APPENDIX P: HYDROLOGICAL CONDITIONS REPORT
(Summary)

Georgetown University Boathouse
Environmental Assessment

April 2006

Georgetown University
Boathouse

HYDRAULIC IMPACT ANALYSIS

Georgetown, Washington D.C.

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Narrative

General Information

Georgetown University is proposing a new boathouse to be constructed on the north bank of the Potomac River on the west end of Georgetown approximately 1000 feet upstream of the Francis Scott Key Bridge. The facility will include a two-story structure and removable wood dock. The building site is located between the old Chessie System rail line (now a paved pedestrian pathway) and the Potomac River. A Vicinity Map has been included in Appendix A. The proposed boathouse will be placed approximately 100 feet upstream from the existing Washington Canoe Club building. Behind the building site is the embankment for the Chesapeake and Ohio (C and O) Canal and towpath which is elevated above the site in this location by approximately 30 feet.

The proposed building was designed as "flood friendly" and is composed of two levels. The ground level will be used for storage only. In a flood event, some of the openings in the lower level (total area determined by FEMA standards) will open automatically so that surging water can enter the lower level of the building. Allowing water to enter the building will eliminate a pressure differential at the building face and thereby reducing flood damage. The first floor elevation of the structure will be at elevation 10.5 and the second floor elevation is 26.5. The second floor elevation is well above the 100-year flood elevation of 19.0.

Purpose of Study

This study was commissioned by Georgetown University in order to assess the impacts of the new building to the floodplain, flow velocities and other flow characteristics along the left bank of the Potomac River. The study makes conclusion on whether the new building will affect the water surface elevations during the 1 percent flood event (the magnitude storm that has a 1 percent chance of occurrence in any one year) also referred to as the 100-year storm. Moreover, the study determines if there will be any negative impact to the Washington Canoe Club structure because of the proposed boathouse.

The hydrologic data for this study was taken from the current Flood Insurance Study (FIS) and were not re-developed for use in this study. PHRA does not guarantee the completeness or accuracy of hydrologic data given in the current FIS and has not prepared any confirmation of the computations used to derive the flow information. However, the purpose of this study is comparative in nature showing only the difference between the pre- and post-construction flow characteristics. Therefore, the accuracy of the current FIS is not a factor in this comparative analysis.

Current Flood Insurance Study

The current Flood Insurance Study (FIS) published by the Federal Emergency Management Agency (FEMA) is dated November 15, 1985. A copy of a portion of that study is included in Appendix B of this report. Included in the report are flood elevations for the subject reach of the Potomac River as well as information for several tributary streams such as the Anacostia River and Rock Creek. A

Flood Boundary and Floodway Map is provided for the current FIS in the rear of Appendix B, which shows the subject reach of the Potomac River. The project is located between Cross Section M and Cross Section N shown on Map Panel 15 (see the pocket in the rear of Appendix B). The current FIS shows that the proposed building site is within the 100-year floodplain. Flood elevations for the 100-year storm event are given in the FIS by referencing the profiles on page 03P and 04P.

In addition to the FIS, data on the Potomac River flood elevations can be found in the HEC-2 computer model which was the basis for the profiles in the FIS. The HEC-2 computer data is presented in Appendix C and includes the original input information for the cross section and bridge information. Water surface elevations from the FIS are presented in Table 1 – Elevation Comparison; Original FIS HEC-2 Model v Original HEC-RAS Model

The elevation corresponding to the 100-year flood at the proposed site can be interpolated from the elevations given at the cross section shown in the FIS and in the HEC-2 computer output in Appendix C. That elevation is approximately 19.0 which can also be scaled from the profile 4P given in Appendix B.

Existing Conditions

The proposed building site has a heavy brush cover with some small caliper (up to 14") trees. The slope of the area is flat (around 3 percent) with steeper slopes near the bank and on the C and O Canal embankment. The elevations of the building pad area range from 11 at the northwest corner to around 8 at the southeast corner. An old Chessie System Railroad bed which has been paved as a pedestrian path exists at the rear of the building site. The flatter area is approximately 130 feet wide which includes the railroad bed. Aerial photographs are presented in Appendices D and E. Appendix D is at 1" = 1000' and E is at 1" = 500'.

HEC-RAS Model Descriptions

In order to assess the effect of the new building on the water surface elevations in the Potomac River during the 1% chance storm, three HEC-RAS models were created. The first model duplicates information from the HEC-2 computer input to create a HEC-RAS model to match the November 1985 FIS. To achieve this, the cross section, bridge, n value and coefficient information was taken from the HEC-2 printout (Appendix C) and entered into HEC-RAS. This first model was entitled "Original FEMA FIS" in both the geometric data set and the plan data set. The steady flow data is entitled "Original FEMA FIS 100-Year Only". For this model cross sections lettered K, L, M, N, and O were entered directly from the HEC-2 model (see Appendix C). In addition to these lettered cross sections, additional sections from Appendix C were added. These sections were in the original HEC-2 model but were not shown on the Flood Boundary and Floodway Map. These sections were given a letter title for this analysis, namely L0 (just downstream of the Key Bridge), and M0 (just upstream of cross section M). To complete the analysis, the NH cards were used to insert horizontal variation in Manning's n factor and the Bridge Table and Special Bridge cards were used to enter information on the Key Bridge.

Upon completion of the first model, the HEC-RAS was executed and the results compared to the current FIS. Water surface elevations were used to compare the model to the current FIS and are shown in Table 1 – Elevation Comparison; Original FIS HEC-2 Model versus Original HEC-RAS Model. Based on the results of the model the elevations in the new model are close to the FIS elevations.[1] Elevations downstream of the Key Bridge in the HEC-RAS model vary from the current FIS. However, since the purpose of the report are to compare the effect of the building upstream of the Key Bridge, the model is considered accurate for the purpose of this study.

The results of this HEC-RAS model are presented in Appendix K. Included in Appendix K are the Plan view, cross section plots, profile plots and a HEC-2 format output file. The information in Appendix K shows the data used including n factors, hydrology and bridge information.

Table 1
Elevation Comparison
Original FIS HEC-2 Model v Original HEC-RAS Model

Cross Section	River Station	100- Year Water Surface Elevation	
		Original FIS (based on HEC-2 model)	Original HEC-RAS (based on HEC-RAS model
O	52,977	21.49	21.46
N	50,627	19.51	19.60
M0	48,592	18.62	18.91
M	48,372	18.80	18.56
L0	48,292	17.49	18.28
L	48,072	17.38	18.50
K	46,352	16.79	16.79

The second model developed for HEC-RAS, modifies the first model to add three cross sections near the proposed construction. Since the current FIS does not include a cross section at the proposed site, it is necessary to add cross sections to the current FIS to provide a basis for comparison. The cross sections added reflect the existing conditions of the site and the neighboring site (Washington Canoe Club). The existing ground elevations at the site were taken from a survey provided by Muse Architects. The existing topographic features in the vicinity of the proposed construction are shown on the Site Plan and Cross Section Map attached as Appendix J.

The cross sections added include cross sections M1, M2 and N1. Cross section M1 is at the downstream side of the proposed building and section N1 is on the upstream side of the proposed building. These two sections are at the location of the proposed building, however the building is not shown on these sections as this model was developed for the existing conditions of the site. Cross section M2 is located on the upstream side of the Washington Canoe Club building.

[1] Elevations generated in the HEC-RAS model in the area of the proposed construction are well within a 2 percent degree of accuracy in comparison to the current FIS.

With the addition of the new cross sections and using the same flow data as in the first model, flood elevations, velocities and shear stress amounts were generated by HEC-RAS. The results for this model are presented in Appendix L and are tabularized for comparison in Table 2 – Elevation Comparison; Original HEC-RAS v Modified HEC-RAS.

The third model uses the same flow data as the previous two models and all the same geometric data accept for the ground elevations along sections M1 and N1. In this modified model, the proposed boathouse was added to the cross section data as well as the change in ground conditions from heavy underbrush to manicured lawn. With the addition of the building, ineffective flow areas were assumed in the rear of the building. In allowing for ineffective flow, the velocities and water surfaces would be more dramatically affected than if considered effective flow (i.e. the ineffective area requires that the water be confined to a narrower width of flow). The resulting water surface elevations for the modified run are compared to the elevations prior to the building construction and are shown in Table 2 – Elevation Comparison; Original FIS HEC-RAS v Modified HEC-RAS. The detailed output for this model can be reviewed in Appendix M.

Table 2
Elevation Comparison
Original HEC-RAS Model v Modified HEC-RAS Model

Cross Section	River Station	100- Year Water Surface Elevation	
		Original HEC-RAS Model (with added sections)	Modified HEC-RAS Model (with added sections)
O	52,977	22.03	22.04
N	50,627	20.32	20.32
N1	49,484	20.46	20.44
M1	49,192	20.15	20.15
M2	49,098	20.10	20.10
M0	48,592	18.91	18.91
M	48,372	18.56	18.56
L0	48,292	18.28	18.28
L	48,072	18.50	18.50
K	46,352	16.79	16.79

In addition to the water surface elevation comparison, velocities and shear stress was also compared in the last two models. In order to determine if there will be any detrimental affect to the Washington Canoe Club structure, shear stress and velocities were compared at section M2 (at the upstream end of the structure) and are presented in Table 3 – Velocity and Shear Stress Comparison; Original HEC-RAS v Modified HEC-RAS. The table compares only the Velocity and Shear in the left overbank where the structure is located. Additional data can be reviewed in Appendices L and M.

Table 3
Velocity and Shear Stress Comparison
Original HEC-RAS Model v Modified HEC-RAS Model

Cross Section	River Station	Original HEC-RAS Model		Modified HEC-RAS Model	
		Velocity (fps) (LOB)	Shear (lb/sf) (LOB)	Velocity (fps) (LOB)	Shear (lb/sf) (LOB)
O	52,977	3.61	0.86	3.61	0.86
N	50,627	1.96	0.08	1.96	0.08
N1	49,484	5.32	0.76	7.33	0.81
M1	49,192	3.53	0.71	6.97	0.75
M2	49,098	4.33	0.30	4.33	0.30
M0	48,592	2.87	0.38	2.87	0.38
M	48,372	2.97	0.45	2.97	0.45
L0	48,292	2.85	0.38	2.85	0.38
L	48,072	1.53	0.05	1.53	0.05
K	46,352	3.98	0.48	3.98	0.48

<u>Results of Study</u>

Based on the results presented in Table 2, the water surface elevations are affected only slightly by the addition of the new Georgetown Boathouse. Going upstream, the elevations are identical from section K (most downstream point) to section M1 (at the downstream side of the new building). At section N1 (upstream side of the new building) the elevation is increased by 0.02 feet and at section O the increase is only 0.01 feet. Based on this information, there is no appreciable increase in water surface elevations for the study reach.

As of the writing of this report, the length of the proposed boathouse has been decreased by 11.5 feet from that shown in the study. A reduction of this magnitude is not expected change the results of the study, and therefore has not been incorporated in the computations at this time.

Based on the results presented in Table 3, the velocities and the shear stress values are unchanged for all sections accept for M1 and N1 which are the two sections at either end of the proposed Georgetown Boathouse. No change in either of these parameters is seen at the Washington Canoe Club structure which is at cross section M2 (river station49,098) in Table 3.

<u>Conclusions</u>

The results of this study show that there is no significant change to flow characteristics studied as a result of the construction of the boathouse. Water surface elevations for this reach of the Potomac River, velocities, and shear stress amounts vary only slightly at the proposed building and do not change at all at the Washington Canoe Club building.