North Limits Drain
Preliminary Water Quality and Stormwater Analysis

Prepared for:

City of Kalamazoo
Kalamazoo Township
Michigan Department of Environmental Quality
Surface Water Quality Division

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TABLE OF CONTENTS

Project Summary

Kalamazoo Township received a grant from the Kalamazoo Foundation's Sustainable Community Watershed Fund ($7,000) to support a lead effort by KIESER & ASSOCIATES (K&A) to contduct an assessment of water quality and a preliminary feasibility study examining alternatives to improve environmental conditions associated with discharges to the Kalamazoo River from the North Limits Drain. The Michigan Department of Environmental Quality (MDEQ) provided in-kind services for selected laboratory analyses. The outfall of this drain is near the city of Kalamazoo Water Reclamation Plant (Figure 1). This drain is a designated county drain within Kalamazoo County. It has previously been identified as the State Ditch and Branch Drain in a 1975 Wilkins and Wheaton Kalamazoo County Drain map. The drain is called the North Limits Drain throughout this document.

1.0 Project Setting

1.1 North Limits Drain Watershed

The North Limits Drain watershed encompasses 1,996 acres with 852 acres falling within the City of Kalamazoo's corporate boundary and the remaining 1,144 acres located in Kalamazoo Township. The North Limits Drain discharges to the Kalamazoo River just north of the City of Kalamazoo Water Reclamation Plant (WRP) (Figure 1). The watershed is divided into three subwatersheds (Figures 1-3): Upper, Middle and Lower for purposes of this report. The three subwatershed areas were selected to represent three very different sections of the larger North Limits Drain watershed to facilitate discussions of potential management practices appropriate for each area.

Based on 1997 LANDSAT 5 satellite data, the Upper Subwatershed (1,041.6 acres) is predominantly forested land cover (36%) and open land (31%), with the remaining area consisting of: residential (14%); transportation (6%); barren land (5%); wetland (2%); commercial (2%); shrubland (1.5%); agriculture (1.5%); and water (<1%). The Middle Subwatershed (251.5 acres) is also dominated by open land (31%) and forest (27%), with the remaining area consisting of: residential (11%); commercial (10%); barren land (9%); transportation (6%); shrubland (2%); water (2%); and wetland (2%). The Lower

Subwatershed (702.3 acres), located furthest east, has a greater percentage of residential and commercial land cover. While 39% is forested, residential areas comprise 21% of the total area and commercial areas account for 25% of the land cover. The remaining Lower Subwatershed land cover consists of: open land (8%); transportation (4.5%); barren land (1.5%); water (0.7%); wetland (0.3%); and shrubland (0.03%). Land use/land cover percentages and drainage area acreages for each subwatershed are presented in Tables 1-3.

1.2 The North Limits Drain Study

This study was part of a collaborative effort between the City of Kalamazoo, Kalamazoo Township and the Michigan Department of Environmental Quality-Surface Water Quality Division (MDEQ-SWQD) to evaluate the generalized drainage conditions and quality of North Limits Drain outfall discharges to the Kalamazoo River. The project goal was to conduct a stormwater drainage feasibility study that generated sufficient information to assist with future stormwater management decisions in the drainage areas of this water conveyance system. U.S. EPA Phase II Stormwater Regulations, a Total Maximum Daily Load (TMDL) for phosphorus on the Kalamazoo River and Michigan's Drain code were the drivers for undertaking this effort. The City of Kalamazoo and Kalamazoo Township are both designated Phase II communities that will be required to comply with new stormwater regulations. Thus, their participation as partners provided valuable on this project. The MDEQ-SWQD was interested in the quality of discharges from this County

Drain, particularly in relation to the TMDL. Their contributions of sample analyses through the state laboratory was also a valuable asset to the project. The Kalamazoo County Drain Commission Office met with partners at the onset of this project in November 2000. Limited information regarding the North Limits Drain was found during a subsequent visit with the Drain Commissioner in December 2000. Most of this information was available through other sources. The Drain Commissioner declined participation as a partner in the project.

2.0 Scope of Work

For this study, KIESER & ASSOCIATES (K&A) focused on a current assessment of drainage conditions providing recommendations for water quality improvement opportunities of the North Limits Drain discharge to the Kalamazoo River. Recommendations are based on an assessment of water quality impacts combining limited water quality sampling, preliminary hydrologic modeling, and generalized stormwater pollutant loading calculations. The components of this study include:

- Drainage characteristics
- Water quality monitoring
- Hydrologic classification and estimated storm flows
- Pollutant loading estimates
- Recommended management options

Details are addressed in the remainder of this report. Supporting information is provided in tables, figures and appendices.

3.0 Drainage Characteristics

Drainage characteristics of the North Limits Drain watershed were documented previously (Jones & Henry Engineers, 1976). In this previous study, the North Limits drainage area and the Zantman drainage area were grouped as one watershed. With the use of City of Kalamazoo electronic storm sewer maps, Geographic Information System (GIS) data, preliminary hydrologic modeling, electronic topographic data analysis, and watershed reconnaissance, the North Limits Drain watershed was revised to include the areas shown in Figure 1. The Upper "non-contributing" subwatershed (i.e., rural, non-sewered, topographic low areas, etc.) is 1,042 acres in size. The Middle Subwatershed is 252 acres and the Lower Subwatershed is 702 acres as defined through these efforts.

To characterize the North Limits Drain watershed (and subwatersheds) and provide information for hydrologic modeling and pollutant load estimates, a GIS approach was utilized. Raster land cover data for the project area were generated from 1997 Landsat 5 Thematic Mapper satellite data. (Land cover information in raster format is desirable for various hydrologic modeling and load calculations.) Computer Aided Drafting (CAD) files depicting the City of Kalamazoo's storm sewer system were obtained from the City. In addition, the Kalamazoo County Soil Survey map was added to the GIS to identify varying soil types with land cover. Aerial photographs and U.S. Geological Survey (USGS) maps were also added as GIS layers.

A reconnaissance survey of the drainage area was completed by KIESER & ASSOCIATES (K&A) to refine the watershed boundary, observe general watershed conditions/potential problem areas,

and identify land available for potential stormwater treatment areas. The results of this survey are provided in Appendix A. In general, it was determined that the Upper Subwatershed may be contributing only minimally, if at all, to the North Limits Drain. Areas west of Nichols Road were found to have retention facilities (leaching basins, ponds) within the residential areas and were, therefore, not included in the drainage delineation. The Upper Subwatershed drainage is served by a large 11.4 acre wetland located on the east side of Nichols Road and the south side of Ravine Road. This wetland complex appears to be capturing much of the stormwater runoff along Nichols Road to the north. Further investigation revealed that several retention areas (ponds, wetlands) are located upstream of the Statler Brothers Concrete Company at 1800 Ravine Road. These wetlands and other retention areas likely capture the bulk of the stormwater runoff, though further investigation during wet weather conditions would be required to quantify actual volumes.

A groundwater baseflow appears to originate on the Statler Brother's property to the west of the quarry area. This groundwater baseflow is diverted underground through the Statler property to two separate drains. One drain passes along the north side of Ravine Road and is diverted north prior to reaching Douglas Avenue. This drain then flows in front of the Hammond Roto-Finish facility (Figures 4-5). The second drain is located on the south side of Ravine Road where it eventually crosses back to the north of Ravine Road at the intersection of Ravine Road and Douglas Avenue. These two drains converge on the west edge of Versluis Park.

The North Limits Drain is an open channel through Versluis Park, following which it enters the City's storm sewer system at Woodward Avenue (Figure 6). The City of Kalamazoo storm drain sysstem is extensive as noted in Figure 1. The Drain becomes open again northwest of the WRP until it reaches the Kalamazoo River. There is a known National Pollutant Discharge Elimination System (NPDES) discharger directly upstream of Versluis Park in the North Limits Drain. This is a cooling water discharge from the A.M. Todd Co.

4.0 Water Quality Monitoring

Limited water quality monitoring was conducted for this study during two wet-weather (May 21, 2001 and June 21, 2001) and two dry weather (May 9, 2001 and May 29, 2001) events. Rainfall depths recorded at the K&A rain gauge (located at the Western Michigan University Goldsworth Valley Pond) were 0.81 and 0.86 inches for the May 21 and June 21, 2001 storm events, respectively.

4.1 Sampling Locations

Water samples were collected from the North Limits Drain at two locations: Middle Subwatershed and Lower Subwatershed. Sampling associated with the Middle Subwatershed was conducted within the North Limits Drain just west of Woodward Avenue as depicted in Figure 3. This sampling location represents stormwater runoff from the area upstream of Versluis Park. Sampling for the Lower Subwatershed occurred at the WRP property within the North Limits Drain west of the access drive culvert and east of the access drive culvert during the May 21, 2001 wet weather sampling. Samples from these locations represent contributions from the entire North Limits Drain watershed. The Upper Subwatershed was not sampled upon determining that the majority of the runoff from this area is likely retained in small retention areas, infiltration basins and a large 11.4 acre wetland complex. It is

possible that some stormwater runoff from the Upper Subwatershed may drain to the Middle Subwatershed in larger magnitude storm events, though the contribution is expected to be minimal due to the extensive retention/depressional areas in this drainage area. Further investigation of the Upper Subwatershed during larger magnitude storms may be warranted to better understand the connectivity of this drainage area to the Middle Subwatershed.

4.2 Parameters Sampled

K&A personnel collected grab samples at the two locations (Versluis Park and WRP) for all four sampling events. Field measurements of temperature, specific conductance, dissolved oxygen (DO), pH and stream flow were recorded. The following water quality parameters were analyzed by the City of Kalamazoo laboratory: total suspended solids (TSS), total phosphorus (TP), ammonia-nitrogen (NH_3-N), and total nitrogen (TN). In addition, fecal coliform, biochemical oxygen demand (BOD), and metals were analyzed for all WRP location samples. (Metals analyses were performed by the State of Michigan Laboratory.

4.3 Sampling Results

Results from the water quality sampling events are presented in Table 4, with metals data provided in Table 5. Copies of the analytical laboratory reports are provided in Appendix B. Samples collected during these events were discrete, grab samples and not necessarily representative of "first-flush" conditions at these sites.

Results from both the Versluis Park and WRP samples displayed consistently high TP concentrations ranging from 0.19 to 1.81 mg/L at Versluis Park and from 0.16 to 2.74 mg/L at the WRP site. As a reference, U.S. Environmental Protection Agency (USEPA) event mean concentrations (EMCs) for total phosphorus range from 0.24 mg/L in commercial areas to 0.47 mg/L for residential areas. (Note: EMC values presented here serve only as a means of comparing 'typical' stormwater concentrations in areas with similar land uses and are not intended to represent water quality standards or criteria.) The wet weather TP concentration detected at Versluis Park for the May 21, 2001 event was 1.81 mg/L, nearly four times greater than a 'typical' residential stormwater concentration. Dry weather TP concentrations at Versluis Park were detected at elevated concentrations, as well (0.21 and 0.52 mg/L). Total phosphorus concentrations observed at the WRP sampling site displayed similar high levels. A TP concentration of 2.74 mg/L was recorded for the May 9, 2001 dry weather sampling event. Fecal coliform levels ranged from 80 to 6000 cfu/100 mL at the WRP sampling location. As a reference, EPA criterion for fecal coliform for recreational waters is 200 cfu/100 mL.

Reported NH_3-N values were converted to the concentration present as the toxic, unionized form present at each site and are displayed in Table 4. This calculation accounts for both the pH and temperature recorded at the monitoring location. A pH value of 8.3 was assigned for the May 9, 2001 sampling event where pH data were unavailable. Unionized ammonia values detected during all four events at both Versluis Park and the WRP sampling locations were below the Michigan Department of Environmental Quality Aquatic Maximum Value (AMV) of 0.160 mg/L for coldwater and 0.210 mg/L for warmwater systems.

Samples at the WRP site were analyzed for metals for the two dry and two wet weather sampling events (See Table 5). The following metals were analyzed: calcium, chromium, hardness, magnesium, selenium, sodium, arsenic, barium, cadmium, copper, lead, silver and zinc. Measured concentrations were compared to MDEQ Aquatic Maximum Values (AMVs) criteria (MDEQ, 1997). AMVs are defined as the highest concentration of a material in the ambient water column to which an aquatic community can be briefly exposed without resulting in unacceptable effects. Because the AMVs for several of the metals are calculated based on the hardness of the receiving water, the criteria will differ for each sampling event. Where the hardness values are highest, the criteria will increase accordingly. Exceedances of the AMVs for copper, lead and zinc were noted during both wet weather sampling events.

4.4 Flows

Flows were measured at both the Versluis Park and WRP sampling locations during the four water quality sampling events using a Marsh-McBirney Flo-Mate Model 2000 portable flow meter. Discharge rates in cubic feet per second (cfs) were subsequently calculated based on channel geometry. These results are presented within Table 4 in addition to the analytical data (detailed cross-section data are presented in Appendix C). Dry weather discharge rates were recorded as 0.83 cubic feet per second (cfs) on May 9, 2001 and as 0.13 cfs on May 29, 2001 at the Versluis Park sampling location. Wet weather flows at this location were measured as 8.87 and 3.11 cfs for May 21, 2001 and June 21, 2001, respectively. Dry weather flows recorded at the WRP sampling location were 0.22 cfs and 0 cfs for May 9 and May 29, 2001, respectively. (It should be noted that the Kalamazoo River was back-flowing into the North Limits Drain at this sampling location due to high water conditions observed during the May 29, 2001 sampling event. The US Geological Survey hydrograph at the Kalamazoo River-Comstock location is provided in Appendix C for additional reference.) Wet weather flows recorded at the WRP location were 16.34 cfs on May 21, 2001 and at 5.21 cfs for the June 21, 2001 event.

5.0 Hydrologic Classification

The 1,996 acre watershed was divided into three subwatershed areas: Upper, Middle, and Lower (Figure 1) as noted previously. Each subwatershed was further divided into land use designations adapted from satellite-derived land use/land cover imagery. Hydrologic soil groups were determined for the watershed from information available in the electronic *Soil Survey of Kalamazoo County, MI* (USDA, 1993). Soils were classified as group A, B, C or D, with A possessing the lowest runoff potential (highest infiltration capacity) and group D having the highest runoff characteristics. Soils within the North Limits Drain study area were observed to be the following types: Adrian (A/D), Glendora (A/D), Kalamazoo (B), Oshtemo (B), Pits (B), Urban land (B), Urban land Glendora (A/D), and Urban land Kalamazoo (B). (Soil hydrologic group designations are given in parentheses.) The soil survey information was laid with the land use/land cover layer and topographic data using ArcView software to yield the specific areas within each subwatershed area possessing certain runoff characteristics.

A runoff curve number (CN) was assigned to each of the areas possessing unique runoff characteristics based on information in the 1993 USDA Natural Resources Conservation Service (NRCS) document *Urban Hydrology for Small Watersheds* (Technical Release 55). An area-weighted curve number was determined for each of the three subwatersheds. The calculated CN for the Upper subwatershed is 68.6, the Middle CN is 72.1, and the Lower subwatershed CN is 74.8 (Tables 1-3).

These composite CNs were used in the NRCS runoff equation to estimate runoff volumes produced from various rainfall events. Rainfall depths for the various storm events were obtained from the *Rainfall Frequency Atlas of the Midwest* (Huff and Angel, 1992). Tables 6-8 present the computed rainfall runoff depths, runoff volumes and corresponding precipitation amounts for various rainfall events.

6.0 Pollutant Loading Estimates

Pollutant loads from stormwater runoff were calculated for the three North Limits Drain subwatersheds using the Event Mean Concentration (EMC) method. EMCs are estimates of nonpoint source pollution determined in the USEPA Nationwide Urban Runoff Program (NURP). With this method, stormwater pollutant loadings are based on pollutant loading factors that vary by land use type and percent imperviousness (Wayne County, 1998). Loads can be computed using Equations 1 and 2 as follows:

$$M_L = EMC_L * R_L * K \qquad Eq.\ 1$$

Where:

M_L = Loading factor from land use L (lbs/ac/yr)
EMC_L = Event mean concentration of runoff from land use L (mg/L)
R_L = Total average annual surface runoff from land use L computed from Eq. 2
K = Unit conversion factor of 0.2266

Runoff Equation:

$$R_L = [\ C_P + (\ C_I - C_P\ )\ IMP_L\ ] * I \qquad Eq.\ 2$$

Where:

R_L = Total average annual surface runoff from land use L (in/yr)
IMP_L = Fractional imperviousness of land use L
I = Long term average annual precipitation (in/yr)
C_P = Pervious area runoff coefficient *(0.20)*
C_I = Impervious area runoff coefficient *(0.95)*

Equation 1 shows that the loading factor (M_L) for land use *L* is the product of the event mean concentration for land use *L*, the annual runoff for land use *L*, and a unit conversion factor. The runoff calculation in Equation 2 provides the R_L value used in Equation 1 through the product of the annual rainfall depth (34" from Kalamazoo rainfall records) and the percent imperviousness of land use *L*, with the tuning coefficients C_P and C_I. The loading factor, M_L, is multiplied by the area of land use *L* to obtain a total annual loading for that land use. Loads for each land use category within the three subwatersheds were subsequently totaled. Tables 9-11 display estimated annual pollutant loads to the Upper, Middle, and Lower subwatersheds using this approach.

Estimated loads from the Upper watershed (Table 9) are similar to those predicted for the Lower Subwatershed (Table 11). The likelihood of these loads reaching the Middle Subwatershed is low due to the apparent lack of a direct water course. Loads from the smaller middle subwatershed reach the lower stretches of the drain contributing to the Kalamazoo River. As there were no apparent storm water best management practices noted to be in place in either the Middle or Lower Sub watersheds, and as there are direct contributions from City of Kalamazoo storm sewers in both these areas, it is likely that loading estimates in Table 10 and 11 may be reasonable. Monitoring data suggests that North Limits Drain concentrations of total phosphorus, for example, are much higher than national averages. Thus, the substantial loads delivered to the drain and subsequently to the Kalamazoo River are considered significant in comparison to other MDEQ measured tributary loads such as those coming from other well-studied Kalamazoo County drains (e.g., OlmstedDrain [a.k.a. Davis Creek];see Table 2, page 30 at http://www.kalamazooriver.net/tmdl/docs/loadreport.pdf.)

7.0 Recommended Management Options

The findings from this study indicate that phosphorus, and to a lesser extent, total suspended solids, are the measured water quality parameters displaying high relative concentrations in the North Limits Drain watershed compared to other local urbanized tributaries (e.g., see http://www.kalamazooriver.net/pa319/arcadia/arcadia.wq.htm). Therefore, best management practices should be considered to reduce the addition of these pollutants to the North Limits Drain. Potential options for the three subwatersheds are presented as follows.

7.1 Upper Subwatershed

While the Upper subwatershed is likely contributing very minimally to North Limits Drain, there is a large 11.4 acre wetland complex within this watershed that may be negatively impacted by stormwater contributions from the Nichols Road runoff. This wetland serves to mitigate large flows and pollutants to the Middle and Lower subwatersheds. Figures 8 and 9 show significant sediment accumulation occurring at the southeast corner of the intersection of Nichols and Ravine Roads. Potential options for the Upper Subwatershed therefore include:

- Regular maintenance and clean-out of sediment within ditches along Nichols Road
- Installation of check dams or grass swales in series along Nichols Road to enhance detention of suspended sediment prior to entering the wetland
- Construction of a stormwater detention pond to the west of the wetland to reduce existing loads entering this complex

7.2 Middle Subwatershed

The Middle Subwatershed appears to be contributing a significant amount of total phosphorus to the North Limits Drain based upon the analytical data from the four sampling events conducted by K&A. There is at least one known point source cooling water discharge location upstream of the Versluis Park sampling location. In addition, the Statler Brothers Concrete Company is located immediately upstream. There are surficial storm water collection grates in the Statler Brothers gravel work area which are

connected directly to the diverted water flowing into the North Limits Drain. Furthermore, east of Douglas Road, much of the land adjacent to the North Limits Drain is closely mown, providing little buffering capacity for overland storm water flow (Figures 4 and 5). The apartment complex immediately south of the Versluis Park sampling location also appears to contribute trash and miscellaneous debris to the Drain (Figure 6). Potential options for the Middle Subwatershed therefore include:

- Construction of stormwater detention ponds/wetlands in the vacant area previously occupied by the drive-in theater. This parcel is 10.8 acres and could provide stormwater treatment for areas west of Ravine Road. As presented in Table 7, a 2-year/24-hour storm event would produce an estimated 9.8 acre-feet of stormwater runoff from the Middle Subwatershed. This magnitude storm event could be detained and treated off-line within a created stormwater treatment system on this parcel.
- Plant buffer zones along the North Limits Drain where vegetation is currently closely mown (e.g., Hammond Roto-Finish) to allow settling of solids from overland flow prior to entering the waterway.
- Construct a small stormwater wetland where the Drain crosses the Hammond Roto-Finish property.
- Regular maintenance of the open drain channel and grate at Woodward Avenue to remove trash and other debris
- Review of maintenance practices at the Woodward Avenue apartment complex to establish changes in dumpster locations, trash removal, "no mow" riparian zones etc. that could result in improvements to the North Limits Drain.

7.3 Lower Subwatershed

The North Limits Drain is primarily piped underground within the City of Kalamazoo storm sewer system in the Lower Subwatershed. In addition, very little vacant land is available for potential treatment areas within this highly developed residential and commercial drainage area. There is an industrial corridor within the City of Kalamazoo located on the west bank of the Kalamazoo River near the City's WRP. The Eaton property, located just north of the WRP, does appear to be contributing to the North Limits Drain based on field reconnaissance. Additionally, obvious soil erosion is occurring near the WRP sampling location along the access road (Figure7). Potential options for the WRP subwatershed include:

- Construction of an off-line stormwater treatment cell (detention pond) on City of Kalamazoo-owned property near the WRP sampling location. The City owns the two parcels of land adjacent to the North Limits Drain to the north and south of the WRP sampling location that are approximately 46 acres total. The WRP is situated to the south of these areas on a 31.2 acre parcel. Runoff volumes for the Lower Subwatershed are provided in Table 8. A 6-month/24-hour storm event would produce an estimated 11.2 acre-feet of runoff, while a 1-year/24-hour storm event would produce about 20.5 acre-feet. Based on these estimates, 10-15 acres of treatment area could provide significant stormwater treatment capacity.
- Disconnection from the North Limits Drain of all treatment lagoons and ponds on the former Eaton property

- **$** Street sweeping to minimize solids and total phosphorus from entering storm sewer curb inlets
- **$** Public education focusing on practices that reduce runoff from private properties and other efforts related to Phase II stormwater requirements.

9.0 References

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Appendix A

North Limits Drain Reconnaissance Survey

Appendix B

North Limits Drain Analytical Reports

Appendix C

North Limits Drain Channel Geometry and USGS Kalamazoo River Hydrograph

NORTH LIMITS DRAIN FEASIBILITY STUDY

TABLES

NORTH LIMITS DRAIN FEASIBILITY STUDY

FIGURES

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