Michigan Department of Environmental Quality
Surface Water Quality Division
May 2002

Total Maximum Daily Load for Biota of Carrier Creek, Eaton County

INTRODUCTION

Section 303(d) of the federal Clean Water Act (CWA) and the United States Environmental Protection Agency's (USEPA's) Water Quality Planning and Management Regulations (Title 40 of the Code of Federal Regulations, Part 130) provides statutory authority for states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are not meeting Water Quality Standards (WQS). The TMDL process establishes the allowable loadings of a pollutant to a waterbody based on the relationship between pollutant sources and in-stream water quality conditions. TMDLs provide states with a basis for determining the pollutant reduction necessary from point and/or nonpoint sources to maintain and/or restore the quality of their water resources. The purpose of this TMDL is to identify an appropriate reduction in sediment loading from existing sources in the Carrier Creek Watershed that will result in the attainment of WQS in Carrier Creek, a small stream in the Grand River Watershed.

PROBLEM STATEMENT

Carrier Creek was first listed in 1996 and continues to be listed in 2002 as containing a "macroinvertebrate community rated poor" (Creal and Wuycheck, 1998 and 2000). The TMDL portion of Carrier Creek (Figure 1) is on the Section 303(d) list as:

Waterbody: **Carrier Creek** WBID# **082812D**
County: Eaton RF3RchID: 04050004 Size 4 M
Location: Grand River Confluence upstream to I-496.
Status: **2** Problem: **Macroinvertebrate community rated poor.**
TMDL YEAR(s): 2002

The 1996 Section 303(d) report listed seven miles of river as being threatened due to sediment loss from a construction site. Additional data collected since 2000 has refocused the actual TMDL reach to the four-mile section described above.

The Carrier Creek Watershed is contained entirely within Delta Township on the east side of Eaton County, Michigan. The creek begins as two agricultural drains. Holly Drain begins in section 34 and Moon and Hamilton Drain begins in section 33. Both drains flow in a northerly direction and join to form Carrier Creek in section 22, immediately south of I-496. The creek flows an additional 4 miles north to its confluence with the Grand River in section 3.

Most of the stream channel was modified (straightened and dredged) 50 years ago to support agricultural land use, including wetland drainage and conversion to crop production. Many of these same channels are occasionally redredged, with the accompanying dredge spoil disposal producing elevated stream banks that effectively act as a barrier between the stream and the adjacent floodplain. The combination of enhanced land drainage, the loss of active floodplains and adjacent wetlands, an increase in land development, and the loss of channel sinuosity has produced a flashy hydrology in Carrier Creek accompanied by significant in-stream sedimentation. These unstable flow conditions and an increase in sedimentation have subsequently reduced macroinvertebrate communities to less than acceptable levels.

A biological survey in 1989 reported a reduction in macroinvertebrate habitat due to sedimentation immediately downstream from I-496 (Goble and Masterson, 1990) where macroinvertebrates were represented by only 11 taxa that were dominated by pollution tolerant species. Downstream stations were reported to contain more algae and aquatic macrophytes, but fish and macroinvertebrates communities were still considered to be depressed.

A 1996 biological survey using the Great Lakes and Environmental Assessment Section's Procedure 51 (MDEQ, 1997) indicated that both the fish and macroinvertebrate communities were rated "acceptable (moderately impaired)" (Hanshue, 1999). "Acceptable" scores range from +4 to -4 with the low end considered to be minimally acceptable. Hanshue (1999) rated the fish and macroinvertebrate communities as -1 and -2, respectively. This report also contained photo documentation of severe soil erosion from a land development construction site (Eyde's property) immediately upstream of the Saginaw Highway crossing. Sediment eroding from the Eyde's property was reported to have caused major in-stream sedimentation and severe habitat impairment to the creek adjacent to the construction site with some portions of the reach unwadable due to unconsolidated sediments. Macroinvertebrates in this unwadable reach were judged to be poor due to the harsh environmental (habitat) conditions. Sedimentation in the downstream portion of the creek was also present on the surface of stable substrates in the river. The 1996 survey effort included visual observations from stream reaches upstream of Saginaw Highway and I-496. These observations reported significant sedimentation, and in-stream habitat degradation were consistent with findings reported by Goble and Masterson (1990).

A biological survey conducted in May 2000 by the Eaton County Drain Commissioner (Harrington, 2000) using Procedure 51 found both the macroinvertebrate community and stream habitat were rated as poor at three stations between Saginaw and St. Joseph Highways upstream of the Eyde's development at the Saginaw Highway crossing. However, this survey effort did not assess the biotic community or stream habitat in the immediate vicinity of the Eyde's property.

A biological survey of Carrier Creek was performed in June 2001 by the Michigan Department of Environmental Quality (MDEQ) (Wuycheck, 2002). Stream habitat was increasingly degraded downstream of Saginaw Highway, reportedly from upstream sediment loadings. The macroinvertebrate community was considered to be depressed and dominated by tolerant taxonomic groups despite an ample amount of hard substrate materials. The macroinvertebrate community was minimally acceptable (-4) adjacent to the Eyde's property, while habitat was considered to be fair.

In summary, the macroinvertebrate community in Carrier Creek downstream from St. Joseph Highway was judged to be poor based on data from the 1997 MDEQ report, Harrington's (2000) description of a macroinvertebrate community that was rated as poor between St. Joseph Highway and Saginaw Highway, and Wuycheck's (2002) report of significant amounts of bedload sediment, severely impairing the biological community downstream from Saginaw Highway.

NUMERIC TARGET

The impaired designated use for Carrier Creek is aquatic life. Rule 100(1)(f) requires that all surface waters of the state are designated for and shall be protected for, among other things, aquatic life and wildlife. Because the quality of the biota in the creek have been reduced due to habitat loss resulting from excessive sediment deposition, achievement of the WQS for designated uses for Carrier Creek will be demonstrated by using an assessment of the macroinvertebrate community, as well as in-stream habitat as it relates to sediment.

The minimum value required to demonstrate water quality attainment for biota (using Procedure 51) is -4. Therefore, a TMDL target value of -4 (lower end of acceptable range) will be used to demonstrate attainment of the WQS for the macroinvertebrate community. The macroinvertebrate community score will be evaluated using Procedure 51 biological assessments conducted in two consecutive years following the implementation of best management practices (BMPs) to minimize sediment loadings to the subject TMDL reach.

A habitat assessment endpoint will also be used as a numeric target. This endpoint will measure changes in stream conditions related to sedimentation. The Procedure 51 habitat assessment is composed of ten individual metrics that provide a subjective measurement of the various aspects that collectively describe and score a riverine habitat. However, because the biological community impairment is due to sedimentation, only sediment related metrics taken from the Procedure 51 protocol will be used to measure change in habitat conditions. These metrics include:

- Bottom Substrate/Available Cover (score range from 0 to 20).
- Embeddedness (0 to 20) (measurement taken only in riffle areas of the stream).
- Bottom Deposition/Sedimentation (0 to 15).

The direct link and inverse relationship between the quality of a biological community and the three metrics described above is well cited and accepted in aquatic related scientific literature. As such, the use of only these three sediment related metrics will provide greater resolution to sediment related changes within the stream channel while providing a definable endpoint that is directly applicable to the biotic community.

The Bottom Substrate/Available Cover metric provides a semi-quantitative description of stable substrates suitable for macroinvertebrate colonization and refugia for fishes. In addition, these stable substrates provide numerous microzones of flow diversity that enables downstream sediment transport, as well as microhabitats for periphyton and macroinvertebrates. The Embeddedness metric serves to evaluate the relative physical effect of solids deposition on and around large substrate. With increased embeddedness of large substrate types (e.g., logs, cobble, and gravel) of the habitat, the quality of the habitat decreases; therefore, the integrity of the biological community is diminished. Bottom Deposition/Sedimentation is an additional metric that assesses the overall area of the channel that is impacted by sediment deposition.

Habitat surveys reported by Harrington (2000) found acceptable macroinvertebrate scores of -2 to -3 associated with scores from the three sediment related metrics above of 44 to 50. Wuycheck (2002) found acceptable macroinvertebrate scores of -2 associated with habitat scores of 30 to 43. Both Harrington and Wuycheck found poor macroinvertebrate community scores of -4 to -7 associated with habitat scores of 11 or less. Based on these data, a score of 30 has been established as the target for the habitat quality. This target will represent an increase in habitat quality of 2 to 14 times the existing score from previous surveys, depending on the upstream station used for comparison. A target score of 30 represents adequate control of anthropogenic sediment sources to ensure attainment of WQS in Carrier Creek.

SOURCE ASSESSMENT

Goble and Masterson (1990) suggested that sediment from road work along I-496 may have impaired Carrier Creek downstream of that location. Hanshue (1999) added that the causes of habitat impairment were largely due to drainage projects (channelization and relocation) throughout the watershed and by erosion. In addition, the watershed contains 27 construction sites covered by permit by rule, including the Eyde's property (Figure 2), and one industrial storm water discharge.

Therefore, sources of sediment to Carrier Creek include soil erosion from land development and stream bank erosion. The loss of natural stream morphology due to unstable stream banks that remain unvegetated, and a distinct separation between the stream and its adjacent wetland floodplain has disrupted the natural hydrology of the area resulting in erosive, flashy flows following precipitation/runoff events. These alterations to the watershed have destabilized stream banks, greatly increased sediment loading to the stream, and reduced or eliminated fish and macroinvertebrate habitats. In addition, increases in development and suburban encroachment within Delta Township are increasing the total area of impervious surface within the watershed. Increases in overland flow are typically associated with increases in surface and bank erosion, leading to an increase in sediment load to the stream (Schueler, 1993).

LINKAGE ANALYSIS

A simple, yet effective method for developing a TMDL to address the impacts to a biological community affected by sedimentation is to measure sediments with regards to impacts on stable structures or substrates in the stream channel and the accompanying changes to the biotic community. Because the endpoint of protection is the biological community, it was concluded that the use of BMPs to reduce sediment loadings from identified sources combined with reassessments of the biological community and habitat would be the most appropriate action for this waterbody. BMPs can be used to minimize anthropogenic sources of sediment loadings.

Increased embeddedness resulting from excessive sedimentation has been demonstrated to impair the biological integrity of rivers (Waters, 1995) by obscuring or reducing the suitability of colonizable or useable substrate by stream biota. A reduction in sedimentation will generally reestablish colonizable substrates for stream biota. Therefore, reductions in in-stream sedimentation will result in an increase in species diversity and richness. Procedure 51 assessment scores for macroinvertebrates and habitat will indicate improvements in Carrier Creek as the biological integrity of the macroinvertebrate community increases with a corresponding decrease in the degree of sedimentation and flashiness.

TMDL DEVELOPMENT

This TMDL is based on the maximum sediment load that can be assimilated by the stream while maintaining WQS. The numeric score of -4 for biota and a modified habitat score of 30 will serve as the targets for this biota TMDL. Concurrent with the selection of numeric endpoints, TMDL development also defines the environmental conditions that will be used when defining allowable levels. Many TMDLs are designed around the concept of a “critical condition.” The “critical condition” is defined as the set of environmental conditions that, if controls are designed to protect, will ensure attainment of objectives for all other conditions. For example, the critical conditions for the control of point sources in Michigan are given in R 323.1090. In general, the lowest monthly 95% exceedance flow for streams is used as a design condition for point sources. Sediment input to Carrier Creek arises from a number of weather-driven nonpoint sources that contribute sediment to the stream or restrict the movement of sediment through and eventually out of the stream. As such, there is no single condition that is protective for all conditions. For these sources, there are a number of different allowable loads that will ensure compliance, as long as they are distributed properly throughout the watershed.

Because the biotic community has been impaired by excessive sediment deposition, this TMDL will be evaluated by the net response to the macroinvertebrate community from sediment removal. As such, this TMDL is not based on a specific mass load that is expressed as a weight (tons) or volume (cubic meters) but rather on a load that does not result in the reduction of the macroinvertebrate community below the target value of -4 and a sediment related habitat score of 30.

ALLOCATIONS

TMDLs are comprised of the sum of individual Waste Load Allocations (WLAs) for point sources and Load Allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for uncertainty in the relation between pollutant loads and the quality of the receiving waterbody. Conceptually, this definition is denoted by the equation:

TMDL = ?WLAs + ? LAs + MOS

The term TMDL represents the maximum loading that can be assimilated by the receiving water while still achieving WQS. The overall loading capacity is subsequently allocated into the TMDL components of WLAs for point sources, LAs for nonpoint sources, and the MOS.

Pollutant loadings are allocated among three categories:

WLA: The WLA is the allocation for an individual point source that ensures that the level of water quality to be achieved by the point source complies with all applicable WQS. There are no permitted continuous point source discharges to this waterbody. Therefore, the WLA equals zero.

LA: The LA is that portion of a receiving water's loading capacity that is attributed to existing or future nonpoint sources, including natural background sources. The anthropogenic sources of sediment loadings to the creek are attributable to nonpoint source erosion and runoff resulting from previous development within the watershed and historical channel alterations. These nonpoint source and background contributions are the LA and comprise 100% of the TMDL loading capacity. It is unnecessary to quantify the sediment load because the reductions through implementation of BMPs will be measured by the response in stream habitat and biotic community.

MOS: The MOS in a TMDL is used, in part, to account for variability of source inputs to the system. An MOS is implicit for a biota TMDL because the quality of the biological community, its integrity, and overall composition represent an integration of the effects of the variability in sediment loadings in the aquatic environment, including temporal and spatial variability due to meteorological events. Biosurveys using Procedure 51 will be conducted in a June to August timeframe during stable flow conditions to provide the most comparable assessment results. The results collected will reflect an MOS that is implicit and express an integration of the effects of variability in sediment loadings in the aquatic environment and minimize seasonal variability.

In addition, the habitat target value of 30 represents a substantial increase over existing scores in the upper half of the creek. This targeted score of 30 is closely associated with macroinvertebrate scores of -3 or more, which is greater than the minimally accepted value of -4. This level of conservation is appropriately high enough to provide a sufficient MOS to minimize temporal and spatial variability within the watershed, and buffer variability within the macroinvertebrate and habitat assessment protocol itself.

SEASONALITY

Seasonality is addressed in the TMDL in terms of sampling periods for macroinvertebrates. To eliminate temporal trends due to changes in life histories, sampling will take place during the same months each year. Temporary impacts due to runoff events will be avoided by targeting periods of stable flow.

MONITORING PLAN

Monitoring will be conducted by the MDEQ to assess progress towards meeting the biota TMDL targets. Following implementation of applicable BMPs, annual sampling of the macroinvertebrate community using Procedure 51 and habitat quality using a modified version of Procedure 51 will be conducted at the proposed stations shown in Figure 3 until the target is met for two consecutive years. Macroinvertebrate samples will be taken during periods of stable flow in a June to August timeframe, with every effort made to duplicate the same sampling period each year.

REASONABLE ASSURANCES

Actions to restore Carrier Creek have been developed using CWA Section 319 and Clean Michigan Initiative Program grants, which currently total $1,000,000 for both the planning phase and implementation portion of this project. These actions are directed towards the installation of BMPs to minimize and control sediment loadings and buffer the number and magnitude of high water events by reestablishing the link between the creek's floodplain and adjacent wetlands. Specifically, much of the rehabilitation plan developed for Carrier Creek calls for:

- Narrowing of the stream channel along many of the previously dredged portions of the creek.
- Lowering the banks in a number of locations where dredge spoils have formed berms that effectively prevent the creek from the flooding into the adjacent floodplain.
- Placement of live stakes, erosion prevention material, seeding, and planting shrubs.
- Placement of biolunkers or logs, tapering banks to lower slope angles, and armoring banks with revetment or gabion basket structures.
- Obtaining easements to restore adjacent floodplain areas.

Once these BMPs are in effect, stable habitats for fish and other aquatic biota will be constructed in areas of the channel where such habitat is absent or repaired/enhanced where habitat is available but functioning poorly.

The MDEQ Guidebook of BMPs for Michigan Watersheds (Peterson et al., 1983) will be used to develop BMP elements for the Carrier Creek Rehabilitation Project. MDEQ approval of BMPs and implementation plans will be required prior to implementation of proposed structural improvements.

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REFERENCES

Creal, W. and J. Wuycheck. 1998. Clean Water Act Section 303(d) List – Michigan Submittal for Year 1998. MDEQ Report #MI/DEQ/SWQ-98/001.

Creal, W. and J. Wuycheck. 2000. Clean Water Act Section 303(d) List – Michigan Submittal for Year 2000. MDEQ Report #MI/DEQ/SWQ-00/018.

Goble, S. and M. Masterson. 1990. Biological Survey of Carrier Creek, Eaton County, Michigan, July 18, 1989. MDNR Report #MI/DNR/SWQ-89/132.

Hanshue, S. A Biological Assessment of Carrier Creek, Eaton County, July 25, 1996. MDEQ Report #MI/DEQ/SWQ-99/005.

Harrington, B. 2000. Carrier Creek Drain Erosion and Biological Assessment. Report prepared by: Wetland and Coastal Resources, Inc., Mason, MI.

MDEQ. 1997. GLEAS Procedure 51 – Qualitative Biological and Habitat Survey Protocols for Wadable Streams and Rivers. January 1997 Revision.

MDEQ. 1998. Update of GLEAS Procedure 51 – Metric Scoring and Interpretation. MDEQ Report #MI/DEQ/SWQ-98/068.

Peterson, A., R. Reznick, S. Hedin, M. Hendges, and D. Dunlap. 1993. Guidebook of Best Management Practices for Michigan Watersheds. MDEQ, SWQD.

Schueler, T. 1993. Mitigating the Adverse Impacts of Urbanization on Streams: A Comprehensive Strategy for Local Government. Conference on Water Quality, Concerns and Development, Grand Valley State University, Grand Rapids, MI.

USEPA. 1999. Protocol for Developing Sediment TMDLs (First Edition). EPA 841-B-9004. Office of Water (4503F), United States Environmental Protection Agency, Washington, DC. 132 pp.

Waters, T. 1995. SEDIMENT IN STREAMS – Sources, Biological Effects and Control. American Fisheries Society Monograph 7, American Fisheries Society, Bethesda, MD.

Wuycheck, J. 2002. A Biological Community and Habitat Assessment of Carrier Creek, Eaton County, Michigan, July 28, 2001. (In Press) MDEQ Report #MI/DEQ/SWQ-02/002.

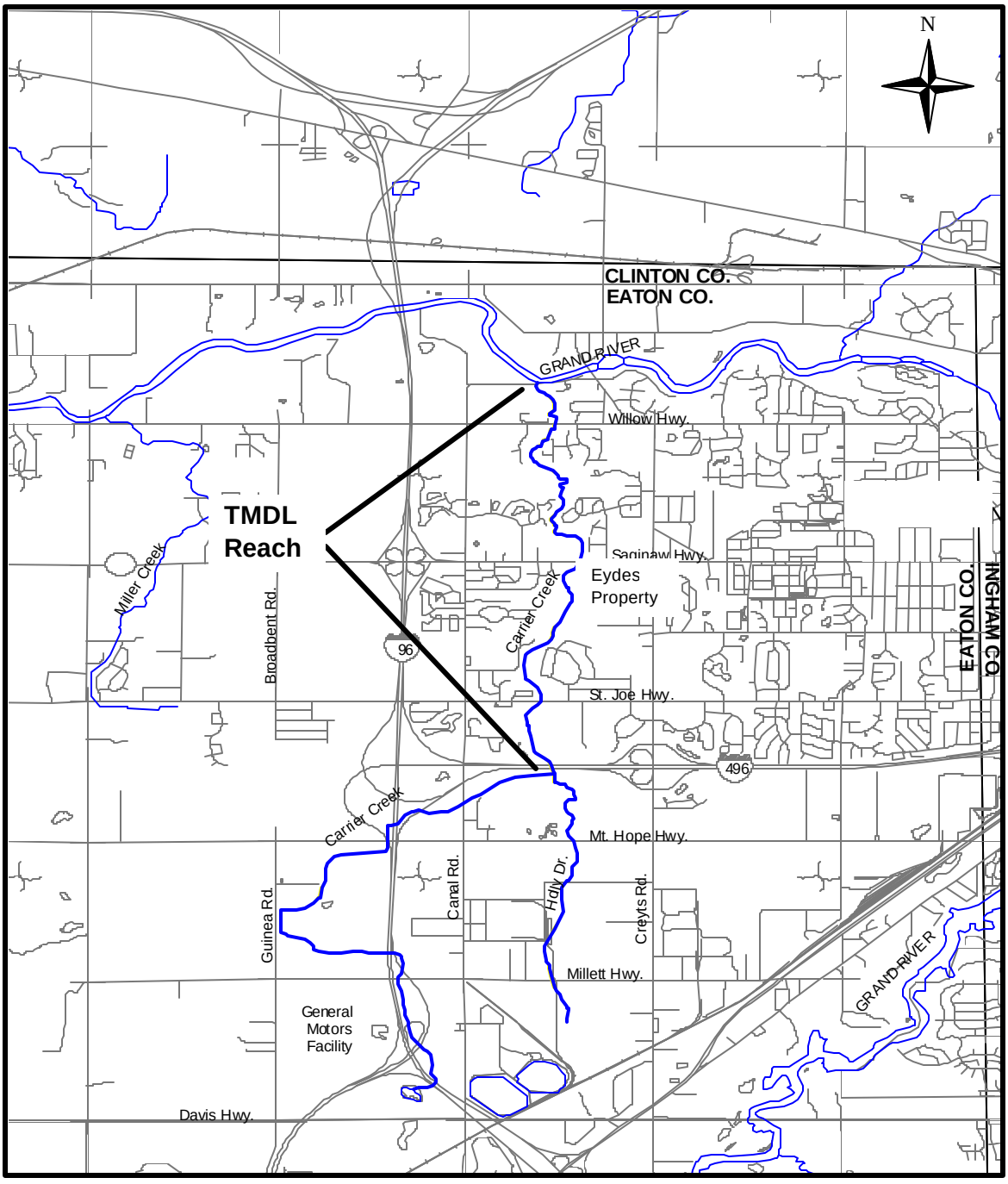

Figure 1. Carrier Creek Watershed indicating the location of the TMDL reach.

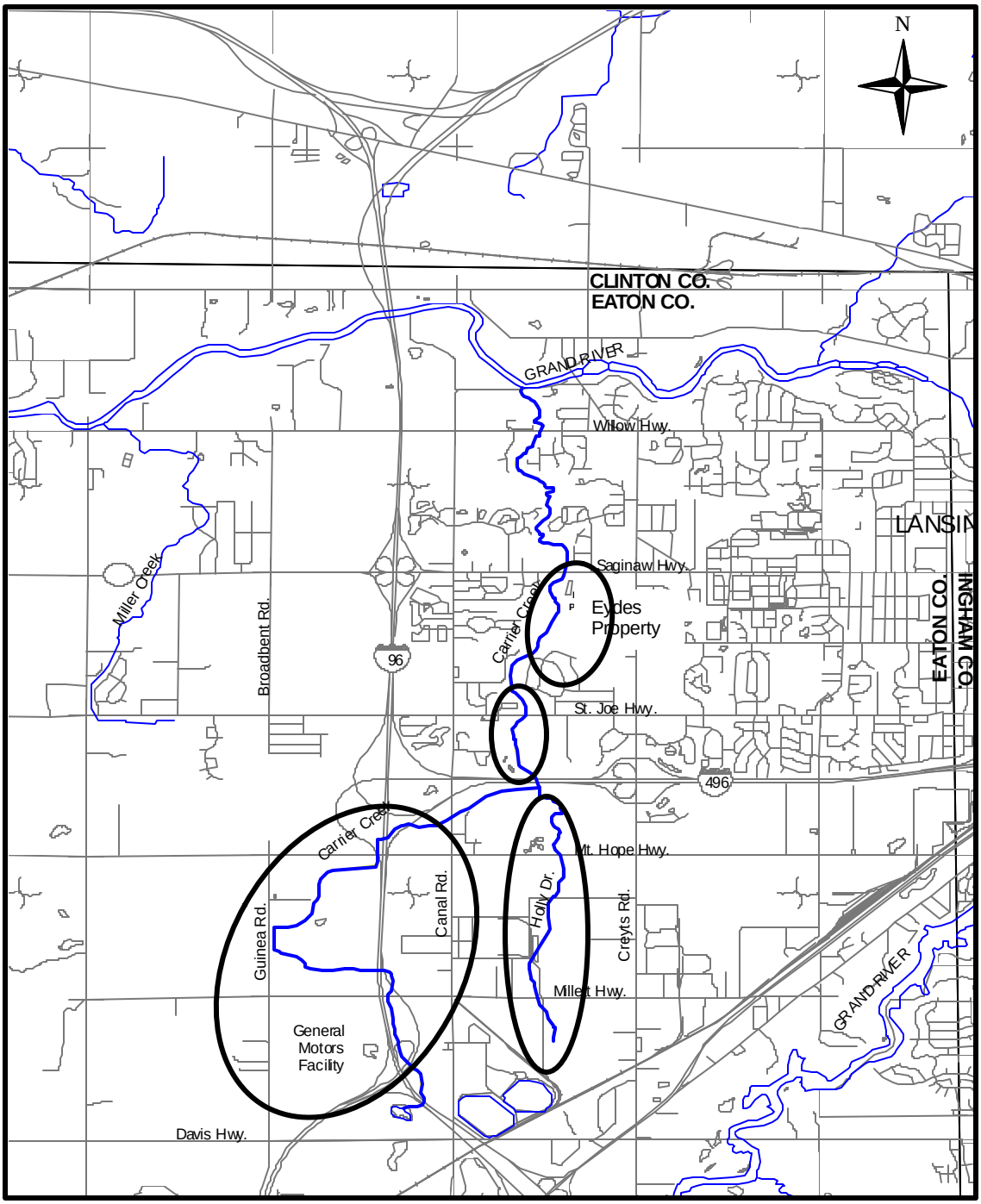

Figure 2. Carrier Creek Watershed indicating sources of impact (circled areas) to the stream.

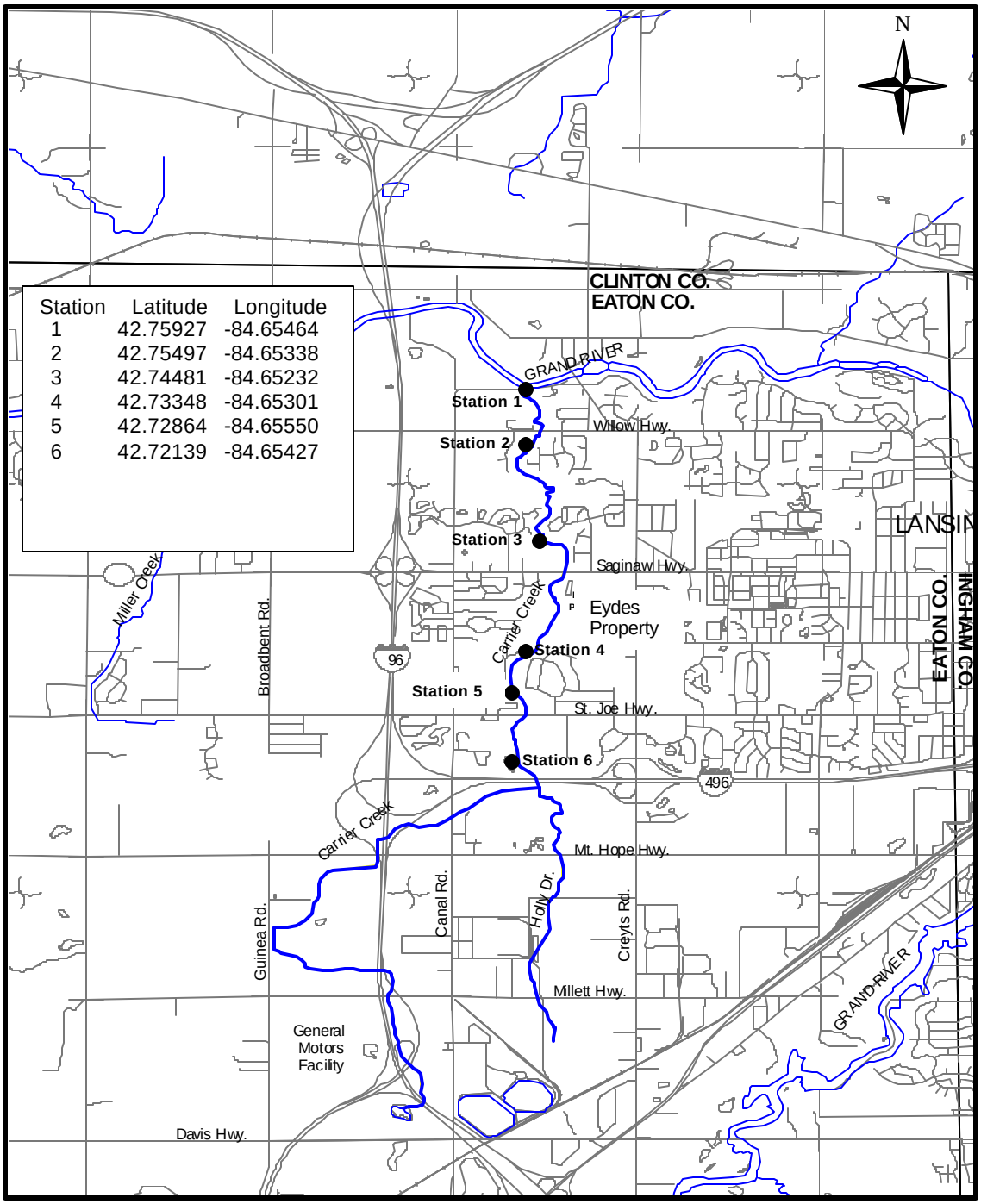

Figure 3. Proposed sediment and biological TMDL monitoring stations on Carrier Creek, Eaton County, Michigan.