APPENDIX A BIOLOGICAL ASSESSMENT OF SAND CREEK

MI/DEQ/SWQ-00/039

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
SURFACE WATER QUALITY DIVISION
MAY 2000

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STAFF REPORT

BIOLOGICAL ASSESSMENT OF SAND CREEK OTTAWA AND KENT COUNTIES, MICHIGAN AUGUST 26, 1993 AND SEPTEMBER 16, 1996

Qualitative biological sampling of Sand Creek was conducted by staff of the Great Lakes Environmental Assessment Section (GLEAS) on two occasions: August 26, 1993 and September 16, 1996. The 1993 survey was requested by the Surface Water Quality Division, Grand Rapids District Office, because of potential impacts from soil erosion, sedimentation, and excessive runoff associated with changing land uses and urban development within its watershed. Prior biological and habitat surveys of Kent County streams suggest that influences from growth and development in Grand Rapids, Rockford, and suburbs have substantially degraded the quality of several areas stream (Stegman Creek, Becker Creek, Little Cedar Creek, Duke Creek, and Armstrong Creek). The 1996 survey was requested by the Land and Water Management Division (LWMD) to assess the biological integrity of Sand Creek and evaluate potential impacts associated with illegal periodic water withdrawals for crop irrigation by a private landowner. Biological sampling in all surveys was conducted following the methods described in GLEAS Procedure #51 (MDEQ, 1997).

Sand Creek originates in the east-central portion of Ottawa County, near Conklin, and flows through Marne into the Grand River west of Grand Rapids. The stream is approximately 20 miles in length and entirely within the Southern Michigan Northern Indiana Till Plains (SMNITP) ecoregion (Omernik and Gallant, 1988). The headwaters of Sand Creek are dominated by agricultural land use.

Grand Rapids District, Fisheries Division, staff indicated that Sand Creek has historically been a managed coldwater stream requiring rotenone treatments to eliminate undesirable fish followed by stocking brown trout (*Salmo trutta*) and steelhead (*Oncorhynchus mykiss*). This stocking was also done to augment the stream's apparent limited ability to support and sustain natural reproduction of salmonids.

A total of three stations were sampled in the 1993 survey: the uppermost station located just upstream of Arthur Street (Station 1a), a middle reach located just upstream of Lincoln Street (Station 2a), and just downstream of Route 45 (Station 3a). Stations 1a, 2a, and 3a are located about 11, 5.5, and 3 miles upstream from the Grand River confluence, respectively (Figure 1). The East Fork Sand Creek was not assessed because of lack of adequate stream flow during the survey period. Two stations were sampled in the 1996 survey, one upstream of the withdrawal site (Station 1b, just upstream of Cleveland Street) and one downstream (Station 2b, just upstream of Arthur Street; Figure 1).

SUMMARY

1. Locations of the biological sampling stations on Sand Creek for the 1993 (1a – 3a) and 1996 (1b and 2b) surveys are shown in Figure 1. Location information is summarized in Tables 3 (1993) and 6 (1996).

2. The results of fish sampling and multimetric evaluations of macroinvertebrate communities are provided in Tables 1A and B (1993), 4A and B (1996), 2A and B (1993), and 5A and B (1996), respectively. Qualitative assessments of the physical habitat at each survey location are provided in Tables 3 (1993) and 6 (1996). A summary of the qualitative ratings for macroinvertebrates and habitat is provided in Table 7.

BIOLOGICAL SAMPLING RESULTS – 1993

Fish – 1993

The fish community sampling results indicated that the fish community at Station 1a, a second order reach of the stream with a width of about 18 feet and a 9 cfs flow during the survey, was dominated by a central mudminnow (*Umbra limi*) population (58% of the total numbers of fish). Stations 2a and 3a, both third order reaches, were dominated by mottled sculpin (*Cottus bairdi*) populations (59 and 40% of the total number of fish, respectively). The stream segments surveyed at Stations 2a and 3a were 35 and 50 feet in width and at the time had estimated flows of 26 and 100 cfs, respectively (Tables 1A and B).

Station 1a had a general paucity of taxa and predominance of tolerant species at this site (Table 1B). The two downstream sites (2a and 3a) both showed and increase in taxa and the presence of rainbow and brown trout (*Oncorhynchus mykiss* and *Salmo trutta*, respectively), and other intolerant taxa like mottled sculpin (Table 1A). Some variation in size classes of the salmonids captured indicated that limited reproduction was potentially occurring, particularly at Station 3a. Percent salmonid composition at Stations 2a and 3a were 2.3 and 7.1%, respectively, thereby meeting designated uses for a coldwater stream; Station 1a (0%) did not meet designated use according to this criterion.

Macroinvertebrates – 1993

The macroinvertebrate communities at Stations 1a, 2a, and 3a (Tables 2A and B) were all rated acceptable based on comparison with reference stream scores. Clay/silt deposition on colonizable substrate effectively reduced habitat for the macroinvertebrate community at each site, particularly at Stations 2a and 3a. Channelization of the stream at and upstream of Station 1a substantially reduced the availability of suitable macroinvertebrate habitat. Instability of existing habitat was also impacted by seasonal extremes in stream flows, most likely attributable to enhanced drainage in the upper watershed. The number of taxa increased with downstream sites, although composite scores were similar for all three stations.

Habitat – 1993

Habitat quality was rated poor (severely impaired) at Station 1a and good (slightly impaired) at Stations 2a and 3a (Table 3). Based on channel morphology and trunk diameters on trees growing along the stream banks, the stream channel in the vicinity of Station 1a was dredged 15 to 20 years ago. Stream channel characteristics at each survey site indicated that stream flow fluctuations are often extreme and unstable. Typical sources of stream quality degradation, such as upland and stream channel erosion, sedimentation, and extreme hydrologic fluctuations were evident throughout the Sand Creek watershed during this survey.

3. BIOLOGICAL SAMPLING RESULTS – 1996

Fish – 1996

Species diversity at Stations 1b and 2b was low and dominated primarily by central mudminnows, creek chubs (*Semotilus atromaculatus*), and johnny darters (*Etheostoma* *nigrum*), all tolerant taxa (Tables 4A and B). Both stations lacked salmonids and other intolerant species, indicating that this portion of Sand Creek was not meeting its designation as a coldwater stream.

Macroinvertebrates – 1996

Macroinvertebrate community evaluations at Stations 1b and 2b were both rated poor (–5 and –6, respectively) and almost totally lacked sensitive mayfly, stonefly, and caddisfly taxa (Tables 5A and B). The taxa composition consisted largely of tolerant gastropods (snails), decapods (crayfish), isopods (sowbugs), and air-breathing hemipterans (true bugs). Most macroinvertebrates present were swimmers, skaters, or burrowers and are indicative of a high amount of fine sediments and a trend toward homogeneous substrate composition. The few clingers, which need larger particle size or other firm substrate to survive, found in the survey may be attributable to the presence of small gravel patches and a logjam at Station 2b.

Habitat – 1996

The aquatic habitat at both stations was rated as fair (moderately impaired) with scores of 52 and 51 for 1b and 2b, respectively (Table 6). Both surveys indicated a high degree of embeddedness and fine sediment deposition, which result in reduced habitat availability for macroinvertebrates and fish. Station 2b (Arthur Street) was rated as having a highly irregular flow pattern, moderately unstable banks, and low bank vegetative stability, all of which may be the direct result of periodic water withdrawal events immediately upstream.

4. The 1993 and 1996 surveys both show a higher level of degradation at upstream sites 1B (Cleveland Street) and 1A/2B (Arthur Street) on Sand Creek. The two downstream stations sampled in 1993 (Lincoln Street and M-45 crossings) both had higher scores in all three metric categories than the surveys at the Arthur Street (1993 and 1996) and Cleveland Street stations upstream. The combination of agricultural land use, periodic dewatering of the stream channel for irrigation, and historic channelization activity at the upstream sites (as noted by field personnel) have combined to reduce habitat for fish and aquatic macroinvertebrates. High levels of embeddedness and bottom deposition often result from improper agricultural uses and channelization processes. This increased sediment load combined with the channel/habitat homogeneity resulting from channelization results in a loss of mayfly, stonefly, and caddisfly taxa and a general shift in the macroinvertebrate community toward taxa more tolerant of fine sediments (Waters, 1995). Water diversion activities between sites 1B and 1A/2B have reportedly been occurring since 1982, prior to either of these surveys. As a result of LWMD actions, in 1998 the landowner responsible for the diversion was forced to place a weir in the stream channel so that baseflow conditions could be maintained downstream.

   The downstream stations had a higher diversity of fish and macroinvertebrate taxa and a more heterogeneous and stable stream channel providing a variety of habitats for fish and insects. Mitigating factors at these stations may be the lack of historical channelization at these stations, as well as the additional flow from East Fork and other smaller tributaries to Sand Creek. Future survey activity should sample at historic sites in order to investigate whether the perpetuation of baseflow conditions enables Station 1A/2B to approach the conditions of the higher-quality downstream sites.

REFERENCES

MDEQ. 1997. Qualitative biological and habitat survey protocols for wadable streams and rivers. GLEAS Procedure No. 51. Michigan Department of Environmental Quality, Surface Water Quality Division, Lansing, Michigan.

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Waters, T.F. 1995. Sediment in streams: sources, biological effects, and control. American Fisheries Society Monograph 7.

Field Work By: Scott Hanshue, Aquatic Biologist
Jack Wuycheck, Aquatic Biologist
Bill Taft, Aquatic Biologist
Great Lakes and Environmental Assessment Section
Surface Water Quality Division

Amy Hilt, Fisheries Division, MDNR

Report By: Kevin Goodwin, Aquatic Biologist
Great Lakes and Environmental Assessment Section
Surface Water Quality Division

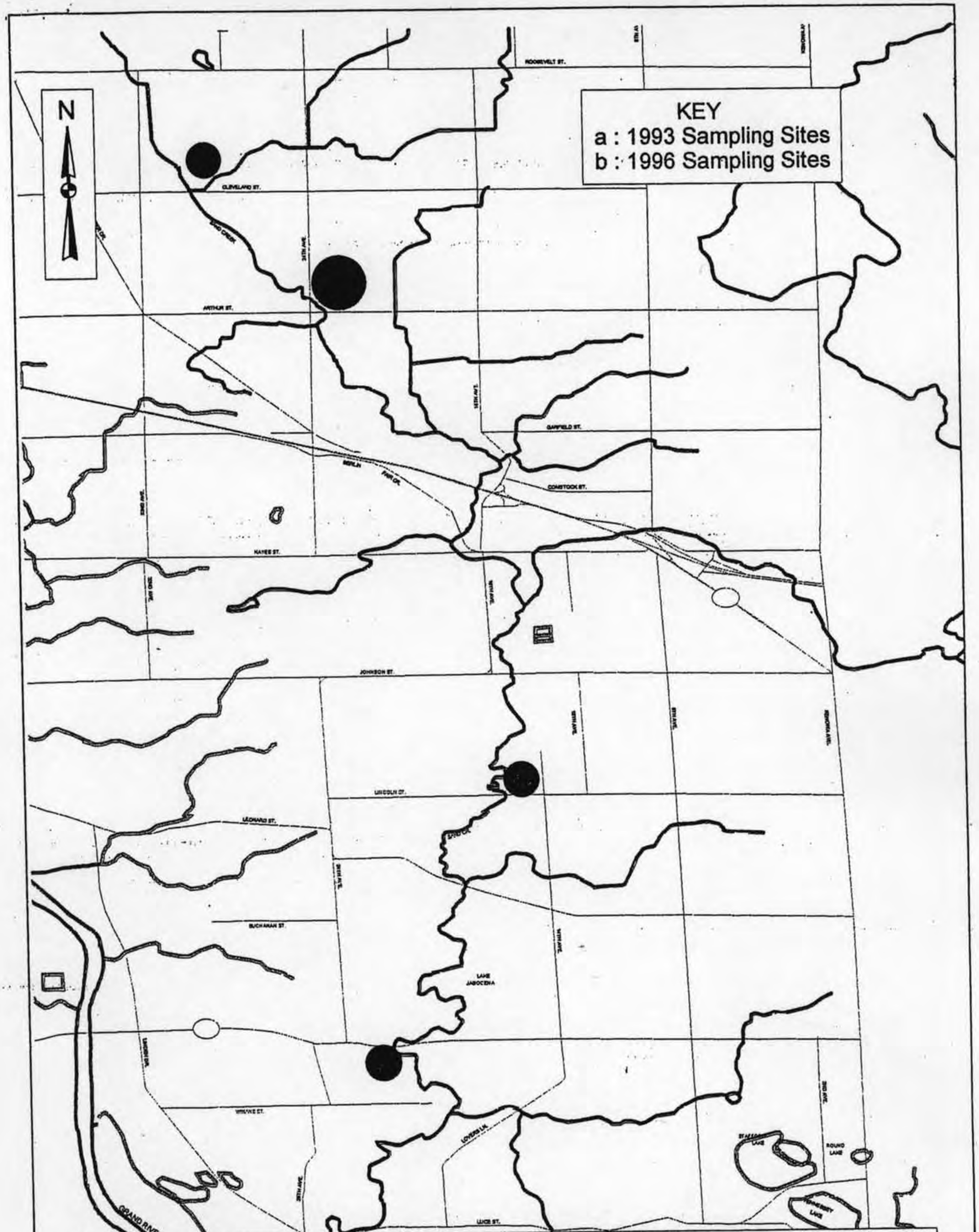


Figure 1. Locations of Sand Creek biosurvey sites for 1993 (1a-3a) and 1996 (1b, 2b).

Table 1A. Qualitative fish sampling results for Sand Creek (Ottawa County, Michigan), a designated coldwater stream located in the S. Michigan/N. Indiana Till Plains ecoregion, August 26, 1993.

TAXA	STATION 1 Arthur Rd.	STATION 2 Lincoln Rd.	STATION 3 d/s of M-45
Salmonidae (trouts)			
Oncorhynchus mykiss (Rainbow tr.)		2	6
Salmo trutta (Brown trout)		1	3
Umbridae (mudminnows)			
Umbra limi (Central mudminnow)	66		4
Esocidae (pikes)			
Esox lucius (Northern Pike)		2	
Cyprinidae (minnows and carps)			
Semotilus atromaculatus (Creek chub)	24	2	1
Notropis volucellus (Mimic sh.)			4
Pimephales notatus (Bluntnose m.)			2
Rhinichthys atratulus (Blacknose d.)			19
Cottidae (sculpins)			
Cottus bairdi (Mottled sculpin)		78	50
Catostomidae (suckers)			
Catostomus commersoni (W. sucker)		21	23
Moxostoma erythrurum (Golden redh.)			1
Gasterosteidae (sticklebacks)			
Culaea inconstans (Brook)	21		
Centrarchidae (sunfish)			
Ambloplites rupestris (Rock bass)			2
Lepomis cyanellus (Green sunfish)			2
Percidae (perch)			
Etheostoma caeruleum (Rainbow d.)			1
Etheostoma nigrum (Johnny darter)	2	26	8
TOTAL INDIVIDUALS	113	132	126
Number of hybrid sunfish	0	0	0
Number of anomalies	0	0	0
Percent anomalies	0	0	0
Percent salmonids	0.000	0.023	0.071
Density	0.025	0.009	0.006
Gear	Backpack	Backpack	Backpack

Table 1B. Fish metric evaluation of Sand Creek, Ottawa County, Michigan, August 26, 1993.

METRIC	STATION 1 Value	STATION 2 Value	STATION 3 Value
TOTAL NUMBER OF TAXA	4	7	14
NO. OF DARTER, SCULPIN, MADTOM TAXA	1	2	3
NUMBER OF SUNFISH TAXA	0	0	2
NUMBER OF SUCKER TAXA	0	1	2
NUMBER OF INTOLERANT TAXA	0	3	5
PERCENT TOLERANT	81.4	37.1	46.8
PERCENT OMNIVOROUS TAXA	79.6	17.4	38.9
PERCENT INSECTIVOROUS TAXA	20.4	78.8	52.4
PERCENT PISCIVOROUS TAXA	0.00	1.5	1.6
% SIMPLE LITHOPHILIC SPAWNER TAXA	0.00	15.9	34.9

Table 2A. Qualitative macroinvertebrate sampling results for Sand Creek (Ottawa County, Michigan) a coldwater designated stream located in the S. Michigan/N. Indiana Till Plains ecoregion, August 26, 1993.

TAXA	STATION 1 Arthur Rd.	STATION 2 Lincoln Rd.	STATION 3 d/s of M-45
PORIFERA (sponges)		8	
PLATYHELMINTHES (flatworms)			
Turbellaria	1		
ANNELIDA (segmented worms)			
Oligochaeta (worms)	1	3	1
ARTHROPODA			
Crustacea			
Amphipoda (scuds)		5	
Decapoda (crayfish)		15	8
Isopoda (sowbugs)	15	2	
Arachnoidea			
Hydracarina			1
Insecta			
Ephemeroptera (mayflies)			
Ephemeridae			2
Heptageniidae	8	5	5
Oligoneuriidae			2
Odonata			
Zygoptera (damselflies)			
Calopterygidae		5	5
Hemiptera (true bugs)			
Belostomatidae	1		
Corixidae	1	5	5
Gerridae	1	3	5
Mesoveliidae			5
Notonectidae			4
Megaloptera			
Corydalidae (dobson flies)			1
Sialidae (alder flies)	8		
Trichoptera (caddisflies)			
Hydropsychidae	5	5	5
Limnephilidae	5	8	5
Coleoptera (beetles)			
Dytiscidae (total)	1		1
Hydrophilidae (total)			1
Dryopidae		2	
Elmidae	5	2	5
Haliplidae (larvae)			5
Diptera (flies)			
Chironomidae	10	10	15
Simuliidae		8	8
Tabanidae		2	
Tipulidae			8
MOLLUSCA			
Gastropoda (snails)			
Ancylidae (limpets)		1	2
Lymnaeidae			1
Physidae		4	2
Pelecypoda (bivalves)			
Sphaeriidae (clams)	15	3	5
TOTAL INDIVIDUALS	77	96	107

Table 2B. Macroinvertebrate metric evaluation of Sand Creek, Ottawa County, Michigan, August 26, 1993.

	STATION 1		STATION 2		STATION 3	
METRIC	Value	Score	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	14	0	19	0	25	1
NUMBER OF MAYFLY TAXA	1	-1	1	-1	3	0
NUMBER OF CADDISFLY TAXA	2	0	2	0	2	0
NUMBER OF STONEFLY TAXA	0	-1	0	-1	0	-1
PERCENT MAYFLY COMP.	10.39	0	5.21	0	8.41	0
PERCENT CADDISFLY COMP.	12.99	0	13.54	0	9.35	0
PERCENT CONTR. DOM. TAXON	19.48	1	15.63	1	14.02	1
PERCENT ISOPOD, SNAIL, LEECH	19.48	-1	7.29	0	4.67	0
PERCENT SURF. AIR BREATHERS	5.19	1	8.33	0	19.63	-1
TOTAL SCORE		-1		-1		0
MACROINV. COMMUNITY CATEGORY	ACCEPT.		ACCEPT.		ACCEPT.	

Table 3. Habitat evaluation for Sand Creek, Ottawa County, August 26, 1993.

HABITAT METRIC	STATION 1 Arthur Rd.	STATION 2 Lincoln Rd.	STATION 3 d/s of M-45
Bottom Substrate Avail. Cover (20):	3	15	20
Embeddedness (20):	5	15	10
Velocity:Depth (20):	2	16	16
Flow Stability (15):	8	12	11
Bottom Depos. (15):	1	11	11
Pools-Riffles-Runs-Bends (15):	0	15	15
Bank Stability (10):	0	6	5
Bank Vegetative Stability (10):	3	8	8
Stream Cover (10):	6	8	8
TOTAL SCORE (135)	28	106	104
HABITAT CONDITION CATEGORY	POOR (SEVERELY IMPAIRED)	GOOD (SLIGHTLY IMPAIRED)	GOOD (SLIGHTLY IMPAIRED)
Date:	August 26, 1993	August 26, 1993	August 26, 199
Stream Type:	Coldwater	Coldwater	Coldwater
Weather:	Sunny	Sunny	Sunny
Ecoregion:	SMNITP	SMNITP	SMNITP
Air Temperature:	81 Deg. F.	78 Deg. F.	75
Water Temperature:	67 Deg. F.	67 Deg. F.	66
Ave. Stream Width:	18 Feet	35 Feet	50
Ave. Stream Depth:	1 Feet	1.5 Feet	2
Surface Velocity:	0.5 Ft./Sec.	0.5 Ft./Sec.	1
Estimated Flow:	9 CFS	26.25 CFS	100
Stream Modifications:			
Nuisance Plants (Y/N):	N	N	N
Basin Code:	4050006	4050006	4050006
Report Number:	94/041	94/041	94/041
COMMENTS:			

Table 4A. Qualitative fish sampling results for Sand Creek, Ottawa County, September 16, 1996.

TAXA	STATION 1 Cleveland St.	STATION 2 Arthur St.
Umbridae (mudminnows)		
Umbra limi (Central mudminnow)	50	22
Esocidae (pikes)		
Esox americanus (Grass Pike)	5	3
Cyprinidae (minnows and carps)		
Semotilus atromaculatus (Creek)	49	25
Catostomidae (suckers)		
Catostomus commersoni (W. sucker)	12	1
Gasterosteidae (sticklebacks)		
Culaea inconstans (Brook)		7
Centrarchidae (sunfish)		
Lepomis cyanellus (Green sunfish)	16	7
Lepomis macrochirus (Bluegill)	1	2
Micropterus salmoides (Lm. bass)		1
Percidae (perch)		
Etheostoma nigrum (Johnny darter)	24	29
TOTAL INDIVIDUALS	157	97
Number of hybrid sunfish	0	0
Number of anomalies	0	0
Percent anomalies	0.000	0.000
Percent salmonids	0	0
Density	0.039	0.012
Gear	bps	bps

Table 4B. Fish metric evaluation of Sand Creek, Ottawa County, September 16, 1996.

METRIC	STATION 1 Value	STATION 2 Value
TOTAL NUMBER OF TAXA	7	9
NO. OF DARTER, SCULPIN, MADTOM TAXA	1	1
NUMBER OF SUNFISH TAXA	2	2
NUMBER OF SUCKER TAXA	1	1
NUMBER OF INTOLERANT TAXA	0	0
PERCENT TOLERANT	96.2	86.6
PERCENT OMNIVOROUS TAXA	70.7	49.5
PERCENT INSECTIVOROUS TAXA	26.1	46.4
PERCENT PISCIVOROUS TAXA	3.2	4.1
% SIMPLE LITHOPHILIC SPAWNER TAXA	7.6	1.0

Table 5A. Qualitative macroinvertebrate sampling results for Sand Creek, Ottawa County, September 16, 1996.

TAXA	STATION 1 Cleveland St.	STATION 2 Arthur St.
ARTHROPODA		
Crustacea		
Decapoda (crayfish)	10	25
Isopoda (sowbugs)	20	20
Insecta		
Ephemeroptera (mayflies)		
Heptageniidae		2
Odonata		
Zygoptera (damselflies)		
Calopterygidae		5
Hemiptera (true bugs)		
Belostomatidae	1	
Corixidae	5	
Gerridae	5	5
Notonectidae	5	5
Saldidae		5
Megaloptera		
Sialidae (alder flies)	16	
Coleoptera (beetles)		
Dytiscidae (total)		1
Diptera (flies)		
Chironomidae	8	5
Culicidae	1	
Tipulidae		1
MOLLUSCA		
Gastropoda (snails)		
Ancylidae (limpets)		
Lymnaeidae	18	
Physidae	15	10
Pelecypoda (bivalves)		
Sphaeriidae (clams)	15	15
TOTAL INDIVIDUALS	119	99

Table 5B. Macroinvertebrate metric evaluation of Sand Creek, Ottawa County, September 16, 1996.

	STATION 1		STATION 2	
METRIC	Value	Score	Value	Score
TOTAL NUMBER OF TAXA	12	0	12	0
NUMBER OF MAYFLY TAXA	0	-1	1	-1
NUMBER OF CADDISFLY TAXA	0	-1	0	-1
NUMBER OF STONEFLY TAXA	0	-1	0	-1
PERCENT MAYFLY COMP.	0.00	-1	2.02	-1
PERCENT CADDISFLY COMP.	0.00	-1	0.00	-1
PERCENT CONTR. DOM. TAXON	16.81	1	25.25	0
PERCENT ISOPOD, SNAIL, LEECH	44.54	-1	30.30	-1
PERCENT SURF. AIR BREATHERS	14.29	0	16.16	0
TOTAL SCORE		-5		-6
MACROINV. COMMUNITY CATEGORY		POOR		POOR

Table 6. Habitat evaluation for Sand Creek, Ottawa County, September 16, 1996.

HABITAT METRIC	STATION 1 Cleveland St.	STATION 2 Arthur St.
Bottom Substrate Avail. Cover (20):	3	10
Embeddedness (20):	5	5
Velocity:Depth (20):	6	11
Flow Stability (15):	8	
Bottom Depos. (15):	3	3
Pools-Riffles-Runs-Bends (15):	3	5
Bank Stability (10):	8	5
Bank Vegetative Stability (10):	9	4
Stream Cover (10):	7	8
TOTAL SCORE (135)	52	51
HABITAT CONDITION CATEGORY	FAIR (MODERATELY IMPAIRED)	FAIR (MODERATELY IMPAIRED)
Date:	9/16/96	9/16/96
Stream Type:	Coldwater	Coldwater
Weather:	Sunny	Sunny
Ecoregion:	SMNITP	SMNITP
Air Temperature:	56 Deg. F.	56 Deg. F.
Water Temperature:	52 Deg. F.	64 Deg. F.
Ave. Stream Width:	9 Feet	13 Feet
Ave. Stream Depth:	0.3 Feet	0.6 Feet
Surface Velocity:	0.75 Ft./Sec.	0.75 Ft./Sec.
Estimated Flow:	2.03 CFS	5.85 CFS
Stream Modifications:		
Nuisance Plants (Y/N):	N	N
Basin Code:	4050006	4050006
Report Number:		
COMMENTS:		

Table 7. Summary of the fish and macroinvertebrate community and aquatic habitat evaluations for Sand Creek, Southern Michigan/Northern Indiana Till Plains Ecoregions, August 1993 and September 1996.

Station Number	Station Location/Year	Macroinvertebrate Community Rating	Macroinvertebrate Community Score	Habitat Evaluation Rating	Habitat Evaluation Score
SC96-01 (2a)	Cleveland Street/ 1996	Poor	-5	Fair	52
SC93-01 (1a)	Arthur Street/ 1993	Acceptable	-1	Poor	28
SC96-02 (2b)	Arthur Street/ 1996	Poor	-6	Fair	51
SC93-02 (1b)	Lincoln Street/ 1993	Acceptable	-1	Good	106
SC93-03 (1c)	M-45/ 1993	Acceptable	-1	Good	104

APPENDIX B ROAD/STREAM CROSSINGS INVENTORY

Sand Creek, Ottawa County

Watershed Summary, 2002

By: Ryan Grant, MDEQ

Lower Sub-Watershed

Summary

The majority of this section of Sand Creek flows through Aman Park, which allows the area to remain relatively natural. The main contributor to degradation along this stretch would be the MDOT project occurring on M45. Although it is evident that Best Management Practices were incorporated into the project, erosion pathways were still evident and large areas of disturbed land were left un-vegetated. Other potential problems that exist, which could also exist throughout the entire watershed are failing residential septic tanks.

General Comments Indicated on Field Sheets

- **LSC-1**, MDOT barrels in the water downstream. Landowner's road being installed on right upstream side with high degree of potential for runoff.
- **LSC-3**, Downstream the old oil lines crossing the stream should be removed.
- **LSC-5**, Ongoing construction and loose soil on upstream side.
- **LSC-6**, Downstream flow is using west road ditch.

Mid-Lower Sub-Watershed

Summary

This portion of Sand Creek flows through a rural, wooded, residential area south of Marne. Problems noted in this section included a large gully formed by road runoff located on the main branch at the Leonard crossing. Other problems include resident waterfront owners not buffering the stream from their maintained lawns. At MLSC-4, a potential contamination problem exists due to containment tanks located adjacent to the stream.

General Comments Indicated on Field Sheets

- **MLSC-1**, Upstream water flowing in on right hand side is fast moving and green.

- **MLSC-4**, Upstream to right, containment tanks with dirt containment barrier. Has pipe that dips into cut 55-gallon barrel in ditch / looks oily.
- The rest of the comments indicated that the sites looked relatively good.

Mid-Upper Sub-Watershed

Summary

The land-use in the northern half of this sub-watershed is primarily agricultural and the southern half is residential to urban. Tributaries in this sub-watershed had very little water in them or were dry, but there was evidence of high channel forming flows. An unknown tile discharging nutrient rich water was observed at site MUSC-7. Bank erosion due to animal access was observed at two sites MUSC-8 and MUSC-13. Runoff from the roads, in downtown Marne, drain directly to Sand Creek. Drainage pipes were observed at MUSC-4 along with a substantial gully, which was formed due to road runoff. Runoff from dirt / gravel parking lots adjacent to the stream at MUSC-1 looked to have an impact on the creek.

General Comments Indicated on Field Sheets

- **MUSC-1**, Boat storage both sides with runoff from parking lots.
- **MUSC-2**, Maintained lawns both sides, water low and stagnant.
- **MUSC-6**, Hard to find, gravel pit on upstream side.
- **MUSC-8**, The culvert to the north contains stagnant water. Downstream, there is an unknown water pipe source.
- **MUSC-14**, Culvert to upstream side eroded on both sides of culvert.
- The rest of the comments stated that the sites were relatively good.

Upper Sub-Watershed

Summary

The land use within the upper sub-watershed of Sand Creek consists of mainly agricultural fields (corn and soybean) and orchards. Much of the channels are delegated as county drains and are maintained. Although the surveys were conducted during base flow, it was evident that high flow levels are common during rain events. The culverts are set up for extreme volumes of water in that, some sites had three large diameter culverts at the crossing. Much of the roads in the sub-watershed were gravel and there was evidence that sediment from the roads were entering the stream at the crossings. One particular site USC-7, there is no preventative measures taken to prohibit road runoff above the new box culvert. Stream bank erosion due to animal access was noticed at USC-8 (Janice Tompkins talked with property owner). Nutrient input from surrounding agricultural fields were impacting USC-13. Excessive amounts of algae were observed along the edges, on the substrate, and throughout the water column of the stream. Sites USC-17 and 18 were heavily impacted by road runoff and orchard access areas.

General Comments Indicated on Field Sheets

- **USC-1**, An intensive horse operation is located on the south side of Cleveland, east side of the creek. Manure was notice near the creek. The road ditch is very deep allowing extensive erosion on southwest side.
- **USC-3**, Garbage observed downstream, on the left side. Cropland needs horizontal tilling. The culvert is undercut.
- **USC-4**, Tiles from surrounding fields drain directly into he stream on both sides.
- **USC-11**, The Culvert is over 1/3 filled with sediment. Considerable erosion on hillside coming down the road to stream (Upstream, left side). Sediment from the road enters the stream.
- **USC-12**, Downstream crop fields need larger buffer zones. One of two culverts dry and ½ full of sand.
- **USC-13**, Upstream crop fields need larger buffer zones. Two of three culverts filled in with sediment, on both sides.
- **USC-14**, Downstream crop fields, on the left side need larger buffer zones.
- **USC-15**, Sheep pasture adjacent to upstream side. The sheep are allowed to drink from the creek at a 5 ft wide spot.
- **USC-16**, Road runoff directly into stream.
- **USC-18**, Upstream, pipe from adjacent field drains directly into stream (foamy water). Film on water but did not look like oil or bacteria.

- **USC-19**, White 8” pipe draining directly into the upstream side of the stream.

East Fork Sub-Watershed

Summary

The landuse characteristics in this sub-watershed range from agricultural / orchard in the northern reaches, rural residential to slightly urban in the mid-section and rural residential to mostly forested in the lower reaches. Observed problems affecting the watershed include hydrology issues, agricultural runoff, and possible septic system contamination. Extensive channel erosion caused by high volumes of runoff were noticed at EFSC-5, 6, 10, and 19. Agricultural runoff was greater in the Lau Bach Inter-County Drain region of the sub-watershed, evidence being the high amount of vegetative matter at EFSC-15. A possible septic contamination was noticed by Janice Tompkins at EFSC-14 on 10/16/2002 while conducting surveys with Howard Miller Volunteers. Along with the channel erosion at site EFSC-10, deep gullies from road runoff and residential runoff indicate degrading sources.

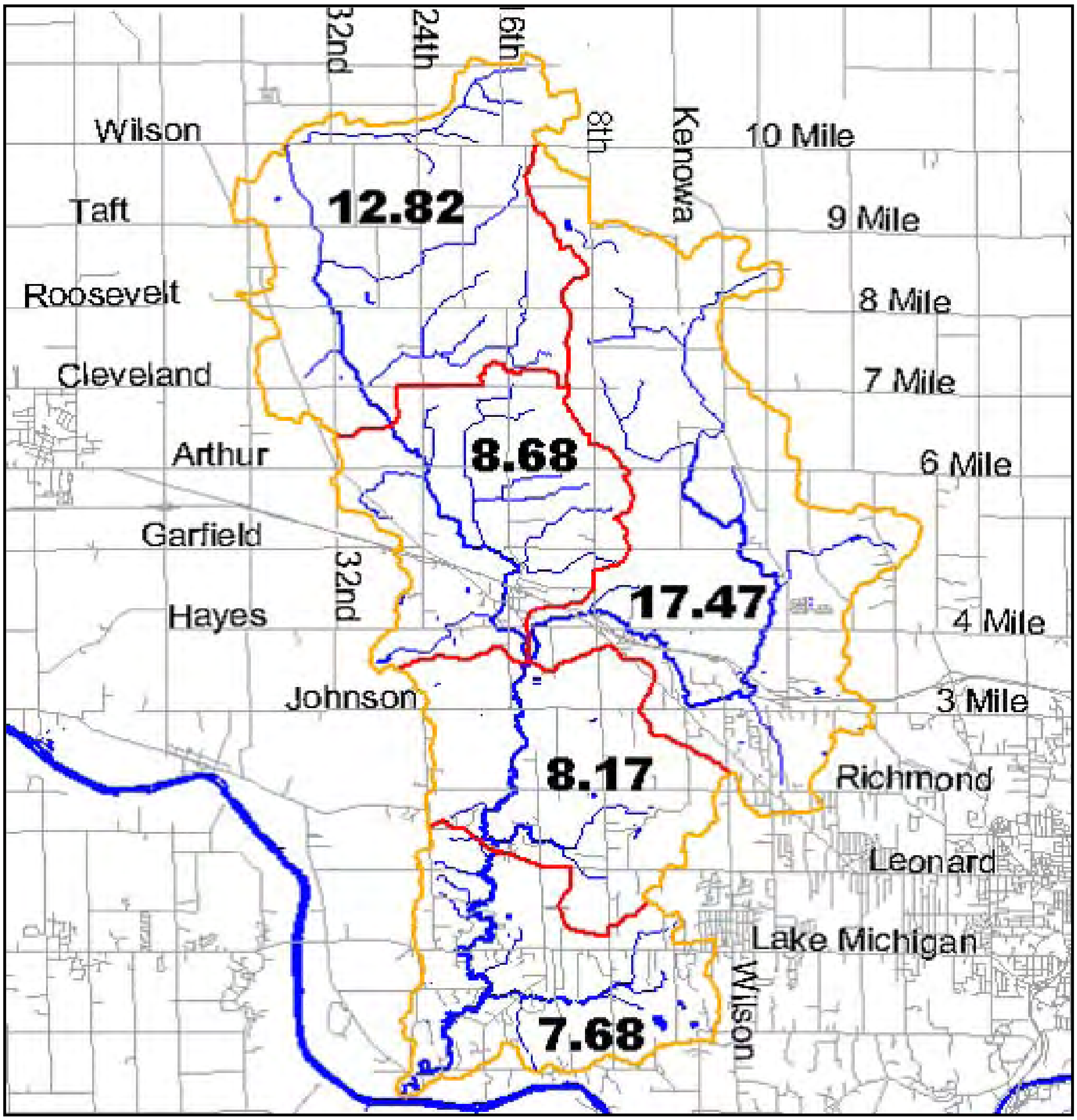
General Comments Indicated on Field Sheets

- **EFSC-1**, Installation of sewer main line at crossing causing potential source issues.
- **EFSC-2**, Residential maintained lawn on left upstream side. Potential highway (I96) runoff on left downstream side.
- **EFSC-3**, No geo-textile material placed to hold roadside vegetation after restoration following pipeline (gas) construction.
- **EFSC-6**, Upstream side culvert is deteriorated (rusted out) at the bottom.
- **EFSC-12**, Septic system (raised) next to dry streambed.
- **EFSC-13**, Significant aquatic plant growth, upstream.
- **EFSC-14**, Grey water noticed, possible septic system failure.
- **EFSC-15**, Good riparian buffers downstream, but high nutrient loading.
- **EFSC-19**, Holes at the top of the culvert.
- **EFSC-20**, Loose soil around both culverts.

Sand Creek Sub-Watershed Breakdown

Yellow Line = Sand Creek Watershed Boundary
Red Line = Sub-Watershed Boundary
Blue Line = River, Stream, and Drain Channels
Note, Numbers represent square miles

- **7.68** - Lower Sand Creek Sub-Watershed
- **8.17** - Mid-Lower Sand Creek Sub-Watershed
- **8.68** - Mid-Upper Sand Creek Sub-Watershed
- **12.82** - Upper Sand Creek Sub-Watershed
- **17.47** - East Fork Sub-Watershed



Road / Stream Crossing Inventory for Sand Creek 2002

Count	Site ID	Sub-Watershed Name	Location	Township/County	Stream Name	Inventory Date
1	LSC-1	Lower Sand Creek	Luce west of 20th	Tallmadge / Ottawa	Sand Creek	10/16/2002
2	LSC-2	Lower Sand Creek	Lovers Lane southwest of 14th	Tallmadge / Ottawa	Trib to Sand Creek	10/16/2002
3	LSC-3	Lower Sand Creek	M45 west of 14th	Tallmadge / Ottawa	Trib to Sand Creek	10/16/2002
4	LSC-4	Lower Sand Creek	M45 west of 14th	Tallmadge / Ottawa	Sand Creek	10/16/2002
5	LSC-5	Lower Sand Creek	M45 east of 8th	Tallmadge / Ottawa	Trib to Sand Creek	10/16/2002
6	LSC-6	Lower Sand Creek	8th south of M45	Tallmadge / Ottawa	Trib to Sand Creek	10/16/2002
7	LSC-7	Lower Sand Creek	8th north of Luce	Tallmadge / Ottawa	Trib to Sand Creek	10/16/2002
8	MLSC-1	Mid-Lower Sand Creek	Johnson east of 12th	Tallmadge / Ottawa	Sand Creek	10/16/2002
9	MLSC-2	Mid-Lower Sand Creek	Lincoln east of 12th	Tallmadge / Ottawa	Sand Creek	10/16/2002
10	MLSC-3	Mid-Lower Sand Creek	Leonard west of 14th	Tallmadge / Ottawa	Sand Creek	10/16/2002
11	MLSC-4	Mid-Lower Sand Creek	14th north of Leonard	Tallmadge / Ottawa	Trib to Sand Creek	10/16/2002
12	MLSC-5	Mid-Lower Sand Creek	Leonard east of 14th	Tallmadge / Ottawa	Trib to Sand Creek	10/16/2002
13	MLSC-6	Mid-Lower Sand Creek	8th south of Lincoln	Tallmadge / Ottawa	Trib to Sand Creek	10/16/2002
14	MUSC-1	Mid-Upper Sand Creek	16th south of Hayes	Tallmadge / Ottawa	Sand Creek	10/16/2002
15	MUSC-2	Mid-Upper Sand Creek	Hayes west of 16th	Wright / Ottawa	Trib to Sand Creek	10/16/2002
16	MUSC-3	Mid-Upper Sand Creek	Berlin Fair north of Hayes	Wright / Ottawa	Sand Creek	10/16/2002
17	MUSC-4	Mid-Upper Sand Creek	State east of 16th	Wright / Ottawa	Sand Creek	10/16/2002
18	MUSC-5	Mid-Upper Sand Creek	16th south of Garfield	Wright / Ottawa	Trib to Sand Creek	10/8/2002
19	MUSC-6	Mid-Upper Sand Creek	8th south of Garfield	Wright / Ottawa	Trib to Sand Creek	10/8/2002
20	MUSC-7	Mid-Upper Sand Creek	8th north of Garfield	Wright / Ottawa	Trib to Sand Creek	10/8/2002
21	MUSC-8	Mid-Upper Sand Creek	16th north of Garfield	Wright / Ottawa	Trib to Sand Creek	10/8/2002
22	MUSC-9	Mid-Upper Sand Creek	16th south of Arthur	Wright / Ottawa	Trib to Sand Creek	10/8/2002
23	MUSC-10	Mid-Upper Sand Creek	16th north of Arthur	Wright / Ottawa	Trib to Sand Creek	10/8/2002
24	MUSC-11	Mid-Upper Sand Creek	16th south of Cleveland	Wright / Ottawa	Trib to Sand Creek	10/8/2002
25	MUSC-12	Mid-Upper Sand Creek	Arthur west of 16th	Wright / Ottawa	Trib to Sand Creek	10/8/2002
26	MUSC-13	Mid-Upper Sand Creek	Juniper southeast of Arthur	Wright / Ottawa	Trib to Sand Creek	10/8/2002
27	MUSC-14	Mid-Upper Sand Creek	24th south of Arthur	Wright / Ottawa	Trib to Sand Creek	10/8/2002
28	MUSC-15	Mid-Upper Sand Creek	Arthur east of 24th	Wright / Ottawa	Sand Creek	10/8/2002
29	USC-1	Upper Sand Creek	Cleveland west of 24th	Wright / Ottawa	Sand Creek	10/16/2002
30	USC-2	Upper Sand Creek	24th north of Cleveland	Wright / Ottawa	Kauf Drain	10/16/2002
31	USC-3	Upper Sand Creek	Roosevelt east of 24th	Wright / Ottawa	Trib to Sand Creek	10/16/2002
32	USC-4	Upper Sand Creek	16th north of Cleveland	Wright / Ottawa	Kauf Drain	10/16/2002
33	USC-5	Upper Sand Creek	Roosevelt west of 14th	Wright / Ottawa	Kauf Drain	10/16/2002
34	USC-6	Upper Sand Creek	32nd north of Cleveland	Wright / Ottawa	Trib to Sand Creek	10/16/2002
35	USC-7	Upper Sand Creek	Roosevelt west of 32nd	Wright / Ottawa	Sand Creek	10/16/2002

Road / Stream Crossing Inventory for Sand Creek 2002

Count	Site ID	Sub-Watershed Name	Location	Township/County	Stream Name	Inventory Date
36	USC-8	Upper Sand Creek	28th north of Roosevelt	Wright / Ottawa	Trib to Sand Creek	10/16/2002
37	USC-9	Upper Sand Creek	24th north of Roosevelt	Wright / Ottawa	Trib to Sand Creek	N/A
38	USC-10	Upper Sand Creek	20th south of Taft	Wright / Ottawa	Trib to Sand Creek	10/16/2002
39	USC-11	Upper Sand Creek	Berry east of 20th	Chester / Ottawa	Trib to Sand Creek	10/16/2002
40	USC-12	Upper Sand Creek	Taft west of 30th	Chester / Ottawa	Sand Creek	10/8/2002
41	USC-13	Upper Sand Creek	Wilson west of 32nd	Chester / Ottawa	Sand Creek	10/8/2002
42	USC-14	Upper Sand Creek	32nd north of Wilson	Chester / Ottawa	Sand Creek	10/8/2002
43	USC-15	Upper Sand Creek	Wilson west of 24th	Chester / Ottawa	Sand Creek	10/8/2002
44	USC-16	Upper Sand Creek	24th north of Wilson	Chester / Ottawa	Sand Creek	10/8/2002
45	USC-17	Upper Sand Creek	16th south of Harding	Chester / Ottawa	Trib to Sand Creek	10/8/2002
46	USC-18	Upper Sand Creek	16th south of Harding	Chester / Ottawa	Trib to Sand Creek	10/8/2002
47	USC-19	Upper Sand Creek	16th south of Harding	Chester / Ottawa	Trib to Sand Creek	10/8/2002
48	EFSC-1	East Fork Sand Creek	Hayes east of 16th	Wright / Ottawa	East Fork	10/16/2002
49	EFSC-2	East Fork Sand Creek	8th north of 4 Mile	Wright / Ottawa	East Fork	10/8/2002
50	EFSC-3	East Fork Sand Creek	8th north of 4 Mile	Wright / Ottawa	Trib to East Fork	10/8/2002
51	EFSC-4	East Fork Sand Creek	4 Mile east of 8th	Wright / Ottawa	East Fork	10/8/2002
52	EFSC-5	East Fork Sand Creek	3 Mile west of Kinney	City of Walker / Kent	Trib to East Fork	10/8/2002
53	EFSC-6	East Fork Sand Creek	Kinney south of 3 Mile	City of Walker / Kent	Trib to East Fork	10/16/2002
54	EFSC-7	East Fork Sand Creek	4 Mile west of Fruit Ridge	Alpine / Kent	East Fork	10/8/2002
55	EFSC-8	East Fork Sand Creek	Fruit Ridge south of 5 Mile	Alpine / Kent	Trib to East Fork	10/8/2002
56	EFSC-9	East Fork Sand Creek	Hendershot south of 6 Mile	Alpine / Kent	Trib to East Fork	10/8/2002
57	EFSC-10	East Fork Sand Creek	Peach Ridge south of 6 Mile	Alpine / Kent	Trib to East Fork	10/8/2002
58	EFSC-11	East Fork Sand Creek	5 Mile west of Fruit Ridge	Alpine / Kent	East Fork	N/A
59	EFSC-12	East Fork Sand Creek	6 Mile west of Stage	Alpine / Kent	Trib to East Fork	10/8/2002
60	EFSC-13	East Fork Sand Creek	6 Mile east of Kenowa	Alpine / Kent	Laubach Inter-County Drain	10/8/2002
61	EFSC-14	East Fork Sand Creek	Kenowa north of 6 Mile	Alpine / Kent	Trib to Laubach Inter-County Drain	10/16/2002
62	EFSC-15	East Fork Sand Creek	Stage and Gibbs	Alpine / Kent	Laubach Inter-County Drain	10/16/2002
63	EFSC-16	East Fork Sand Creek	Hayes west of Stage	Alpine / Kent	Laubach Inter-County Drain	10/16/2002
64	EFSC-17	East Fork Sand Creek	8th north of Dickinson	Wright / Ottawa	Trib to Laubach Inter-County Drain	10/16/2002
65	EFSC-18	East Fork Sand Creek	Roosevelt east of 8th	Wright / Ottawa	Trib to Laubach Inter-County Drain	10/16/2002
66	EFSC-19	East Fork Sand Creek	8 Mile west of Fruit Ridge	Alpine / Kent	Trib to Laubach Inter-County Drain	10/16/2002
67	EFSC-20	East Fork Sand Creek	Fruit Ridge north of 8 Mile	Alpine / Kent	Trib to Laubach Inter-County Drain	10/16/2002

APPENDIX C PHYSICAL INVENTORY OF SAND CREEK

Summary of Sand Creek Physical Inventory

Section	Sub-section	Description of Site	Recommendations	Location
Headwaters downstream to Roosevelt St. crossing	None	This stream section had a large amount of sediment in the streambed. When talking with farmer he indicated that he dredged creek periodically to increase its storage capacity. To note, debris was found in overhanging tree branches up to 2 ft. above the water level.	Reduce volume of agricultural runoff through wetland restoration. Reduce sedimentation through establishment of adequate buffer/filter strips and agricultural BMPs to reduce crop field erosion (e.g. no till). Discourage dredging through farmer workshop.	Headwaters to Roosevelt St. crossing
		Crops were grown in floodplain allowing only a small buffer width.	Plant adequate buffer/filter strips along streambanks.	Headwaters to Roosevelt St. crossing
		Residential lawn is mowed up to streambanks creating an insufficient buffer width.	Plant adequate buffer strip. Schedule riparian owner workshop incorporating landscaping for water quality.	Lawn and pasture are located on Roosevelt St. just west of Sand Creek
		Fenced cow pasture adjacent to insufficient stream buffer. Manure inputs suspected.	Relocate cow pasture an adequate distance from creek. Plant adequate buffer/filter strips along streambanks.	See above
		Project Manager witnessed ORV being taken into creek. After ORV became stuck on streambank, users struggled to force ORV into the creek for 15+ minutes tearing up streambank and contributing sediment to creek.	Riparian owner workshop on use of ORVs.	West streambank located on Roosevelt St. just west of Sand Creek near west streambank
		Gravel access road located next to creek may contribute sediment.	Put in porous pavement along access drive.	Access road located on Roosevelt St. just west of Sand Creek
Roosevelt St. crossing downstream to Cleveland St. crossing	None	Several eroded banks noted throughout stream section.	Consider streambank stabilization, wetland restoration, and adequate buffer/filter strips to address erosion and hydrology issues. Schedule farmer workshop.	43º 5’ 19.32” N 85º 52’ 6.24” W
				40 ft. downstream of 43º 5’ 14.28” N 85º 52’ 0.48” W
				43º 5’ 13.56” N 85º 52’ 0.84” W
		Large pile of logs, cement blocks, and aluminum siding are obstructing flow.	Remove obstruction.	43º 5’ 14.28” N 85º 52’ 0.48” W
		Metal debris found on west streambank.	Remove metal debris.	20 ft. downstream from 43º 5’ 5.28” N 85º 52’ 0.48” W
		Oil sheen noted. Oil most likely originated from 32nd Ave. or upstream.	Address management of road runoff with Ottawa County Road Commission.	43º 4’ 57.00” N 85º 51’ 56.87” W
		Stream buffer is not wide enough to filter agricultural runoff from adjacent corn fields. Where corn field is planted up to streambank, runoff is suspected of running directly to creek and contributing fertilizer.	Plant adequate buffer/filter strips along streambanks.	Within 150 ft. downstream of culvert located at 17206 32nd Ave.
		Drainage pipe, with a small steady flow, is contributing what looks like rust residue to the creek.	Consider replacing drainage pipe.	350 - 500 ft. downstream from culvert located at 17206 32nd Ave.
		Rill erosion, due to runoff from corn fields, is suspected of contributing sediment to creek. Insufficient stream buffer noted.	Place rip rap in path of agricultural runoff. Consider sufficient buffer/filter strips and wetland restoration to reduce the volume of storm water runoff.	
		Landowner installed rip rap, but did not succeed in preventing erosion of steep bank. Hay fields are adjacent to creek. Severe bend erosion noted. Crop fields adjacent to creek.	Consider streambank stabilization, wetland restoration, and adequate buffer/filter strips to address erosion and hydrology issues. Schedule farmer workshop.	43º 4’ 46.56” N 85º 51’ 58.31” W
		Rill erosion due to runoff from corn fields is contributing sediment to creek.	Place rip rap in path of agricultural runoff. Consider sufficient buffer/filter strips and wetland restoration to reduce the volume of storm water runoff.	500-850 ft. downstream of 43º 4’ 46.56” N 85º 51’ 58.31” W

Summary of Sand Creek Physical Inventory

Section	Sub-section	Description of Site	Recommendations	Location
Cleveland St. crossing downstream to Arthur St. crossing	None	Stream undercutting and eroded banks noted at several locations throughout the stream section.	Consider streambank stabilization, wetland restoration, and adequate buffer/filter strips to address erosion and hydrology issues. Schedule farmer workshop.	Throughout stream section
		Fenced horse pastures are within 10-15 ft. of creek, one of which allows horse access to creek. Manure noted 5 ft. from creek on horse trail skirting creek.	Relocate horse pastures and trail a sufficient distance from creek. Plant adequate buffer/filter strips. Completely fence 3rd horse pasture to prevent access to the creek.	Pasture is 600 - 900 ft. downstream of Cleveland St. crossing
		Water pump expelling water into water retention area covered in algae.	Address nutrient runoff from crop fields by planting an adequate buffer/filter strip around water retention area.	43º 4' 4.80" N 85º 51' 17.63" W
		Approx. 100 ft. long, 7 ft. high streambank is severely eroded with approx. 0º slope. Bank sediment can be found on streambed. Potential tree falls were evident.	Consider streambank stabilization, wetland restoration, and adequate buffer/filter strips to address erosion and hydrology issues. Schedule farmer workshop.	East streambank is approx. 1000 ft. downstream from 43º 4' 4.80" N 85º 51' 17.63" W
Garfield St. south to Hayes St. crossing	Garfield St. south to Ironwood Dr. crossing	Farmer takes tractor through creek at three locations. Streambank is severely degraded.	Construct bridges allowing tractor access to agricultural fields.	43º 2' 31.56" N 85º 49' 35.40" W
		Stretch of a steep streambank is eroding. Rip rap and silt fence placed by riparian owners downstream.	Consider streambank stabilization, wetland restoration, and adequate buffer/filter strips to address erosion and hydrology issues. Schedule farmer workshop.	Downstream of 43º 2' 31.56" N 85º 49' 35.40" W
		ORV track in forested area behind residential home may contribute sediment to the creek.	Riparian owner workshop on use of ORVs.	Track is most likely behind residential house located at 15145 16th Ave.
		Several residential lawns along 16th Ave. are mowed up to streambank resulting in a reduction of stream cover. To note, banks are not bare but vegetated with grass.	Plant adequate buffer strip. Schedule riparian owner workshop incorporating landscaping for water quality.	Residential lawns along 16th Ave. upstream from Ironwood Dr. crossing
		Tall, steep bank is eroded. Recent tree fall has contributed to streambank erosion.	Consider streambank stabilization, wetland restoration, and adequate buffer/filter strips to address erosion and hydrology issues. Schedule farmer workshop.	Streambank is near residencies along 16th Ave. upstream from Ironwood Dr. crossing
	Ironwood Dr. crossing downstream to State St. crossing	Approx. 300 ft. of streambank is mowed by riparian owner resulting in reduction of stream cover. To note, banks are not bare but vegetated with grass.	Plant adequate buffer strip. Schedule riparian owner workshop incorporating landscaping for water quality.	Lawn located on east streambank downstream of Ironwood Dr. and upstream of 43º 2' 14.28" N 85º 49' 46.56" W
		ORV tracks indicate that riparian owner takes ORV into the creek. Impacted streambank has deteriorated.	Riparian owner workshop on proper use of ORVs.	43º 2' 14.28" N 85º 49' 46.56" W
		Discharge from a large concrete drainage pipe has severely eroded streambank despite the concrete slabs placed in the path of discharge.	Work with Ottawa County Road Commission to place and fan out rock rip rap to reduce discharge velocity and erosion.	Approx. 400 ft. upstream from State St. crossing

Summary of Sand Creek Physical Inventory

Section	Sub-section	Description of Site	Recommendations	Location
Garfield St. south to Hayes St. crossing cont'd	State St. crossing downstream to Hayes St. crossing	Severe bank erosion (small area) due to runoff from parking lot. Trash is carried to creek via runoff.	Place and fan out rock rip rap in the path of flow to capture sediment and reduce surface flow velocity. Pick up parking lot trash regularly.	Parking lot is behind River City Benefit Designs located at 14637 16th Ave., Marne
		Trash receptacle located on gravel parking lot is overflowing contributing trash to creek. Birds were picking through trash frequently. Gravel from lot is suspected of washing into creek.	Empty trash receptacle regularly. Install porous pavement.	Gravel parking lot/ trash receptacle is across the street from the Interurban Depot Café located at 1580 Arch Street, Marne
		Approx. 250 ft. of streambank is mowed by riparian owner.	Plant adequate buffer strip. Schedule riparian owner workshop incorporating landscaping for water quality.	Streambank located near 16th Ave. and is upstream of the Berlin Fair Dr. crossing
		Riparian owner piles grass clippings 30 ft. from the creek contributing nutrients to the creek	Riparian owner workshop on proper yard waste disposal.	Yard waste located upstream of Berlin Fair Dr. crossing
		Large drainage pipe, carrying runoff from Berlin Fair Drive, discharges to forested area adjacent to creek. Discharge scours the forest floor and has eroded the streambank in two locations upstream of Hayes St.	Work with Ottawa County Road Commission to place and fan out rock rip rap to reduce discharge velocity and erosion.	Drainage pipe is located at Berlin Fair Dr. crossing, west of Berlin Fair Dr. and north of Sand Creek
Hayes St. crossing downstream to Johnson St. crossing	Hayes St. crossing downstream to 16th Ave. crossing	Approx. 150 ft. of streambank is mowed by riparian owner resulting in <25% stream cover. To note, banks are not bare but vegetated with grass.	Plant adequate buffer strip. Schedule riparian owner workshop incorporating landscaping for water quality.	Lawn is located on the west bank between Hayes St. and 16th Ave. crossings
		Oil sheen noted downstream of previous site. Most likely oil runoff originated from Hayes St. or upstream.	Address storm water management with Ottawa County Road Commission.	Oil most likely originated from Hayes St or northern roadway
		Storm water runoff, from uphill residential area, runs into the creek at two locations, one of which leads to a large algae pool. Potential fertilizer runoff from residential area is suspect.	Fertilizer management. Plant adequate buffer strips.	Residential lawns located north of creek between Hayes St .and 16th Ave. crossings
		Algae and numerous pieces of trash were found in creek and were being retained by a minor log pile. Trash was most likely from passersby on 16th Avenue and possibly from boat lot owned by Camp and Cruise.	Schedule stream cleanup.	Trash from 16th Avenue and boat lot owned by Camp and Cruise
	16th Ave. crossing downstream to Johnson St. crossing	Several tires were seen here. To note, tires were frequently seen throughout the entire main branch of the Sand Creek.	A stream cleanup to help remove trash, including the numerous tires found throughout the creek.	Downstream of 16th Ave. crossing behind boat lot. Lot owned by Camp and Cruise located at 1613 Hayes.
		Road runoff, directed by turnout off of Hayes St., has led to rill erosion through the adjacent forest. Runoff has eroded the streambank and contributed sediment to the creek. (Silt fencing, placed at turnout due to nearby construction of utility building was retaining a large amount of sediment.)	Widen and fan out rock rip rap to capture more sediment and reduce surface flow velocity. Implement soil erosion and sediment control (SESC) plans during future construction projects.	Turnout is located on south side of Hayes St. next to boat lot owned by Camp Cruise
		Camp and Cruise has an unpaved boat lot located on Hayes St. adjacent to stream buffer. Sediment inputs are suspected.	Put in porous pavement	Boat lot, owned by Camp and Cruise, is located on the south side of Hayes St.
		Fenced area containing pet farm animals (i.e. llama and sheep) was within 60 feet of the streambank. A large nearby structure indicates that additional animals are housed here. Manure runoff suspected.	Relocate fenced area a sufficient distance from creek. Plant adequate buffer strip. Implement manure management.	Property located on 16th Ave., south of 1400 16th Avenue and upstream of Johnson St. crossing

Summary of Sand Creek Physical Inventory

Section	Sub-section	Description of Site	Recommendations	Location
Hayes St. crossing downstream to Johnson St. crossing cont'd	16th Ave. crossing downstream to Johnson St. crossing cont'd	Runoff from 16th Ave. has eroded streambank at two separate locations.	Address storm water management with Ottawa County Road Commission.	Streambanks are located downstream of 1400 16th Avenue and upstream of Johnson St. crossing
		Approx. 100 ft. of streambank is mowed by riparian owner resulting in <50% stream cover.	Plant adequate buffer strip. Schedule a riparian owner workshop incorporating landscaping for water quality.	Residential lawn is located on 16th Avenue, south of 1400 16th Avenue and upstream of Johnson St. crossing
		Riparian owner, mentioned above, has used concrete slabs to stabilize streambank resulting in a failed attempt as bank is undercut.	Consider streambank stabilization, wetland restoration, and adequate buffer/filter strips to address erosion and hydrology issues.	
Johnson St. crossing downstream to Lincoln St. crossing	None	Three oil sheens were seen on exposed streambed through this stream section. Source of oil may have originated from Johnson St. or upstream.	Address storm water management with Ottawa County Road Commission.	Johnson St. or other northern roadway
		Probable manure inputs from a fenced 450 sq. ft. area housing at least 25 animals (i.e. deer, goats, swans, and cows). Watering pond is covered in Duckweed and overflows into creek at three locations. One of the locations is within 3 ft. of the creek.	Plant adequate buffer strip. Implement manure management.	Property is located at 0-13101 14th Ave.
		Failed concrete dam.	Remove failed dam.	Property is located at 0-13101 14th Ave.
		Riparian owner mows up to streambank.	Plant adequate buffer strip. Schedule riparian owner workshop incorporating landscaping for water quality.	Property is located at 0-13101 14th Ave.
		Cow pasture adjacent to creek. Manure runoff suspected. To note, creek does have a narrow buffer strip.	Plant sufficient buffer/filter strip. If not implemented already, consider manure management.	Pasture is adjacent to residency located at 0-13101 14th Ave.
		Residential lawn is mowed to streambank. To note, resident has placed shed directly on streambank 10-15 ft. from water's edge.	Plant adequate buffer strip. Schedule riparian owner workshop incorporating landscaping for water quality.	Property is located at or by 1519 Lincoln St.
		Flow from drain pipe on residential lot has cut a 2-3 foot wide rill and eroded bank.	Place and fan out more rock rip rap to capture more sediment and reduce surface flow velocity.	
		Drainage pipe from the nearby paved lot carries trash into creek and has eroded the streambank.	Place and fan out more rock rip rap to capture more sediment and reduce surface flow velocity. Plant adequate buffer strip.	Drainage pipe located near the parking lot owned by Bolthouse Brothers Growers on Bolthouse Dr. PVT.
Lincoln St. crossing downstream to Leonard St. crossing	None	Approx. a 5" by 3.5" sediment pile near west bank. Suspect storm water runoff from Lincoln St. road ditch of streambank erosion.	Work with Ottawa County Road Commission to place and fan out rock rip rap to reduce discharge velocity and erosion.	Just downstream of Lincoln St. crossing
		Riparian owner mows up to streambank.	Plant adequate buffer strip. Schedule riparian owner workshop incorporating landscaping for water quality.	Property located at 0-1608 Lincoln St.
		Flow from drainage pipe on residential lot has eroded bank.	Place and fan out more rock rip rap to capture more sediment and reduce surface flow velocity.	

Summary of Sand Creek Physical Inventory

Section	Sub-section	Description of Site	Recommendations	Location
Lincoln St. crossing downstream to Leonard St. crossing cont'd	None	Riparian owner disposes of yard waste on a 10" x 13" area directly on streambank contributing nutrients to creek. (Owner has placed shed <10 ft. from water's edge.)	Riparian owner workshop on proper yard waste disposal.	Property located at 0-1608 Lincoln St.
		Approx. 50 ft. of streambank is mowed by riparian owner resulting in <50% stream cover. To note, banks are not bare but vegetated with grass.	Plant adequate buffer strip. Schedule riparian owner workshop incorporating landscaping for water quality.	Brick house just west of 0-1608 Lincoln St.
		Approx. 3" x 2" area of streambank is eroded due to boat launches by riparian owner.	Put in porous pavement.	
		Riparian owner disposes of yard waste on a 10 - 15 ft. stretch of streambank contributing nutrients to creek.	Riparian owner workshop on proper yard waste disposal.	
		Approx. 1/2 ft. diameter drainage pipe has eroded hill set back > 50 ft. west of streambank.	Place and fan out more rock rip rap to capture more sediment and reduce surface flow velocity.	Pipe located in field between creek and 1774 18th Ave PVT.
		Ground cover from a residential yard has spread over a 100" x 30" area of streambank prohibiting tree growth.	Pull ground cover by hand as soon as possible and monitor for future growth.	Residential yard is located at 0-1821 Leonard St.
		Riparian owner mows up to streambank resulting in <25% stream cover.	Plant adequate buffer strip. Schedule riparian owner workshop incorporating landscaping for water quality.	Lawn located just downstream of Sunset Creek and upstream of Leonard St. crossing
Leonard St. crossing to M45 crossing	Leonard St. crossing to west intermittent stream	Sediment pile, approx. 15" x 2.5", is next to streambank adjacent to wet area. Rill erosion downstream with associated sediment piles. Road and agricultural runoff suspect.	Encourage agricultural BMPs to reduce erosion. Plant adequate buffer strips. Work with the Ottawa County Road Commission to address road runoff if necessary.	East streambank located 35 ft. downstream of Leonard St. crossing
		Failed Dam (Root Dam) allows for only a 2 ft. wide passage for flow.	Remove failed dam.	Downstream of Leonard St. crossing
		Approx. 3 ft. diameter drainage pipe on west streambank is 1/4 full of sediment and tree branches.	Work with the Ottawa County Road Commission to address storm water and sediment runoff from Leonard St.	15 ft. downstream of failed dam south of Leonard St.
		Riparian owners mow up to streambank. To note, banks are not bare but vegetated with grass.	Plant adequate buffer strip. Neighboring resident could improve riparian buffer also. Schedule riparian owner workshop incorporating landscaping for water quality.	Gray and white houses on west drive off of Leonard St.
		Oil sheen noted on exposed streambed by wet area south of Leonard St. crossing. Runoff from Leonard St. or northern roadway suspected.	Work with the Ottawa County Road Commission to address road runoff from Leonard St.	Leonard St. crossing or northern roadway
		Drainage pipe runs under residential driveway and drains surface runoff from residential area into nearby 50 ft. gully. Some erosion control measures have been taken but could be improved upon.	Place and fan out more rock rip rap to capture more sediment and reduce surface flow velocity.	42º 59' 21.83" N 85º 50' 3.84" W

Summary of Sand Creek Physical Inventory

Section	Sub-section	Description of Site	Recommendations	Location
Leonard St. crossing to M45 crossing cont'd	Aman Park (Sand Creek Bridge to M45 crossing)	Several streambank erosion sites evident along creek. One particular bank, eroded due to public access, has led to visible sedimentation. Sediment has been retained by a tree fall.	Consider streambank stabilization, wetland restoration, and adequate buffer/filter strips to address erosion and hydrology issues.	Aman Park
		Discharge from 1 ft. diameter drainage pipe is eroding bank.	Work with Ottawa County Road Commission to place and fan out rock rip rap to reduce discharge velocity and erosion.	Aman Park
		Discharge from 1.5 ft. diameter drainage pipe is eroding streambank 6 ft. from the water's edge.	Work with Ottawa County Road Commission to place and fan out rock rip rap to reduce discharge velocity and erosion.	Aman Park
		Streambank 25 ft. high with very little vegetation is impacted from road runoff from M45. Trash debris by M45 brought to streambank via storm water runoff.	Consider working with MDOT to address storm water runoff from M45. Vegetate bare area on bank.	Aman Park
		Noted invasive species in Aman Park: Garlic Mustard and Autumn Olive.	Eradicate invasive species to prevent elimination of native species	Aman Park
		In general, harmful changes in stream's flow regime have eroded streambank.	Address hydrology issues to prevent streambank erosion (e.g. wetland restoration).	Aman Park
		In general, foot traffic and public access have led to sedimentation and erosion contributing sediment to the creek.	Address public access issue by baring inappropriate access and defining trails (e.g. boardwalk, etc.) to reduce sedimentation and erosion.	Aman Park
	Aman Park (unofficial trail)	"Unofficial trail", close to the edge of the stream, has led to numerous public access points causing streambank erosion. Trail on steep slopes has led to greater erosion.	Consider building boardwalk or paving "unofficial trail" to allow access but reduce sediment inputs to the creek via foot traffic. Create boardwalk "outlook" areas along trail to reduce current streambank erosion.	Aman Park
		Rill erosion noted on steep trail leading to the Aman Park Bridge. Steep trail contributes sediment to creek.	Consider placing steps on steep hill for foot traffic and consider additional soil control measures.	Aman Park
		Rill erosion noted on steep bank opposite the "unofficial trail".	Consider vegetating bare area on bank. Address public access issue by baring access to steep hill.	Aman Park
M45 crossing downstream to Country Trail Court	M45 crossing to east intermittent stream	Riparian owner mows approx. 100 ft. of streambank resulting in <25% stream cover.	Plant adequate buffer strip. Schedule riparian owner workshop incorporating landscaping for water quality.	First house downstream of M45
		Eroded, steep bank most likely affected by runoff from M45 and topography.	Work with MDOT to address storm water runoff from M45.	Downstream of M45
		Public access trail from riparian owner's land leads down to the creek and traverses a steep hill leading to erosion problems.	Recommend placing steps on steep hill to prevent erosion.	Residence (brown house) is located downstream of M45 west of streambank
		Public access has eroded bank despite the placement of concrete slabs for steps. Access trail begins at paved residential road.	Establish stairway to access creek to reduce erosion of streambank.	Downstream of residence noted above
		ORV tracks indicate that landowner takes ORV into creek. Sand bags were placed at suspected entrance point. Impacted streambank has deteriorated.	Riparian owner workshop on recommended use of ORVs	Downstream of residence noted above
		Approx. 75 ft. stretch of west streambank is periodically mowed resulting in nearly 0% cover on west bank. Currently, grasses and forbs are established.	Allow shrubs and trees to establish allowing for greater stream cover.	West bank is between M45 and downstream east intermittent stream

Summary of Sand Creek Physical Inventory

Section	Sub-section	Description of Site	Recommendations	Location
M45 crossing downstream to Country Trail Court cont'd	East intermittent stream to Country Trail Court	Stream buffer on west streambank is only 5 ft. wide. To note, a bridge has been created to allow vehicles to pass over the creek.	Widen buffer by allowing vegetation to extended into mowed lawn.	Residency is located at the east end of Winants St. NW
		Three children seen swimming in the creek.	Assess whether this location meets the designated use of total body contact.	South of Little Sand Creek near west fallow field
		Less than 25% stream cover due to lack of sufficient cover. Currently, grasses and forbs are established.	Allow shrubs and trees to establish allowing for greater stream cover.	Fallow field can be found on west side of the creek west of Little Sand Creek
		Overflow from constructed residential pond runs through a rock lined channel and has eroded the streambank and most likely contributes fertilizer runoff to the creek. To note, owner has placed rock rip rap around the most of the pond's perimeter to prevent erosion.	Add and fan out rock rip rap at the end of the rock lined channel to capture more sediment and reduce surface flow velocity to protect streambank. Plant vegetation around the pond.	Property located near southern end of fallow field located on the west side of the creek south of Little Sand Creek
		ORV track around the pond and near the creek may contribute small amounts of sediment during storm events. Doesn't appear that owner takes ORV into the creek, but it is a possibility.	Riparian owner workshop on recommended use of ORVs.	
		Riparian owner mows up to streambank.	Plant adequate buffer strip. Schedule riparian owner workshop incorporating landscaping for water quality.	Gray colored house located on a private drive off of Lover's Lane NW
		Riparian owner mows up to streambank.	Plant adequate buffer strip. Schedule riparian owner workshop incorporating landscaping for water quality.	Tan colored house located on a private drive off of Lover's Lane NW
		Riparian owner has a sloped, paved drive most likely for the purpose of bringing lawnmower from the uphill garage to the downhill lawn. Runoff from the slopped paved track, and nearby drainage pipe, have eroded the streambank.	Place and fan out rock rip rap in the path of flow capture sediment and reduce surface flow velocity.	
		Discharge from residential drainage tubing with 3 inch diameter is eroding streambank.	Place and fan out rock rip rap to capture sediment and reduce surface flow velocity or extend tubing into creek.	South of Little Sand Creek and north of 42º 57' 37.44" N 85º 50' 31.20" W
		Gully erosion on a 40 ft. high, 8 ft. wide, 5 ft. deep area.	Revegetate eroded area. Address storm water runoff.	South of Little Sand Creek and north of 42º 57' 37.44" N 85º 50' 31.20" W
		Discharge from 2 drain pipes has eroded a 20-25 ft. long 3.5 ft. deep area on streambank. Concrete slabs are not preventing erosion. Drainage pipes are located near a maintained lawn.	Work with Ottawa County Road Commission to place and fan out rock rip rap to reduce discharge velocity and erosion. Plant adequate buffer strips.	42º 57' 37.44" N 85º 50' 31.20" W
		ORV track skirts streambank resulting in little to no vegetation.	Riparian owner workshop on proper use of ORVs. Plant adequate buffer strip.	Near open, grassed field on west side of the creek downstream of 42º 57' 37.44" N 85º 50' 31.20" W
		Landowner has a sloped, paved drive to bring lawnmower from the uphill garage to the downhill lawn. Drainage pipe adds additional runoff to track. Discharge from a second drain pipe along with drive runoff is eroding the streambank.	Place and fan out rock rip rap in the path of flow to capture sediment and reduce surface flow velocity. Extend first drain pipe into the creek to prevent adding additional flow to sloped, paved drive.	42º 59' 21.83" N 85º 50' 3.84" W

APPENDIX D HYDROLOGIC MODEL OF THE SAND CREEK WATERSHED

A Hydrologic Study of the
Sand Creek Watershed

Dave Fongers
Hydrologic Studies Unit
Geological and Land Management Division
Michigan Department of Environmental Quality

July 17, 2003

DEQ
Michigan's
Nonpoint Source
Program

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For comments or questions relating to this document, contact Dave Fongers at:

517-373-0210
fongersd@michigan.gov
MDEQ, GLMD, P.O. Box 30458, Lansing, MI 48909

DEQ Michigan's Nonpoint Source Program

Summary

A hydrologic model of the Sand Creek watershed was developed by the Hydrologic Studies Unit (HSU) of the Michigan Department of Environmental Quality (MDEQ) using the Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS). The hydrologic model was developed to help determine the effect of land use changes in the watershed on Sand Creek's flow regime and to provide design flows for streambank stabilization Best Management Practices (BMPs). The Sand Creek Watershed Committee may combine this information with other determinants, such as open space preservation, to decide what locations are the most appropriate for wetland restoration, stormwater detention, in-stream BMPs, or upland BMPs. The communities within the watershed could also use the information to help develop stormwater ordinances.

The hydrologic model does not attempt to simulate the effect of the dam that was located below Leonard from approximately 1860 until May 21, 1989. A memo discussing the possible effects of the dam failure is included as Appendix B.

The hydrologic model has four scenarios corresponding to 1800, 1978, 1998, and build-out land use. The build-out scenario is based on zoning maps provided by the local units of government. Because the zoning maps do not show any wetland areas, this scenario is further subdivided to model the effect of retaining or eliminating the wetland storage. General land use changes are shown in Figure 1, which shows that urban land uses are projected to continue to increase, with a net loss of natural areas. More specific information is provided in Table 1.

Because of these land use trends, the model predicts increases in runoff volumes and peak flows from 1800 to 1978/1998 and from 1978/1998 to build-out for all three design storms analyzed, as shown in Figures 2 through 7. The model predicts nearly identical flows for the 1978 to 1998 land use scenarios. The 1978 scenario has therefore been omitted from Figures 2 through 7 for clarity. Flow details for the land use scenarios are listed in Tables 2 through 7.

The projected runoff volume and peak flow increases from the 10 and 4 percent chance (10-year and 25-year), 24-hour storms, Figures 4 through 7, would aggravate the flooding problems that are reported throughout the watershed, unless mitigated through the use of effective stormwater management techniques.

The projected increases from the 50 percent chance (2-year), 24-hour storm, Figures 2 and 3, will increase channel-forming flows. The channel-forming flow in a stable stream usually has a one- to two-year recurrence interval. These relatively modest storm flows, because of their higher frequency, have more effect on channel form than extreme flood flows. Hydrologic changes that increase this flow can cause the stream to become unstable. Stream instability is indicated by excessive erosion at many locations throughout a stream reach. The projected increase in volume and peak flow would therefore further increase streambank erosion that is already reported to be excessive in Sand Creek below Leonard Street. Stormwater management techniques used to mitigate flooding can also help mitigate projected channel-forming flow increases. However, channel-forming flow criteria should be specifically considered in the

stormwater management plan so that the selected BMPs will be most effective. For example, detention ponds designed to control runoff from the 4 percent chance, 24-hour storm often do little to control the runoff from the 50 percent chance, 24-hour storm unless the outlet is specifically designed to do so.

The Sand Creek watershed is in Kent and Ottawa Counties. The model stormwater ordinance adopted by Kent County is currently being considered by Ottawa County. The Kent County model stormwater ordinance calls for a maximum release rate of 0.05 cubic feet per second per acre (cfs/acre) for runoff from the 50 percent chance, 24-hour storm for Zone A areas, the most environmentally sensitive of the three zones. Currently, the average yield from this storm for the Sand creek watershed is 0.02 cfs per acre, well below the 0.05 standard, with no subbasins higher than 0.05 cfs/acre. The yield from five of the fifteen subbasins may exceed 0.05 cfs/acre with continued development. The ordinance also calls for a maximum release rate of 0.13 cfs/acre for runoff from the 4 percent chance, 24-hour storm for Zones A and B. Currently, the average yield from this storm for the Sand Creek watershed is 0.10 cfs per acre, with three subbasins higher than 0.13 cfs/acre. The yield from eleven of the fifteen subbasins may exceed 0.13 cfs/acre with continued development. Additional details are shown in Figures 8 and 9 and listed in Table 8. The developers of the Sand Creek watershed plan may want to consider whether the proposed standards will adequately protect Sand Creek and its tributaries.

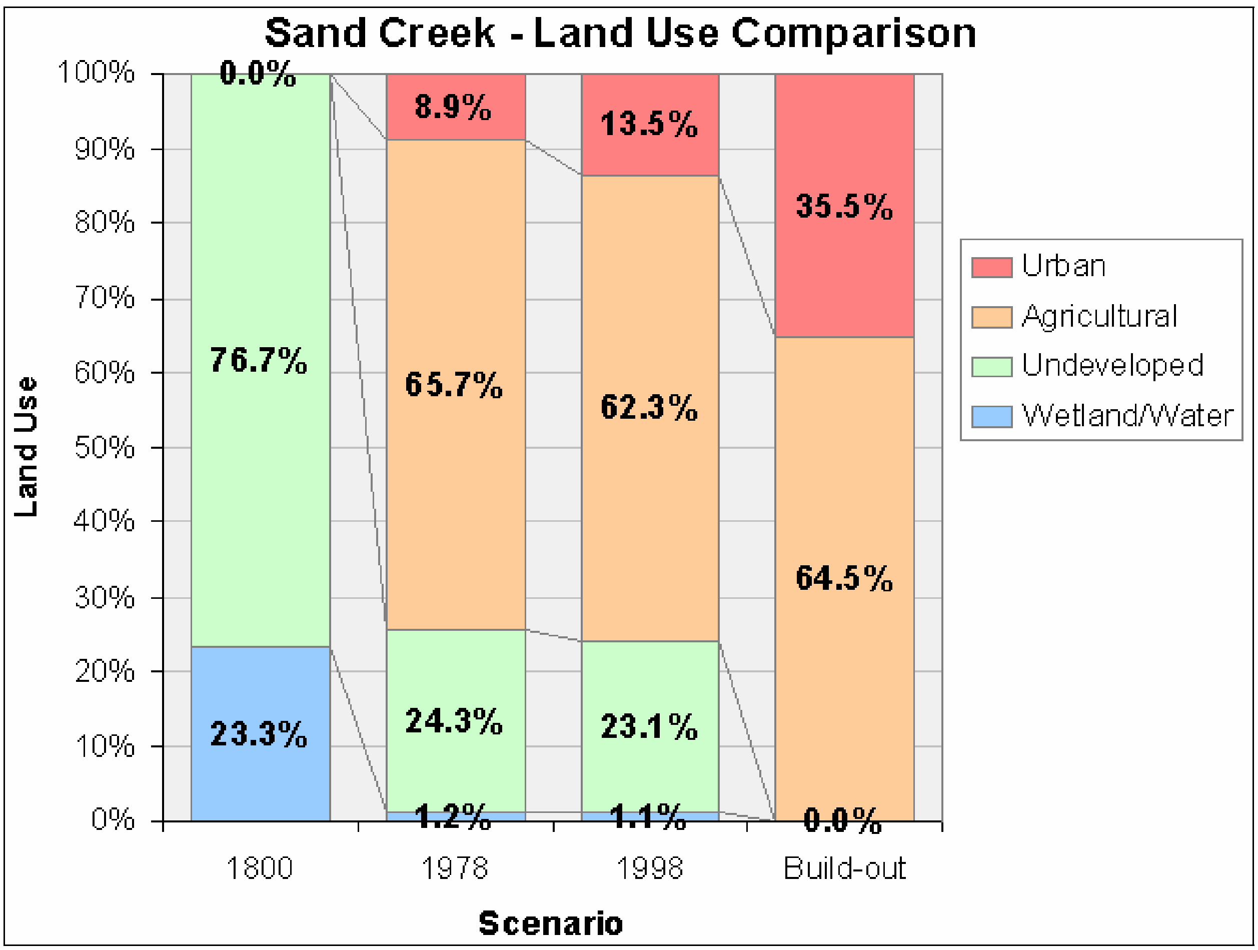

Figure 1: Land Use Comparison

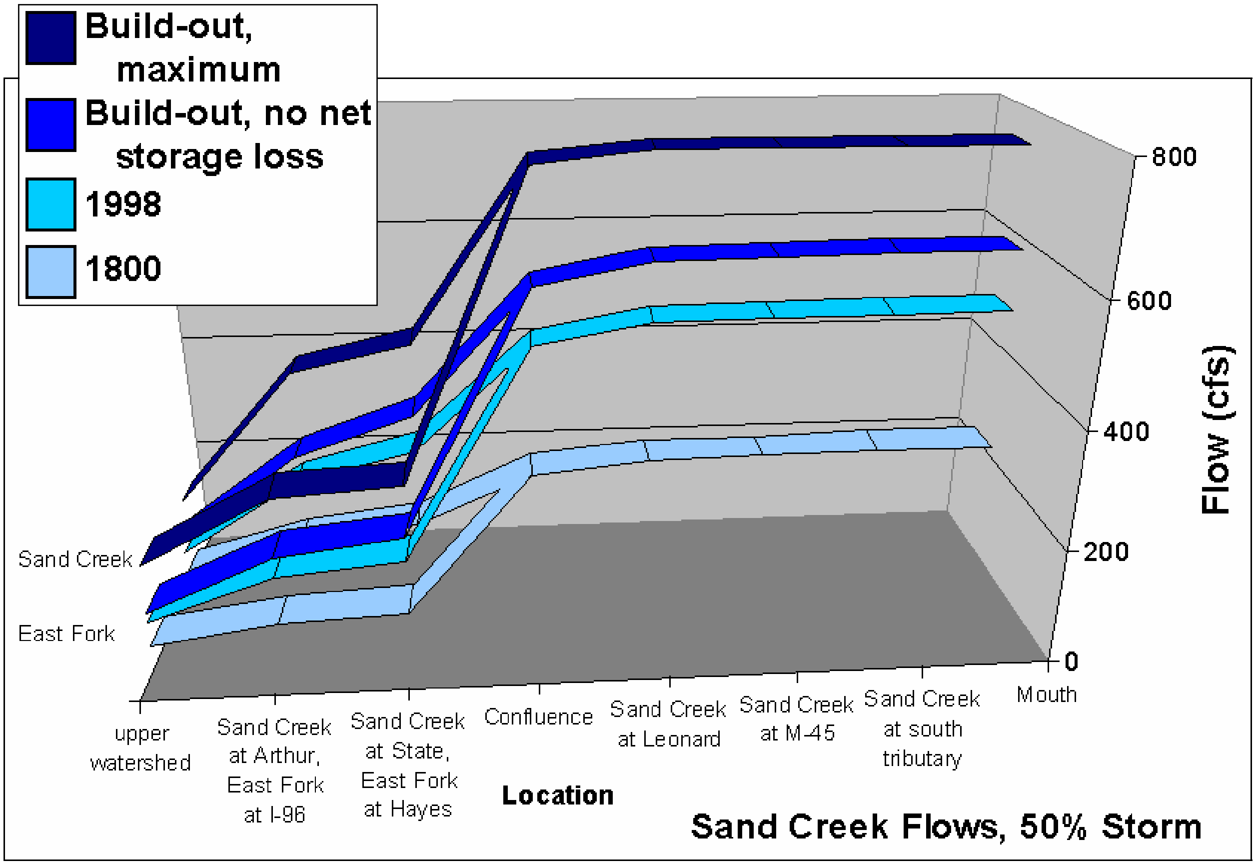

Figure 2: Predicted peak flows from 50 percent chance, 24-hour storm

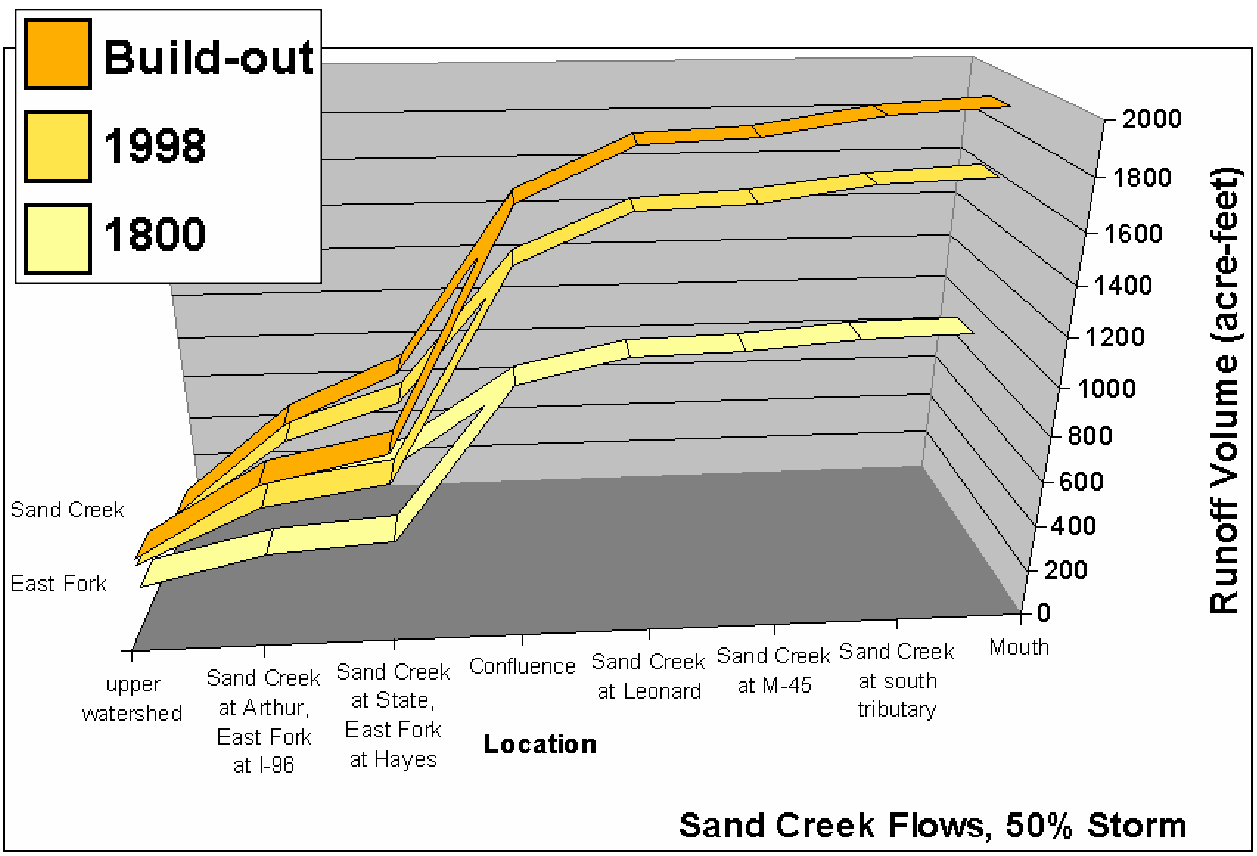

Figure 3: Predicted runoff volumes from 50 percent chance, 24-hour storm

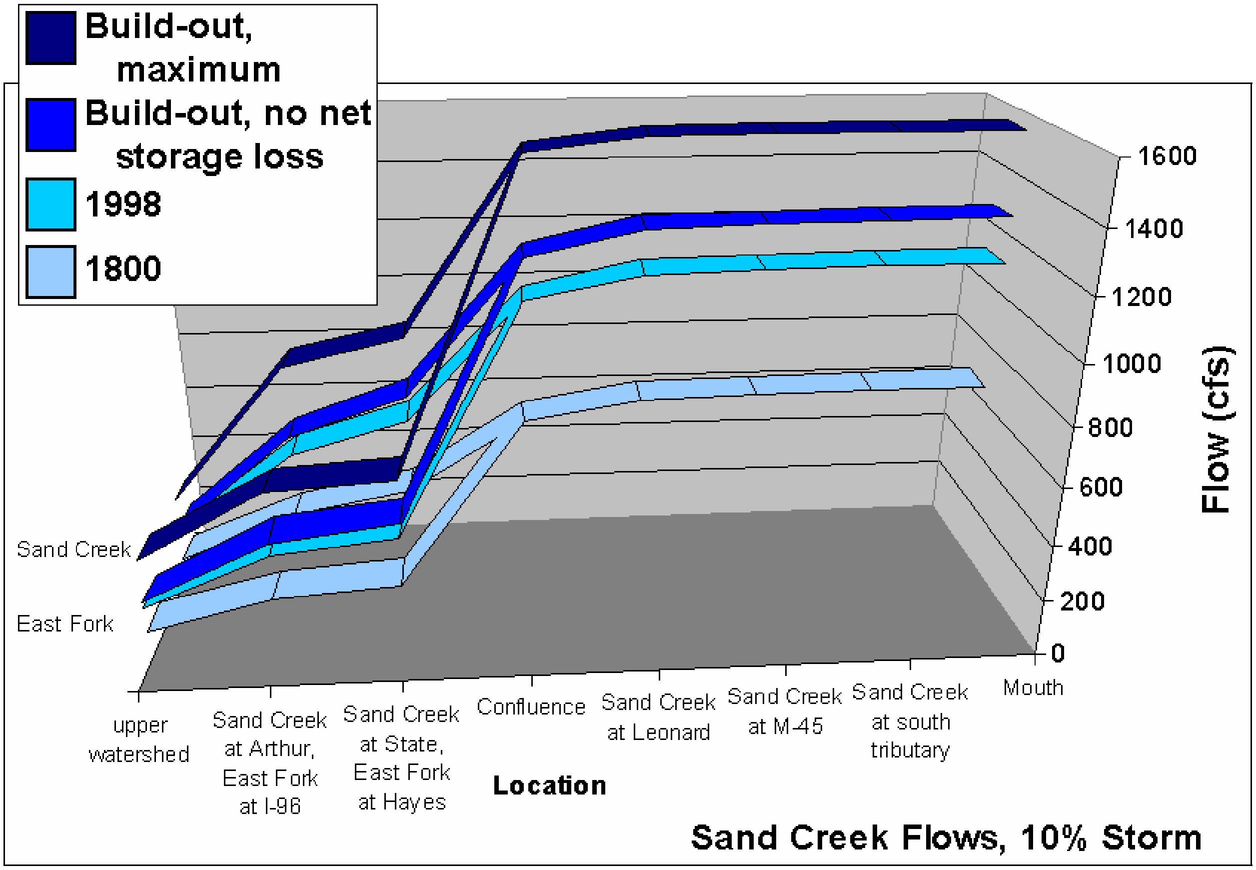

Figure 4: Predicted peak flows from 10 percent chance, 24-hour storm

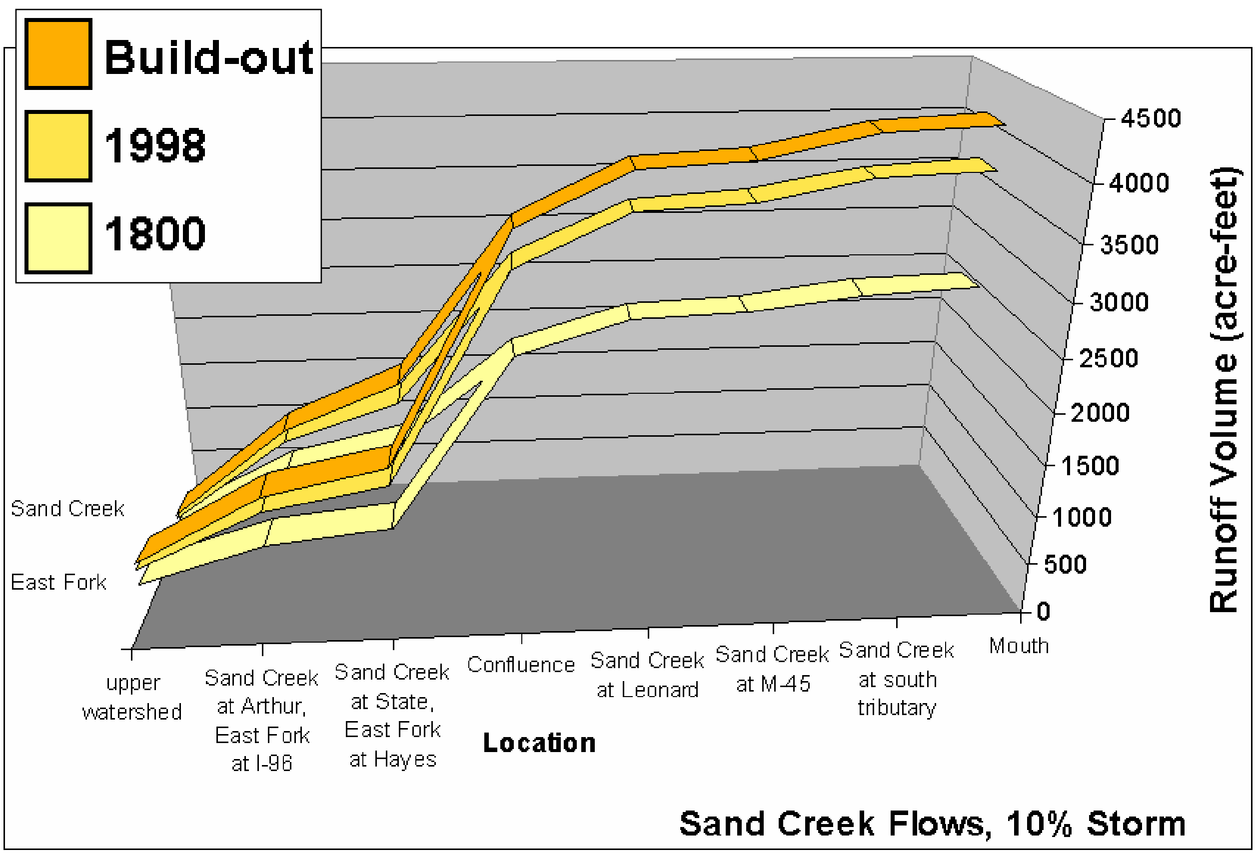

Figure 5: Predicted runoff volumes from 10 percent chance, 24-hour storm

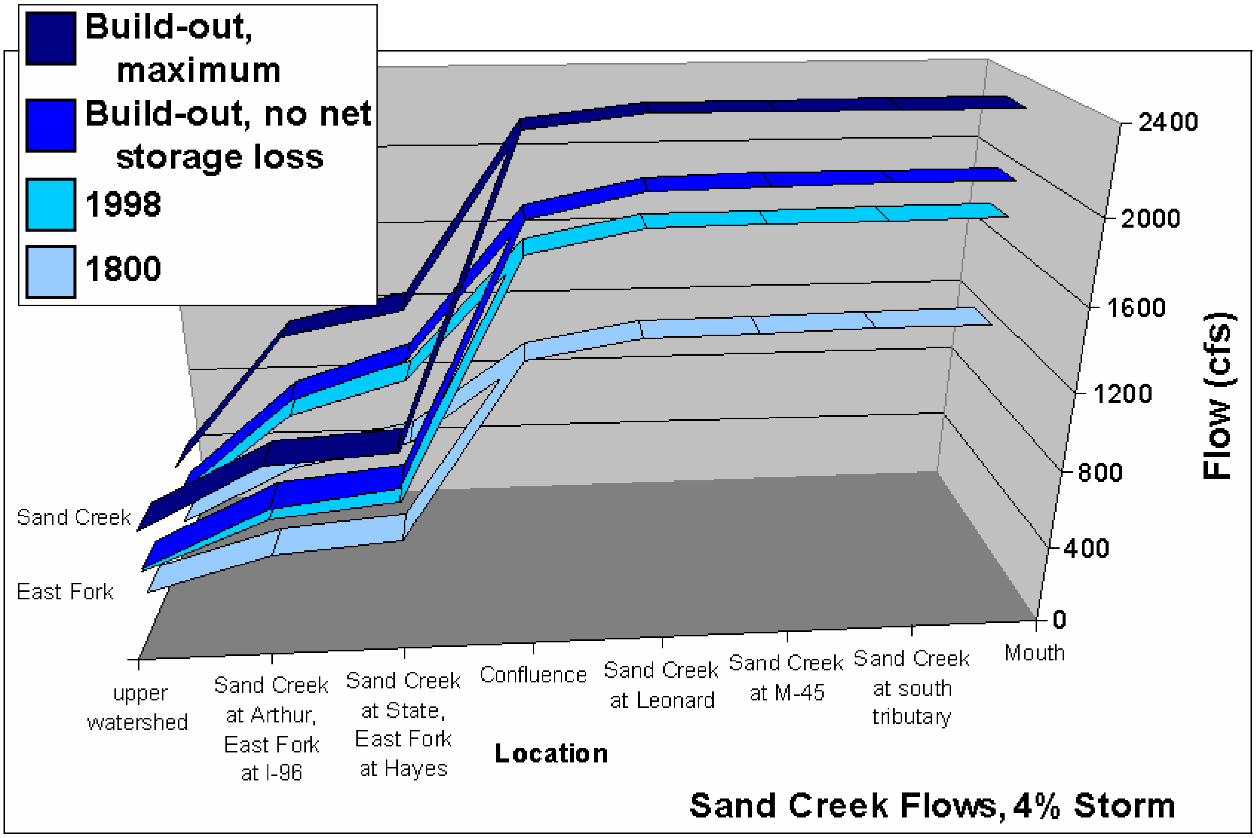

Figure 6: Predicted peak flows from 4 percent chance, 24-hour storm

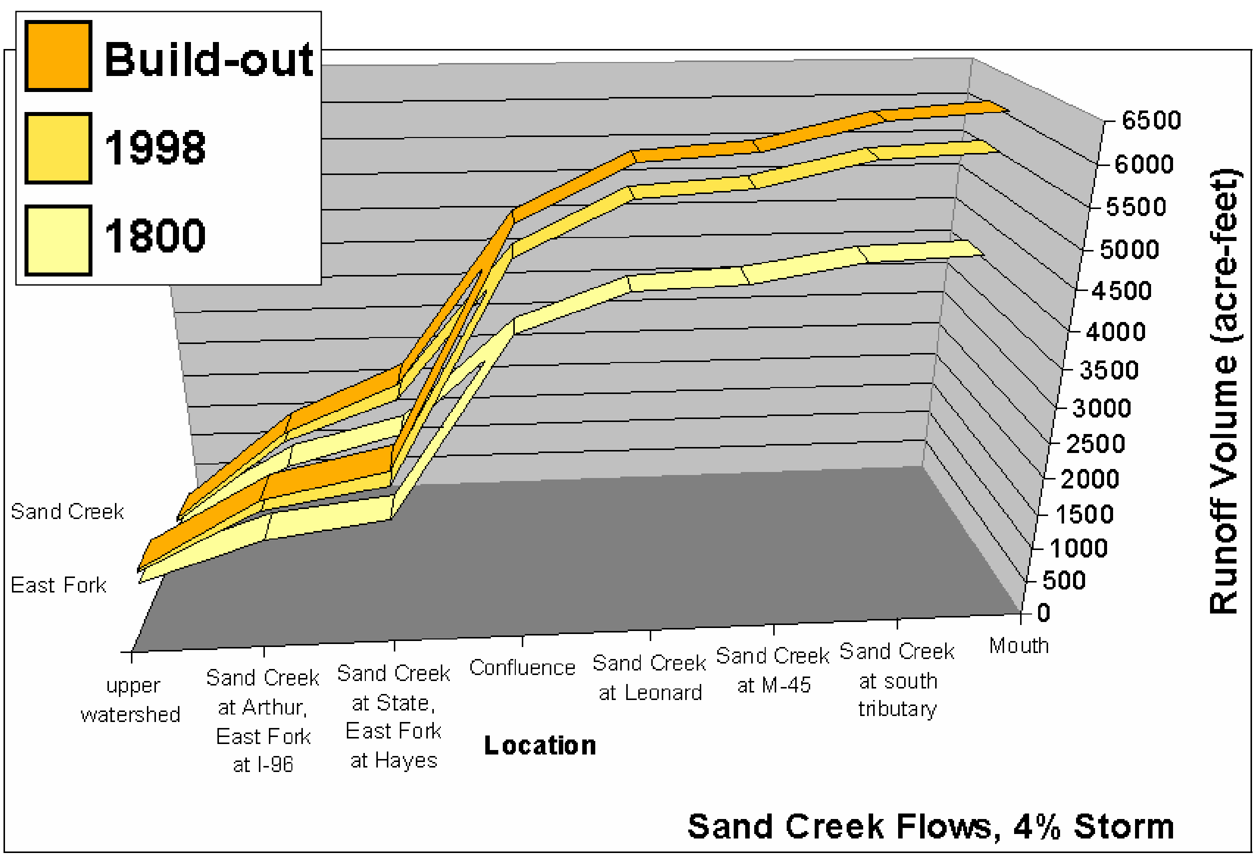

Figure 7: Predicted runoff volumes from 4 percent chance, 24-hour storm

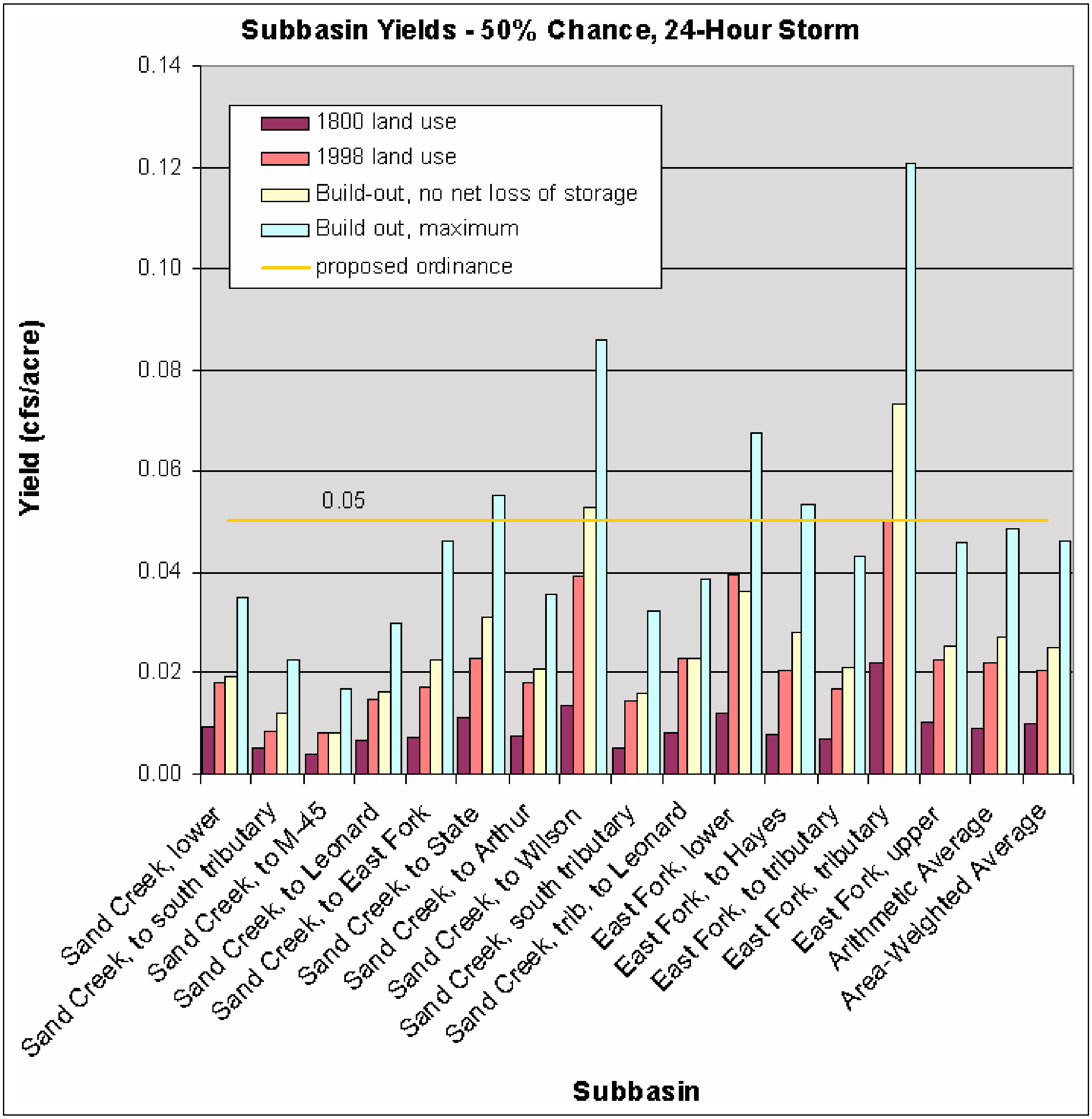

Figure 8: Subbasin Yields, 50 percent chance, 24-hour storm

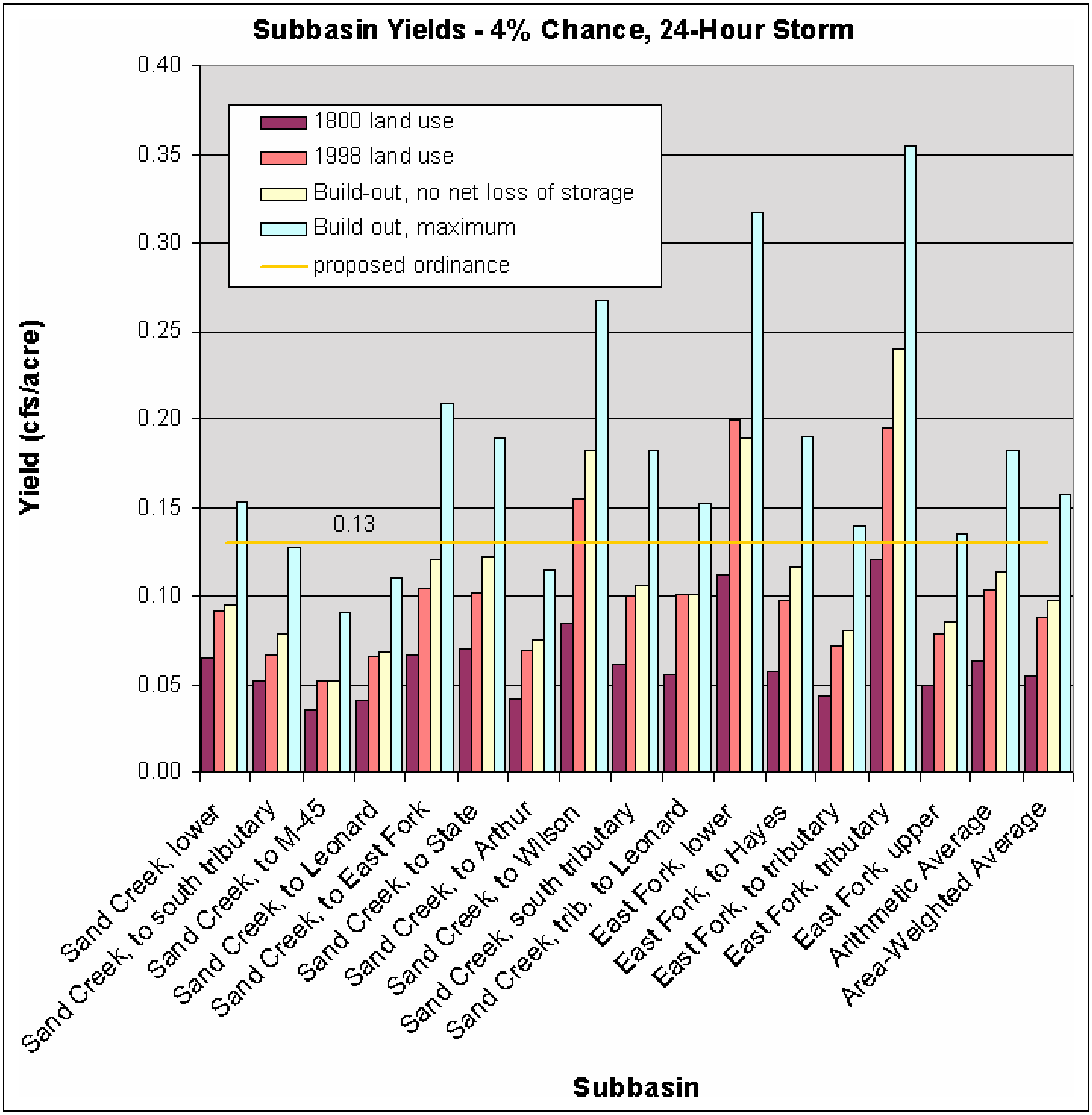

Figure 9: Subbasin Yields, 4 percent chance, 24-hour storm

Project Goals

The Sand Creek hydrologic study was initiated in support of a Lower Grand watershed project, which is funded in part by a United States Environmental Protection Agency (USEPA) Part 319 grant administered by the MDEQ. The goals of this study are:

- To better understand the watershed's hydrology and the impact of hydrologic changes, especially land use changes, in the Sand Creek watershed.
- To facilitate the selection and design of suitable BMPs.
- To provide information that can be used by local units of government to develop or improve stormwater ordinances.

Watershed Description and Model Parameters

The 54.8 square mile Sand Creek watershed, Figure 10, is located in Ottawa and Kent Counties. Sand Creek outlets to the Grand River in Ottawa County. The study divides the watershed into fifteen subbasins, as shown in Figure 11.

Our analysis of the watershed uses the curve number technique to calculate surface runoff volumes and peak flows. This technique, developed by the Natural Resources Conservation Service (NRCS) in 1954, represents the runoff characteristics from the combination of land use and soil data as a runoff curve number. The curve numbers for each subbasin, listed in Appendix A, were calculated from digital soil and land use data using Geographic Information Systems (GIS) technology.

Runoff curve numbers were calculated from the land use and soil data shown in Figures 12 through 16. Land use maps based on the MDEQ GIS data for 1800 and 1978 are shown in Figures 12 and 13, respectively. The 1800 land use information is provided at the request of the Sand Creek watershed committee. The MDEQ Nonpoint Source program does not expect or recommend that the flow regime calculated from 1800 land use be used as criteria for BMP design or as a goal for watershed managers. The 1998 land use map, Figure 14, is based on HSU's analysis of 1998 aerial photos and field verification. The build-out analysis, Figure 15, assumes land use is developed to the maximum allowed under zoning regulations. Zoning information was compiled by HSU from information provided by Ottawa County, the City of Walker, and Chester, Tallmadge, and Wright Townships. Because the zoning maps do not show any wetland areas, the Build-Out scenario is further subdivided to model the effect of retaining or eliminating the wetland storage. In the *Build-Out, No Net Loss of Storage* scenario, the 1998 storage coefficients were retained for the build-out condition. For the *Build-Out, Maximum* scenario, the storage coefficients were set equal to the times of concentration.

Land use information by subbasin is also detailed in Table 1. The Natural Resources Conservation Service (NRCS) soils data for the watershed is shown in Figure 16. Where the soil is given a dual classification, B/D for example, the soil type was selected based on land use. In these cases, the soil type is specified as D for natural land uses or the alternate classification (A, B, or C) for developed land uses. The runoff curve numbers calculated from the soil and land use data are listed in Appendix A.

The time of concentration for each subbasin, which is the time it takes for water to travel from the hydraulically most distant point in the watershed to the design point, was calculated from the United States Geological Survey (USGS) quadrangles. The storage coefficients, which represent storage in the subbasin, were iteratively adjusted to provide a peak flow reduction equal to the ponding adjustment factors described further in Appendix A. The two build-out scenarios differ only in their storage coefficients. In the *Build-Out, No Net Loss of Storage* scenario, the 1998 storage coefficients were used for the build-out condition to simulate the effect of retaining all of the wetlands. For the *Build-Out, Maximum* scenario, the storage coefficients were set equal to the corresponding time of concentration, which models the effect of eliminating all of the wetland storage. Lag for each reach, which is the travel time of water within each section of the river, is also calculated from the USGS quadrangles. These values are listed in Appendix A.

The selected precipitation events were the 50, 10, and 4 percent chance (2-, 10-, and 25-year), 24-hour storms. Design rainfall values for these events are tabulated in *Rainfall Frequency Atlas of the Midwest*, Bulletin 71, Midwestern Climate Center, 1992, pp. 126-129, and summarized for this site in Appendix A. These values have been multiplied by 0.946 to account for the size of the watershed.

These parameters were then incorporated into a HEC-HMS model to compute runoff volume and flow. Some refinements to the model are possible based on calibration data from flow monitors currently installed at four locations in the watershed.

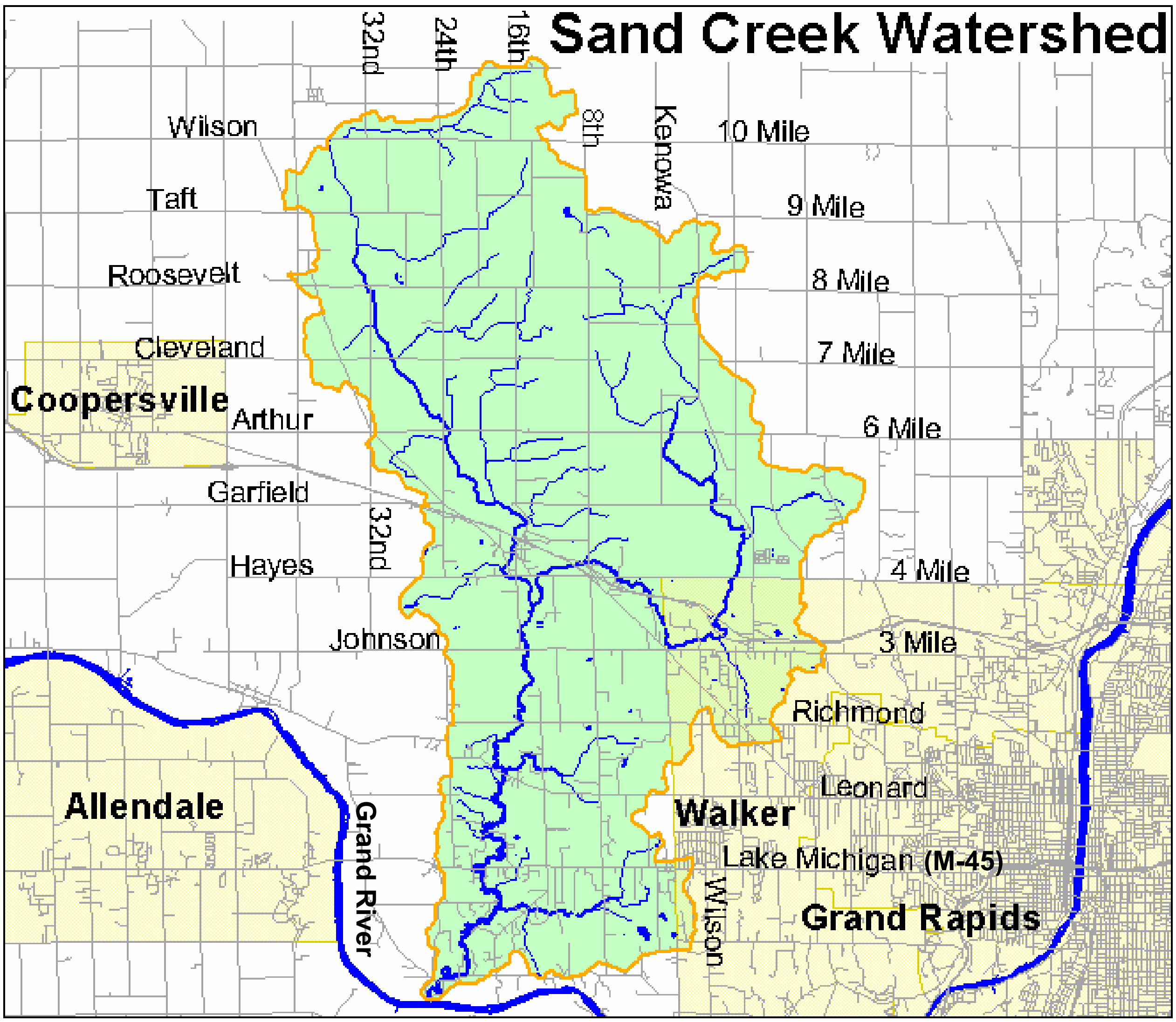

Figure 10: Delineated Sand Creek Watershed

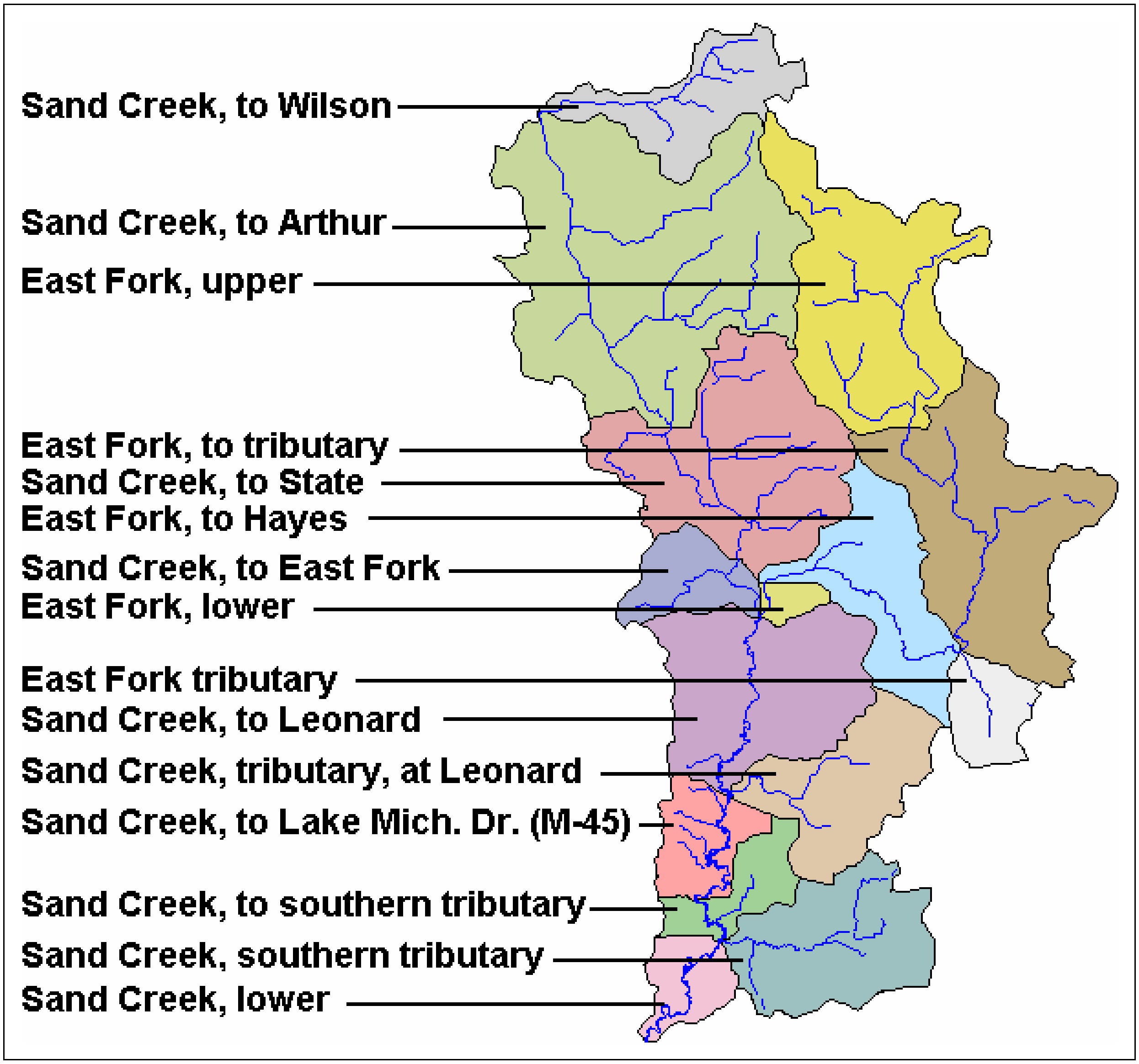

Figure 11: Subbasin Identification

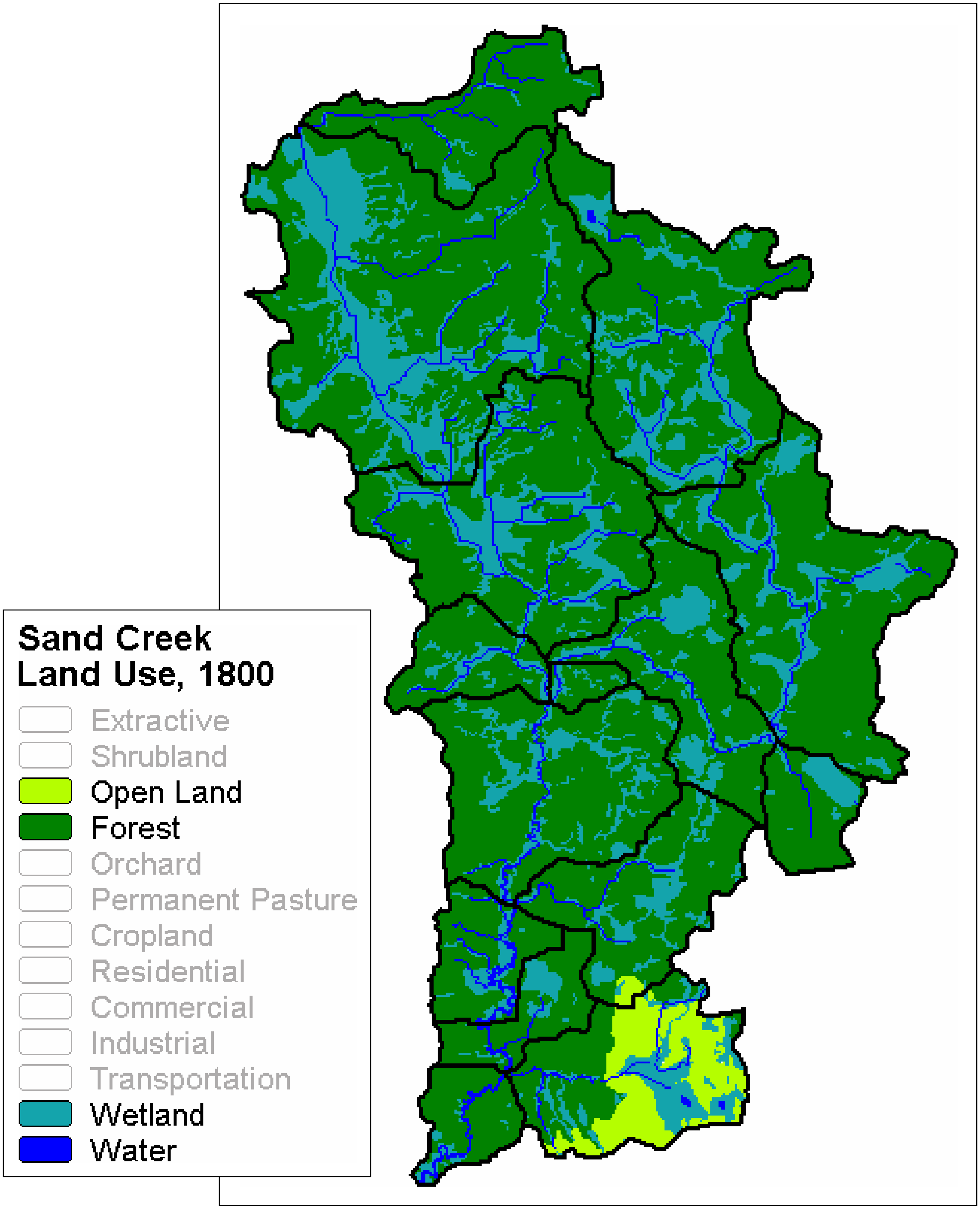

Figure 12: 1800 Land Use Data

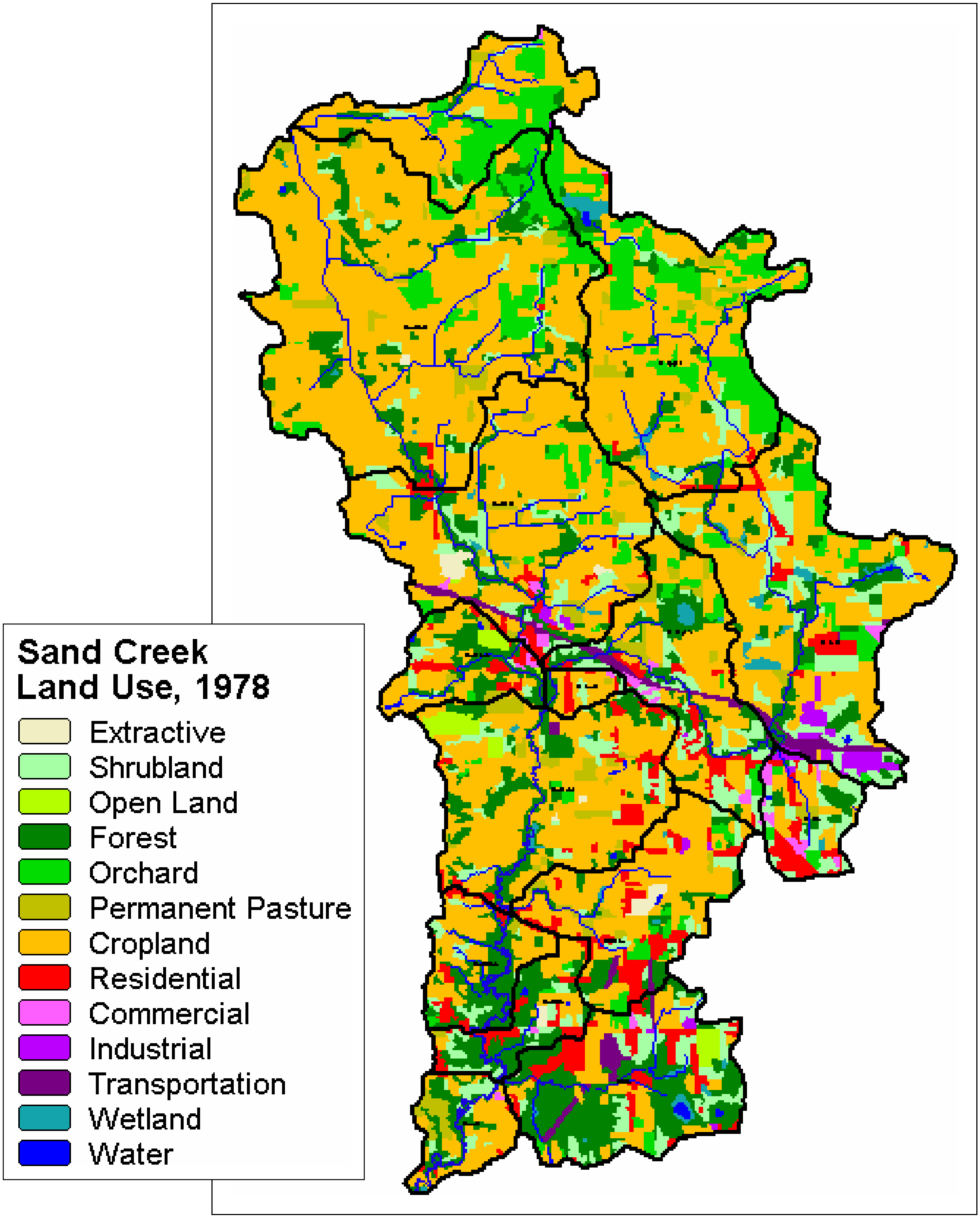

Figure 13: 1978 Land Use Data

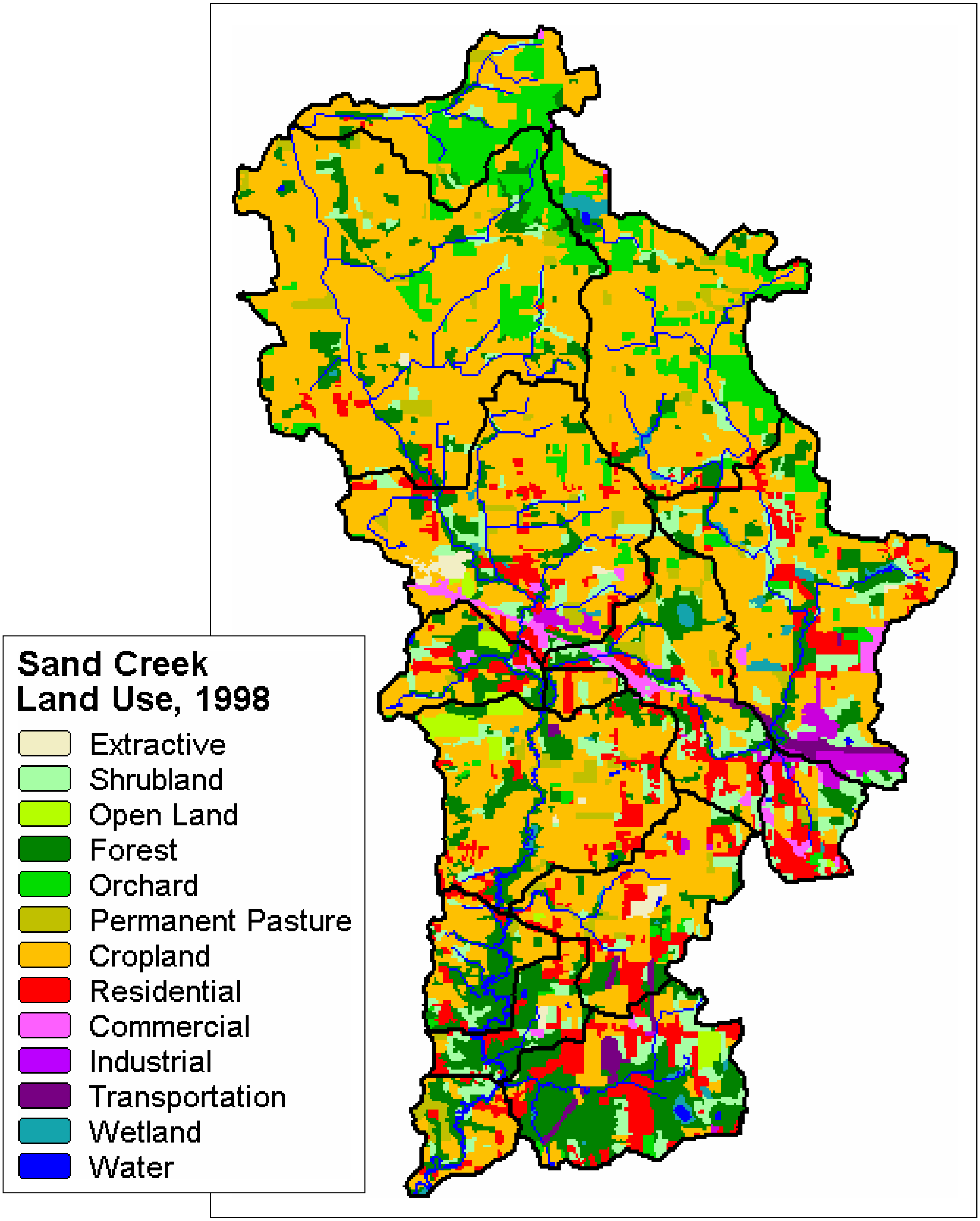

Figure 14: 1998 Land Use Data

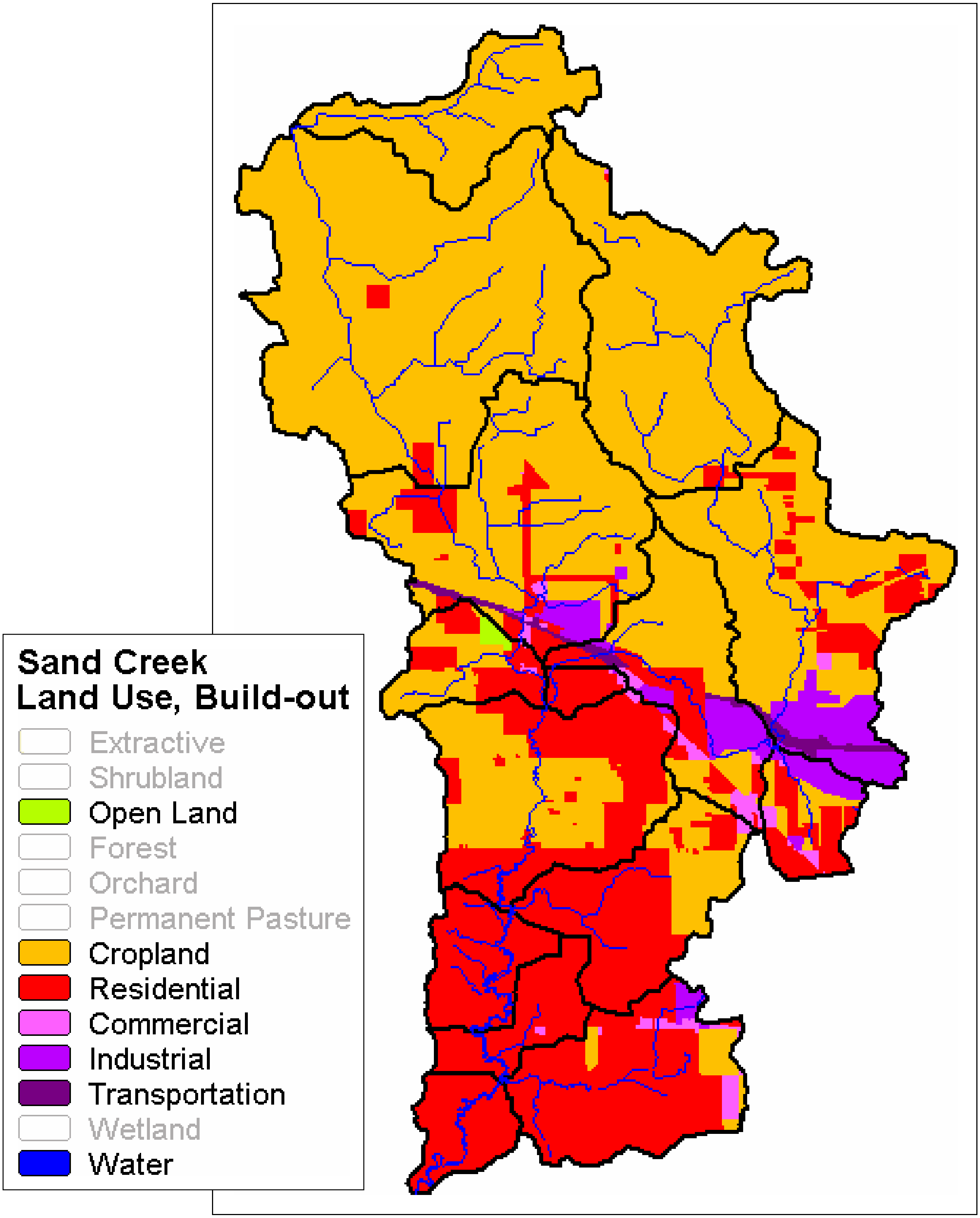

Figure 15: Zoned, or Build-Out, Land Use Data

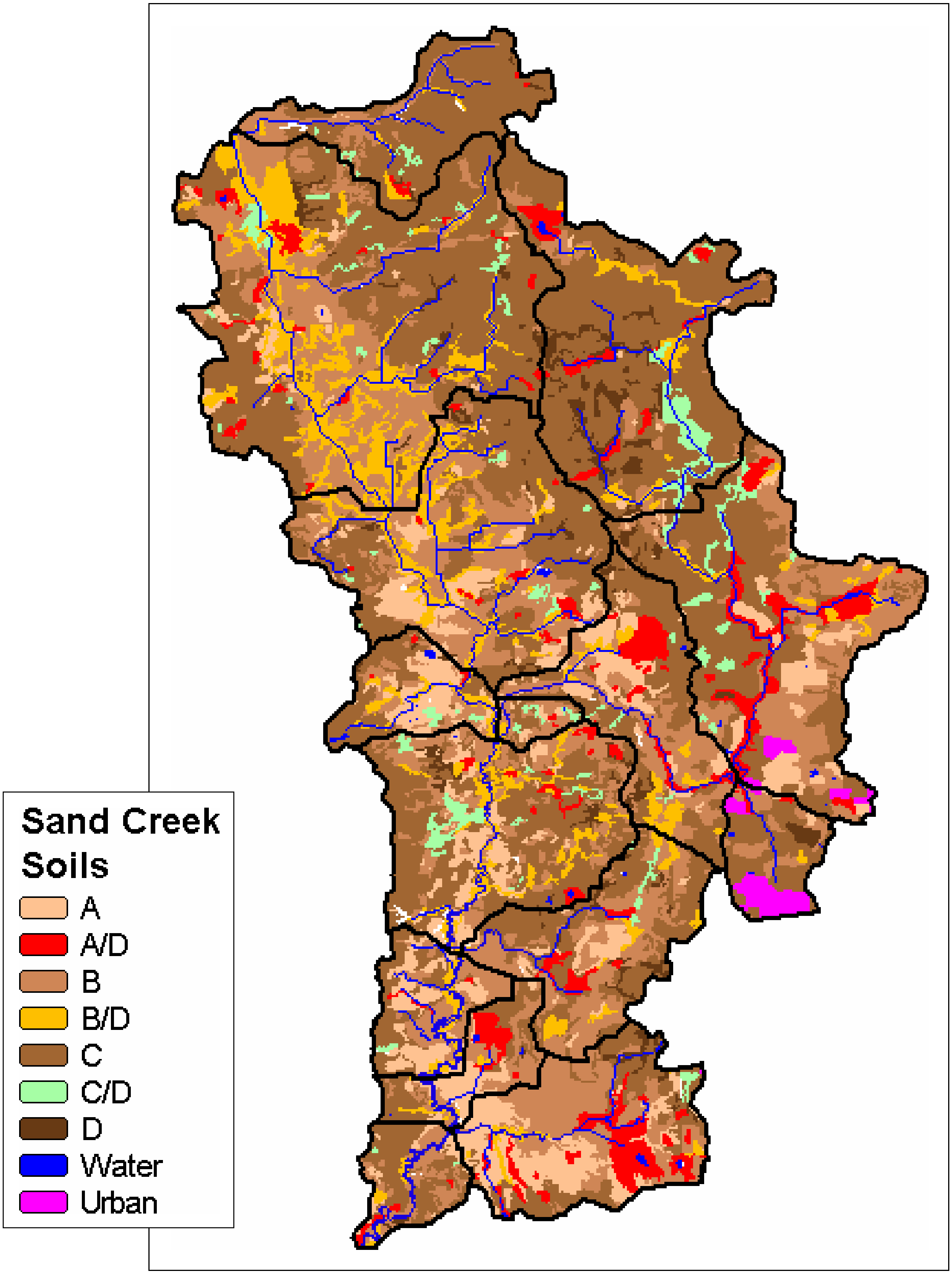

Figure 16: NRCS Soils Data

Table 1: Land Use by Subbasins (Land uses less than 0.5 percent are not listed because all percentages are rounded to the nearest percent)

Description	Scenario	Residential	Commercial	Industrial	Road	Pit	Cemeteries, Outdoor Rec.	Cropland	Orchard	Pasture	Herbaceous Openland	Forest	Water	Wetland
Sand Creek, lower	1800											88%		12%
	1978	3%	1%					47%		11%	10%	28%		
	1998	12%						39%		10%	11%	28%		
	Build-out	100%												
Sand Creek, to south tributary	1800											84%		16%
	1978	16%				2%		21%	1%	1%	15%	42%	1%	
	1998	20%	1%			2%		18%	1%	1%	14%	43%	1%	
	Build-out	99%	1%											
Sand Creek, to M-45	1800											78%		22%
	1978	9%						41%	2%	1%	8%	40%		
	1998	10%						40%	2%	1%	7%	40%		
	Build-out	100%												
Sand Creek, to Leonard	1800											80%		20%
	1978	6%					4%	58%	1%	6%	6%	18%		1%
	1998	10%					5%	55%	1%	4%	6%	17%		1%
	Build-out	52%	1%					47%						
Sand Creek, to East Fork	1800											80%		20%
	1978	11%	2%				5%	39%	2%	4%	6%	30%	1%	
	1998	15%	3%				6%	35%		3%	6%	31%	1%	
	Build-out	44%	1%				5%	49%						
Sand Creek, to State	1800											73%		27%
	1978	3%	1%	1%	2%	2%		65%	5%	4%	7%	10%		1%
	1998	8%	3%	2%		2%	1%	61%	3%	3%	7%	10%		1%
	Build-out	14%	1%	4%	2%			78%						
Sand Creek, to Arthur	1800											69%		31%
	1978							71%	11%	4%	3%	11%		
	1998	1%						73%	9%	3%	3%	11%		
	Build-out	2%						98%						
Sand Creek, to Wilson	1800											95%		5%
	1978							59%	28%	2%	3%	7%		
	1998							55%	33%	2%	3%	7%		
	Build-out							100%						
Sand Creek, south tributary	1800										43%	33%		24%
	1978	13%		1%	4%		3%	19%	2%		15%	40%	1%	2%
	1998	22%			4%		3%	13%	1%		13%	40%	1%	2%
	Build-out	83%	5%	3%				9%						

Description	Scenario	Residential	Commercial	Industrial	Road	Pit	Cemeteries, Outdoor Rec.	Cropland	Orchard	Pasture	Herbaceous Openland	Forest	Water	Wetland
Sand Creek, tributary to Leonard	1800										2%	79%		19%
	1978	14%		1%	2%	2%		55%	6%	4%	5%	10%		1%
	1998	17%		1%	2%	2%		57%	2%	4%	5%	10%		1%
	Build-out	70%	1%					29%						
East Fork, lower	1800											79%		21%
	1978	19%	2%					50%		2%	11%	15%		
	1998	19%	2%					50%		2%	11%	15%		
	Build-out	94%	5%	1%										
East Fork, to Hayes	1800											76%		24%
	1978	8%	2%		4%			41%	5%	5%	16%	19%		1%
	1998	13%	5%		1%			41%	1%	5%	13%	19%		1%
	Build-out	22%	6%	13%	3%			56%						
East Fork, to tributary	1800											79%		21%
	1978	4%		4%	3%			50%	8%	1%	15%	13%		2%
	1998	9%	2%	6%	3%			48%	5%	1%	12%	13%		2%
	Build-out	14%		14%	3%			69%						
East Fork, tributary	1800											82%		18%
	1978	20%	7%	4%				22%	4%	3%	27%	11%		1%
	1998	33%	8%	8%			1%	15%	2%	3%	21%	9%		
	Build-out	49%	6%	23%				23%						
East Fork, upper	1800											74%		26%
	1978	1%						55%	27%	4%	4%	7%		2%
	1998	2%						63%	21%	3%	3%	7%		2%
	Build-out	1%						99%						
Totals	1800										3%	74%		23%
	1978	5%	1%	1%	1%		1%	53%	9%	3%	8%	16%		1%
	1998	9%	1%	1%	1%	1%	1%	53%	7%	3%	7%	16%		1%
	Build-out	30%	1%	4%	1%			65%						

Model Results

The modeled results for the 50, 10, and 4 percent chance, 24-hour storms and the 1800, 1978, 1998, and build-out land use scenarios are illustrated in Figures 2 through 7 and detailed in Tables 2 through 7. Because the runoff volumes computed for the *Build-Out, No Net Loss of Storage* and the *Build-Out, Maximum* scenarios are identical, these values are only shown once and labeled *Build-Out*. Table 2 lists the predicted peak flows from each subbasin. These values represent the peak flow contribution from the subbasins, not the flow in the creek. Table 3 lists the predicted peak flows at locations in the creek. Table 4 compares peak flow changes from 1800 to 1998 and from 1998 to build-out conditions. Table 5 lists the predicted runoff volumes from each subbasin. Table 6 lists the predicted runoff volumes at locations in the creek. Table 7 compares runoff volume changes from 1800 to 1998 and from 1998 to build-out conditions.

The model does not predict significant flow changes from 1978 to 1998. The projected increases in stormwater runoff volume and peak flows from 1998 to build-out conditions are of primary interest to Sand Creek watershed's stormwater managers. Model predictions based on this land use change show significant increases in runoff volumes and peak flows for all three design storms. Peak flows and runoff volumes from the 50 percent chance, 24-hour storm are predicted to increase more, on a percentage basis, than flows from the 10 percent chance, 24-hour storm or the 4 percent chance, 24-hour storm. The projected increases in runoff volumes and peak flows from the 50 percent chance storm would increase the channel forming flow, which will increase streambank erosion that is already reported to be excessive in Sand Creek below Leonard Street. The projected increases in runoff volumes and peak flows from the 10 and 4 percent chance storms will aggravate flooding problems, which are reported throughout the watershed. These projected increases can be moderated through the use of effective stormwater management techniques.

The Sand Creek watershed is within Kent and Ottawa Counties. The model stormwater ordinance adopted by Kent County is currently being considered by Ottawa County. The Kent County model stormwater ordinance calls for a maximum release rate of 0.05 cfs/acre for runoff from the 50 percent chance, 24-hour storm for Zone A areas, the most environmentally sensitive of the three zones. Currently, the average yield from this storm is 0.02 cfs per acre, with no subbasins higher than 0.05 cfs/acre, as shown in Figure 15. The yield from five of the fifteen subbasins may exceed 0.05 cfs/acre with continued development. The ordinance also calls for a maximum release rate of 0.13 cfs/acre for runoff from the 4 percent chance, 24-hour storm for Zones A and B. Currently, the average yield from this storm is 0.10 cfs per acre, with three subbasins higher than 0.13 cfs/acre, as shown in Figure 16. The yield from eleven of the fourteen subbasins may exceed 0.13 cfs/acre with continued development. Additional details are listed in Table 8.

Table 2: Peak flows per subbasin

Subbasin	Peak Flow (cfs) from 50% chance, 24-hour storm					Peak Flow (cfs) from 10% chance, 24-hour storm					Peak Flow (cfs) from 4% chance, 24-hour storm				
	1800 land use	1978 land use	1998 land use	Build-out, no net loss of storage	Build-out, max.	1800 land use	1978 land use	1998 land use	Build-out, no net loss of storage	Build-out, max.	1800 land use	1978 land use	1998 land use	Build-out, no net loss of storage	Build-out, max.
Sand Creek, lower	7	14	13	14	25	24	40	37	40	68	47	69	66	69	111
Sand Creek, to south tributary	4	7	7	10	18	20	28	28	35	60	42	54	54	64	105
Sand Creek, to M-45	4	8	8	8	17	17	27	27	27	52	35	51	51	51	89
Sand Creek, to Leonard	21	52	48	52	95	69	129	123	129	225	129	217	208	217	350
Sand Creek, to East Fork	7	16	16	21	43	30	52	52	63	118	62	97	97	113	195
Sand Creek, to State	44	100	93	125	221	153	256	242	300	501	281	428	409	487	758
Sand Creek, to Arthur	55	129	129	148	256	164	304	304	334	551	295	492	492	532	819
Sand Creek, to Wilson	23	72	67	90	146	77	173	164	202	308	144	274	263	311	455
Sand Creek, south tributary	12	35	35	39	77	66	127	127	136	248	146	240	240	254	437
Sand Creek, tributary to Leonard	17	47	47	47	78	58	122	122	122	196	113	205	205	205	311
East Fork, lower	3	9	9	8	15	12	26	26	25	44	26	46	46	44	73
East Fork, to Hayes	17	41	44	61	116	64	116	123	153	269	126	200	210	251	412
East Fork, to tributary	28	65	70	86	175	94	164	172	200	380	176	278	290	327	566
East Fork, tributary	18	38	41	59	98	54	93	98	126	196	98	150	157	193	286
East Fork, upper	40	82	88	100	179	110	185	194	213	362	192	295	307	331	526

Table 3: Peak flows in Sand Creek

Location	Peak Flow (cfs) from 50% chance, 24-hour storm					Peak Flow (cfs) from 10% chance, 24-hour storm					Peak Flow (cfs) from 4% chance, 24-hour storm				
	1800 land use	1978 land use	1998 land use	Build-out, no net loss of storage	Build-out, max.	1800 land use	1978 land use	1998 land use	Build-out, no net loss of storage	Build-out, max.	1800 land use	1978 land use	1998 land use	Build-out, no net loss of storage	Build-out, max.
East Fork at 6 mile	40	82	88	100	179	110	185	194	213	362	192	295	307	331	526
East Fork at I-96	72	148	159	188	286	210	344	361	405	580	369	547	568	624	842
East Fork at Hayes	83	167	179	215	299	245	388	407	462	608	426	614	638	706	884
Sand Creek at Wilson	23	72	67	90	146	77	173	164	202	308	144	274	263	311	455
Sand Creek at Arthur	77	200	195	237	376	240	471	462	529	788	436	749	737	822	1160
Sand Creek at State	105	257	248	306	421	321	596	582	672	880	569	933	915	1027	1293
Sand Creek at confluence with East Fork	192	426	429	526	719	574	993	997	1146	1487	1009	1560	1566	1750	2177
Sand Creek at Leonard	213	465	466	565	738	638	1078	1080	1232	1531	1110	1684	1687	1875	2243
Sand Creek at M-45	215	469	469	568	739	644	1087	1088	1240	1533	1121	1696	1699	1887	2246
Sand Creek at south tributary	219	472	473	572	739	651	1091	1093	1246	1533	1129	1701	1703	1891	2245
Sand Creek at mouth	220	473	474	573	739	653	1093	1094	1247	1533	1131	1703	1705	1894	2245

Table 4: Predicted peak flow changes

Location	1800 to 1998			1998 to build-out, no net storage loss			1998 to build-out, maximum		
	50% Chance Storm	10% Chance Storm	4% Chance Storm	50% Chance Storm	10% Chance Storm	4% Chance Storm	50% Chance Storm	10% Chance Storm	4% Chance Storm
Flow Changes in Creek									
Sand Creek at M-45	118%	69%	52%	21%	14%	11%	57%	41%	32%
Sand Creek/East Fork	124%	74%	55%	23%	15%	12%	67%	49%	39%
Sand Creek at State	137%	81%	61%	24%	16%	12%	70%	51%	41%
East Fork at Hayes	115%	66%	50%	20%	13%	11%	67%	49%	39%
Flow Changes from Subbasins									
Sand Creek, lower	41%	54%	95%	5%	6%	9%	70%	83%	95%
Sand Creek, to south tributary	29%	39%	64%	19%	23%	36%	93%	115%	155%
Sand Creek, to M-45	44%	56%	102%	0%	0%	0%	75%	91%	105%
Sand Creek, to Leonard	61%	77%	130%	4%	5%	8%	68%	83%	97%
Sand Creek, to East Fork	55%	72%	131%	17%	21%	31%	101%	129%	168%
Sand Creek, to State	45%	58%	108%	19%	24%	36%	85%	107%	139%
Sand Creek, to Arthur	67%	85%	134%	8%	10%	15%	67%	81%	98%
Sand Creek, to Wilson	83%	112%	191%	18%	23%	35%	73%	88%	119%
Sand Creek, south tributary	64%	93%	180%	6%	7%	10%	82%	96%	120%
Sand Creek, tributary to Leonard	82%	108%	176%	0%	0%	0%	51%	61%	68%
East Fork, lower	78%	112%	225%	-5%	-6%	-8%	59%	67%	70%
East Fork, to Hayes	67%	93%	155%	20%	25%	36%	96%	119%	160%
East Fork, to tributary	64%	84%	152%	13%	16%	23%	96%	121%	152%
East Fork, tributary	61%	79%	128%	23%	29%	45%	82%	101%	140%
East Fork, upper	60%	77%	117%	8%	10%	14%	71%	86%	104%

Table 5: Runoff volumes per subbasin

Subbasin	Runoff Volume (acre-feet) from 50% chance 24-hour storm				Runoff Volume (acre-feet) from 10% chance 24-hour storm				Runoff Volume (acre-feet) from 4% chance 24-hour storm			
	1800 land use	1978 land use	1998 land use	Build-out	1800 land use	1978 land use	1998 land use	Build-out	1800 land use	1978 land use	1998 land use	Build-out
Sand Creek, lower	15	26	24	26	46	64	61	64	77	101	97	101
Sand Creek, to south tributary	11	14	14	19	40	45	45	55	71	79	79	91
Sand Creek, to M-45	13	23	23	23	48	66	66	66	85	110	110	110
Sand Creek, to Leonard	74	144	134	144	214	330	314	330	356	505	485	505
Sand Creek, to East Fork	16	26	26	34	52	70	70	83	90	115	115	131
Sand Creek, to State	94	182	169	224	269	416	396	480	448	636	611	714
Sand Creek, to Arthur	216	370	370	423	566	812	812	891	913	1219	1219	1315
Sand Creek, to Wilson	48	95	89	115	128	204	194	233	209	303	292	338
Sand Creek, south tributary	29	56	56	62	107	160	160	170	195	267	267	280
Sand Creek, trib. to Leonard	48	86	86	86	136	201	201	201	227	310	310	310
East Fork, lower	4	9	9	8	14	22	22	20	23	34	34	32
East Fork, to Hayes	46	78	85	113	137	193	203	248	231	304	317	372
East Fork, to tributary	95	184	197	241	272	420	441	508	453	643	669	749
East Fork, tributary	29	42	45	62	72	92	96	120	113	138	143	172
East Fork, upper	151	233	248	281	366	490	512	559	571	722	749	805

Table 6: Runoff volumes in Sand Creek

Location	Runoff Volume (acre-feet) from 50% chance 24-hour storm				Runoff Volume (acre-feet) from 10% chance 24-hour storm				Runoff Volume (acre-feet) from 4% chance 24-hour storm			
	1800 land use	1978 land use	1998 land use	Build -out	1800 land use	1978 land use	1998 land use	Build -out	1800 land use	1978 land use	1998 land use	Build -out
East Fork at 6 mile	151	233	248	281	366	490	512	559	571	722	749	805
East Fork at I-96	275	458	490	585	709	1002	1050	1188	1137	1503	1561	1726
East Fork at Hayes	320	536	575	698	845	1195	1253	1435	1368	1807	1878	2098
Sand Creek at Wilson	48	95	89	115	128	204	194	233	209	303	292	338
Sand Creek at Arthur	263	465	459	539	695	1016	1006	1124	1122	1522	1511	1653
Sand Creek at State	357	647	628	762	963	1432	1402	1604	1570	2158	2121	2367
Sand Creek at confluence with East Fork	697	1219	1238	1502	1873	2719	2747	3143	3050	4113	4148	4627
Sand Creek at Leonard	816	1448	1457	1731	2220	3249	3262	3674	3631	4927	4942	5442
Sand Creek at M-45	827	1471	1480	1755	2264	3315	3328	3740	3713	5037	5052	5552
Sand Creek at south tributary	866	1541	1550	1835	2409	3521	3534	3965	3978	5383	5398	5924
Sand Creek at mouth	879	1566	1573	1861	2451	3585	3594	4030	4051	5485	5495	6025

Table 7: Predicted runoff volume changes

Location	1800 to 1998			1998 to build-out		
	50% Chance Storm	10% Chance Storm	4% Chance Storm	50% Chance Storm	10% Chance Storm	4% Chance Storm
Runoff Volume Changes in Creek						
Sand Creek at M-45	79%	47%	36%	19%	12%	10%
Sand Creek/East Fork	78%	47%	36%	21%	14%	12%
Sand Creek at State	76%	46%	35%	21%	14%	12%
East Fork at Hayes	80%	48%	37%	21%	15%	12%
East Fork, upper	64%	40%	31%	13%	9%	7%
Runoff Volume Changes from Subbasins						
Sand Creek, lower	57%	34%	26%	8%	5%	4%
Sand Creek, to south tributary	26%	15%	11%	36%	21%	16%
Sand Creek, to M-45	72%	39%	30%	0%	0%	0%
Sand Creek, to Leonard	80%	47%	36%	8%	5%	4%
Sand Creek, to East Fork	63%	36%	28%	28%	18%	14%
Sand Creek, to State	80%	47%	36%	32%	21%	17%
Sand Creek, to Arthur	72%	43%	34%	14%	10%	8%
Sand Creek, to Wilson	85%	51%	40%	30%	20%	16%
Sand Creek, south tributary	95%	50%	37%	10%	6%	5%
Sand Creek, tributary to Leonard	80%	47%	36%	0%	0%	0%
East Fork, lower	103%	58%	44%	-7%	-5%	-4%
East Fork, to Hayes	84%	49%	37%	33%	22%	17%
East Fork, to tributary	108%	62%	48%	23%	15%	12%
East Fork, tributary	54%	35%	27%	37%	25%	20%
East Fork, upper	64%	40%	31%	13%	9%	7%

Table 8: Subbasin yields

Subbasin	Yield (cfs/acre) from 50% chance 24-hour storm					Yield (cfs/acre) from 4% chance 24-hour storm				
	1800 land use	1978 land use	1998 land use	Build-out, no net loss of storage	Build-out, max.	1800 land use	1978 land use	1998 land use	Build-out, no net loss of storage	Build-out, max.
Sand Creek, lower	0.01	0.02	0.02	0.02	0.04	0.06	0.10	0.09	0.10	0.15
Sand Creek, to south tributary	0.01	0.01	0.01	0.01	0.02	0.05	0.07	0.07	0.08	0.13
Sand Creek, to M-45	0.00	0.01	0.01	0.01	0.02	0.04	0.05	0.05	0.05	0.09
Sand Creek, to Leonard	0.01	0.02	0.02	0.02	0.03	0.04	0.07	0.07	0.07	0.11
Sand Creek, to East Fork	0.01	0.02	0.02	0.02	0.05	0.07	0.10	0.10	0.12	0.21
Sand Creek, to State	0.01	0.02	0.02	0.03	0.06	0.07	0.11	0.10	0.12	0.19
Sand Creek, to Arthur	0.01	0.02	0.02	0.02	0.04	0.04	0.07	0.07	0.07	0.12
Sand Creek, to Wilson	0.01	0.04	0.04	0.05	0.09	0.08	0.16	0.15	0.18	0.27
Sand Creek, south tributary	0.01	0.01	0.01	0.02	0.03	0.06	0.10	0.10	0.11	0.18
Sand Creek, tributary to Leonard	0.01	0.02	0.02	0.02	0.04	0.06	0.10	0.10	0.10	0.15
East Fork, lower	0.01	0.04	0.04	0.04	0.07	0.11	0.20	0.20	0.19	0.32
East Fork, to Hayes	0.01	0.02	0.02	0.03	0.05	0.06	0.09	0.10	0.12	0.19
East Fork, to tributary	0.01	0.02	0.02	0.02	0.04	0.04	0.07	0.07	0.08	0.14
East Fork, tributary	0.02	0.05	0.05	0.07	0.12	0.12	0.19	0.19	0.24	0.35
East Fork, upper	0.01	0.02	0.02	0.03	0.05	0.05	0.08	0.08	0.08	0.13
Arithmetic Average	0.01	0.02	0.02	0.03	0.05	0.06	0.10	0.10	0.11	0.18
Area-Weighted Average	0.01	0.02	0.02	0.03	0.05	0.05	0.09	0.09	0.10	0.16

Appendices

Appendix A: Sand Creek Hydrologic Model Parameters

This appendix is provided so that the model may be recreated by an engineering consultant, or others, if desired. Table A1 provides the design rainfall values specific to the region of the state where Sand Creek is located. Figure A1 summarizes the hydrologic elements in the HEC-HMS model. Tables A2 and A3 provide the parameters that were specified for each of these hydrologic elements. The initial loss field in HEC-HMS is left blank so that the default equation based on the curve number is used. Table A4 provides the reach parameters for the routing method. The control specified in HEC-HMS was for a seven day duration using a five-minute time interval.

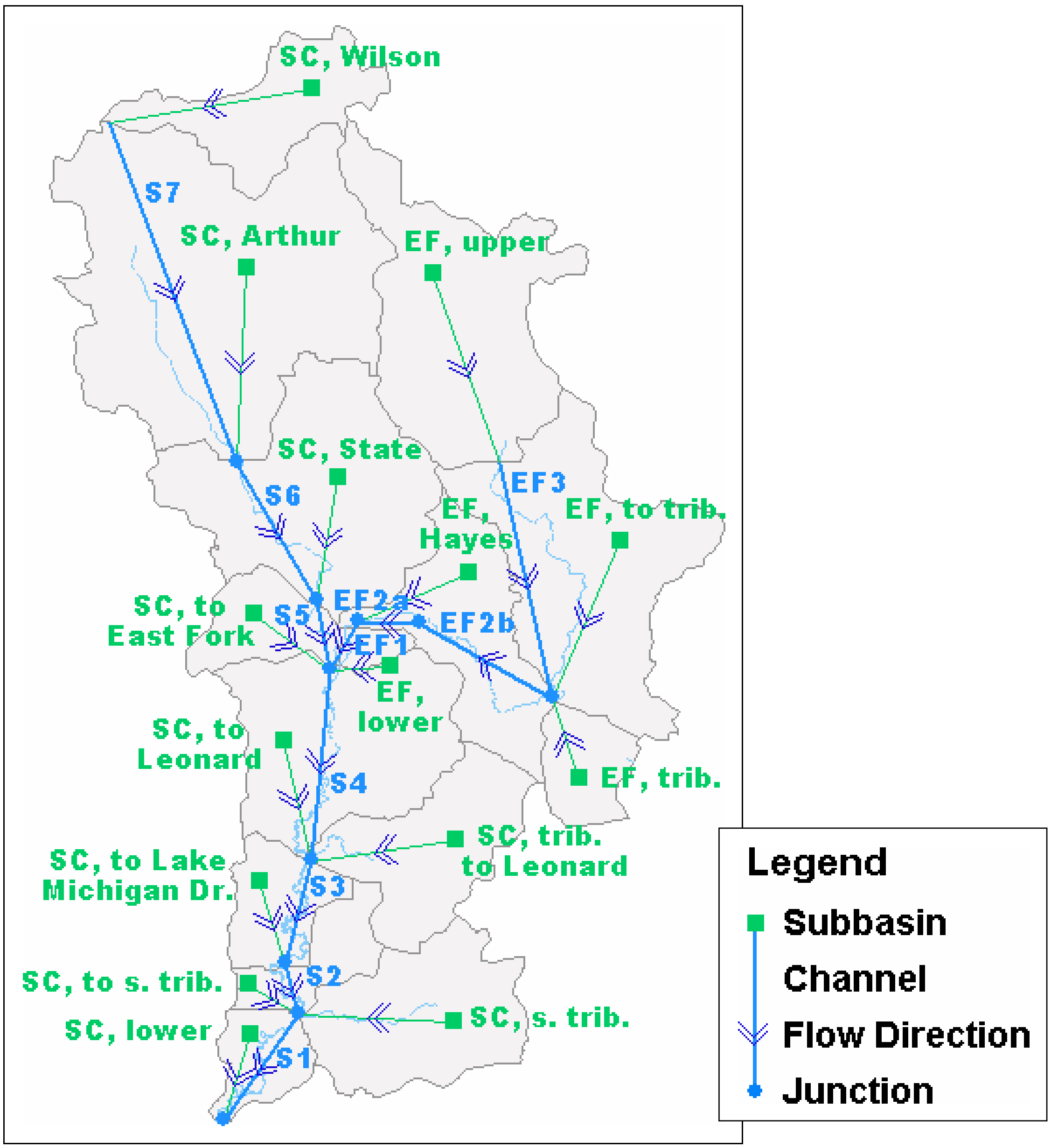

Figure A1: Hydrologic Elements defined for HEC-HMS model

Table A1: Design Rainfall Values for Kent and Ottawa County (Region 8)

Precipitation Event	Precipitation*
50% chance (2-year), 24-hour storm	2.24”
10% chance (10-year), 24-hour storm	3.33”
4% chance (25-year), 24-hour storm	4.21

*standard values were multiplied by 0.946 to account for the watershed size

Table A2: Subbasin Parameters – Area, Curve Number, Time of Concentration

Subbasin	Area (sq. mi.)	Initial Loss	Curve Number				Time of Concentration (hours)
			1800	1978	1998	Build-out	
Sand Creek, lower	1.1	Default	67	73	72	73	5.00
Sand Creek, to south tributary	1.3	Default	63	65	65	68	4.53
Sand Creek, to M-45	1.5	Default	63	68	68	68	7.16
Sand Creek, to Leonard	5.0	Default	68	76	75	76	9.16
Sand Creek, to East Fork	1.5	Default	65	70	70	73	3.38
Sand Creek, to State	6.3	Default	68	76	75	79	5.42
Sand Creek, to Arthur	11.1	Default	71	78	78	80	10.61
Sand Creek, to Wilson	2.7	Default	70	79	78	82	4.08
Sand Creek, south tributary	3.7	Default	62	68	68	69	3.06
Sand Creek, trib. to Leonard	3.2	Default	68	75	75	75	5.69
East Fork, lower	0.4	Default	66	74	74	73	1.98
East Fork, to Hayes	3.4	Default	67	73	74	78	5.10
East Fork, to tributary	6.3	Default	68	76	77	80	8.34
East Fork, tributary	1.3	Default	73	78	79	84	3.15
East Fork, upper	6.1	Default	74	80	81	83	10.07
Total	**54.8**						

Table A3: Subbasin Parameters – Storage Coefficients

Subbasin	50% chance, 24-hour storm			10% chance, 24-hour storm			4% chance, 24-hour storm		
	1800	1978, 1998	Build-out	1800	1978, 1998	Build-out	1800	1978, 1998	Build-out
Sand Creek, lower	17.3	12.4	5.0	12.9	11.0	5.0	11.2	10.00	5.0
Sand Creek, to south tributary	20.8	13.2	4.5	13.5	10.3	4.5	11.2	9.20	4.5
Sand Creek, to M-45	18.3	23.3	7.2	10.2	18.9	7.2	8.0	6.70	7.2
Sand Creek, to Leonard	29.7	22.7	9.2	22.3	20.4	9.2	18.5	16.20	9.2
Sand Creek, to East Fork	32.0	10.1	3.4	26.0	8.5	3.4	22.5	18.20	3.4
Sand Creek, to State	23.5	12.4	5.4	17.8	11.3	5.4	14.8	10.40	5.4
Sand Creek, to Arthur	17.8	23.5	10.6	11.3	21.7	10.6	9.2	7.40	10.6
Sand Creek, to Wilson	15.0	8.2	4.1	11.8	7.6	4.1	10.7	10.30	4.1
Sand Creek, south tributary	36.0	9.6	3.1	30.4	7.5	3.1	26.3	19.80	3.1
Sand Creek, trib. to Leonard	14.8	12.5	5.7	11.2	11.4	5.7	9.7	7.20	5.7
East Fork, lower	9.2	5.1	2.0	6.0	4.6	2.0	5.0	4.20	2.0
East Fork, to Hayes	21.5	13.1	5.1	15.7	11.4	5.1	13.0	10.40	5.1
East Fork, to tributary	30.5	23.3	8.3	24.0	20.6	8.3	20.5	18.20	8.3
East Fork, tributary	10.4	6.5	3.2	8.4	6.1	3.2	7.4	5.70	3.2
East Fork, upper	34.0	23.3	10.1	29.0	21.5	10.1	25.0	19.60	10.1

Table A4: Channel Reach Parameters

Reach	Lag (hours)
Sand Creek 1: mouth to southern tributary	5.90
Sand Creek 2: southern tributary to M-45	1.95
Sand Creek 3: M-45 to Leonard	6.88
Sand Creek 4: Leonard to confluence with East Fork	8.71
Sand Creek 5: confluence with East Fork to State	2.15
Sand Creek 6: State to Arthur	5.39
Sand Creek 7: Arthur to Wilson	10.50
East Fork 1: Confluence with Sand Creek to Hayes	1.04
East Fork 2: Hayes to near I-96	5.23
East Fork 3: near I-96 to 6 mile	8.35

Appendix B: Sand Creek Dam Failure

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY

INTEROFFICE COMMUNICATION

May 21, 2002

TO: Janice Tompkins, Surface Water Quality Division
Grand Rapids District Office

FROM: Dave Fongers, Hydrologic Studies Unit
Land and Water Management Division

SUBJECT: Sand Creek, Ottawa and Kent Counties

At your request on behalf of a recently-formed Sand Creek watershed group, the Hydrologic Studies Unit (HSU) of the Land and Water Management Division (LWMD) began a watershed monitoring study on April 11, 2002. The locations of the flow monitors and rain gages within the watershed are shown in Figure 1.

This study was requested because increased magnitude and frequency of flood (out of bank) flows and streambank erosion have been identified as problems throughout the watershed. The stream reach that appears to be experiencing the most extensive streambank erosion is located from approximately Leonard Street to Lake Michigan Drive. Increases in the flow regime and the associated streambank erosion would be reduced below Lake Michigan Drive because the Grand River is a hydraulic control that attenuates peak flows near its confluence with Sand Creek.

Changes in the flow regime of Sand Creek as a result of changes in the hydrologic characteristics of the watershed are thought to be a contributing cause of the increased erosion and flood flows, particularly because portions of the watershed are under development pressure from the expanding Grand Rapids metropolitan area. A better understanding of these problems and their causes is necessary to identify and design appropriate Best Management Practices (BMPs) to rehabilitate the stream. This assessment would be required for the installation of BMPs funded through a Clean Michigan Initiative (CMI) grant.

As part of these watershed monitoring studies, we routinely measure discharge at each monitoring location to develop a stage-discharge relationship, termed a rating curve. While doing this at the Leonard Street site, we discovered the remains of a failed dam, shown in Figures 2 and 3. We have researched this dam with the assistance of Jim Hayes with the LWMD's Dam Safety Program. A dam has been at this site since approximately 1860. In a January 1980 report, the hydraulic height, normal pool storage capacity, and maximum pool storage capacity of the dam were listed as 9.8 feet, 80 acre-feet, and 200 acre-feet, respectively. The design of the dam is shown in Figure 4.

The dam foundation failed on May 21, 1989. Photos of the site on May 22, 1989 are shown in Figures 5, 6, and 7. As a result of the failure, the sediment that had accumulated behind the dam was released downstream. The hydraulic gradient, or slope, of the stream increased significantly, increasing the water velocity and erosive stress on the banks. The movement of the sediment and changes in the flow regime could easily have altered the form, or morphology, of the channel. The sediment released by the dam failure may now be relatively stationary, deposited in the Grand River, near the mouth of Sand Creek, or on the Sand Creek floodplain. We would not, however, expect the channel morphology to have fully adapted to the altered flow regime in thirteen years. Other researchers have indicated that streams can take 60 years or more to adapt to an altered flow regime. Excessive and extensive streambank erosion is a typical symptom of unstable channel morphology.

The HSU recommends that current land use in the watershed be compared to 1978 land use. If land use has not changed significantly, hydrologic modeling to help identify the cause of the streambank erosion would not be needed. Modeling may still be needed to provide data for the selection and design of appropriate BMPs. Modeling solely to address flooding questions would not be appropriate under the Section 319 grant that is funding this watershed study. Because the monitors require no maintenance, we recommend that the monitoring program be continued until all parties involved decide whether hydrologic modeling is needed.

cc: Ralph Reznick, SWQD
Ric Sorrell, LWMD
Gerald Fulcher, LWMD
Jim Hayes, LWMD

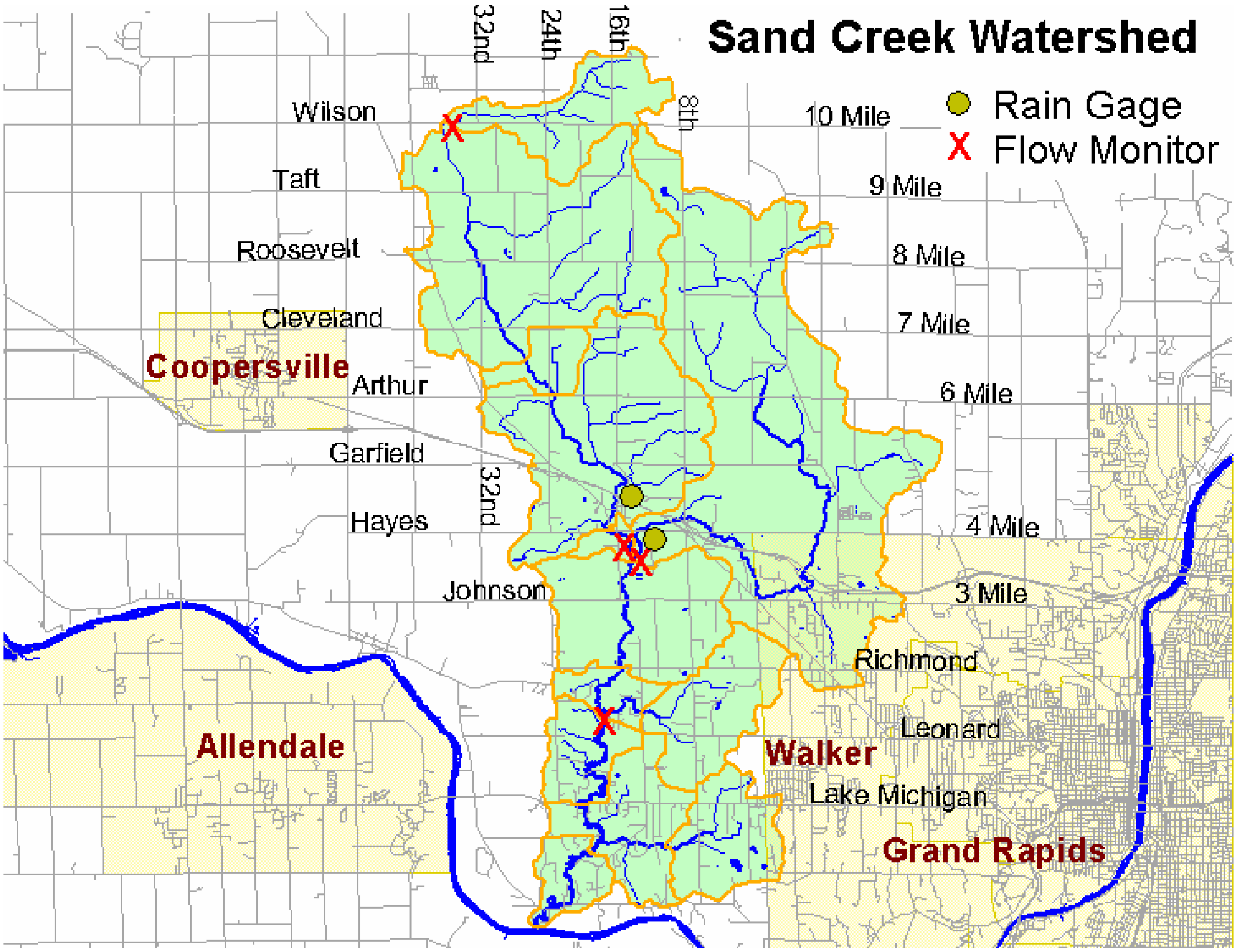

Figure 1: Watershed Study Monitoring Locations

Figure 2: Failed dam below Leonard Street, May 2002

Figure 3: Failed dam below Leonard Street, May 2002

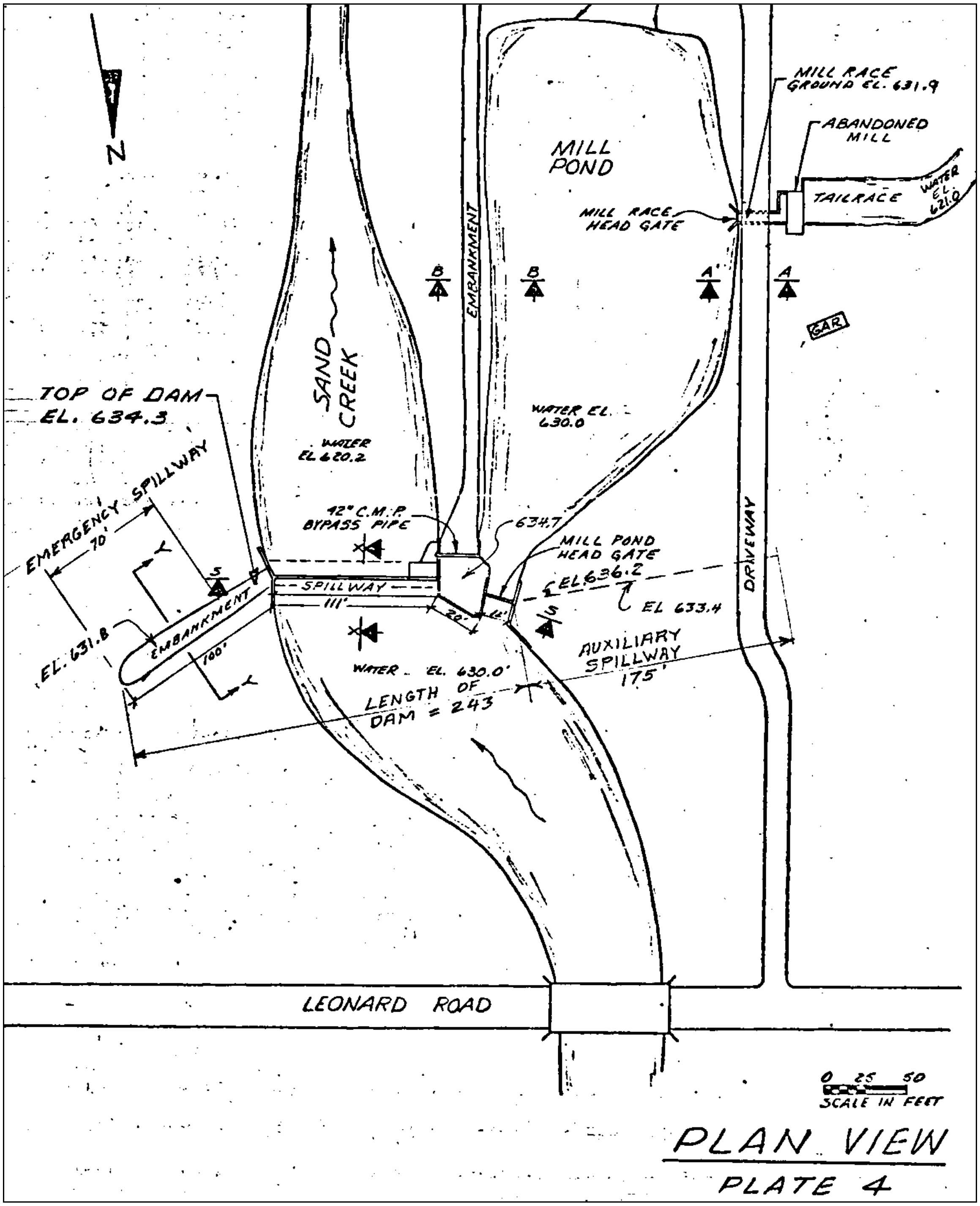

Figure 4: Plan View of Root Dam

Figure 5: Root Dam on 5/22/1989, one day after failure

Figure 6: Root Dam on 5/22/1989, one day after failure

Figure 7: Impoundment of Root Dam on 5/22/1989, one day after failure

APPENDIX E DATA RESULTS FROM THE PRELIMINARY WATERSHED ASSESSMENT OF THE SAND CREEK WATERSHED

Preliminary Watershed Assessment of the Sand Creek Watershed: Data Set

Date	Station	TSS mg/L	Cl mg/L	S04 mg/L	N03-N mg/L	NH3-N mg/L	SRP-P mg/L	TP-P mg/L	TKN-N mg/L	E. coli per 100 mL
5/8/2003	Arthur St.	2	24	52	2.8	0.05	0.05	0.06	0.81	
5/8/2003	Berlin Fair Dr.	3	25	51	2.3	0.10	0.04	0.05	1.10	
5/8/2003	8th Ave.	3	23	29	0.21	0.03	0.09	0.12	1.27	
5/8/2003	Leonard St.	5	35	40	1.4	0.09	0.05	0.07	1.14	
5/8/2003	Aman Park	5	37	40	1.4	0.11	0.05	0.06	1.02	
5/8/2003	Luce St.	9	38	39	1.3	0.07	0.05	0.08	1.19	
5/15/2003	Arthur St.	2	20	25	0.21	0.03	0.09	0.13	1.02	
5/15/2003	Berlin Fair Dr.	1	23	49	2.5	0.06	0.05	0.06	0.82	
5/15/2003	8th Ave.	1	22	51	3.1	0.04	0.05	0.06	0.81	
5/15/2003	Leonard St.	8	30	35	1.3	0.06	0.06	0.09	1.03	
5/15/2003	Aman Park	10	32	35	1.3	0.08	0.06	0.10	0.85	
5/15/2003	Luce St.	12	33	34	1.2	0.05	0.06	0.09	0.71	
5/22/2003	Arthur St.	1	46	52	2.8	0.05	0.03	0.06	0.78	200
5/22/2003	Berlin Fair Dr.	3	41	34	0.60	0.03	0.10	0.15	0.97	33 *
5/22/2003	8th Ave.	2	38	51	2.2	0.05	0.03	0.06	0.75	17 *
5/22/2003	Leonard St.	5	37	36	1.3	0.06	0.05	0.09	1.09	0
5/22/2003	Aman Park	8	64	36	1.3	0.07	0.05	0.09	0.95	33 *
5/22/2003	Luce St.	15	52	33	1.2	0.06	0.05	0.10	0.87	33 *
6/5/2003	Arthur St.	2	38	50	1.8	0.06	0.04	0.09	0.69	
6/5/2003	Berlin Fair Dr.	2	101	49	1.3	0.06	0.03	0.06	0.54	
6/5/2003	8th Ave.	3	54	43	0.59	0.03	0.07	0.10	0.61	
6/5/2003	Leonard St.	3	77	45	1.2	0.04	0.04	0.08	0.67	
6/5/2003	Aman Park	2	65	43	1.3	0.09	0.05	0.10	0.61	
6/5/2003	Luce St.	3	61	43	1.2	0.03	0.03	0.07	0.45	
6/12/2003	Arthur St.	2	20	54	2.2	0.03	0.08	0.09	0.65	97
6/12/2003	Berlin Fair Dr.	3	25	50	1.8	< 0.01	0.06	0.08	0.77	192
6/12/2003	8th Ave.	2	24	49	0.73	0.01	0.09	0.11	0.74	503
6/12/2003	Leonard St.	6	35	44	1.5	0.03	0.06	0.08	0.70	253
6/12/2003	Aman Park	5	39	44	1.5	0.02	0.06	0.08	0.68	-
6/12/2003	Luce St.	4	43	45	1.5	0.02	0.05	0.07	0.86	245
6/19/2003	Arthur St.	1	61	54	1.7	0.03	0.03	0.10	0.92	116
6/19/2003	Berlin Fair Dr.	6	55	52	1.3	0.02	0.02	0.07	0.72	311
6/19/2003	8th Ave.	2	56	52	0.85	< 0.01	0.04	0.09	0.60	2233
6/19/2003	Leonard St.	10	68	47	1.1	0.04	0.02	0.07	0.84	432
6/19/2003	Aman Park	7	73	43	1.1	0.04	0.02	0.06	0.75	167
6/19/2003	Luce St.	5	68	43	1.1	0.08	< 0.01	0.05	0.90	193
6/26/2003	Arthur St.									302
6/26/2003	Berlin Fair Dr.									668
6/26/2003	8th Ave.									1467
6/26/2003	Leonard St.									146
6/26/2003	Aman Park									129
6/26/2003	Luce St.									114
6/27/2003	Arthur St.	4	46	45	1.39	0.12	0.08	0.16	0.65	
6/27/2003	Berlin Fair Dr.	3	50	44	0.90	0.07	0.04	0.08	0.49	
6/27/2003	8th Ave.	2	84	41	0.42	0.04	0.03	0.07	0.16	
6/27/2003	Leonard St.	13	72	48	1.01	0.08	0.01	0.09	0.22	
6/27/2003	Aman Park	8	59	41	1.02	0.05	0.03	0.07	0.37	
6/27/2003	Luce St.	5	76	46	1.13	0.06	0.03	0.07	0.35	
7/2/2003	Arthur St.	6	29	52	1.40	0.06	0.11	0.19	0.39	1500
7/2/2003	Berlin Fair Dr.	6	62	48	1.04	0.06	0.05	0.10	0.42	1167
7/2/2003	8th Ave.	6	94	40	0.43	0.04	0.04	0.18	0.23	594
7/2/2003	Leonard St.	8	79	46	1.18	0.05	0.04	0.08	0.27	210
7/2/2003	Aman Park	9	51	46	1.24	0.04	0.03	0.08	0.26	110
7/2/2003	Luce St.	8	79	42	1.12	0.05	0.04	0.08	0.28	179
7/10/2003	Arthur St.	19	44	43	1.4	0.04	0.22	0.25	0.78	1133
7/10/2003	Berlin Fair Dr.	70	64	34	0.78	0.14	0.11	0.26	0.86	TNTC
7/10/2003	8th Ave.	59	100	20	0.43	0.04	0.10	0.21	0.82	TNTC
7/10/2003	8th Ave. (duplicate)	60	83	20	0.41	0.04	0.10	0.22	0.78	TNTC
7/10/2003	Leonard St.	47	67	38	0.96	0.04	0.07	0.10	0.37	988
7/10/2003	Aman Park	18	81	42	1.0	0.03	0.07	0.11	0.38	690
7/10/2003	Luce St.	10	84	42	1.0	0.03	0.07	0.09	0.40	404

Preliminary Watershed Assessment of the Sand Creek Watershed: Data Set

Date	Station	TSS mg/L	Cl mg/L	S04 mg/L	N03-N mg/L	NH3-N mg/L	SRP-P mg/L	TP-P mg/L	TKN-N mg/L	E. coli per 100 mL
7/17/2003	Arthur St.	3	45	49	1.6	0.04	0.07	0.24	0.42	341
7/17/2003	Berlin Fair Dr.	6	57	51	1.2	0.04	0.07	0.08	0.39	737
7/17/2003	8th Ave.	4	98	41	0.60	0.03	0.07	0.08	0.51	522
7/17/2003	Leonard St.	9	67	46	1.3	0.02	0.06	0.07	0.34	248
7/17/2003	Aman Park	6	76	49	1.4	0.02	0.06	0.07	0.43	348
7/17/2003	Aman Park (dup)	6	73	48	1.3	0.01	0.06	0.06	0.33	219
7/17/2003	Luce St.	9	69	49	1.4	0.02	< 0.01	0.07	0.40	370
8/6/2003	Arthur St.	2	30	50	1.6	0.09	0.19	0.16	1.04	1200
8/6/2003	Berlin Fair Dr.	9	45	43	1.6	0.12	0.11	0.14	0.95	TNTC
8/6/2003	8th Ave.	6	41	34	1.8	0.08	0.10	0.16	1.42	424
8/6/2003	Leonard St.	15	57	35	1.2	0.13	0.08	0.14	0.96	1033
8/6/2003	Aman Park	22	63	36	1.4	0.13	0.08	0.16	1.00	1167
8/6/2003	Luce St.	21	36	36	1.4	0.14	0.07	0.14	1.02	768
9/9/2003	Arthur St.	5	202	41	0.85	0.05	0.15	0.22	0.25	231
9/9/2003	Berlin Fair Dr.	2	63	49	1.25	0.03	0.03	0.06	0.20	233 *
9/9/2003	8th Ave.	2	67	52	0.62	0.03	0.02	0.04	0.22	224
9/9/2003	Leonard St.	1	55	49	1.34	0.03	0.02	0.05	0.14	116
9/9/2003	Aman Park	1	80	49	1.46	0.02	0.02	0.05	0.20	163
9/9/2003	Luce St.	0	71	51	1.34	0.02	0.01	0.04	0.17	1020
9/18/2003	Arthur St.	2	27	43	1.14	0.05	0.03	0.28	0.50	100 *
9/18/2003	Arthur St. (duplicate)	1	54	47	1.22	0.04	0.04	0.28	0.47	82
9/18/2003	Berlin Fair Dr.	3	46	48	1.19	0.02	0.03	0.07	0.23	342
9/18/2003	8th Ave.	2	79	41	0.48	0.03	0.03	0.08	0.23	8100 **
9/18/2003	Leonard St.	1	68	45	1.29	0.02	0.02	0.06	0.20	153
9/18/2003	Aman Park	1	69	44	1.38	0.01	0.03	0.05	0.20	153
9/18/2003	Luce St.	2	235	42	0.99	< 0.01	0.02	0.05	0.23	432
10/14/2003	Arthur St.	2	23	56	0.26	0.06	0.07	0.15		< 33
10/14/2003	Berlin Fair Dr.	2	68	50	0.67	0.08	0.01	0.07		289
10/14/2003	8th Ave.	1	79	45	0.14	0.03	0.03	0.04		258
10/14/2003	Leonard St.	2	57	48	0.75	0.03	0.02	0.05		< 33
10/14/2003	Aman Park	2	60	47	0.77	0.03	0.02	0.04		67 *
10/14/2003	Luce St.	4	53	49	0.87	0.02	0.02	0.04		129
10/28/2003	Arthur St.	0	34	57	0.35	< 0.01	0.01	0.07		< 33
10/28/2003	Berlin Fair Dr.	0	51	52	0.69	0.02	0.04	0.05		116
10/28/2003	8th Ave.	2	65	46	0.30	0.01	0.02	0.04		663
10/28/2003	Leonard St.	1	46	48	0.81	< 0.01	0.03	0.04		33
10/28/2003	Aman Park	0	58	51	0.87	0.01	0.03	0.03		< 33.3 *
10/28/2003	Luce St.	2	67	51	0.90	0.01	0.01	0.03		58
11/4/2003	Arthur St.	25	57	61	6.70	0.08	0.13	0.21	1.38	TNTC
11/4/2003	Arthur St. (duplicate)	36	59	47	2.50	0.11	0.13	0.25	1.22	TNTC
11/4/2003	Berlin Fair Dr.	33	30	53	5.91	0.18	0.13	0.32	1.48	TNTC
11/4/2003	8th Ave.	15	40	33	0.97	0.10	0.15	0.19	0.89	TNTC
11/4/2003	Leonard St.	38	66	46	2.48	0.12	0.13	0.26	1.05	TNTC
11/4/2003	Aman Park	34	59	43	2.04	0.11	0.11	0.21	1.01	TNTC
11/4/2003	Luce St.	43	59	38	1.52	0.09	0.09	0.16	1.12	TNTC

* Arithmetic mean used since one of the observed counts was 0.
** Number represents only one of the observed counts (one of the observed counts is indefinite or too numerous to count).
*** Positive result but number of colonies could not be determined.
TNTC Observed count was too numberous to count (>6000).

APPENDIX F STRUCTURAL AND VEGETATIVE BEST MANAGEMENT PRACTICES

Structural and Vegetative Best Management Practices

BEST MANAGEMENT PRACTICE	DESCRIPTION	POLLUTANT ADDRESSED	POLLUTANT REMOVAL EFFICIENCY	POTENTIAL SOURCES OF POLLUTANTS	ADDITIONAL BMPS TO COMPLETE TREATMENT TRAIN	EXPECTED LIFE SPAN	MAINTENANCE REQUIREMENTS	TRAINING REQUIREMENTS	APPLICABILITY TO SITE	ENVIRONMENTAL CONCERNS	HYDROLOGIC EFFECTS TO CONSIDER	INSTALLATION COSTS	OPERATION AND MAINTENANCE COSTS	SPECIAL CONSIDERATIONS	COMMUNITIES USING BMP	MDEQ/ NRCS LINK
PRETREATMENT (ex. sediment traps, drainage channels, water quality inlets)																
Catch basin inlet devices	Devices that are inserted into the storm drain inlets to filter or absorb sediment, pollutants, and sometimes oil and grease. The capture of hydrocarbons can be enhanced with the use of absorbents.	Solids, sediments	Moderate to high; 70% of total suspended solids(5); <20% of total phosphorous. Assume same as Hydrodynamic Separators.	Storm water runoff	Catch basin cleaning program	2 - 5 years	High; Remove and dispose of sediment, trash and debris, and change filters as needed (approximately every 6 months)	Low/moderate	Needs less than 5 acres of drainage area	Proper disposal of sediment		$50 - 1,500 (5)	$300/Catch Basin/year (5)	Useful for retrofit	MDOT	
Permanent Sediment Basin (including forebays)	Man-made depression in the ground where runoff water is collected and stored to allow suspended solids to settle out. May have inlet and outlet structures to regulate flow.	Sediments, solids	Moderate to high; 50% of Total Suspended Solids(4);<20% of Total Phosphorous (4)	Storm water runoff	Detention/Infiltration	50+ years	Moderate; Remove and dispose of sediment, trash and debris, and repair erosion.	Low	Use for large drainage areas (≥ 1 acre), at storm sewer outfalls, may be included with detention pond, and to collect overland flow.			Low; Capital Cost: $0.60/cft of storage volume excluding land purchase. (1)	7% of capital cost/year. (1)	Not always aesthetically pleasing	Wyoming	http://www.deq.state.mi.us/documents/deq-swq-nps-sb.pdf
Combination curb with water spreader and vegetated swale	Curb with cut outs. Storm water is directed off the street at the cut out areas (not spillways).	Sediments, water volumes	High; 80% of total suspended solids. 50% of total phosphorous.	Storm water runoff	Vegetated swale, detention pond	30+ years (6)	Moderate; Remove and dispose of sediment, trash and debris, and repair erosion.	Low			Capacity must be equal to swale or channel	Moderate	Low	Need to stabilize cut out sections behind curb to prohibit soil erosion. Requires a vegetated swale behind the curb. Street sweeping.		
Check dams, Grade control structures (NRCS practice 410)	Stones, sandbags, or gravel generally used to stabilize grades in natural or artificial channels by carrying runoff from one grade to another. Designed to prevent banks from slumping, reduce runoff velocity, and prevent channel erosion from an excessive grade.	Sediment and attached pollutants, hydrologic flow	High (classic gully erosion) (12) Moderate (streambank erosion) (12) Low (runoff/ flooding) (12)	Streambank erosion, soil erosion, storm water runoff	Buffer/filter strips, grassed waterway, diversion, critical area planting	20+ years	Low. Periodic inspections. Repair/replace failing structures. Address any vegetation and erosion problems.	Moderate. Design and installation should be done by a registered professional engineer	Widely applicable to erosive areas with an excessive grade. Place in drainage channel.	Concentrated flows may cause erosion downstream - discharge point should be investigated.	Cause backwater effect; slows down water velocities; capacity equal to channel	Low to moderate. $4,650/structure or $800/vegetated chute (9) - EQIP, WHIP	Low. $60/structure (9)	Use native grasses when planting filter strip. Easements or permits may need to be obtained.	GVSU; Barry, Ionia, Ottawa County Road Commissions	http://www.deq.state.mi.us/documents/deq-swq-nps-cd.pdf
Hydrodynamic Separator Units (CDS Units, Stormceptors, Vortechnics, Downstream Defender)	Precast, flow-through, underground units that capture sediments, debris, and oils (in some units). The capture of oils can be enhanced with the use of absorbents. (CDS, Vortechs, Downstream Defender, Stormceptor)	Sediment, solids	Effective; 60% TSS Removal (1); <20% of total phosphorous (4)	Storm sewer system	Street sweeping, stream protection practices	50+	Moderate; Remove and dispose of sediment, trash and debris	Minimum	Use for small drainage areas (≤ 1 acre) with high pollutant loads, in-line with storm sewer system, and to collect overland flow	Proper disposal of sediment	Catches first flush. High flows by-pass unit through pipe system	High. $15,000/acre of impervious (2); 6,000/cfs capacity	$500/practice (2); $1,000/year (3)	Placed upstream of storm sewer discharge. Unit is below grade. Need to allow access for cleaning the chambers.	East Grand Rapids	http://www.deq.state.mi.us/documents/deq-swq-nps-ogs.pdf
DETENTION/RETENTION (ex. extended detention basin)																
Ponded Type Detention Basin (wet pond)	Small, man-made basin to maintain a permanent pool of water with emergent wetland vegetation around the bank. Designed to capture and remove particulate matter, nonsoluble metals, organic matter and nutrients through settling. It generally has inlet and outlet structures to regulate flow.	Sediment; nutrients; hydrologic flow	Moderate; 80% of total suspended solids (4) 50% of total phosphorous (4). Of the detention/retention basins, this practice may be the most effective in removing pollutants.	Storm water runoff	Sediment forebay or other form of pretreatment, Riprap, Sediment Basin, Filter	50+ years (1,6)	Low; Remove and dispose of sediment, trash and debris; repair erosion; and plant replacement vegetation as needed.	Low. Design and installation should be done by a professional	Use for large drainage areas (≥ 10 acre), at storm sewer outfalls, and to collect overland flow. Ponds generally will not work in soils with high infiltration rates.	Possible downstream warming; low bacteria removal; West Nile Virus (aerator can remove threat of West Nile Virus)	Provides full control of peak discharges for large design storms.	Low to moderate; $1/cft of storage volume, excluding land purchase (1)	5% of capital cost/year. (1)	Need available land area, can include sediment forebay, requires more planning, maintenance and land to construct.	East Grand Rapids, OCRC, Housing developments in Barry County, Industrial areas of Wright Township	http://www.deq.state.mi.us/documents/deq-swq-nps-wdb.pdf
Dry Detention Basin	Small, man-made basin designed to capture and remove particulate matter. It generally has inlet and outlet structures to regulate flow, but is dry for most of the year.	Sediment; hydrologic flow	Moderate; 80% of total suspended solids (4) 50% of total phosphorous (4)	Storm water runoff	Sediment forebay or other form of pretreatment	50+ years	Low; Remove and dispose of sediment, trash and debris; repair erosion.	Minimum	Needs land that will allow inlet at a higher elevation than outlet	Low bacteria and nutrient removal. If vegetation is not maintained, erosion and resuspension will occur.	Reduced peak flows and no standing water	Low to moderate	Low to moderate	Basin grading very important to prevent pools of standing water.	MDOT, OCDC	
Extended Detention Basin	Extended detention basins are designed to receive and detain storm water runoff for a prolonged period of time, typically up to 48 hours. Benefits include: receives and detains storm water runoff, minimizes downstream erosion, reduces flooding, and provides enhanced pollutant removal.	Sediment and attached pollutants, nonsoluble metals, nutrients, hydrologic flow	Moderate to high	Storm water runoff	Riprap, grassed waterways, sediment basins		Moderate to High	Mow buffer/filter strip, remove debris and inspect basin regularly during wet weather, and remove sediment from basin every 5-10 years.	Depends on infiltration rates and soil permeability	Can significantly warm the water in the marsh area over a short period of time	Designed to receive and detain storm water runoff for a prolonged period of time. Outlet device regulates the flow from the basin.			Determine site location of BMP through a hydrologic analysis. Designed as either single-stage or two-stage. Need spill response plan.	Housing developments in Barry County	http://www.deq.state.mi.us/documents/deq-swq-nps-edb.pdf
Parking lot storage	Storage of storm water on parking lots is used primarily to reduce the peak discharge of storm water from the surrounding area during moderate storms. Will reduce peak runoff from small sites and provide some flood storage. This helps reduce stream bank erosion and flooding.	Sediment and attached pollutants, hydrologic flow		Storm water runoff, soil erosion	Grassed Waterway, Porous or Modular Pavement, Infiltration Trench, Buffer/Filter Strip, Street Sweeping		Low to Moderate - Sweep and clear debris from the parking lot after storms. Regularly inspect and clean the release drain.	Design and installation should be done by a professional	This BMP will work best in areas that do not have a steep slope. Parking lot slope should be 1% or less.	Because detention time is small, only some large solids will settle. Solids must be removed often to prevent resuspension.	Reduces peak runoff from small sites, provides some flood storage, and reduces flooding.			A spill response plan must be developed. BMP is most effective when used with other BMPs that allow for infiltration or sediment trapping.	City of Grand Rapids	http://www.deq.state.mi.us/documents/deq-swq-nps-pls.pdf

Structural and Vegetative Best Management Practices

BEST MANAGEMENT PRACTICE	DESCRIPTION	POLLUTANT ADDRESSED	POLLUTANT REMOVAL EFFICIENCY	POTENTIAL SOURCES OF POLLUTANTS	ADDITIONAL BMPS TO COMPLETE TREATMENT TRAIN	EXPECTED LIFE SPAN	MAINTENANCE REQUIREMENTS	TRAINING REQUIREMENTS	APPLICABILITY TO SITE	ENVIRONMENTAL CONCERNS	HYDROLOGIC EFFECTS TO CONSIDER	INSTALLATION COSTS	OPERATION AND MAINTENANCE COSTS	SPECIAL CONSIDERATIONS	COMMUNITIES USING BMP	MDEQ/ NRCS LINK
Water and Sediment Control Basin (638)	An earth embankment or a combination ridge and channel generally constructed across the slope and minor watercourses to form a sediment trap and water detention basin. Improves water quality by trapping sediment on uplands and reducing gully erosion. Grass cover may provide wildlife habitat. Dissolved substances, such as nitrates, may be removed from discharge to downstream areas because of the increased infiltration.	Sediment and attached pollutants, nutrients, hydrologic flow	High (gully erosion) (12) Moderate (runoff/ flooding) (12) Low (streambank erosion) (12)	Soil erosion, agricultural runoff	Nutrient management, terraces, grassed waterways, contouring, conservation cropping system, conservation tillage, and crop residue management	10 years (9)	Reseed and fertilize as needed. Check basins after large storm events and make necessary repairs.	NRCS available for assistance	Widely applicable.	Over application of fertilizer possible.	Traps storm water runoff and prevents it from reaching lowlands. Moderate decrease in runoff/ flooding. Slight increase in excess subsurface water. (12)	$2,100 - 3,150/basin (11)	5% of original cost per unit (11)	Basin must be large enough to control the runoff from a 10-year storm without overtopping.	City of Grand Rapids, Southwest Michigan	ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/638.pdf
Regional Detention	Large, man-made basin designed to capture and remove particulate matter. It generally has inlet and outlet structures to regulate flow from large drainage areas.	Sediment; nutrients; hydrologic flow	Moderate	Storm water runoff	Sediment forebay or other form of pretreatment	50+ years	Low; Remove and dispose of sediment, trash and debris; repair erosion.	Minimum	Use for large drainage areas (≥ 1 acre), at storm sewer outfalls, and to collect overland flow.	Possible downstream warming; low bacteria removal; West Nile Virus	Reduced peak flows, storage	Moderate	Low to moderate	Need available land area, can include sediment forebay.	OCDC, KCDC, City of Wyoming	
VEGETATED TREATMENT (ex. constructed wetland, grassed swale)																
Constructed Wetland	Excavated basin with irregular perimeters and undulating bottom contours into which wetland vegetation is placed to enhance pollutant removal from storm water runoff.	Sediment, nutrients, bacteria	Moderate to high depending on season; 80% of total suspended solids (4) 50% of total phosphorous (4)	Storm water runoff	Sediment forebay or other form of pretreatment	50+ years (1)	High; Remove and dispose of sediment, trash and debris; repair erosion.	Moderate to High	Significant land use requirement; needs appropriate soils, slope, and hydrology	Potential for nutrient release in winter months	Slows flow and reduces peak flow	Moderate to high; $500 - $1000 excluding purchase of land (3)	2% of capital cost/year (1)	2% of drainage area needs to be wetland for efficient pollutant removal. Harvesting may be necessary if plants are taking up large amounts of toxics. Needs supplement water to maintain water level.	Ottawa County Road Commission	http://www.deq.state.mi.us/documents/deq-swq-nps-conw.pdf
Restored Wetland (NRCS practice 657)	Rehabilitation of a drained or degraded wetland where hydrology and the vegetative community are returned to their natural condition to the extent practicable. Provides natural pollution control by removing pollutants, filtering and collecting sediment, reducing both soil erosion and downstream flooding, and recharging groundwater supplies.	Sediment and attached pollutants, nutrients, hydrologic flow, bacteria, chemicals	Moderate to high (depending on season); 80% of total suspended solids from sheet, rill, wind, or ephemeral gully erosion (4) 50% of total phosphorous (4).	Storm water runoff, soil erosion	Sediment forebay or other form of pretreatment. In agricultural areas cattle exclusion fencing, buffer/filter strip, grassed waterway	50+ years (1)	High; Remove and dispose of sediment, trash and debris, and repair eroded areas.	Moderate to High. Design and installation should be done by a professional	Site must have previously been a wetland	Can increase water temperature. Potential for nutrient release in winter months	Stores storm water and may reduce downstream runoff and flooding. Slows flow and reduces peak flow.	Low: $200 cost to landowner if wildlife organization involved. Break tile and build berm. $2,350/acre (scwmp)	3% of original cost (11)	Many wetlands release water slowly into the ground which recharges groundwater supplies. One acre of wetland can store up to 1.5 million gallons of floodwater (enough to fill 30 Olympic size swimming pools) (EPA, 2002)	Barry County, Ionia State Park Recreational Area	ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/657.pdf
Rain Gardens and other "Landscaping for Water Quality" techniques	Small, vegetated depressions used to promote infiltration and evapo-transpiration of storm water runoff. A rain garden combines shrubs, grasses, and flowering perennials in depressions that allow water to pool for only a few days after a rain. Landscaping for water quality involves planting native gardens in place of turf grass using native grasses, sedges, and wildflowers. Protects water quality, captures rainwater, reduces flooding, eases soil erosion, increases infiltration., and requires less fertilizer and water to thrive.	Sediment and attached pollutants, nutrients, thermal pollution, solids, chemicals, oils, salt, hydrologic flow	High; 75% - 90% of total suspended solids. (3)(8) 75% of total phosphorous. (8)	Storm water runoff, fertilizers	Mulching	Assume 25 years, based on rain gardens installed in the early 1990s in Prince George County, MD which are still functioning. Depends on plant types and owner maintenance.	Low - Medium; Remove and dispose of sediment, trash, and debris, repair erosion, revegetate, and weed, water, and mulch, annually	Moderate, initial work to establish plant community. Aesthetic maintenance after initial establishment of rain garden. Center for Environmental Study, Master Gardeners Program, West Michigan Environmental Action Council available for assistance.	Site specific, depends on soils. Use for drainage areas ≤ 5 acres (8), at storm sewer outfalls, and to collect overland flow. Highly suitable for residential areas, not on steep slopes	Introduction of exotic/invasive plant species possible. Landowner may treat vegetation with herbicides or pesticides which could be carried via runoff to surface waters.	Will reduce the velocity of storm water runoff and increase infiltration	$1,075 - $12,355/ rain garden (dependent on surrounding land use)	Low. Assume $100/year (similar to yearly landscaping maintenance)	Use native plant species. Soils adequate for infiltration are required. Cold climates may reduce evapotranspiration and infiltrative capacity. Practice not suitable for slopes greater than 20% (1). Pretreatment (sediment basin) needed in high sediment load areas. Not used in wellhead protection areas.	City of Grand Rapids, City of Holland, City of Grand Rapids, Kalamazoo Public Schools	
Vegetated Buffers or Filter Strips (NRCS Practice 393)	A buffer/filter strip is a vegetated area adjacent to a water body. The buffer/filter area may be natural, undeveloped land where the existing vegetation is left intact, or it may be land planted with vegetation. Practice protects water bodies from pollutants such as sediment, nutrients and organic matter, prevents erosion, provides shade, leaf litter, and woody debris. Buffer/filter strips often provide several benefits to wildlife, such as travel corridors, nesting sites and food sources.	Sediment and attached pollutants, nutrients, thermal pollution	High to Moderate (streambank erosion) (12) Insignificant (runoff/ flooding) (12)	Runoff from parking lots, roof tops, and outflow from ponds, soil erosion, agricultural runoff	Conservation tillage in agricultural areas	10-20 years (9)	Low. Perform periodic inspections to identify concentrated flows and to verify that vegetative cover is maintaining its effectiveness. Address stream bank erosion if identified. Damaged areas should be repaired.	Low. NRCS available for assistance	Widely applicable		Will reduce the velocity of storm water runoff and increase infiltration.	Low. $350/acre (10). $250/ herbaceous acre (11) - CRP, EQIP	Low. $10/acre (9)	Several researchers have measured >90% reductions in sediment and nitrate concentrations; buffer/filter strips do a reasonably good job of removing phosphorus attached to sediment, but are relatively ineffective in removing dissolved phosphorus (Gilliam, 1994).	Typical in counties of the LGRW.	http://www.deq.state.mi.us/documents/deq-swq-nps-bfs.pdf ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/393.pdf
Vegetated Buffers or Filter Strips (NRCS Practice 393)	A buffer/filter strip is a vegetated area adjacent to a water body. The buffer/filter area may be natural, undeveloped land where the existing vegetation is left intact, or it may be land planted with vegetation. This practice protects water bodies from pollutants such as sediment, nutrients and organic matter, prevents erosion. Buffer/filter strips often provide several benefits to wildlife, such as travel corridors, nesting sites and food sources.	Sediment and attached pollutants, nutrients, thermal pollution	High to Moderate (streambank erosion) (12) Insignificant (runoff/ flooding) (12)	Runoff from parking lots, roof tops, and outflow from ponds, soil erosion, agricultural runoff	Conservation tillage in agricultural areas	10-20 years (9)	Low. Perform periodic inspections to identify concentrated flows and to verify that vegetative cover is maintaining its effectiveness. Address stream bank erosion if identified. Damaged areas should be repaired.	Low. NRCS available for assistance	Widely applicable		Will reduce the velocity of storm water runoff and increase infiltration.	Low. $350/acre (10). $250/ herbaceous acre (11) - CRP, EQIP	Low. $10/acre (9)	Several researchers have measured >90% reductions in sediment and nitrate concentrations; buffer/filter strips do a reasonably good job of removing phosphorus attached to sediment, but are relatively ineffective in removing dissolved phosphorus (Gilliam, 1994).	Typical in counties of the LGRW.	http://www.deq.state.mi.us/documents/deq-swq-nps-bfs.pdf ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/393.pdf

Structural and Vegetative Best Management Practices

BEST MANAGEMENT PRACTICE	DESCRIPTION	POLLUTANT ADDRESSED	POLLUTANT REMOVAL EFFICIENCY	POTENTIAL SOURCES OF POLLUTANTS	ADDITIONAL BMPS TO COMPLETE TREATMENT TRAIN	EXPECTED LIFE SPAN	MAINTENANCE REQUIREMENTS	TRAINING REQUIREMENTS	APPLICABILITY TO SITE	ENVIRONMENTAL CONCERNS	HYDROLOGIC EFFECTS TO CONSIDER	INSTALLATION COSTS	OPERATION AND MAINTENANCE COSTS	SPECIAL CONSIDERATIONS	COMMUNITIES USING BMP	MDEQ/ NRCS LINK
Forested or Wooded Riparian Buffer (NRCS practice 390)	Forested or wooded areas adjacent to stream	Sediment and attached pollutants, nutrients, thermal pollution	High (sheet, rill, wind, streambank, soil mass movement, road bank/construction erosion; organics, fertilizers, pesticides, runoff/ flooding) (12)	Runoff from parking lots, roof tops, and outflow from ponds, soil erosion, storm water runoff	Filter strip	15 years (9)	Low. Perform periodic inspections to identify concentrated flows and to verify that vegetative cover is maintaining its effectiveness. Address stream bank erosion if identified. Damaged areas should be repaired.	Moderate to high. NRCS/MDA available for assistance	Widely applicable	Poor or lack of maintenance may cause increased erosion if trees fall into stream	Trees in the floodplain may catch debris and impede flow.	Low. $475/forrested acre (11) - CRP, EQIP	1% of original cost (11)	Keep south and west sides of streams wooded to provide shade. Several researchers have measured >90% reductions in sediment and nitrate concentrations; buffer/filter strips do a reasonably good job of removing phosphorus attached to sediment, but are relatively ineffective in removing dissolved phosphorus (Gilliam, 1994).	Ottawa County Parks, typical in counties of the LGRW (e.g. Barry County)	ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/390.pdf
Two-stage channel design	A practical procedure that can be used to correctly size the stream channel and minimum bench widths for stable, effective discharge in agricultural drainage ditches. The bench of a two-stage ditch acts as a floodplain within the ditch to dissipate energy, reduce the erosive potential of high flow volumes, and reduce the shear stress on the bank toe. Two-stage ditches will have improved conveyance capacity, will be more self-sustaining, will create and maintain better habitat, and will improve water quality.	Sediment, hydrologic flow		Agricultural runoff	Filter/buffer strips		May require less maintenance then conventional ditches.	The Nature Conservancy has information available for assistance.	Widely applicable.		Two-stage ditches have improved conveyance capacity compared to conventional ditches and enhance drainage	In comparison to conventional ditches, additional costs are related to increased width and more initial earthwork.	May result in less annual O&M costs then conventional ditches.	Evidence and theory both suggest that ditches prone to filling with accumulated sediment may require less frequent "dipping out" if constructed in a two-stage form.		
INFILTRATION (ex. infiltration basin)																
Infiltration Trench	An excavated trench (3 - 12 feet deep), backfilled with stone aggregate, and lined with filter fabric. Infiltration trenches remove fine sediment and the pollutants associated with them.	Nutrients, sediment, metals, hydrologic flow (soluble pollutants - dependent on holding time)	High; 100% of total suspended solids(4); 60% of total phosphorous.	Storm water runoff	Sediment basin, buffer/filter strips, oil/grit separators	Short; 10 years or less (1)	Low to Moderate - Annual; Remove and dispose of sediment, trash and debris. Eroding or barren areas must be revegetated.	Moderate. Design and installation should be done by a professional	Site specific; depends on soils. Soil infiltration rates must be greater than 0.52 inches per hour, with clay content less than 30%.	If storm water runoff contains high amounts of soluble contaminants, groundwater contamination can occur.	Provides full control of peak discharges for small sites, provides groundwater recharge, may augment base stream flow, and allow infiltration.	Moderate; Average $8/cubic feet of storage (1)	9% of capital cost (1)	Avoid areas with potential hazardous material contamination. Soils with high infiltration rates required. Cold climates may hinder infiltrative capacity, fines will clog pore space in soil, and practice is not suitable for steep slopes. Use as part of a "treatment train," where soluble organic substances, oils, and coarse sediment are removed prior to storm water entering the trench. A very high failure rate occurs with infiltration trenches if they are not maintained.	MDOT, Ottawa and Barry Counties	http://www.deq.state.mi.us/documents/deq-swq-nps-it.pdf
Infiltration Pond	Water impoundment over permeable soils which received storm water runoff and contains it until it infiltrates the soils.	Nutrients, sediment, metals	High	Storm water runoff	Sediment forebay or other form of pretreatment	25+ years	Annual	Moderate	Site specific depends on soils	Potential to contaminate groundwater	May recharge groundwater	Moderate	Moderate	Avoid areas with potential hazardous material contamination	MDOT	http://www.deq.state.mi.us/documents/deq-swq-nps-ib.pdf
Porous or Modular Pavement	Permeable asphalt or interlocking paving blocks providing infiltration. When the brick or concrete is laid on a permeable base, water will be allowed to infiltrate. Benefits include: removal of fine particulates and soluble pollutants; attenuation of peak flows; reduction in the volume of runoff; reduction in soil erosion; and groundwater recharge.	Nutrients, sediment, metals, hydrologic flow	High; 95% TSS removal rate (2)	Storm water runoff	Vacuum sweeping, Subsurface Drains, Extended Detention Basin, Infiltration Basin.	10+ years	Moderate; Bi-nnual sweeping required. Periodically inspect, especially after large storms. If severe clogging occurs, may have to replace filtering material.	Low. Design and installation should be done by a professional	This practice should only be used on sites with soils which are well or moderately well drained. Must use special materials for high traffic areas	Potential risk to groundwater due to oils, greases, and other substances that may leak onto the pavement and leach into the ground.	Provides soil infiltration, attenuation of peak flows, reduction in the volume of runoff leaving the site and entering storm sewers, and groundwater recharge.	Moderate	Low to moderate	Pretreatment of storm water is recommended where oil and grease or other potential groundwater contaminants are expected. Avoid areas with potential hazardous material contamination	MDOT, East Grand Rapids - Reed's Lake boat launch	http://www.deq.state.mi.us/documents/deq-swq-nps-pap.pdf
FILTRATION (ex. sand filters)																
Vegetated Swale or Bio-filtration	A broad, shallow channel consisting of dense vegetation and designed to accommodate concentrated flows without erosion.	Sediment	High; 75% - 80% of total suspended solids (2)(4); 50% of total phosphorous (4)	Storm water runoff	Native vegetation	20-50 years	Moderate; Remove and dispose of sediment, trash and debris, and repair erosion.	Moderate	Highly applicable to residential areas, not suited to steep slopes	Potential to contaminate groundwater	Slows flow	Low; $0.50/square foot of swale (7)	$0.03/square foot/year. (7)	Does not require a large land area. Should not be used in steep areas or well head areas. Soils adequate for infiltration required to discourage ponding on slopes less than 2%.	MDOT	
Sand Filters	Area designed to hold and treat the first half inch of runoff discharging from an adjacent impervious area.	Sediment, Bacteria, Nutrients, Metals	Moderate; 83% TSS removal rate (2)	Storm water runoff		Yet to be determined	Moderate to high depending on amount of sediment	Moderate	Suitable for individual developments; requires less land and can be placed underground.	Will not filter soluble nutrients and toxics		Low to moderate	5% of initial construction costs (1)	BMP performance is still experimental		
AGRICULTURAL BMPS																

Structural and Vegetative Best Management Practices

BEST MANAGEMENT PRACTICE	DESCRIPTION	POLLUTANT ADDRESSED	POLLUTANT REMOVAL EFFICIENCY	POTENTIAL SOURCES OF POLLUTANTS	ADDITIONAL BMPS TO COMPLETE TREATMENT TRAIN	EXPECTED LIFE SPAN	MAINTENANCE REQUIREMENTS	TRAINING REQUIREMENTS	APPLICABILITY TO SITE	ENVIRONMENTAL CONCERNS	HYDROLOGIC EFFECTS TO CONSIDER	INSTALLATION COSTS	OPERATION AND MAINTENANCE COSTS	SPECIAL CONSIDERATIONS	COMMUNITIES USING BMP	MDEQ/ NRCS LINK
Cattle Exclusion (NRCS practices: Use Exclusion (472), Fence (382))	Fencing to exclude cattle from waterbodies and protect streambanks. Fencing prevents cattle from trampling banks, destroying vegetation, depositing waste in the stream, and stirring up sediment in the streambed.	Sediment and attached pollutants, nutrients, pathogens	Moderate to high (12)	Livestock access, animal manure	Buffer/filter strip, alternative water sources for livestock, planned grazing system, stream crossing and livestock access	10 years (use exclusion) (15) 20 years (fence) (9)	Repair fence as needed. Remove off-stream watering systems in the winter, if needed.	NRCS available for assistance	Widely applicable	Increased grazing in confined areas may reduce vegetative cover	Fencing in floodplain may catch debris and restrict flow -	$1.90/ft of fence (9) - EQIP (use exclusion) WHIP (fence)	$0.05/ft of fence (9)	Additional BMPs (e.g. Buffer/Filter Strips) are needed to prevent animal waste runoff from entering the stream.	Typical in counties of the LGRW (e.g. Barry County)	ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/472.pdf ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/382.pdf
Agricultural Waste Storage Facility (313)	A waste storage impoundment that protects water bodies from manure runoff by storing manure until conditions are appropriate for field application. Several options exist including an earthen storage pond, above or below ground tank, pit underneath a confinement facility, or a sheltered concrete slab area. Allows for field application when conditions are right. Field application cuts fertilizer costs and reduces nutrient losses.	Nutrients, pathogens	Moderate (organics and fertilizers) (12)	Animal manure	Cattle exclusion fencing, roof runoff management, diversion, Comprehensive Nutrient Management Plan (CNMP)	15 years (15)	Inspect storage structures for leaks or seepage periodically and make necessary repairs. Repair any damaged fences immediately. Empty storage structure twice a year.	NRCS available for assistance	Widely applicable	Leaks or seepage of the structure could add nutrients and bacteria to downstream water bodies via runoff.		Approximately $10,000 - 250,000 (14) - (12) - EQIP	$250 - 1,000 maximum (14)	Storage period should be determined by manure use schedule and application rates.	Typical in counties of the LGRW (e.g. Barry County, Ottawa County)	ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/313.pdf
Alternative Water Sources (Watering Facility (614), Water Well (642))	A readily available source of clean drinking water for cattle located away from water bodies. Reduces the direct deposition of cattle waste into water bodies by changing animal behavior through providing alternate drinking water.	Sediment and attached pollutants, nutrients, pathogens		Livestock access, animal manure	Cattle Exclusion Fencing, buffer/filter strip, planned grazing system, stream crossing and livestock access	10 years / watering facility (15) 20 years / water well (15)	Watering facility: check for materials in the trough which may restrict the inflow or outflow system; check for leaks and repair immediately; check the automatic water level device to insure proper operation. Water well: create a maintenance plan including a log of identified problems, corrective actions taken, etc.	NRCS available for assistance	Widely applicable	Depending on the structure, it may not protect watercourse if contiguous with it.	Diversion of water	$1,050 / water facility (11) - EQIP	2% original cost (watering facility) (11) 1% original cost (water well) (11)	Areas adjacent to source that will be trampled by livestock should be graveled, paved, or otherwise treated to provide firm footing and reduce erosion.	Typical in counties of the LGRW (e.g. Barry County, Ottawa County)	ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/614.pdf ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/642.pdf
Cover Crop (340)	A crop of close-growing, grasses, legumes, or small grain grown primarily for seasonal protection and soil improvement. It usually is grown for 1 year or less, except where there is permanent cover as in orchards. Temporarily protects ground from wind / water erosion, adds organic matter to the soil, recycles or holds nutrients, improves soil tilth, reduces weed competition, retained soil moisture by acting as a mulch, and fixes atmospheric nitrogen (legumes).	Sediment and attached pollutants, nutrients, chemicals (pesticide), hydrologic flow, chloride (salt)	High (sheet, rill, wind, gully irrigation induced erosion, runoff/ flooding) (12) Moderate (salts, organics, fertilizers, pesticides) (12)	Soil erosion, agricultural runoff	Pest management, nutrient management, conservation crop rotation, crop residue management	1 year (9)	Plant cover crop annually, kill cover crop in the spring, restrict grazing if necessary	NRCS available for assistance	Widely applicable. Consider soil type, slopes, etc.	Requires pest management (IPM) to ensure that pesticide use is not increased	Significant decrease in runoff/ flooding, moderate reduction in excess subsurface water	$30/acre (9) - EQIP	$0/acre (9)	Requires livestock for feed use or market for hay	Organic Farmers of the LGRW	ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/340.pdf
Windbreak/Shelterbelt Establishment (380)	Rows of trees and shrubs that protect areas from wind and provide food and cover for wildlife. Reduces wind erosion, conserves energy, provides food and cover for wildlife, and beautifies a farmstead.	Sediment and attached pollutants	High (wind erosion only) (12)	Soil erosion	Cattle exclusion fencing	15 years (9)	Control competing vegetation, inspect regularly	NRCS available for assistance	Widely applicable	Over application of herbicides or pesticides possible	Will reduce storm water runoff and increase infiltration	$150 - 1,000 seedlings (13) - EQIP, WHIP	10% of original cost (11)	Consider if the mature windbreak will cast a shadow over the driveway or nearby road, prolonging icy conditions.	Muck farmers in Barry, Kent, Ottawa, and Allegan Counties	ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/380.pdf
Conservation Cover (327)	Establishing and maintaining perennial vegetative cover to protect soil and water resource on land retired from agricultural production. Reduces erosion and increases soil tilth due to perennial cover establishment of species adapted to site. Improves water quality when nutrients and sediments are retained on the field. Reduces weed sources. Wildlife food, cover, and water needs will be met.	Sediment and attached pollutants, hydrologic flow, nutrients	High (sheet, rill, wind, gully erosion; runoff/ flooding) Moderate (streambank erosion) (12)	Soil erosion, agricultural runoff	Upland wildlife habitat management, wildlife food plot, tree/shrub establishment	10 years (15)	If necessary, mow during the establishment period to reduce competition from annual weeds. Annual mowing of the conservation cover stand for general weed control is not recommended. Control noxious weeds.	NRCS available for assistance	Widely applicable	Over application of herbicides or pesticides possible	Significant decrease in runoff/ flooding, moderate reduction in excess subsurface water	$260 - 460/acre (9) - CRP, EQIP	$35/ acre (9)	Use of fertilizers, pesticides and other chemicals should not compromise the intended purpose. Maintenance practices and activities should not disturb cover during the primary nesting period for grassland species in each state.	Typical in counties of the LGRW (e.g. Barry and Ionia County)	ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/327.pdf
Pasture and Hayland Planting (512)	Planting grass and legumes to reduce soil erosion and improve production in a low-producing pasture, hayfield, or eroding cropfield. Reduces soil erosion by wind and/or water, extends length of the grazing season, provides cover and habitat for wildlife, protects water quality by filtering runoff and increasing filtration, and adds organic matter to the soil	Sediment and attached pollutants, nutrients, chemicals (pesticides), hydrologic flow	High (sheet, rill, wind ephemeral gully, irrigation inducted erosion; fertilizers, pesticides, runoff/ flooding) (12)	Soil erosion, agricultural runoff	Nutrient management, pest management, prescribed grazing	10 years (9)	Mow weeds, apply fertilizer and herbicide as needed	NRCS available for assistance	Widely applicable. Consider soil type	Over application of herbicides or pesticides possible	Significant decrease in runoff/ flooding and excess subsurface water	$75/acre (11) - EQIP, CRP	5% of original cost per unit (11)	Do not mix warm and cool season grasses in the same pasture. Choose species that will help reduce the use of pesticides and herbicides.	Typical in counties of the LGRW	ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/512.pdf

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Critical Area Planting (342)	Establishing permanent vegetation on sites that have or are expected to have high erosion rates, and on sites that have physical, chemical or biological conditions that prevent the establishment of vegetation with normal practices. Stabilizes areas with existing or expected high rates of soil erosion by water and wind. Restores degraded sites that cannot be stabilized through normal methods.	Sediment and attached pollutants, salts	High (sheet, rill, wind, gully, streambank, soil mass movement, road bank/construction erosion) (12) Moderate (salts) (12)	Soil erosion, agricultural runoff	Diversions, riprap, grade stabilization structures, filter/buffer strips, subsurface drains, grassed waterways, nutrient management	10 years (9)	Periodic burning (if needed), prohibit grazing until year 2, prevent overgrazing, inspect after severe storms	NRCS available for assistance	Widely applicable. Consider soil type, slopes, etc. Apply on any area which is difficult to stabilize.	Use of non-native or invasive species is not recommended. Use by recreational users may degrade area.	Will reduce the velocity of storm water runoff and increase infiltration.	$460 - $815/acre (2001 and 2004) EQIP, WHIP, WRP	1 % of original cost per unit (11)	Use native plants with low long term maintenance requirements. Soil tests should be done to determine the nutrient and pH content of the soil.	Typical in counties of the LGRW (e.g. Ottawa County)	ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/342.pdf
Grassed Waterway (412)	The establishment and shaping of grass in a natural drainageway to prevent gullies from forming. Vegetation filters runoff and provides cover for wildlife.	Sediment and attached pollutants, hydrologic flow	High (ephemeral gully erosion) (12) Low (reduction in classic gully erosion, runoff/ flooding) (12)	Soil erosion, agricultural runoff	Grade stabilization structure	10 years (9)	Yearly regrading, reseeding, and inspection of subsurface drain and related outfall may be needed. Fertilize as needed and mow periodically.	Design and installation should be done by a professional. NRCS available for assistance.	Widely applicable	Better conveyance enhances storm water runoff velocities and possible contamination to surface waters	Drainageway directs runoff to an outlet	$800/acre (without tile) (9) $4,500/acre (with tile) (9) CRP, EQIP	$105/acre (9)	A nurse crop, temporary cover or mulching may be necessary until permanent cover is established. Avoid planting end rows along the waterway.	Typical in counties of the LGRW	ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/412.pdf
Diversion (362)	Earthen embankment that directs runoff water from a specific area. Reduces soil erosion on lowlands. Vegetation filters runoff water and provides cover. Allows better crop growth on bottomland soils.	Sediment, nutrients, chemicals (pesticide), hydrologic flow	High (ephemeral gully erosion, runoff/ flooding) (12) Moderate (classic gully, soil mass movement, road bank/construction erosion) (12) Low (sheet, rill, streambank erosion, organics, fertilizers, pesticides) (12)	Soil erosion, agricultural runoff	Sediment basin or stabilized outlet, buffer/filter strip, nutrient management	10 years (9)	Clear outlet of debris, maintain vegetative cover on ridge, ridge repair, fertilize as needed	Design and installation should be done by a professional	Widely applicable. Do not build in high sediment producing areas unless other conservation measures are installed.	Over application of fertilizer possible	Catches storm water runoff and prevents it from reaching lowlands, reducing runoff velocity and increasing infiltration	$5.00/ft (9) - EQIP	$0.26/ft (9)	Important as SESC in developing sites. Each diversion must have an outlet.	?	ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/362.pdf
OTHER																
Abandoned Well Closures (Well Decommissioning (351))	Well decommissioning seals an abandoned well. Abandoned wells are wells which are no longer in use or are in such disrepair that groundwater can no longer be obtained from them. Benefits include: a) Reduces the risk of groundwater contamination, b) Eliminates the risk of injury, c) Avoids liability under the Michigan Polluter Pay Law	Sediment and attached pollutants, chemicals, nutrients, chloride (salt), pathogens, hydrocarbons	High (13)	Agricultural runoff, hazardous waste spills	Stand alone practice	20 years (9)		High: Professional required. A drilled, deep bedrock and artesian wells should be closed by a licensed well driller. Farm*A*Syst available for assistance.	Widely applicable.	Groundwater contamination may already be present.	Will prevent surface water from reaching the groundwater supply via the abandoned well.	$50 - $500/closure - Michigan Groundwater Stewardship Program, MDA, EQIP	Low (14)	Filling a well with rocks/gravel won't reduce the groundwater contamination risk. Technical assistance is required to properly close an abandoned well.	Spring Lake Village, Ionia and Barry County	ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/351.pdf
Streambank and Shoreline Protection (580)	Treatment(s) used to stabilize and protect banks of streams or constructed channels, and shorelines of lakes, reservoirs, or estuaries, such as bioengineering, rip rap, geotextile materials, and vegetative techniques.	Sediment and attached pollutants	High (streambank erosion, soil mass movement) (12)	Soil erosion	Livestock exclusion, prescribed grazing, buffer/filter strips, diversions, or additional sediment control measures.	20 years (9)	Site inspections conducted to ensure the stream bank structures are staying in place within the first few months of installation and following storm events.	Consult the MDEQ (Water Division or Land Division), local Conservation District, NRCS, or other agencies or consultants.	Widely applicable: site-specific practices will depend on soil type, slope of the bank, river gradient, flow, and uses of the watercourse.		Maintains the capacity of the stream channel.	EQIP: 50% cost share (15)	10% of original cost (11)	Since each reach of a watercourse is unique, stream bank protection techniques must be selected on a site-by-site basis; the specifications for each technique differ. Utilize vegetative species that are native and/or compatible with local ecosystems.	Barry County Drain Commission	ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/580.pdf
Dam Removal	Releases made from dams commonly cause a decrease in summer temperatures and an increase in winter temperatures downstream. Dam removal benefits fish by: (a) removing obstructions to upstream and downstream migration; (b) restoring natural riverine habitat; (c) restoring natural seasonal flow variations; (d) eliminating siltation of spawning and feeding habitat above the dam; (e) allowing debris, small rocks and nutrients to pass below the dam, creating healthy habitat; (f) eliminating unnatural temperature variations below the dam; and (g) removing turbines that kill fish.	Thermal pollution		Dam	Will depend on the effects of dam removal. Streambank stabilization may be necessary.	Permanent		Design and removal should be done by a professional	Widely applicable to unsafe dams and dams that no longer serve a purpose.	Recent studies show removal of small dams can have limited negative environmental impacts while restoring stream functions. Negative impacts include elevated sediment loads in addition to transformed channel morphology and hydrology. Dam removal may also wreak havoc on already highly disturbed ecosystems. Reservoirs that store high levels of contaminants may release them following dam removal, creating a contaminant plume.	Dam removal will restore natural stream flow and natural seasonal flow variations.	A number of studies (River Alliance of Wisconsin 2003, American Rivers 2003) have found removal costs to be up to 1/3 to 1/5 the cost of repair, especially when the benefits of the dam are minor. Funding sources include: private or community foundation funding, environmental grants, and state or federal assistance programs.	None	Many aging dams are no longer economically practical or cost-effective to operate. Similarly, dam operation and maintenance costs tend to increase as a dam ages. These increased costs, combined with the potentially lower revenue, allow for removal to become the most cost-effective alternative for the dam owner.	Stronach Dam, on the Pine River, Manistee County Big Rapids Dam on Muskegon River, Mecosta County	

Structural and Vegetative Best Management Practices

BEST MANAGEMENT PRACTICE	DESCRIPTION	POLLUTANT ADDRESSED	POLLUTANT REMOVAL EFFICIENCY	POTENTIAL SOURCES OF POLLUTANTS	ADDITIONAL BMPS TO COMPLETE TREATMENT TRAIN	EXPECTED LIFE SPAN	MAINTENANCE REQUIREMENTS	TRAINING REQUIREMENTS	APPLICABILITY TO SITE	ENVIRONMENTAL CONCERNS	HYDROLOGIC EFFECTS TO CONSIDER	INSTALLATION COSTS	OPERATION AND MAINTENANCE COSTS	SPECIAL CONSIDERATIONS	COMMUNITIES USING BMP	MDEQ/ NRCS LINK
Stabilized Outlets	Outlets are areas which receive discharge water. Stabilized outlets are outlets which reduce the velocity of discharge water to non-erosive velocities. Stabilized outlets help reduce erosion in the area where water is released. Some outlets may also provide treatment of various types of pollutants. Types of outlets include: Conveyance Outlets (Grassed Waterway, Stone Filters, Stormwater Conveyance Channel); Water Storage Outlets (Sediment Basin, Infiltration Basin, Detention/ Retention Basin, Oil/Grit Separators, Wet ponds and wetlands); Conduits; and Outlet Protection.	Sediment and attached pollutants, hydrologic flow	Dependent on type of outlet used.	Storm water runoff, streambank erosion	Riprap, if needed	Dependent on type of outlet used.	Requires regular maintenance.	Stabilized outlets should be designed by a registered professional engineer.	Widely applicable.	If outlets are not maintained, excessive sediment may be introduced to surface waters downstream.	Stabilized outlets will reduce the velocity of discharge water to non-erosive levels.	Dependent on type of outlet used.	Dependent on type of outlet used.	If the outlet is a county or intercounty drain, permission to discharge must be obtained from the drain commissioner or drain board. The actual structure may require a MDNR permit if the outlet is in a watercourse or if wetlands are impacted.		http://www.deq.state.mi.us/documents/deq-swq-nps-so.pdf
Emergency Spill Kit	Kit materials capture oil, gasoline, and diesel spills on water.	Hydrocarbons		Boat spill					Applicable to lakes							
Pond Construction and Management (378)	A water impoundment made by constructing an embankment or by excavating a pit or dugout. Excavated ponds are made for conditions which require a small supply of water such as a golf course hazard. Embankment ponds hold larger volumes of water. Ponds can be used for storm water management and to attract wildlife. Properly designed and maintained embankment ponds provide a safe, reliable means of water supply, and may become the settling area for sediment and contaminants in the drainage area. If water quantity is more critical than quality, runoff can be used to maintain higher pond levels of an excavated pond.	Sediment and attached pollutants, chemicals, nutrients, flooding	Low (gully erosion, streambank erosion, flooding) None (sheet and rill erosion) N/A (chemicals, nutrients)	Storm water runoff	Slope/Shoreline Stabilization, Seeding, Mulching, Sodding, Pond Sealing or Lining	20 years (2004)	Moderate to High	Design and installation should be done by a professional	Depends on soil suitability. Build ponds in areas where the water supply is adequate for the intended use.	Purple loosestrife (Lythrum salicaria) is an undesirable, exotic perennial which often becomes established in disturbed sites.	Ponds can be used for storm water management.		1% of original cost per unit (2001)	For excavated ponds, consider drainage characteristics, including depth to the water table. For embankment ponds, consider upstream drainage characteristics and how the pond will affect downstream flows, temperatures, etc.	City of Grand Rapids, Barry and Ionia Counties	
Composting Facility (317)	A facility for the biological stabilization of waste organic material. The purposed is to treat waste organic material biologically by producing a humus-like material that can be recycled as a soil amendment and fertilizer substitute or otherwise utilized in compliance with all laws, rules, and regulations. Keeps organic debris out of surface waters and away from floodplains, which helps prevent the depletion of oxygen in surface waters.	Nutrients, low DO		Upland source (yard trimmings and kitchen waste)	NA	15 years / composting facility (2004)	Composting requires proper aeration, watering and mixing in order to result in a useable end-product. Product can be sold, delivered, and applied.	Design and installation should be done by a professional	Widely applicable to dense residential or riparian sites. Soils, topography and climate will all affect the types of composting options available.	Waste needs to be composted and correctly applied as fertilizer. Runoff from compost application may contaminate surface waters.	NA	$37,000/ composting facility (2004)	Annual Maintenance: $370/ year /composting facility (2004)	As of March 27, 1993, yard waste collected or generated in Michigan on public property is banned from land fills and incinerators.	Green Rock Landscape Supply, Rockford Phoenix Resources, Alto Eagle Ottawa Leather Company, Grand Haven	
Mulching (484)	The process of placing a uniform layer of straw, wood fiber, wood chips or other acceptable materials over a seeded or landscaped area. Helps keep soil particles and their associated attached chemicals (e.g. phosphorus & pesticides) from entering surface waters. Will suppress weed growth and provide a moist area for vegetative growth.	Sediment and attached pollutants	Low to moderate	Soil erosion	Seeding, Soil Management, Fertilizer Management, Grading Practices, Diversions (if needed).	1 year (2004)	Low - inspect mulched areas following storm events to ensure mulch has stayed in place.	Low	Widely applicable	None known.	Seeded area will eventually reduce the velocity and increase infiltration of storm water runoff.	$3.00/acre (2001)	Annual Maintenance: 100% of original cost per unit (2001)	Mulch should be applied immediately after seeding has occurred. Anchoring of the mulch should be done immediately after the mulch is applied.	City of Grand Rapids, Barry County Drain Commission	
Riprap	A permanent cover of rock used to stabilize stream banks, provide in-stream channel stability, and provide a stabilized outlet below concentrated flows. The use of riprap protects stream banks and discharge channels from higher erosive flow velocities and decreases sediment input to a watercourse.	Sediment and attached pollutants	High	Soil erosion, agricultural runoff	Filters. (Riprap is often used in making Stabilized Outlets, in Stream bank Stabilization, etc.)	10 + years (SV)	Low - Periodically inspect underlying fabric, adjust and add riprap as needed.	Low - consult technical resources	Widely applicable: Riprap is most often used in stream banks, on slopes, and at outlets.	Potential to cause additional erosion downstream.	Reduces downcutting and lateral cutting of erosive flow velocities. Typically not a significant velocity reducer.	$70/square yard (2003b) Including geotextile		MDEQ permit may be required if placed in waters of the state. Explore downstream impacts.	Road Commissions	

1. Evaluation of Best Management Practices for MDOT, 2002.
2. Source Area and Regional Storm Water Treatment Practices, Bannerman.
3. Guidebook of Best Management Practices for Michigan, MDEQ, 1996.
4. National Pollutant Removal Performance Database, EPA, June 2000.
5. Hydro-Compliance Management, Inc.
6. Governmental Accounting Focus, Estimating Useful Lives for Capital Assets.
7. Rouge River National Wet Weather Demonstration Project, 2001
8. Rain Gardens, Beautiful Solutions for Water Pollution, Rain Gardens of West Michigan, 2003
9. Field Office Technical Guide, Section 1 Cost Information (draft). USDA-NRCS-MICH, 2004
10. Michigan Area 3 Component Data, USDA-NRCS, June 2003
11. [Michigan] Sample County Practice and Maintenance Costs, USDA-NRCS-MICH, 2001
12. Conservation Practice Physical Effect Worksheet[s]. USDA-NRCS, 2004
13. Information provided by the Technical Committee of the Lower Grand River Watershed Project, 2004
14. Personal Communication with District Conservationalist of the NRCS Grand Rapids Service Center, 2004
15. FY04 Michigan EQIP Statewide Eligible Practice List, Land Management Practices (Incentive Payments), USDA-NRCS-MICH, 2004

APPENDIX G MANAGERIAL BEST MANAGEMENT PRACTICES

Managerial Best Management Practices

BEST MANAGERIAL PRACTICES	DESCRIPTION	BENEFIT	POLLUTANT ADDRESSED	POTENTIAL SOURCES OF POLLUTANTS	ENVIRONMENTAL IMPACTS AND SPECIAL CONCERNS	COMPARATIVE COSTS	COMMUNITIES USING BMP	MDEQ/ NRCS LINK
AGRICULTURAL								
Crop Residue Management (329A-C, 344), includes no till, mulch till, ridge till, and seasonal	Leaving last year's crop residue on the surface before and during planting operations, providing soil cover at a critical time of the year. The residue is left on the surface by reducing tillage operations and turning the soil less. Pieces of crop residue shield soil particles from rain and wind until plants can produce a protective canopy.	Ground cover prevents soil erosion and protects water quality. Residue improves soil tilth and adds organic matter to the soil as it decomposes. Fewer trips and less tillage reduces soil compaction.	Sediment and attached pollutants	Agricultural runoff, soil erosion	Consider if crop will produce enough residue. Planning for residue cover should begin at harvest. Time, energy, and labor savings are possible with fewer tillage trips. Equipment for specialized tillage techniques needed. Additional chemical treatments may be necessary to control pests. Assistance available from USDA office or Conservation District. No local government controls in place. Crop reside reduces the velocity of storm water runoff and improves infiltration	$28-36/acre (includes no-till and strip till, ridge till) (11). Maintenance costs are 100% of original cost (11). Environmental Quality Incentive Program (EQIP) (for mulch till, ridge till, and seasonal residue management). Equipment rental or purchase $40+ per acre. Consider costs for pest control.	Typical in Counties of the Lower Grand River Basin (e.g. Kent County)	ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/329a.pdf ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/329b.pdf ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/329c.pdf ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/344.pdf
Conservation Crop Rotation (328)	A sequence of crops designed to provide adequate organic residue for maintenance or improvement of soil tilth and fertility. Other BMPs to use include nutrient and pest management, buffer/filter strips, cover crops	· Reduces sheet, rill, and wind erosion · Maintains or improve soil organic matter content · Manages the balance of plant nutrients · Improves water use efficiency · Manages saline seeps · Manages plant pests (weeds, insects, and diseases) · Provides food and cover for wildlife - Reduces fertilizer needs and may reduce pesticide needs	Sediment and attached pollutants	Soil erosion, agricultural runoff	Rotations that include grains, such as corn, or meadow provide better erosion control. Where excess plant nutrients or soil contaminants are a concern, utilizing deep rooted crops or cover crops in the rotation can help recover or remove the nutrient or contaminant from the soil profile. Over application of fertilizer or pesticide is possible. Plants will reduce the velocity of storm water runoff and increase infiltration.	$4.00/acre (11) - EQIP	Typical in Counties of the Lower Grand River Basin (e.g. Kent County)	ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/328.pdf
Planned Grazing System	Pasture is divided into two or more pastures or paddocks with fencing. Cattle are moved from paddock to paddock based on forage availability and livestock nutrition needs. Other BMPs to use include alternative water source, cattle exclusions, nutrient management, and soil testing	Improves vegetative cover, reduces erosion, and improves water quality by reducing sediment and nutrient runoff. Rotating also evenly distributes manure and nutrient resources.	Sediment and attached pollutants, nutrients, pathogens	Soil erosion, agricultural runoff	Keep fencing secure. Apply fertilizer and nutrients according to soil tests, mow or hay paddocks if needed, & update rotation schedule if needed. Practice is widely applicable. Consider adequacy of the mix of grass and legumes to meet livestock needs. Sediment and nutrient runoff is not eliminated just reduced. This practice will increase harvest efficiently and help ensure adequate forage throughout the grazing season.	EQIP can fund establishment. $25/acre for maintenance (14)	Typical in Counties of the Lower Grand River Basin (e.g. Kent County)	
Irrigation Water Management (449)	Determining and controlling the rate, amount, and timing of irrigation water in a planned and efficient manner. Other BMPs to use include Nutrient management, pest management, crop residue management, soil conservation measures	Management of the irrigation system should provide the control needed to minimize losses of water and discharge of sediment and sediment-attached and dissolved substances, such as plant nutrients and herbicides.	Sediment and attached pollutants, nutrients, hydrologic flow	Agricultural runoff	Poor management may allow the loss of dissolved substances from the irrigation system to surface or groundwater. There is an insignificant reduction in runoff/ flooding and slight reduction in excess subsurface water. Consider the effects irrigation water has on wetlands, water related wildlife habitats, riparian areas, cultural resources, and recreation opportunities.	EQIP can fund establishment.	Typical in Counties of the Lower Grand River Basin (e.g. Kent County)	ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/449.pdf
Contour strip cropping (585)	Crop rotation and contouring combined in equal-width strips of corn or soybeans planted on the contour and alternated with strips of oats, grass, or legumes. Other BMPs to use include field border, fertilizer management, grassed waterways.	Meadow slows runoff, increases infiltration, traps sediment and provides surface cover. Ridges formed by contoured rows slow water flow which reduces erosion. May reduce fertilizer costs.	Sediment and attached pollutants, hydrologic flow	Agricultural runoff, soil erosion	Keep strip widths consistent from year to year. Make adjustments in rotation schedule if needed. Over application of fertilizer possible, if used. Will reduce the velocity of storm water runoff and increase infiltration. Strip cropping is not as effective if crop strips become too wide, especially on steep slopes.	$10.00/acre (9) - EQIP	Typical in Counties of the Lower Grand River Basin (e.g. Kent County)	ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/585.pdf
Contour farming (330)	Hillsides are cultivated and planted in rows along the hillside contour, not up and down the hill. Crop row ridges on the contour create hundreds of small berms. Other BMPs to use include field border, grassed waterways, and terraces or strip cropping if needed.	Reduces sheet and rill erosion and transport of sediment and other water-borne contaminants. Ridges, built by tilling and planting on the contour, slow water flow and increase infiltration, which reduces erosion by as much as 50% from up and down hill farming.	Sediment and attached pollutants, hydrologic flow	Agricultural runoff, soil erosion	To avoid having to lay out new contour lines every year, establish a narrow permanent strip of grass along each key contour line. All tillage and planting operations should be performed parallel to the key contour line. Contour farming will reduce the velocity of storm water runoff, increase infiltration, moderately decrease runoff/ flooding, and slightly increase excess subsurface water. Contouring is less effective in preventing soil erosion on steeper or longer slopes.	$10.00/acre (9)	Typical in Counties of the Lower Grand River Basin (e.g. Kent County)	ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/330.pdf

Managerial Best Management Practices

BEST MANAGERIAL PRACTICES	DESCRIPTION	BENEFIT	POLLUTANT ADDRESSED	POTENTIAL SOURCES OF POLLUTANTS	ENVIRONMENTAL IMPACTS AND SPECIAL CONCERNS	COMPARATIVE COSTS	COMMUNITIES USING BMP	MDEQ/ NRCS LINK
Pest Management (595)	Crops are scouted to determine type of pests and the stage of development. The potential damage of the pest is then weighed against the cost of control. Finally, if pest control is economical, all alternatives are evaluated based on cost, results, and environmental impact. Precaution is taken to keep any chemicals from leaving the field by leaching, runoff, or drift. Other BMPs include buffer/filter strips, crop rotation, and erosion control measures.	Treatments tailored for specific pests on identified areas of a field prevents over-treatment of pests. Using fewer chemicals improves water quality.	Chemicals (Pesticide)	Agricultural runoff	Continual scouting to best identify pests and control methods. Keep records to track costs and chemical application. Calibrate spray equipment. Consider which soils on farm are likely to leach pesticides. Consider pest control alternatives.	100% of cost/unit (11) - EQIP		ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/595.pdf
Nutrient Management (590) (Comprehensive Nutrient Management Plan (CNMP))	Crop nutrient needs are determined after a soil test, setting realistic yield goals, and taking credit for contributions from previous years' crops and manure applications, crop nutrient needs are determined. Nutrients are then applied at the proper time by the proper application method. Nutrient sources include animal manure, sludge, and commercial fertilizers. Other BMPs include manure testing, soil testing, soil conservation measures, waste management system, waste storage facility, and waste utilization.	This practice properly budgets and supplies nutrients for plant production. It also reduces the potential for nutrients to infiltrate into water supplies by preventing over application. Correct manure and sludge application on all fields can improve soil tilth and organic matter. It is very applicable on Concentrated Animal Feeding Operations (CAFOs).	Nutrients	Agricultural runoff, over application of fertilizers.	Maintenance requirements: - Perform a periodic plan review to determine necessary adjustments - Protect nutrient storage facilities from weather and accidental leakage/spillage - Calibrate application equipment and document application rates - Spread wastes away from waterbodies on an adequate land base and incorporate ASAP - Analyze manure and other organic waste for nutrient content before field application and determine appropriate application rate - Test soils once every three years according to Extension recommendations - Establish a winter cover crop if nitrogen leaching is possible due to poor crop yield * Consider the Michigan Agriculture Environmental Assurance Program (MAEAP). The CNMP must be developed by a trained technical person (service provided by NRCS or Conservation District). Consider potential groundwater contamination - proximity to waterbodies critical.	$5.00/acre (9) - EQIP (Costs associated with waste water collection, soil testing, Integrated Crop Management are low but have a high start up.)	Typical in Counties of the Lower Grand River Basin (e.g. Kent County)	ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/590.pdf
Organic Farming Practices	Organic farming differs from other farming systems in a number of ways. It favors renewable resources and recycling, returning to the soil the nutrients found in waste products. Where livestock is concerned, meat and poultry production is regulated with particular concern for animal welfare and by using natural foodstuffs. Organic farming respects the environment's own systems for controlling pests and disease in crops and livestock. Organic farmers use a range of techniques that help sustain ecosystems and reduce pollution. Other BMPs include filter/buffer strips, crop rotation, organic manuring, composting, limited chemical intervention, conservation of wildlife and natural habitats, management of livestock, recycling of organic materials.	Organic farming conserves biodiversity, provides a wide range of habitats, saves energy, improves soil fertility, and protects groundwater and surface waters from nitrates, phosphates, and pesticides. Organic food is grown without using any synthetic pesticides, herbicides, insecticides, fungicides, fertilizers, or hormones.	Nutrients, chemicals (pesticides)	Agricultural runoff	Organic farming methods are usually more labor intensive than conventional farming, so the cost of organic farming will usually be more.	EQIP funds supporting practices such as cover crops, conservation crop rotation, nutrient management, pest management.	Roseland Organic Farms, Cassopolis, MI FOGG Organic Farmers and Market, Leslie, MI	
Soil testing of cropland	For proper management, a soil test for available nutrients should be made every 3-5 years. Use Integrated Crop Management (ICM)	Testing will help prevent over application of nutrients from fertilizers, manures and other sources.	Nutrients	Agricultural runoff.	Soil should be tested to determine nutrient levels. Care should be taken to not add nutrients already present in adequate levels. Soil testing should be undertaken by lab or local MSU Extension office. Proper collection of a soil sample is important. Accuracy of analysis depends on the collection of a representative soil sample.	Costs associated with Integrated Crop Management (ICM). Typically a yearly expense. Low cost technique of monitoring soil. EQIP	Prevalent on agricultural land in rural communities. Typical in Counties of the Lower Grand River Basin.	

Managerial Best Management Practices

BEST MANAGERIAL PRACTICES	DESCRIPTION	BENEFIT	POLLUTANT ADDRESSED	POTENTIAL SOURCES OF POLLUTANTS	ENVIRONMENTAL IMPACTS AND SPECIAL CONCERNS	COMPARATIVE COSTS	COMMUNITIES USING BMP	MDEQ/ NRCS LINK
Agriculture Incentive Programs	Farm Bill programs that offer a rental payment to landowners that agree to take environmentally sensitive areas out of production. Continuous sign-ups for these programs are available to riparian and wetland areas. Rental rates are set by county boards.	Creates incentive for landowners to conserve riparian buffers, wetlands, and wildlife habitats.	Sediment, nutrients, hydrologic flow, pathogens, chemicals (pesticides)	Agricultural runoff	Property enrolled in Farm Bill programs are not protected in perpetuity. Fertilizer cannot be applied to areas under contract. In some cases, land values or crop yields may discourage landowners to use these incentive programs.	In some counties soil rental rates can be very high.		http://www.nrcs.usda.gov/programs/
ZONING ORDINANCES/LAND USE POLICIES								
Development/Enforcement of Storm Water Ordinance	Ordinance can provide for the regulation and control of storm water runoff; provide for storm water permits and the procedures and standards for the issuance; provide regulations for the inspection, sampling and monitoring of storm water and other discharges; establish performance and design standards for storm water management in specified zones of the Township/Municipality; and provide penalties for the violations of the ordinance.	Storm water runoff rates and volumes are controlled in order to protect floodways. Controls soil erosion and sedimentation; minimizes deterioration of existing watercourses, culverts, bridges, etc.; and encourages groundwater recharge.	Sediment and attached pollutants, hydrologic flow	Storm water runoff	Establishing storm water management control will minimize storm water runoff rates and volumes from identified new land development and encourage groundwater recharge. Proposed Model Storm Water Ordinance for Kent County recommends the following release rates: 0.05 cfs/acre for a 2-year storm event for Zone A; 0.13 cfs/acre per Kent County Drain Commission rules for Zone B	$8,000/ordinance development (Grand Valley Community Survey)	Algoma, Cannon, and Courtland Townships of Kent County	
Development/Enforcement of Stream Buffer Ordinance	Ordinance protects a given area of buffer adjacent to stream systems. Protected buffers can provide numerous environmental protection and resource management benefits.	Moderate to high. Reduces the risk of sediment and contaminants entering the stream. Provides long term solution to water quality concerns.	Sediment and attached pollutants, nutrients, thermal pollution	Storm water runoff from impervious surfaces (e.g. parking lots and roof tops) and outflow from ponds.	Lack of maintenance can increase erosion if trees fall into streams. At a minimum, keep south and west sides of streams wooded to provide shade. Trees in floodway can impede flow.	$8,000/ordinance development (Grand Valley Community Survey)	Cannon Township	
Development/Enforcement of Wetland Ordinance	Ordinance promotes a policy to avoid or minimize damage to wetlands and coordinate the planning and zoning process with federal and state wetland programs.	Wetland benefits are preserved. Wetlands provide natural pollution control by removing pollutants, filtering and collecting sediment, reducing both soil erosion and downstream flooding, and recharging groundwater supplies.	Sediment and attached pollutants, hydrologic flow, nutrients, pathogens, chemicals (pesticides), salts	Storm water runoff	Part 303, section 324.30307 authorizes local units of government to adopt and administer their own wetland regulations that address wetlands not protected by the state, provided they are at least as restrictive as state regulations. The DEQ must be notified if a community adopts a wetland ordinance, but it has no review or approval authority.	$8,000/ordinance development (Grand Valley Community Survey)	Salem Township	
Green Space Protection Ordinance	Ordinance preserves environmentally sensitive and open areas. Can also use filter strips and tree planting to enhance protection.	High if properly executed. Provides protection of natural pollutant removal methods.	Thermal pollution, sediment, nutrients, hydrologic flow	Construction zones, developed parcels, agricultural land		$3/sqft. Land acquisition and management costs depend on site. Affected property may double as park/open space usage with related costs.	Ottawa County Parks and Recreation Commission, Land Conservancy of West Michigan	
Low Impact Design Practices	Land use planning to incorporate practices on-site. Examples include: bioretention, dry wells, filter strips, vegetated buffers, grass swales, rain barrels, cisterns, infiltration trenches. Involves careful site planning to reduce the impact to water resources by eliminating impervious surfaces and protecting infiltration areas.	Numerous water quality benefits. Long term solution to concerns.	Thermal pollution, solids, sediments, nutrients, metals	Rainfall, runoff, solar, fertilizers				http://www.lid-stormwater.net/
Illicit Discharge Ordinance (MDOT)	Program to seek out and prohibit illicit discharges and connections to municipal separate storm sewers	High if properly executed. Eliminate hazardous and harmful discharges	Hazardous wastes	Industrial, residential, commercial		$2/ac (assuming 1 system monitored every 5 sq. miles). Maintenance program. $0.83/acre/year, $50/ac/yr (with TV inspection)	Phase II communities, MDOT	
Pet waste disposal ordinance	Ordinance to require pet owners to clean up after their pets. Can be enhanced by installing signs and pet waste collection facilities in high traffic areas	Moderate	Nutrients, bacteria	Animals, dogs or other household pets				
Development/Enforcement of Septic System Ordinance	Ordinance abates water pollution caused by failing on-site sewage disposal systems; minimizes infiltration of seepage from systems into the storm water drainage system, and establishes penalties for its violation.	Ordinance can be used to enforce regular maintenance of disposal systems, which will minimize threats to public health and combat the degradation of surface and subsurface waters.	Bacteria	Septic systems	Lack of ordinance enforcement (regular inspection) can introduce pollution into groundwater reserves.	$8,000/ordinance development (Grand Valley Community Survey)	Wayne County	
Development/Enforcement of Yard and Kitchen Waste Ordinance	Ordinance prohibits the disposal of yard and kitchen waste on streambanks and outlines acceptable disposal methods, such as composting or disposal at a permitted disposal facility.	Proper disposal of yard and kitchen waste ensures that nutrients from these materials are not released into surface and groundwater supplies.	Nutrients	Upland source (yard/kitchen waste)	If yard and kitchen waste are composted on landowner's premises, nutrient runoff should not reach nearby surface water bodies.	$8,000/ordinance development (Grand Valley Community Survey)		
Development/Enforcement of Watercraft Control Ordinance	Ordinance prohibits the operator of a recreational watercraft to exceed a "slow - no wake" speed when within x feet of the shoreline.	Enforcing "no wake" zones will reduce streambank erosion.	Sediment and attached pollutants	Recreational watercraft	Issues concerning trespass, disorderly conduct, or damage caused to private property by the wake of vessels are not valid safety considerations for establishing a local ordinance.	$8,000/ordinance development (Grand Valley Community Survey)	City of Detroit (Detroit and Rouge River)	

Managerial Best Management Practices

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Public Access Ordinance	Ordinance controls access to a designated waterbody by limiting hours of access, number of users, etc.	By controlling public access to a waterbody, sediment pollution is reduced.	Sediment and attached pollutants	Public access, boat wakes	Consider using porous/ modular pavement at boat launches locations.	$8,000/ordinance development (Grand Valley Community Survey)		
Development/Enforcement of Fertilizer Ordinance	Ordinance prohibits the use of fertilizers containing more than 1% by weight of anhydric phosphoric acid.	Moderate; other sources of phosphorus may be present in the watershed.	Phosphorus	Fertilizers	Sources of low phosphorus fertilizers are few.	High: $8,000/ordinance development (Grand Valley Community Survey)	East Grand Rapids	
RECYCLING/COMPOSTING								
Household hazardous waste management	Proper buying, using, storing and disposal of Hazardous materials such as automotive waste, household cleaners and paint.	Moderate: eliminates disincentives and discourages illegal dumping of products into storm sewers and onto the ground	Hazardous wastes	Residents: Used oil, paints, cleaning products, etc.	Proper credentials needed for management. Typically consultant based.	Recycling station expenses.		http://www.deq.state.mi.us/documents/deq-swq-nps-hhhw.pdf
Composting	Converting plant debris, grass, leaves, pruned branches, etc. to compost. Use with lawn maintenance, pesticide and fertilizer management, and diversions (if needed)	Keeping organic debris out of surface waters and away from floodplains. Will help prevent the depletion of oxygen in surface waters. Widely applicable to dense residential or riparian sites.	Nutrients, chemicals, and pesticides, low dissolved oxygen, trash and debris	neighborhoods, agricultural areas, yard, and kitchen waste	Compost piles placed near floodplains will contribute to the depletion of oxygen in surface waters. Composting requires proper aeration, watering and mixing in order to result in a useable end-product. Soils, topography and climate will all affect the types of composting options available.	Recycling vs. garbage hauler costs. Establishment of large scale facility $190,000, land dependant. $70,000 annual maintenance.	Larger facilities are generally operated by private business. Ex: in Sec 36, Zeeland Township, Ottawa County	
Yard waste collection and disposal program	Municipalities collect yard waste for compost.	Widely applicable to dense residential or riparian sites	Nutrients and organic sediment, trash and debris	Yard waste and leaf litter	Waste needs to be composted and correctly applied as fertilizer. Need large collection facility for compost operations.	Low	Cascade Township, City of Wyoming, City of Kentwood, City of Grand Rapids, Byron Township, Ada Township, City of Coopersville, Georgetown Twp	
Recycling Program (MDOT)	Collection of recyclable materials either by curb-side pick up or at drop off centers	Reduction in potential clogging and harmful discharge	trash, used construction material reuse	Highways, travelers, vehicle debris	Some materials may require more energy to collect and recycle than using new products. However, recycling programs do build awareness	$200,000/year. $1.15/person/yr		
Used oil recycling program (MDOT)	Central collection facilities that allow residents to drop off used motor oil. Can be operated by local governments or businesses that recycle oil.	Reduces risk of surface water and groundwater contamination	Used oil and other transportation fluids reuse, hydrocarbons, metals, nutrients	Vehicle maintenance facilities. Vehicles or other equipment requiring lubrication.	Oil may easily become contaminated during collection making it a hazardous waste.	$79 - $179 recovery charge. Administrative costs to organize. Minimal personnel cost to collect and temporarily store oil. Opportunity to be paid by private business for waste material	MDOT, OCRC	
TURF MANAGEMENT								
Pesticide management for turf grass and ornamentals	Use of all available strategies (Resistant Turf, Cultural controls, Biological controls, Mechanical controls and Pesticides) to manage pests so that an acceptable yield and quality can be achieved economically with the least disruption to the environment. Used with lawn maintenance, fertilizer management, and soil management.	Moderate to high	Harmful chemicals, pesticides, insecticides	Landscaping, storm water runoff	Must have proper training and credentials to commercially apply pesticides and manage turf.	Pesticide management should reduce application rates and related costs.	Public parks, administrative offices thru out region. Typically private contractor based.	http://www.deq.state.mi.us/documents/deq-swq-nps-pm.pdf
Lawn maintenance	Includes mowing, irrigating, pesticide and fertilizer management, soil management and the disposal of organic debris such as lawn clippings and leaves.		Phosphorus, nutrients, and sediments	Landscaping, storm water runoff	Consider minimizing lawn with more native species	Lawn alternatives may reduce mowing but still require regular maintenance of weed control and pest management.		http://www.deq.state.mi.us/documents/deq-swq-nps-lm.pdf
Fertilizer management	Includes the proper selection, use, application, storage and disposal of fertilizers. Used with pesticide management, lawn maintenance, and nutrient management	Moderate;	Nutrients	Landscaping, storm water runoff	Consider consulting professional, such as Michigan State University Extension.	Material cost reduction may conflict with traditional aesthetic values. Fertilizer management should reduce chemical costs but may impact maintenance and watering.		http://www.deq.state.mi.us/documents/deq-swq-nps-fm.pdf
Soil testing of lawns and gardens			Nutrients	Lawn and garden fertilizer	Testing should be done at qualified lab	Typically yearly testing required, contact local MSU Extension office. Test results may result in operations and maintenance costs. Low cost tool in management of lawns and gardens. $9.50 per test.	Typically associated with private property or public administration sites.	
OPERATIONS & MAINTENANCE								
Operation and maintenance programs			Sediment, hydrocarbons, metals, nutrients	Erosion of road footprint and related infrastructure, leaking equipment, etc.		Labor intensive. Equipment required.	MDOT, OCRC and other Public Works Departments	
BMP Inspection and Maintenance Plan for roads (MDOT)		A regular inspection and maintenance program will maintain the effectiveness and structural integrity of the BMPs.	Sediment, hydrocarbons, metals, nutrients, etc.	Road related sediments /pollutants	Materials needed for emergency structural repairs may not be easily obtainable and may require stockpiling (MDOT). Should be designed and implemented by trained professional.	$150-$9,000 depending on the BMP. Specialized BMP installation involves planning, design, construction and maintenance costs.	MDOT, Drain Commission's and other Public Works Departments	

Managerial Best Management Practices

BEST MANAGERIAL PRACTICES	DESCRIPTION	BENEFIT	POLLUTANT ADDRESSED	POTENTIAL SOURCES OF POLLUTANTS	ENVIRONMENTAL IMPACTS AND SPECIAL CONCERNS	COMPARATIVE COSTS	COMMUNITIES USING BMP	MDEQ/ NRCS LINK
Material Management Plan (MDOT)	Identified hazardous and non-hazardous materials in the facility. Assures that all containers have labels. Identifies hazardous chemicals that require special handling, storage, and disposal.		Chemicals and other potentially hazardous materials.	Varies depending on type of material usage at specific facilities. Oil, salt, degreasers, solvents, antifreeze, etc. Industrial sites where chemicals are used.	Extensive training typically required to prepare and administer plan.	Plan preparation and updates. Inspections mandated. Plan development typically needs consultant or knowledgeable employee. Operation typically employee dependant.	MDOT, Public Works Departments	
Clean and maintain storm drain channels (MDOT)		Prevent erosion in channels. Improve capacity by removing sediment. Remove debris toxic to wildlife.	Sediment, trash, woody debris	Development, natural erosion, vehicle remnants, road winter safety operations .	Should be implemented by trained professional.	$21/acre/year, $45-60 per acre (rural). Channels are less expense to construct and easier to maintain than enclosed systems.	MDOT, Public Works Departments, Road and Drain Commission's	
Clean and maintain storm inlets and catch basins (MDOT)	Catch basins are periodically inspected and cleaned out using a vacuum truck.	Moderate; Reduces pollutant slugs during the first flush, prevents downstream clogging, and restores sediment trapping capacity of the catch basin.	Solids, sediments, metals, oils	Storm water runoff, automobiles	Requires continual maintenance every 1 - 3 years. General fund, KCRC road maintenance budget - $250,000	Moderate/high; Total annual cost per catch basin = ($8/catch basin) + ($40/catch basin) = $48/catch basin. (GR BMP Study). $21/acre/year maintenance.	City of Grand Rapids, East Grand Rapids, KCRC contracts out to Plummer's Environmental, MDOT	
Annual Road/Stream Crossing Inspections	Inspections of stream crossings for evidence of erosion, debris, etc.	Moderate	Sediment	Erosion of streambank		Moderate; regular inspection can prevent major expenditures for potential major points of erosion	Coopersville, OCRC, KCRC	
MUNICIPAL OPERATIONS								
Snow and ice control operations	Removal of snow and ice from roadways, utilizing plows, salt, and sand.		Salts	Snow melt runoff	Moderate, all KCRC equipment operators are trained. Training of road maintenance crew required.	KCRC winter maintenance budget - $3.5 million. Maintenance costs $1000/lane/mile, dependant on severity of winter.	KCRC maintains State trunk lines for Michigan Department of Transportation (MDOT), primary, local and gravel roads within Kent County. Subdivisions and Platted areas contracted out.	
Calibrated Salt Delivery		Low	Salts	Over application of salt	Calibration does not guarantee efficient application of road salt. Annual training and calibration necessary.	Low upfront cost. Long term equipment maintenance vs. reduced salt. Equipment costs $1500 per truck, minimal additional cost.	Wyoming, KCRC, OCRC	
Pre wet road salt application		High if also used with environmentally friendly alternatives to salt	Salts	Road salt		Low/Moderate; $25/lane/mile, Equipment maintenance costs - $5000 per truck.	East Grand Rapids, OCRC	
Snow removal storage on grassy areas		Low	Sediment, metals, hydrocarbons, salt	Snow melt runoff	Snow storage may damage vegetation and possibly cause soil erosion. Piled snow melts at a slower rate. Need ROW for snow removal. Need large grassed area adjacent to buildings and parking areas and properly spaced from waterbody.	Dependant on amount of trucking, distance to site, etc. Cleanup after melt	City of Grandville, City of Grand Haven, City of Holland	
Minimizing effects from road deicing (MDOT)			Salts & chemicals	Maintaining agency, Snow melt runoff, spring rains		Varies	MDOT	
Street Sweeping	The use of specialized equipment to remove litter, loose gravel, soil, vehicle debris and pollutants, dust, de-icing chemicals, and industrial debris from road surfaces. There are generally 2 types of sweepers: mechanical broom street sweepers and vacuum-type street sweepers.	Moderate; 60% TSS removal rate. Reduction in potential clogging of storm drains. Some oil and grease control (MDOT). When done regularly, can remove 50 - 90% of street pollutants (1), makes road surfaces less slippery in light rains, improves aesthetics by removing litter, and controls pollutants.	Sediment, metals, hydrocarbons	Atmosphere, construction, vehicles	Sweeping may wash sediments into catch basins if wash is not vacuumed. Disposal of collected materials must be handled by the governing agency (MDEQ, Public Health, Transportation). Sweeping schedules and timing critical - sweep after snow melt and before spring rains. Vehicle maintenance required.	KCRC Road maintenance budget - $300,000/yr. Ottawa County:. Mechanical - $119.40/curb mile. Vacuum Assisted - $87.95/curb mile (GR BMP Study)	City of Grand Rapids, City of East Grand Rapids, Cascade Township, City of Wyoming, City of Kentwood, Gerald R. Ford International Airport - Mostly contracted out to Semisweet by KCRC, MDOT	http://www.deq.state.mi.us/documents/deq-swq-nps-sw.pdf
Emergency Spill Response and Prevention Plan	Plans detail emergency procedures to respond to a release of hazardous materials. Also plans that describe procedures for proper handling and storage of chemical materials.	Low to high, depending on preparedness. Can be highly effective at reducing the risk of surface and ground water contamination	Hazardous wastes	Equipment, poor training, accidents, Industrial, commercial, residential, and transportation related spills, chemical storage areas	Speed and containment are critical. Requires a well-planned and clearly defined plan, updated regularly. May require training, protective gear, containment and retrieval knowledge. Equipment must be readily available. (MDOT)	Management plan preparation with upgrades. Cost of simulations. In public sector, typically subcontracted to private contractor	Ottawa County, MDOT, Kent County, local municipalities	
Soil Erosion and Sedimentation Control (SESC) plans	Plans that specifies the actions that will be taken on a construction site to minimize erosion and sedimentation	High if properly executed. Reduce erosion and sedimentation during construction project. Increased removal using Floc Logs through construction.	Sediment	unvegetated areas, land development	State training, Soil Erosion and Sedimentation Control and/or Certified Operator.	Act 91 mandated, ongoing local administrative costs. Fee based to landowner option.	Commonly used by many communities.	
Dust Control (MDEQ)	Using measures such as Watering, Fencing, Mulching and Vegetation to prevent soil and attached pollutants from leaving a site and/or entering nearby waterways.	High if properly executed.	Sediment	Lack of vegetation typically associated with dirt or gravel roads	Salt and other potential pollutants are used in the dust control mixture. Rural, urbanizing, and transportation sites subject to wind erosion. Air pollution issue if neglected.	$100 to $500 per treatment. Employee administrative expense. Maintenance of water truck (minimal) - Roads-50-55 cents per gal - 1500 gal per mile for a single pass		http://www.deq.state.mi.us/documents/deq-swq-nps-dc.pdf
Urban forestry	Management of woods and trees in an urban setting.	Moderate to high. Increases greenspace, reduces storm water runoff and thermal pollution. Long term solution to concerns.	Thermal pollution, solids, sediments	Rainfall, Solar	Woody debris and detritus may require annual maintenance. May eliminate original line of sight			
OTHER								

Managerial Best Management Practices

BEST MANAGERIAL PRACTICES	DESCRIPTION	BENEFIT	POLLUTANT ADDRESSED	POTENTIAL SOURCES OF POLLUTANTS	ENVIRONMENTAL IMPACTS AND SPECIAL CONCERNS	COMPARATIVE COSTS	COMMUNITIES USING BMP	MDEQ/ NRCS LINK
Invasive plant species management	Invasive plant species are controlled using appropriate and effective removal methods for particular species.	Population and spread of invasive plant species is reduced or eliminated.	Invasive plant species	Accidental/purposeful introduction, natural dispersion	Invasive alien plants thrive in disturbed sites. Native plant communities fragmented by human disturbance are most vulnerable to invasion, but the most invasive species can infest even intact ecosystems. Invasive alien plants are free of natural controls such as insects and diseases that keep them in balance in their native habitats. Invasive species can also significantly reduce forest regeneration.		Grand Rapids Audubon Society (garlic mustard)	
Woody Debris Management								
Goose Management								
INFORMATION & EDUCATION								
Public Education Program (MDOT)		Can reduce improper disposal of hazardous waste	Potentially all			$200,000/year	METRO Council, Grand Rapids City, MACC	
Grounds maintenance training		Moderate	Nutrients and organic sediment	Leaf litter, grass clippings, fertilizer, and pesticides		Low	Cascade Township, City of Grandville, City of Grand Rapids	
Employee Training (MDOT)		Low cost and easy to implement storm water management BMPs	Potentially all				MDOT	
Storm Drain Stenciling	Painting Storm Drain Inlets with "No Dumping" signs and symbols.	Moderate; Educates the general public that the storm drain discharges into a natural waterbody. Can tie into hazardous waste collection, yard waste collection	Hazardous waste and nutrients	Household hazardous waste, motor oil, pet waste and yard waste	Volunteers need to take care with paint around storm drains. Permanent castings or decals may be more effective. Public education campaign is also needed for effective reduction in illegal dumping. Short term effectiveness.	$0.45/inch - Mylar stencils $5-$6 each - ceramic tiles $100 or more - metal stencils	East Grand Rapids, MDOT, Spring Lake Lake Board	

1. Evaluation of Best Management Practices for MDOT, 2002.
2. Source Area and Regional Storm Water Treatment Practices, Bannerman.
3. Guidebook of Best Management Practices for Michigan, MDEQ, 1996.
4. National Pollutant Removal Performance Database, EPA, June 2000.
5. Hydro-Compliance Management, Inc.
6. Governmental Accounting Focus, Estimating Useful Lives for Capital Assets.
7. Rouge River National Wet Weather Demonstration Project, 2001
8. Rain Gardens, Beautiful Solutions for Water Pollution, West Michigan Rain Gardens, 2003
9. Field Office Technical Guide, Section 1 Cost Information (draft). USDA-NRCS-MICH, 2004
10. Michigan Area 3 Component Data, USDA-NRCS, June 2003
11. [Michigan] Sample County Practice and Maintenance Costs, USDA-NRCS-MICH, 2001
12. Conservation Practice Physical Effect Worksheet[s]. USDA-NRCS, 2004
13. Information provided by the Technical Committee of the Lower Grand River Watershed Project, 2004
14. Personal Communication with District Conservationist of the NRCS Grand Rapids Service Center, 2004
15. FY04 Michigan EQIP Statewide Eligible Practice List, Land Management Practices (Incentive Payments), USDA-NRCS-MICH, 2004

APPENDIX H I&E STRATEGY COMPONENTS

SECTION 1 AUDIENCE CHARACTERISTICS

Target Audience Profile

Target Audience: Rural Pilot Project Areas

1. What is the makeup of the target audience?
   b. Average Age Varied Families
   c. Gender M & F
   d. Place of Residents (home or apartment, any unique characteristics) 66.86% owner occupied 33.13% renter occupied
   e. Level of Education: 85.94% High School Ed or higher (25yrs and older)
   f. Level of Income: median family income $56, 471
   g. Other pertinent facts: 38.38% of families have children under 18

2. How do they communicate with each other? Grand Rapids Press, Grand Rapids Times, Grand Rapids Business Update, Paper, On-The-Town Magazine, Community Voice, Ottawa Press, West Michigan Christian Newspaper, Associated Press, Michigan Outdoor News, Catholic Connector, The Holland Sentinel. West Michigan Today, Alive, Mlive, Bulletin Boards, Church newsletters, Restaurants

3. How do they receive information on environmental issues? Mass Media and possibly through organizations active in the area.

4. Of what other community organizations are they members? Timberland Resource Conservation & Development Area Council, Marne American Legion, Girl Scouts of Michigan Trails, Boy Scouts of America, UAW-United Automobile, Aerospace & Agricultural Implement Workers of America, Rotary Club of Grand Rapids, Kent County Conservation League, Kent County Farm Bureau, Marne Conservation Club, Grand Rapids Lions Club, Optimist Club of Grand Rapids, West Walker Sports's Club, Blandford Nature Center, Land Conservancy of West Michigan, West Michigan Alive, The Nature Conservancy, Sand Creek Group, Friends of the Musketawa Trail

5. What are their major environmental concerns: Residents are concerned about flooding (which is caused by extreme changes in hydrologic flow and worsens due to lack of storage) and sedimentation (which is caused by agricultural uses and lack of BMPs).

Target Audience: **Rural Pilot Project Areas, Extra Information**

Rural Pilot Project Area

General Demographic Profile
Using Demographic Profile 1 (DP-1) Profile of Genera Characteristics: 2000
DP-2 Profile of Selected Social Characteristics: 2000
DP-3 Profile of Selected Economic Characteristics: 200
Geographic Comparison Table-Population Housing (GCT-PHI) Population, Housing, Area, and Density: 2000

Using the United States Census Bureau, American Fact Finder, www.factfinder.census.gov

Information was collected from above sources for the following Minor Civil Divisions (MCD): Alpine Township, Kent County; Chester Township, Ottawa County; Tallmadge Township, Ottawa County; City of Walker, Kent County; Wright Township, Ottawa County.

- Total Population: 48,300-for whole townships (15,484 when clipped to watershed boundaries)
- Female Population: 24, 157
- Male Population: 24,143
- Average Water Area/square mile/MCD: 0.262
- Total Water Area/square mile: 1.31
- Average Population Density/square mile of land use/ MCD: 325.26
- Average Housing Unit Density/square mile of land use/MCD: 130.72
- Number of Owner Occupied Housing Units: 12,296
- Number of Renter Occupied Housing Units: 6,093
- Median Household Income/MCD: $48,771.00
- Median Family Income/MCD: $56, 471.00
- Average % of Families with Children Under 18/MCD: 38.38%
- Average % Have High School Education or Up/MCD: 85.94%
- Average % Have BA or Higher/MCD: 16.21%
- Average % Have only High School: 37.34%

Target Audience Profile

Target Audience: Agricultural Community

1. What is the makeup of the target audience (answer if appropriate)?
   a. Average Age N/A
   b. Gender N/A
   c. Place of Residents (home or apartment, any unique characteristics) Homes in watershed
   d. Level of Education: N/A
   e. Level of Income: refer to following table
   f. Other pertinent facts: Major crops for Kent and Ottawa County are corn, oats, and soybeans

2. How do they communicate with each other? Michigan State University Extension, Farm Bureau, Natural Resource Conservation District, Natural Resource Conservation Service, Internet, 4-H fairs

3. How do they receive information on environmental issues? Mass Media, local publications, small group discussions.

4. Of what other community organizations are they members? Places of worship, sporting clubs

5. What are their major environmental concerns: Flooding, water storage, dredging of drains (sedimentation)

Target Audience Profile

Target Audience: Agricultural Community, Extra Information

AGRICULTURAL CENSUS INFORMATION FOR KENT COUNTY, MICHIGAN			
	1997	**1992**	**1987**
Farms (number)	1,136	1,190	1,368
Land in farms (acres)	186,453	190,706	203,842
Land in farms - average size of farm (acres)	164	160	149
Land in farms - median size of farm (acres)	63	(N)	(N)
Estimated market value of land and buildings@1: average per farm (dollars)	453,387	301,712	202,820
Estimated market value of land and buildings@1: average per acre (dollars)	2,686	1,832	1,274
Estimated market value of all machinery/equipment@1: average per farm (dollars)	74,189	59,263	42,890
Farms by size: 1 to 9 acres	97	97	126
Farms by size: 10 to 49 acres	383	347	430
Farms by size: 50 to 179 acres	399	470	489
Farms by size: 180 to 499 acres	178	196	234
Farms by size: 500 to 999 acres	45	52	62
Farms by size: 1,000 acres or more	34	28	27
Total cropland (farms)	1,043	1,113	1,268
Total cropland (acres)	149,898	154,552	163,275
Total cropland, harvested cropland (farms)	934	1,046	1,175
Total cropland, harvested cropland (acres)	127,476	119,403	121,233
Irrigated land (farms)	128	164	144
Irrigated land (acres)	6,120	9,030	7,445
Market value of agricultural products sold ($1,000)	121,041	105,990	82,983
Market value of agricultural products sold, average per farm (dollars)	106,550	89,067	60,660
Market value of ag. prod. sold-crops, incl. nursery and greenhouse crops ($1,000)	91,987	73,688	50,383
Market value of ag. products sold - livestock, poultry, and their products ($1,000)	29,054	32,302	32,600
Farms by value of sales: Less than $2,500	309	325	397
Farms by value of sales: $2,500 to $4,999	152	139	163
Farms by value of sales: $5,000 to $9,999	127	157	196
Farms by value of sales: $10,000 to $24,999	158	161	188
Farms by value of sales: $25,000 to $49,999	87	99	105
Farms by value of sales: $50,000 to $99,999	89	96	108
Farms by value of sales: $100,000 or more	214	213	211
Total farm production expenses@1 ($1,000)	93,300	88,084	66,289
Total farm production expenses@1, average per farm (dollars)	82,131	74,082	48,421
Net cash return from agricultural sales for the farm unit (see text)@1 (farms)	1,136	1,189	1,369
Net cash return from agricultural sales for the farm unit (see text)@1 ($1,000)	27,844	19,863	16,075
Net cash return from ag. sales for farm unit (see text)@1, average per farm (dollars)	24,510	16,705	11,742

AGRICULTURAL CENSUS INFORMATION FOR KENT COUNTY, MICHIGAN			
Operators by principal occupation: Farming	487	536	625
Operators by principal occupation: Other	649	654	743
Operators by days worked off farm: Any	667	701	809
Operators by days worked off farm: 200 days or more	501	531	610
Livestock and poultry: Cattle and calves inventory (farms)	356	431	531
Livestock and poultry: Cattle and calves inventory (number)	27,633	32,184	34,672
Beef cows (farms)	189	184	227
Beef cows (number)	2,769	2,327	3,286
Milk cows (farms)	93	148	173
Milk cows (number)	9,097	11,218	12,343
Cattle and calves sold (farms)	336	391	519
Cattle and calves sold (number)	11,272	13,420	17,002
Hogs and pigs inventory (farms)	52	88	108
Hogs and pigs inventory (number)	7,949	14,203	17,065
Hogs and pigs sold (farms)	49	89	112
Hogs and pigs sold (number)	14,364	26,356	27,198
Sheep and lambs inventory (farms)	27	27	37
Sheep and lambs inventory (number)	523	1,282	949
Layers and pullets 13 weeks old and older inventory (see text) (farms)	32	45	62
Layers and pullets 13 weeks old and older inventory (see text) (number)	976	(D)	2,795
Broilers and other meat-type chickens sold (farms)	5	11	10
Broilers and other meat-type chickens sold (number)	283	782	880
Corn for grain or seed (farms)	373	404	596
Corn for grain or seed (acres)	42,188	39,798	39,847
Corn for grain or seed (bushels)	4,550,863	3,271,022	3,684,369
Wheat for grain (farms)	155	206	205
Wheat for grain (acres)	6,918	7,744	5,565
Wheat for grain (bushels)	361,368	318,398	243,064
Soybeans for beans (farms)	123	85	38
Soybeans for beans (acres)	14,120	5,743	2,520
Soybeans for beans (bushels)	526,560	163,833	91,803
Dry edible beans, excluding dry limas (farms)	17	18	9
Dry edible beans, excluding dry limas (acres)	2,876	2,243	1,346
Dry edible beans, excluding dry limas (hundredweight)	50,270	32,961	19,108
Hay-alfalfa, other tame, small grain, wild, grass silage, green chop, etc. (see txt) (farms)	553	634	757
Hay-alfalfa, other tame, small grain, wild, grass silage, green chop, etc (see txt)(acres)	30,713	34,196	39,950
Hay-alfalfa, other tame, small grain, wild, grass silage, green chop, etc (see txt)(tons, dry)	78,350	89,707	109,579
Vegetables harvested for sale (see text) (farms)	80	114	118
Vegetables harvested for sale (see text) (acres)	3,747	4,507	4,311
Land in orchards (farms)	184	236	257
Land in orchards (acres)	15,143	16,988	16,332

(D) Withheld to avoid disclosing data for individual farms.
(N) Not available.

Data From: “Census of Agriculture: 1987, 1992, 1997.” GovStats. Oregon State University Libraries. Updated: February 28, 2002. Retrieved: November 23, 2003. <http://govinfo.kerr.orst.edu/php/agri/show2.php>

AGRICULTURAL 2000 CENSUS INFORMATION FOR OTTAWA COUNTY, MICHIGAN			
	1997	**1992**	**1987**
Farms (number)	1,292	1,367	1,471
Land in farms (acres)	170,627	176,305	177,894
Land in farms - average size of farm (acres)	132	129	121
Land in farms - median size of farm (acres)	51	(N)	(N)
Estimated market value of land and buildings@1: average per farm (dollars)	395,504	268,234	207,266
Estimated market value of land and buildings@1: average per acre (dollars)	3,066	2,026	1,754
Estimated market value of all machinery/equipment@1:aver per farm (dollars)	78,117	61,705	52,554
Farms by size: 1 to 9 acres	149	142	156
Farms by size: 10 to 49 acres	476	457	479
Farms by size: 50 to 179 acres	426	493	541
Farms by size: 180 to 499 acres	171	213	242
Farms by size: 500 to 999 acres	48	50	43
Farms by size: 1,000 acres or more	22	12	10
Total cropland (farms)	1,199	1,287	1,380
Total cropland (acres)	140,978	146,319	146,152
Total cropland, harvested cropland (farms)	1,096	1,220	1,305
Total cropland, harvested cropland (acres)	119,789	112,242	112,721
Irrigated land (farms)	323	297	296
Irrigated land (acres)	14,811	13,659	10,537
Market value of agricultural products sold ($1,000)	299,985	232,853	182,959
Market value of agricultural products sold, average per farm (dollars)	232,187	170,339	124,378
Market value of ag. prod. sold-crops, incl. nursery and greenhouse crops ($1,000)	160,066	108,015	78,706
Market value of ag. products sold - livestock, poultry, and their products ($1,000)	139,919	124,838	104,253
Farms by value of sales: Less than $2,500	252	251	309
Farms by value of sales: $2,500 to $4,999	140	132	164
Farms by value of sales: $5,000 to $9,999	150	180	205
Farms by value of sales: $10,000 to $24,999	177	170	204
Farms by value of sales: $25,000 to $49,999	117	123	131
Farms by value of sales: $50,000 to $99,999	118	155	136
Farms by value of sales: $100,000 or more	338	356	322
Total farm production expenses@1 ($1,000)	243,970	196,812	152,637
Total farm production expenses@1, average per farm (dollars)	188,685	143,868	103,694
Net cash return from agricultural sales for the farm unit (see text)@1 (farms)	1,293	1,368	1,472
Net cash return from agricultural sales for the farm unit (see text)@1 ($1,000)	56,728	33,087	30,571
Net cash return from ag. sales for farm unit (see text)@1, average per farm (dollars)	43,873	24,187	20,768
Operators by principal occupation: Farming	658	724	742

AGRICULTURAL 2000 CENSUS INFORMATION FOR OTTAWA COUNTY, MICHIGAN			
Operators by principal occupation: Other	634	643	729
Operators by days worked off farm: Any	713	782	852
Operators by days worked off farm: 200 days or more	506	552	623
Livestock and poultry: Cattle and calves inventory (farms)	451	545	607
Livestock and poultry: Cattle and calves inventory (number)	36,159	41,580	40,843
Beef cows (farms)	184	196	211
Beef cows (number)	2,421	3,644	2,266
Milk cows (farms)	137	184	205
Milk cows (number)	13,177	13,470	12,517
Cattle and calves sold (farms)	429	517	584
Cattle and calves sold (number)	46,743	23,626	40,069
Hogs and pigs inventory (farms)	96	177	176
Hogs and pigs inventory (number)	69,018	89,434	90,617
Hogs and pigs sold (farms)	97	181	193
Hogs and pigs sold (number)	162,430	168,499	168,880
Sheep and lambs inventory (farms)	35	32	23
Sheep and lambs inventory (number)	713	938	462
Layers and pullets 13 weeks old and older inventory (see text) (farms)	46	50	69
Layers and pullets 13 weeks old and older inventory (see text) (number)	2,336,067	983,741	2,392,286
Broilers and other meat-type chickens sold (farms)	20	18	21
Broilers and other meat-type chickens sold (number)	9,166	3,032	369,297
Corn for grain or seed (farms)	410	525	683
Corn for grain or seed (acres)	42,224	42,362	42,328
Corn for grain or seed (bushels)	4,862,900	3,724,693	4,055,681
Wheat for grain (farms)	199	206	109
Wheat for grain (acres)	6,118	4,863	2,011
Wheat for grain (bushels)	318,173	206,383	82,869
Soybeans for beans (farms)	132	34	33
Soybeans for beans (acres)	9,232	1,289	1,148
Soybeans for beans (bushels)	369,525	36,483	38,364
Dry edible beans, excluding dry limas (farms)	2	0	0
Dry edible beans, excluding dry limas (acres)	(D)	0	0
Dry edible beans, excluding dry limas (hundredweight)	(D)	0	0
Hay-alfalfa, other tame, small grain, wild, grass silage, green chop, etc (see txt)(farms)	535	628	745
Hay-alfalfa, other tame, small grain, wild, grass silage, green chop, etc. (see txt)(acres)	29,015	29,723	33,541
Hay-alfalfa, other tame, small grain, wild, grass silage, green chop, etc. (see txt) (tons, dry)	71,942	76,358	84,903
Vegetables harvested for sale (see text) (farms)	103	126	152
Vegetables harvested for sale (see text) (acres)	3,362	3,752	4,475
Land in orchards (farms)	65	95	101
Land in orchards (acres)	6,170	6,985	6,804

(D) Withheld to avoid disclosing data for individual farms.
(N) Not available.

Data From: “Census of Agriculture: 1987, 1992, 1997.” GovStats. Oregon State University Libraries. Updated: February 28, 2002. Retrieved: November 23, 2003. <http://govinfo.kerr.orst.edu/php/agri/show2.php>

Target Audience Profile

Target Audience: Builders and Developers

1. What is the makeup of the target audience (answer if appropriate)?
   a. Average Age N/A
   b. Gender Majority are Male
   c. Place of Residents (home or apartment, any unique characteristics) Focused on Ottawa and Kent County, not townships
   d. Level of Education: Specialized on building tasks, not overly scientific technical information.
   e. Level of Income: varies by number of projects and size of company
   f. Other pertinent facts: Group does better with hands on items that can be used at work site rather than with products or meetings that take them away from projects.

2. How do they communicate with each other? Newsletters, workshops, educational programs supplied by Home Builders Association

3. How do they receive information on environmental issues? Regulations governing construction activities, classes required to obtain permits, newsletters, and mass media.

4. Of what other community organizations are they members? Home Builders Association

5. What are their major environmental concerns: Depends on builder, a lot of emphasis is put on erosion and sediment controls, will want environmental practices that help to sell homes, atheistically, practically, and financially.

Information from Home Builders Association, phone interview with Mr. Chris Hall, November 24, 2003

Target Audience Profile

Target Audience: Environmental/Recreational Groups

1. What is the makeup of the target audience (answer if appropriate)?
   a. Average Age Varied
   b. Gender M/F
   c. Place of Residents (home or apartment, any unique characteristics) Primarily in Ottawa County
   d. Level of Education: Varied
   e. Level of Income: Varied
   f. Other pertinent facts: Have been active in other watershed efforts during planning phase of project.

2. How do they communicate with each other? Primarily through meetings and specific group publications/paper updates.

3. How do they receive information on environmental issues? Mass media, and through other environmental publications, possibly nation wide publications.

4. Of what other community organizations are they members? Places of worship, schools, some government venues.

5. What are their major environmental concerns: Remains particular to group. Some interest in making land available to the public through development of parks (Lions Club)

Target Audience: Schools K-College

1. What is the makeup of the target audience (answer if appropriate)?
   a. Average Age 4-22
   b. Gender M/F
   c. Place of Residents (home or apartment, any unique characteristics) Primarily in Ottawa County
   d. Level of Education: Varied
   e. Level of Income: Varied/Majority existing on parents' income or small part time employment
   g.Other pertinent facts: Grand Valley State University students have been active in other watershed efforts during planning phase of project.

2. How do they communicate with each other? Through school activities, clubs, extracurricular events, classroom activities and lessons, social groups.

3. How do they receive information on environmental issues? Mass media, lessons, social groups, extracurricular events.

4. Of what other community organizations are they members? Places of worship, clubs, teams, 4-H.

5. What are their major environmental concerns: Interest in world around them, understanding what is happening in their environment, what they can do to help.

Target Audience Profile

Target Audience: Homeowners

1. What is the makeup of the target audience (answer if appropriate)?
   h. Average Age________
   i. Gender M/F
   j. Place of Residents (home or apartment, any unique characteristics) 12,296 homeowner occupied housing units.
   k. Level of Education: 85% high school education or higher
   l. Level of Income: median family income $56,471
   m. Other pertinent facts: can get possible riparian homeowner listing from Ottawa County.

2. How do they communicate with each other? Through mass media, Advance is the local newspaper, attending children's' school events, church events, one on one

3. How do they receive information on environmental issues? Flyers, newspaper, radio, television, home improvement stores.

4. Of what other community organizations are they members? Environmental groups, places of worship, schools, local units of government.

5. What are their major environmental concerns: Flooding, having water safe for contact, having environment safe for family, protecting home investment

Data from same source as rural residents.

Target Audience Profile

Target Audience: Watershed Management Members

1. What is the makeup of the target audience (answer if appropriate)?
    n. Average Age 24 and up
    o. Gender M/F
    p. Place of Residents (home or apartment, any unique characteristics) Reside in watershed and surrounding watersheds
    q. Level of Education: high school plus some
    r. Level of Income: varied
    s. Other pertinent facts: have been working together for last couple of years, have existing networks for information dissemination, looking to become non-profit entity

2. How do they communicate with each other? Meetings, email, phone calls

3. How do they receive information on environmental issues? Researchers, professors, state resources, presentations, flyers, regulations, meetings, articles, tours, workshops.

4. Of what other community organizations are they members? Local units of government, some ties to Boy Scouts, local clubs, and places of worship.

5. What are their major environmental concerns? Flooding needs to be reduced, stream to be a resource, farming is to be sustained.

Data is from personal experience of project managers, participation at Sand Creek group meetings, and a review of group meeting minutes.

Target Audience Profile

Target Audience: Locally Elected Bodies

1. What is the makeup of the target audience (answer if appropriate)?
   a. Average Age 30+
   b. Gender M/F
   c. Place of Residents (home or apartment, any unique characteristics) Generally residing in watershed or close to watershed, many living in own homes
   d. Level of Education: High school and up
   e. Level of Income: varied
   f. Other pertinent facts: Have townships of Alpine, Chester, Tallmadge, and Wright, and City of Walker involved, along with Ottawa County Commissioners

2. How do they communicate with each other? Board meetings, planning meetings, day-to-day operations. Also, often being friends and neighbors of the same community, there are ample opportunities to communicate at local venues such as church and school functions as well as local socially oriented businesses such as restaurants or entertainment spots.

3. How do they receive information on environmental issues? Since many locally elected officials have "day jobs" it depends on their other associations. Many are involved in occupations where they may receive information on such issues from sources slanted to a point of view, depending upon the occupation. Also, information on a specific issue upon which they are deliberating may well be supplied by applicants or professionals hired to inform them on specific aspects of such an issue as part of the legislative or administrative review. Information may also be found in publications associated with membership organizations such as those cited below.

4. Of what other community organizations are they members? Grand Valley Metro Council, Michigan Township Association, Michigan Municipal League, Michigan Association of Counties, local chapters of some of these organizations as well as national counterparts organizations, though these are not as active. There may also be memberships associated with smaller geographical levels such as neighborhood associations, business associations and other special purpose organizations such as watershed groups or multi-jurisdictional discussion groups. Other important groups are based more on profession such as Michigan Local Government Managers Association, and ICMA.

5. What are their major environmental concerns? Accomplishing the decisions of their constituents, to implement cost effective measures, meet regulated standards for storm water. To ensure appropriate levels of development and redevelopment occurs without causing health and safety concerns for local residents, businesses, and other constituents. Getting their jobs done on a daily basis without doing great and obvious harm to major environmental assets.

Information is from Andy Bowman, Grand Valley Metro Council, on November 26, 2003.

SECTION 2. WORKSHEET FOR PROJECT STATUS AND EVALUATION

I/E Evaluation Project Worksheet

Questions to Answer at Project Evaluation Meetings

Date:

1. Are the planned activities being implemented according to the schedule?

2. Is additional support needed?

3. Are additional activities needed?

4. Do some activities need to be modified/eliminated?

5. Are the resources allocated sufficient to carry out the tasks?

6. Are all of the target audiences being reached?

7. What feedback has been received, and how does it affect the I/E program?

8. How do the technical activities on the Lower Grand River Watershed project affect the I/E plan?

SECTION 3. CHECKLIST FOR TRACKING STATUS OF TASKS AND PRODUCTS

Checklist for Tracking the Status of Tasks and Products
Fill in boxes appropriately as tasks are selected for completion. Example:

Proposed Activities	Details	Status	Team Lead	Changes/Comments
Storm Drain Stenciling Activities	Date/time/location selected Supplies purchased Volunteers organized Transportation	Finished On- order Yes Working on	IE Coordinator in cooperation with Volunteer Group Leader	Need more help with transportation, not enough drivers

Proposed Activities	Details	Status	Team Lead	Changes/Comments
Advertise oil recycling programs				
Develop partnerships with pertinent organizations to identify appropriate sites for wetland restoration				
Distribute "Did you know?" list				
Distribute "Operating and Maintaining UST Systems in Michigan" to UST owners				
Distribute fact sheet with cost saving examples				
Distribute materials Best Management Practices				
Distribute materials on agricultural Best Management Practices				
Distribute materials on alternative waste disposal				
Distribute materials on landscaping for water quality				
Distribute resources packets on available governmental/environmental agency programs				

Proposed Activities	Details	Status	Team Lead	Changes/Comments
Distribute Riparian Homeowner Guidebook				
Distribute Septic System Owner's Guidebook				
Distributed irrigation water use GAAMP				
Distribution of proposed Kent/Ottawa Storm Water Ordinance				
Form partnership with the City of Grand Rapids to implement structural and vegetative BMPs to improve Aman Park access sites.				
Media releases/articles				
Participate in the "adopt-a-highway program" through MDOT				
Presentations throughout the watershed				
Storm drain stenciling activities				
Target training workshop for riparian owner and farmers				
Targeted training workshop				
Targeted training workshop for contractors and engineers				
Targeted training workshop for farmers				
Targeted training workshop for farmers and orchard owners				
Targeted training workshop for local decision makers on the Kent/Ottawa Storm Water Ordinance				

Proposed Activities	**Details**	**Status**	**Team Lead**	**Changes/Comments**
Targeted training workshop for riparian owners				
Tours of successful Best Management Practices				
Volunteer river clean-ups				
Work with land owners to remove inoperable/dismantled vehicles in junk yards				
Workshop for developers/zoning agencies to encourage reduction of impervious surfaces and alternative BMPs in new developments.				
Workshop for local decision makers				

TABLE 1. SUMMARY OF TARGET AUDIENCES REACHED BY THE VARIOUS FORMATS AND THE DESIRED OUTCOME.

Desired Outcome	**Formats**	**Target Audiences**							
		Category 1							**Category 2**
		Residents of Rural Pilot Project Areas	Agricultural Community	Builders/ Developers	Environmental/ Recreational Groups	Schools K-College	Homeowners	Watershed Management Members	Locally Elected Bodies
Awareness	Storm Drain Stenciling	**X**				**X**	**X**		
	Advertise Oil Recycling	**X**	**X**				**X**		
	Media Releases/articles			**X**					
	“Did You Know List”	**X**	**X**	**X**			**X**		**X**
Education	Presentations Throughout Watershed	**X**	**X**	**X**	**X**	**X**		**X**	**X**
	Tours of Successful BMP sites	**X**	**X**				**X**	**X**	**X**
	Fact Sheets with Cost/Savings Examples		**X**	**X**				**X**	**X**
	Distribute Resource Packets on Available Government/ Environmental Agency Programs	**X**	**X**				**X**	**X**	**X**
	Distribute Materials on Alternative Waste Disposal	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
	Distribute Materials on Landscaping for Water Quality	**X**	**X**	**X**	**X**		**X**		
	Distribute Materials on Agricultural Best Management Practices	**X**	**X**						
	Distribute Materials on Storm Water Best Management Practices/Ordinances			**X**				**X**	**X**
	Distribute Materials for Pet Waste	**X**					**X**		
	Distribute “Operating and Maintaining Underground Storage Tank Systems in Michigan”			**X**	**X**				**X**
	Distribute Generally Accepted Agricultural Management Practices on Irrigational Water Use								
	Distribute Septic System Owner Guidebooks	**X**	**X**				**X**	**X**	**X**
	Distribute Riparian Homeowner Guidebooks	**X**	**X**				**X**	**X**	**X**
Action	River Trail Clean Ups	**X**			**X**	**X**	**X**	**X**	**X**
	Targeted Workshops	**X**	**X**	**X**			**X**		**X**
	Adopt-A-Highway	**X**			**X**		**X**		
	Partnership for Access Sites in Aman Park	**X**						**X**	**X**
	Landowner Partnership to Remove Debris from Property	**X**	**X**				**X**		
	Partnership to Identify Wetland Restoration Sites	**X**	**X**		**X**		**X**		

TABLE 2. POSSIBLE DISTRIBUTION MECHANISMS FOR OUTREACH MATERIALS					
Field of Interest	**Contact Name**	**Address**		**Phone (616 pre-fix)**	**Internet**
Builders	Classic Homes & Development	125 Luce St. SW	Tallmadge Twp MI 49544	791-8042	
	Verwoert Construction	0705 Tallmadge Woods Dr	Tallmadge Twp MI 49544	735-9117	
	Homestead Timbers Log Homes	14840 16th Ave	Marne, MI 49435	677-5262	
Concrete	Consumers Concrete Corp	10600 Linden NW	Grand Rapids, MI 49504	677-1226	
	A Beene Concrete Construction	2799 Royal Point Dr. NW	Grand Rapids, MI 49544	791-0166	
	Decorative Concrete	5000 Fruit Ridge NW	Grand Rapids, MI 49544	785-8581	
	M C Concrete Inc	1616 Kinney Ave NW	Grand Rapids, MI 49544	735-9817	
	Meyering Concrete Inc	1035 Comstock St	Marne, MI 49435	677-1600	
	Schepers Concrete Construction	10578 Linden Dr M NW	Tallmadge Twp MI 49544	677-0053	
	TS Max Poured Walls Inc	1975 Cleveland St E	Marne, MI 49435	677-9929	
Contractors	Austin Construction Services	2914 3 mile NW	Walker MI 49544	735-9962	
	Elmridge Construction Co	2727 Elmridge NW	Grand Rapids, MI 49544	942-6824	
	Kaptein Trenching & Dozing Inc	12244 24th	Marne, MI 49435	677-1158	
	Jansma Underground Contractors Inc	856 Comstock St	Marne, MI 49435	677-3654	
	Ironwood Construction Company	1140 Wilson NW	Walker MI 49544	453-1241	
	New Dimension Building & Supply	2850 Mullins Ct	Grand Rapids, MI 49544	453-3470	
Engineers	Engineered Material Sales	4250 Lake Michigan Dr NW	Grand Rapids, MI 49544	791-1275	
	Environmental Health Resources Inc	2930 3 mile Rd NW	Grand Rapids, MI 49544	735-1515	
	Superior Environmental Corp	14445 16th Ave	Marne, MI 49435	677-5255	
Excavating	Jack Dykstra Excavating	3677 3 mile Rd NW	Grand Rapids, MI 49544	453-4827	
	Kamps Brothers Excavating	11303 3rd Ave NW	Grand Rapids, MI 49544	453-0204	
	Koster Farms Contracting	0-10763 Linden Dr	Grand Rapids, MI 49544	677-5818	
	Midwest Hydrovac	12635 14th Ave	Tallmadge Twp MI 49544	677-4445	
	Ottawa Excavators	2890 Leonard St	Marne, MI 49435	677-3065	

Field of Interest	Contact Name	Address		Phone (616 pre-fix)	Internet
Landscaping	AAA Lawn Care	14202 Ironwood Dr	Tallmadge Twp MI 49544	677-4000	www.aaalawncare.com
	Grand Valley Land Development Company	0699 Tallmadge Woods Dr	Grand Rapids, MI 49504	791-7240	
	Creekside Garden Center	4015 Fruit Ridge Ave NW		785-1177	
	Botanical Endeavors		Marne	677-9908	
	Landscape Enhancement	0-1483 Lake Michigan Drive	Grand Rapids, MI 49504	677-0054	
	Legend Services Inc	1242 Comstock St	Marne, MI 49435	677-3305	
	Motman's Greenhouses	0-2617 Lake Michigan Drive NW	Grand Rapids, MI 49544	677-1525	
Agricultural	Koster Farms Contracting	010763 Linden Dr	Grand Rapids, MI 49544	677-5818	
	West Michigan Agricultural Products	5261 Egner Rd NE	Cedar Springs MI 49319	696-0340	
	Robert Motman Farms	0-2617 Lake Michigan Dr NW	Grand Rapids, MI 49544	677-1525	
	Robach Dairy Farms	17126 8th Ave	Marne, MI 49435	677-5103	
	David Vandyke	15637 16th Ave	Wright Twp MI 49435	677-5097	
	Zahm Bros Farm	4724 5 mile Rd NW	Grand Rapids, MI 49544	785-9505	
	Hanover Farms	8th Ave			
	Clayton Farms	8th Ave			
	Farmers CO-OP	6535 Alpine NW	Alpine Township, MI 49321	784-1068	
	Bolthouse Brothers Land Inc.	1663 Lincoln	Tallmadge Township, MI 49504	616-677-2949	
	River Ridge Farms Inc.	15585 68th Ave.	Coopersville, MI 49404	616-837-7307	
Waste Disposal	Ed's Rubbish Removal	O-888 Lincoln St NW	Grand Rapids, MI 49544	677-5433	
	Kent County Solid Waste Operations				
	Pitsch Companies	675 Richmond St NW		363-4895	
	Green Valley Disposal Service	3744 Dykstra Dr NW	Grand Rapids, MI 49544	647-1400	
	Log Jam Forest Products Inc	15342 24th St	Marne, MI 49435	677-2560	
	Top Service Inc	14112 12th Ave	Marne, MI 49435	677-5446	

Field of Interest	Contact Name	Address		Phone (616 pre-fix)	Internet
Centers of Worship	Berlin Baptist Church	1519 Jackson St	Marne, MI 49435	677-3936	
	St. Mary's Church	15164 Juniper Dr	Marne MI 49435	677-3753	
	St. Paul's Anglican Catholic Church	2560 Lake Michigan NW		791-2187	
	Second Baptist Church	840 Wilson NW	Grand Rapids, MI 49544	791-9370	
	Westwood Community Church	2828 Richmond NW	Grand Rapids, MI 49504	791-4921	
	Marne United Methodist Church	14861 Washington St	Marne, MI 49435	677-3957	
	Riverside Christian Church	0835 Luce	Grand Rapids, MI 49544	735-2770	
	Grace Protestant Reform Church	11225 8th Ave NW	Tallmadge Twp MI 49544	791-8751	
	Orchard Hill Reformed Church	1465 3 mile Rd NW	Walker MI 49544	784-4060	
	Tallmadge Wesleyan Church	1428 Leonard Rd	Grand Rapids, MI 49544	677-3339	
Papers	Grand Rapids Press	155 Michigan St NW		222-5455	
	Grand Rapids Times	2016 Eastern Ave SE	Grand Rapids, MI 49507	245-8737	
	Grand Rapids Business Update	2150 44th St SE	Grand Rapids, MI 49508	281-3800	
	On-The-Town Magazine	2141 Port Sheldon St	Jenison, MI 49428	669-1366	
	Community Voice	1066 Grandville Ave SW	Grand Rapids, MI 49503		
	Ottawa Press				
	West Michigan Christian Newspaper	749 W Woodmeade Ct SE	Grand Rapids, MI 49546	977-9550	
	Dieconnect.com Inc	16180 8th Ave	Marne, MI 49435		
	Associated Press	155 Michigan St NW	Grand Rapids, MI 49503		
	Michigan Outdoor News	4603 Pinehurst Ave SW	Grand Rapids, MI 49548	530-7657	
	Catholic Connector	660 Burton SE	Grand Rapids, MI 49507	243-1463	
	The Holland Sentinel				HollandSentinel.com
	West Michigan Today				Westmichigantoday.com
	Alive				Westmichiganalive.com
	Mlive.com				

Field of Interest	Contact Name	Address		Phone (616 pre-fix)	Internet
Organizations	Timberland Resource Conservation & Development Area Council Inc	6655 Alpine NW	Alpine Twp MI 49321 MI	956-9411	
	Marne American Legion Post 376	1469 Arthur St	Marne MI 49435		
	Girl Scouts of Michigan Trails	3275 Walker MI 49544	Walker MI 49544	784-3341	
	Boy Scouts of America	3213 Walker MI 49544	Walker MI 49544	785-2662	
	UAW- United Automobile, Aerospace & Agricultural Implement Workers of America	4330 Stafford SW	Wyoming, MI 49548	261-4878	
	Rotary Club of Grand Rapids	161 Ottawa Ave NW	Grand Rapids, MI 49503	459-5640	
	Kent County Conservation League	8461 Conservation NE	Ada Twp MI 49301	676-1056	
	Kent County Farm Bureau	6525 Alpine NW	Comstock Park 49321	784-1092	
	Ottawa County Farm Bureau	16731 Ferris Street	Grand Haven, MI 49417	846-8770 x5	
	Marne Conservation Club	12929 8th Ave	Tallmadge Township, MI 49504	677-1337	
	Grand Rapids Lions Club	7241 Greentree Dr	Jenison, MI 49428	669-7279	
	Marne Lions Club	5839 Leonard	Coopersville, MI 49404	677-3282	
	REAP			837-6472	
	West Walker Sportsmen's' Club	0-599 Leonard	Grand Rapids, MI 49503	453-5081	
	Blandford Nature Center	1715 Hillburn Ave NW	Grand Rapids, MI 49504	453-6192	
	Land Conservancy of West Michigan	1345 Monroe Ave NW	Grand Rapids, MI 49503	451-9476	
	The Nature Conservancy	456 Plymouth St NE	Grand Rapids, MI 49505	776-0230	busytrail@aol.com
	Friends of the Musketawa Trail			231-821-0553	
Places of Interest	Musketawa Trail				
	Berlin Fairground and Raceway	Berlin Fair Drive	Marne MI 49435	677-5000	www.berlinfair.org
	Aman Park	0-1859 Lake Michigan Dr. NW	Tallmadge Twp MI 49544		
	Indian Trails Camp	1622 Lake Michigan Dr NW	Tallmadge Twp MI 49544	677-5251	
	Sand Creek Golf Course	1831 Johnson St	Marne, MI 49435	677-3379	
	Western Greens Golf Course	2475 Johnson St	Tallmadge Twp MI 49544	677-3677	
	Walker Ice & Fitness Center	4151 Remembrance Rd	Grand Rapids MI 49544	735-6286	
	Walker Meadows Senior Center	1101 Wilson NW	Walker MI 49544		

Field of Interest	Contact Name	Address		Phone (616 pre-fix)	Internet
Schools	West Michigan Academy Environmental Sciences	4463 Leonard NW	Walker MI 49544	791-7320	
	St. Joseph Catholic School				
	Lamont Christian School				
	Walker Charter Academy	1801 3 mile Rd NW	Walker MI 49544	785-2700	www.ci.Walker.mi.us
Government	City of Walker	4243 Remembrance	Walker MI 49544	791-6890	
	Wright Township	1565 Jackson St	Marne, MI 49435	677-3048	
	Tallmadge Township	1451 Leonard Rd	Tallmadge Township 49544	677-1248	www.tallmadge.com/
	Alpine Township	5255 Alpine NW	Comstock Park, MI 49321	784-1262	www.gvmc.org/mich/cities/alpine/
	Chester Township	3616 Coolidge St	Conklin, MI 49426		
	Kent County	826 Fuller NE	Grand Rapids, MI	336-3265	www.co.kent.mi.us/
	MSU Extension office				
	Community Development	4300 Cascade Rd SE	Grand Rapids, MI 49504	336-4200	
	Drain Commissioner	1500 Scribner, NW	Grand Rapids, MI 49504	336-3688	
	Environmental Health			336-3089	
	General Sanitation Complaints			336-3089	
	Park Commission	1500 Scribner, NW	Grand Rapids, MI 49504	336-3697	
	Recycling Information			336-2570	www.co.ottawa.mi.us
	Road Commission	1500 Scribner, NW	Grand Rapids, MI 49504	242-6900	
	Ottawa County				
	Community Action Agency	12251 James St	Holland MI 49423	393-5697 ext. 5697	
	Community Programs			1-866-512-4357	
	Drain Commission	414 Washington St.	Grand Haven, MI 49417	846-8220	
	Geographic Information System	12220 Fillmore St	West Olive, MI 49460	738-4881	
	Environmental Health	3100 Port Sheldon Rd	Hudsonville, MI 49428	662-3100	
	Parks & Recreation	12220 Fillmore St	West Olive, MI 49460	738-4810	
	Recycling/Household Hazardous Waste	12251 James St	Holland, MI 49423	393-5638	
	Road Commission	526 W Cleveland St	Coopersville, MI	837-8000	
	Soil Erosion/Sediment Control Agency	414 Washington	Grand Haven, MI 49417	846-8222	

Field of Interest	Contact Name	Address		Phone (616 pre-fix)	Internet
Federal Departments	Agriculture Department	3260 Eagle Park Dr NE	Grand Rapids		
	APHIS – Plant Protection & Quarantine	350 Ottawa NW	Grand Rapids	356-0600	
	Natural Resources Conservation Service	3260 Eagle Park Dr NE	Grand Rapids	942-4111	
	Rural Development	3260 Eagle Park Dr NE	Grand Rapids	942-4111	
	Department of Interior	U.S. Fish and Wildlife Service Division Law Enforcement		942-2381	
U.S. Senators	Carl Levin	459 Russell Senate Office Building	Washington D.C. 20510	616 456-2531	www.senate.gov
	Debbie Stabenow – Stabenow.senate.gov	United States Senate	Washington D.C. 20510	202 224-4822	
	Vern J. Ehlers, U.S. Congress	3rd District			
State of Michigan	Department of Agriculture	350 Ottawa NW	Grand Rapids, MI	356-0600	
	House of Representative				
	Department of Environmental Quality			1-800-662-9278	
Libraries	Comstock Park Library	3943 West River Drive	Grand Rapids, MI 49321	647-3860	
	Walker Library	4293 Remembrance	Walker MI 49544	647-3970	
	Alpine Library	5255 Alpine Ave	Comstock Park MI 49321	647-3810	

TABLE 3. PROJECT PARTNERS			
Agencies/Companies/Nonprofits	**Cities / Villages**	**Townships**	**Government Departments**
Center for Environmental Studies	City of Walker	Alpine Township	Natural Resources Conservation Service
Herman Miller, Inc.		Chester Township	Grand Rapids Parks and Recreation
Land Conservancy of West Michigan		Tallmadge Township	Ottawa County Conservation District
Marne Conservation Club		Wright Township	Kent County Drain Commission
Marne Lions Club			Kent County Road Commission
Michigan Farm Bureau			Ottawa County Road Commission
The Land Conservancy			Michigan Department of Transportation
The Nature Conservancy			Ottawa County Drain Commission
Timberland RC&D			Kent County Conservation District
West Michigan Environmental Action Council			