Senate within 180 days of enactment of this legislation into law.

The Nation deserves the best, most reliable, most economical tools which technology can provide for the protection of its citizenry and their property when confronted with natural disaster. The conferees are aware of the preliminary testing of the Rapid Deployment Flood Wall at the Engineering Research and Development Center in Vicksburg, Mississippi. This technology has shown promise in the effort to fight floods. Its proponent's claim and preliminary tests tend to confirm, that it can be cost-effective, quick to deploy, and superior to traditional sandbags in protecting property from flood damages totaling millions in dollars each year. The conferees therefore direct the Corps of Engineers, within funds available in the Flood Control and Coastal Emergencies account, to act immediately to devise real world testing procedures for this and other promising alternative flood fighting technologies, and to provide a status report to the Committees on Appropriations with 180 days of enactment of this legislation.

Appendix B
Project Management Plan

Executive Summary

Project Management Plan for Flood Fighting Structures Demonstration and Evaluation Program

Through the General Investigation Research and Development (GI R&D) Program, the U.S. Army Corps of Engineers (USACE), Engineer Research and Development Center (ERDC) has been conducting research and developing a procedure for the prototype testing of temporary flood-fighting structures intended to increase levels of protection during floods. The Rapid Deployment Flood Wall (RDFW) is one commercial product example of this type of structure. Per direction from Congress in the Energy and Water Development Bill for 2004, "*The conferees therefore direct the Corps of Engineers, within funds available in the Flood Control and Coastal Emergencies account, to act immediately to devise real world testing procedures for this and other promising alternative flood fighting technologies, and to provide a status report to the Committees on Appropriations with 180 days of enactment of this legislation.*"

A wave research basin at ERDC has been modified specifically for testing of temporary, barrier-type, flood-fighting products. Modifications to the wave basin were sponsored by GI R&D through the Technologies and Operational Innovations for Urban Watershed Networks (TOWNS) Program. GI R&D funding has also been used to develop a draft standardized protocol for prototype-scale, laboratory testing of temporary flood fighting products, although this protocol has not yet been tested. This standardized testing protocol includes both laboratory setting operational parameters (man-hours to construct and disassemble, equipment required, suitability for unskilled labor, fill requirements, ability to construct around corners, disposal of fill material), and performance parameters (hydrostatic testing, hydrodynamic testing with waves and overtopping, and structural impact testing with a floating log). A standard sandbag flood barrier will be tested through GI R&D sponsorship using the protocol to develop baseline data to which data from other types of structures may be compared.

After the baseline sandbag data has been collected in the research basin (laboratory), the current project proposes that the RDFW and two "other promising alternative flood-fighting technologies" be tested in the same facility using the standard test protocol and compared to the sandbag flood barrier baseline results. Concurrent with the research basin tests, a sandbag barrier, the RDFW, and the two alternative technologies will be tested in the field at a selected site in the Vicksburg, MS, area. The Product Delivery

Team (PDT) will approve the final selection of the field test site. Field activity will allow full-scale, real world, assessment of operational concerns such as construction of the structure on uneven or sloping ground, end effects or tiebacks, and undercutting.

The two alternate technologies to be tested will be selected from proposals received from an advertisement in the FedBizOpps Web page. Final selection of the two alternate technologies will be made by the evaluation team and then approved by the PDT based on selection criteria developed prior to placing the advertisement. The PDT includes ERDC, USACE Headquarters, Emergency Management personnel, and other representatives of the flood-fighting community from USACE District offices and levee boards. In addition to evaluation of the RDFW and two other technologies, these tests will allow an evaluation by field experts and input and advancement of the standardized testing protocol to insure that the protocol provides the best possible information to the field.

For both the laboratory and field testing, quantifiable operational data such as man-hours for construction and disassembly, special equipment requirements, and quantity of fill material will be recorded. Representatives on the PDT will evaluate the test structures for qualitative operational factors such as suitability for construction by unskilled labor, suitability for construction on sloping or uneven ground, susceptibility to end effects or undercutting, long-term durability and repairability, and reasonableness of special equipment or materials when considering use at a remote location. Susceptibility of construction materials to puncture or tear, and ability to make in-field repairs will also be considered. The ability to increase structure height by one additional foot after its initial construction will be evaluated at the field test site only. Disposal, reusability, and storage requirements of the structure and material will also be evaluated, and any previous real-world experience with the technology will be documented. This level of evaluation goes beyond the GI R&D developed protocol, but is required in order to address the "...real world testing procedures..." requirement contained within the Congressional directive.

Results of all tests will be posted on a publicly accessible Web site developed through the GI R&D program. The research basin and field tests will be conducted in FY04 at an estimated cost of $481,500 for the research basin (laboratory) tests, $870,500 for the field tests, plus $123,500 for planning, coordination, and management shared by both the laboratory and field testing. An additional $75,000 will be required for vendor reimbursement of the RDFW and the two other selected technologies. The total estimated costs of the laboratory and field test is $1,550,500.

Point of Contact

Questions regarding the attached Project Management Plan and Standardized Testing Protocol may be directed to Dr. Donald Ward, CEERD-HC-PS, 601-634-2092, FAX 601-634-3433, e-mail Donald.L.Ward@erdc.usace.army.mil, or Dr. Johannes Wibowo, CEERD-GS-E, 601-634-4129, e-mail: Johannes.L.Wibowo@erdc.usace.army.mil. For information concerning the field tests, questions should be directed to Mr. George Sills, CEERD-GS-E, 601-634-3165, e-mail: George.L.Sills@erdc.usace.army.mil, or Mr. Fred Pinkard, CEERD-HC-R, 601-634-3086, e-mail: Fred.Pinkard@erdc.usace.army.mil.

Project Authority: Through the General Investigation Research and Development (GI R&D) Program, the U.S. Army Corps of Engineers (USACE), Engineer Research and Development Center (ERDC) has been conducting research and developing a procedure for the prototype testing of temporary barrier type flood-fighting structures intended to increase levels of protection during floods. The Rapid Deployment Flood Wall (RDFW) is one commercial product example of this type of structure. Per direction from Congress in the Energy and Water Development Bill for 2004,

"The Nation deserves the best, most reliable, most economical tools which technology can provide for the protection of its citizenry and their property when confronted with natural disaster. The conferees are aware of the preliminary testing of the Rapid Deployment Flood Wall at the Engineering Research and Development Center in Vicksburg, Mississippi. This technology has shown promise in the effort to fight floods. Its proponent's claim, and preliminary tests tend to confirm, that it can be cost-effective, quick to deploy, and superior to traditional sandbags in protecting property from flood damages totaling millions in dollars each year. The conferees therefore direct the Corps of Engineers, within funds available in the Flood Control and Coastal Emergencies account, to act immediately to devise real world testing procedures for this and other promising alternative flood-fighting technologies, and to provide a status report to the Committees on Appropriations with 180 days of enactment of this legislation." (See Attachment 1)

Project Description: A wave research basin at ERDC has been modified specifically for testing of temporary, barrier style, flood-fighting products. Modifications to the wave basin were sponsored by GI R&D through the Technologies and Operational Innovations for Urban Watershed Networks (TOWNS) Program. GI R&D funding has also been used to develop a draft standardized protocol for prototype-scale, laboratory testing of temporary barrier-type flood-fighting products, although the protocol has not yet been tested. This standardized testing protocol includes both performance parameters (hydrostatic testing, hydrodynamic testing with waves and overtopping, and structural impact testing with a floating log) and laboratory setting operational parameters.

For both the laboratory and field testing, quantifiable operational data such as man-hours for construction and disassembly, special equipment requirements, and quantity of fill material will be recorded. Representatives from the PDT will evaluate the test structures for qualitative operational factors such as suitability for construction by unskilled labor, suitability for construction on sloping or uneven ground, susceptibility to end effects or undercutting, long-term durability and repairability, and reasonableness of special equipment or materials when considering use at a remote location. Susceptibility of construction materials to puncture or tear, and ability to make in-field repairs will be evaluated. The ability to increase structure height by one additional foot after its initial construction will be evaluated at the field test site only. Disposal, reusability, and storage requirements of the structure and material will also be evaluated, and any previous real-world experience with the technology will be documented. This level of evaluation goes beyond the GI R&D developed protocol, but is required in order to address the "...real world testing procedures..." requirement contained within the congressional directive.

A standard sandbag flood barrier will be tested in the research basin through GI R&D sponsorship using a modified standard test protocol to develop baseline data to which data from other types of structures may be compared. The modification to the standard test protocol includes changes to the structure alignment to allow testing of oblique angles with the wave generator.

After the baseline sandbag data have been collected in the research basin, the current project proposes testing the RDFW and two "other promising alternative flood-fighting technologies" in the same facility using the modified standard test protocol and compared to the sandbag flood barrier baseline results. Results of all laboratory tests will be posted on a publicly accessible Web site developed through the GI R&D program, along with information on man-hours and special equipment required to construct and disassemble the flood-fighting structure, and reusability of the materials. These tests will not only evaluate the RDFW and the two other selected technologies but will allow an evaluation by field experts and input to the standardized testing protocol to insure the protocol provides the best information possible for field application.

Concurrent with the research basin experiments, the RDFW, the two other technologies, and a sandbag barrier will be constructed on a field site at Vicksburg, MS, where conditions representative of real-world conditions are expected. The four technologies will be tested at the field site concurrently. Results of the field testing will also be posted on a publicly assessable Web site. The field activity will allow a complete assessment of operational concerns such as construction of the structure on uneven or sloping ground, end effects or tiebacks, and undercutting.

To select the two "other promising alternative technologies," an advertisement will be placed in the FedBizOpps Web page seeking proposals for products to be tested. Selection criteria will be prepared prior to placing the advertisement. Final selection of the alternative technologies will be made by the evaluation team and then approved by the study Project Delivery Team (PDT) based on selection criteria developed prior to placing the advertisement. The PDT includes members of ERDC, USACE Headquarters (HQUSACE), Emergency Management (EM) personnel, and other representatives of the flood-fighting community from USACE District offices and levee boards.

Coordination with Corps Districts: Geocell Systems, the manufacturer of RDFW, has provided a list of Corps Districts with which they have had contact concerning the use of their product. To better understand the Corps involvement with RDFW and to insure that our proposed field testing plans and site are as fair as possible to all vendors and is reasonably representative of conditions typically encountered in Corps flood-fight efforts, these Districts were contacted. The Districts include St. Paul, Nashville, Seattle, Portland, Sacramento, Los Angeles, Philadelphia, and Little Rock. Responses from the Districts varied as to their contact with Geocell. The contacts range from telephone conversations, to formal presentations, to product demonstrations, to the purchasing of RDFW, to actual installation of a section of RDFW in a flood-fight effort. Most Districts resisted purchasing or using the product to prevent the perception that the Corps of Engineers was endorsing the RDFW. Some of the Districts recommended to Geocell Systems local entities to contact about demonstrations and use of the RDFW. All the contacted Districts were interested in the proposed laboratory and field testing plans. The Districts realize that no one site will include all of the conditions (flow, duration of floods, soils, right of way limits, weather, availability of equipment and materials, etc.) that every District could encounter in a real-world flood fight. However, the contacted Districts generally concurred that the field testing plan is fair and reasonable. The Districts also concurred that the Vicksburg, MS, site is reasonably representative of real-world flood-fight conditions typically experienced by the Corps of Engineers.

Congressional Interest: Rep. Jo Ann Emerson, MO
Rep. Kenny Hulhof, MO
Rep Todd Akin, MO
Rep. Sam Graves, MO
Rep. John T. Doolittle, CA
Rep. John Shimkus, IL
Rep. Jerry Costello, IL

Rep. Tom Latham, IA
Rep. Marion Berry, AR

Sponsor: USACE Flood Control and Coastal Emergency (FCCE) Program with leveraging from the GI R&D sponsored technical team and vendor funding of vendor's costs.

Project Delivery Team (PDT): The PDT serve for both laboratory and field testing and will include the Technical Director, Program Manager, co-Principal Investigators (PI's), engineering support staff, and ERDC representatives from Office of Counsel, Resource Management Office, and Contract Office. In addition, the PDT will include advisors from the USACE Districts including the GI R&D Program Product Selection Committee, EM personnel assigned by Headquarters, USACE (HQUSACE), and local sponsor representatives as recommended by District PDT participants (Table B1).

Scope of Project: ERDC has been directed by HQUSACE, CECW-HS to "act immediately to devise real-world testing procedures for this (note: RDFW) and other promising alternative flood-fighting technologies."

Research Basin (Laboratory) Testing. A test facility is available for testing a variety of flood-fighting structures at prototype scale, and a standard test protocol representing real-world flood levels and forces including impacts by waves and debris has been developed, but not yet tested.

The scope of work for the existing project is contingent upon completion of tests on a sandbag structure through the GI R&D's TOWNS program. Testing of the protocol and accumulation of baseline information (both operational criteria and performance parameters) from the sandbag tests are critical for the project described herein. The sandbag tests must be completed prior to testing the RDFW.

Table B1
Project Delivery Team

Title	Name and Affiliation
Technical Director	Ms. Joan Pope
Program Manager(s)	Dr. Kathleen White (CEERD-HC-T) Dr. Jack E. Davis, (CEERD-HC-T)
Principal Investigators (Laboratory)	Dr. Donald Ward, CEERD-HC-PS Dr. Johannes Wibowo (CEERD-GS-E)
Principal Investigators (Field)	Mr. Fred Pinkard (CEERD-HC-R) Mr. George Sills (CEERD-GS-E)
Geotechnical Engineer	Mr. Perry A. Taylor (CEERD-GEEB)
Hydraulic Engineering Technician	Mr. Thomas Murphy)CEERD-HC-PS)
Instrumentation Support Engineer	Mr. Thad Pratt (CEERD-HC-EM)
Information Technical Specialist	Mr. Terry Jobe, (CEERD-GM-A)
Environmental Engineer	Mr. Mike Channel (CEERD-EP-E)
ERDC Office of Technology Transfer and Outreach	Ms. SharonBorland
HQUSACE	Mr. Jeff Jensen (CECW-HS-E) Mr. Andrew Buzewicz (CECW-HS) Mr. Leonard Kotkiewicz (CECW-HS)
GI R&D Program Product Selection Committee/Field Representatives to PDT	John W. Hunter (CELRN-EC-H), Chairman (currently in Iraq) Chuck Mendrop (CEMVK-ED-G), Vice-Chairman Larry Buss (CENWO-ED-H), Representative of the National Nonstructural Flood Proofing Committee Patrick Conroy (CEMVS–ED-GF) Marv Martens (CEMVR-ED-HH) Michael Ramsbotham (CESPK-ED-G) Glendon Stevens (CENAP-EC-H) Willis Walker (CESWG-EC-ES)
District EM Personnel	Mr. Clyde Scott (CEMVK-OD-E) Mr. Mathew Hann (CEMVS)
Local Sponsor	Mr. Renold Minsky, President, Fifth Louisiana Levee Board Mr. Bump Calloway, Director, Warren County (MS) Civil Defense

The scope of research basin testing of the existing project is to use the test facility and protocol to subject the RDFW and two other "promising alternative flood-fighting technologies" to a precise and consistent series of prototype-scale experiments. The number of alternative technologies to be tested under this Project Management Plan (PMP) is dependent upon the availability of Federal FCCE funding, but a minimum of two technologies in addition to the RDFW are recommended. Reaction of the test structures, seepage rates through the structures, and operational demands of construction, operation, and demobilization will be recorded and reported on a publicly-accessible Web page, along with the corresponding baseline data collected with the sandbag tests. EM personnel from the PDT will advise on operational concerns pertinent to use of the technologies in real-world emergencies and will also provide documentation on any previous real-world experience with the technologies.

It is anticipated that the non-selected vendors will have future opportunities to have their products tested in the ERDC facility against the standard testing protocol through vendor sponsorship and a negotiated Testing Services Agreement (TSA). Such a program is being initiated with the USACE National Non-Structural Flood Proofing Committee and the Association of State Flood Plain Managers. However, this vendor-sponsored program will not include the more rigorous level of field operational assessments proposed here and required to address the congressional directive.

Field Testing. Field testing will be conducted concurrent with the research basin testing, using the same technologies plus a sandbag barrier. Based on recommendations from the PDT, a site at Vicksburg, MS, has been selected where a real-world flooding challenge is expected. Operational criteria including ease of construction, man-hours, and special equipment requirements, use of unskilled personnel, required fill materials, and suitability to uneven or sloping terrain will be evaluated and compared to the sandbag data. The ability to increase structure height by one additional foot after its initial construction will also be evaluated. The performance of the technologies (sandbag and selected alternative technologies) will be documented, evaluated and reported. EM personnel on the PDT will assess the suitability of the technologies to other site conditions likely to be encountered in a real event (different slopes or substrate materials, different levels of site accessibility, curves or sharp corners, different hydrodynamic loadings, etc).

Planning

Selection of Test Structures

In order to comply with the language of the congressional directive a real-world evaluation of the RDFW is proposed. A minimum of two other "promising alternative flood-fighting technologies" will also be tested. Selection of the other technologies will be based on proposals received in response to an advertisement placed in the FedBizOpps Web page and using predetermined selection criteria. Selected members of the PDT will make the final selection. Background information on alternative technologies for the expedient raising of the level of flood protection works has been developed through the GI R&D Program and is contained in a database of available products.

The same technologies tested in the research basin will be tested at a preselected field location. The field site will allow room for each of the structures, including a sandbag barrier, to be constructed at the same time and subjected to the same flooding.

Testing Scenario

In the research basin tests, the products will be tested in a controlled laboratory setting, but under conditions that emulate the scenario of an impending flood overtopping a levee along a riverbank with moderate flow. The vendor will be required to arrive at the test facility with all equipment, supplies, and personnel required to erect its product prior to testing. ERDC and other members of the PDT will not assist the construction, but will observe and document the selected protocol-defined metrics associated with the construction. Selected ERDC and PDT members will observe time required to install the test wall and any special equipment requirements. ERDC and PDT participation will be funded through FCCE funds. After construction, the vendor will not be allowed to adjust the structure during any of the tests specified in the protocol. The protocol does allow the vendor access to the structure a maximum of three times between tests for a limited length of time if such access is required. Any such access to the structure will be recorded. A delivery service contract will be signed between vendor and ERDC prior to any study and guidelines for vendor involvement and responsibilities will be delineated in this document. As all testing costs will be borne by the Government, this contract will be written in a manner that assures government ownership and responsibility for distribution of the testing results.

If, in the opinion of the PDT and pending availability of funds and time, supplementary tests are required for a specific structure to supply information deemed crucial to evaluation of the structure, these supplementary tests will be conducted in a manner that will not interfere with the standardized testing protocol. An example of a test that may be conducted in addition to the standardized testing protocol is evaluation of seepage rates on a structure with a punctured or torn seepage membrane.

Field testing of the products will be performed during the month of May 2004 with the possibility of extending into June 2004. The exact date is dependent on the Mississippi River stage at Vicksburg. Selected vendors may choose to preposition material at a Government furnished site in the Vicksburg, MS, area. Each selected vendor will be contacted and given a notice to proceed to install his barrier. Each selected vendor must have his barrier installed at the field site within five calendar days from the time he receives the notice to proceed. Each site will be provided with a marked 25-ft right of way for construction. Each barrier must be constructed within a 15-ft-wide footprint for the structure within the 25-ft right of way. Actual right-of-way used by each vendor within the provided 25-ft right of way will be measured and reported. The Government will install a large buried concrete tank inside each selected vendor's barrier to collect seepage water. Each selected vendor is required to adapt their construction to overcome any problems that might arise from the tank. The Government will prepare four separate work areas at the field test site for installation of four different temporary barrier type products. A random drawing will be conducted to determine which product is constructed on each area.

Construction

The manufacturer (or designated representatives) of each product will be responsible for construction of their product in the test facility. There are no restrictions on number of personnel that may be used. Restrictions on heavy equipment (front-end loaders, fork lifts, etc) are based only on what may safely be used at the test facility. However, total man-hours and types of equipment used will be recorded and included in the report. The vendor shall be responsible for construction and removal, transportation, and delivery of his product.

For field testing, the selected vendors will be required to furnish the appropriate quantity of their flood barrier material. Each selected vendor will also be required to install his product at the test site. Subsequent to completion of all testing, the selected vendors will also be required to remove their product. If the vendors anticipate that their product and materials are reusable, then the removal should be conducted so as to maintain the reusability of the product. The Government will monitor both the installation and removal. The field test section will be in general, a u-shaped or half box shaped structure. The test section will be placed along the channel bankline and tied back into high ground. The riverward face of the structure will be a minimum 100 ft long. The length of the tieback sections could vary depending upon the river stages at which the structures will be tested but each could be as much as 50 ft long. The Government will grade to bare ground a portion of the field test site footprint for the barrier structures prior to installation of the selected vendors' products. The Government reserves the right to artificially wet the field-testing site prior to the selected vendor's installation of their products to best simulate possible real-world flood-fight field conditions. Each selected vendor's product must be sufficiently high to protect against 3 ft of water against the structure. The selected vendors will also be required to add one additional foot of protection during the testing as directed by the Government. Each selected vendor can use the method of his choice to achieve this additional 1-ft of protection.

Engineering

ERDC activities will include engineering support of the testing procedures, instrumentation, observation, and analysis of the structural response to the flood forces, and reporting of the results. ERDC personnel will not assist with construction or removal of the structure.

ERDC engineers and technicians will conduct the field and laboratory tests including operation and maintenance of pumps and valves, operation of the wave generator, and operation of the automated data control and processing computers and equipment. The instrumentation support technician on the PDT will assist the engineers as needed with operation and maintenance of the equipment.

Instrumentation for the laboratory tests will include a laser measurement system for determining seepage rates through the structure, laser measurements of deflection of the structure at various key locations, capacitance wave rods to measure incident wave conditions during hydrodynamic testing, and acoustic Doppler velocimeter measurements of flow rates along the structure. In addition, continuous video recordings will be made from two angles during the entire test period, plus additional video and still shots to fully document all phases of construction, disassembly, and testing.

Instrumentation for the field tests includes capacitance wave rods for measuring water elevation within the structures and external to the structures, capacitance wave rods for incident wave conditions, method for calculating seepage rates, and continuous video captures on each structure. Additional video and still shots will be used to fully document the construction and disassembly of each structure, plus the actual testing of the structures.

Non-ERDC members of the PDT will observe the tests, advise ERDC members on the appropriateness of elements of the test, and provide input to the reporting. They will also be asked to provide summary documentation on any real-world experience they may have with the technologies being tested and will assist in developing the final report.

Environmental

The environmental engineer on the PDT will issue an environmental opinion concerning use and disposal of products used in the tests. The opinion will include consideration that the product may become contaminated during exposure to floodwaters.

Communication

PDT. Communication with all members of the PDT will be maintained through conference calls, e-mails, and progress reports. After receipt of funding, a conference call will be initiated by ERDC to insure all members are fully apprised of the PMP and testing protocol.

During research basin and field tests, selected members of the PDT will be onsite to observe all construction and disassembly of the structures and portions of all tests. In addition to ERDC engineers and technicians, onsite members of the PDT will include at least one District field person from EM, hydraulic engineering, and geotechnical engineering, and one person from a non-Corps levee board or similar non-Federal agency.

A draft letter report detailing the performance of each product tested will be sent to each member of the PDT following the completion of testing of that product. ERDC will initiate a conference call with all members of the PDT following receipt of the report to discuss results of the testing.

At the conclusion of the research basin and field tests, ERDC will initiate a conference call with all members of the PDT to discuss final results of the testing.

Additional communications will be initiated as appropriate and required.

Other. Input to status report on test program will be provided to HQUSACE by 1 May 2004. Monthly progress reports and reports on performance of each product tested will be provided to HQUSACE through the HQUSACE members of the PDT.

Safety and Occupational Health

All vendors and their crews will be required to follow guidance found in AR-385-10, The Army Safety Program, EM-385-1-1, USACE Safety and Health Requirements Manual. Specific guidelines and requirements will be included in the delivery service contract to be signed with each vendor. A complete Safety and Occupational Health Plan is being developed in conjunction with the ERDC Office of Safety.

Quality Management Plan

The quality management philosophy is to do the right things, the right way, for the right reasons, and to constantly strive for improvement. Quality will be managed through the "Plan-Do-Check-Act" cycle. This cycle will be used at both the project level and the process level.

Plan. The PDT will plan for and build quality into the work at each step in the process. A systematic planning process will be used to identify the quality goals; develop an effective plan and processes to achieve those goals, and measure the attainment of the quality objectives. It is essential that the PDT understand the costs and benefits of selected quality standards and the processes to be used to achieve the mutual objectives. The PDT will identify appropriate standards and determine how to achieve them. The PDT will consider the risk factors and complexity of the project, and adapt processes to provide the requisite level of quality.

Do. The PDT will do work according to approved plans and standard operating procedures. The actions of the PDT will be documented in sufficient detail to ensure that actions are performed correctly and completely each time. Project execution is a dynamic process. It requires the PDT to communicate and adapt to changing conditions and modify project plans to ensure project objectives are met.

Check. Sufficient independent technical review, management oversight, and verification will be performed to ensure that the quality objectives documented in the Project Management Plan are met. PDT members periodically check performance against the plan and verify sufficiency of the plan and actual performance to meet or exceed agreed-on objectives. Findings are shared with the PDT to facilitate continuous improvement.

Act. Specific corrective actions will be taken to fix the systemic cause of any nonconformance, deficiency, or other unwanted effect. Quality will be improved through systematic analysis and refinement of work processes. The process of continuous quality improvement leads to the refinement of the overall quality system. Quality improvements may include appropriate revisions to the quality management plans, alteration of procedures, or adjustments to resource allocations.

Schedule and Work Breakdown

It is anticipated that testing of the sandbag barrier under GI R&D funding will be completed in March 2004. Research basin testing of RDFW and other technologies is therefore scheduled to begin in April 2004. All laboratory testing will be completed by the end of FY 04 (Table B2). The selected vendors will be required to initiate installation of their products within 7 calendar days of being directed to do so by the Government. Also, the selected vendors will be required to remove their products within 7 calendar days of being directed to do so by the Government.

Table B2
Field and Laboratory Testing Schedule

Date	Accomplishments
March 2004	Select alternative structures to be tested.
1 April 2004 – 15 May 2004	Install and test the RDFW in the laboratory.
1 May 2004	Provide Congressional requested status report on test program to HQUSACE.
16 May 2004 – 30 June 2004	Install and test Alternative Structure 1 (laboratory); analyze data and prepare draft letter report on RDFW laboratory tests.
May 2004 – Jun 2004	Conduct field test of all four temporary flood barriers.
1 July 2004 – 15 August 2004	Install and test Alternative Structure 2 (laboratory); analyze data and prepare draft letter report on Alternative Structure 1 laboratory tests and on all field tests.
16 Aug 2004 – 30 Sep 2004	Analyze data and prepare draft letter report on Alternative Structure 2 (laboratory).
1 Aug 2004 – 30 Sept 2004	Prepare draft report for both laboratory and field testing.
(Activities beginning on 1 April and thereafter are contingent upon timely receipt of funding.)	

Testing of each product is expected to require 6 weeks, including 1 week for mobilization and installation, 3 weeks for actual testing, 1 week for removal and demobilization, and 1 week for contingencies.

During the testing of each product following the RDFW, data collected during the preceding test series will be analyzed; a draft letter report will be prepared, and forwarded to HQUSACE. Data results will be posted on the GI R&D-sponsored Web site. A draft final report will be prepared within 3 months of completion of tests on the final product and submitted to HQUSACE.

The field testing will be conducted during May 2004 with the possibility of extending into June 2004. The selected vendors must be ready to initiate installation of their product on the field test site by 1 May 2004. However, the field test installation will be initiated only after it has been directed by the Government. The installation must be completed within 5 calendar days from the time that the Government notifies the selected vendors that the installation will begin. The duration of the field test is dependent upon the stages on the Mississippi River but is anticipated to last at least 2 weeks and could last up to a month or longer. The selected vendors will be required to remove their flood barrier upon direction by the Government once the testing is completed. The removal must be completed within 5 calendar days from the time that the Government notifies the selected vendors that the removal will begin.

Input for the congressionally-mandated USACE status report on the test program will be prepared and submitted to HQUSACE in May 2004 (as mandated in Attachment 1 to provide a status report within 180 days).

Cost Estimate and Funding Schedule. The total estimated costs of the laboratory and field testing is $1,550,500. Of that total, the laboratory cost is estimated to be $481,500. Field test cost is estimated to be $870,500. The remaining $198,500 includes $75,000 for vendor costs, $50,000 for initial planning and coordination of the laboratory and field testing PMP, and for coordination and management associated with both the laboratory and field efforts. All vendors will include in their proposals the total cost of their involvement in the research basin tests and the field tests. Vendors will be reimbursed up to a total of $25,000 for the combined research basin and field tests, per vendor. Total vendor cost is, therefore, not to exceed $75,000 for tests of the RDFW and two other technologies. These funds will cover the vendor's cost of furnishing their product, transporting their product to the ERDC laboratory and the field test site, and installing and removing their product from both the laboratory and field site. The laboratory costs will cover preparation of the PMP and meetings and communiqués regarding the PMP; costs of operating the test facility during the setup, testing, and cleanup of each technology; funding of offsite members of the PDT that will participate in the laboratory testing and require reimbursement for travel, per diem, salary, and reporting. The actual amount of funding required is dependent upon the size of the PDT that will participate in the laboratory testing. The field costs include the hydraulic and geotechnical efforts for coordinating, planning, conducting, and analyzing the field tests including required instrumentation, and reporting. Also, coordination between the field team and the laboratory team is included. The field testing costs also include $95,000 for the Vicksburg District to provide labor and equipment. This $95,000 should be funded directly to the Vicksburg District. The estimate also includes a maximum of $25,000 for stockpiled fill materials. The actual fill material costs will be dependent upon which promising alternative flood-fight technologies are selected. The funds for stockpiled materials should be provided directly to the Vicksburg District once the technologies to be tested are selected. A cost breakdown is included in Attachment 2.

The proposed laboratory and field testing and associated reporting are required to be completed by the end of FY 04. Due to the short duration of this effort (approximately 6 months), the project funds should be made available in a timely manner. The estimated total cost of $1,500,500 is required by 30 April 2004. Table B3 is the required funding schedule.

Table B3
Required Funding Schedule

Date	Scheduled Work	Funding ($)
20 February 2004	Develop PMP and initial coordination.	50,000
17 March 2004	Advertisement of promising technologies. Vendor contracts. Field and laboratory tests planning and coordination.	150,000
1 April 2004	RDFW Contract Award. Laboratory testing of DRFW. Pre-field testing site planning, coordination, and investigation including instrumentation. Selection of vendors and contract award.	300,000
15 April 2004	Field testing including instrumentation.	600,000
30 April 2004	Alternative technologies laboratory testing. Evaluation, documentation, and reporting for field and laboratory testing.	450,500

Point of Contact

Questions regarding this Project Management Plan may be directed to Dr. Donald Ward, CEERD-HC-PS, 601/634-2092, FAX 601/634-3433, e-mail: Donald.L.Ward@erdc.usace.army.mil, or Dr. Johannes Wibowo, CEERD-GEEB, 601/634-4129, e-mail: Johannes.L.Wibowo@erdc. usace.army.mil. For information concerning the field tests, questions should be directed to or Mr. George Sills, CEERD-GS-E, 601/634-3165, e-mail: George.L.Sills@erdc.usace.army.mil, or Mr. Fred Pinkard, CEERD-HC-R, 601/634-3086, e-mail: Fred.Pinkard@erdc.usace.army.mil.

2 Attachments

MAKING APPROPRIATIONS FOR ENERGY AND WATER DEVELOPMENT FOR THE FISCAL YEAR ENDING SEPTEMBER 30, 2004, AND FOR OTHER PURPOSES

CONFERENCE REPORT

TITLE I

DEPARTMENT OF DEFENSE—CIVIL

DEPARTMENT OF THE ARMY

CORPS OF ENGINEERS—CIVIL

FLOOD CONTROL AND COASTAL EMERGENCIES

In light of the recent replenishment of the Flood Control and Coastal Emergencies reserve fund, the conferees have provided no additional funds for this account. The recent depletion of this account, however, calls attention to two areas of concern about how this account is funded and administered. First, the drawing down of funds which could have been used to respond to actual emergency events to meet routine administrative and readiness expenses suggests that the Nation would be better served if response and readiness funds were provided and administered separately.

Second, justification provided by the Corps of Engineers suggests that those administrative and readiness expenses have grown to unacceptable levels. The Secretary is directed to consider changes in the separate management of these funds, and to report to the Appropriations Committees of the House and Senate within 180 days of enactment of this legislation into law.

The Nation deserves the best, most reliable, most economical tools which technology can provide for the protection of its citizenry and their property when confronted with natural disaster. The conferees are aware of the preliminary testing of the Rapid Deployment Flood Wall at the Engineering Research and Development Center in Vicksburg, MS. This technology has shown promise in the effort to fight floods. Its proponent's claim, and preliminary tests tend to confirm, that it can be cost-effective, quick to deploy, and superior to traditional sandbags in protecting property from flood damages totaling millions in dollars each year. The conferees therefore direct the Corps of Engineers, within funds available in the Flood Control and Coastal Emergencies account, to act immediately to devise real world testing procedures for this and other promising alternative flood fighting technologies, and to provide a status report to the Committees on Appropriations with 180 days of enactment of this legislation.

Attachment 1

Cost Breakdown

Laboratory Testing of 3 Products (RFDW + 2 other promising technologies)

- ERDC costs for setup and testing	$291,000
- Field Representatives to be on site during testing	$75,000
- Facility Costs	$43,500
- Report/Coordination Through Committee & USACE	$72,000
Laboratory Total for 3 tests	**$481,500**

Field Testing of 4 Products (Sand bags + RDFW + 2 other promising technologies)

- ERDC coordination, planning, testing	$385,000
- Instrumentation	$228,500
- Field Representatives to be onsite during testing	$50,000
- Report/Coordination Through Committee &USACE	$87,000
- Vicksburg District labor and equipment	$95,000
- Stockpiled Fill Materials	$25,000

Field Total for 4 tests $870,500

Laboratory and Field Testing (RDFW + 2 other promising technologies)

- Initial Project Planning plus Coordination and Preparation of PMP	$50,000
- Reimbursement to Vendors	$75,000
- ERDC Management and Coordination Between Field and Laboratory	$73,500
Total Shared Costs	$198,500

Total Cost (Laboratory + Field + Vendor) $1,550,500

Attachment 2

Appendix C
Laboratory Testing Protocol

STANDARDIZED TESTING PROTOCOL FOR EVALUATION OF EXPEDIENT FLOOD-FIGHT STRUCTURES

By
Dr. Johannes Wibowo, Robert Carver, Perry Taylor, and Dr. Donald Ward

1.0. Introduction

The primary purpose for developing this protocol is to test and evaluate the effectiveness of various types of expedient flood-fighting devices. Vendors of a wide range of commercial expedient structures are competing for U.S. Army Corps of Engineers emergency flood-fighting funds. These structures vary widely in form and function. For the most part, the only technical literature available on the products comes from the vendors themselves. Few vendors have tested their products at established laboratories; the majority base their performance expectations on results of their own testing. Some vendors promote products that are conceptual or in prototype development stage only. Financial decision-makers within Federal, state, and local government agencies responsible for flood-fighting are the primary targets-of-opportunity for these vendors. The fundamental problem faced by these decision-makers is that they have no basis for substantiation of the claims made by these vendors. A Standardized Testing Protocol (STP) developed, administered, and executed by the U.S. Army Engineer Research and Development Center (ERDC) laboratories is a logical and necessary tool for providing unbiased, objective technical performance data. In order to participate in the testing program, the vendors of the various products will supply funding, materials, equipment and labor to assemble their systems in accordance with the STP, and in accordance with a Testing Services Agreement (TSA) to be executed between each vendor and ERDC.

The STP focuses on configuring expedient structures as a wall or impoundment within one of the Coastal and Hydraulics Laboratory's wave basins (Attachment 1). Several key performance factors will be evaluated using STP guidelines. Structures will be subjected to hydrostatic loads, wave-induced dynamic loads, impact loads and overtopping, with the response of the structure to each test mode evaluated. Using this STP, a variety of expedient structures may be tested under the same set of controlled conditions. The results of the tests will allow the end user to determine applicability, benefits, and product performance for various situations.

2.0. Classes of Expedient Structures

The range and diversity of products used or intended for expedient flood-fighting is quite large. Products can be classified several ways. We have chosen to categorize these products into three major types:

(a) Permanent.

(b) Semipermanent.

(c) Temporary.

Because of the size and high cost associated with modeling permanent and semi-permanent flood-fighting systems, only temporary flood-fighting devices will be tested under this program. The temporary structures may be further classified as:

C-i Commercially available products that are complete flood-fighting systems in and of themselves (e.g., water-filled, air-filled, soil-and-sand-filled bladders, cells, or geotextiles; Jersey barriers; steel and concrete foldable barriers).

C-ii Systems that are composed of readily available materials without a single sponsor marketing and selling the complete systems (e.g., sandbags, mud boxes, fabric fold-back walls, plywood or planking flashboards with or without earth backing).

It may be difficult to identify a sponsor for type "C-ii", classified systems since no one company may market the complete systems. However, if the method is assigned a high priority by the selection committee consisting of representatives from District offices and other Federal agencies, testing will likely be performed at government expense.

3.0. Selection Criteria

At present there are a variety of products available or entering the market for expedient flood-fighting structures. The selection committee will invite and query vendors as to their interest in participation in the testing program. Time and labor constraint will not permit testing of every available product. In order to qualify for the testing the vendor should:

(a) Provide an analytical study of the "structural integrity" of the product under flood loading. The functionality must be supported by sound engineering and physics principles. As a minimum, calculations should be provided for sliding, uplift, overturning, required tiedown configuration per unit length of structure, and stake pullout strength. All should be calculated for static, dynamic impact and wave conditions.

(b) Provide the cost per 100 ft of flood-fighting product, including tie downs, stakes, geotextiles, membranes, sandbags, and other associated materials as required for an in-place system of a typical height placed on soil, rock, and concrete surfaces. Include an estimate of installation man-hours required per 100 ft of flood-fight product.

(c) Provide list of materials, tools, and construction sketch needed to build the flood-fight structure, including tiedowns or other anchors and how this will be performed in soils, concrete and asphalt concrete foundations.

(d) Complete description of procedures for construction of the flood-fight system, with detailed information including, but not limited to, the basic unit assembly, connection of individual units, description of all anchors, tiedowns, strapping, etc., to form the complete system.

(e) Provide accurate information to address environmental concerns for the product in the unused state, and also provide information on any environmental issues related to the product after it is used and potentially contaminated by floodwater (i.e., procedures for disposal of a potentially contaminated flood-fight structure). Explain in detail how the unit is to be taken apart and stored. If the unit is filled with a material (gas, liquid, semisolid, or solid), explain how to handle and dispose of these materials (at a minimum, Material Safety Data Sheets, as appropriate), to include procedures for disposal or treatment should they become contaminated.

(f) Supply an adequate amount of the complete system product for model testing. Water depths ranging from approximately 2 to 3.75 ft will be used to test all flood-fighting products.

(g) Provide consultation support during the testing of the product and provide assistance as requested by ERDC.

(h) Agree to construct/install the candidate flood-fighting device at ERDC testing facility in Vicksburg, MS.

(i) Assure that the structure (as constructed by the vendor or their representative in the ERDC test facility) meets the vendors' standard of construction.

(j) Agree to accept results and allow publication by ERDC of test results.

Once the evaluation committee selects products from all the candidates, the next step will be establishment of a Cooperative Research and Development Agreement (CRADA) with each vendor.

4.0. Standardized Testing Protocol

The STP utilizes a physical model testing facility to subject the expedient flood-fighting structures to loading similar to that found in a real flood situation. One important facet of the STP is to establish a baseline of performance for comparing the effectiveness of the new products. The integrity of the new products will be evaluated against the performance of a sandbag levee built according to typical COE guidelines. The STP will include documentation of construction requirements, material costs, labor, hydraulic performance, environmentally acceptable materials, and structural integrity of the baseline case as well as each product tested.

The following elements form the basis of the STP:

- The base (floor) for the Innovative Flood-Fighting Structures (IFFS) to be tested will be constructed in the area shown in Attachment 1. Each IFFS structure will be configured as an approximately 30-ft-long levee with two additional 10-ft-long levees at each end of, and at right angles to, the 30-ft-long levee. The two 10-ft-long levees will perpendicularly abut the concrete wing walls of the testing section. The IFFS will be constructed to between 2 ft and 3.75 ft high.
- The IFFS base must fit within the construction base area. Additional membranes used for seepage reduction and occasional sandbags used as membrane hold-downs may be used in the pool area simulating the floodwater side of the IFFS. No IFFS structure parts, sandbags or membranes will be allowed inside the "off-limit" area shown in Attachment 1.
- Structures will be subjected to hydrostatic loads from incrementally increasing floodwater head, or depth.
- Structures will be subjected to hydrodynamic loads by applying waves of incrementally increasing height.
- Structures will be subjected to steady-state overtopping at 100 percent of IFFS height plus 1 in. or less, as governed by the maximum pumping capacity available to recirculate the overtopping water into the test basin.

- Structures will be subjected to a prototypical impact log test.
- Measurements of seepage and movement of IFFS will be made during all phases of the testing.
- Observations of movement of IFFS, fatigue or structural deterioration will be made during all phases of the testing.
- Up to three relatively small-scale repairs of documented damage are allowed during a test series.

5.0. Constructability Evaluation

Vendors will construct and install their own product at the ERDC test facility in Vicksburg, MS. The construction process will be recorded using a video camera. These tapes may be used later as part of Corps flood-fight training material. The first evaluation of the STP deals with issues of construction. Documentation and evaluation will be made of specific constructability issues. These issues include:

(a) Manpower requirements.
(b) Foundation requirements.
(c) Material and equipment required.
(d) Ease of construction.
(e) Construction duration.
(f) Special construction considerations.
(g) Application limitations.

6.0. Hydrostatic Testing Protocol

The initial and most basic component of the STP is to evaluate the structural and hydraulic response of each IFFS to quasistatic, slowly rising hydrostatic head. The testing protocol for the hydrostatic head test will consist of flooding the basin on the riverside (or "wet" side) of the barrier or wall to the desired water level. Three water levels will be used for testing: 33-1/3 percent, 66-2/3 percent, and 95 percent of the height of the structure, also shown in Attachment 2. At each increment, the water level will be held at constant stage for a minimum of 22 hr. Continuous measurements will be made of seepages through the interface and the body of IFFS. Any observable movement of the IFFS will be documented and recorded on video. The wall will be measured for any lateral deflection at up to eight different locations as shown in Attachment 2 in order to determine whether it is sound under increasing static loading. Measurements in terms of average volumetric quantity per unit of time will be used to calculate amounts of water flowing under or through the barrier. This will allow the engineer to determine how much water may become impounded, for a given duration, behind the wall.

7.0. Wave-induced Hydrodynamic Load Testing Protocol

The purpose of wave-induced dynamic load testing is to observe the structural response of the IFFS under hydrodynamic loading conditions. Typical hydrodynamics failures of temporary structures (Class C-i) include material failure or fatigue, fill loss, wall sliding or overturning, and deformation. The protocol specifies that packets of monochromatic waves with a wave period of $T = 2.0$ seconds be generated to impinge against the barrier. The wave tests will be conducted at two different calm water depths: 66 percemt x h and 80 precent x h , where h is design water depth for the structure or 3.5 ft, whichever is lower. At 66 percent x h waves of approximately 3 in. height (measured from trough to crest) will be generated continuously for a period of 7 hr. The following day waves ranging from 7 in. to 9 in. (measured from trough to crest) will be allowed to impact the structure for 30 min in 13-min increments. Afterward, the wave height will range from 10 in. to 13 in. and will be allowed to impact the structure for one 10-min increment. The water will then be brought to a level of 80 percent x h and the preceding tests will be repeated (Attachment 2). At the end of each 10-min increment of wave testing (excluding the 7 hr of 3-in. waves), the basin will be stilled for up to 45 min to allow the waves to dissipate.

The seepage observations and displacement measurement as described in Section 6.0 will also be done during hydrodynamic testing. As waves grow in height, a certain portion of the wave spills over the IFFS, depending on frontal geometry, porosity, and roughness. This quantity of water can have a significant impact on the volume of seepage.

8.0. Additional Observations and Measurements of Failing Structures During Static and Dynamic Tests

Observations and measurements of any structural damage, such as material breakage, fatigue, component failure, and an estimate fill loss will be made. Three repairs of the IFFS will be allowed during the test series as will be described in Section 11. This allows an evaluation of the expediency of the repair, method used, and integrity of the repair.

9.0. Static Overtopping

Static overtopping will be caused to occur at a riverside water level equal to 100 percent of structure height plus 1 in. (IFFS height is below 3.75 ft), and the results of the overtopping with time will be recorded and evaluated. Water level on the flood (wet) side of the IFFS will be slowly raised until the depth of flow over the structure is 1 in. (depth of water several feet out from the structure will be approximately 4 in. greater than structure height). Pumps on the dry side of the IFFS will return the water to the basin to maintain a constant head in the basin and to keep the water level on the dry side of the IFFS as low as practical. This overtopping test will proceed for 1 hr after steady state conditions are achieved or until failure occurs. If the structure floats up, the water will be raised to the appropriate elevation and the pumping will begin even though no overtopping occurs. The performance of IFFS during overtopping includes recording the movement of the structure, and observation from one or more video cameras.

10.0. Debris Impact Test

Following the overtopping test, the vendor will have the opportunity, if desired, to remove all of the water from the basins and to rebuild the IFFS to its original condition before the static, dynamic, and overtopping tests. The reconstruction procedure should be the same as the construction before static loading tests. The water level will be filled to a height of 66-2/3 percent of the height of the IFFS, and the debris impact test will be performed (Attachment 3). The purpose of this test is to evaluate the structural response of the IFFS to a simulated debris load. The IFFS will be struck with two different floating logs. A log will be pulled into the IFFS using an electric winch system to provide an impact with a velocity of 7 ft/sec, or about 5 mph. The trajectory angle between the log and the levee will be about 75 deg. Twelve-in. and 17-in. diam logs, each 12 ft long, will be used. The smaller log will be used first, followed by the bigger one. The movement and damage to the IFFS, if any, from the smaller log impact test will be observed before continuing to the larger log impact test. If the IFFS is leaking profusely or has experienced more than 6 in. permanent movement after the smaller impact log test, the bigger impact log test may not be performed. ERDC personnel will determine if it is safe to continue with the next impact log tests.

11.0. Repairs to Innovative Flood-Fight Structures

Up to a total of three minor repairs to a candidate's IFFS structure will be allowed during the three major tests (hydrostatic, hydrodynamic, and overtopping). This does not mean three repairs during each test. A minor repair is hereby defined as "a repair requiring a maximum of 30 min using a maximum of four men, using only materials available on site." There will be seven opportunities to make repairs, and the vendor can only make three repair attempts. The vendor must understand the STP completely before deciding the condition under which these three minor repairs will take place. The testing will not be halted during a particular test phase to make a repair. The repairs must all be made after the test or tests at one level is/are complete; this becomes more important during the dynamic testing, which is discussed in the following paragraphs. The three types of repairs are described as follows:

11.1. Static Test/Repair Description

During a static test, the water elevation will be raised to three different levels: 33 percent x *h*, 66 percent x *h* and 95 percent x *h*, and each level is maintained for a minimum of 22 hr while seepage, displacement, and material loss are recorded (Attachment 2). If the need for a minor repair develops at 33 percent x *h* or the 66 percent x *h*, the vendor may choose whether or not to perform the minor repairs before the tests proceed to the next level. If the vendor wants to make a repair after the 95 percent x *h* depth, safety dictates that they must wait until the water level is dropped to the 66 percent x *h* level and prior to the dynamic test to make this repair.

11.2. Dynamic Test/Repair Description

During a dynamic test, the water level will be raised to an elevation corresponding to either 66 percent x *h* or 80 percnet x *h*. For each water elevation, three different wave magnitudes (3 in., 7 in. to 9 in., and 10 in. to 13 in.) will be allowed to impact the structure. The first wave height will run for 7 hr, followed by the second wave height for 30 min (three 10-min packets), followed by the third wave height for 10 min (one 10-min packets) (see Attachment 2). Repairs will only be allowed after first wave height is completed and after the third wave height is completed for the elevation being tested.

11.3. Overtopping Test/Repairs

There is no need to do a minor repair after the overtopping test is completed, because the levee must be repaired to its original condition preceding the log impact test. This repair is not counted as one of the three minor repairs. A maximum of 8 hr will be allowed for this repair with no limit on the number of personnel. This repair will be the responsibility of the product vendor. The method of construction should be consistent to the original method without any modification.

11.4. Review of the Three Repairs Allowed and When They May Be Performed

In summary, three minor repairs are allowed and can be performed out of seven different times of opportunity as shown in Table 1. After the overtopping test, vendor may need to do repair or rebuild if necessary for debris impact test. All of the repair materials must be onsite to make the needed repairs in and at the times specified. Repairs must be made from like materials or repair kits for the structure.

Table C-1
IFFS Testing Matrix

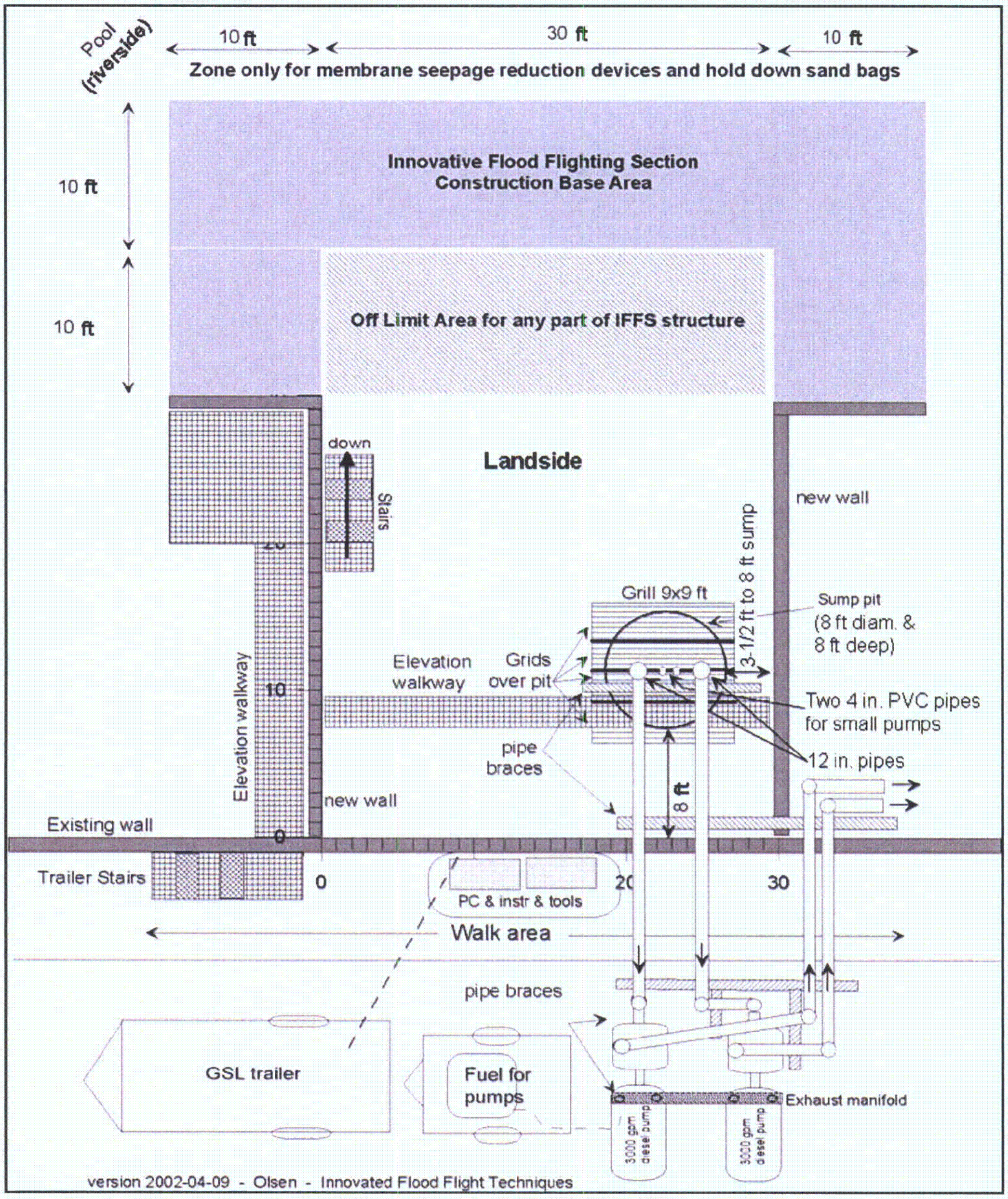
Test	Condition	Repair Allowed
Hydrostatic	33-1/3 % h, 22 hr	After 22-hr test
	66-2/3 % h, 22 hr	After 22-hr test
	95 % h, 22 hr	After 22-hr test, and water level lower to 66-2/3 % h
Hydrodynamic	66% h, Low Wave, 7 hr	After finish of 7 hr
	66 % h, Med Wave, 3 x 10 min test	After finish 66% h, High Wave Test
	66 % h, High Wave, 1 x 10 min test	
	80 % h, Low Wave 7 hr	After finish of 7 hr
	80 % h, Med Wave, 3 x 10 min test	After finish 80% h, High Wave Test
	80 % h, High Wave 1 x 10 min test	
Overtopping	1 in overflow, 1 hr	Major repair or rebuild
Impact Debris	12 in log, 5mph 17 in log, 5 mph	Removal of all material

12.0. Environmental Evaluation

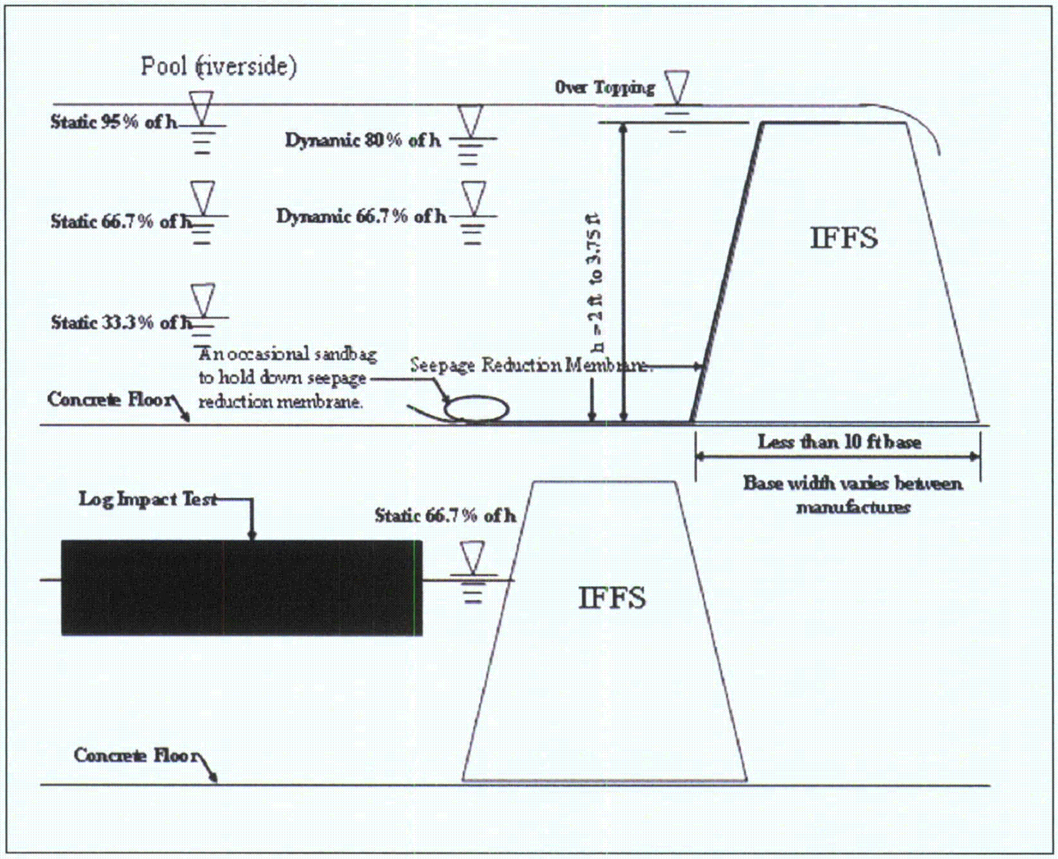
Material that will be used for the construction of protective barriers will be required to have an MSDS attached if it is required by the properties of the material. The MSDS will provide information as to the chemical makeup and physical properties of the material. The Environmental Laboratory (EL) will review the MSDS and determine if the material will pose any environmental risk when placed on or in the protective barrier. Also, EL will evaluate the material to determine any environmental effects the material might have if it comes in contact with certain such items as sewage, oil, debris, etc. EL will determine special handling and disposal procedures that will need to be implemented in the case that the material is released from the barrier or if it is contaminated with other material from the environment.

13.0. Evaluation Process

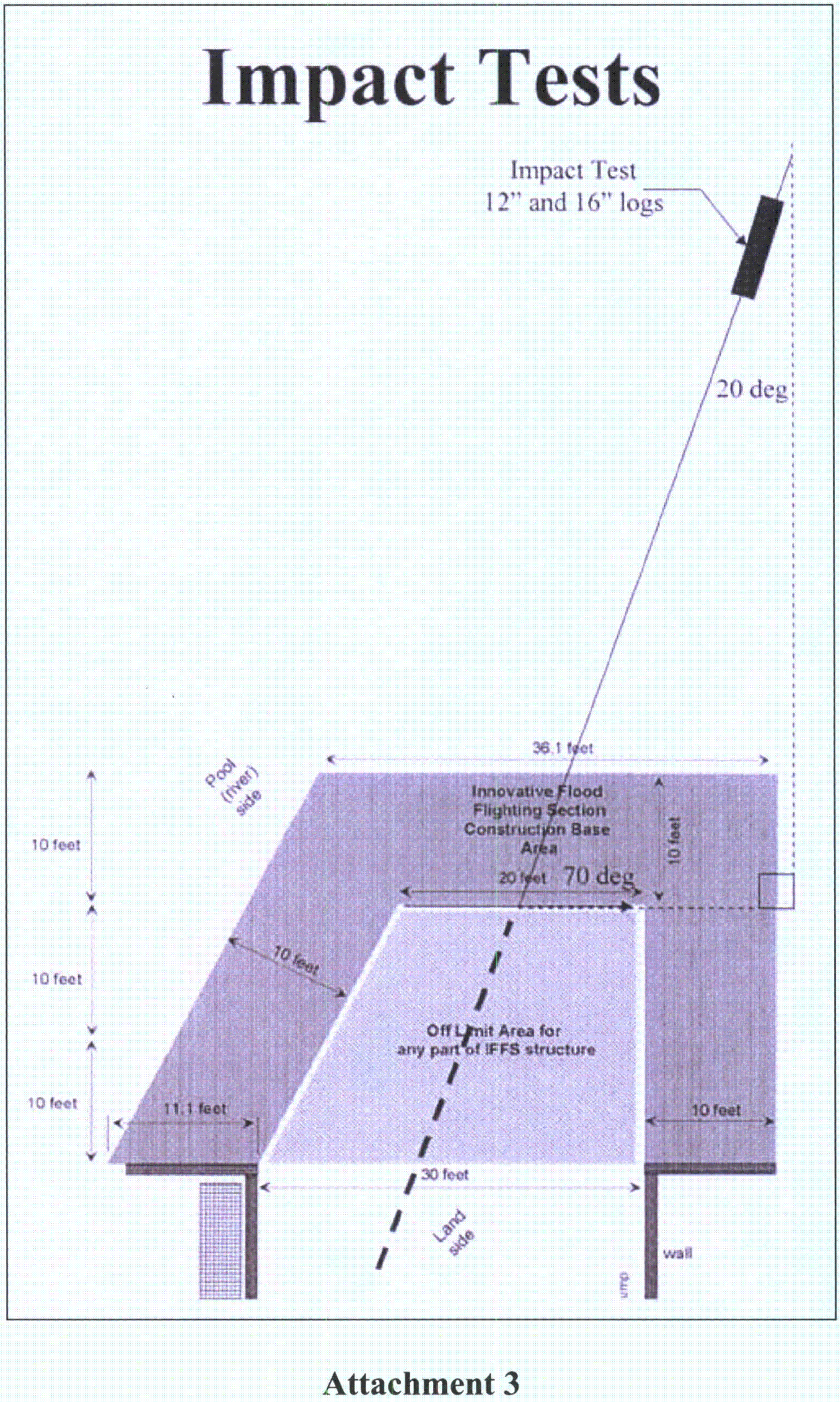
At the end of the test sequence, all measurement data will be compiled and presented in tables and charts. Photographs of IFFS during construction, during test, and after test will also be presented. The results obtained for the IFFS will be compared to the results obtained with sandbag tests, which are intended as a baseline performance reference. There will be no quantitative comparison of the results of tests for IFFS performance or of other IFFS products evaluated in this study. For qualitative performance evaluations (constructability and repair difficulty), the sandbag levee performance will also be used as a reference baseline. The final evaluation report will include narrative, photographs, drawings, and tables. The report will not draw conclusions, rather it will assist the field engineer in making informed decisions about the application of flood-fight products to a particular application.



Attachment 1



Attachment 2



Attachment 3

REPORT DOCUMENTATION PAGE

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14. ABSTRACT

Within the United States, sandbags have traditionally been the product of choice for temporary, barrier type flood fighting structures. However, sandbag structures are labor intensive and time consuming to construct. Therefore, a need exists for more expedient, cost effective, temporary barrier type flood-fighting technologies. In 2004, Congress directed the U.S. Army Corps of Engineers to devise real-world testing procedures for Rapid Deployment Flood Wall (RDFW) and other promising alternative flood-fighting technologies. In response to that directive, the U.S. Army Engineer Research and Development Center (ERDC) developed a comprehensive laboratory and field-testing program for RDFW and two other flood-fighting products. Those two products, Portadam and Hesco Bastion, were selected on technical merit from proposals submitted by companies who manufacture temporary, barrier type flood-fight products. A standard sandbag structure was also tested in both the laboratory and field to provide a baseline by which the other products could be evaluated.

(Continued)

15. SUBJECT TERMS

Flooding	Laboratory testing	Portadam
Flood fighting	Field testing	Rapid Deployment Flood Wall (RDFW)
	Sandbags	Hesco Bastion Concertainer

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14. ABSTRACT (Continued)

During 2004, laboratory and field testing was conducted in Vicksburg, MS, under stringent testing protocols. The lab testing was conducted in a modified wave basin at ERDC. The field testing was conducted at the Vicksburg Harbor. The lab and field protocols included both performance parameters and operational parameters. These tests will provide the flood-fighting community results that will assist in the selection of the product that best fits their temporary, barrier type flood-fighting needs.