Final Report

Portage River/Little Portage Creek Watershed Planning Project
Geomorphic Assessment
Grant Tracking Number: 2012-0017

Prepared for:

Michigan Department of Environmental Quality

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Suggested Citation: Riser, B., M. Rubley, and R. Pierson, 2015. Portage River/Little Portage Creek Watershed Planning Project Geomorphic Assessment. Prepared for Michigan Department of Environmental Quality.

Table of Contents

Introduction

Located in Kalamazoo and St. Joseph Counties, the adjacent Portage River (PR) Watershed (PRW) (0405000101) and Little Portage Creek (LPC) Watershed (LPCW) (0405000109) encompass a combined 185,518 acres. Portage River Watershed encompasses an area of 125, 543 (196 mi^2) acres in the southern part of Kalamazoo County and the northern part of St. Joseph County. Little Portage Creek encompasses an area of 59,975 acres (93.71 mi^2) in southeast Kalamazoo County, northeast St. Joseph County, and southwest Calhoun County. Both are tributaries of the St. Joseph River (04050001) which drains 4,685 square miles of southern Michigan and northern Indiana and enters Lake Michigan in the City of St. Joseph.

Agricultural influence has affected the watershed since settlement in the mid to late 1800's. Drainage practices to lower the water table and create more upland areas for settlement and agriculture have altered the hydrology and hydraulics of both systems. Much of the Portage River Mainstem has evaded dredging and maintains a sinuous pattern representative of pre-modified conditions. Smaller tributaries have been altered and established/maintained as designated drains by the Kalamazoo, St. Joseph, and Calhoun County Drain and Water Resource Commissions. Areas of intense modification in the PRW include the Headwaters of the Portage River (HUC 12: 0501), Indian Lake-Portage River (HUC 12: 0505), and Butternut Creek-Bear Creek (HUC 12: 0504). The majority of Little Portage Creek from the confluence with the St. Joseph in Mendon, MI to its headwaters near Climax, MI is maintained as a designated drain and as a result has increased erosion and sedimentation throughout.

As part of watershed assessment, channel processes (i.e. lateral migration, etc.) are crucial to understanding the consequences of cumulative effects on changes and provides insight into mitigation or changed management direction to reduce future impacts and encourage channel stability recovery Rosgen and Silvey (2005). In order to gain a better understanding of conditions throughout the watershed a modified geomorphic analysis consisting of Bank Erosion Hazard Index (BEHI), near-bank stress (NBS) and bank and toe pin installations were performed and analyzed.

Methods

Twenty-four sites were selected throughout both watersheds in order to gain a better understanding of types of stream reaches throughout both watersheds and to evaluate erosion rates and sources of sediment. The study spanned a total of two years. All stream stability measurements and data collection followed procedure/protocol within appropriate portions of Rosgen and Silvey (2005). A modified classification system of Flowchart 1-1. Hierarchy of River Inventory and Assessment (Rosgen, 1996), was used to characterize stream reaches within the twenty-four selected sites or a modified Level II Morphological Stream Channel Classification. Bank pins and toe pins, the Bank Erosion Hazard Index (BEHI), and near-bank stress (NBS) were performed to gain a better understanding of in stream conditions and lateral erosion risk and rates.

Site Selection:

Sites were selected based upon aerial imagery, location within the watershed, stream order, designated and undesignated portions of drains, pre-modified and modified conditions, land use, site access, and

crew safety. Within the LPC four sites were established within the headwaters region, four sites within lateral drains, and four sites on the mainstem. Within the PR three sites were established within the headwaters region, four sites within lateral drains and creeks in the middle portion of the watershed, two small lateral drains in the lower portion of the watershed and three sites on the mainstem. Sites established in pre-modified or “reference” reaches were hypothesized to contribute little to no erosion. Sites near highly modified stream reaches from agriculture and heavy drain modification were predicted to contribute larger quantities of erosion.

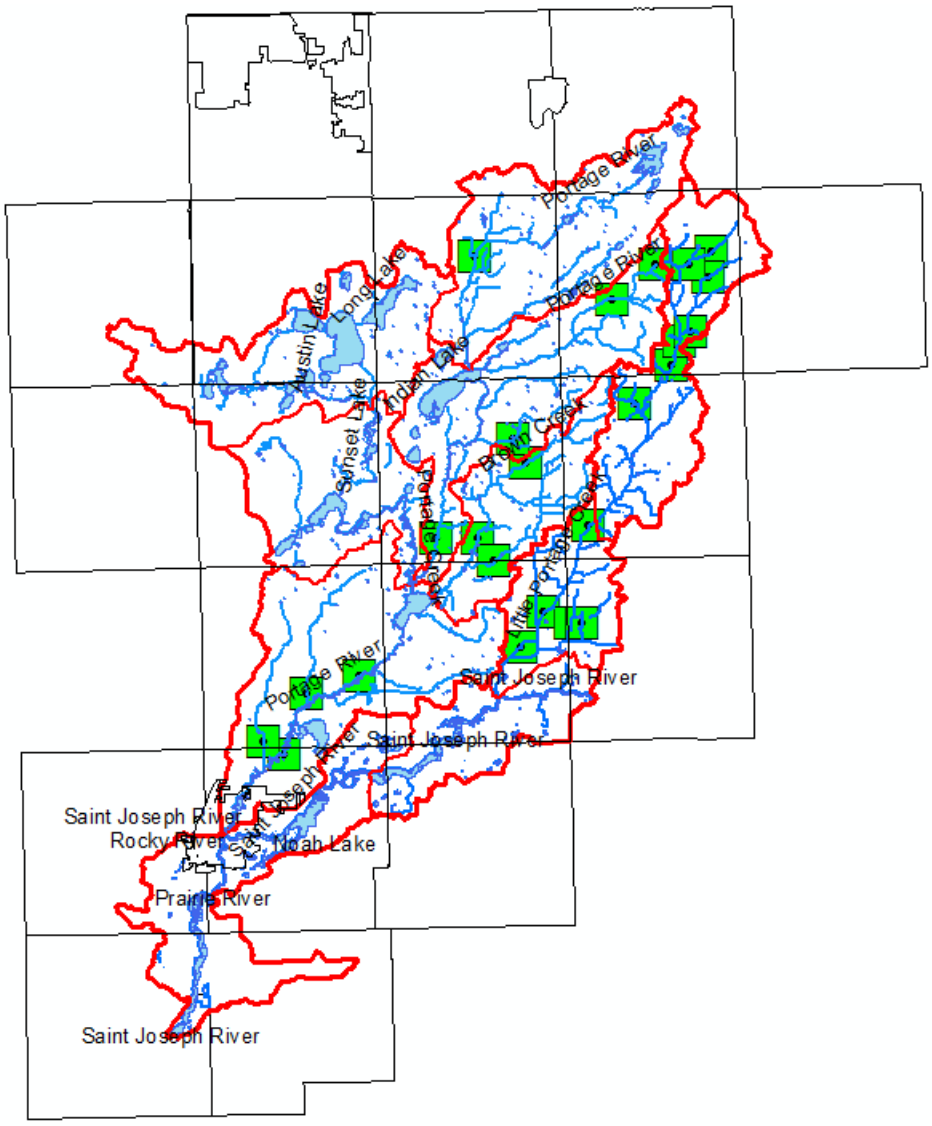
Sites were named based on order of establishment and proximity to nearest road stream crossing.

See **Table 1** on the following page:

Stream	Station ID	Township/Section	Nearest Road/Stream Crossing	Land Use/Modification	Stability Hypothesis
LPC/Willow Swamp Drn./Mainstem	Site 1 - TS Ave.	Climax/Section 34	TS Ave.	Riparian Forest/Modification	Unstable
LPC/Willow Swamp Drn./Mainstem	Site 2 - S. Ave	Climax/Section 27	S Ave.	Agricultural/Modification	Unstable
LPC/Lateral Drn.	Site 3 - 45th St.	Climax/Section 26	45th St.	Riparian Forest and Drain Two-Track/Modification	Unstable
PR/Johnson Drn./Headwater	Site 4 - 43rd St.	Climax/Section 15	43rd St.	Riparian Forest/Modification	Unstable
PR/Johnson Drn./Headwater	Site 5 - 40th	Climax/Section 20	40th St.	Agricultural Pasture and Riparian Forest/Modification	Unstable
PR/Reinbold Drn./Middle-Drn.	Site 6 - V Ave.	Brady/Section 14	V Ave.	Riparian Forest/Modification	Unstable
PR/Bear Creek/Middle-Creek	Site 7 - Y Ave.	Brady/Section 34	Y Ave.	Shrub and Scrub/No	Stable
PR/Parker Drn./Middle-Drn.	Site 8 - 34th St.	Brady/Section 14	34th St.	Shrub and Scrub/No	Stable
PR/Butternut Creek/Middle-Creek	Site 9 - Buckner	Mendon/Section 3	Buckner/31st. St.	Shrub and Scrub/No	Stable
LPC/Section Line Drn./Lateral Drn.	Site 10 - Taylor	Mendon/Section 23	Taylor Rd	Agricultural/Modification	Unstable
LPC/Mainstem	Site 11 - 38th St.	Wakeshma/Section 30	38th St.	Riparian Forest/Modification	Unstable
PR/Mainstem	Site 12 - Y Ave	Brady/Section 32	Y Ave.	Riparian Forest/No	Stable
PR/Headwaters	Site 13 - OP Ave.	Pavilion/Section 10	OP Ave.	Riparian Forest/Modification	Unstable
PR/Lateral Drn.	Site 14 - Edgarton Rd.	Park/Section 32	Edgarton Rd.	Agricultural/Modification	Unstable
PR/Lateral Drn.	Site 15 - Moorepark Rd.	Park/Section 27	Moorepark Rd.	Shrub and Scrub/Yes	Unstable
PR/Mainstem	Site 16 - Carpenter Rd.	Lockport/Section 4	Carpenter	Riparian Forest/No	Stable
PR/Mainstem	Site 17 - Parkville Rd.	Park/Section 24	Parkville Rd.	Riparian Forest/No	Stable
LPC/Woods Lake Drn	Site 18 - Wing Rd. West	Leonidas/Section 18	Wing Rd.	Agricultural/Modification	Unstable

West/Lateral Drn.					
LPC/Woods Lake Drn. East/Lateral Drn.	Site 19 Wing Rd. East	Leonidas/Section 18	Wing Rd.	Agricultural/Modification	Unstable
PR/Lateral Drn.	Site 20 - U Ave.	Wakeshma/Section 4	U Ave.	Riparian Forest/Modification	Unstable
LPC/Longman Drn./Headwater	Site 21 - 46th St.	Climax/Section 14	46th St.	Riparian Forest/Modification	Unstable
LPC/Willow Swamp Drn.	Site 22 - 47th St.	Climax/Section 12	47th St.	Pasture/Modification	Unstable
LPC/Mainstem	Site 23 - Michigan Ave.	Mendon/Section 12	Michigan Ave.	Agricultural/Modification	Unstable
LPC/Willow Swamp Drn./Headwater	Site 24 - 45th St.	Climax/Section 14	45th St.	Riparian Forest/Modification	Unstable

Figure 1: Map of Geomorphic Locations



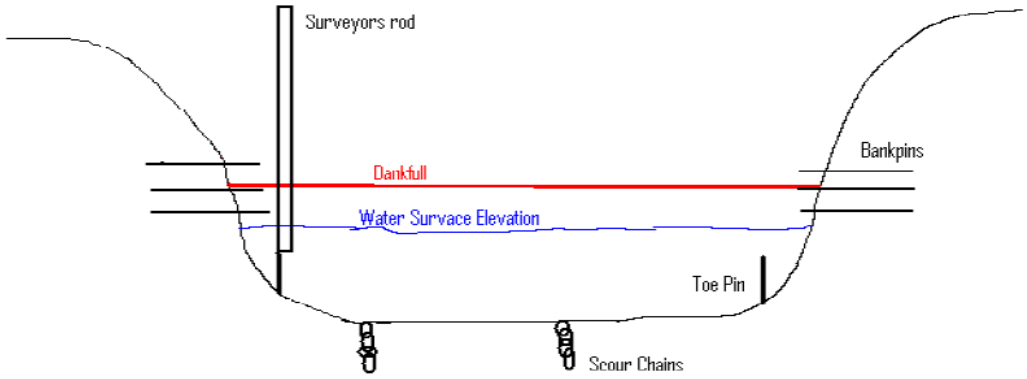
Initial Data Collection:

Once appropriate reaches had been located, the reach was waded and walked to insure that conditions existed for at least twenty bankfull widths and that the reach was outside the influence of the road stream crossings influence. A riffle cross-section was located and either the left bank or right bank was selected (direction facing downstream).

Cross-sections were marked with rerod posts driven vertically into the streambed substrate on the side of the stream at the toe or the edge/start of the bank. Bank pins (smooth steel rod) were driven horizontally into the stream bank below, at, and above bankfull elevations. Coordinates of all the installed rerod pins were documented with GPS for future reference. Surveying of the cross-section

consisted of a Cam-Line Measuring line to measure bankfull width, bankfull depth, and wetted perimeter and a 25 ft. survey rod in 10ths and 100ths. Channel dimensions were recorded across the cross-section from bank to bank. The surveyor's rod was placed on the toe pin with a level for vertical measurement and a pocket rod in feet, 10ths and 100ths was used to measure horizontally. This was used in conjunction with a line level to determine bank pin location. These measurements were recorded on Worksheet 4-2 Bank profile and bank erosion summary data form (Rosgen, 2006). A BEHI was conducted for each site to rank channel bank susceptibility to erosion in Worksheet 3-11 Form to calculate Bank Erosion Hazard Index variables and overall BEHI rating. Figure 3-7 from Rosgen and Silvey (2005) was used to analyze BEHI variables. A level III (5) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb}/d_{bkf}) NBS risk rating was determined and recorded in Worksheet 3-12. All of the data was entered into Rivermorph Software.

Figure 2: Bank Pin Cross Section Illustration



Follow-Up Data Collection:

Sites were re-surveyed in subsequent years or after bankfull events had occurred. Re-surveying of stations included re-evaluating bank profiles. GPS was used to relocate the general pin locations and a metal detector was used to help locate pins that had sediment or vegetation covering the locations. Once, toe pins were located measurements of the bank profile and bank pins was performed. Measurements were taken from the surveyor's rod to the exposed end of the pin and from the surveyor's rod to the bank. Measurements were recorded to the appropriate data sheets to use for comparison to previous measurements. This data was entered into Rivermorph Software for analysis of change.

Stream Stability and Recovery Potential:

Stability for streams was determined utilizing a matrix based on the EPA Function-Based Framework (Harmon et al, 2012). The matrix was based on five parameters consisting of floodplain connectivity, Simon's channel evolution model, lateral stability, riparian buffer, and bed form diversity. For this geomorphic assessment due to measurements made the latter will not be used. For each parameter, the stream was classified as functioning, functioning at-risk, or not functioning. An overall classification for

each reach was determined by adding the number of times a stream was categorized as functioning/stable, functioning-at-risk/stability-at-risk, and not functioning/unstable (Appendix A).

Recovery potential and sensitivity to disturbance for each stream was derived based on stream classification (Rosgen, 1994). Recovery potential for streams indicates the ability of the stream to stabilize without further human involvement (Harmon et al, 2012). Sensitivity to disturbance indicates how much affect disturbing the stream and surroundings will have on the natural state and stability of the stream. Recovery potential and disturbance sensitivity of the stream should be taken into account prior to implementing a project to determine the effect of stream stability.

Results:

Morphological Survey, Assessment and Analysis

The Morphological Assessment consisted of collection, preparation, and interpretation of data from each study reach in the PR/LPC watersheds. After completion of the reach survey, data was analyzed to determine the morphological characteristics of each subject reach. The results of the analysis for the reaches are described below.

A modified Level II Morphological Stream Channel Classification was performed for the following reaches:

Site 1 – TS Ave: Little Portage Creek-Willow Swamp Drain has a drainage area of 12 square miles. The reach is a Rosgen G5 entrenched gully, step/pool low width/depth ratio stream type, highly incised channel with a dominant stream bed material consisting of sand. The reach shows signs of dredging, but is beginning to form depositional features with point bars and mid-channel bars within the confined gully.

Table 2: Survey of Morphological Stream Parameters Using Rosgen Method Level II Stream Classification: Site 1 TS Ave. Little Portage Creek-Willow Swamp Drain

Parameter	Value
Bankfull Width (Wbkf) - feet	15.5
Mean Depth (dbkf) - feet	1.62
Bankfull Cross-Sectional Area (Abkf) - square feet	N/A
Width/Depth Ratio (W/d)	9.57
Maximum Depth (dmbkf) - feet	1.86
Width of Flood-Prone Area (Wfpa) - feet	20
Entrenchment Ratio (ER)	1.29
Channel Materials	Sand
Water Surface Slope (s) - feet per foot	N/A
Channel Sinuosity (K)	N/A
Calculated Bankfull Discharge (Q) - cubic ft/second	N/A
Stream Type	G5

Site 2 – S Ave: Little Portage Creek-Willow Swamp Drain has a drainage area of 11.66 square miles. The reach is a Rosgen G5 entrenched gully, step/pool low width/depth ratio, highly incised stream type with a dominant stream bed material consisting of sand. The reach has a narrow floodplain and shows signs of dredging within the last five years. Bankfull indicators are located within the entrenched channel and are difficult to identify since they are not fully developed and there is little floodplain.

Table 1.3 Survey of Morphological Stream Parameters Using Rosgen Method Level II Stream Classification: Site 2 – S Ave. Little Portage Creek-Willow Swamp Drain

Parameter	Value
Bankfull Width (Wbkf) - feet	15
Mean Depth (dbkf) - feet	2.04
Bankfull Cross-Sectional Area (Abkf) - square feet	N/A
Width/Depth Ratio (W/d)	7.35
Maximum Depth (dmbkf) - feet	2.26
Width of Flood-Prone Area (Wfpa) - feet	21
Entrenchment Ratio (ER)	1.4
Channel Materials	Sand
Water Surface Slope (s) - feet per foot	N/A
Channel Sinuosity (K)	N/A
Calculated Bankfull Discharge (Q) - cubic ft/second	N/A
Stream Type	G5

Site 3 – 45th St: A lateral drain of LPC it has a drainage area of 0.2 square miles. The reach is a Rosgen E6 riffle/pool stream with low width/depth ratio, highly incised stream type with a dominant stream bed material consisting of silt/clay. The reach has a brood floodplain on the south side of the stream and shows signs of dredging. Bankfull indicators are difficult to identify within the slightly entrenched channel. The left bank provides the best indication of bankfull.

Table 1.4 Survey of Morphological Stream Parameters Using Rosgen Method Level II Stream Classification: Site 3 – 45th St. Lateral Drain

Parameter	Value
Bankfull Width (Wbkf) - feet	11
Mean Depth (dbkf) - feet	1.93
Bankfull Cross-Sectional Area (Abkf) - square feet	N/A
Width/Depth Ratio (W/d)	5.7
Maximum Depth (dmbkf) - feet	2.46
Width of Flood-Prone Area (Wfpa) - feet	125
Entrenchment Ratio (ER)	11.36
Channel Materials	Silt/Clay
Water Surface Slope (s) - feet per foot	N/A
Channel Sinuosity (K)	N/A

Parameter	Value
Calculated Bankfull Discharge (Q) - cubic ft/second	N/A
Stream Type	E6

Site 4 - 43rd St: A headwater creek that is maintained as a drain with a drainage area of 3.5 square miles. The reach is a Rosgen G6 entrenched gully step/pool with a low width to depth ratio, highly incised stream channel type with a dominant stream bed material consisting of silt/clay. Bankfull indicators are difficult to identify within the entrenched channel. The reach show signs of dredging probably not within the last 10 yrs, however.

Table 1.5 Survey of Morphological Stream Parameters Using Rosgen Method Level II Stream Classification: Site 4 – 43rd St. Headwater Creek

Parameter	Value
Bankfull Width (Wbkf) - feet	14.5
Mean Depth (dbkf) - feet	1.37
Bankfull Cross-Sectional Area (Abkf) - square feet	N/A
Width/Depth Ratio (W/d)	10.58
Maximum Depth (dmbkf) - feet	1.82
Width of Flood-Prone Area (Wfpa) - feet	18
Entrenchment Ratio (ER)	1.24
Channel Materials	Silt/Clay
Water Surface Slope (s) - feet per foot	N/A
Channel Sinuosity (K)	N/A
Calculated Bankfull Discharge (Q) - cubic ft/second	N/A
Stream Type	G6

Site 5 – 40th St: A headwater creek maintained as a drain with a drainage area of 6.25 square miles. The reach is a Rosgen E5 riffle/pool stream with a low width/depth ratio, not entrenched, highly incised stream type with a dominant stream bed material consisting of sand. Bankfull indicators are evident on the right bank, with evidence of channel dredging.

Table 1.6 Survey of Morphological Stream Parameters Using Rosgen Method Level II Stream Classification: Site 5 – 40th St. Headwater Creek

Parameter	Value
Bankfull Width (Wbkf) - feet	11.2
Mean Depth (dbkf) - feet	1.34
Bankfull Cross-Sectional Area (Abkf) - square feet	N/A
Width/Depth Ratio (W/d)	8.36
Maximum Depth (dmbkf) - feet	1.49
Width of Flood-Prone Area (Wfpa) - feet	200

Parameter	Value
Entrenchment Ratio (ER)	17.86
Channel Materials	Sand
Water Surface Slope (s) - feet per foot	N/A
Channel Sinuosity (K)	N/A
Calculated Bankfull Discharge (Q) - cubic ft/second	N/A
Stream Type	E5

Site 6 – V Ave: A creek within the middle reaches of the PRW maintained as a designated drain with a drainage area of 2.87 square miles. The reach is a Rosgen C5 meandering, point bar, riffle/pool, alluvial channel with broad, well defined floodplains stream type with a dominant stream bed material consisting of sand. The moderately incised, not entrenched, moderate to high width to depth ratio channel has depositional features like bankfull benches to use as indicators. There is little indication of dredging in the last 20 years even though it is a designated drain.

Table 7 Survey of Morphological Stream Parameters Using Rosgen Method Level II Stream Classification: Site 6 – V Ave. Reinbold Drn.

Parameter	Value
Bankfull Width (Wbkf) - feet	15
Mean Depth (dbkf) - feet	1.03
Bankfull Cross-Sectional Area (Abkf) - square feet	N/A
Width/Depth Ratio (W/d)	14.56
Maximum Depth (dmbkf) - feet	1.15
Width of Flood-Prone Area (Wfpa) - feet	500
Entrenchment Ratio (ER)	33
Channel Materials	Sand
Water Surface Slope (s) - feet per foot	N/A
Channel Sinuosity (K)	N/A
Calculated Bankfull Discharge (Q) - cubic ft/second	N/A
Stream Type	C5

Site 7 – Y Ave: A creek within the middle reaches of the PRW with a drainage area of 9.85 square miles. The reach is a Rosgen E5 stream type meandering, riffle/pool stream, with a low width/depth ratio, not incised, not entrenched, well-vegetated banks, with a dominant stream bed material consisting of sand. Bankfull is easily defined with the broad floodplain, exposed root hairs and small benches within channel reach. There is no indication of dredging and appears to be pre-modified.

Table 8 Survey of Morphological Stream Parameters Using Rosgen Method Level II Stream Classification: Site 7 Y Ave. Bear Creek

Parameter	Value
Bankfull Width (Wbkf) - feet	16
Mean Depth (dbkf) - feet	1.76
Bankfull Cross-Sectional Area (Abkf) - square feet	N/A
Width/Depth Ratio (W/d)	9.09
Maximum Depth (dmbkf) - feet	2.06
Width of Flood-Prone Area (Wfpa) - feet	1000
Entrenchment Ratio (ER)	62.5
Channel Materials	Sand
Water Surface Slope (s) - feet per foot	N/A
Channel Sinuosity (K)	N/A
Calculated Bankfull Discharge (Q) - cubic ft/second	N/A
Stream Type	E5

Site 8 – 34th St: A creek in the middle reaches of the PRW. It has a drainage area of 2.68 square miles. The reach is a Rosgen E3 stream type – meandering riffle/pool stream with low width/depth ratio, little depostition, well vegetated banks and a dominant stream bed material consisting of cobble. The reach has very little to no sign of drain maintenancing. Bankfull indicators are fairly easy to identify, with depositional features like - low benches, exposed roots, and floodplains.

Table 9 Survey of Morphological Stream Parameters Using Rosgen Method Level II Stream Classification: Site 8 – 34th St. Parker Drn.

Parameter	Value
Bankfull Width (Wbkf) - feet	10
Mean Depth (dbkf) - feet	1.17
Bankfull Cross-Sectional Area (Abkf) - square feet	N/A
Width/Depth Ratio (W/d)	8.55
Maximum Depth (dmbkf) - feet	1.2
Width of Flood-Prone Area (Wfpa) - feet	500
Entrenchment Ratio (ER)	50
Channel Materials	Cobble
Water Surface Slope (s) - feet per foot	N/A
Channel Sinuosity (K)	N/A
Calculated Bankfull Discharge (Q) - cubic ft/second	N/A
Stream Type	E3

Site 9 – Buckner Rd: A small creek within the middle reaches of the PRW. It has a drainage area of 4.12 square miles. The reach is a Rosgen E6 stream type – meandering riffle/pool stream with a low width/depth ratio, well vegetated banks, not entrenched, not incised and a dominant stream bed material consisting of silt/clay.

Table 10: Survey of Morphological Stream Parameters Using Rosgen Method Level II Stream Classification: Site 9 – Buckner Rd. Small Creek in Middle Reaches of PRW

Parameter	Value
Bankfull Width (Wbkf) - feet	10
Mean Depth (dbkf) - feet	1.11
Bankfull Cross-Sectional Area (Abkf) - square feet	
Width/Depth Ratio (W/d)	9.01
Maximum Depth (dmbkf) - feet	1.37
Width of Flood-Prone Area (Wfpa) - feet	210
Entrenchment Ratio (ER)	21
Channel Materials	Silt/Clay
Water Surface Slope (s) - feet per foot	N/A
Channel Sinuosity (K)	N/A
Calculated Bankfull Discharge (Q) - cubic ft/second	N/A
Stream Type	E6

Site 10 Taylor Rd: A lateral drain in the lower reaches of the LPC with a drainage area of 0.5 square miles. The reach is a Rosgen G5 stream type – entrenched gully, step/pool with a low width/depth ratio, highly incised, entrenched, with very little bank vegetation and a dominant stream bed material consisting of sand. The reach shows signs of recent heavy dredging and manipulation.

Table 11: Survey of Morphological Stream Parameters Using Rosgen Method Level II Stream Classification: Site 10 Taylor Rd. Lateral Drain within the Lower Reaches of the LPC Watershed

Parameter	Value
Bankfull Width (Wbkf) - feet	10
Mean Depth (dbkf) - feet	1.55
Bankfull Cross-Sectional Area (Abkf) - square feet	N/A
Width/Depth Ratio (W/d)	6.45
Maximum Depth (dmbkf) - feet	2
Width of Flood-Prone Area (Wfpa) - feet	15
Entrenchment Ratio (ER)	1.5
Channel Materials	Sand
Water Surface Slope (s) - feet per foot	N/A
Channel Sinuosity (K)	N/A
Calculated Bankfull Discharge (Q) - cubic ft/second	N/A
Stream Type	G5

Site 11 – 38th St: The site is on the mainstem of LPC and has a drainage area of 27.95 square miles. The reach is a Rosgen F5 stream type – entrenched meandering riffle/pool channel, with a moderate to high

width/depth ratio, entrenched, but not incised with a dominant stream bed material consisting of sand. Bankfull indicators are somewhat difficult to identify within the entrenched channel, with silver maple and basswood trees growing above, at, and below bankfull. The reach shows signs of dredging with large amounts of spoil berms on the south side of the channel, but not recent with tree growth next to the channel.

Table 12 Survey of Morphological Stream Parameters Using Rosgen Method Level II Stream Classification: Site 11 Mainstem of LPC at 38th St.

Parameter	Value
Bankfull Width (Wbkf) - feet	32
Mean Depth (dbkf) - feet	2.05
Bankfull Cross-Sectional Area (Abkf) - square feet	N/A
Width/Depth Ratio (W/d)	15.61
Maximum Depth (dmbkf) - feet	2.68
Width of Flood-Prone Area (Wfpa) - feet	43
Entrenchment Ratio (ER)	1.34
Channel Materials	Sand
Water Surface Slope (s) - feet per foot	N/A
Channel Sinuosity (K)	N/A
Calculated Bankfull Discharge (Q) - cubic ft/second	N/A
Stream Type	F5

Site 12 – Y Ave: The site is on the mainstem of the PR and has a drainage area of 69.53 square miles. The reach is classified as a Rosgen C4 stream type – meandering, point bar, riffle/pool, and alluvial channel, with broad well defined floodplains, slightly entrenched, not incised, with a dominant stream bed material consisting of gravel. Bankfull indicators are easily recognizable with floodplains, depositional features, and exposed roots. The site has a high bank most likely formed from glaciation. The reach is pre-modified most likely due to the large expansive floodplain.

Table 13 Survey of Morphological Stream Parameters Using Rosgen Method Level II Stream Classification: Site 12 – Y Ave. Mainstem

Parameter	Value
Bankfull Width (Wbkf) - feet	51
Mean Depth (dbkf) - feet	2.13
Bankfull Cross-Sectional Area (Abkf) - square feet	N/A
Width/Depth Ratio (W/d)	23.94
Maximum Depth (dmbkf) - feet	2.89
Width of Flood-Prone Area (Wfpa) - feet	300
Entrenchment Ratio (ER)	5.89
Channel Materials	Gravel
Water Surface Slope (s) - feet per foot	N/A

Parameter	Value
Channel Sinuosity (K)	N/A
Calculated Bankfull Discharge (Q) - cubic ft/second	N/A
Stream Type	C4

Site 13 – OP Ave: A reach in the PR headwaters area above Indian Lake with a drainage area of 6.68 square miles. The reach is a Rosgen B5 stream type moderately entrenched, deeply incised, riffle dominated with infrequently-spaced pools, moderate to high width/depth ratio, well vegetated banks and a dominant stream bed material consisting of sand. The reach shows signs of dredging. Bankfull indicators are somewhat difficult in the moderately entrenched channel.

Table 14 Survey of Morphological Stream Parameters Using Rosgen Method Level II Stream Classification: Site 13 – OP Ave. Mainstem Headwaters Region

Parameter	Value
Bankfull Width (Wbkf) - feet	23
Mean Depth (dbkf) - feet	1.69
Bankfull Cross-Sectional Area (Abkf) - square feet	N/A
Width/Depth Ratio (W/d)	13.61
Maximum Depth (dmbkf) - feet	2
Width of Flood-Prone Area (Wfpa) - feet	35
Entrenchment Ratio (ER)	35
Channel Materials	Sand
Water Surface Slope (s) - feet per foot	N/A
Channel Sinuosity (K)	N/A
Calculated Bankfull Discharge (Q) - cubic ft/second	N/A
Stream Type	B5

Site 14 – Edgarton Rd: A lateral drain in the lower reaches of the PRW with a drainage area of 8.44 square miles. The reach is a Rosgen G5 stream type – entrenched gully, step/pool, with a low width/depth ratio, very little bank vegetation, and a dominant stream bed material consisting of sand. The reach shows signs of dredging. Bankfull indicators are tough to identify within the highly entrenched channel.

Table 15 Survey of Morphological Stream Parameters Using Rosgen Method Level II Stream Classification: Site 14 – Edgarton Rd. Lateral Drain

Parameter	Value
Bankfull Width (Wbkf) - feet	11
Mean Depth (dbkf) - feet	1.3

Parameter	Value
Bankfull Cross-Sectional Area (Abkf) - square feet	N/A
Width/Depth Ratio (W/d)	8.46
Maximum Depth (dmbkf) - feet	1.55
Width of Flood-Prone Area (Wfpa) - feet	15
Entrenchment Ratio (ER)	1.36
Channel Materials	Sand
Water Surface Slope (s) - feet per foot	N/A
Channel Sinuosity (K)	N/A
Calculated Bankfull Discharge (Q) - cubic ft/second	N/A
Stream Type	G5

Site 15 – Moorepark Rd: A lateral drain in the lower reaches of the PRW with a drainage area of 7.06 square miles. The reach is a Rosgen E5 stream type meandering, moderately incised, slightly entrenched, riffle/pool stream with low width/depth ratio, well-vegetated banks, a moderate floodplain, and a dominant stream bed material consisting of sand. Bankfull indicators are somewhat difficult to identify within the slightly entrenched channel. The reach shows signs of dredging.

Table 16 Survey of Morphological Stream Parameters Using Rosgen Method Level II Stream Classification: Site 15 – Moorepark Rd. Lateral Drain

Parameter	Value
Bankfull Width (Wbkf) - feet	15
Mean Depth (dbkf) - feet	1.89
Bankfull Cross-Sectional Area (Abkf) - square feet	N/A
Width/Depth Ratio (W/d)	7.94
Maximum Depth (dmbkf) - feet	2.28
Width of Flood-Prone Area (Wfpa) - feet	120
Entrenchment Ratio (ER)	8
Channel Materials	Sand
Water Surface Slope (s) - feet per foot	N/A
Channel Sinuosity (K)	N/A
Calculated Bankfull Discharge (Q) - cubic ft/second	N/A
Stream Type	E5

Site 16 – Carpenter Rd: A reach in the lower portions of the PRW on the mainstem, with a drainage area of 179.82 square miles. The reach is a Rosgen C5 stream type – meandering, point bar, riffle/pool, alluvial channel with broad well developed floodplains, not incised, not entrenched, with a moderate to high width/depth ratio and a dominant stream bed material consisting of sand. The reach is pre-modified most likely due to the expansive floodplains and wide stream channel. Bankfull indicators are

easily identifiable with floodplains, depositional features, and exposed roots. The banks are heavily armored due to silver maple and basswood root structures.

Table 17 Survey of Morphological Stream Parameters Using Rosgen Method Level II Stream Classification: Site 16 – Carpenter Rd. Mainstem

Parameter	Value
Bankfull Width (Wbkf) - feet	96
Mean Depth (dbkf) - feet	2.91
Bankfull Cross-Sectional Area (Abkf) - square feet	N/A
Width/Depth Ratio (W/d)	32.99
Maximum Depth (dmbkf) - feet	3.69
Width of Flood-Prone Area (Wfpa) - feet	1000
Entrenchment Ratio (ER)	10.42
Channel Materials	Sand
Water Surface Slope (s) - feet per foot	N/A
Channel Sinuosity (K)	N/A
Calculated Bankfull Discharge (Q) - cubic ft/second	N/A
Stream Type	C5

Site 17 – Parkville Rd: A site in the lower reaches of the PRW on the mainstem with a drainage area of 161.623 square miles. The reach is a Rosgen C4 stream type - meandering, point bar, riffle/pool, alluvial channel, with well-defined floodplains, not entrenched, not incised, with well-developed root structures armoring the banks and a dominant stream bed material consisting of gravel. Bankfull indicators are easily identifiable with floodplains, depositional features, and exposed roots. The site has a natural high bank most likely from glaciation. This site is influenced from a dam upstream.

Table 18 Survey of Morphological Stream Parameters Using Rosgen Method Level II Stream Classification: Site 17 – Parkville Rd. Mainstem

Parameter	Value
Bankfull Width (Wbkf) - feet	53
Mean Depth (dbkf) - feet	2.46
Bankfull Cross-Sectional Area (Abkf) - square feet	N/A
Width/Depth Ratio (W/d)	21.54
Maximum Depth (dmbkf) - feet	2.68
Width of Flood-Prone Area (Wfpa) - feet	1000
Entrenchment Ratio (ER)	18.87
Channel Materials	Gravel
Water Surface Slope (s) - feet per foot	N/A
Channel Sinuosity (K)	N/A
Calculated Bankfull Discharge (Q) - cubic ft/second	N/A

Parameter	Value
Stream Type	C4

Site 18 – Wing Rd. West: A lateral drain in the lower reaches of the LPCW with a drainage area of 0.623 square miles. The reach is a Rosgen E6 stream type riffle/pool, low width/depth ratio, slightly incised, and not entrenched channel with a dominant stream bed material consisting of silt/clay. The reach shows signs of heavy drain maintenancing within the last three years. Bankfull indicators are difficult to identify consisting exposed roots, vegetation, and slope breaks.

Table 19 Survey of Morphological Stream Parameters Using Rosgen Method Level II Stream Classification: Site 18 – Wing Rd. West Lateral Drain

Parameter	Value
Bankfull Width (Wbkf) - feet	10
Mean Depth (dbkf) - feet	1.82
Bankfull Cross-Sectional Area (Abkf) - square feet	N/A
Width/Depth Ratio (W/d)	5.49
Maximum Depth (dmbkf) - feet	2.2
Width of Flood-Prone Area (Wfpa) - feet	300
Entrenchment Ratio (ER)	30
Channel Materials	Silt/Clay
Water Surface Slope (s) - feet per foot	N/A
Channel Sinuosity (K)	N/A
Calculated Bankfull Discharge (Q) - cubic ft/second	N/A
Stream Type	E6

Site 19 – Wing Rd. East: A lateral drain in the lower reaches of the LPCW with a drainage area of 1.2 square miles. The reach is a Rosgen E5 stream type – riffle/pool stream, low width/depth ratio, deeply incised, slightly entrenched and a dominant stream bed material consisting of sand. The reach shows signs of dredging. Bankfull indicators are somewhat difficult to determine in the slightly entrenched channel consisting of vegetation, exposed roots and slope breaks.

Table 20 Survey of Morphological Stream Parameters Using Rosgen Method Level II Stream Classification: Site 19 – Wing Rd. East Lateral Drain

Parameter	Value
Bankfull Width (Wbkf) - feet	11
Mean Depth (dbkf) - feet	1.45
Bankfull Cross-Sectional Area (Abkf) - square feet	N/A
Width/Depth Ratio (W/d)	7.59
Maximum Depth (dmbkf) - feet	1.58
Width of Flood-Prone Area (Wfpa) - feet	120
Entrenchment Ratio (ER)	10.91
Channel Materials	Sand
Water Surface Slope (s) - feet per foot	N/A
Channel Sinuosity (K)	N/A
Calculated Bankfull Discharge (Q) - cubic ft/second	N/A
Stream Type	E5

Site 20 – U Ave: A lateral drain in the middle reaches of the LPCW, it has a drainage area of 1.14 square miles. The reach is a Rosgen C6 stream type point bar, riffle/pool, alluvial channel, with well-defined floodplains, slightly entrenched, moderately incised, moderate to high width/depth ratio, and a dominant stream bed material consisting of silt/clay. The reach shows signs of dredging but not recently due to the tree growth along the channel. Bankfull indicators are fairly identifiable in the slightly entrenched channel consisting of floodplains, slope breaks, exposed roots, and vegetation.

Table 21 Survey of Morphological Stream Parameters Using Rosgen Method Level II Stream Classification: Site 20 – U Ave. Lateral Drain

Parameter	Value
Bankfull Width (Wbkf) - feet	20
Mean Depth (dbkf) - feet	1.37
Bankfull Cross-Sectional Area (Abkf) - square feet	N/A
Width/Depth Ratio (W/d)	14.59
Maximum Depth (dmbkf) - feet	1.55
Width of Flood-Prone Area (Wfpa) - feet	75
Entrenchment Ratio (ER)	3.75
Channel Materials	Silt/Clay
Water Surface Slope (s) - feet per foot	N/A
Channel Sinuosity (K)	N/A
Calculated Bankfull Discharge (Q) - cubic ft/second	N/A
Stream Type	C6

Site 21 – 46th St: A headwater creek in the LPCW maintained as a designated drain, with a drainage area of 1.86 square miles. The reach is a Rosgen E5 stream type riffle/pool, low width/depth ratio, slightly incised, not entrenched channel with a dominant stream bed material consisting of sand. The reach

shows signs of dredging but not recently due to the establishment of streamside tree growth. Bankfull indicators are fairly identifiable with slope breaks, exposed roots, and vegetation.

Table 22 Survey of Morphological Stream Parameters Using Rosgen Method Level II Stream Classification: Site 21 – 46th St. Headwater Creek

Parameter	Value
Bankfull Width (Wbkf) - feet	13
Mean Depth (dbkf) - feet	1.44
Bankfull Cross-Sectional Area (Abkf) - square feet	N/A
Width/Depth Ratio (W/d)	9.03
Maximum Depth (dmbkf) - feet	1.65
Width of Flood-Prone Area (Wfpa) - feet	150
Entrenchment Ratio (ER)	11.54
Channel Materials	Sand
Water Surface Slope (s) - feet per foot	N/A
Channel Sinuosity (K)	N/A
Calculated Bankfull Discharge (Q) - cubic ft/second	N/A
Stream Type	E5

Site 22 – 47th St: A headwater creek in the LPCW, it has a drainage area of 1.9 square miles. The stream reach is a Rosgen B5 stream type – moderately entrenched, deeply entrenched, deeply incised, riffle dominated channel with infrequent spaced pools, moderate to high width/depth ratio and a dominant stream bed material consisting of sand. The reach shows signs of dredging but not any recent activity. Bankfull indicators are slightly difficult to identify with slope breaks, small benches, and exposed roots and vegetation.

Table 23 Survey of Morphological Stream Parameters Using Rosgen Method Level II Stream Classification: Site 22 – 47th St. Headwater Creek

Parameter	Value
Bankfull Width (Wbkf) - feet	13
Mean Depth (dbkf) - feet	0.86
Bankfull Cross-Sectional Area (Abkf) - square feet	N/A
Width/Depth Ratio (W/d)	15.11
Maximum Depth (dmbkf) - feet	1.08
Width of Flood-Prone Area (Wfpa) - feet	23
Entrenchment Ratio (ER)	1.77
Channel Materials	Sand
Water Surface Slope (s) - feet per foot	N/A
Channel Sinuosity (K)	N/A
Calculated Bankfull Discharge (Q) - cubic ft/second	N/A
Stream Type	B5

Site 23 – Michigan Ave: A reach on the mainstem of LPC in the lower reaches of the watershed, with a drainage area of 34.94 square miles. The reach is a Rosgen G5 stream type – entrenched, deeply incised, gully step/pool, low width/depth ratio, vegetated banks, and a dominant stream bed material consisting of sand. Bankfull indicators within the entrenched channel are fairly difficult to identify with slope breaks, exposed roots, and vegetation as indicators. The stream shows signs of dredging.

Table 24 Survey of Morphological Stream Parameters Using Rosgen Method Level II Stream Classification: Site 23 – Michigan Ave. Mainstem

Parameter	Value
Bankfull Width (Wbkf) - feet	29
Mean Depth (dbkf) - feet	2.81
Bankfull Cross-Sectional Area (Abkf) - square feet	N/A
Width/Depth Ratio (W/d)	10.32
Maximum Depth (dmbkf) - feet	3.45
Width of Flood-Prone Area (Wfpa) - feet	40
Entrenchment Ratio (ER)	1.38
Channel Materials	Sand
Water Surface Slope (s) - feet per foot	N/A
Channel Sinuosity (K)	N/A
Calculated Bankfull Discharge (Q) - cubic ft/second	N/A
Stream Type	G5

Site 24 – 45th St: A headwater creek maintained as a designated drain in the LPCW with a drainage area of 2.87 square miles. The reach is a Rosgen G5 entrenched gully, deeply incised, step/pool, low width/depth ratio and a dominant stream bed material consisting of sand. Bankfull indicators are somewhat difficult to identify within the entrenched channel and consist of slope breaks, exposed roots,

and vegetation. The stream shows signs of dredging, but not recently due to the tree growth along the channel.

Table 25 Survey of Morphological Stream Parameters Using Rosgen Method Level II Stream Classification: Site 24 – 45th St. Headwater Creek

Parameter	Value
Bankfull Width (Wbkf) - feet	14
Mean Depth (dbkf) - feet	1.55
Bankfull Cross-Sectional Area (Abkf) - square feet	N/A
Width/Depth Ratio (W/d)	9.03
Maximum Depth (dmbkf) - feet	1.85
Width of Flood-Prone Area (Wfpa) - feet	18
Entrenchment Ratio (ER)	1.29
Channel Materials	Sand
Water Surface Slope (s) - feet per foot	N/A
Channel Sinuosity (K)	N/A
Calculated Bankfull Discharge (Q) - cubic ft/second	N/A
Stream Type	G5

Bank Profile

Bank profiles were surveyed at a representative riffle location, either riffle left or riffle right (facing downstream), on each study reach. Table 26 depicts the average annual erosion rate measured from bank pins with positive numbers indicating the amount of stream bank slumping into the stream and negative numbers indicating the amount of stream bank eroding into the stream.

Site 1 – TS Ave.

Toe Pin Area	Bank Height	Difference in Toe Pin Area (ft^2)	Average Erosion Rate (ft.)
5.98 ft^2	3.26 ft.	0.33	0.1012

Bank Pin	Ft of Erosion
LB	0.11
MB	0.1
UB	0.08
Total	0.29

BEHI					
Predicted Erosion (yd^3/yr.)	Predicted Erosion (ton/yr.)	Rosgen Numerical Rating	BEHI Worksheet Rating	NBS #5	NBS #1
0.02	0.03	39.4 High	38.3 High	0.99 V. low	Transverse Bar=Extreme

Site 2 – S Ave.

Toe Pin Area	Bank Height	Difference in Toe Pin Area (ft^2)	Average Erosion Rate (ft.)
21.36	6.31	4.9	0.7765

Bank Pin	Ft of Erosion
LB	0.5
MB	0.46
UB	0.96

BEHI					
Predicted Erosion (yd^3/yr.)	Predicted Erosion (ton/yr.)	Rosgen Numerical Rating	BEHI Worksheet Rating	NBS #5	NBS #1
0.01	0.01	29.5 Moderate	35.83 High	1.35 Low	0 Low

Site 3 – 45th St.

Toe Pin Area	Bank Height	Difference in Toe Pin Area (ft^2)	Average Erosion Rate (ft.)
5.95	3.32	0.01	0.003

Bank Pin	Ft of Erosion
LB	0
MB	-0.09
UB	-0.06

BEHI					
Predicted Erosion (yd^3/yr.)	Predicted Erosion (ton/yr.)	Rosgen Numerical Rating	BEHI Worksheet Rating	NBS #5	NBS #1
0.03	0.04	36.5 High	35.2 High	1.00 Low	0 Low

Site 4 – 43rd St.

Toe Pin Area	Bank Height	Difference in Toe Pin Area (ft^2)	Average Erosion Rate (ft.)
14.24	5.7	0.05	0.0088

Bank Pin	Ft of Erosion
LB	-0.01
MB	-0.01
UB	0.02

BEHI					
Predicted Erosion (yd^3/yr.)	Predicted Erosion (ton/yr.)	Rosgen Numerical Rating	BEHI Worksheet Rating	NBS #5	NBS #1
0.03	0.05	35.2 High	34.7 High	V. Low	0 Low

Site 5 – 40th St.

Toe Pin Area	Bank Height	Difference in Toe Pin Area (ft^2)	Average Erosion Rate (ft.)
1.14	1.65	0.02	0.0121

Bank Pin	Ft of Erosion
LB	0.18
MB	0
UB	-0.04

BEHI					
Predicted Erosion (yd^3/yr.)	Predicted Erosion (ton/yr.)	Rosgen Numerical Rating	BEHI Worksheet Rating	NBS #5	NBS #1
0.02	0.03	36.6 High	35.5 High	1.11 Low	0 Low

Site 6 – 43rd St.

Toe Pin Area	Bank Height	Difference in Toe Pin Area (ft^2)	Average Erosion Rate (ft.)
3.05	1.71	0.06	0.0351

Bank Pin	Ft of Erosion
LB	0.16
MB	0
UB	-0.14

BEHI					
Predicted Erosion (yd^3/yr.)	Predicted Erosion (ton/yr.)	Rosgen Numerical Rating	BEHI Worksheet Rating	NBS #5	NBS #1
0.03	0.04	37.4 High	37 High	1.12 Low	0 Low

Site 7 – Y Ave.

Toe Pin Area	Bank Height	Difference in Toe Pin Area (ft^2)	Average Erosion Rate (ft.)
0.5	1.2	0	0

Bank Pin	Ft of Erosion
LB	0
MB	0
UB	0

BEHI					
Predicted Erosion (yd^3/yr.)	Predicted Erosion (ton/yr.)	Rosgen Numerical Rating	BEHI Worksheet Rating	NBS #5	NBS #1
0	0	19.5 Low	19 Low	1.17 Low	0 Low

Site 8 – 34th St.

Toe Pin Area	Bank Height	Difference in Toe Pin Area (ft^2)	Average Erosion Rate (ft.)
2.23	1.74	0.01	0.0057

Bank Pin	Ft of Erosion
LB	0.01
MB	0
UB	0

BEHI					
Predicted Erosion (yd^3/yr.)	Predicted Erosion (ton/yr.)	Rosgen Numerical Rating	BEHI Worksheet Rating	NBS #5	NBS #1
0.02	0.02	32 High	31.4 High	1.03 Low	0 Low

Site 9 – Buckner Rd.

Toe Pin Area	Bank Height	Difference in Toe Pin Area (ft^2)	Average Erosion Rate (ft.)
0.49	0.86	N/A	N/A

Bank Pin	Ft of Erosion
LB	N/A
MB	N/A
UB	N/A

*Note – Unable to identify on re-visit.

BEHI					
Predicted Erosion (yd^3/yr.)	Predicted Erosion (ton/yr.)	Rosgen Numerical Rating	BEHI Worksheet Rating	NBS #5	NBS #1
0	0.01	28 Moderate	27.8 Moderate	1.23 Low	0 Low

Site 10 – Taylor Rd. RB

Toe Pin Area	Bank Height	Difference in Toe Pin Area (ft^2)	Average Erosion Rate (ft.)
89.76	13	1.02	0.0785

Bank Pin	Ft of Erosion
LB	0.22
MB	-0.07
UB	-0.12

BEHI					
Predicted Erosion (yd^3/yr.)	Predicted Erosion (ton/yr.)	Rosgen Numerical Rating	BEHI Worksheet Rating	NBS #5	NBS #1
0.2	0.26	53.5 Extreme	55.4 Extreme	1.29 Low	Extreme

Site 10 – Taylor Rd. LB

Toe Pin Area	Bank Height	Difference in Toe Pin Area (ft^2)	Average Erosion Rate (ft.)
118.65	13	1.2	0.0923

Bank Pin	Ft of Erosion
TP	-0.26
LB	buried
MB	-1.06
UB	0.6

BEHI					
Predicted Erosion (yd^3/yr.)	Predicted Erosion (ton/yr.)	Rosgen Numerical Rating	BEHI Worksheet Rating	NBS #5	NBS #1
0.01	0.01		48.4 Extreme	0.71 Very low	0 Low

Site 11 – 38th St.

Toe Pin Area	Bank Height	Difference in Toe Pin Area (ft^2)	Average Erosion Rate (ft.)
19.23	5.85	0.14	0.0239

Bank Pin	Ft of Erosion
LB	0.05
MB	0
UB	0.01

BEHI					
Predicted Erosion (yd^3/yr.)	Predicted Erosion (ton/yr.)	Rosgen Numerical Rating	BEHI Worksheet Rating	NBS #5	NBS #1
0.05	0.07	35.5 High	35.1 High	1.01 Low	0 Low

Site 12 – Y Ave.

Toe Pin Area	Bank Height	Difference in Toe Pin Area (ft^2)	Average Erosion Rate (ft.)
29.24	7.16	0.07	0.0098

Bank Pin	Ft of Erosion
LB	-0.02
MB	-0.1
UB	-0.03

BEHI					
Predicted Erosion (yd^3/yr.)	Predicted Erosion (ton/yr.)	Rosgen Numerical Rating	BEHI Worksheet Rating	NBS #5	NBS #1
0.07	0.09	36 High	36.1 High	1.36 Low	0 Low

Site 13 – OP Ave.

Toe Pin Area	Bank Height	Difference in Toe Pin Area (ft^2)	Average Erosion Rate (ft.)
3.32	1.83	0	0

Bank Pin	Ft of Erosion
LB	-0.07
MB	none
UB	0.02

BEHI					
Predicted Erosion (yd^3/yr.)	Predicted Erosion (ton/yr.)	Rosgen Numerical Rating	BEHI Worksheet Rating	NBS #5	NBS #1
0.01	0.02	30.5 High	29.9 Moderate	1.01 Low	0 Low

Site 14 – Edgarton Rd.

Toe Pin Area	Bank Height	Difference in Toe Pin Area (ft^2)	Average Erosion Rate (ft.)
6.08	3.82	0.09	0.0236

Bank Pin	Ft of Erosion
LB	-0.02
MB	-0.04
UB	-0.06

BEHI					
Predicted Erosion (yd^3/yr.)	Predicted Erosion (ton/yr.)	Rosgen Numerical Rating	BEHI Worksheet Rating	NBS #5	NBS #1
0.04	0.05	41.1 V. High	41.2 V. High	1.19	0 Low

Site 15 – Moorepark Rd.

Toe Pin Area	Bank Height	Difference in Toe Pin Area (ft^2)	Average Erosion Rate (ft.)
2.43	1.8	0.01	0.0056

Bank Pin	Ft of Erosion
LB	0.12
MB	0.04
UB	0

BEHI					
Predicted Erosion (yd^3/yr.)	Predicted Erosion (ton/yr.)	Rosgen Numerical Rating	BEHI Worksheet Rating	NBS #5	NBS #1
0	0	24.9 Mod	24.5 Mod	1.48 Low	0 Low

Site 16 – Carpenter Rd.

Toe Pin Area	Bank Height	Difference in Toe Pin Area (ft^2)	Average Erosion Rate (ft.)
0.54	0.92	N/A	N/A

Bank Pin	Ft of Erosion
LB	N/A
MB	N/A
UB	N/A

*Note – Site was compromised

BEHI					
Predicted Erosion (yd^3/yr.)	Predicted Erosion (ton/yr.)	Rosgen Numerical Rating	BEHI Worksheet Rating	NBS #5	NBS #1
0	0	17.4 Low	17.5 Low	1.27 Low	0 Low

Site 17 – Parkville Rd.

Toe Pin Area	Bank Height	Difference in Toe Pin Area (ft^2)	Average Erosion Rate (ft.)
11.57	5.42	0.2	0.0369

Bank Pin	Ft of Erosion
LB	-0.2
MB	-0.8
UB	0

BEHI					
Predicted Erosion (yd^3/yr.)	Predicted Erosion (ton/yr.)	Rosgen Numerical Rating	BEHI Worksheet Rating	NBS #5	NBS #1
0.08	0.11	47.2 Extreme	48 Extreme	1.09 Low	0 Low

Site 18 – Wing Rd. West

Toe Pin Area	Bank Height	Difference in Toe Pin Area (ft^2)	Average Erosion Rate (ft.)
3.26	2.21	0.22	0.0995

Bank Pin	Ft of Erosion
LB	0
MB	0.12
UB	0.2

BEHI					
Predicted Erosion (yd^3/yr.)	Predicted Erosion (ton/yr.)	Rosgen Numerical Rating	BEHI Worksheet Rating	NBS #5	NBS #1
0.02	0.03	42.5 V. High	42.5 V. High	1.26 Low	0 Low

Site 19 – Wing Rd. East

Toe Pin Area	Bank Height	Difference in Toe Pin Area (ft^2)	Average Erosion Rate (ft.)
4.25	2.48	0.05	0.0202

Bank Pin	Ft of Erosion
LB	0.04
MB	0.06
UB	0.04

BEHI					
Predicted Erosion (yd^3/yr.)	Predicted Erosion (ton/yr.)	Rosgen Numerical Rating	BEHI Worksheet Rating	NBS #5	NBS #1
0.02	0.03	42.6 V. High	42 V. High	1.09 Low	Transverse bar- High

Site 20 – U Ave.

Toe Pin Area	Bank Height	Difference in Toe Pin Area (ft^2)	Average Erosion Rate (ft.)
3.86	2.1	0.02	0.0095

Bank Pin	Ft of Erosion
LB	0
MB	0
UB	0

BEHI					
Predicted Erosion (yd^3/yr.)	Predicted Erosion (ton/yr.)	Rosgen Numerical Rating	BEHI Worksheet Rating	NBS #5	NBS #1
0.02	0.03	45 V. High	46 Extreme	1.09 Low	0 Low

Site 21 – 46th St.

Toe Pin Area	Bank Height	Difference in Toe Pin Area (ft^2)	Average Erosion Rate (ft.)
3.52	2.01	0	0

Bank Pin	Ft of Erosion
LB	-0.14
MB	0.06
UB	0.1

BEHI					
Predicted Erosion (yd^3/yr.)	Predicted Erosion (ton/yr.)	Rosgen Numerical Rating	BEHI Worksheet Rating	NBS #5	NBS #1
0.02	0.02	41.1 V. High	41 V. High	1.13 Low	0 Low

Site 22 – 47th St.

Toe Pin Area	Bank Height	Difference in Toe Pin Area (ft^2)	Average Erosion Rate (ft.)
9.46	4.09	0.2	0.0489

Bank Pin	Ft of Erosion
LB	0.02
MB	0.01
UB	0

BEHI					
Predicted Erosion (yd^3/yr.)	Predicted Erosion (ton/yr.)	Rosgen Numerical Rating	BEHI Worksheet Rating	NBS #5	NBS #1
0.04	0.05	44.9 V. High	45.75 V. High	1.26 Low	Transverse Bar - High

Site 23 – Michigan Ave.

Toe Pin Area	Bank Height	Difference in Toe Pin Area (ft^2)	Average Erosion Rate (ft.)
82.6	12	0.15	0.0125

Bank Pin	Ft of Erosion
LB	0.3
MB	0.2
UB	0.4

BEHI					
Predicted Erosion (yd^3/yr.)	Predicted Erosion (ton/yr.)	Rosgen Numerical Rating	BEHI Worksheet Rating	NBS #5	NBS #1
0.11	0.14	33.1 High	33.5 High	1.23 Low	Transverse bar - High

Site 24 – 45th St.

Toe Pin Area	Bank Height	Difference in Toe Pin Area (ft^2)	Average Erosion Rate (ft.)
36.93	7	0.02	0.0029

Bank Pin	Ft of Erosion
LB	0
MB	0.05
UB	0

BEHI					
Predicted Erosion (yd^3/yr.)	Predicted Erosion (ton/yr.)	Rosgen Numerical Rating	BEHI Worksheet Rating	NBS #5	NBS #1
0.04	0.06	50.9 Extreme	51 Extreme	0.97 Low	0 Low

Morphological Assessment Results

Reference Data:

Twenty-four sites were located and installed within the PR/LPC Watersheds in order to gain a better understanding of lateral erosion rates and risks posed by different types of stream reaches. Of these six potential "reference reaches" were established. Lateral erosion rates for reference reach sites 7, 9, 12, and 16 were established. Of the reference sites average "natural" rates of erosion were determined for those banks.

The sites consisted of Rosgen E5, E6, C4 and C5 stream types. E stream types are generally described as low gradient, meandering, riffle/pool streams with low width/depth ratio and little deposition that are very efficient and stable. C stream types are generally considered to be low gradient, meandering point bar, riffle/pool streams with broad well defined floodplains (Rosgen and Silvey, 2005).

Site 7 had an average erosion rate of 0 feet/year and a difference of toe pin area 0.00 (ft^2) a year with a bank height of 1.2 ft. (low bank height). Bank height was 1.2 feet and a reach length of 1760 feet totaled for a contribution of 0 tons/year. A creek within the middle reaches of the PRW with a drainage area of 9.85 square miles. The reach is a Rosgen E5 stream type with no indication of dredging and appears to be pre-modified.

Site 8 had an average erosion rate of 0.0057 feet/year and difference in toe pin area 0.01 (ft^2) a year with a bank height of 1.74 ft. (low bank height) and an average bank height of 1.69 feet. The reach was 1575 feet in length and resulted in a calculated total erosion load of 0.14 tons/year. A creek in the middle reaches of the PRW. It has a drainage area of 2.68 square miles. The reach is a Rosgen E5 stream type with little to no signs of modification.

Site 9 had a 0.92 bank height (low) but was unable to be recovered due to complications with locating the pins and as a result has no data. A small creek within the middle reaches of the PRW. It has a drainage area of 4.12 square miles. The reach is a Rosgen E6 stream type with little to no signs of modification.

Site 12 had an average erosion rate of 0.0098 feet/year and difference in toe pin area 0.07 (ft^2) a year with a bank height of 7.16 ft. (high bank height) and average bank height of 4.18 feet. The reach length

was 2125 feet, with a total annual load of 3.91 tons/year. The site is on the mainstem of the PR and has a drainage area of 69.53 square miles. The reach is classified as a Rosgen C4 stream type and is pre-modified most likely due to the large expansive floodplain.

Site 16 had a bank height of 0.92 feet but was compromised due to a mature tree uprooting itself in a wind storm. As a result, reference data was not gathered for this reach. However, it was suspected to be very low due to the lack of movement from the rest of the bank surrounding the area. It is a reach in the lower portions of the PRW on the mainstem, with a drainage area of 179.82 square miles. The reach is a Rosgen C5 stream type. The reach is pre-modified most likely due to the expansive floodplains and wide stream channel.

A simple data analysis determined that average erosion rates for reference reaches was 0.005 feet/year and an average toe pin area of 0.026 (ft^2) a year.

Non-Reference Data:

The remaining sites were chosen due to evidence of modification, drainage area/stream order, and location within the watersheds. Site 1-6, 10, 11, 13, 14, 15, and 18-24 represented sites with varying degrees of modification.

Non-reference sites consisted of stream types G, E, C, F, and B. G stream types are generally considered entrenched gullies typically unstable, E stream types are generally described as low gradient, meandering, riffle/pool streams with low width/depth ratio and little deposition that are very efficient and stable. C stream types are generally considered to be low gradient, meandering point bar, riffle/pool streams with broad well defined floodplains. F stream types are entrenched laterally unstable reaches. B type streams are generally moderately entrenched and stable (Rosgen and Silvey, 2005).

Site 17 on the mainstem of the Portage River, experienced influence from hydraulic alterations from an upstream dam. It had an average annual erosion rate of 0.0369 feet/year with an average bank height of 3.27 feet accounting for a total load of 22.96 tons/year. Site 8, a small creek within the middle reaches of the PRW, had average bank height of 1.52 feet and a reach of 1575 feet. Total load erosion rates were determined to be 0.14 tons/year. Site 6 is a small creek maintained as a designated drain in the middle reaches of the PRW, with evidence of dredging but any recent activity. Site 6 has an average bank height of 1.69 feet, and the reach length totaled 1545 feet. Average lateral erosion rates were 0.0351 feet/year and a calculated annual load of 8.346 tons/year.

Site 18, a small lateral drain with heavy agricultural and dredging impacts. The reach was 1525 feet in length with average bank height of 2.13. Average lateral erosion totaled 0.0995 and a calculated load of 30.18 tons/year. Site 10 was a lateral drain in the LPCW. The site was heavily channelized and impacted from agriculture. The reach totaled 989 feet with an average bank height of 13 feet. Average lateral erosion rates were 0.0923 feet/year and a combined total load of 106.803 tons/year. Site 1, on the mainstem of the LPC in the upper reaches, was impacted from dredging but not recently, probably within the last 20 years. The reach totaled 1380 feet/year and had an average bank height of 3 feet. The average lateral erosion rate was 0.1012 feet/year and total load of 40.975 tons/year. Site 2, on the mainstem of LPC, was a recently dredged, heavily impacted by agriculture stream reach. The average bank height was 5.97 and the reach length totaled 2565 feet. Average lateral erosion rates were 0.78 feet/year and a total load of 1131.83 tons/year. The largest amount of erosion contribution from all stream reaches and conditions.

Site 23, on the mainstem in the lower reaches of LPC, highly entrenched, with established vegetative banks and signs of aggradation and lateral migration. An average lateral erosion rate of 0.0125, the reach length 2248 feet contributes 15.17 tons/year. Site 11 on the mainstem of LPC in the middle reach, has evidence of historical dredging. An average lateral erosion rate of 0.024 feet/year and average bank height of 5.15 feet. Total load contributions from the 2198 foot reach is 11.57 tons/year. Site 22, a headwater drain, with historical dredging. An average bank height of 4.01 feet and reach length of 1097 feet. Average lateral erosion rate of 0.0489 feet/year and a total load of 19.78 tons/year. Site 24 another headwater drainage, with an average bank height of 6.97 feet and reach total length of 1248 feet. Average erosion was 0.0029 feet/year and a total of 2.28 tons/year. Site 5 is impacted from recent dredging. The reach is 1150 feet long and has an average bank height of 1.59 feet. Average annual erosion is 0.012 feet/year and a total calculated erosion rate of 2.05 tons/year. Site 20 is a small lateral drain with evidence of dredging, but not recent. It is stable and has an average bank height of 2ft. The reach length is 1027 feet with an average erosion rate of 0.095 and a total load of 9.21 tons/year. Site 4 is a headwater drain impacted from dredging but not recently. Site 4 has an average bank height of 5.59 feet and a reach length of 1027 feet. Average lateral erosion rates of 0.009 feet/year and a total load of 4.74 tons/year.

Morphological Assessment Results

Site	Stability	Average Erosion Rate (ft.)	Higher or Lower than Reference Rates Determined for PR/LPC	Hypothesis
Site 1 - TS Ave.	Unstable tending towards stability-at-risk	0.101	Much higher	Unstable
Site 2 - S. Ave	Unstable	0.777	Extremely higher	Unstable
Site 3 - 45th St.	Stable tending toward stability-at-risk	0.003	Lower	Unstable
Site 4 - 43rd St.	Stability-at-risk	0.009	Slightly higher	Unstable
Site 5 - 40th	Stable tending toward stability-at-risk	0.012	Slightly higher	Unstable
Site 6 - V Ave.	Stable tending toward stability-at-risk	0.035	Slightly higher	Unstable
Site 7 - Y Ave.	Stable	0.000	Lower	Stable
Site 8 - 34th St.	Stable	0.006	Same	Stable
Site 9 - Buckner	Stable	N/A	N/A	Stable
Site 10 - Taylor	Unstable tending toward stability-at-risk	0.085	Much Higher	Unstable
Site 11 - 38th St.	Stable tending toward stability-at-risk	0.024	Slightly higher	Unstable
Site 12 - Y Ave	Stable	0.010	Slightly higher	Stable
Site 13 - OP Ave.	Stable tending toward stability-at-risk	0.000	Lower	Unstable
Site 14 - Edgarton Rd.	Unstable tending toward stability-at-risk	0.024	Slightly higher	Unstable

Site	Stability	Average Erosion Rate (ft.)	Higher or Lower than Reference Rates Determined for PR/LPC	Hypothesis
Site 15 - Moorepark Rd.	Stable tending toward stability-at-risk	0.006	Same	Unstable
Site 16 - Carpenter Rd.	Stable	N/A	N/A	Stable
Site 17 - Parkville Rd.	Stable	0.037	Slightly higher	Stable
Site 18 - Wing Rd. West	Unstable tending towards stability-at-risk	0.100	Much higher	Unstable
Site 19 Wing Rd. East	Stability-at-risk	0.020	Slightly higher	Unstable
Site 20 - U Ave.	Stable tending toward stability-at-risk	0.010	Slightly higher	Unstable
Site 21 - 46th St.	Stable tending toward stability-at-risk	0.000	Lower	Unstable
Site 22 - 47th St.	Stable tending toward stability-at-risk	0.049	Higher	Unstable
Site 23 - Michigan Ave.	Unstable tending towards stability-at-risk	0.013	Slightly higher	Unstable
Site 24 - 45th St.	Unstable tending towards stability-at-risk	0.003	Lower	Unstable

Color	Comparison to reference data
	Extremely higher
	Much higher
	Higher
	Slightly higher
	lower or same

*Sites 9 and 16 do not have erosion rates available

Discussion

Site 2 had the highest average erosion rates of any reach. This site was over 100 fold the amount of average erosion as the average for the reference reach value. Site 2 has a drainage area of 11.66 square miles. The reach is a Rosgen G5 entrenched gully, step/pool low width/depth ratio, highly incised stream type with a dominant stream bed material consisting of sand. The reach has a narrow floodplain and shows signs of dredging within the last five years. Bankfull indicators are located within the entrenched channel and are difficult to identify since they are not fully developed and there is little floodplain. Due to the extremely recent dredging activities the elevated levels of average erosion rates is not surprising.

Sites 1, 10, and 18 had the second highest average rates of erosion. Site 1 was approximately twenty times the amount of erosion as the reference reach value. Site 1 is a Rosgen G5 entrenched gully. The site appears to have not been altered recently due to the amount of woody growth next to the stream channel. Site 10 has seventeen-times the amount of average erosion rates as the reference reach average. Site 10 is a lateral drain in the lower reaches of the LPC with a drainage area of 0.5 square miles. The reach is a Rosgen G5 stream type with recent dredging activity and observed herbicide

application and tillage reducing the amount of bank vegetation. Large amounts of aggradation appeared to occur as the toe pin at this site was buried 0.26 feet. An evidenced by large amounts of the lower bank upstream eroding into the stream. Surprisingly, to the practitioners this site has less average erosion than Site 1 as Site 10 has had more recent manipulation. Site 18 has twenty-times the amount of erosion as the reference reach average. Site 18 is a lateral drain in the lower reaches of the LPCW with a drainage area of 0.623 square miles. The reach is a Rosgen E6 stream type. Recent manipulation to the drain has been performed.

Site 22 had higher average erosion rates than the reference reach average. Site 22 was experienced approximately ten-times the amount of average erosion as the reference average. Site 22 is a headwater creek in the LPCW, it has a drainage area of 1.9 square miles. The stream reach is a Rosgen B5 stream type. The site shows signs of dredging within the last twenty years.

Sites 4, 5, 6, 11, 12, 14, 17, 19, 20, and 23 were slightly higher ranging from seven-times to two-time the amount of average erosion rates as the reference value. These sites were identified as Rosgen G, E, C, and F types. Site 4 is headwater creek that is maintained as a drain with a drainage area of 3.5 square miles. The reach is a Rosgen G6 entrenched gully. Established tree growth has most likely secured banks in the entrenched gully due to a lack of maintenancing. It is also a much smaller drainage. Site 5 is headwater creek maintained as a drain with a drainage area of 6.25 square miles. The reach is a Rosgen E5 stream type. Recent dredging activity, however a small vegetative buffer on the south bank with low bank heights and riparian buffer to the north of the reach most likely reduce erosion rates. Site 6, a creek within the middle reaches of the PRW, maintained as a designated drain with a drainage area of 2.87 square miles. The reach is a Rosgen C5. Good riparian forest buffer most likely provides some lateral stability but surprisingly higher average erosion rates than other sites within the slightly higher average erosion rate category. Site 11, is on the mainstem of LPC and has a drainage area of 27.95 square miles. The reach is a Rosgen F5 stream type. Evidence of historic dredging and higher bank height most likely contribute to average erosion rates, even though the entrenched channel has not been manipulated recently. Site 12 (reference) is on the mainstem of the Portage River and has a drainage area of 69.53 square miles. The reach is classified as a Rosgen C4 stream type. A stable stream channel erosion is attributed to natural high bank along the reach. Site 14, is a lateral drain in the lower reaches of the PRW with a drainage area of 8.44 square miles. The reach is a Rosgen G5 stream type. Surprisingly this site has slightly higher erosion values, this is attributed to the woody vegetation stabilizing the west bank. Site 17 is a site in the lower reaches of the PRW on the mainstem with a drainage area of 161.623 square miles. The reach is a Rosgen C4 stream type. Even classifying as a C4 stream type, high banks and a dam upstream creating higher velocities contribute to erosion rates within the reach. Site 19 is a lateral drain in the lower reaches of the LPCW with a drainage area of 1.2 square miles. The reach is a Rosgen E5 stream type with surprisingly lower erosion rates than expected. Site 20 is a lateral drain in the middle reaches of the LPCW, it has a drainage area of 1.14 square miles. The reach is a Rosgen C6 stream with historic dredging but due to low bank heights, a lack of recent manipulation and establishment of riparian forest the reach is recovering with lower rates of erosion. Site 23 a reach on the mainstem of LPC in the lower reaches of the watershed, with a drainage area of 34.94 square miles. The reach is a Rosgen G5 stream type. Extreme amounts of aggradation is evidenced by mid-channel bar formations throughout the reach. Lower erosion rates are attributed to heavy vegetation along stream banks. Evidence of lateral erosion and bank sloughing is occurring however within the channel, and the stream is likely headed toward a stream channel succession shift from a G channel type to F channel or

widening and eventually it is hypothesized that aggradation will shift the F channel towards a C and E type channel.

Sites 3, 7, 8, 13, 15, and 21 had rates of average erosion at or lower than the reference reach value. Site 3 is lateral drain of LPC it has a drainage area of 0.2 square miles. The reach is a Rosgen E6. Low erosion values are attributed to riparian woody and green vegetation, and a small drainage area. Aggradation within the reach is occurring as the toe pin was covered with 0.17 feet of silt. Site 7 (reference) is a creek within the middle reaches of the PRW with a drainage area of 9.85 square miles. The reach is a Rosgen E5 stream type meandering stream with heavily vegetated banks and a low bank height ratio. These factors contribute to low average erosion rates. Site 8 is creek in the middle reaches of the PRW. It has a drainage area of 2.68 square miles. The reach is a Rosgen E3 stream type with low bank heights and vegetated banks. Site 15 is lateral drain in the lower reaches of the PRW with a drainage area of 7.06 square miles. The reach is a Rosgen E5 stream type. Low erosion rates are attributed to heavy vegetation along stream banks. Site 21 is a headwater creek in the LPCW maintained as a designated drain, with a drainage area of 1.86 square miles. The reach is a Rosgen E5 stream type. A stream type with evidence of dredging, riparian forestation and lower bank heights are attributed to low average erosion rates.

Sites 9 and 16 were intended to be reference reaches but due unforeseen complications data was not able to be retained. It was hypothesized that both reaches would have low rates of erosion.

Conclusion

A simple data analysis determined that average erosion rates for reference reaches was 0.005 feet/year and an average toe pin area of 0.026 (ft^2) a year. Out of 24 sites within the PR/LPC Watersheds Site 2 was unstable with “extremely higher” rates of erosion. Three sites (Sites 1, 10, 18) had “much higher” rates of erosion and a stability rating of unstable tending towards stability-at-risk. Two sites were unstable tending toward stability-at-risk (Sites 14 and 23); two sites received stability ratings of stability-at-risk (Site 4 and 19); four sites were stable tending toward stability-at-risk (Sites 5, 6, 11, and 20); and two sites were stable (Sites 12 and 17) — all with slightly higher rates of erosion. Two sites are stable (Sites 7 and 8); four stable tending toward stability-at-risk (Sites 3, 13, 15, and 21); and one unstable tending toward stability-at-risk—all with equal or lower values than the reference values. Two sites are stable with no data for average erosion rates, but predicted values of equal or lower rates.

The highest rates of erosion were on G type stream reaches, typically along recently modified, high bank, low vegetation, and steep banks. This is not surprising, however, site 1 has not been recently modified with a riparian buffer zone. Stream channel succession from a type G – F – C – E is most likely causing lateral migration of the thalweg and contributing to lateral erosion within the confined channel.

The lowest rates of erosion were on six E, one B, one C, and surprisingly one G type stream reach. Site 24, the G type stream, lack of lateral erosion is attributed to the lack of recent dredging activity and riparian tree growth. As expected, sites 7 and 12 yielded low type erosion rates, but surprisingly sites 8, 15, 21, and 24 yielded significantly low erosion rates. Also, subsequent years of follow up analysis is hypothesized to change the results of this data analysis.

Site 2 suggests that extreme amounts of erosion can occur in a short-period of time in entrenched, modified, and agricultural impacted reaches. Site 1 had higher levels of lateral erosion, suggesting that

even recovering drains with well-established root systems still are susceptible to evolving channel migration. Site 8, suggests that even in historically dredged systems, low bank height ratios due to a lack of spoil berms can result in low lateral erosion rates.

Sites 22 has a lower bank/higher erosion rate than Site 24 higher bank/lower erosion rate. Both are in similar reaches. One hypothesized factor is that both sides of site 22 is heavily rooted with mature trees, stabilizing the bank, but it is probably due to the cattle influence (bank trampling) from cattle accessing one side of the bank speeding up the lateral migration of the channel toward the opposite bank increasing near bank stress.

Sites 5 has a lower bank/higher lateral erosion rate and lower total load in tons per year. Site 4 has a higher bank/lower lateral erosion rate and higher total load in tons per year. The lateral erosion rates are similar suggesting bank height is the primary factor increasing rates in this instance. They are both located within the same drainage approximately a mile apart.

It is suggested that more seasons and bankfull events be evaluated in order to gather a more consistent and conclusive data set. A more definitive set of conclusions could be drawn over a longer period of time involving more bankfull events and result in better averages, erosion rates and loads.

A summary of stream stability, recovery potential, and sensitivity to disturbance for stream management considerations can be found at the end of Appendix A.

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Appendix A: From Stream Functional Assessment Results (Harmon et al, 2012)

Table A1. Floodplains Connectivity Performance Standards

MEASUREMENT METHOD	PERFORMANCE STANDARD		
	FUNCTIONING	FUNCTIONING-AT-RISK	NOT FUNCTIONING
Bank Height Ratio (BHR)	1.0 to 1.2	1.3 to 1.5	> 1.5
Entrenchment Ratio (ER) for C and E Stream Types	> 2.2	2.0 to 2.2	< 2.0
Entrenchment Ratio (ER) for B and Bc Stream Types	> 1.4	1.2 to 1.4	< 1.2
Dimensionless rating curve	Project site Q/Q_{bkf} plots on the curve	Project site Q/Q_{bkf} plots above the curve	Project site Q/Qbkf of 2.0 plots above 1.6 for $d/_{dbkf}$

Site	Stream Type	Entrenchment Ratio	Functional Category
Site 1 - TS Ave.	G5	2.63 (BHR)	Not Functioning
Site 2 - S. Ave	G5	2.79 (BHR)	Not Functioning
Site 3 - 45th St.	E6	11.36	Functioning
Site 4 - 43rd St.	G6	3.13 (BHR)	Not Functioning
Site 5 - 40th	E5	17.86	Functioning
Site 6 - V Ave.	C5	33	Functioning
Site 7 - Y Ave.	E5	62.5	Functioning
Site 8 - 34th St.	E3	50	Functioning
Site 9 - Buckner	E4	21	Functioning
Site 10 - Taylor	G5	7 (BHR)	Not Functioning
Site 11 - 38th St.	F5	1.05 (BHR)	Functioning
Site 12 - Y Ave	C4	5.89	Functioning
Site 13 - OP Ave.	B5	1.52	Functioning
Site 14 - Edgarton Rd.	G5	2.61(BHR)	Not Functioning
Site 15 - Moorepark Rd.	E5	8	Functioning
Site 16 - Carpenter Rd.	C5	10.42	Functioning
Site 17 - Parkville Rd.	C4	18.87	Functioning
Site 18 - Wing Rd. West	E6	30	Functioning
Site 19 Wing Rd. East	E5	10.91	Functioning
Site 20 - U Ave.	C6	3.75	Functioning

Site	Stream Type	Entrenchment Ratio	Functional Category
Site 21 - 46th St.	E5	11.54	Functioning
Site 22 - 47th St.	B5	1.77	Functioning
Site 23 - Michigan Ave.	G5	3.47 (BHR)	Not Functioning
Site 24 - 45th St.	G5	3.83 (BHR)	Not Functioning

Table A2. Performance Measurement for Simon's Channel Evolution Stages

Simon (1989) Channel Evolution Model Stages

	FUNCTIONING	FUNCTIONING-AT-RISK	NOT FUNCTIONING
1. Sinuous, pre-modified	✓		
2. Channelized			✓
3. Degradation			✓
4. Degradation and			✓
5. Aggradation and		✓ *	
6. Quasi-equilibrium	✓		

* Only late Stage 5 of the Simon model, where the stream has begun to construct a new floodplain at a lower elevation, is considered to be Functioning-at-Risk.

Site	Stream Type	Simon Channel Evolution Model Stage	Functional Category
Site 1 - TS Ave.	G5	2	Not functioning
Site 2 - S. Ave	G5	2	Not functioning
Site 3 - 45th St.	E6	2	Not functioning
Site 4 - 43rd St.	G6	2	Not functioning
Site 5 - 40th	E5	2	Not functioning
Site 6 - V Ave.	C5	2	Not functioning
Site 7 - Y Ave.	E5	1	Functioning
Site 8 - 34th St.	E3	1	Functioning
Site 9 - Buckner	E4	1	Functioning

Site	Stream Type	Simon Channel Evolution Model Stage	Functional Category
Site 10 - Taylor	G5	2	Not functioning
Site 11 - 38th St.	F5	2	Not functioning
Site 12 - Y Ave	C4	1	Functioning
Site 13 - OP Ave.	B5	2	Not functioning
Site 14 - Edgarton Rd.	G5	2	Not functioning
Site 15 - Moorepark Rd.	E5	2	Not functioning
Site 16 - Carpenter Rd.	C5	1	Functioning
Site 17 - Parkville Rd.	C4	1	Functioning
Site 18 - Wing Rd. West	E6	2	Not functioning
Site 19 Wing Rd. East	E5	2	Not functioning
Site 20 - U Ave.	C6	2	Not functioning
Site 21 - 46th St.	E5	2	Not functioning
Site 22 - 47th St.	B5	2	Not functioning
Site 23 - Michigan Ave.	G5	2	Not functioning
Site 24 - 45th St.	G5	2	Not functioning

Table A3. Lateral Stability Performance Standards

MEASUREMENT METHOD	FUNCTIONING	FUNCTIONING- AT-RISK	NOT FUNCTIONING
Lateral Erosion Rate (Bank Pins and Bank Profiles)	Erosion rate is similar to reference reach values, generally < 0.1 ft/yr	0.1 to 0.5 ft/yr	> 0.5 ft/yr

Site	Stream Type	Lateral Erosion Rate (ft/yr)	Functional Category
Site 1 - TS Ave.	G5	0.101	Functioning-at-risk
Site 2 - S. Ave	G5	0.777	Not functioning
Site 3 - 45th St.	E6	0.003	Functioning
Site 4 - 43rd St.	G6	0.009	Functioning
Site 5 - 40th	E5	0.0121	Functioning
Site 6 - V Ave.	C5	0.035	Functioning
Site 7 - Y Ave.	E5	0	Functioning
Site 8 - 34th St.	E3	0.006	Functioning
Site 9 - Buckner	E4	N/A	N/A
Site 10 - Taylor	G5	0.079	Functioning
Site 11 - 38th St.	F5	0.024	Functioning
Site 12 - Y Ave	C4	0.01	Functioning
Site 13 - OP Ave.	B5	0	Functioning
Site 14 - Edgarton Rd.	G5	0.024	Functioning
Site 15 - Moorepark Rd.	E5	0.006	Functioning
Site 16 - Carpenter Rd.	C5	N/A	N/A
Site 17 - Parkville Rd.	C4	0.037	Functioning
Site 18 - Wing Rd. West	E6	0.11	Functioning-at-risk
Site 19 Wing Rd. East	E5	0.02	Functioning
Site 20 - U Ave.	C6	0.011	Functioning
Site 21 - 46th St.	E5	0	Functioning
Site 22 - 47th St.	B5	0.059	Functioning
Site 23 - Michigan Ave.	G5	0.013	Functioning
Site 24 - 45th St.	G5	0.003	Functioning

Table A4. Riparian Buffer Performance Parameters

MEASUREMENT METHOD	FUNCTIONING	FUNCTIONING- AT-RISK	NOT FUNCTIONING
EPA Rapid Bioassessment Protocol (RBP) Habitat Assessment	Width of riparian zone > 18 meters on each side; human activities have not impacted zone (Optimal, 9-10)	Width of riparian zone 12-18 meters on each side; human activities have impacted zone only minimally (Sub-Optimal, 6-8); width of riparian zone 6-12 meters on each side;	Width of riparian zone <6 meters on each side; little or no riparian vegetation due to human activity (Poor, 0-2)

Site	**Stream Type**	**Width of Riparian Zone**	**Functional Category**
Site 1 - TS Ave.	G5	>18 meters no human impact	Functioning
Site 2 - S. Ave	G5	<6 meters on each side; little riparian vegetation due to human activity	Not functioning
Site 3 - 45th St.	E6	12-18 meters on each side; human activities have impacted zone minimally	Functioning-at-risk
Site 4 - 43rd St.	G6	>18 meters no human impact	Functioning
Site 5 - 40th	E5	12-18 meters on each side; human activities have impacted zone minimally	Functioning-at-risk
Site 6 - V Ave.	C5	>18 meters no human impact	Functioning
Site 7 - Y Ave.	E5	>18 meters no human impact	Functioning
Site 8 - 34th St.	E3	>18 meters no human impact	Functioning
Site 9 - Buckner	E4	>18 meters no human impact	Functioning
Site 10 - Taylor	G5	<6 meters on each side; little riparian vegetation due to human activity	Not functioning
Site 11 - 38th St.	F5	>18 meters no human impact	Functioning
Site 12 - Y Ave	C4	>18 meters no human impact	Functioning
Site 13 - OP Ave.	B5	12-18 meters on each side; human activities have impacted zone minimally	Functioning-at-risk
Site 14 - Edgarton Rd.	G5	<6 meters on each side; little riparian vegetation due to human activity	Not functioning
Site 15 - Moorepark Rd.	E5	>18 meters no human impact	Functioning
Site 16 - Carpenter Rd.	C5	>18 meters no human impact	Functioning
Site 17 - Parkville Rd.	C4	>18 meters no human impact	Functioning

Site	Stream Type	Width of Riparian Zone	Functional Category
Site 18 - Wing Rd. West	E6	<6 meters on each side; little riparian vegetation due to human activity	Not functioning
Site 19 Wing Rd. East	E5	<6 meters on each side; little riparian vegetation due to human activity	Not functioning
Site 20 - U Ave.	C6	>18 meters no human impact	Functioning
Site 21 - 46th St.	E5	>18 meters no human impact	Functioning
Site 22 - 47th St.	B5	12-18 meters on each side; human activities have impacted zone minimally	Functioning-at-risk
Site 23 - Michigan Ave.	G5	12-18 meters on each side; human activities have impacted zone minimally	Functioning-at-risk
Site 24 - 45th St.	G5	12-18 meters on each side; human activities have impacted zone minimally	Functioning-at-risk

Overall Stability Rating

Table A5

Site	Stable or Functioning	Stability-at-risk or Functioning-at-risk	Unstable or not functioning	Overall Conclusion
Site 1 - TS Ave.	1	1	2	Unstable tending towards stability-at-risk
Site 2 - S. Ave	0	0	4	Unstable
Site 3 - 45th St.	2	1	1	Stable tending toward stability-at-risk
Site 4 - 43rd St.	2	0	2	Stability-at-risk
Site 5 - 40th	2	1	1	Stable tending toward stability-at-risk
Site 6 - V Ave.	3	0	1	Stable tending toward stability-at-risk
Site 7 - Y Ave.	4	0	0	Stable
Site 8 - 34th St.	4	0	0	Stable
Site 9 - Buckner	3	0	0	Stable
Site 10 - Taylor	1	0	3	Unstable tending toward stability-at-risk
Site 11 - 38th St.	3	0	1	Stable tending toward stability-at-risk
Site 12 - Y Ave	4	0	0	Stable
Site 13 - OP Ave.	2	1	1	Stable tending toward stability-at-risk
Site 14 - Edgarton Rd.	1	0	3	Unstable tending toward stability-at-risk
Site 15 - Moorepark Rd.	3	0	1	Stable tending toward stability-at-risk
Site 16 - Carpenter Rd.	3	0	0	Stable
Site 17 - Parkville Rd.	4	0	0	Stable
Site 18 - Wing Rd. West	1	1	2	Unstable tending towards stability-at-risk

Site	Stable or Functioning	Stability-at-risk or Functioning-at-risk	Unstable or not functioning	Overall Conclusion
Site 19 Wing Rd. East	2	0	2	Stability-at-risk
Site 20 - U Ave.	3	0	1	Stable tending toward stability-at-risk
Site 21 - 46th St.	3	0	1	Stable tending toward stability-at-risk
Site 22 - 47th St.	2	1	1	Stable tending toward Stability-at-risk
Site 23 - Michigan Ave.	1	1	2	Unstable tending towards stability-at-risk
Site 24 - 45th St.	1	1	2	Unstable tending towards stability-at-risk

Management Considerations

Table A6

Site	Stability	Recovery Potential	Sensitivity to disturbance
Site 1 - TS Ave.	Unstable	Poor	High
Site 2 - S. Ave	Unstable	Poor	High
Site 3 - 45th St.	Stable tending toward stability-at-risk	High	Poor
Site 4 - 43rd St.	Stability-at-risk	Moderate	Fair
Site 5 - 40th	Stable tending toward stability-at-risk	High	Poor
Site 6 - V Ave.	Stable tending toward stability-at-risk	High	Poor
Site 7 - Y Ave.	Stable	High	Poor
Site 8 - 34th St.	Stable	High	Poor
Site 9 - Buckner	Stable	High	Poor
Site 10 - Taylor	Unstable	Poor	High
Site 11 - 38th St.	Stable	High	Poor
Site 12 - Y Ave	Stable	High	Poor
Site 13 - OP Ave.	Stability-at-risk	Fair	Moderate
Site 14 - Edgarton Rd.	Unstable	Poor	High
Site 15 - Moorepark Rd.	Stable	High	Poor
Site 16 - Carpenter Rd.	Stable	High	Poor
Site 17 - Parkville Rd.	Stable	High	Poor
Site 18 - Wing Rd. West	Unstable tending towards stability-at-risk	Poor	High
Site 19 Wing Rd. East	Stability-at-risk	Poor	High
Site 20 - U Ave.	Stable	High	Poor
Site 21 - 46th St.	Stable	High	Poor

Site	Stability	Recovery Potential	Sensitivity to disturbance
Site 22 - 47th St.	Stable tending toward stability-at-risk	High	Poor
Site 23 - Michigan Ave.	Unstable tending towards stability-at-risk	Fair	Moderate
Site 24 - 45th St.	Unstable tending towards stability-at-risk	Fair	Moderate

Appendix B: Visual of Geomorphic Sites

Site 1 - TS Ave.:

Photo TS-1: Looking upstream (N)

Photo TS-2: Left bank

Photo TS-3: Looking downstream

Site 2 - S. Ave:

Photo S. Ave.-1: Looking upstream (N)

Photo S. Ave.-2: Left Bank (E)

Photo S. Ave.-3: Looking downstream (S)

Site 3 - 45th St.

Photo 45th St. - 1: Looking upstream

Photo 45th St. - 2: Right bank (N)

Photo 45th St. – 3: Looking downstream (W)

Site 4 - 43rd St.:

Photo 43rd St. - 1: Looking upstream (E)

Photo 43rd St. – 2: Right bank (N)

Photo 43rd St. – 3: Looking downstream (W)

Site 5 - 40th:

Photo 40th St. - 1: Looking upstream (E)

Photo 40th St. - 2: Left bank (S)

Photo 40th St. - 3: Looking downstream (W)

Site 6 - V Ave.:

Photos V-Ave. - 1: Looking upstream (N)

Photos V-Ave. - 2: Left bank (E)

Photos V-Ave. - 3: Looking downstream (S)

Site 7 - Y Ave.:

Photos Y Ave. – 1: Looking upstream (NE)

Photos Y Ave. – 2: Left bank (S)

Photos Y Ave. – 3: Looking downstream (SW)

Site 8 - 34th St.:

Photos 34th St.-1: Looking upstream (NE)

Photos 34th St.-2: Left bank (S)

Photos 34th St. - 3: Downstream (SW)

Site 9 – Buckner

Photos Buckner-1: Looking upstream (E)

Photos Buckner-2: Left bank (S)

Photos Buckner 3- Looking downstream (W)

Site 10 – Taylor:

Photos Taylor Rd.-1: Looking upstream (NE)

Photos Taylor Rd.-2: Left bank (E)

Photos Taylor Rd.-3: Looking downstream (S)

Site 11 - 38th St.:

Photos 38th St. - 1: Looking upstream (E)

Photos 38th St. - 2: Left bank (S)

Photos 38th St. - 3: Looking downstream (SW)

Site 12 - Y Ave.:

Photos Y Ave.-1: Looking upstream (NE)

Photos Y Ave.-2: Right bank (W)

Photos Y Ave.-3: Looking downstream (S)

Site 13 - OP Ave.:

Photo OP Ave. - 1: Looking upstream (N)

Photo OP Ave. - 2: Left bank (E)

Photo OP Ave. - 3: Looking downstream (S)

Site 14 - Edgarton Rd.:

Photo Edgarton Rd. – 1: Looking upstream (N)

Photo Edgarton Rd. – 2: Right bank (W)

Photo Edgarton Rd. – 3: Looking downstream (S)

Site 15 - Moorepark Rd.:

Photo Moorepark Rd. – 1: Looking upstream (N)

Photo Moorepark Rd. – 2: Left bank (E)

Photo Moorepark Rd. – 3: Looking downstream (S)

Site 16 - Carpenter Rd.:

Photo Carpenter Rd. - 1: Looking upstream (NE)

Photo Carpenter Rd. - 2: Left bank (S)

Photo Carpenter Rd. - 3: Looking downstream (SW)

Site 17 - Parkville Rd.:

Photo Parkville Rd. – 1: Looking upstream (NE)

Photo Parkville Rd. – 2: Left bank (S)

Photo Parkville Rd. – 3: Looking downstream (SW)

Site 18 - Wing Rd. West

Photo Wing Rd. West – 1: Looking upstream (N)

Photo Wing Rd. West – 2: Left bank (E)

Photo Wing Rd. West – 3: Looking downstream (S)

Site 19 Wing Rd. East

Photo Wing Rd. East – 1: Looking upstream (N)

Photo Wing Rd. East – 2: Left bank (E)

Photo Wing Rd. East – 3: Looking downstream (S)

Site 20 - U Ave

Photo U Ave. – 1: Looking upstream (N)

Photo U Ave. – 2: Right bank (W)

Photo U Ave. – 3: Looking downstream (S)

Site 21 - 46th St.:

Photo 46th St. – 1: Looking upstream (E)

Photo 46th St. – 2: Left bank (S)

Photo 46th St. – 3: Looking downstream (W)

Site 22 - 47th St.:

Photo 47th St. – 1: Looking upstream (E)

Photo 47th St. – 2: Left bank (S)

Photo 47th St. – 3: Looking downstream (SW)

Site 23 - Michigan Ave.:

Photo Michigan Ave. – 1: Looking upstream (NE)

Photo Michigan Ave. – 2: Right bank (W)

Photo Michigan Ave. – 3: Looking downstream (S)

Site 24 - 45th St.:

Photo 45th St. – 1: Looking upstream (E)

Photo 45th St. – 2: Right bank (N)

Photo 45th St. – 3: Looking downstream (W)