

**OFFICE OF BRIDGE DEVELOPMENT
MANUAL ON HYDROLOGIC AND HYDRAULIC
DESIGN**

**CHAPTER 7
SCOUR CRITICAL BRIDGES**



SEPTEMBER 2007

Please note that Chapter 7 is under revision to incorporate a
Plan of Action for County Bridges

**PLAN OF ACTION FOR SCOUR CRITICAL BRIDGES
MARYLAND SHA OFFICE OF BRIDGE DEVELOPMENT (OBD)**

SEPTEMBER 2007

1. OVERVIEW.

A. PLAN OF ACTION (POA) DATA BASE

The Office of Bridge Development has developed a Data Base for tracking the status of scour critical bridges. The POA Data Base is maintained by the Interdisciplinary Scour Team. This database consists of three parts:

1. Basic information on the bridge regarding its location, Plan of Action category, Item 113 rating, plans and schedules for installing scour countermeasures, etc.
2. Electronic links to other data bases and information in the Bridge Management Files:
 - Bridge Development (bridge plans, photos, borings, etc.)
 - SI&A (ratings and appraisals) for Item 113, Scour Critical Bridges; Item 61, Channel and Channel Protection; Item 71, Waterway Adequacy, etc,
 - BIRE Work List for proposed scour countermeasures and other bridge work.
 - OBD Plan of Action Overview (Word Document)

Various other information sources (hard copy) files in the Office of Bridge Development are available to augment the electronic files including:

- H&H files for scour evaluations for riverine and tidal bridges
- BIRE files for (1) Soundings and (2) Underwater Inspections
- Standing arrangements with District Office personnel regarding bridge closures, detours and other coordination during periods of flooding.
- Standing arrangements with the Office of Public Affairs concerning dissemination of public information.

The input form for the database is presented on the following page.

Maryland State Highway Administration
Office of Bridge Development

PLAN OF ACTION FOR SCOUR CRITICAL BRIDGES
DATABASE

Bridge Number	
Route No.	Waterway
County	District
Foundations: 1 Spread footing__ 2 Pile__ 3 Paved__ Unknown__	
OBD Contact Person:	
District Contact Person:	
Scour Vulnerability	
(Refer to OBD Plan of Action Overview for further information)	
Current Item 113 Rating	
Previous Rating(if different)	Date
Plan Of Action Category (check all that apply)	
<ul style="list-style-type: none"> • Monitor • Underwater Inspection • Install Countermeasures • Other (Special Considerations) 	
Source of Rating (1.field inspection; 2. office evaluation)	
Scour Critical Foundation Elements (list)	
Scour Evaluation History, Summary and Recommendations (provide written description):	
HYPERLINKS <ul style="list-style-type: none"> • File Room Bridge Development • SI&A Data Base • BIRE Work List (Scour Countermeasures) • OBD Plan of Action (Overview) 	

B. ITEM 113 CODES

OBD uses the following codes to describe categorize Maryland Bridges for Item 113, Scour Critical Bridges:

N – Bridge not over a waterway

9 – Bridge foundation, including piles, well above flood waters

8P – Bridge is a culvert type structure with a paved bottom

8L – Bridge has been evaluated/assessed as a low risk structure, and no further evaluation is planned

7 – Countermeasures have been installed to mitigate a previously existing scour problem. Risk of failure during or immediately after flood event is reduced.

6N – Bridge has not been evaluated for scour

6R – Bridge is scheduled for major rehabilitation or replacement within the next 5 years. The scour study is deferred to the location/design phase of the bridge. Periodic monitoring may be necessary.

6T – Bridge over tidal waters has not been evaluated for scour, but considered low risk. Bridge will be monitored until an evaluation is performed.

6U – Bridge foundations are unknown; the bridge site conditions have been evaluated/assessed with cursory study in the field and office and the risk of potential damage from scour is judged to be moderate or mild. Structure has no history of scour problems. Further evaluation is deferred.

5 – A detailed scour study (analysis) has been made and the structure is rated as stable.

4 – Bridge foundations determined to be stable based on a scour evaluation and/or analysis. Bridge inspection reveals that action is needed to protect exposed piles from effects of additional erosion or corrosion

3A Bridge is rated as scour critical based on an evaluation and/or analysis. The potential risk is judged to be mild, and no actions are planned other than monitoring.

3B Bridge is rated as scour critical based on an evaluation and/or analysis. The potential risk is judged to be moderate, and no actions are planned other than monitoring.

3C Bridge is rated as scour critical based on an evaluation and/or analysis. The potential risk is judged to be severe, and scour countermeasures are planned. Monitoring is to be performed until scour countermeasures are in place.

2 Bridge is scour critical. Field review indicates that extensive scour has occurred at a bridge foundation. Immediate action is required to provide scour countermeasures.

1 Bridge is scour critical. Field review indicates that failure of piers/abutments is imminent; bridge is closed to traffic.

0 Bridge is scour critical. Bridge has failed and is closed to traffic

Please refer to the Attachment for a breakdown of on-system and off-system bridges in each of the code categories listed above.

C. MANAGEMENT STRATEGY

OBD has developed a management strategy for dealing with scour critical bridges based on the following concepts:

- Maryland has no bridges on interstate/major highways that are coded as scour critical. The typical scour critical bridge is an older structure located on a secondary highway.
- Maryland has no bridges on large rivers that are coded as scour critical. The typical scour critical bridge is located on a small stream with a small drainage area and a relatively short time to peak for flood hydrographs. This makes it impractical to get crews to each scour critical bridge to monitor the structure during the rising limb of the flood hydrograph.
- A flood represents a dynamic event during which conditions may change by the hour. It is our experience that “paper” plans prepared years before a flood event occurs may turn out to be inadequate to address the actual situation on the ground. This can be particularly true for deciding on matters such as detour routes for closed bridges. It is our view that such decisions are best made by a coordinated approach between OBD and the District Office based on current conditions.
- Maryland is a relatively small state in which all of our bridges can be reached by OBD personnel in a matter of a few hours. OBD inspection teams are well organized and maintain close communications via cell phones with the OBD Office in Baltimore and with their counterparts in the District Offices.
- The key elements of an effective plan of action include experienced inspectors who are knowledgeable about the bridges assigned to them, and good coordination between the inspectors in the field and the OBD and District Offices.

- OBD has taken a conservative approach in designing bridges to resist scour, and in coding bridges as scour critical. Further, OBD pursues a pro-active approach in monitoring, inspecting and protecting the foundations of scour critical bridges. To date, the program has been successful in minimizing damage to bridges from scour and in protecting the safety of the public.

2. PLAN OF ACTION

Based on the management strategy described above, OBD has developed the following general Plans of Action (POA's) for dealing with scour critical bridges. Each scour critical bridge, depending upon its Item 113 code, is assigned one of the plans of actions described below. Bridges with a rating of 3A or 3B are assigned a Plan of Action for Monitoring. Bridges with a rating of 3C are assigned a Plan of Action for Installing Countermeasures. Bridges with special conditions may be assigned a Plan of Action for Special Structures. These general plans of action are described below. Details of the inspection procedures are set forth later on in this Plan of Action.

A. Plan of Action for Monitoring

This POA applies to bridges rated as 3A or 3B. These bridges are inspected on a regular frequency of two years (5 years for underwater inspections), as well as after major storms.

Flood Events:

- a. Pre-event preparation: Impending major storms and hurricanes are regularly and carefully tracked and identified by the media in Maryland. For any type of region-wide storm, there is usually ample time to mobilize the inspection teams.
- b. All scour critical bridges have been identified and are known to the bridge inspectors. All inspection teams have laptop computers containing detailed files of their assigned bridges that they take to the bridge site during inspections.
- c. In addition to the OBD bridge inspectors, there are also District personnel (who are familiar with the problem bridges in their districts) as well as law enforcement officers who are on the road during the onset of a major storm. Communications of these various monitoring groups are coordinated through the District Office.
- d. When a bridge overtops, the road is closed. The road remains closed until after the bridge is inspected by OBD and found to be stable. This inspection typically occurs after the flood waters recede, especially if an underwater inspection is necessary. The decision to close the road is made by the District who is also responsible for erecting appropriate barricades at the bridge and for establishing and marking detour routes when necessary. (However, if a bridge failure is imminent, anyone can stop traffic and close the road until such a time as District Office personnel arrive.) The decision to post a law enforcement office at the bridge is made on a case-by-case basis depending on the particular circumstances surrounding the bridge closure. This is not a common decision. The District decides when to reopen the road.

- e. A bridge may be closed even if the bridge/roadway does not overtop, although this particular condition does not occur very often.
- f. All public information statements regarding road closures, emergency traffic plans or other communications with the media are handled by the SHA Office of Public Affairs. Engineers from the District and OBD remain in close communication with the Office of Public Affairs regarding the details of such statements.
- g. Emergency actions to protect a bridge undergoing severe scour may be necessary under some conditions. Sources of riprap or other materials are known to District personnel. Arrangements for obtaining the services of OBD and District contractors for delivering riprap to the site are based on various factors such as the proximity and availability of equipment at these sites or in the District offices.

Scheduled Inspections

The procedures followed during scheduled inspections are described on Page 9.

B. Plan of Action for Installing Countermeasures

This POA applies to bridges rated as 3C or lower. Bridges coded as 3C are inspected and monitored following the regular procedures used at all scour critical bridges described in the POA 1 for Monitoring. In addition, the 3C bridges receive first priority in regard to monitoring during flood events. The frequency of regular inspections is established for each 3C bridge depending of the degree of risk that exists at the site.

A part of the plan of action for each 3C bridge is to take action as soon as possible to reduce the scour problem by providing scour countermeasures. Scour countermeasures are classified as temporary or permanent measures.

Temporary measures are installed to protect the bridge for a limited time period. These measures (for example grout bags) may be effective for a structure that is scheduled for replacement in the near future, but requires additional protection for the interim period. Depending on the type of temporary countermeasure and its performance after installation, the structure may still be classified as scour critical; alternately, with good performance of the scour countermeasure over time, the structure may be reclassified with a rating of 7.0 (See also Scour Countermeasures below).

Permanent measures are those designed and constructed in accordance with the OBD Manual for Hydrologic and Hydraulic Design. Such measures would normally consist of installing a riprap blanket. However, there are many other measures that could be taken to address a particular type of problem (underpinning, sheeting, channel modification, rock channel control structures, etc.) The appropriate choice is selected by the engineer. After installation of a permanent measure, the Item 113 rating is changed in accordance with the type of countermeasure installed. Options include codes of 7 (for a riprap

countermeasure); 5 or 8 (low risk for a major structural underpinning or reconstruction) with appropriate scour evaluation.

C. Plan of Action for Special Structures

There are certain bridges for which a specific Plan of Action may be developed to address special site conditions existing at the bridge. The original Woodrow Wilson Bridge, before it was torn down, was placed in this category, even though it was not rated as a scour critical bridge. The POA for the Woodrow Wilson Bridge is included on the following pages. The special site conditions for this bridge include:

- A major interstate highway carrying extremely high traffic volumes
- A concern with the scour potential in the event of a major flood.
- Use of sonar scour meters to monitor scour
- High flow depths during flood stage
- A number of jurisdictions involved in a traffic plan for rerouting of traffic in the event of a bridge closure.

3. HISTORY AND CURRENT METHODS OF THE OBD BRIDGE SCOUR PROGRAM

A. PROGRAM INITIATION

The Office of Bridge Development (OBD) implemented a program in the early 1990's for the inspection of bridges for Item 113, Scour Critical Bridges. This program remains in effect today, and has served effectively to:

- identify bridges with actual or potential scour problems
- establish a process for taking action to minimize the scour problems and
- minimize any safety hazards to the public.

This program has been implemented for all publicly owned bridges in Maryland (SHA, federal, county and municipal bridges). The actions described below by OBD have been carried out by non-SHA bridge owners as well. Basic elements of the program include:

- Use of Interdisciplinary Scour Teams comprised of USGS Hydrologists, OBD Bridge, BIRE and Hydraulic Engineers and Soils and Geologists from the Brooklandville Labs.
- Scour evaluations/assessments of all bridges and subsequent rating of all bridges for Item 113, Scour Critical Bridges.
- An active inspection and monitoring program.
- Prompt actions to minimize any safety hazards to the public due to scour by a) bridge rehabilitation or replacement or b) installation of scour countermeasures.
- Training of bridge inspectors with regard to the scour program.
- An active cooperative program with county and municipal bridge owners

Early coordination and training sessions were set up with county engineers so that their process for evaluating Item 113 Scour Critical Bridges was consistent with the OBD Program. OBD also assisted in selecting and training the consultants to conduct the Item 113 scour evaluations of county bridges.

OBD has continued this cooperative program with the counties up to the present time. Primary emphasis is on maintenance of the bridge data base (SI&A forms) and on general oversight of the county scour programs.

OBD recognizes the value of training in the scour monitoring program Bridge inspectors attend periodic in-house training sessions regarding the procedures to follow and the appropriate actions to take regarding bridge inspections and follow-up actions.

B. INITIAL RATING OF SCOUR CRITICAL BRIDGES

In the early 1990's OBD developed a detailed procedure for rating bridges for Item 113. The procedure consisted of a risk-based approach taking into consideration such things as:

- Bridge history and performance over its service life
- Information from the SI&A files
- Whether the bridge in on a tidal or non-tidal waterway.
- Estimated flood discharges and velocities provided by the U.S. Geological Survey
- Bridge plans, including foundation types, pile lengths, etc.
- Subsurface soils and rock, borings, etc.
- Information obtained from field inspections
- Any unusual or unique features existing at the bridge site.

Based on the above data, the Interdisciplinary Team rated each bridge as low risk or scour critical. The use of Category 6U, unknown foundation, was used in the item 113 evaluation primarily for bridges on spread footings. A cooperative program with the soils engineers was initiated to investigate all such 6U sites as described below. The data and scour evaluations for each OBD bridge are available to bridge inspectors in a special Item 113 file located in OBD.

C. CURRENT RATING SYSTEM FOR SCOUR CRITICAL BRIDGES

As noted above, all Maryland bridges have been rated by interdisciplinary teams. With few exceptions, the bridges are placed in one of the following categories:

- Low risk, ratings 5, and 8
- Scour countermeasures installed, coded as a 7
- Scour critical

Inspection Procedures

Scour critical bridges are subdivided in three categories as 3A mild risk, 3B moderate risk or 3C severe risk. In rare cases, a bridge in very bad shape may receive a rating of 2 or 1. Category 3A and 3B bridges are monitored on a two-year schedule (5-year schedule for underwater inspections) as well as after significant flood events:

- If there is a significant change observed at the bridge site, the bridge inspector issues a “screamer” for immediate attention of the OBD managers. Actions may range from bridge closure to a change in the Item 113 rating code.
- The SHA District Engineer may be notified for further action when appropriate.
- The interdisciplinary scour team is normally requested to review changes in the scour critical classifications.
- Category 3C bridges may be monitored more frequently than the two year schedule depending on the perceived risk, and require further action to protect the bridge. Arrangements are made as soon as possible for installing either temporary or permanent scour countermeasures, depending on such considerations as the degree of severity of the scour and the future plans for bridge replacement.
- Inspection procedures include evaluation of the superstructure, substructure, riprap/scour countermeasures and measurements of the stream channel upstream, through and downstream of the bridge. Stream measurements are compared with previous inspection results. Significant changes of 2 feet or more require preparation of a screamer and notification to the interdisciplinary team. The amount of debris at the structure is evaluated, and recommendations are made when judged necessary for debris removal. Written guidance as to what to look for in a bridge inspection is set forth in the OBD Inspectors Guide.

If a fully designed and installed riprap scour countermeasure is provided to protect a bridge with a scour problem, the Item 113 category is changed to a 7. If special structural measures and studies are taken to protect the bridge at the vulnerable substructure unit, the bridge could be rated as a 5. On the other hand, if a temporary scour countermeasure such as grout bags is used for protection, then a bridge with an Item 113 rating of 3C may have the rating reduced to a 3B or 3A. This use of a temporary scour countermeasure is often used at a bridge that is scheduled for rehabilitation or replacement in the near future. If the temporary measures are observed to perform in a satisfactory manner, this rating may be upgraded to a 7 after a period of time.

D. SCOUR COUNTERMEASURES

Scour countermeasures in use in Maryland include:

- Temporary measures such as grout bags to protect a structure until a more permanent solution to the scour problem is constructed. A scour critical bridge may be classified as a 3A, 3B if temporary measures are used. The installation may also be upgraded to a Code 7 if it performs satisfactorily.

- Permanent measures where a designed and constructed riprap installation based on OBD design criteria is used. The item 113 scour critical rating is changed to a 7 for this type of installation.
- Judgment is involved in the rating of a bridge at which scour countermeasures have been installed. Even if a “permanent measure” such as riprap has been installed at a scour critical bridge, the bridge is still checked out along with the other scour critical bridges during a flood event. On the other hand, a Category 3C bridge at which a temporary measure such as grout bags is installed may have the rating code reduced to a 3B or 3A, but it is still carried as a scour critical bridge. However, the code for the grout bag installation may be changed to a 7 if, in the opinion of the inspectors/interdisciplinary scour team, the grout bags perform satisfactorily for a reasonably long period time. Such decisions are made on a case-by-case basis, always keeping in mind the safety of the public. The coding of a bridge scour countermeasure is always subject to change, depending on its current condition and performance.
- Structural measures such as underpinning of piers, etc. The item 113 rating is revised in the appropriate manner.
- Bridge reconstruction or replacement, designed in accordance with OBD criteria and studies. The Item 113 rating is changed to a 5.
- Monitoring using instruments such as was done with the Woodrow Wilson Bridge.

E. UNKNOWN FOUNDATIONS

1. Spread Footings

SHA has taken a conservative, risk-based assessment approach to rating bridges for Item 113. Early priority attention was given to structures on spread footings, and many such structures were classified as scour critical. The footings of a number of old bridges built in the 1930’s and 1940’s were designed by the Project Engineer in the field. In some cases, the as-built plans were lost over time so that the footing elevations were no longer documented. All such structures were identified and prioritized. A program was then initiated to drill through the footings of these bridges, determine the elevation of the footing and the material on which the footing was placed. The Item 113 rating was then reassessed based on the outcome of the subsurface explorations.

Most of these structures have been in place for many years and have not experienced scour damage. For the most part, they are considered to have a low risk of experiencing significant scour damage. The interdisciplinary team continues to analyze these bridges as time and resources permit.

2. Pile Foundations

There are a number of OBD structures for which pile tip elevations are not known.

OBD’s approach to evaluating these bridges for Item 113 has been as follows:

- At an early date in the scour evaluation program, a directive was sent to construction personnel advising them of the need to document pile tip elevations on the as-built plans for new SHA structures. Recent follow-up reviews have indicated that this procedure has not always been followed in recent years in some District offices, and OBD is taking action to remind the Districts of their responsibility in this regard.
- As noted in the above section on “Initial Rating of Scour Critical Bridges”, an intensive scour assessment review was made of every SHA Bridge. A similar approach was followed by the County Engineers. Based on the results of this assessment, bridges were categorized as low risk or scour critical, even though the pile tip elevations were not always documented on the plans. Two examples of this risk assessment process are cited below to illustrate the approach taken:

Example of a Non-tidal Bridge: Route 1 Northbound over the Patuxent River.

The old plans for this bridge contained information on the subsurface soils and depicted rock within a short distance below the stream channel. The piers near the channel were on piles. The judgment of the Interdisciplinary Team was that a reasonable engineer would drive the piles to rock. The bridge was rated on this basis.

Examples for Tidal Bridges

OBD made a hydraulic review of 256 tidal bridges. With few exceptions, these bridges are located on streams or estuaries tributary to the Chesapeake Bay. The hydraulic analyses indicated that in most cases flow velocities and resulting scour would be low, even for the 100-year flood. Since these bridges, for the most part, are founded on piles, the risk of scour damage was found to be minimal and the bridges were rated as low risk.

However, this evaluation process also revealed locations where a tidal basin is constricted by the highway structure and where high flow velocities occur for major flood events. In one case, MD 286 over Back Creek near Chesapeake City on the Eastern Shore, scour at the existing bridge was severe and the bridge was replaced with a new structure, designed for the anticipated scour depths.

4. SUMMARY

In summary, the OBD approach to rating bridges with unknown foundations for item 113 Scour Critical Bridges is as follows:

1. Collect information (hydrology, hydraulics, structural design data, soils, etc.) about each structure from field and office investigations.
2. Use the interdisciplinary scour team to make a judgment about each bridge with unknown foundations for Item 113 using the results of the investigations. SHA has taken a generally conservative approach in making such judgments.
3. Install countermeasures wherever appropriate to minimize the risk of scour damage or bridge collapse
4. Continue to inspect and evaluate the bridges and to revise the item 113 rating as appropriate

Plan of Action for Scour Monitoring of the Original Woodrow Wilson Bridge

1. BACKGROUND

Traffic is now being carried by the new Woodrow Wilson Bridge and the old bridge has been demolished. Until the traffic was shifted to the new bridge, however, the existing bridge was monitored for scour to assure that it remained in a safe operating condition for its remaining service life.

Scour monitoring was initiated in 1999 and sonar devices were installed on five piers. Monitoring of these 5 piers (See table below) was continued until traffic was shifted off the bridge. There have been some gaps in the records due to technical problems with the meters and the remote communication system; however, the record to date indicates that measured scour was very small and did not represent a significant concern regarding the stability of the bridge. An overview of the monitoring program is outlined below:

2. MONITORING RESPONSIBILITIES

The Office of Bridge Development (OBD) has primary responsibility for oversight of the monitoring system:

- The Structure Hydrology and Hydraulics Unit (H&H) will download the data from the bridge at least once per month. More frequent readings will be obtained in the event of a flood event, or if the scour plots indicate any significant change in the channel elevations.
- If there is a problem in downloading the data, H&H will contact Bea Hunt of the consultant firm of Hardesty and Hanover. Hardesty and Hanover will make remote checks to troubleshoot the electronic system. If a visit to the site is required, Hardesty and Hanover will make appropriate arrangements for repairs after receiving approval from OBD to make the field visit and carry out the repair work.
- H&H will work cooperatively with the Bridge Inspection and Remedial Engineering Unit to expeditiously authorize funds for any needed repair work.

- The firm of Whitman, Requardt and Associates (WRA) has the overall contract for maintaining the Woodrow Wilson Bridge. All funding transactions will be carried out through arrangements with WRA.

3. MONITORING DURING FLOOD EVENTS

In the event of a flood event, the downloading of scour readings will be increased as necessary to assure continued safe operation of the bridge.

Previous evaluation structure stability studies have been carried out for the purpose of determining alert depths, action depths and failure depths as depicted in the table below.

Action Plan Scour Critical Depths

(Established in a 1999 Report by WRA entitled Pier Analysis and Target Scour Depths)

Pier ID Number	Channel Elevation	Alert Depth	Action Depth	Failure Depth
1W	-34.7	-45	?	
1E	-36	-45	?	
25E	-10	-13	-23	-32
27 E	-17	-17	-24	-33
29 E	-16	-17	-24	-29.4
V1	-34.7	-45	?	
M1	-36.2	-45	?	

4. ALERT DEPTH

If the “Alert Depth” elevations are recorded by the scour equipment, OBD will initiate a more intense monitoring program that may include:

- Confirm scour depths by on-site inspectors using portable scour equipment (This will be more easily accomplished for Piers 25E, 27E and 29E; it may be more difficult for Piers 1E and 1W, the bascule piers for the existing bridge)
- Increased frequency of downloading scour data,
- Diving inspections of scoured piers, if conditions permit,
- Notification of appropriate agencies of the possible need for a traffic detour plan. The SHA Statewide Operations Center will coordinate with other jurisdictions in developing a plan for rerouting of traffic.

The alert depth elevations for Piers 27E and 29E have occurred more or less continuously at various times during the monitoring period, and in fact were recorded during bridge inspections before the monitoring system was initiated. These alert depths were established in a very conservative manner. With the experience gained through the monitoring program, they are no longer considered to be critical values to trigger the “alert depth” actions noted above. However, any further lowering of the channel bed for these piers will be monitored at frequent intervals to determine whether a trend of increased scour is occurring and whether the “alert depth” program should be initiated.

Please note that Piers V1 and M1 are the piers for the main bascule span for the new bridge. These piers will also be included in increased monitoring activities triggered by any “alert depth” actions.

5. ACTION DEPTH

If scour proceeds to the “Action Depth” elevation, OBD will take immediate action to protect the bridge and ensure the safety of the public. Such actions may include:

- Placement of scour countermeasures (riprap) and/or
- Bridge closure and rerouting traffic in accordance with the plan established by the SHA Statewide Operations Center.

6. CONTACT PERSONNEL

Name	Work Number	Cell Number	Home Number
Earle Freedman, Director OBD	410 545-8060		
Robert Healy, SHA	410 545-8063	703 898-5913	410 721-4317
Joseph Miller, SHA	410 545-8311	443 690-6080	410 239-3724
Andy Kosicki, SHA	410 545-8340		410 747-8331
Len Podell, SHA	410 545-8363		
SHA Statewide Operations Center	410 582-5605 or 410 582-5630		
Bea Hunt, Hardesty and Hanover	212 944-1150 ext. 3203		718 263-5479
Bill Geschrei, Whitman Requardt and Associates (WRA)	410 480-1610	410 952-2626	