Appendix C
Lessons Learned - Case Histories

C-1. General

This appendix will review some of the major and minor problems that have been experienced on navigation dam projects designed and built prior to 1993. Also, references will be given to Corps districts and divisions and other Corps organizations involved and to published material which relates to a specific problem and the follow-up action taken.

C-2. Concrete

Several Corps districts have experienced problems with concrete durability in stilling basins and buckets, apparently due to below-average-quality concrete, insufficient reinforcing steel, and the abrasive action of ice, drift, gravel, stones, etc., carried in the spillway discharge water. The damage to the concrete has varied from surface abrasions to loss of enough concrete to expose the reinforcing steel, which originally had 4 in. or more of cover. The Pittsburgh and Nashville districts have experienced problems of this type. Not much can be done about the materials carried in the spillway discharges, but current engineering manuals have updated concrete quality (higher strength, more durable aggregates, etc.) and reinforcing steel guidance to prevent most problems of this type. Refer to Chapter 12 for further details. Since it is not possible, on most projects, to unwater the spillway bucket for repair without using extremely costly steel pile cofferdams and, during high flood flows, interfering with spillway discharges, it is highly desirable to follow the published design criteria and guidance for stilling basin concrete and reinforcing.

C-3. Spillway Tainter Gates

a. Use of submergible gates. When the first of the "current generation" Ohio River navigation dams were designed and built in the 1950s and 1960s, it was deemed advisable to use double-skin plated overflow tainter gates (submergible gates) for the purpose of passing ice and debris through some of the spillway bays at a project. The other spillway bays would also have similar double-skin plate gates, but they would rest on the sill and would not be submergible. Vibration problems, in addition to horizontal sealing problems at the sill, developed on the submergible gates from the beginning of their operation. It was also discovered that these gates were not satisfactory for passing ice and/or debris unless almost fully lowered--a condition which could cause damage to the stream bed stone protection downstream of the stilling basin. After several years of unsuccessful attempts to solve the vibration and seal problems, the Corps adopted a policy of not using submergible tainter gates on future projects. Many of the submergible tainter gates remain in use on Ohio River navigation dam projects, but they are no longer operated as submergible gates. It was discovered that ice and debris could be passed satisfactorily through the spillways by raising the gates off the sill a sufficient distance to create enough discharge velocity to draw the ice and debris to and through the spillway bay underneath the gate. At Cheatham Dam on the Cumberland River in the Nashville district, the seven submergible tainter gates were modified to be nonsubmergible and to rest on a modified sill with a new ogee crest shape. The costs of the modifications at this project were almost balanced out by the revenue from additional power generated by savings in water losses (leakage) where the submergible gate failed to seal at the horizontal sill. The Huntington, Pittsburgh, and Louisville districts have background information on the problems and actions taken on the submergible gates on the Ohio River.

b. Passing of ice and debris. In addition to the submergible tainter gates described in paragraph C-3*a* above, the Corps has used "piggy-back" tainter gates on some projects in the Pittsburgh district. These gates are composed of an upper section and a lower section which operate independently of each other, the intent being to raise the upper section out of the water and thus allow ice and debris to pass over the lower section which remains in place on the sill. This arrangement has not proved satisfactory, however, and recent tainter gate designs have not used the "piggy-back" concept.

c. Cables (wire ropes) versus chains. Link chains for use in raising and lowering spillway tainter gates are composed of links, pins, spacer sleeves, spacer washers, racking collars, and retaining rings. The holes in the links and pins are machined to specific tolerances to allow easy movement of the link with relation to the pin. Links and pins are made of 4140 steel. Pins have been cadmium coated and chain-bearing surfaces coated with graphite lubricant during assembly. No grease grooves or grease fittings are provided for the pins; thus, all greasing of the pins and links has to be by manual application to exposed surfaces. These chains function well with no special problems for that portion that stays out of the water where normal maintenance and greasing can be done readily on a periodic basis. However, the portion of the chain that is continually submerged is subject to corrosion and pitting damage and can become less flexible and possibly inoperative due to infrequent maintenance and greasing of the pins. The Nashville district experienced many operational and maintenance difficulties with the chains on the Cheatham Dam tainter gates, and eventually all the portions of the chains that were continually submerged had to be replaced. The replacement links and pins were made of AISI 4140 steel and had basically the same components except that copolymer washers were added on each side of all links. Also, each new pin was provided with three grease grooves and three grease fittings to allow lubrication of the pin-link contact surfaces. Chains were used exclusively until manufacturers developed a wire rope which could be wound on itself. These stainless steel wire ropes have proven to be much better from an operational and maintenance standpoint, and all new projects will use wire rope for tainter gate hoisting operations. For more information on stainless steel rope, see EM 1110-2-2702.

d. Treatment of bottom lip of tainter gates. Several Corps districts have experienced problems with the shape of the bottom lip of tainter gates, as well as problems with horizontal rubber seals used on the lip to provide a more positive seal at the sill.

(1) Shape of lip. The relatively broad shape of the lip of the gates at Barkley Dam on the Cumberland River in the Nashville district, coupled with an attached flat rubber sill seal and seal retainers, caused gate vibrations for a range of gate openings and tailwater levels. Investigations by the Nashville district, aided by WES, resulted in removal of the rubber seals and retainers and grinding of the bottom of the gate to obtain a satisfactory metal-to-metal seal. A report on this specific situation is available from WES. For new applications, emphasis is placed on making the lip of the gate as sharp as possible so that negative pressures, which can cause gate vibrations, are not created.

(2) Rubber seal on lip of tainter gate.

(a) The navigation dams on the Arkansas River in the Little Rock district had tainter gates which were equipped with horizontal rubber "J" seals, mounted on the gate lips for gate sealing at the sill level. Use of these "J" seals resulted in gate vibration problems when the gates were opened to pass water. These vibration problems were essentially solved by removing the seal and retainers. A WES report of its investigations and the resulting remedial actions is available. Experience and knowledge gained in the above two instances and from WES model tests indicate that the use of rubber seals of any type on the lips of tainter gates could result in excessive gate vibrations.

(b) In most cases, an adequate metal-to-metal seal between the lip and sill can be obtained by proper adjustment (grinding) of the lip to precisely match the sill plate. However, if it is necessary to conserve every bit of water possible, a properly designed flat rubber seal assembly similar to that used on the Red River (Louisiana) dams tainter gates may be provided after proper coordination with and recommendations from WES and district hydraulic engineers. Rubber "J" seals should not be used at this particular gate lip location.

(3) Excessive leakage at lip of gate. The Cordell Hull navigation dam on the Cumberland River in the Nashville district has conventional tainter gates with ASTM A-36 steel lips that rest on embedded stainless steel sill plates. Because river flows are normally routed through the power plant adjacent to the spillway, the tainter gates are only off the sill when they are opened to pass flood flows. After the project had been in operation for several years, it was noticed that the gates had excessive leakage at the horizontal lip-sill contact. One gate was unwatered for inspection by using the spillway bulkheads, and a badly worn lip was revealed. The deterioration of the lip was judged to be due to lack of cathodic protection on the gates, and erosion-corrosion plus some cavitation. In order to remedy this situation, a stainless steel lip was installed on the gate and carefully adjusted for a better seal contact with the embedded stainless steel sill plate. Cathodic protection was also installed on the gates.

e. Side seals and rubbing plates for tainter gates. Molded rubber "J" seals have proven to function very efficiently as side seals for spillway tainter gates. However, when these seals were used with ordinary structural steel (ASTM A-36) embedded rubbing plates, the seals would frequently suffer damage if any undue offsets, irregularities, or heavy rusting was present on the steel rubbing surfaces. Also, the seals were subject to considerable wear as they slid along the steel plate, due to the high friction factor of the rubber. On some Corps projects, maintenance and/or replacement of the seals was considered to be too frequent. To remedy this undesirable situation, two things were done:

(1) The side seal rubbing plate was specified to be made of either stainless steel or stainless clad steel.

(2) The ball of the rubber "J" seal was provided with a teflon coating so that the teflon, and not the bare rubber, contacted the side seal rubbing plate. The teflon coating in this application has functioned well and is very durable. It also has a friction factor of about one tenth that of bare rubber. The successful use of these two items makes it highly desirable that all future Corps projects seriously consider using stainless steel side seal rubbing plates with teflon coated rubber "J" seals for spillway tainter gates.

C-4. Streambed Scour Protection

One of the most important features of a navigation dam project is the streambed scour protection that must be provided downstream of the concrete dam structure. Several Corps projects have experienced near-catastrophic situations due to failure of the stone protection to function as intended. Some of the projects had failures during flood conditions, and others had gradual progressive failures over a long period of time. After many years of operation, Dams 52 and 53 on the Ohio River in the Louisville district developed scour holes over 100 ft deep in the streambed downstream of the navigable pass dam sill after the scour protection failed. One section of Dam 52 actually had some downstream movement but did not fail. The overall remedial action required to prevent potential failure of these two dams consisted of filling the scour holes with large stone at a cost of several million dollars.

a. Model tests and studies. Model tests are very helpful in determining the extent and location of scour protection required downstream of a navigation dam structure. In some cases, histories of prototype experiences and required remedial measures are also very helpful in assessing scour protection needs for new projects. Studies of these past experiences have revealed that conservative designs are advisable. Chapter 5, paragraph 5-11 of EM 1110-2-1605 covers the design of downstream streambed protection. See also Chapter 8, Channel Protection, in this manual. Paragraph 8-5 of EM 1110-2-1605 covers rehabilitation methods for failed scour protection in detail, and paragraph 8-6 gives a tabulation of model studies conducted to evaluate major rehabilitations required as a result of scour protection failures at several Corps projects.

b. Other information. Other pertinent information concerning major problems with scour protection at Corps projects is available as follows: Old River Control Structure--Louisiana-New Orleans district; Dams 52 and 53, Ohio River--Louisville district; Red River Dams--Louisiana-Vicksburg district; and Jonesville and Columbia Dams--Louisiana-Vicksburg district. It has also been emphasized by experience and by WES model studies that, in some cases, streambed scour protection is essential during construction to prevent excessive scouring of the streambed material. This is especially true when a steel pile cofferdam is in place and the river flows through a limited opening.

C-5. Cofferdams

a. Steel sheet pile tees and wyes. Welded, in lieu of riveted, steel sheet pile tees and wyes, which were used quite often in the construction of steel pile cells for cofferdams, did not prove suitable because of failures of some welds during driving of these items. The failures were probably due to the fact that the pile material was not of weldable quality, coupled with the high impact on the tees and wyes when they were driven. Subsequently, the Corps took the lead in developing an alternative extruded wye section. However, this extruded wye was used only for a few years and then abandoned. The section was very compact, which resulted in its being very limber and difficult to handle and drive in long lengths. Splicing of the wyes was also not practical. After this, the Corps adopted a policy of using only riveted or high-strength bolted tees and wyes.

b. Use of new and used steel sheet piling. In the early stages of construction, it is advisable to use only new sheet piling because of the considerable risk and liability associated with sheet piling that has inadequate interlock strength or anomalies in the interlocks that cause them to fuse during driving. Use of piling that has been used on two previous projects is subject to approval of higher authority. However, where staged construction is to be used, plans should include reuse of sheet piling in later stage cofferdams, taking the precautions described below.

c. Inspection of used piling. Any steel sheet piling that is to be reused in a subsequent cofferdam should be carefully processed and inspected after it is extracted. The important items in processing and inspecting each sheet of the piling for reuse are as follows: proper handling and storage so that permanent bends are not introduced into the piling and the piling is not damaged to the extent it cannot be reused; visual inspection of the pile webs for any undue rusting, nicks, tears, and splits, and either rejection of the entire sheet or removal of the damaged portion; visual inspection of the interlocks for any damage due to handling, driving, or extraction that would be cause for rejection; gaging of the full length of all pile interlocks with a metal gage to ensure that the configuration of the interlock is within allowable limits to properly grip the adjoining interlock and develop the proper interlock strength; load testing of coupons from the piling if required to calibrate gaging operations; and reduction of the allowable interlock tension to a conservative value.

C-6. Markland Incident of 1967

This incident resulted from a barge tow breaking loose from an upstream mooring (tied to a tree on the bank that pulled out) and floating into the dam. The barges sank in the dam gate bays with some of the barges wrapping around the piers, preventing the tainter gates from closing during a return from open river conditions. The resulting loss of pool caused major damage to harbors, stranded boats, sloughed highway embankments, and exposed water intakes and sewer outfalls. Figure C-1 shows the removal of one barge from the Markland Dam. Based on this incident, the Corps developed recommendations for future applications as summarized in the following paragraph.

C-7. Summary of Recommendations Based on the Markland Incident

The following edited version of the recommendations contains guidance that relates to the lock and dam design and operation.

a. Prevention of accidents -- lock and dam.

(1) Recommend installing remote control systems to provide for operation of spillway gates from the operations building.

(2) Recommend that Corps of Engineers Regulations prohibit operators from mooring unattended tows within 10 river miles upstream of a dam, except at commercial docks, facilities that have been designed for mooring, government-furnished mooring facilities, or fleeting areas.

Figure C-1 - Removal of barge wrapped around dam pier - Markland Lock and Dam, Ohio River, 1967

(3) Recommend installation of mooring facilities both upstream and downstream of navigation structures for tows awaiting lockages.

(4) Recommend each district institute training programs for lock and dam personnel to familiarize them with decisions that need to be made in emergency situations.

b. Coordinate efforts with other agencies and navigation interests.

(1) Recommend the Corps of Engineers establish formal liaison and participate with the Coast Guard, other federal agencies, and navigation industry groups in public deliberations and studies concerning the enforcement of safe navigation on the canalized rivers.

(2) Subjects that may be discussed by these and other bodies which could significantly influence the Corps' plans for protection of its navigation structures and on which the Corps' view should be made known include the following: the analysis of requirements for permanent mooring facilities between dams; the development of more specific regulations affecting mooring procedures; regulation of the size and power of tows to ensure safe control of the tow's movement under any reasonably anticipated river conditions; Coast Guard examination and licensing of selected personnel on towboats and self-propelled barges; and mechanical inspection of towboats by the Coast Guard.

c. Engineering modifications. Recommend engineering and economic feasibility studies for installation of protective barriers or lengthened guidewalls upstream of dams, or modification of piers, to prevent major damage to structures by runaway tows.

d. Recovery operations equipment.

(1) Recommend whirler-type derrick-boat of approximately 300-ton capacity be made readily available for emergency use.

(2) Recommend the provision (either by lease or procurement) of a towboat for each district or applicable waterway of sufficient thrust and size to facilitate handling of floating plant that would be used in a recovery operation.

(3) Recommend each district fabricate or procure effective power-driven cutting beams to separate barges wrapped around the dam pier structures.

(4) Recommend technical assistance from HQUSACE and other engineer agencies, such as Engineer Research and Development Laboratories, to determine feasibility of utilizing explosive anchors for emergency mooring of recovery rigging to the lock and dam structures.

(5) Recommend each district examine its capabilities to ensure the following: capability for rigging of heavy wire ropes and chains, and for underwater cutting of steel by torch; development of sounding techniques to accurately determine the underwater positions of sunken barges and obstructions; provision of heavy anchors, and of suitable anchor derrick and winch barge for use in safely positioning floating plant above dam; supply of assorted heavy slings and haul cables with suitable terminal fittings and quick-release devices; development of grappling devices and techniques for quick attachment of haul cables to submerged barges not accessible for conventional attachment; development of equipment and techniques for quick introduction of compressed air into sunken barge compartments; and provision of adequate radio communications during recovery operations between government, navigation, and contractor interests.

e. Modification of lock and dam structures.

(1) Recommend provision of adequate facilities on river walls, piers, and abutments both upstream and downstream of navigation structures for positioning floating plant and for rigging during recovery operations.

(2) Recommend design and procurement of special lifting beams for use with overhead bulkhead cranes.

(3) Recommend engineering, economic, and feasibility studies to provide for use of versatile overhead piggy-back cranes of 50-ton capacity and for clamshell bucket operation and lowering of personnel to work areas.

(4) Recommend engineering and economic feasibility studies for pre-installation of chain slings in gatebays to expedite removal of objects with bulkhead crane.

(5) Recommend each district install anchor bolts on river wall immediately upstream of the dams to facilitate timely installation of portable winches.

f. Organization.

(1) Recommend each district organize a marine disaster recovery team to ensure adequate supervision of three-shift recovery operations over an extended period.

(2) Recommend each district have a trained, experienced Technical Liaison Office as a single point of contact for coordination of public information activities during emergencies.

(3) Recommend each district maintain a current list of marine contractors and contractors' equipment available for possible use in marine disaster recovery operations.

(4) Recommend that periodic seminars be conducted with key personnel, such as Chiefs of Branches and Construction Resident Engineers, reviewing plans and capabilities and pre-establishing key emergency team members for recovery operations.

g. Applications. Not all the above recommendations will be possible or practical in every Corps district with navigation dams. The recommendations appear to be written more specifically for the navigation dam projects on the Ohio River. Some of the recommendations have been implemented and some have not. It is recognized that some of them would be difficult to design into a project and would be very expensive.

C-8. Maxwell Incident of 1985 (Pittsburgh District)

a. General. On November 5, 1985, as a direct result of storms generated by Gulf storm "Juan," floodwaters in the Monongahela River basin reached record levels in many locations from Charleroi, Pennsylvania, south into the mountains of West Virginia. As a result, as many as 120 barges that had been moored at various landings in the navigation pool broke their moorings and began to float downstream. As they moved in their uncontrolled journey, some were intercepted by towboat crews, some were beached on lowland areas, and others either sank or ended up against highway or railroad bridges or Corps of Engineers dam piers.

(1) At the Maxwell Locks and Dam project located at river mile 61.2 on the Monongahela River, 20 coal barges, both loaded and empty, either individually or in groups of two or three, approached the dam, which had all five of the 84-ft-wide tainter gates in the fully open position. Two barges passed through the gate bays and sank just downstream of the dam. The other 18 impacted on the dam piers and stacked themselves up in positions that required much effort and time to remove. Four empty barges were still afloat and were retrieved by government and contractor towboats. The remaining 14 barges either sank or became entangled against the dam piers or rested broken atop the upper guard wall. The positioning of the barges around the piers prevented four of the five 84-ft tainter gates of the dam from closing, and this resulted in the eventual loss of the Maxwell pool.

(2) At Locks and Dam 2 at mile 11.2 on the Monongahela River, seven barges (six coal and one tanker) floated uncontrolled into the locks and obstructed navigation through the two lock chambers. The empty tanker barge came to rest nearly perpendicular to the river flow and balanced itself across the land wall just upstream of the land chamber emergency dam. It extended some 80 ft into the upper approach to the large lock chamber. An empty coal barge came to rest atop the upper middle wall and upper guard wall, completely blocking the upper approach to the small lock chamber and virtually all of the approach to the large lock chamber. An empty coal barge remained buoyant on one end just upstream of the river chamber's emergency floodway bulkhead for a short time after the waters receded below the top of the lock walls. As the lock crew removed the last panel of the floodway bulkhead after closing the downstream lock gates, the barge surged downstream, hit the bulkhead panel, and later sank within the small lock chamber. Another empty coal barge sank across the upper middle wall, obstructing both lock approaches. Two more empty coal barges sank across the upstream end of the guard cell. In addition, another empty coal barge impacted against this guard cell and rested atop the two other sunken barges.

(3) Numerous other barges and pleasure boats were observed going over the fixed-crest dam during the height of the flood.

b. Causes of incident.

(1) Highest flood of record on the Monongahela River basin.

(2) Possible inadequate mooring of some barges which broke away and impacted other moored barges, which then also became free-floating and uncontrolled.

c. Major impacts of incident.

(1) The blocking of navigation traffic at Lock 2 and the loss of the Maxwell pool caused navigation traffic to cease on the Monongahela River for some six weeks. As a result of this traffic stoppage and its ripple effect on dependent business interests, plus loss of the barges, tremendous economic losses were incurred.

(2) Structural damage to Lock 2 and to Maxwell Dam.

(3) Damage to highways and highway bridges, and railroads and railroad bridges.

(4) Four municipal water companies with intakes in the Maxwell pool were adversely affected and had to have special help from Corps personnel in order to maintain water services to their customers.

d. Recovery operations. The overall recovery operations to restore normal navigation traffic movement on the river and to return all other affected interests to their fully operational conditions were conducted November 5, 1985, through December 16, 1985. The United States Coast Guard, the commercial towing industry, the affected water companies, salvage contractors, and explosive demolition contractors joined the Corps of Engineers in this recovery effort.

e. Summary of recommendations based on November 1985 Maxwell Incident. The following emergency action plans were suggested by the Pittsburgh district as observations and recommendations for consideration by all Corps organizations when preparing for or responding to similar incidents.

(1) Contingency plans should be developed by every interest that would be affected when a pool is lost.

(2) River recording gages and staff gages should be protected as well as possible from the effects of flooding. Staff gages should be placed in such a way that they can be observed at all times.

(3) Operational contingency plans covering all types of emergencies should be prepared for all district installations, particularly navigation dams.

(4) Minutes of meetings, daily memos of organization activities, and cataloging of slides and photos are necessary during all recovery activities for future report preparation and for use in any subsequent litigation.

(5) Maintain close contacts with the National Weather Service.

(6) Involve affected commercial navigation interests as soon as possible after an incident.

(7) The Corps should take the lead in helping navigation interests develop standardized mooring facilities and procedures for assuring their proper and continued usage.

(8) Conduct research on physical and economic feasibility of constructing a structural barrier just upstream of each gated dam.

(9) Assure that radio contact will always exist between locks and the District Office.

(10) Determine the availability of horizontal pulling equipment that could be readily contracted in an emergency.

(11) Establish separate account numbers to identify efforts expended on each vessel and the separate identifiable tasks involved in the total operation.

(12) Notify railroad and highway interests when conditions indicate that loss of a navigation pool is imminent.

f. Report. A comprehensive report covering all aspects of this incident can be obtained from the Pittsburgh district. The report, dated December 1986, is entitled "After Action Report - Monongahela River Barge Breakaway Incident - November 1985." Excerpts from the Pittsburgh report have been used in this manual.

C-9. Maxwell Incident of 1990 (Pittsburgh District)

a. General. During December 1989, Pittsburgh district rivers and adjoining streams were frozen with thickening ice. The United States Coast Guard issued three notices to mariners between December 21 and 26, 1989, warning that icing conditions were continuing to worsen along the Allegheny, Ohio, and Monongahela Rivers with reports of ice ranging from four to eight inches thick; that operators of fleeting areas be advised to remain on constant alert for ice floes which might cause barge breakaways when temperature rises occur; and that operators double up on their mooring lines, provide for towboat assistance, and keep a constant surveillance of their fleeting areas to minimize barge breakaways.

(1) A combination of moderation of the weather and heavy rains between December 29, 1989, and January 1, 1990, caused breakup of ice in the river and melting of some snow on the watershed. This combination of events caused flooding and movement of ice on the Monongahela River. The fast-flowing high water and breaking ice jams knocked about 60 barges from their moorings on

January 1, 1990, along the Monongahela and Ohio Rivers and slammed the barges into bridges, locks, and dams. Thirty-seven coal barges moored at a coal-processing facility in the Maxwell pool broke their moorings and began traveling downstream. Upon reaching the Maxwell Locks and Dam, two of the barges passed through the gate bays and sank downstream of the dam, and one barge sank about 1 mile upstream of the dam. The remaining 34 barges collided with the dam piers and stacked up on one another and sank.

(2) Fourteen barges were also adrift in the lower Monongahela River below Maxwell Dam and the adjacent Ohio River. These barges were retrieved before they could cause any extensive damage. Some bridges on the Monongahela and Ohio Rivers were damaged by the runaway barges in the Maxwell pool and downstream to Pittsburgh.

b. Causes of incident.

(1) Flooding and ice floes caused by rising temperatures, heavy rains, snow melt, and ice break-up.

(2) Possible inadequate mooring of some barges, which drifted downstream and caused other barges to break their moorings.

c. Major impacts of incident.

(1) Thirty-four barges collided with the Maxwell Dam piers and sank after piling on top of each other as described above.

(2) One spillway gate at Maxwell Dam could not be closed.

(3) Tainter gates and steel sheet piling at Maxwell Locks and Dam suffered structural damage.

(4) Dollar losses for barges and for coal on barges were sustained.

(5) Five bridges hit by the barges were temporarily closed.

(6) Drawdown of Maxwell pool affected water supply facilities and navigation traffic.

d. Recovery operations. Recovery operations spanned the period January 1, 1990, through February 19, 1990. Restoration of all facilities to pre-incident conditions involved concentrated efforts by government forces, private towing companies, marine surveyors, salvage contractors, and local affected interests.

e. Summary of recommendations based on January 1990 Maxwell Incident. The following emergency action plans were suggested by the Pittsburgh district as observations and recommendations for consideration by all Corps organizations when preparing for or responding to incidents similar to this one.

(1) Require all facility operators with Waterfront Facility Operation Guides to revise their guides to include precautionary procedures to follow in river icing and ice flow conditions.

(2) Provide a public affairs representative immediately after an incident for media and general public contacts. Station this person in the project manager's office until a separate public affairs facility is established.

(3) Equipment for salvage of sunken barges should include:

(a) Two A-frames with a minimum lifting capacity of 200 tons each.

(b) Four derrick boats with 100 ft of boom and lifting capacities between 50 and 150 tons.

(c) A clam shell bucket without teeth having a capacity of 3 to 4 cu yd.

(d) Two horizontal pulling winches having a minimum pulling capacity of 100 tons each.

(e) Two towboats with a minimum of 800 hp.

(4) When salvage work requires a diver, it is recommended that the Corps require salvage contractors performing diving operations to have a standby diver equipped with scuba gear tend the first diver, due to unpredictable and dangerous conditions associated with the diving activities.

f. Report. A comprehensive report covering all aspects of this incident can be obtained from the Pittsburgh district. The report, dated January 1991, is entitled "After Action Report - Monongahela Barge Breakaway Incident - January 1990." Excerpts from the Pittsburgh report have been used in this manual.