

APPENDIX

Stabilization of Ravines, Adjacent Beaches and Bluffs on Lake Michigan

By

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Plant Data

Method: In order to qualitatively and quantitatively monitor the vegetation, quadrats were used as a sampling method. The circular quadrat used in this project was prepared from a pipe 1.57 m in length, joined together to form 0.25 m² circular frame. This round quadrat shape was then randomly placed along transects. The number of quadrats sampled varied based on the size of the area surveyed. While monitoring the natural community, a complete list of species present in each quadrat along with their estimated cover was recorded. The estimated cover was defined as the ground area covered by vertical projection of the above-ground plan parts. Next, the percent cover was estimated for each species within a quadrat. Cover classes combined percent cover estimates into broader categories as follows 1=1-10%, 2=11-30%, 3=31-50%, and 4=51-100% (Packard and Mutel 1997). Sites were surveyed in August 2005 and October 2007.

Glencoe Plant Surveys – August 2005. Data for Wooded Upland and Wet to Mesic Streamside are not included due to size of files but are available from the author.

Sandy Beach Prairie Glencoe

Spec. \ Plot	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Average	
<i>Acer negundo</i>																1							1
<i>Achillea millefolium</i>			1																				1
<i>Ambrosia artemisiifolia</i>						1				2	3			2	3		1						1
<i>Andropogon scoparius*</i>	3	3	3	2		2	1		3	4		3		2		2	3	4	3	3			2
<i>Bromus latiglumis</i>												2									1		1
<i>Calamovilfa longifolia*</i>																2							1
<i>Cassia fasciculata*</i>	2					3	2				3						2						1
<i>Daucus carota</i>																					3		1
<i>Elymus canadensis*</i>	1	1	1	3	1	2		2	3	1		1	3			2					1	2	1
<i>Melilotus alba</i>		1				1											1		1	1	1		1
<i>Oenothera biennis*</i>	1	1			2			1		1				3	2	2						2	1
<i>Petalostemum Purpureum*</i>			1																	1			1
<i>Rudbeckia hirta*</i>	3	2	4	4	4	4		3		3	4	4		3	4	4	4	4	4	4	4	3	3

The figures in the table refer to cover classes.

The cover classes are as follows:

Class 1 = 1 - 10%

Class 2 = 11 - 30%

Class 3 = 31 - 50%

Class 4 = 51 - 100%

* Species were planted

Lake Bluff Plant Surveys - August 2005. Data for Wooded Upland is not included due to its size but is available from the author.

Wet to Mesic Streamside Lake Bluff 2005

Plot Spec.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
<i>Arctium minus</i>																			
<i>Aster lateriflorus</i>																			
<i>Bidens frondosa</i>															3				
<i>Bromus latiglumis</i>									4										
<i>Circaea quadrisculata</i>																			
<i>Fragaria Virg. (Wild Strawberry)</i>																			
<i>Eupatorium rugosum</i>																			
<i>Epilobium coloratum</i>																			
<i>Daucus carota</i>					4														
<i>Equisetum arvense</i>																	3	3	3
<i>Glyceria striata</i>																			
<i>Impatient canadensis</i>																			
<i>Lactuca scariola</i>																			
<i>Lobelia siphilitica</i>																			
<i>Lotus corniculatus</i>												4							
<i>Melilotus alba</i>	4										4	4	4	4					
<i>Leersia oryzoides</i>																			
<i>Oenothera biennis</i>																3			
<i>Polygonum persicaria</i>																			
<i>Populus deltoides</i>																			
<i>Prairie brome</i>																			
<i>Rumex crispus</i>																			
<i>Rhus glabra</i>																			
<i>Solidago altissima</i>		4	4	4		4	4	4		4									
<i>Solidago flexicaulis</i>																			
<i>Solidago species</i>																			
<i>Thalicum dioicum</i>																			

Plot Spec.	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
<i>Arctium minus</i>																			
<i>Aster lateriflorus</i>																	2		
<i>Bidens frondosa</i>													4						
<i>Bromus latiglumis</i>																			
<i>Circaea quadrisculata</i>																			
<i>Fragaria Virg. (Wild Strawberry)</i>					4														
<i>Eupatorium rugosum</i>																			
<i>Epilobium coloratum</i>																			
<i>Daucus carota</i>																			
<i>Equisetum arvense</i>	3	3																	
<i>Glyceria striata</i>										1									
<i>Impatient canadensis</i>						3		3	1		3		1		4				1
<i>Lactuca scariola</i>			1	1															
<i>Lobelia siphilitica</i>																			
<i>Lotus corniculatus</i>																			
<i>Melilotus alba</i>																			
<i>Leersia oryzoides</i>							4			4						4	4	4	
<i>Oenothera biennis</i>																			
<i>Polygonum persicaria</i>			1											4					
<i>Populus deltoides</i>			1	2															
<i>Prairie brome</i>			1																
<i>Rumex crispus</i>																			
<i>Rhus glabra</i>																			
<i>Solidago altissima</i>												4							
<i>Solidago flexicaulis</i>																			
<i>Solidago species</i>					4														
<i>Thalicum dioicum</i>																			

Plot Spec.	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	Average
<i>Arctium minus</i>																	4	1
<i>Aster lateriflorus</i>			2	3	4			1			4				1			1
<i>Bidens frondosa</i>																		1
<i>Bromus latiglumis</i>																		1
<i>Circaea quadrisculata</i>												4	4	4				1
<i>Fragaria Virg. (Wild Strawberry)</i>																4		1
<i>Eupatorium rugosum</i>																		1
<i>Epilobium coloratum</i>										4								1
<i>Daucus carota</i>																		1
<i>Equisetum arvense</i>																		1
<i>Glyceria striata</i>																		1
<i>Impatiens canadensis</i>																		1
<i>Lactuca scariola</i>																		1
<i>Lobelia siphilitica</i>										1								1
<i>Lotus corniculatus</i>																		1
<i>Melilotus alba</i>																		1
<i>Leersia oryzoides</i>						4												1
<i>Oenothera biennis</i>							1	3	2									1
<i>Polygonum persicaria</i>																		1
<i>Populus deltoides</i>																		1
<i>Prairie brome</i>																		1
<i>Rumex crispus</i>															1			1
<i>Rhus glabra</i>																		1
<i>Solidago altissima</i>																		1
<i>Solidago flexicaulis</i>	4																	1
<i>Solidago species</i>								2		4								1
<i>Thalicum dioicum</i>		1																1

Sandy Beach Praire - Lake Bluff

Plot Spec.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Average
<i>Cruciferae species</i>				4																1
<i>Elymus riparius</i>																		4	4	1
<i>Helianthus strumosus</i>											4									1
<i>Oenothera biennis</i>	3	3			4	2	2	4	4	4		4						1		2
<i>Rhus glabra</i>													4							1
<i>Saponaria officinalis</i>			3																	1
<i>Solidago graminifolia</i>														4	4	4	4			1

The figures in the table refer to cover classes

The cover classes are as follows:

Class 1 = 1 - 10%

Class 2 = 11 - 30%

Class 3 = 31 - 50%

Class 4 = 51 - 100%

Glencoe Plant Surveys - Fall 2007

WOODED UPLAND GLENCOE

PLOT	1	2	3	4	5	6	7	8	9	10	11	12
SPECIES												
<i>Aster lateriflorus*</i>			2		2							
<i>Aster sagittifolius</i>			1	1								
<i>Cornus sericea</i>		3		3		2						
<i>Elymus virginicus*</i>					1	1		1				
<i>Eupatorium rugosum*</i>	3		2		2		3		3		3	
<i>Fraxinus pennsylvanica</i>								1		1		
<i>Parthenocissus quinquefolia</i>									1	2		2
<i>Rhamnus cathartica</i>									1	1		1
<i>Smilax ericchata</i>		1		1							1	
<i>Solidago flexicaulis*</i>									1	1	2	3
<i>Hamamelis virginiana</i>							1					
<i>Fragaria virginiana</i>	2	2	1									
<i>Thalictrum dioicum</i>			2	3	3	1						
<i>Berberis thunbergii</i>						1		1				

WET TO MESIC STREAMSIDE GLENCOE

PLOT	1	2	3	4	5	6	7	8	9	10	11	12
SPECIES												
<i>Aster lateriflorus*</i>	1			1		1						
<i>Carex blanda*</i>										4	4	4
<i>Cinna arundinacea*</i>							3	4	3			
<i>Equisetum arvense</i>		3	3	3			3					
<i>Eupatorium rugosum*</i>					1	1						
<i>Leersia oryzoides</i>									3	3	3	
<i>Rumex crispus</i>	1				1							
<i>Solidago graminifolia</i>	1	1		1								
<i>Verbena hastata*</i>					1							
<i>Rudbeckia laciniata</i>		1	2	1								
<i>Tilia Americana</i>							1					
<i>Smilax ericchata</i>				1		1						
<i>Solanum dulcamara</i>				1	1							
<i>Fraxinus pennsylvanica</i>		1	1									

SANDY BEACH PRAIRIE GLENCOE Fall 2007

PLOT	1	2	3	4	5	6	7	8	9	10	11	12
SPECIES												
<i>Sorghastrum nutans</i>	2	2	1		1							
<i>Andropogon scoparius*</i>				3		3	1	2	1		1	
<i>Andropogon gerardii</i>				1	1							
<i>Populus deltoids</i>	1	1		1				1				
<i>Melilotus alba</i>							2	2	1	1		
<i>Elymus Canadensis*</i>			1	1					3	3	2	3
<i>Oenothera biennis*</i>	1		2		3		3				3	2
<i>Aster saittifoliosus</i>		1										
<i>Vitis riparia</i>	1											

The figures in the tables refer to cover classes.

The cover classes are as follows:

Class 1 = 1-10%

Class 2 = 11-30%

Class 3 = 31-50%

Class 4 = 51-100%

*Species were planted

Foss Park Plant Surveys 2007

BLUFF SLOPE FOSS PARK NORTH CHICAGO (ABOVE PATH)

PLOT	1	2	3	4	5	6	7	8	9	10	11	12
SPECIES												
<i>Aster nova-angliae*</i>		3	2		3			2		2	3	
<i>Aster sagittifolius*</i>		1		2	1							
<i>Andropogon scoparius*</i>	2		3	1		1			1			
<i>Rudbeckia hirta*</i>							2		1			
<i>Aster laevis*</i>						2	1					
<i>Elymus virginicus*</i>												3
<i>Bouteloua curtipendula*</i>	1	1										
<i>Solidago graminifolia*</i>		1	3	1				1	1			
<i>Melilotus alba</i>					1	2						1
<i>Solidago Canadensis</i>				2						2	3	
<i>Cirsium arvense</i>	1				1							
<i>Populus deltoids</i>						1			1		1	
<i>Robinia pseudoacacia</i>	1		1				1					
<i>Arctium minus</i>	1											
<i>Rumex crispus</i>								1	1			
<i>Rosa multiflora</i>											2	2
<i>Rhamnus cathartica</i>										2	1	1
<i>Daucus carota</i>		1	1									
<i>Vitis riparia</i>												1
<i>Salix alba</i>									2			

BLUFF SLOPE FOSS PARK NORTH CHICAGO (BELOW PATH)

PLOT	1	2	3	4	5	6	7	8	9	10	11	12
SPECIES												
<i>Amorpha canescens*</i>					1							1
<i>Andropogon gerardii*</i>										1	1	1
<i>Andropogon scoparius*</i>	3	2	2									
<i>Bouteloua curtipendula*</i>		1	1									
<i>Elymus virginicus*</i>						1			1			
<i>Aster lateriflorus</i>				2		2	2					
<i>Aster sagittifolius*</i>				2	2							
<i>Aster novae-angliae*</i>						3		1	2	3		1
<i>Cassia fasciculata*</i>							1					
<i>Rudbeckia hirta*</i>		1			1		1					
<i>Rudbeckia subtomentosa*</i>										1		
<i>Solidago graminifolia*</i>		2	3		1							
<i>Robinia psuedoacacia</i>	1			1								
<i>Melilotus alba</i>					1							1
<i>Achillea millefolium</i>		1	2									
<i>Ratabida columnifera</i>		1										
<i>Ratabida pinnata*</i>				1							1	
<i>Gaillardia aristata*</i>					1							
<i>Coreopsis lanceolata*</i>				1						2		
<i>Helianthus sp.</i>						1	1					
<i>Linaria vulgaris</i>									2			
<i>Arctium minus</i>	1											
<i>Lotus corniculatus</i>	3											
<i>Cirsium arvense</i>		1	1									

SANDY BEACH PRAIRIE FOSS PARK NORTH CHICAGO

PLOT	1	2	3	4	5	6	7	8	9	10	11	12
SPECIES												
<i>Andropogon scoparius*</i>			3	3	3		1	1				
<i>Bouteloua curtipendula*</i>		1	1									
<i>Cassia fasciculata*</i>	1											
<i>Oenothera biennis*</i>									1	3	3	1
<i>Ratabida columnifera</i>	1	1										
<i>Linum perrene</i>		3	2	3		1						
<i>Acillea millefolium</i>	4					3						
<i>Arctium minus</i>									3			2
<i>Lotus corniculatus</i>							3	2				
<i>Populus deltoids</i>										2	2	
<i>Robinia pseudoacacia</i>												3
<i>Ammophila breviligulata</i>					4	2	1					

BEACH/FILTRATION SWALE FOSS PARK NORTH CHICAGO

PLOT	1	2	3	4	5	6	7	8	9	10	11	12
SPECIES												
Carex bebbii*			1	1				1				
Carex stipata*		2			1	1			1			
Juncus torreyi*			1		1							
Scirpus atrovirens*	1			1	1							
Solidago graminifolia						1	1					
Phragmites australis	3	3	3	1	3	2	4	4	3	2	4	3
Populus deltoids	1		1	1			1		1	1		
Salix alba									1			1

The figures in the tables refer to cover classes.

The cover classes are as follows:

Class 1 = 1-10%

Class 2 = 11-30%

Class 3 = 31-50%

Class 4 = 51-100%

*Species were planted

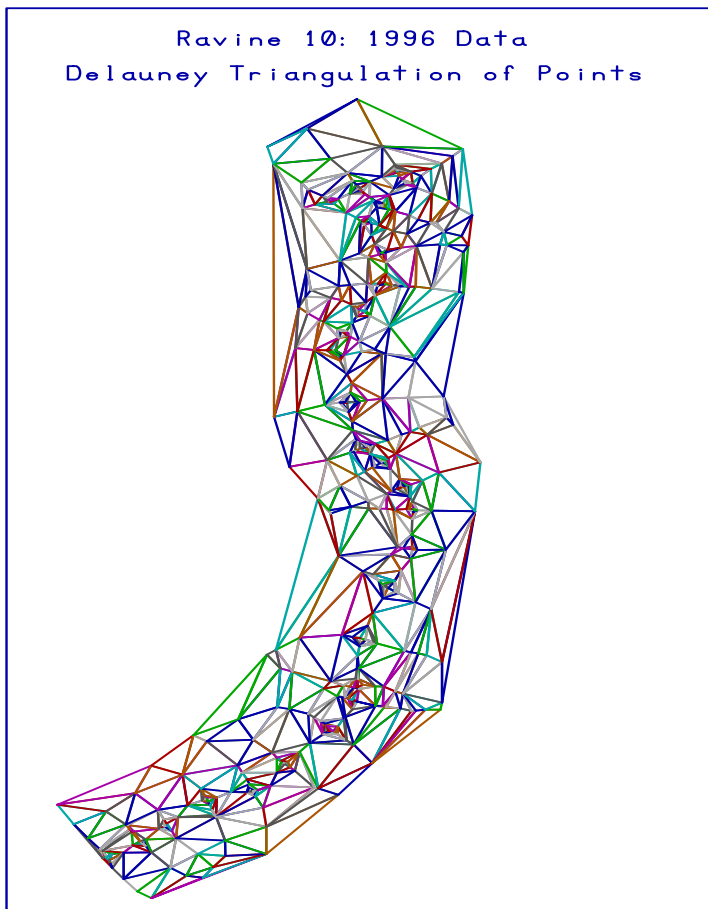
Sedimentation

Lake Bluff and Highland Park Ravines 1996–2007:

Survey measurements were made in Lake Bluff (September 25, 1996 and June 12, 2007) and Highland Park (October 2-5, 1996 and June 13, 2007), using standard procedures with an electronic total station. Measurements include points along the axis of the channel, cross sections, and other points of interest. As many as possible of the survey markers established in 1996 were located in 2007. These were reoccupied to provide a starting point and orientation for the comparative survey. New markers were established as necessary wherever the old markers could not be found or were in unsatisfactory condition. As an additional check against major errors, however, new measurements were made to all of the 1996 markers that could be located without regard to condition. Horizontal and vertical positions (X,Y, and Z) were established for each point and related to NAD27/NGVD29 datum. Surveyed positions in all surveys were referenced to the Illinois State Plane Coordinate System, Illinois East Zone.

The survey data points from 1996 and 2007 were organized into a profile of the channel of each ravine and one or more cross-sectional profile across the ravines. The cross sections are presented as viewed downstream with distances along the cross sections increasing from left to right. The cross sections are numbered from one (1) at the upstream end of the study area. The profile of the channel from each of the surveys (1996 and 2007) was compared to determine the amount of downcutting and the cross sections were used for making calculations of sediment loss.

In order to prepare cross-sectional profiles from 1996 and 2007, points lying approximately along cross sections were selected and placed in order. The difficulty of surveying in the heavily wooded ravines in 2007 prevented precise re-occupation of all 1996 survey points. To deal with this problem, a work map showing the approximate contours of slopes of the ravines was prepared for both years. A Delauney triangulation of the set of data points was first constructed. Contours were then interpolated across each triangle and connected to form the contour lines. These work maps used all of the measured points including those in the channel and those not directly associated with specific cross sections.



The cross-section data points for each year were then projected along the contour lines to a location of co-linearity, and a cross section line was prepared from the points. Polygons were constructed between the 1996 and 2007 ground surface lines, and the area of the polygons was determined. Where there was a decline in elevation, the area was considered to be negative (red), but positive where the elevation increased. The positive and negative areas were then added to get a total change of area for each cross section. To obtain volumes, each cross section was considered to be representative of the state of the ravine for the part lying closer to it than to any other cross section. The area between the 1996 and 2007 profiles was then multiplied by the length of ravine to get the change in volume (see Figures 9 and 21).

While the use of channel and cross sections is standard procedure for modeling creek/river systems (notably one-dimensional modeling in estimating flood hazards), there are some inherent limitations in its application, for example:

1. Erosion (whether from soil creep, slumping, mass wasting, surface wash, etc.) from the upper part of the ravine slope combined with deposition along the lower area actually represents erosion, but appears in the volume calculations to represent stasis (e. g. Profile 3). Similar considerations introduce uncertainty in the analysis of downcutting along the channel. The aggregate loss is nevertheless regarded as an indication of material carried completely out of the system.
2. Ancient, undisturbed, sediment appears the same as disturbed or recent ravine sediment in the volume calculations, although its response to erosive processes is quite different.

3. It was not possible to establish precise co-linearity of the cross-section points, because of heavy vegetal cover in most of the ravine. Likewise, it was impractical to recover 1996 data points exactly. This adds a certain amount of uncertainty to the morphology of the cross sections. Differences of less than a foot on the slopes of the ravine may not be significant, despite accuracy of the survey equipment and methods. The control points in and near the channel are considerably more closely spaced, and the accuracy of the cross sections is correspondingly better near the channel.
4. Whether the individual profiles are actually representative of the whole, is subject to debate, even with the density of cross sections used for this study. Surveys of cross section points are more likely to be obtainable where vegetation is sparse and erosion active. On the other hand, measurements are also more likely to be obtainable where access is comparatively easy because of moderate slope, thus favoring areas of less active erosion.
5. Because of intentionally random emplacement of experimental structures in Ravine 10, the erosional regime has been altered in ways that may apply locally, but present difficulties for extrapolation to the whole system.

Despite the limitations, volume calculations were determined in order to estimate the loss of sediment from the studied section of each ravine. The quantitative sediment loss calculations are consistent with qualitative field observations.

Lake Bluff Ravine Calculations:

Elevation change in ravine channel profiles: $\frac{\text{Area of difference}}{\text{Channel length}} = \text{Net elevation change}$

Entire channel:	$\frac{- 35.076 \text{ ft}^2}{590.68 \text{ ft}}$	$\times \frac{12 \text{ in}}{\text{ft}}$	= -0.71 in (loss)
Profile of armored channel:	$\frac{+ 57.35 \text{ ft}^2}{481.168 \text{ ft}}$	$\times \frac{12 \text{ in}}{\text{ft}}$	= +1.43 in (accretion)
Unarmored channel:	$\frac{- 92.433 \text{ ft}^2}{109.5 \text{ ft}}$	$\times \frac{12 \text{ in}}{\text{ft}}$	= -10.12 in (.843 ft) loss

$$0.843 \text{ ft} \times 8 \text{ ft} = 6.747 \text{ ft}^2 \text{ (unarmored channel cross-section area)}$$

$$6.747 \text{ ft}^2 \times 3,000 \text{ ft (unarmored channel length)} = 20,240 \text{ ft}^3 \text{ (750 yd}^3\text{)}$$

$$20,240 \text{ ft}^3 \times .03075 \text{ (clay loam dry weight)} = 622 \text{ tons eroded from unarmored channel}$$

Glencoe Ravine Calculations:

Installed BMPs for the Glencoe Ravine project were divided into two categories: streambanks stabilization¹, and water and sediment control basins² (WASCOBS). The total acreage protected and estimated total soil savings per year were calculated from the following:

1. STREAMBANKS STABILIZATION

- East settling pond - approximately 2700 ft² of bank area was planted
- West settling pond - approximately 600 ft² of bank area was planted

Total acres protected = 3300 ft^2 divided by $43560 \text{ ft}^2/\text{acre}$ = **0.075 acres**

Using the GLC's Bank/Channel erosion equation, the estimated annual total soil savings achieved by streambanks stabilization at the Glencoe ravine project is as follows:

3300 ft^2 (estimated area of streambanks planted with native vegetation) length of ravine) x 0.3 ft/yr (moderate side of 'severe' lateral erosion) x 0.0375 (clay loam dry soil weight) = **37 tons/year**

2. WATER AND SEDIMENT CONTROL BASINS (WASCOBS)

- Average ravine bed width at project site is approximately 15 feet.

Total acres protected = 15 ft (ravine bed width) x 3575 ft (length of ravine) = 53625 ft^2 divided by $43560 \text{ ft}^2/\text{acre}$ = **1.2 acres**

Using the GLC's Bank/Channel erosion equation, the estimated annual total soil savings achieved by the Glencoe ravine project is as follows:

3575 ft (length of ravine) x 6 ft (average bank height of ravine) x 0.3 ft/yr (moderate side of 'severe' lateral erosion) x 0.0375 (clay loam dry soil weight) = **241 tons/year***

* The recommended GLC Gully Erosion Equation was determined not to be applicable for the installed check dams and settling ponds. Using this formula the estimated soil savings was calculated at 4133 tons/year for the project ravine. This number is far greater than the 241 tons/year estimated above. Therefore the more conservative value is used.

Sediment volume was calculated using the following:

1. Cross sectional area of Section 'A' is approximately 11.2 ft^2

$11.2 \text{ ft}^2 \times 37 \text{ ft}$ (estimated linear length of west pond with a net accumulation of sediment) = 414 ft^3

$414 \text{ ft}^3 \times 0.0375$ (clay loam dry soil weight) = 16 tons

2. Cross sectional area of Section 'B' is approximately 14.3 ft^2

$14.3 \text{ ft}^2 \times 77 \text{ feet}$ (estimated linear length of east pond with a net accumulation of sediment) = 1101.1 ft^3

$1101.1 \text{ ft}^3 \times 0.0375$ (clay loam dry soil weight) = 41 tons

3. Total accumulation in both settling ponds:
 $41 \text{ tons} + 16 \text{ tons} = 57 \text{ tons}/11 \text{ months}$ or 5.2 tons per month

Estimated annual sediment accumulation of system is approximately **62 tons per year.**

It is assumed that an average annual rate of erosion for a typical eroding urban ravine is 13.6 tons/year per 100 ft of ravine (Shabica, 1998). With the project's retention pond system trapping 1.7 tons/year per 100 feet of ravine, we hypothesize that approximately 11.9 tons of sediment per 100 ft of ravine bypasses the system annually.

Ravine 10 Calculations:

Horizontal distances along channel in feet:

Upstream from Cross section 1, 104.975
Between Cross Section 1 and Cross Section 2: 207.367
Between Cross Section 2 and Cross Section 3: 108.950
Between Cross Section 3 and Cross Section 4: 100.030
Between Cross Section 4 and Cross Section 5: 128.541
Between Cross Section 5 and Cross Section 6: 90.489
Downstream from Cross section 6: 173.467

Cross Section 1: Channel distance = $104.975 + (207.367 / 2.0) = 207.659$ ft
Total Area Change = -193.1 ft²
Volume Change = $-193.1 \times 207.659 = -40098.953$ cu ft = -1485.15 cu yds (**-7.15 cu yd/ft**)

Cross Section 2: Channel distance = $(207.367 / 2.0) + (108.950 / 2.0) = 157.159$
Total Area Change = -5.7 ft²
Volume Change = -899.264 cu ft = -33.31 cu yds (**-0.21 cu yd/ft**)

Cross Section 3: Channel distance = $(108.950 / 2.0) + (100.030 / 2.0) = 104.490$
Total area change = -26.260
Volume change = -2743.907 cu ft = -101.63 cu yds (**-0.97 cu yd/ft**)

Cross Section 4: Channel distance = $(100.030 / 2.0) + (128.541 / 2.0) = 114.286$
Total area change = 6.6691
Volume change = 764.688 cu ft = 28.32 cu yds (**+0.25 cu yd/ft**)

Cross Section 5: Channel distance = $(128.541 / 2.0) + (90.489 / 2.0) = 109.515$
Total area change = -64.5273
Volume change = -7055.707 cu ft = -261.730 cu yds (**-2.39 cu yd/ft**)

Cross Section 6: Channel distance = $(90.489 / 2.0) + 173.467 = 131.978$
Total area change = -193.9360
Volume change = -25595.285 cu ft = -947.87 cu yds (**-7.18 cu yd/ft**)

Volumetric change based on profiles:

Total volume change = -2801.37 cu yds
Total channel length = 913.819 ft
Average Change = **-3.1 cu yds/ft**

Channel profile:

Total channel change = -123.7348 ft²
Total channel length = 913.819 ft
Elevation change = -1.6 in