MOORES RUN, BALTIMORE CITY, MARYLAND
2007 ABBREVIATED GEOMORPHIC CONDITION AND CHANNEL STABILITY RESURVEY

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Stream Habitat Assessment and Restoration Program
U.S. Fish and Wildlife Service
Chesapeake Bay Field Office

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I. INTRODUCTION

The City of Baltimore (City) and the U.S. Fish and Wildlife Service, Chesapeake Bay Field Office (Service) entered into a cooperative agreement (Agreement 51410-1902-5047) to facilitate stream and riparian habitat assessment and restoration projects within the City. The survey of Moores Run., which is part of a stream monitoring network under the City's National Pollutant Discharge Elimination System (NPDES) permit, is included under this agreement.

The Service conducted an initial geomorphic condition and channel stability field survey for Moores Run in October 2003. Under that project scope of work, the Service conducted a limited data analysis, including a comparison of existing City data sets with the data gathered by the Service, a bank erosion prediction, and Rosgen Level III stream stability and sediment supply analysis. In 2005, the Service completed an abbreviated geomorphic survey in order to validate stability predictions made in 2003. In 2007, the Service completed another abbreviated geomorphic survey in order to evaluate current channel conditions, as well as to validate stability predictions made in 2005.

This report contains a summary of the field data collected by the Service, the comparison between 2003, 2005 and 2007 data, as well as a Rosgen Level III stream stability and revised sediment supply analysis.

II. MOORES RUN EXISTING CONDITIONS

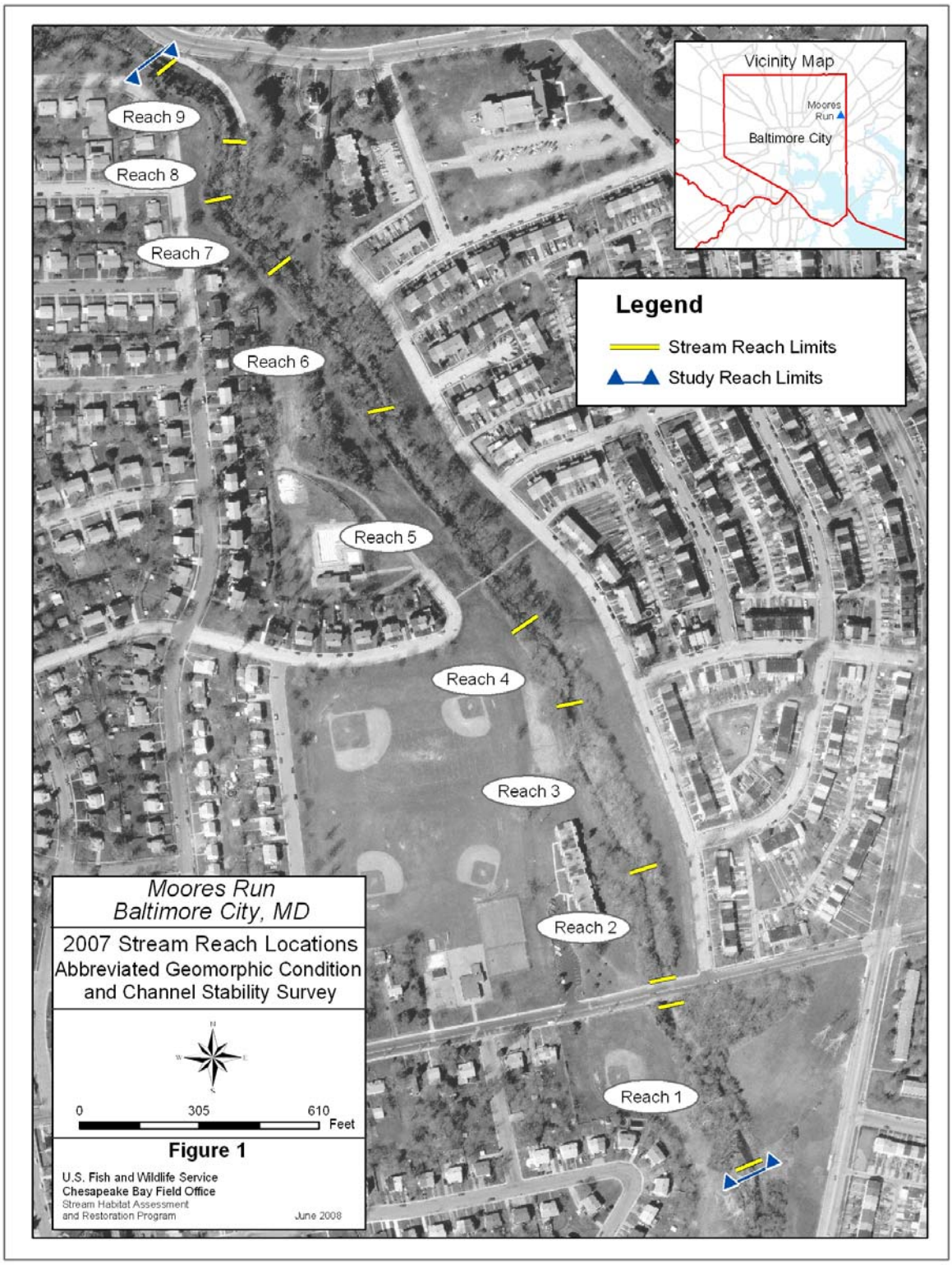
The Moores Run assessment area starts at the quadruple-cell box culvert located near the intersection of Hamilton Avenue and Evanshire Avenue, and ends approximately 520 feet downstream of the Radecke Road crossing in Baltimore City, Maryland (Figure 1).

A. Moores Run 2007 Reach Delineation

In 2003, the Service divided Moores Run into nine stream reaches based on geomorphic characteristics and stability conditions (Table 1). Since the stream type and stability conditions of the reaches did not significantly change, the 2007 resurvey of Moores Run was conducted on the same nine reaches originally identified (Figure 1).

Table 1. Reach Number and Length.

Reach Number	Reach Length (ft)	Reach Number	Reach Length (ft)
01	520	06	489
02	255	07	134
03	448	08	169
04	317	09	354
05	672	Total	3,358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0
305
610
Feet
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B. Rosgen Stream Types

In 2007, the Moores Run assessment area partitioned into four Rosgen Level I stream types (*i.e.,* B, C, D, and F) (Rosgen 1996). The F stream type represents 44 percent, the C stream type represents 28 percent, the D stream type represents 23 percent, and the B stream type represents 5 percent of the classified stream reaches (Table 2). Reaches 04 and 09 were transitional, predominately pools, which the Service did not classify. In the assessment area, the bed material is predominately cobble with combinations of cobble and boulders or bedrock. Reaches 01 and 04 have gravel with bedrock, and gravel/cobble substrate with bedrock, respectively. Reach 09 has a predominately sand and gravel substrate.

Reach 01, the farthest downstream reach, is a Rosgen C stream type that is slightly entrenched with a moderate width/depth ratio, shallow slope, and a gravel substrate with bedrock grade control. Reach 02 is also a Rosgen C stream type but with a moderately steep slope, and a cobble/boulder substrate. Reach 03 and 08 are Rosgen D (*i.e.*, braided) stream types, which are slightly entrenched with moderate width/depth ratios. Reach 03 has a moderately steep slope and cobble substrate and Reach 08 has a highly steep slope and a cobble substrate with bedrock control.

Reaches 05 and 06 are Rosgen F stream types, which are highly entrenched with moderate width/depth ratios, moderately steep slopes, and a cobble/boulder substrate. Reach 06 has bedrock control. Reach 07 is a Rosgen B stream type that is moderately entrenched with a moderate width/depth ratio, highly steep slope, and a cobble/boulder substrate.

Table 2. Rosgen stream type classification delineation values**.** One value for sinuosity was calculated for the entire Moores Run assessment area.

Reach	Classification Cross Section	Stream Type	Entrenchment Ratio	Width/ Depth Ratio	Sinuosity	Reach Slope (ft/ft)	Substrate
01	Service XS G	C	2.87	21.0	1.07	0.0035	Gravel with Bedrock
02	Baltimore XS 32	C	3.18	18.9		0.0114	Cobble with Boulder
03	Service XS A	D	5.06	14.0		0.0119	Cobble
05	Service XS C	F	1.20	23.1		0.0105	Cobble with Boulder
06	None in 2007	F	N/A	N/A		0.0168	Cobble with Bedrock
07	None in 2007	B	N/A	N/A		0.0365	Cobble with Boulder
08	Similar to Reach 03	D	N/A	N/A		0.0199	Cobble with Bedrock

III. SERVICE FIELD DATA COMPARISON SUMMARY

In order to assess the 2007 stream stability, sediment supply, bank stability, and erosion quantities for Moores Run the Service collected the following geomorphic condition and channel stability field data:

- Cross Section Bank Erosion Hazard Index Assessment
- Reach Average Bank Erosion Hazard Index Assessment
- Pfankuch Channel Stability Assessment
- Cross Section Survey
- Longitudinal Profile Survey
- Bank Profiles

The data and assessments were compared with the surveys conducted in 2003 and 2005 in order to validate predictions and determine trends. The Service 2007 field data and comparison plots are located in the appendices. The Moores Run field protocol document provides descriptions of survey tasks (Eng *et al,* 2004*).*

A. Stream Stability and Sediment Supply Assessment

The Service conducted a Rosgen Level III stream stability and sediment supply assessment (Rosgen 2001b) in 2007. This assessment provides predictions of lateral and vertical stability, channel enlargement potential, Pfankuch channel stability, and sediment supply for Moores Run. The Service was unable to conduct all of the Level III assessment procedures. The Service did not assess study/reference confinement ratio due to the lack of reference meander width ratios for the Maryland Piedmont streams. The Service did not collect bar samples because of the large substrate (*i.e*., boulder and large cobble substrate) and sand substrate and consequently, did not assess critical dimensionless shear stress and critical shear stress. Lastly, due to the lack of sediment yield curves, the Service did not model sediment capacity. Additionally, the Service did not conduct a Rosgen Level III assessment in 2007 for Reach 09, because of the on-going bank stabilization project in this study reach.

Despite the absence of these criteria, the Service had sufficient data to support the overall predicted stability ratings. In cases where individual stability criteria values were not available and their absence affected the overall stability rating, the Service reviewed the collective individual criteria ratings and selected an overall predicted lateral and vertical stability rating and enlargement potential rating for the existing conditions. A summary of the 2007 Rosgen Level III assessment data is in Appendix E.

The Service further documented stream stability in Moores Run by conducting monumented cross section and longitudinal profile resurveys. The overlays associated with the resurveys allow the Service to observe trends in the Moores Run vertical and lateral stability over time, as well as to validate predictions made in previous years. Lateral stability potentials were validated using cross section overlays; vertical stability potentials were validated using both longitudinal profile overlay data and cross section overlays.

1. Lateral Stability

Lateral stability of Moores Run was determined by conducting the Rosgen Level III lateral stability potential assessment. The assessment predicts lateral stability potentials by evaluating width/depth ratios, depositional patterns, meander patterns, dominant BEHI/NBS, and confinement. The Service used cross section resurveys to provide further verification of lateral stability potential.

a. Lateral Stability Potential Results

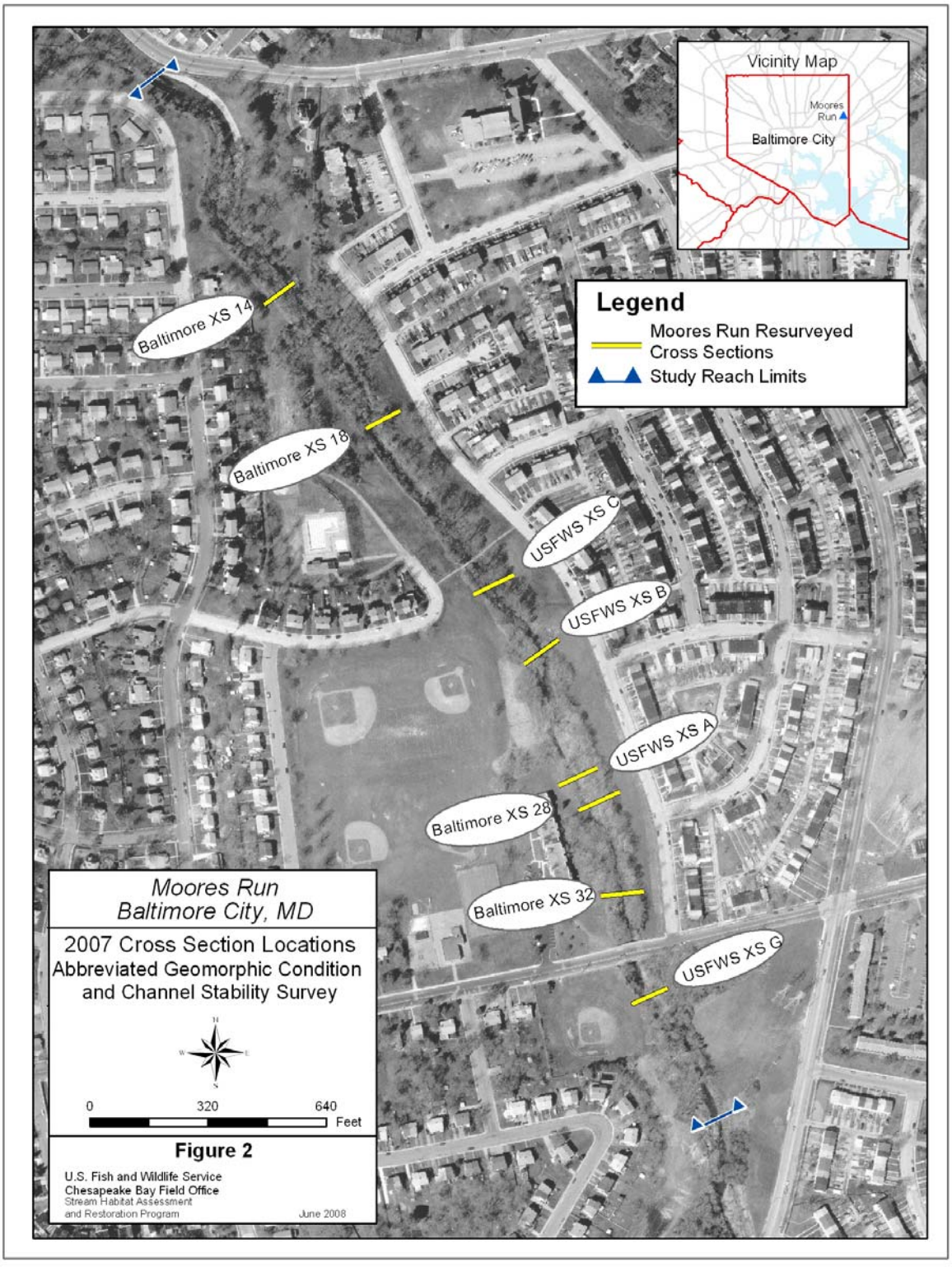
For 2007, the Moores Run lateral stability assessment of the eight reaches resulted in three ratings: stable, moderately unstable, and unstable. The lateral stability prediction for Reaches 01, 03, 04, 06, 07, and the right channel of Reach 08 have not changed since 2003. The ratings for Reaches 02, 05, and the left channel of Reach 08 changed one rating category, from stable to moderately unstable (Table 3). The stable rating represents 23 percent, the moderately unstable rating represents 45 percent, and the unstable rating represents 23 percent of the assessment area. The remaining 9 percent is associated with Reach 09.

Table 3. Lateral Stability Potential Comparison

Reach	2003 Lateral Stability	2005 Lateral Stability	2007 Lateral Stability
01	Unstable	Unstable	Unstable
02	Stable	Stable	Moderately Unstable
03 (Left Channel)	Stable	Stable	Stable
03 (Right Channel)	Unstable	Unstable	Unstable
04	Stable	Stable	Stable
05	Stable	Stable	Moderately Unstable
06	Moderately Unstable	Moderately Unstable	Moderately Unstable
07	Stable	Stable	Stable
08 (Left Channel)	Stable	Stable	Moderately Unstable
08 (Right Channel)	Moderately Unstable	Moderately Unstable	Moderately Unstable
09	Highly Unstable	On-going bank stabilization project	On-going bank stabilization project

b. Cross Section Comparison

In order to reassess channel stability conditions and to validate erosion rates the Service resurveyed the eight cross sections selected in 2005 (Figure 2). The cross sections selected represented the range of conditions present in Moores Run (Eng *et al*. 2007). The Service did not survey the remaining cross sections established in 2003 by the City of Baltimore and the Service because they represent duplicate bank erosion conditions, less dominant bank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320
640
Feet
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erosion conditions, or low erosion potentials. Due to the continuing on-going bank stabilization construction, the Service was again unable to survey a cross section for Reach 09.

To document vertical and lateral channel adjustments the Service overlaid 2003, 2005, and 2007 cross section data. All cross section overlay plots, data, and photographs are in Appendix A. Table 4 shows the total change in channel characteristics for all cross sections. Total changes in bankfull width ranged from a decrease of 1.22 feet to an increase of 3.85 feet. Total changes in bankfull area ranged from a decrease of 11.61 square feet to an increase of 26.25 square feet. The width/depth ratio changes ranged from a decrease of 6.02 to an increase of 1.97. The cross sections indicate that laterally there is little change in Moores Run with the exception of Reaches 03, 05, and 06, which show some widening. The majority of cross sections surveyed in Moores Run follow trends observed in 2005, with the exception of Reaches 01 and 03. The cross sections in these reaches are approaching conditions originally observed in 2003. Discussion of the cross section vertical stability results will be in the vertical stability section.

c. Data Analysis

For the most part, the lateral stability of Moores Run has not changed significantly between 2005 and 2007 based on the comparable results from the cross section overlays and lateral stability potential predictions. Additionally, with the exception of Reach 02, the results of the cross section overlays validate the lateral stability predictions. Information from the cross section in Reach 02 shows it to be stable, with little change since 2005.

However, the lateral stability prediction for Reach 02 is moderately unstable. This discrepancy is due to a change in the BEHI rating for half of the reach from low to moderate. Based on this BEHI rating, the potential for lateral adjustment exists. Future surveys will validate this prediction.

Although there is some lateral change in Moores Run, particularly in Reaches 03, 05, and 06, overall the data indicate that Moores Run is laterally stable. However, the Service recommends further monitoring, particularly in Reaches 07, 08, and 09. Since there were no cross sections surveyed in these reaches the Service was unable to validate the lateral stability predictions. In addition, Reaches 08 and 09 are currently under construction, with the addition of a new 48-inch culvert in Reach 08 and concrete banks in Reach 09. Monitoring will indicate whether the new culvert and on-going construction will affect the stream flow regime and stability.

Table 4. Monumented Cross Section Data Comparison

Cross Section			Year				
			2003	2005		2007	
Reach	Name	Parameter		Data	Change	Data	Change
01	Service XS G	Width (ft)	46.50	46.97	0.47	46.80	-0.17
		Depth (ft)	2.17	2.47	0.30	2.23	-0.24
		Area (ft^2)	101.10	116.19	15.09	104.58	-11.61
		Maximum Depth (ft)	4.48	4.01	-0.47	3.82	-0.19
		Wetted Perimeter (ft)	51.72	50.66	-1.06	49.31	-1.35
		Hydraulic Radius (ft)	1.95	2.29	0.34	2.12	-0.17
		Width/Depth Ratio	21.43	19.02	-2.41	20.99	1.97
02	Baltimore XS 32	Width (ft)	45.10	45.30	0.20	45.90	0.60
		Depth (ft)	2.29	2.43	0.14	2.44	0.01
		Area (ft^2)	103.48	110.07	6.59	111.91	1.84
		Maximum Depth (ft)	3.87	4.12	0.25	4.06	-0.06
		Wetted Perimeter (ft)	46.37	46.93	0.56	47.32	0.39
		Hydraulic Radius (ft)	2.23	2.35	0.12	2.37	0.02
		Width/Depth Ratio	19.69	18.64	-1.05	18.81	0.17
03	Baltimore XS 28	Width (ft)	54.10	55.82	1.72	54.60	-1.22
		Depth (ft)	1.87	1.90	0.03	1.82	-0.08
		Area (ft^2)	101.14	105.80	4.66	99.43	-6.37
		Maximum Depth (ft)	4.10	4.08	-0.02	3.50	-0.58
		Wetted Perimeter (ft)	61.70	60.91	-0.79	57.55	-3.36
		Hydraulic Radius (ft)	1.64	1.74	0.10	1.73	-0.01
		Width/Depth Ratio	28.93	29.38	0.45	30.00	0.62
	Service XS A	Width (ft)	44.00	39.50	-4.50	41.90	2.40
		Depth (ft)	2.28	2.52	0.24	2.99	0.47
		Area (ft^2)	100.23	99.65	-0.58	125.90	26.25
		Maximum Depth (ft)	3.81	3.86	0.05	5.30	1.44
		Wetted Perimeter (ft)	50.08	42.88	-7.20	45.55	2.67
		Hydraulic Radius (ft)	2.00	2.32	0.32	3.16	0.84
		Width/Depth Ratio	19.30	15.67	-3.63	14.01	-1.66
04	Service XS B	Width (ft)	60.20	59.88	-0.32	59.09	-0.79
		Depth (ft)	3.50	3.60	0.10	3.93	0.33
		Area (ft^2)	210.98	215.70	4.72	232.15	16.45
		Maximum Depth (ft)	6.24	6.29	0.05	6.72	0.43
		Wetted Perimeter (ft)	65.34	65.43	0.09	65.43	0.00
		Hydraulic Radius (ft)	3.23	3.30	0.07	3.55	0.25
		Width/Depth Ratio	17.20	16.63	-0.57	15.04	-1.60
05	Baltimore XS 18	Width (ft)	41.62	42.02	0.40	45.87	3.85
		Depth (ft)	2.73	2.79	0.06	3.09	0.30
		Area (ft^2)	113.64	117.22	3.58	141.83	24.61
		Maximum Depth (ft)	5.09	4.83	-0.26	4.68	-0.15
		Wetted Perimeter (ft)	49.94	46.67	-3.27	49.81	3.14
		Hydraulic Radius (ft)	2.28	2.51	0.23	2.85	0.34
		Width/Depth Ratio	15.25	15.06	-0.18	14.84	-0.22
	Service XS C	Width (ft)	50.00	50.00	0.00	49.2	-0.80
		Depth (ft)	2.17	2.23	0.06	2.13	-0.10
		Area (ft^2)	108.35	111.47	3.12	104.55	-6.92
		Maximum Depth (ft)	3.11	3.19	0.08	3.10	-0.09
		Wetted Perimeter (ft)	51.81	51.90	0.09	50.87	-1.03
		Hydraulic Radius (ft)	2.09	2.15	0.06	2.06	-0.09
		Width/Depth Ratio	23.04	22.42	-0.62	23.10	0.68
06	Baltimore XS 14	Width (ft)	44.12	45.57	1.45	47.91	2.34
		Depth (ft)	2.84	2.96	0.12	3.07	0.11
		Area (ft^2)	125.09	134.78	9.69	146.89	12.11
		Maximum Depth (ft)	5.13	4.75	-0.38	5.55	0.80
		Wetted Perimeter (ft)	53.21	51.48	-1.73	53.31	1.83
		Hydraulic Radius (ft)	2.35	2.62	0.27	2.76	0.14
		Width/Depth Ratio	15.54	15.40	-0.14	15.61	0.21

2. Vertical Stability

The Service, as part of the Rosgen Level III assessment, evaluated the following parameters: degree of incision, width/depth ratios, stream type stage, depositional patterns, meander pattern, entrenchment, and confinement. Overlays of the longitudinal profile and cross section resurveys also give an indication of vertical stability, as well as provide validation for stability predictions.

a. Vertical Stability Potential Results

For 2007, the Moores Run vertical stability assessment of the eight reaches resulted in three rating categories: stable, aggrading, and degrading (Table 5). The Service was unable to complete the vertical stability assessment of Reach 04, 06 and 07 due to the lack of riffle cross section data. The predictions for these reaches were determined through analysis of longitudinal profile overlays. The vertical stability potential in Moores Run has not changed since 2003.

Table 5. Vertical Stability Potential Comparison

Reach	2003 Vertical Stability	2005 Vertical Stability	2007 Vertical Stability
01	Stable	Stable	Stable
02	Stable	Stable	Stable
03 (Left Channel)	Aggrading	Aggrading	Aggrading
03 (Right Channel)	Degrading	Degrading	Degrading
04	Stable	Stable	Stable
05	Stable	Stable	Stable
06	Stable	Stable	Stable
07	Stable	Stable	Stable
08 (Left Channel)	Stable	Stable	Stable
08 (Right Channel)	Stable	Stable	Stable
09	Stable	On-going bank stabilization project	On-going bank stabilization project

b. Longitudinal Profile Comparison

The Service surveyed 3,378 feet of stream for the 2007 longitudinal profile (Appendix B). The 2005 and 2007 longitudinal profile overlay indicates a change in bed elevation over 68 percent of Moores Run; approximately 35 percent of the bed had an elevation decrease, while approximately 33 percent of the bed increased in elevation (Table 6). Reaches 02, 04, 05, and 06 are relatively stable with areas of localized scour ranging from 0 feet to 1.8 feet and localized deposition ranging from 0 feet to 2.7 feet. Adjustment is occurring through the entirety of Reaches 01 and 03 with scour up to 1.4 feet and deposition up to 2.2 feet. The most change occurs in Reaches 07, 08 and 09 with bed elevations up to 3.2 feet higher than in 2005.

Table 6. 2007 Moores Run Bed Elevation Changes

Reach	Total Reach Length (ft)	Elevation Decrease			Elevation Increase		
		Length (ft)	Depth (ft)	Percent	Length (ft)	Depth (ft)	Percent
1	520	200	1.4	38	255	2.2	49
2	255	128	1.8	50	71	0.4	28
3	448	228	1.2	51	172	0.7	38
4	317	175	1.2	55	151	2.7	48
5	672	0	0	0	0	0	0
6	489	261	1.5	53	125	1.2	26
7	134	28	0.4	21	106	2.5	79
8	169	0	0	0	130	3.2	77
9	354	165	0.85	47	90	1.8	25
All	**3358**	**1185**		**35**	**1100**		**33**

There are few consistent trends in the bed elevation change for Moores Run from 2003 to 2007. Overall, however, the amount of scour over the study area did not change significantly since 2003; while 15 percent more of Moores Run has an increase in bed elevation (Table 7).

Table 7. Moores Run Bed Elevation Change Comparison.

Reach	Elevation Decrease			Elevation Increase		
	2005 Percent	2007 Percent	Change	2005 Percent	2007 Percent	Change
1	45	38	-7	36	49	13
2	86	50	-36	14	28	14
3	92	51	-41	4	38	34
4	0	55	55	0	48	48
5	0	0	0	0	0	0
6	50	53	3	50	25	-25
7	100	21	-79	0	79	79
8	N/A	0	N/A	N/A	77	N/A
9	48	47	-1	28	25	-3
All	**42**	**35**	**-7**	**18**	**33**	**15**

c. Data Analysis

To validate the 2005 overall vertical stability ratings, the Service compared the overall stability ratings to the changes shown in the 2005 and 2007 longitudinal profile overlay. Overall, the Service found that stability ratings accurately predicted the vertical stability of Reaches 01, 02, 03, 04, 05, and 06. Although there was some localized scour and deposition,

there was no change in the baseline bed elevation in Moores Run in these reaches. Longitudinal profile overlays and cross section data support the vertical stability predictions for these reaches.

Data appear to show that vertical stability prediction and longitudinal profile data for Reaches 07 and 08 do not agree. However, these results are misleading due to particular circumstances in each of these reaches.

The discrepancy between the vertical stability prediction and longitudinal profile survey for downstream portion of Reach 07 is related to channel material and a change in the survey thalweg location. Reach 07 is a boulder dominated reach, made up of particles larger than 2 feet. The adjustment of a few boulders would give the appearance that the bed is aggrading; however, this is not the case since the overall base elevation in this portion of the reach does not change. The longitudinal profile overlay for the downstream part of Reach 07 (Appendix B) clearly shows that the low points in the bed are the same from 2005 to 2007.

Although the 2007 longitudinal survey depicts significant changes in the streambed for Reaches 08 and 09, the Service is unable to predict or verify vertical stability for these reaches. The Service believes the changes in Reaches 08 and 09 occurred as a result of fluvial processes or are associated with the on-going streambank stabilization activities. Both reaches show localized aggradation in pools located directly downstream of new culverts. Future monitoring, after the completion of the stabilization project, is required to validate vertical stability in Reaches 08 and 09.

3. Enlargement Potential

The Rosgen Level III assessment predicts enlargement potentials by evaluating lateral stability, vertical stability, and Rosgen stream type successional stage.

a. Enlargement Potential Results

For 2007, the Moores Run enlargement potential of the eight assessed reaches resulted in three rating categories: stable, slight increase, and moderate increase. There were no changes in the enlargement prediction for Reaches 01, 03, 04, 07, and 08 (Table 8). Reaches 02, 05, and the left channel of Reach 08 had an increase in one enlargement potential category, while Reach 06 had a decrease (Table 8). The stable rating represents 23 percent, and the slight increase rating represents 40 percent of the assessment area. The moderate increase rating represents 28 percent of the assessment area. The remaining 9 percent is associated with Reach 09.

Table 8. Enlargement Potential Comparison

Reach	2003 Enlargement Prediction	2005 Enlargement Prediction	2007 Enlargement Potential
01	Moderate Increase	Moderate Increase	Moderate Increase
02	Stable	Stable	Slight Increase
03 (Left Channel)	Stable	Stable	Stable
03 (Right Channel)	Slight Increase	Slight Increase	Slight Increase
04	Stable	Stable	Stable
05	Slight Increase	Slight Increase	Moderate Increase
06	Moderate Increase	Moderate Increase	Slight Increase
07	Stable	Stable	Stable
08 (Left Channel)	Stable	Stable	Slight Increase
08 (Right Channel)	Slight Increase	Slight Increase	Slight Increase
09	Extensive	On-going bank stabilization project	On-going bank stabilization project

b. Data Analysis

While the prediction of enlargement potential is based on several criteria, cross section data are the field data used to best validate the predications. The channel changes depicted in the cross section data concur with and validate the 2005 enlargement predictions.

4. Pfankuch Channel Stability Assessment

The Pfankuch Channel Stability (Pfankuch) assessment provides an overall channel stability rating by evaluating such parameters as: mass wasting, vegetative banks, debris jams, channel capacity, cutting, deposition, consolidation of particles, and aquatic vegetation (Pfankuch 1975).

a. Pfankuch Channel Stability Results

For 2007, the Moores Run lateral stability assessment of the eight reaches resulted in two rating categories: stable and moderately unstable (Table 9). The stable rating represents 65 percent, and the moderately unstable rating represents 24 percent of the assessment area. The Pfankuch rating for Reach 06 changed from stable to moderately unstable (Table 9). The Pfankuch data are located in Appendix E.

b. Data Analysis

While the Pfankuch rating changed from stable to moderately unstable for Reach 06, the Pfankuch score only changed 13 points out of a possible 121 points. Most of the change in the Reach 06 Pfankuch rating reflects a shift in assessment parameters of one rating category (i.e. “excellent” to “good” or “good” to “fair”). This rating category change indicates slight increases in bank rock content, bank slope gradient, scouring and deposition, and the amount

of raw banks present in the reach. However, since the changes are minor, the stability condition of Reach 06 did not significantly change based on the Pfankuch assessment method.

Table 9. Pfankuch Channel Stability Comparison

Reach	Pfankuch Rating		
	2003	2005	2007
01	Stable	Stable	Stable
02	Stable	Stable	Stable
03	Moderately Unstable	Stable	Stable
04	Stable	Stable	Stable
05	Stable	Stable	Stable
06	Stable	Stable	Moderately Unstable
07	Moderately Unstable	Moderately Unstable	Moderately Unstable
08	Moderately Unstable	Moderately Unstable	Moderately Unstable
09	Moderately Unstable	On-going bank stabilization project	On-going bank stabilization project

5. Sediment Supply

The Rosgen Level III assessment predicts the sediment supply based on the results of the lateral and vertical stability, channel enlargement potential, and Pfankuch channel stability rating. The results are given a numeric value. The individual values are added together to get a total score for the reach. A higher score indicates a larger potential for sediment contribution from the study reach.

a. Sediment Supply Results

For 2007, the Moores Run sediment supply assessment for the eight reaches resulted in three rating categories: low, moderate, and high (Table 10). Predictions for Reaches 02, 05 and the left channel of Reach 08 changed from low to moderate. All other reaches remained the same. The low rating represents 12 percent, and the moderate rating represents 68 percent of the assessment area. The high rating represents 11 percent of the assessment area. The remaining 9 percent represents Reach 09.

b. Data Analysis

While the prediction of potential sediment supply is based on several criteria, cross section and longitudinal data are the field data used to best validate the predications. The channel changes depicted in the Moores Run cross section and longitudinal data concur with and validate the potential sediment supply predictions.

Table 10. Sediment Supply Potential Comparison

Reach	2003	2005	2007
01	Moderate	Moderate	Moderate
02	Low	Low	Moderate
03 (Left Channel)	Moderate	Moderate	Moderate
03 (Right Channel)	High	High	High
04	Low	Low	Low
05	Low	Low	Moderate
06	Moderate	Moderate	Moderate
07	Low	Low	Low
08 (Left Channel)	Low	Low	Moderate
08 (Right Channel)	Moderate	Moderate	Moderate
09	High	On-going bank stabilization project	On-going bank stabilization project

B. Bank Stability

The Service evaluated bank stability using the Bank Erosion Hazard Index (BEHI) and channel erosional forces using the near bank shear stress (NBS) for all stream banks prone to erosion within the study area. BEHI and NBS measurements were also made at individual cross sections in order to validate bank erosion predictions made in 2005. Reach BEHI data, photographs, and maps are located in Appendix C and cross section BEHIs and cross section bank profile data are provided in Appendix A.

1. Reach BEHI and NBS

Reach BEHI and NBS ratings are used in bank erosion predictions and the Rosgen Level III stability assessment.

a. Reach BEHI and NBS Results

For the 2007 survey, the Service assessed 4,783 feet of stream bank of the total 6,716 feet of bank (Figure 3). The Service did not assess banks in Reach 09 because of an on-going bank stabilization project. A summary of the reach BEHIs and NBS ratings are provided in Table 11. A geomorphic map with detailed 2007 BEHI bank locations is located in Appendix C. BEHI ratings range from low to extreme. The low ratings represent 27 percent of the banks while the moderate rating represents 27 percent of the banks. The high and very high ratings represent 45 percent. The extreme rating represents approximately 1 percent of the banks. NBS ratings range from low to high, with the low rating representing 67 percent of banks and the moderate rating representing 26 percent of banks. The high NBS rating represents the remaining 7 percent of banks.

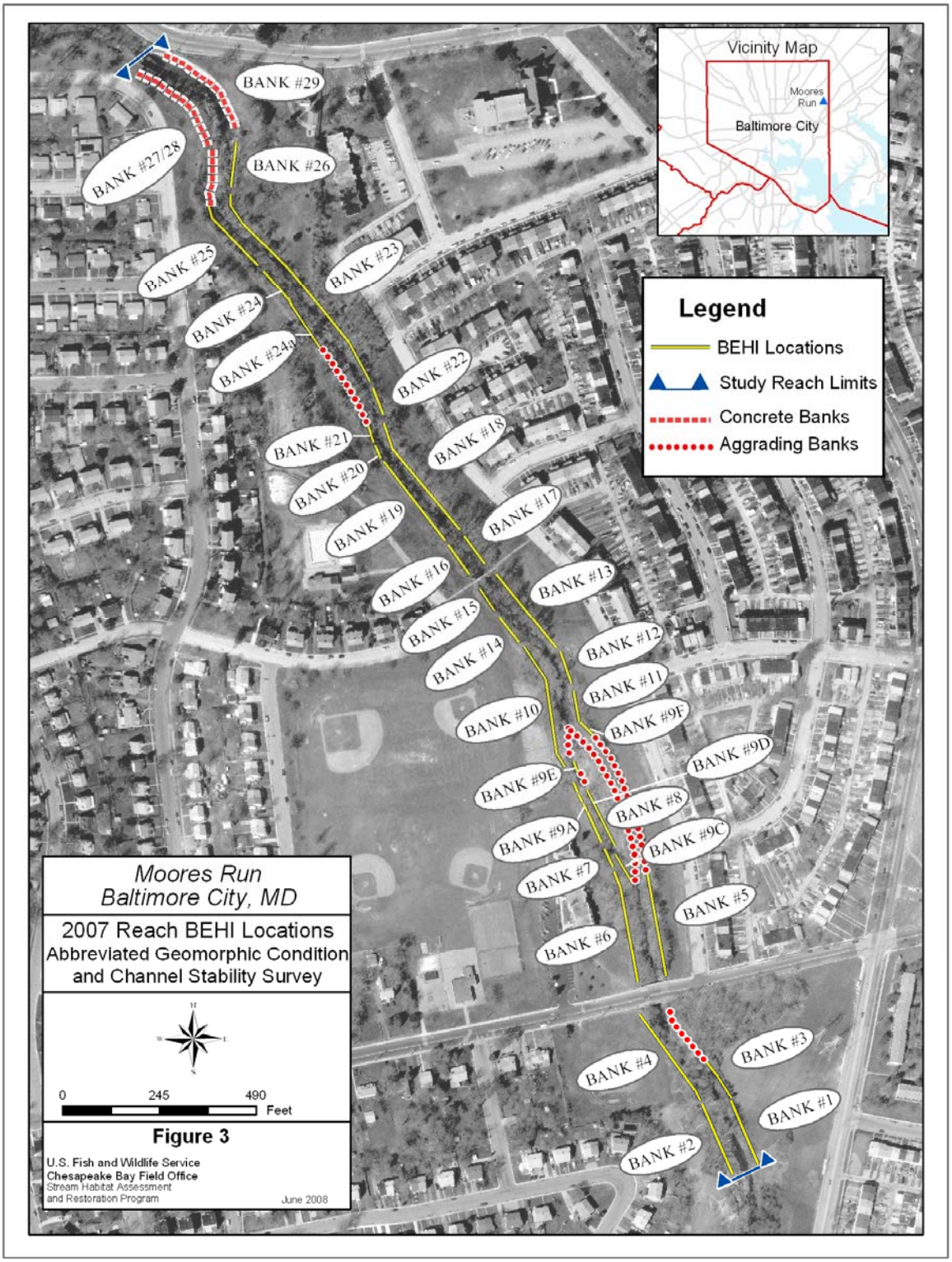
Vicinity Map
Moores Run
Baltimore City
Legend
BEHI Locations
Study Reach Limits
Concrete Banks
Aggrading Banks
BANK #29
BANK #27/28
BANK #26
BANK #25
BANK #23
BANK #24
BANK #24a
BANK #22
BANK #21
BANK #18
BANK #20
BANK #19
BANK #17
BANK #16
BANK #13
BANK #15
BANK #12
BANK #14
BANK #11
BANK #10
BANK #9F
BANK #9D
BANK #9E
BANK #8
BANK #9A
BANK #9C
BANK #7
BANK #5
BANK #6
BANK #4
BANK #3
BANK #1
BANK #2
Moores Run
Baltimore City, MD
2007 Reach BEHI Locations
Abbreviated Geomorphic Condition
and Channel Stability Survey
0
245
490
Feet
Figure 3
U.S. Fish and Wildlife Service
Chesapeake Bay Field Office
Stream Habitat Assessment
and Restoration Program
June 2008

Table 11. Study Reach BEHI and NBS Comparison

Reach		Study Reach BEHI and NBS								
		2003			2005			2007		
		Length of Bank (ft)	BEHI Rating	Near Bank Stress Rating	Length of Bank (ft)	BEHI Rating	Near Bank Stress Rating	Length of Bank (ft)	BEHI Rating	Near Bank Stress Rating
1	Bank 1	120	Moderate	Low	120	Moderate	Low	120	Moderate	Low
	Bank 2	151	Low	Low	151	Low	Low	151	Low	Low
	Bank 3	74	High	Low	74	High	Low	74	High	Moderate
	Bank 4	268	Extreme	High	268	Extreme	Moderate	268	Extreme	Moderate
2	Bank 5	260	Moderate	Moderate	260	Moderate	Moderate	260	Moderate	Low
	Bank 6	250	Low	Low	250	Low	Low	250	Moderate	Low
3	Bank 7	54	Very High	Moderate	54	High	Moderate	54	Very High	Moderate
	Bank 8	110	Moderate	High	110	Moderate	High	110	Moderate	Low
	Bank 9a[1]	80	Very High	Moderate	58	Very High	Moderate	114	Very High	Low
	Bank 9b	21	Moderate	Low	21	Moderate	Low	Not surveyed in 2007		
	Bank 9c	75	Low	Low	75	Low	Low	75	Low	Low
	Bank 9d	125	Low	Low	125	Moderate	Low	125	Low	Low
	Bank 9e	20	Moderate	Moderate	20	Moderate	Moderate	20	High	Moderate
	Bank 9f	35	Low	Low	35	Low	Low	35	Low	Low
	Bank 9g	Not surveyed in 2003			35	High	Moderate	Not surveyed in 2007		
4	Bank 10	392	Low	Low	392	Low	Low	392	Low	Low
	Bank 11	52	Moderate	Moderate	52	Moderate	Moderate	52	Moderate	Moderate
	Bank 12	88	High	Moderate	88	Moderate	Moderate	88	High	Moderate
	Bank 13	102	High	Low	102	High	Low	102	High	Low
5	Bank 13	153	High	Low	153	High	Low	153	High	Low
	Bank 14	75	Very High	Low	75	High	Low	75	Very High	Low
	Bank 15	88	High	Low	88	Very High	Low	88	High	Low
	Bank 16	135	Moderate	Low	135	Moderate	Low	135	Moderate	Low
	Bank 17	113	High	Low	113	High	Low	113	High	Low
	Bank 18	350	Moderate	Low	350	Moderate	Low	350	Moderate	Low
	Bank 19	285	High	Low	285	High	Low	285	High	High
	Bank 20	35	Very High	High	35	Extreme	High	35	Very High	High
	Bank 21	63	High	Moderate	63	High	Moderate	Not surveyed in 2007		
6	Bank 22	70	Extreme	High	70	Very High	High	70	Very High	Low
	Bank 23	397	High	Moderate	397	High	Moderate	397	High	Moderate
	Bank 24	155	Low	Low	155	Low	Low	70	Low	Low
	Bank 24a	Not surveyed in 2003 or 2005						108	High	Moderate
7	Bank 23	180	High	Low	180	High	Low	180	High	Moderate
	Bank 25	221	Low	Low	221	Low	Low	221	Low	Low
8	Bank 26	213	Low	Moderate	213	Low	Moderate	213	Low	Low
9	Bank 27	165	Very Low	Extreme	354	On-going Stabilization Project		354	On-going Stabilization Project	
	Bank 28	155	Very High	Extreme	354			354		

1. Reach 3 Bank 9a includes Banks 9a, 9b, and 9g from 2005.

b. Data Analysis

The Service compared the changes between the 2005 and 2007 BEHI and NBS ratings, and found that sixteen banks changed between surveys. Eight banks had a change in BEHI rating, while eight banks had a change in NBS rating. Reach 06 also had an addition of 108 feet of new bank prone to erosion (Table 11). These banks represent a total change of approximately 43 percent. Six banks showed an improvement in stability, which accounts for a 19 percent change. The increase in stability was primarily the result of an increase in root density, decrease in bank angles, and/or an increase in surface protection. The ten remaining banks, accounting for a 24 percent change, had a decrease in stability of one BEHI or NBS category. The decrease in stability was primarily the result of a decrease in root density, an increase in bank angles, and/or a decrease in surface protection.

Overall, however, erosion conditions in Moores Run have not changed significantly from 2005 to 2007. Most of the bank stability changes were minor, with a shift of only one rating category (i.e. "moderate" to "low" or "high" to "very high").

2. Representative Cross Section BEHI, NBS, and Bank Profiles

Cross section BEHI, NBS, and bank profiles are used to validate bank erosion rates. BEHI and NBS assessments are conducted at monumented cross sections, and repeated surveys at these cross sections will show lateral adjustments from which the Service can calculate actual bank erosion rates for the BEHI and NBS combinations.

The Service reassessed BEHI and NBS conditions at eight monumented cross sections (Table 12). The Service resurveyed the cross sections selected in 2005 (Eng *et al.* 2007) in order to determine the percent sediment contribution for these BEHI and NBS combinations. However, the data could not be used for validation since two years had passed between surveys. The City will be able to use the 2007 BEHI and NBS combinations to determine percent sediment contribution following the next resurvey of these cross sections.

C. Bank Erosion Estimates

For the 2007 geomorphic condition and channel stability survey, the Service used reach BEHI and NBS ratings, bank dimensions, and a bank erodibility curve to predict reach average erosion quantities and rates for the study reaches. Because Maryland does not have bank erodibility curves, a bank erodibility curve developed by the Service for Washington, D.C. was used in Moores Run. The Service selected this curve because it represents watershed and stream conditions at Moores Run.

Table 12. 2005 and 2007 Selected Cross Section BEHI and NBS

Reach	Cross Section		Bank	2005		2007	
				BEHI	NBS	BEHI	NBS
1	USFWS	G	Right	Extreme	Moderate	Extreme	Moderate
2	Balt.	32	Left	Low	Moderate	Low	Low
3	Balt.	28	Right	Moderate	High	High	High
	USFWS	A	Right	Moderate	Low	Moderate	Low
4	USFWS	B	Left	High	Moderate	Very High	Moderate
5	Balt.	18	Right	Moderate	Moderate	Moderate	Low
	USFWS	C	Right	Moderate	Low	High	Low
6	Balt.	14	Left	High	Moderate	High	Moderate

In 2007, the Service reassessed the reach BEHI and NBS ratings and bank dimensions for each bank prone to erosion. The Service applied these ratings and dimensions to the draft D.C. curve to predict reach average erosion quantities and rates for the study reaches (Table 13).
The Service predicts that the banks will contribute a total of 749 tons of sediment in 2008, with individual study reaches ranging from 2 tons/year to 349 tons/year. Study reach erosion rates ranged from 0.01 tons/year/feet to 0.81 tons/year/feet.

Table 13. Bank Erosion Prediction

Bank Erosion Prediction Comparison						
Reach	2003 Bank Erosion		2005 Bank Erosion		2007 Bank Erosion	
	Total (tons/year)	Rate (tons/year/feet)	Total (tons/year)	Rate (tons/year/feet)	Total (tons/year)	Rate (tons/year/feet)
1	411	0.96	319	0.74	349	0.81
2	20	0.10	20	0.10	14	0.05
3	47	0.11	51	0.12	29	0.07
4	35	0.08	26	0.08	35	0.11
5	143	0.19	162	0.24	127	0.19
6	149	0.31	117	0.24	143	0.29
7	30	0.22	30	0.22	50	0.37
8	7	0.04	7	0.04	2	0.01
9	269	0.76	Active stabilization project		Active stabilization project	
Total	**1,111**		**732**		**749**	

The Service compared the changes between the 2005 and 2007 bank erosion quantities, and found an increase of 17 tons of sediment per year. Reasons for the difference between the 2005 and 2007 erosion quantities include changes in BEHI ratings and NBS ratings; however, the differences between 2005 and 2007 predictions are minor. Additionally the Service did not make any predictions for Reach 09 because of the on-going bank stabilization project.

III. CONCLUSIONS

Although the stability conditions of Moores Run have changed only slightly between 2005 and 2007, the abbreviated survey indicates that the stream is continuing to adjust. Reaches 02, 04, 05, 06, 07, and 08 (approximately 61 percent of the study area) are generally stable, with some minor localized instability problems. The stability trend of these reaches should remain stable if there are no significant changes in watershed land use character or flow regime. Reaches 01 and 03 (approximately 30 percent of the study area) have widespread instability problems and will continue to adjust until equilibrium is reached. The Service recommends more detailed monitoring of Reaches 07 and 08. The Service did not collect data for these reaches in the past because they were boulder and bedrock dominated. However, modifications to Reach 09 may be influencing the stability conditions of Reaches 07 and 08 more than the Service anticipated. Stability trend predictions for Reach 09 cannot be made until the stream bank stabilization project is complete. In addition, the Service recommends resurveying all of the Moores Run 2007 representative cross sections in order to validate bank erosion predictions.

The stream stabilization project in the upper reaches of Moores Run continued into 2007 with the addition of new concrete banks and a 48” culvert in Reach 08. As part of the stream stabilization project, additional stormwater runoff has been routed into the study area. This change in flow regime can result in changes to stream character and stability. The Service recommends continued monitoring of Moores Run to document any changes that may occur as a result of the additional stormwater flow, and to further validate stability predictions.

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