

# ABOVE WATER INSPECTION OF EXISTING CONCRETE BULKHEAD ALONG THE WINDMILL HILL PARK

**DATE:** January 23, 2009

**LOCATION:** Windmill Hill Park Waterfront  
Alexandria, VA

**INSPECTION TEAM:** Bradford K. Hull, P.E (RK&K)  
Karl Stegmann, P.E. (RK&K)

**WEATHER CONDITIONS:** High 31° F  
Low 20° F  
Mostly Cloudy AM  
Sunny PM

**TIDAL INFORMATION:** 12:22 A.M. Low Tide (0.0 Feet)  
6:07 A.M. High Tide (2.2 Feet)  
12:13 P.M. Low Tide (0.0 Feet)  
6:24 P.M. High Tide (2.5 Feet)

## LOCATION MAP:



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Rummel, Klepper & Kahl, LLP (RK&K) was tasked by The City of Alexandria to conduct an above water inspection on the existing concrete bulkhead located at the Windmill Hill Park in the City of Alexandria, Virginia. On January 23, 2009, the bulkhead was inspected to evaluate its current condition. Since structural plans of the bulkhead are not available, RK&K cannot perform an analysis of the existing structure to establish stability or structural adequacy. Findings and recommendations resulting from this inspection are based solely on data collected at the time of this inspection.

## **DESCRIPTION**

The bulkhead is situated around the perimeter of a cove located on the western bank of the Potomac River approximately half (0.5) mile upstream of the Woodrow Wilson Bridge. The north and south quadrants in the vicinity of the bulkhead are residential townhouses: Harborside and Ford's Landing, respectively. To the immediate west of the bulkhead is an open park area. The bulkhead is open to the public.

The Potomac River is subject to a tidal flow with a high tide elevation of +2.5 ft and low tide elevation of 0.0 feet per the attached tide table in Appendix C. The cove has no protection from waves and flotsam. Ice was observed in the cove at the time of inspection and covered approximately 75% of the water surface in the cove.

The bulkhead consists of two distinct structure types. The north bulkhead wall is approximately 285 feet long and consists of concrete walkway slabs supported by timber sheeting (Photo 21). The concrete walkway is located approximately 3 feet above the mean low water elevation. A concrete retaining wall with brick facing supports the remaining excavation. The second portion of the bulkhead is a full height concrete retaining wall with timber sheeting below the waterline (Photo 10). The top of wall was measured at 6.5 feet above the mudline on the western cove wall. Concrete walkway slabs are located 2 to 5 feet inshore of the top of the concrete bulkhead in this portion of the bulkhead. The structural foundation type of the existing bulkhead is unknown at the time of this inspection. The investigation and inspection of the foundation system was not part of the scope of this inspection.

## **FINDINGS**

The bulkhead will be divided into four different segments (See Appendix B):

1. West River Wall
2. South Cove Wall
3. West Cove Wall
4. North Cove Wall

### WEST RIVER WALL:

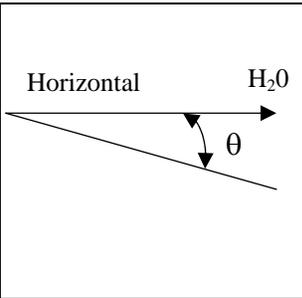
The West River Wall (Photo 1) portion of the bulkhead measured approximately 95 feet in length and supports seven 5'-10" wide concrete walkway slabs. The majority of concrete bulkhead in this section is severely deteriorated and provides minimal structural support.

Two medium full-width cracks, measured at 26 inches and 22 inches long were observed in the first concrete slab. Another full width medium crack was located in Slab 6 (Photo 2). Two (2) shallow spalls without exposed rebar are present in Slab 3.

Differential movement between walkway slabs was observed at various locations along the West River Wall. Between Slabs 1 and 2, there was a 2¼ inch gap with a differential height of 5.5 inches (Photo 3), and a horizontal difference of 5.5 inches was observed along the front face of these slabs (Photo 4). A tree stub and a 1 inch gap were observed between Slabs 3 and 4. Slabs 4 and 5 are separated by a 3 inch horizontal gap with a vertical difference of 5 inches. The gap in the middle of Slabs 5 and 6 was measurable at 1 inch horizontally with no measureable vertical displacement.

The concrete walkway slabs were measured using a digital level and were observed to be tilting down toward the river (east) as shown in the table below:

Walkway Slab Number	Degree of Tilt $\theta$ (deg)	Slope
1	5.7	10.0%
2	15.1	27.0%
3	10.1	17.8%
4	4.9	8.6%
5	6.5	11.4%
6	5.7	10.0%
7	7.2	12.6%



### SOUTH COVE WALL:

The south cove wall (Photo 5) portion of the bulkhead measured approximately 157 feet in length and eleven 5'-6" foot wide concrete walkway slabs are supported behind the wall. The majority of the concrete bulkhead in this section is severely deteriorated and provides minimal structural support.

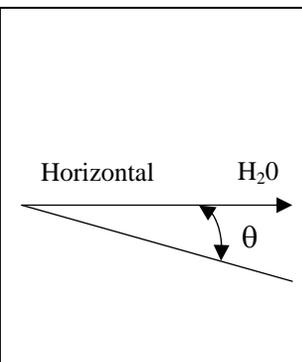
There is a 3'-4" by 1'-4" void in the existing ground behind the slabs at the corner where the South Cove Wall and the West River Wall intersect (Photo 6).

A majority of the concrete slabs behind the wall display large to medium full width cracks. There is a 1¼" wide crack with observable differential vertical and horizontal displacements in Slab 9 (Photo 7). A 15"x13" full depth triangular spall with full width crack was noted in Slab 10 (Photo 8). For a complete description of crack widths, lengths and locations see Appendix B.

Differential movement between walkway slabs was observed at various locations along the South Cove Wall. Between Slabs 7 and 9, there is a 4 inch gap with a differential height of 3.5 inches. A 1 inch gap was observed between Slabs 9 and 10.

The concrete walkway slabs were measured using a digital level and were observed to be tilting down toward the cove (North) as shown in the table below:

Walkway Slab Number	Degree of Tilt $\theta$ (deg)	Slope
8	3.1	5.4%
9	7.4	13.0%
10	8.6	15.1%
11	8.3	14.6%
12	6.5	11.4%
13	6.4	11.2%
14	9.3	16.4%
15	7.4	13.0%
16	6.5	11.4%



A void was observed under the bulkhead near the southwest corner, in front of Slab 16. The base of the concrete wall is heavily deteriorated and a void approximately 5 feet wide by 2 feet tall was observed (Photo 9). The distance the void extends under the bulkhead could not be determined, because access was not available from the top of the bulkhead, but was visually estimated to be 3 feet.

## WEST COVE WALL:

The West Cove Wall (Photo 10) portion of the bulkhead measured approximately 263 feet long. This portion of the wall consisted of the concrete bulkhead supporting walkway slabs with two ramps. The ramps sloped from the existing groundline to the top of the existing concrete bulkhead. The majority of concrete bulkhead in this section is severely deteriorated and provides minimal structural support. A void is located in the concrete bulkhead in front of walkway Slabs 21 and 22 (Photo 11). A 23' long x 7" wide crack is also noted at this location. The void measured approximately 42" deep through the crack. The void has caused the bulkhead to collapse inward on itself and creates a 1½" vertical displacement between Slabs 21 and 22.

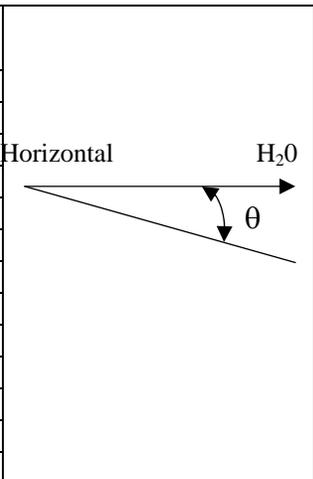
A second void (16" deep) was observed in front of Slabs 30 and 31, where multiple 3" to 4" wide cracks were present. Portions of the concrete bulkhead were missing where these wide cracks terminated along the water's edge. The missing portions of concrete bulkhead measured 15"x28" (Photo 12), 32"x18" (Photo 13) and 25"x20" (Photo 14). There is a 1 foot deep void behind Slab 30 that extends through the concrete bulkhead (Photo 15). A third void (22" deep) was found in front of walkway Slabs 32 and 33, where a 20' long x 3" wide crack was noted (Photo 16). The largest void observed measured 10' wide x 15' long x 3' deep and is located under the concrete slabs in the northwest corner of the cove. This void has caused the top slab to slide and tilt toward the water (Photo 17). Gaps measured between 4 to 5 inches between the slabs above the void. A large 9"x7" deep spall was measured in the bulkhead in front of Slab 26 (Photo 18).

Multiple concrete slabs behind the concrete bulkhead wall displayed signs of distress with medium to large full width cracks and random large spalls. Slab 19 had a 17"x15" shallow spall with no exposed rebar in the southeast corner of the panel. A medium full width crack is present in Slab 20, this crack also measured 1" in vertical displacement. Two shallow spalls measuring 26"x12" and 14"x14" are located in slab panel 21 at the southwest corner and 4 feet south of the northeast corner of the slab, respectively. A 1" wide full width crack travels through Slab 27, and terminates in a large 6" deep spall at the front face of the concrete bulkhead (Photo 19).

Differential movement between walkway slabs was observed at various locations along the West Cove Wall. Between Slabs 21 and 22, there was a differential vertical height of 1.5 inches. Between Slabs 25 and 26, a 1 inch horizontal and 1" vertical displacement gap was observed. A ¾" vertical displacement exists between Slabs 27 and 28.

The concrete walkway slabs were measured using a digital level and were observed to be tilting down toward the cove (East) as shown in the table below:

Walkway Slab Number	Degree of Tilt $\theta$ (deg)	Slope
19	8.0	14.1%
20	8.7	15.3%
21	10.1	17.8%
22	8.6	15.1%
24	4.9	8.6%
25	6.0	10.5%
26	7.1	12.5%
27	8.3	14.6%
28	7.8	13.7%
29	6.1	10.7%
31	5.8	10.2%
32	3.4	5.9%
33	0.2	0.4%



A concrete slab located on the northeast corner of the bulkhead has a large concrete spall with protruding rebar that creates a safety hazard (Photo 20).

## NORTH COVE WALL:

The North Cove Wall (Photo 21) varies in construction compared to the other sections of the bulkhead. Along the North Cove Wall, the walkway slabs are located along the water's edge at approximately 3' feet above low tide. The slabs are supported on soil behind a timber sheeting. The majority of the slabs were severely cracked, uneven, and/or spalled with large voids below the slabs (Photo 22). Multiple full grown trees or tree stubs are present on the slab causing failure of the slabs (Photo 23).

There is a concrete retaining wall with brick facing behind the concrete walkway slabs which supports the remaining fill behind the bulkhead. The depth of embedment of this wall was unknown at the time of the survey. The wall is in fair condition with a few random medium to wide cracks. A majority of the brick facing is missing throughout the wall. The wall was measured for degree of overturning at ten foot intervals, See Appendix D. The overturning angle is indicative of the amount of excessive pressure the wall is withstanding. A typical retaining wall is constructed relatively vertical with a slight amount ( $\pm 5$  degrees) of overturning due to construction tolerances. The larger the overturning angle the more likely the wall is approaching failure. The northeast corner of the wall indicates more overturning with approximate measurements of 82 degrees tilt to the south (toward cove) perpendicular from the groundline. No voids or subsidence in the existing ground was observed behind the wall. There are two staircases in the wall leading to the sidewalk along the top of the bulkhead to the walkway in front of the wall. The staircases are in poor condition, with spalled, uneven, loose bricks, and a large tree stump located near the top of the staircase that caused the landings to vertically separate.

## **RATING:**

These findings discussed above indicate a "Critical" condition for this structure. There is major deterioration in the critical structural components along with obvious vertical and horizontal movement affecting the structural stability of the system and indicating a lack of soil support behind the wall. Total or partial imminent failure of the structure is possible due to a variety of potential loadings including but not limited to tidal action from a heavy storm surge, collision with flotsam or vessel, or heavy ice buildup.

## **RECOMMENDATIONS**

Rummel Klepper & Kahl recommends that the bulkhead be removed and replaced in the near future. The bulkhead is not safe for individuals to utilize due to the numerous tripping and safety hazards. The severe deterioration of the existing wall could cause the structure to become unstable. The amount of the damage to the structure is so extensive that it is beyond repair.

At this time, we suggest that the City close the bulkhead to public use until the bulkhead can be reconstructed. Since the park in the surrounding vicinity of the bulkhead is frequently utilized, it is our recommendation that a fence and "Keep Off" signs should be placed around the perimeter of the structure and on top of the retaining wall along the North Cove Wall blocking access to the stairs until a new structure is constructed.

**APPENDIX A**

**PHOTOS**



Photo # 1 – West River Wall (Note: Uneven settlement of the slabs causing a tripping hazard)

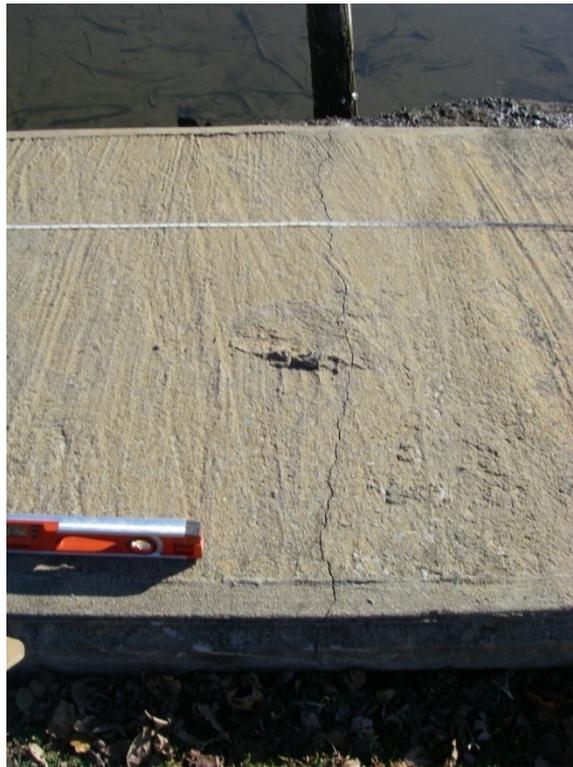


Photo # 2 – Full Width Medium Crack in Slab 6



Photo # 3 – 5.5 inch vertical displacement between Slabs 1 and 2

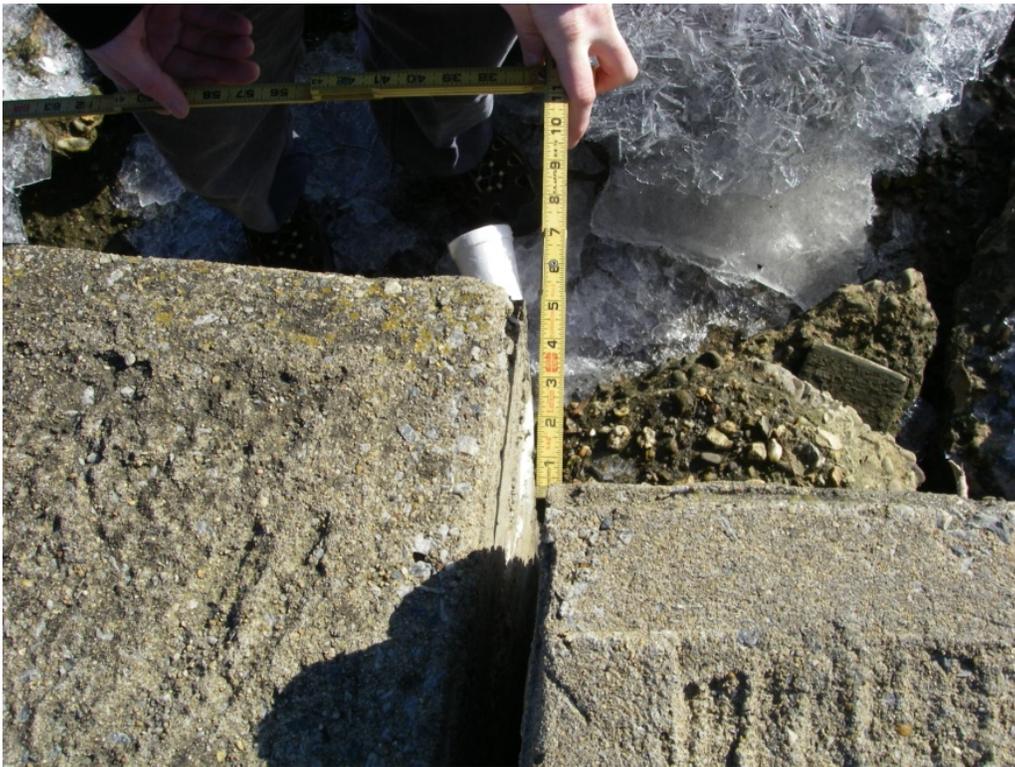


Photo # 4 – 5.5 inch horizontal displacement between Slabs 1 and 2



Photo # 5 – South Cove Wall



Photo # 6 – 3'-4" x 1'-4" void behind Slabs 7 and 8

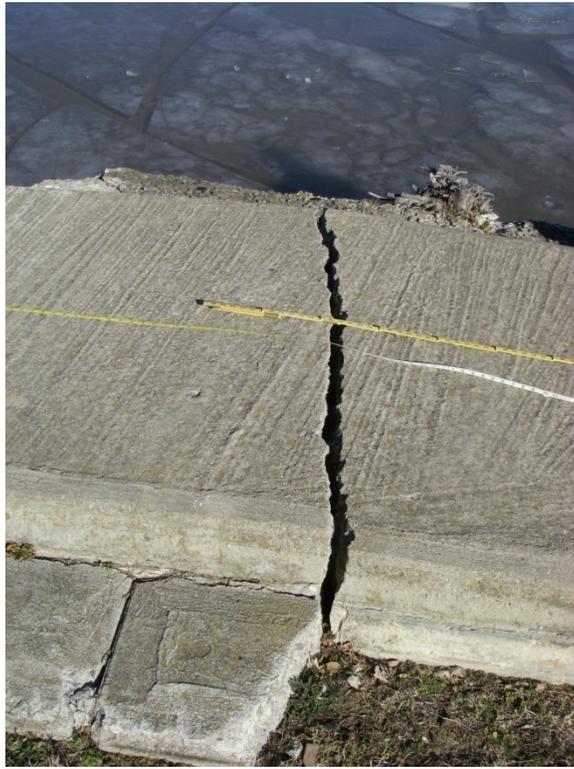


Photo # 7 – 1¼" Wide Full Width Crack in Slab 9



Photo # 8 – 15"x13" spall and wide crack in Slab 10



Photo # 9 – Approximate 5'x2' void under Concrete Bulkhead at Southwest Corner



Photo # 10 – West Cove Wall (Note: Several uneven slabs along the bulkhead causing a tripping hazard)



Photo # 11 – Void under Bulkhead in front of Slabs 21 and 22 (Note: Settlement of the bulkhead and the slabs above the void)



Photo # 12 – 15'x28" Missing Portion of Concrete Bulkhead at Water's Edge in front of Slab 30



Photo # 13 – 32"x18" Missing Portion of Concrete Bulkhead at Water's Edge in front of Slab 30



Photo # 14 – 25"x20" Missing Portion of Concrete Bulkhead at Water's Edge in front of Slab 31



Photo # 15 – Void under Slab 30 (Note: Void extends through the bulkhead)



Photo # 16 – 3” Wide Crack located in front of Slabs 32 and 33



Photo # 17 – Northwest Corner (Note: 10' wide x 15' long x 3'deep void below the slab)



Photo # 18 – 9"x7" Deep Spall in front of Slab 26



Photo # 19 – Full Width Crack and Spall at Slab 27



Photo # 20 – Protruding Rebar located at Northwest Corner of Bulkhead creating a safety hazard



Photo # 21 – North Cove Wall and Retaining Wall (Note: Slabs on bulkhead are uneven, cracked, and spalled)



Photo # 22 – Typical Walkway Slab Panel on North Cove Wall (Note: Cracks and spalls are typical in the slabs)



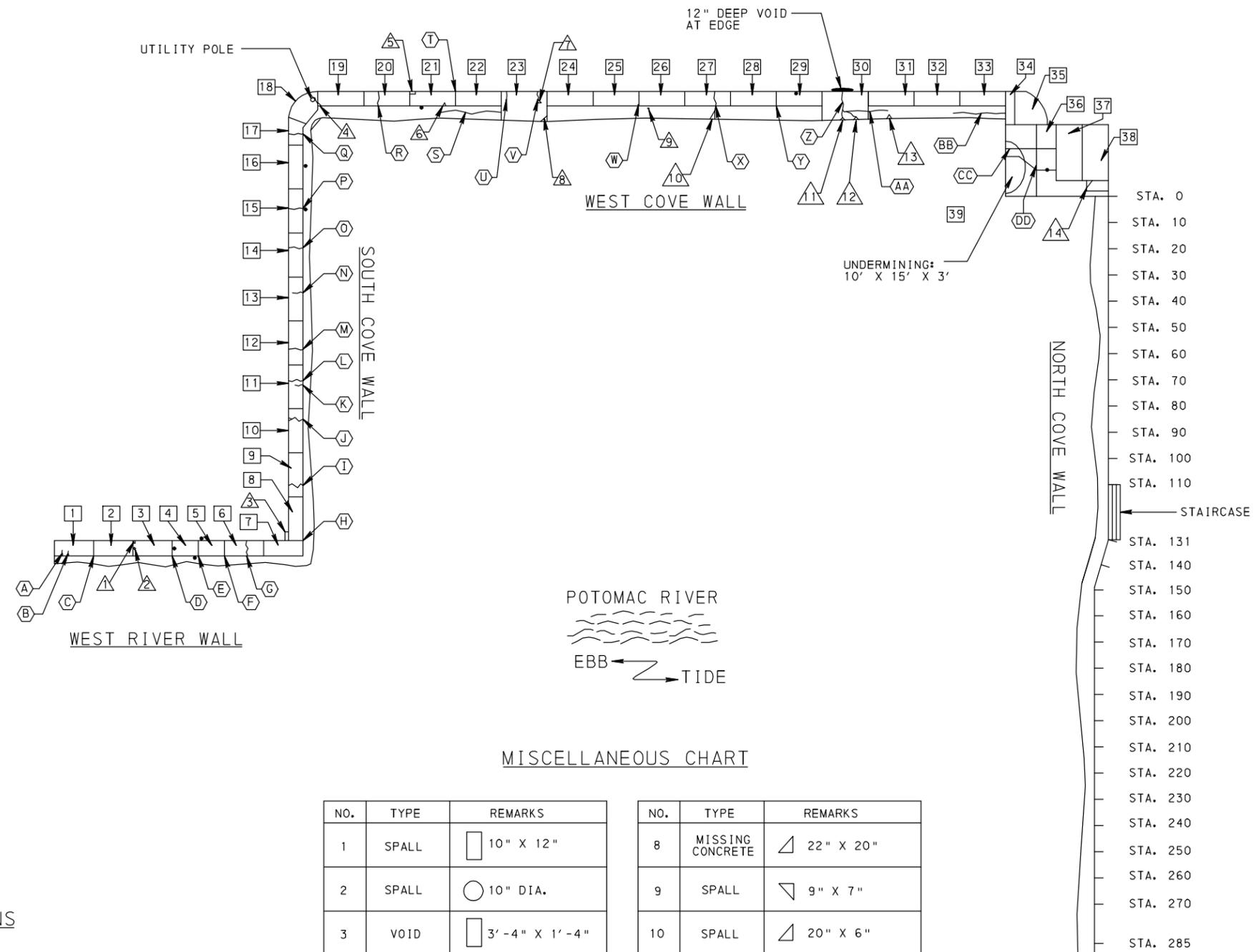
Photo # 23 – Typical Full Grown Trees and Tree Stubs growing out of North Cove Wall and staircase

APPENDIX B

SCHEMATIC OF BULKHEAD

CRACK/SLAB GAPS SIZE CHART

LETTER	LENGTH	GAP	REMARKS
A	26"	MC	
B	22"	MC	
C	GAP	2 1/4"	HORIZONTAL GAP B/W SLAB 1 & 2
D	GAP	1"	HORIZONTAL GAP B/W SLAB 3 & 4
E	GAP	3"	HORIZONTAL GAP B/W SLAB 4 & 5
F	GAP	1"	HORIZONTAL GAP B/W SLAB 5 & 6
G	FW	MC	
H	GAP	4"	HORIZONTAL GAP B/W SLAB 7 & 8
I	FW	1 1/4"	
J	FW	1/4"	13" X 15" SHALLOW SPALL LANDWARD OF CRACK
K	36"	MC	
L	FW	MC	
M	FW	MC	
N	48"	MC	
O	FW	MC	
P	FW	MC	
Q	FW	MC	
R	FW	MC	1" VERTICAL Δ
S	276"	6"-7"	42" VOID UNDER CRACK
T	GAP	-	1 1/2" VERTICAL Δ GAP B/W SLABS 21 & 22
U	36"	1"	
V	36"	1"	
W	GAP	1"	1" VERTICAL Δ GAP B/W SLABS 25 & 26
X	FW	1"	
Y	GAP	-	3/4" VERTICAL Δ GAP B/W SLABS 28 & 29
Z	FW	3"	3" VERTICAL Δ
AA	FW	3"	16" VERTICAL VOID UNDER CRACK
BB	240"	3"	22" VERTICAL VOID UNDER CRACK
CC	GAP	4"	GAP B/W CORNER SLAB
DD	GAP	5"	GAP B/W CORNER SLAB



LEGEND AND ABBREVIATIONS

- 1 SLAB NUMBER
- A AA CRACKING/SLAB GAPS
- ▲ MISCELLANEOUS
- FW FULL WIDTH
- MC MEDIUM CRACK
- TREE STUB

NO.	TYPE	REMARKS
1	SPALL	10" X 12"
2	SPALL	10" DIA.
3	VOID	3'-4" X 1'-4"
4	SPALL	17" x 15"
5	SPALL	26" X 12"
6	SPALL	14" X 14"
7	SPALL	9" X 6"

NO.	TYPE	REMARKS
8	MISSING CONCRETE	22" X 20"
9	SPALL	9" X 7"
10	SPALL	20" X 6"
11	MISSING CONCRETE	28" X 13"
12	MISSING CONCRETE	32" X 18"
13	MISSING CONCRETE	25" X 20"
14	EXPOSED	REBAR

OPERATOR: Iglav in  
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 PLOTTED: Friday, January 30, 2009 AT 11:39 AM

**Rummel, Klepper & Kahl, LLP**  
Consulting Engineers

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YORK, PA  
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VIRGINIA BEACH, VA  
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Project Name:  
**WINDMILL INSPECTION SCHEMATIC**

DATE: JANUARY 23, 2009

APPENDIX C

TIDE CHARTS

## Tides for Alexandria, Va. starting with January 20, 2009.

Day		High /Low	Tide Time	Height Feet	Sunrise Sunset	Moon Time	% Moon Visible
Tu	20	High	3:29 AM	2.2	7:23 AM	Rise 3:00 AM	32
	20	Low	9:31 AM	0.0	5:16 PM	Set 12:25 PM	
	20	High	3:50 PM	2.6			
	20	Low	10:37 PM	0.0			
W	21	High	4:25 AM	2.2	7:22 AM	Rise 3:59 AM	24
	21	Low	10:26 AM	0.0	5:17 PM	Set 1:07 PM	
	21	High	4:44 PM	2.5			
	21	Low	11:31 PM	0.1			
Th	22	High	5:18 AM	2.2	7:21 AM	Rise 4:53 AM	16
	22	Low	11:20 AM	0.0	5:18 PM	Set 1:56 PM	
	22	High	5:36 PM	2.5			
F	23	Low	12:22 AM	0.0	7:21 AM	Rise 5:42 AM	10
	23	High	6:07 AM	2.2	5:20 PM	Set 2:51 PM	
	23	Low	12:13 PM	0.0			
	23	High	6:24 PM	2.5			
Sa	24	Low	1:08 AM	0.0	7:20 AM	Rise 6:24 AM	5
	24	High	6:54 AM	2.3	5:21 PM	Set 3:50 PM	
	24	Low	1:02 PM	0.0			
	24	High	7:09 PM	2.5			
Su	25	Low	1:51 AM	0.0	7:19 AM	Rise 7:00 AM	1
	25	High	7:36 AM	2.3	5:22 PM	Set 4:51 PM	
	25	Low	1:47 PM	-0.1			
	25	High	7:50 PM	2.6			
M	26	Low	2:31 AM	0.0	7:19 AM	Rise 7:31 AM	0
	26	High	8:15 AM	2.4	5:23 PM	Set 5:53 PM	
	26	Low	2:30 PM	-0.1			
	26	High	8:27 PM	2.6			

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For information on regulations for fishing in Potomac River contact: [Maryland Department of Natural Resources](#)

[Virginia Marine Resources Commission](#)  
[Potomac River Fisheries Commission](#)

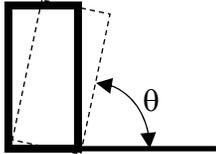
Typhoons, Hurricanes, etc., are NOT included in the predictions. Tidal current direction changes and tide high and low time predictions can be very different. Tide predictions are PREDICTIONS, they can be wrong so use common sense.

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APPENDIX D

NORTH COVE WALL DEGREE OF OVERTURNING

(Field Measurements)

Station	Degree of Overturning (deg)	Sketch
0	86.3	
10	85.2	
20	86.9	
30	88.5	
40	87.3	
50	88.3	
60	84.9	
70	85.8	
80	87.5	
90	88.2	
100	88.9	
110	89.1	
STAIRWAY	n/a	
131	Immeasurable	
140	87.7	
150	89.9	
160	87.5	
170	88.6	
180	87.5	
190	86.8	
200	84.4	
210	85.9	
220	84.6	
230	83.6	
240	82.1	
250	81.1	
260	84.5	
270	Immeasurable	
275	Immeasurable	
Note 1 - See Schematic In Appendix B for Station Locations Note 2 - 90 degrees is complete vertical wall		

APPENDIX E

DEGREE OF TILT OF CONCRETE WALKWAY SLABS

(Field Measurements)

Concrete Walkway Slab #	N/S Degree of Tilt (deg) (+North)	E/W Degree of Tilt (deg) (+ East)
1	+0.5	+5.7
2	+2.3	+15.1
3	-1.6	+10.1
4	-2.1	+4.9
5	+1.2	+6.5
6	+0.8	+5.7
7	+1.5	+7.2
8	+3.1	+1.2
9	+3.2	+2.7
10	+8.6	+6.0
11	+8.3	+0.6
12	+6.5	+2.1
13	+6.4	+2.3
14	+9.3	+0.9
15	+7.4	+0.7
16	+6.5	+0.5
19	+3.4	+8.0
20	+1.1	+8.7
21	+0.2	+10.1
22	+0.7	+8.6
24	+0.6	+4.9
25	-2.0	+6.0
26	-2.0	+7.1
27	-1.2	+8.3
28	-2.4	+7.8
29	-0.1	+6.1
31	+0.8	+5.8
32	-0.5	+3.4
33	-0.2	+0.2
Note 1 – 0.0 degrees is completely level		
Note 2 – Degree of Tilt indicates the slab is tilting downward to that direction		