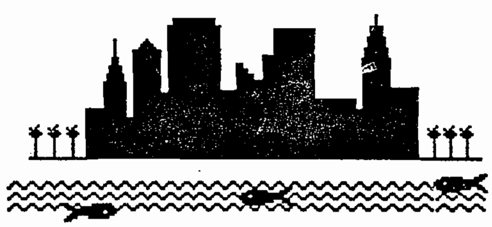
NORTHEAST OHIO
REGIONAL
SEWER DISTRICT

GREATER CLEVELAND AREA

STREAM MONITORING PROGRAM

1987

REPORT



AUGUST 1988

GREATER CLEVELAND AREA
STREAM MONITORING PROGRAM
1987 REPORT
August 1988

NORTHEAST OHIO REGIONAL SEWER DISTRICT

Erwin J. Odeal, Director

Kenneth A. Pew, Chief
Support Services

CONTENTS Pg.

PREFACE

In 1987, the Northeast Ohio Regional Sewer District Industrial Waste Section, James Weber, Manager, began implementation of its Stream Monitoring Program, roughly following the guidelines set forth by Program Developer Timothy Whipple in 1986. At this early stage, the scope of the program has been limited to initial surveys of streams, identification of environmental problems, and establishment of sampling procedures.

Industrial Waste Section personnel were divided into 7 two-person crews, each responsible for an initial visual inspection of its assigned streams. The crews physically walked along (or in) as much of the stream within the NEORSD jurisdiction as was possible. They noted the physical characteristics of the stream including surrounding geography, any visible biota, the nature of the substrates, the apparent water quality, and the suitability of sampling locations chosen by Mr. Whipple. Also identified and reported to appropriate agencies responsible for remediation were the sources of any environmental disruptions encountered during the surveys. The crews subsequently followed up on these disruptions and, as a result, a number of environmental problems were corrected or, at least, steps were taken toward their remediation.

To gain an initial assessment of the present water quality conditions in the streams, the crews began the accumulation of chemical, bacteriological, and benthic sampling data. Sample sites were essentially the same as the 52 locations selected by Mr. Whipple, and his numbering system was followed, with circumstances dictating the selection of a few additional sites. Chemical and bacteriological samplings were supplemented with in-the-field physical measurements, including dissolved oxygen, temperature, and flow determinations. The sampling for benthic macroinvertebrates was limited to being qualitative in nature, using handpicking, a core sampler, and/or a Surber sampler. The taxonomic identification of benthos was accomplished by William Mack.

Each crew recorded its findings and analyzed the data it obtained. Their reports constitute the narrative of this report. The Cuyahoga River was surveyed and sampled by Robert Kleinhenz and Tom Zablotny; Big Creek and Mill Creek by Keith Linn and George Uhl; West Creek by James Laheta and Dan McGrew; Tinkers Creek and Chippewa Creek by Michael Bode and Peter LeCastre; Euclid Creek, Green Creek, and Nine-Mile Creek by Larry Adloff and Richard Connelly; Shaw Brook, Dugway Brook, and Doan Brook by Frank Schuschu and Michael Pavlik; Rocky River by Frank Intihar and Cheryl Green. These reports were edited by Keith Linn, Stream Monitoring Program Coordinator, and the clerical duties were performed by Carmen Comber, Industrial Waste Section Secretary.

INTRODUCTION

The Northeast Ohio Regional Sewer District (NEORSD) was created in 1972 by Court Order to resolve jurisdiction impediments to the massive sewage treatment plant and interceptor sewer replacement and expansion. These sewerage system construction projects were necessary to eliminate severe pollution problems in the Greater Cleveland area.

The pollution problems of the late 1960's and early 70's were infamous and onerous. Everyone recalls the Cuyahoga River so covered with flotsam and oil that it caught fire! The shipping channel of the Cuyahoga River, the old river bed, and harbor area were covered with oil slicks. The waters were malodorous and gassing with methane from the decomposition of organic material that settled to the bottom.

Edgewater Beach on Cleveland's west side had bacteria levels in the millions! It may be recalled that Cleveland, in an effort to make the water safe for bathers, installed floating barriers with plastic curtains anchored to the lake bottom and dosed with high concentrations of chlorine. Even this "Pool-in-Lake" experiment proved ineffective against the volumes of untreated and poorly treated sewage that leaked, overflowed, by-passed, or otherwise discharged to the environment. The sewage treatment plants that were operating at that time were generally undersized and given to frequent by-passes of sewage. There was essentially no control over industrial waste that was discharged to the sewer system. Toxic metals, acids, cyanide, and oil were freely released by industry. These substances further added to the environmental problem by causing inhibition of sewage treatment plant performance. Significant large concentrations of toxic metals passed through the treatment plants to the environment.

The initial focus of the young NEORSD was to build a modern effective pollution control infrastructure. Within the first decade of is existence to remedy these pollution problems, the NEORSD constructed the Northwest Interceptor to eliminate untreated sewage from reaching Cleveland's west shore of Lake Erie. The Westerly Wastewater Treatment Plant was well under construction. On the east side, the Easterly Wastewater Treatment Plant was expanded with new headworks and an effluent pumping station. To the south, Southerly Wastewater Treatment Plant was built and the Cuyahoga Valley Interceptor was nearly completed. Twenty-five computer controlled automated combined sewer regulators were installed which minimize the amount of sewage spilled to the environment during periods of rain. In all, approximately $750 million was committed to capital improvements.

The NEORSD is now in the second decade. The aforementioned projects are now in place and the Heights-Hilltop and Southwest Suburban Interceptors are well under construction. With the massive capital construction program approaching completion, the NEORSD is now expanding its focus to include issues of water quality of area streams. Staff members were added to the Industrial Waste Section to begin the water quality monitoring of the rivers and streams.

The charge of the Stream Monitoring Program is to:

1) Document the Water Quality Improvements due to NEORSD facilities and programs
2) Determine sources of environmental disruptions and make recommendations for their elimination
3) Coordinate monitoring activities with other agencies with interests in water quality and
4) Provide a scientifically sound current information basis for environmental planning and future abatement projects

The NEORSD Stream Monitoring Program has included 53 monitoring locations on 17 streams and rivers with the NEORSD jurisdiction. The monitoring locations are designed to acquire the optimum amount of information through a reasonable number of monitoring locations.

<u>East Side Parallel Direct Drainage Stream</u>

- Euclid Creek	- 4	monitoring	locations
- Green Creek	- 3	monitoring	locations
- Nine-Mile Creek	- 4	"	"
- Shaw Brook	- 1	"	"
- Dugway Brook	- 4	"	"
- Doan Brook	- 4	"	"

<u>Cuyahoga River Basin</u>

- Cuyahoga River	- 7	"	"
- Big Creek	- 6	"	"
- Mill Creek	- 6	"	"
- West Creek	- 3	"	"
- Tinkers Creek	- 4	"	"
- Chippewa Creek	- 3	"	"

<u>Storm Sewer "Streams"</u>

- Walworth Run	- 1	"	"
- Kingsbury Run	- 1	"	"
- Morgana Run	- 1	"	"
- Burke Brook	- 1	"	"

<u>Rocky River Basin</u>

- East Branch Rocky River	- 3	"	"
- West Branch Rocky River	- 1	"	"

The Program includes chemical, physical, and biological sampling. The complete Stream Monitoring Program will be phased in over a three-year period. The first year of the Program, 1987, included walking the stream to locate (and eliminate where possible) dry weather sources of pollution, physical and chemical sampling, and qualitative biological sampling. The second year will follow up on solutions to the noted environmental problems, continue to develop biological analytical skills and focus primarily on the Cuyahoga River. By the third year of the Program it is anticipated that sufficient stream monitoring skills and equipment will be possessed to duplicate Ohio EPA stream monitoring and electrofishing techniques so that application of the fish and macroinvertebrate indices, the Integrity of Biota Index (IBI) and Invertebrate Community Index (ICI) can be calculated.

This report is the first of annual reports that will attempt to describe conditions, problems, and improvements to the surface waters in the Greater Cleveland area.

SUMMARY

In 1987, the Northeast Ohio Regional Sewer District Stream Monitoring Program obtained 186 samples for 35 chemical parameters at more than 53 locations. 168 samples for 3 bacteriological parameters were obtained. The individual data obtained through the analyses of these samples are on file and available for review upon request at the NEORSD Industrial Waste Section offices. Additionally, 57 types of benthic macroinvertebrates were collected and identified to various taxonomic levels, from order to species.

The following is a general summary of the 1987 water quality status of each stream studied based upon the chemical, bacteriological, and benthic data obtained, and upon the visual surveys performed on each stream.

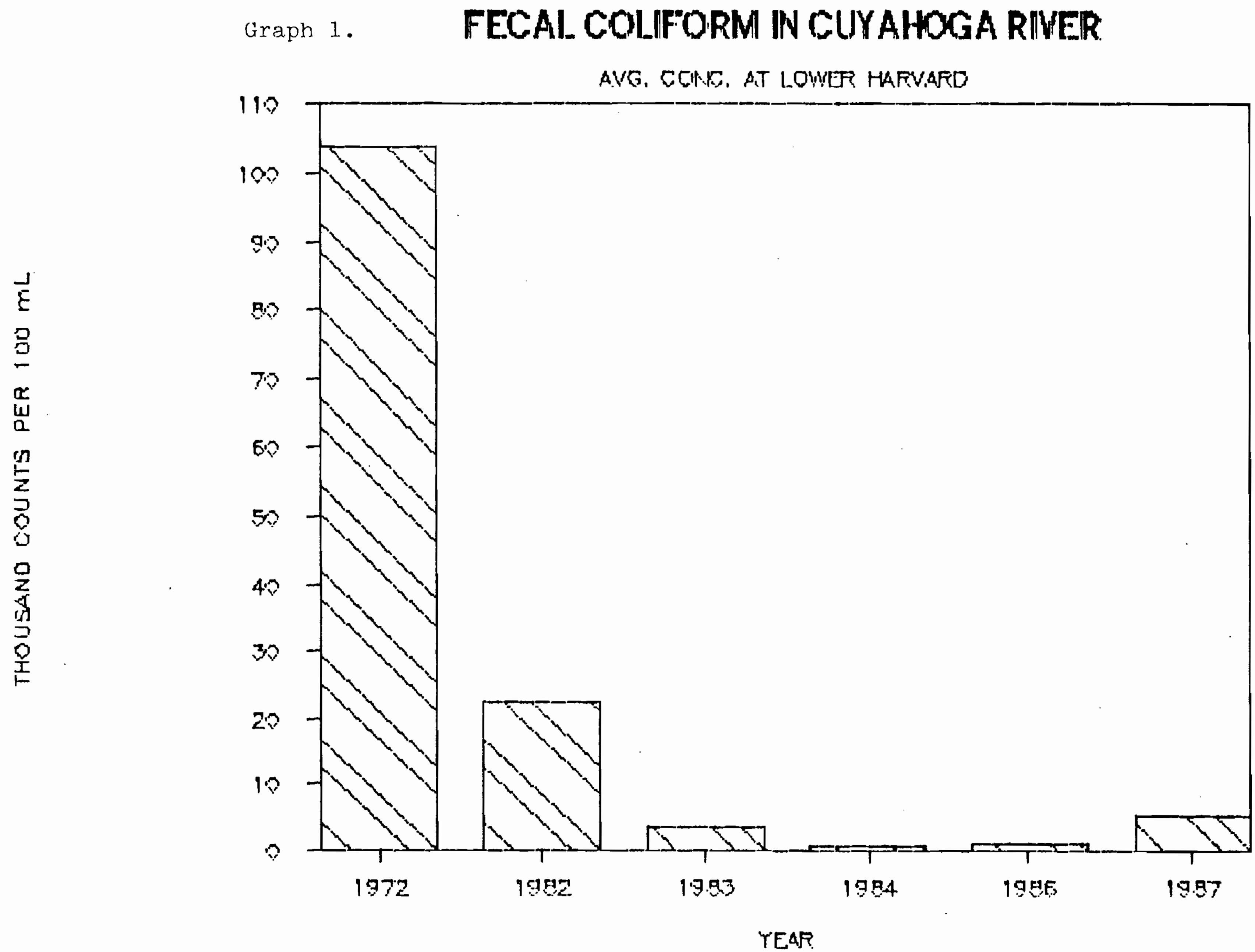
The Cuyahoga River water quality was generally uniform from site to site, according to chemical and bacteriological data. Comparing historical data, dramatic decreases in fecal coliform and metals concentrations in the river have occurred over the last 15 years. (See Graphs 1 and 2).

Qualitative sampling of benthic macroinvertebrates in the Cuyahoga River, however, indicated a wide variation between sample sites. The furthest downstream sites (near the head of navigation) exhibited an extremely low benthic diversity and the presence of only pollution tolerant organism, while the furthest upstream locations (near Route 82) exhibited a high diversity, including the presence of some pollution intolerant organisms. This variance appears to be directly related to the diminished dissolved oxygen levels found downstream as the river's velocity decreases. Also a factor is the Cuyahoga River's high erosion potential and associated silt and sediment load, the impact of which is most severe downstream.

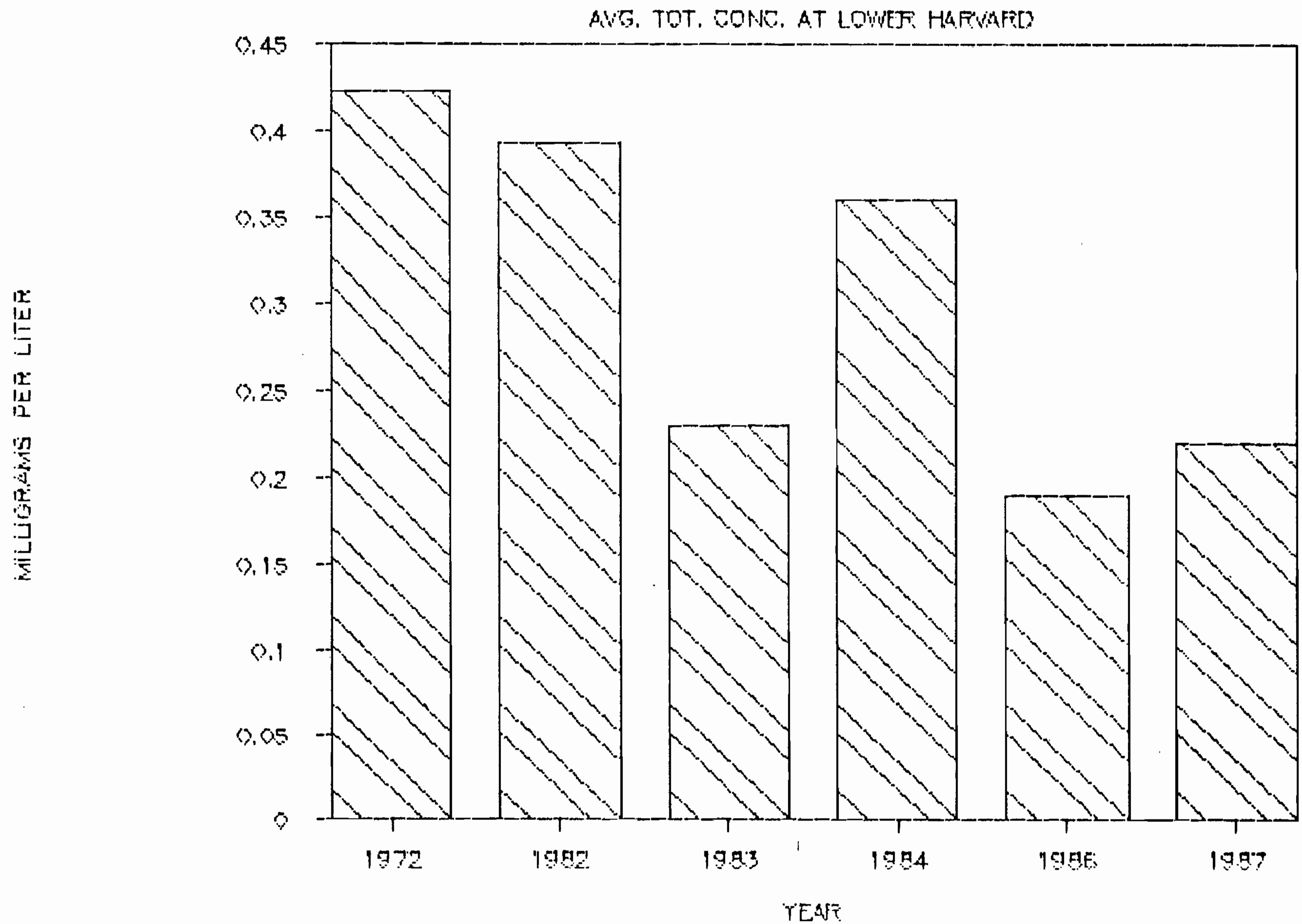
Other factors observed impacting the water quality of the Cuyahoga River include tributary streams polluted by sanitary sewage, and numerous nonpoint sources, such as run-off from roads, landfills, dumpsites, and agricultural areas.

Big Creek, which is tributary to the Cuyahoga River, is severely polluted by sanitary sewage, the sources of which are primarily located on the creek's West Branch. Immediately upstream of its confluence with the West Branch, the creek's East Branch is relatively clean; although, further upstream at Snow Road, a continuous source of sanitary sewage, and on Stickney Creek, occasional problems associated with sewage have been noted. On the other hand, the West Branch's water quality is completely degraded by large volumes of raw sanitary sewage continuously entering the creek at Cooley Avenue and at the double-barreled culvert between Puritas Avenue and West 130th

Graph 1.


FECAL COLIFORM IN CUYAHOGA RIVER
AVG. CONC. AT LOWER HARVARD
THOUSAND COUNTS PER 100 mL
110
100
90
80
70
60
50
40
30
20
10
0
1972
1982
1983
1984
1986
1987
YEAR

Graph 2. NON-FERROUS METALS IN CUYAHOGA RIVER



Street. The result is that Big Creek's water quality on the main stem, downstream of the confluence of the two branches, is also severely degraded throughout its length to its confluence with the Cuyahoga River. These facts are reflected in the bacteriological and benthic data obtained at the Big Creek sample sites.

Mill Creek, also tributary to the Cuyahoga River, is also severely polluted by sanitary sewage. The primary source of this pollution is a large volume of raw sanitary sewage entering a tributary to Mill Creek behind Mapletown Shopping Center in Maple Heights. Downstream of this point, the water quality of Mill Creek is severely degraded throughout its length to its confluence with the river. Upstream of this degradation, several problems have been identified and corrected, and the water quality is much improved.

The other three major open streams tributary to the Cuyahoga River within the NEORSD jurisdictional area, West Creek, Tinkers Creek, and Chippewa Creek, are relatively clean. This fact is reflected in the chemical, bacteriological, and benthic data obtained at the sample sites on these creeks.

Of the streams which are directly tributary to Lake Erie within the NEORSD jurisdictional area, Euclid Creek and Rocky River are also relatively-unpolluted in dry weather conditions according to chemical, bacteriological, and benthic data. The remaining streams tributary to Lake Erie, Green Creek, Nine Mile Creek, Dugway Brook, and Doan Brook, were found during the surveys to be significantly contaminated by sanitary sewage in dry weather. (Shaw Brook is tributary to Lake Erie only in wet weather). Most of these pollution problems appear to be due to sanitary sewage spilling into the streams. This is especially true throughout Dugway Brook, which is mostly culverted, and in which the highest fecal coliform concentrations were found in 1987. On Doan Brook, the furthest upstream sample sites were relatively clean, but the downstream sites were polluted, according to the bacteriological and benthic data.

During the 1987 NEORSD Stream Monitoring Program, a total of 46 specific sources of significant dryweather environmental disruptions were identified, and of these, 25 were remediated. Several of the sources for which remediation has not been accomplished include problems where major sewer rehabilitation is required. These uncorrected sources account for some of the most serious occurrence of pollution. Among them are the overflow at Cooley Avenue and the double-barreled culvert in the City of Cleveland, the sewage discharge behind the Mapletown Shopping Center in Maple Heights, and a residential section of Garfield Heights which is tributary to a storm sewer at Bancroft Avenue.

Only a few problems were found to be caused by unpermitted industrial dischargers. These included: Empire Die Casting Company in Warrensville Heights, discharging to Mill Creek without an NPDES Permit; Franklin Oil Corp. and D. Hamilton Trucking, Inc. in Bedford, which were improperly connected to Tinkers Creek. In each case, Ohio EPA was notified, and they contacted these companies to remedy the discharge problems.

The 1987 Stream Monitoring Program studied open streams under dry weather conditions. Therefore, any environmental impact of combined sewer overflows during wet weather was not observed. Additionally, any effects of combined sewer overflows during storm periods were totally obscured by effects caused by the large amount of dry weather sanitary sewage discharge to the area streams.

CUYAHOGA RIVER

The Cuyahoga River has a long history of sediment and water quality problems. The river has received much attention, especially as of late, not only because of its more persistent pollution problems, but also because of water quality improvements. Significant improvements in the appearance and water quality of the Cuyahoga River have occurred in the last 10-15 years. Large amounts of money have been spent throughout the river basin to control the discharge of pollutants and improvements in dissolved oxygen levels, metals concentrations, bacteriological quality and other water quality parameter concentrations have occurred. Currently, however, there is much concern about the in-place pollutants which have impacted the middle and lower segments of the river and the continued problems associated with industrial discharges, municipal treatment plant discharges, combined sewer overflows, sanitary sewer overflows, storm runoff discharges, nonpoint source runoff from urban and non-urban land uses and sediment loadings to the Cuyahoga River.

In response to the more persistent problems, the State of Ohio and the International Joint Commission (IJC) have identified the lower Cuyahoga River and adjacent areas of Lake Erie as an Area of Concern (AOC) because of the contributions of the river and areas to water quality degradation (SAIC, 1986). As a result of the AOC designation in 1981, a Remedial Action Plan (RAP) has been requested to address water quality, aquatic habitat and use impairment issues in the AOC. This Remedial Action Plan is intended for use as a management tool, providing the basis for future evaluations, remedial measures and the implementation of these measures on the Cuyahoga River. The attention the river is receiving as an AOC earmarks it for continued water quality and aquatic habitat improvements, which in the future, the Stream Monitoring Program conducted by the NEORSD, Industrial Waste Section (IWS) should be able to follow and document.

I. COMMUNITIES SERVED

The Cuyahoga River flows through northeast Ohio and empties into Lake Erie through Cleveland Harbor. The headwaters of the river originate in Geauga County. Flowing south-southwest, the river moves through Lake Rockwell in Portage County and then continues west-southwest through Kent. Entering Summit County, the river flows through Cuyahoga Falls and Akron. At Akron, the river moves north-northwest and continues up through Cuyahoga County and Cleveland (SAIC, 1986).

The Cuyahoga River and its tributaries drain approximately 813 square miles of land. The river drainage basin includes not only parts of four counties, but parts or all of 43 townships and 32 cities (SAIC, 1986). The communities served in and around the IWS Stream Monitoring Program sampling locations on the river include: Sagamore Hills, Northfield, Brecksville, Broadview

Heights, Walton Hills, Independence, Valley View, Bedford, Maple Heights, Garfield Heights, Brooklyn Heights, Warrensville Heights, North Randall, Cuyahoga Heights, Newburgh Heights, Parma, Parma Heights, Brooklyn and Cleveland.

II. SAMPLING LOCATIONS AND PHYSICAL HABITAT OBSERVATIONS

Although the NEORSD and its Stream Monitoring Program are directly concerned with the Cuyahoga River segments which lie within the District's boundaries, the effects of upstream perturbations, of which the District has no control, are undoubtedly reflected in downstream water quality and aquatic habitat assessments. Despite this, however, the District's programs designed to regulate industrial discharges, improve the quality of the Southerly Treatment Plant effluent and reduce combined and sanitary sewer overflows have played an instrumental role in the improvement of water quality in the lower Cuyahoga River.

Seven sampling locations on the Cuyahoga River have been selected to monitor the improvements resulting from the District's activities. These locations include points starting from the river mouth on upstream and are displayed in Figure 1:

#20.	River Mouth (at Fagan's)
#21.	Center Street Bridge
#22.	West 3rd Street Bridge
#22.5.	Newburgh & Southshore R.R. Bridge
#22.51.	Lower Harvard Bridge
#23.	Riverview Road Bridge
#24.	Station Road Bridge

The two sampling sites located furthest upstream represent the river quality that enters the District's jurisdiction. These two locations are in designated Warmwater Habitat. Sampling location #'s 22.5 and 22.51 are in that segment of the river which, in 1986, was also designated as Warmwater Habitat. This designation, however, which is the responsibility of the Ohio Environmental Protection Agency (OEPA), is currently being contested by the NEORSD. The segment in question begins at the point of the District's Southerly Plant effluent discharge and continues downstream to the head of the navigation channel at the Newburg and Southshore R.R. Bridge. Sampling location #'s 20-22 are in the navigation channel.

Field reconnaissance trips taken by IWS Investigators Zablotny and Nowac on 6/2/87 - 6/5/87 and additional trips taken by Investigator Kleinhenz on 9/17/87 with two consultants from EA Science and Technology out of New York and on 12/7/87 with NEORSD Planning Engineer, John Graves and Counselor-at-Law, Sue Flannery, provided an opportunity to assess, by observation, the Cuyahoga River system habitat, defined here as the river's

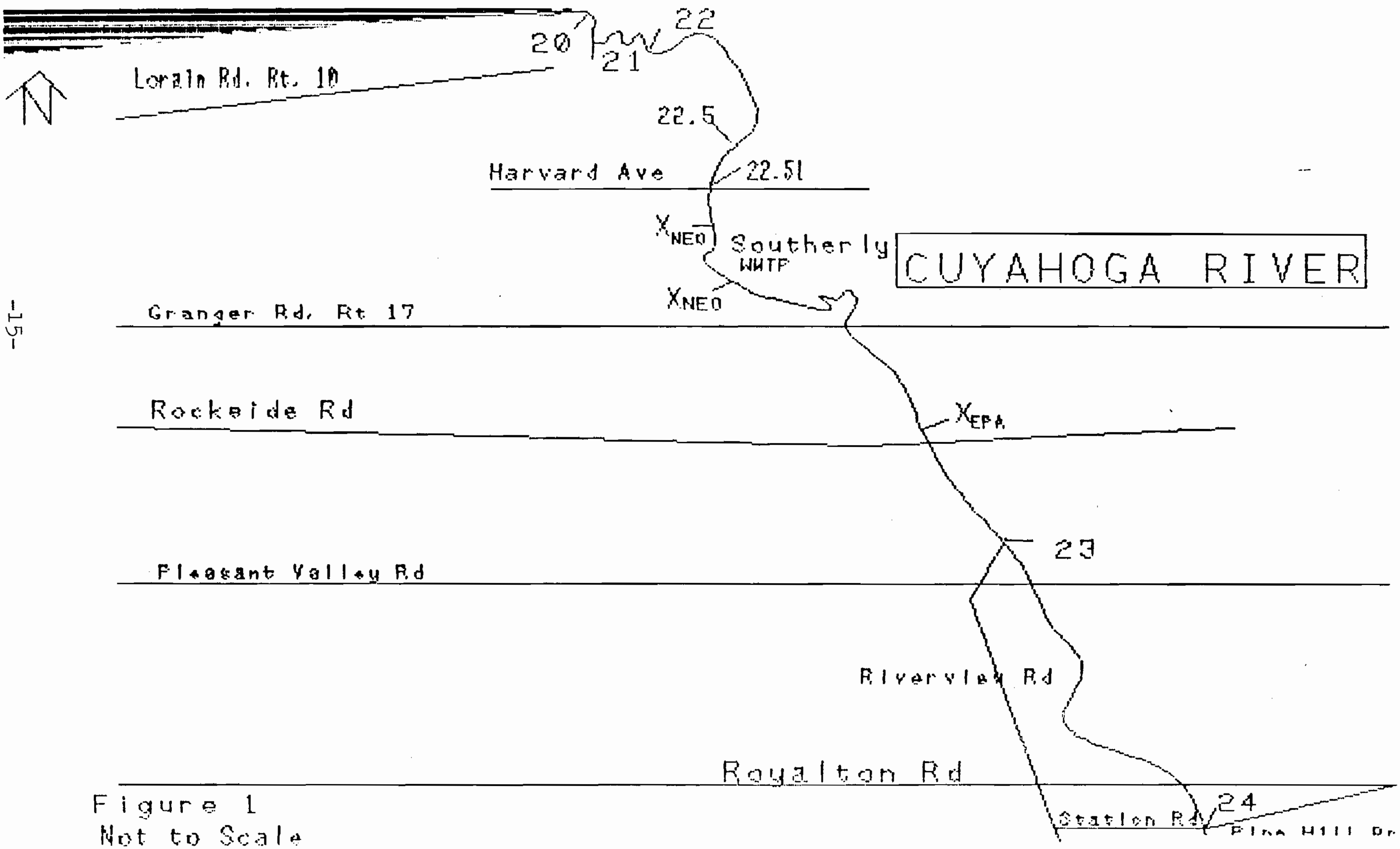


Figure 1
Not to Scale

immediate watershed (upland areas), stream bank and instream habitat characteristics. Observations revealed both uniform and transitional physical environments in and around the river and are described below. These descriptions are rather general due to the lack of any actual field measurements. They are based not only on direct observations, but also on evidence from orthophoto maps (scale: 1 inch = 200 feet) prepared in 1978 by the Cleveland Regional Sewer District (now the NEORSD). Except in shallow riffles and runs, the high turbidity condition of the river, which is more prevalent after a rain event, made instream observations difficult. Also, the natural and altered (man-made) physical characteristics of the river and environment are often mixed, making it difficult to arrive at the following generalizations. An attempt is made, however, to describe the river's general physical characteristics based on similarities in certain segments.

The segment of the river from sampling location #24 (RM 20) downstream through sampling location #23 (RM 13.8) to an area very near the intersection of the river and Rockside Road (RM 13) is more natural or "wild" in appearance as compared to other downstream segments. The immediate watershed along this segment is characterized by open fields with primarily grass and shrub cover, forest and wetland areas, agricultural development, limited suburban development and relatively very little commercial and industrial development along a buffer zone of mixed shrubs and trees adjacent to the river. Along this segment, there is some potential for runoff from the above-mentioned fields, forested areas, etc. For example, the orthophoto maps often show gully erosion in open or poorly vegetated areas. Drain pipes and runoff culverts are evident along this segment, though to a lesser extent as compared to downstream segments. These drain pipes may carry not only runoff water but also combined sewer overflow and/or point source discharges. Banks are generally steep with relatively few barren or thin areas at their top margin. At or near these "raw" spots, the potential for bank erosion exists, especially during high flows. There are also several areas along this segment where the middle bank has been extensively eroded. Very often submerged logs and branches (snag) offer suitable aquatic habitat along the lower bank. Lower bank depositional areas are present but are not as prevalent as in downstream areas. This segment has been affected by bottom scouring and deposition but it is not known to what degree. These affected areas can generally be found behind obstructions, at inside bends in the river and at tributary locations. This segment of the river is shallow (generally 2-5 feet deep), though it could be several feet deep above the canal diversion dam located very near sample site #24, with areas of long stream runs interspersed with riffle habitat. Pool development along this segment is very minimal. Substrate is predominantly sand and gravel with occasional boulders and manmade artifacts present (concrete, bricks, tires, etc). Flow is continuous and generally moderate to swift (annual mean water discharge at USGS Independence Gauge Station = 806 ft^3/s; SAIC, 1986).

The segment of the river from near RM 13 downstream (past the point where the District's Southerly Treatment Plant discharges to the river at approximately RM 10.5) to near but just above sampling location #22.51 (RM 7) shows more evidence of altered physical habitat than the previous segment. The immediate watershed along this segment is characterized by commercial and industrial development with interspersed open areas, which are either barren or vegetated with a mixture of grasses, shrubs and trees at varying densities, as well as forest patches and a few cultivated areas. The potential for nonpoint source runoff is greater along this segment due to the more altered immediate watershed environment. This is evidenced by the drainage channels or ditches which are depicted on the orthophoto maps. The corresponding drain pipe and open trench discharges to the river are fairly prevalent. The percentage of drain pipes carrying point source discharge increases along this segment as well. The buffer zone along much of the bank is narrower and open or raw areas are more predominant. Again, banks are generally steep and are eroded in many areas. As is the case upstream, there is continued evidence of bank vegetation harboring debris and the causative storm flow surges have resulted in mass erosion and bank failure in certain stretches. Submerged logs and branches as well as vegetation overhang continue to offer suitable aquatic habitat along this segment. Manmade artifacts are increasingly more common in the river and along the banks, especially in and around dumping grounds which are quite prevalent on and near the west bank between approximately RM. 8 and RM 10. Lower bank depositional areas are more predominant than in the upstream segment and probably a greater percentage of the instream habitat has been affected by bottom scouring or deposition. There are still riffle areas present along this segment but they are relatively few and far between. This segment is primarily made up of long stream runs with very few small pools. The river begins to widen along this segment and the depth is generally 6 feet or greater. Channelization is evident in certain areas and there are fewer bends in the river as well. Substrate types vary from sand and gravel instream to sand and silt along the lower bank. The flow regime is not much different from the upstream segment.

The segment of the river from sampling location #22.51 (RM 7), just downstream of the confluence of Big Creek and the approximate location of the last riffle, through to sampling location #20 (RM 0.5) has been significantly degraded with regard to physical habitat. As one passes through sampling location #22.51, the physical environment appears highly transitional. The watershed begins to show evidence of complete domination by industrial and commercial development. The highly developed upland area and especially the low lying steel industry greatly increases the potential for considerable nonpoint source runoff to reach the river. The quality of this runoff is probably very poor. Also associated with this development are numerous discharges to the river from industrial point sources, combined sewer overflows, storm runoff, etc., though they are fairly common upstream as well. Much of this segment has been channelized and deposition of gravel, boulders, debris and human artifacts continue to predominate along the shoreline. Little natural bank vegetation is present along the stretch from sampling location #22.51 to #22. The buffer that is present is generally very narrow and patchy. Bank vegetation is virtually non-existent further downstream as much of the natural bank has been replaced with concrete lining or steel bulkheads. The river begins to slow, deepen, and widen through this segment, especially in the navigation channel where the depth is 25-30 feet. Annual maintenance dredging occurs in the lower channel (from sampling #22.51 to the mouth), velocities are low and the substrate is primarily fine sand and muck.

III. SUMMARY OF DATA

The Cuyahoga River was sampled at the seven locations from June 1st to November 24th, 1987. At each location, samples were collected with a plastic bucket and drop line from near the water surface. At sampling location #22, an ISCO automatic sampler (Model 1680) was used to obtain a sample at a depth of 13 feet and 26 feet. All samples were obtained from the center of the river, except those from the river mouth which were obtained from near the east bank. At the time of each sampling, dissolved oxygen and temperature measurements were taken on the sample using a YSI oxygen meter. All samples obtained for bacteriological quality analysis were transported in sterile plastic containers and preserved with ice. Samples obtained for chemical analysis were transported in large cubic containers. All sampling was performed under dry weather conditions.

Analysis of the data from samples collected at location #'s 20-22 show dissolved oxygen (D.O.) levels low enough during early summer that they exceed the nuisance prevention maximum criteria. Although the D.O. concentrations increase during late summer and early fall, water samples, if they were taken from the lower depths of the river, may reveal close to anoxic conditions at the time of summer stratification. Lower depth samples were taken at location #22. However, as evidenced by the temperature and D.O. measurements taken on these samples, the water column appears to be thoroughly mixed. This could have been due to either the time of year or the recent passage of a large ore boat.

BOD and COD concentrations were not unusually high, although they occasionally demonstrated the potential to be so (i.e., 14 ppm BOD on 6/1/87 at location #22 and 30 ppm BOD on 7/27/87 at location #20; 82 ppm COD on 11/12/87 at location #22). These occasional high concentrations are probably sporadic and could be due to episodes of organic enrichment, possibly from a combined sewer overflow, at or near the time of sampling.

Although the solids concentrations are characteristically high, there are no conclusive trends among the locations nor among the sample dates at each location. The total dissolved solids (TDS) concentration, however, is highest on the average at location #21.

Turbidity levels are highly variable among sample dates at all three locations. The reason for this is unclear. Turbidity should reflect the solids concentrations of the sample but no such correlation appears to exist, at least not on a consistent basis.

Ammonia-N (NH_3) levels do not appear to be a problem as all the samples were within the nuisance prevention standard. Concentrations of total and soluble phosphorous (P), nitrates NO_3), nitrites (NO_2), organic-N, total kjeldahl nitrogen (TKN), chlorides (Cl), sulfates (SO_4), hardness and alkalinity demonstrated no significant differences between locations and no conclusive trends across the samples at each location. The fluctuations in these parameters are probably typical and representative of the river's water quality.

With regard to the metals concentrations, exceedance of the hardness dependent standard for maximum concentrations of copper (Cu) and zinc (Zn) occurred on the following dates and at the following locations: 10/6/87 at all locations for Cu; 10/6/87 at location #20, 9/29/87 at location #21 and 9/29/87 at location #22 for Zn. The sources of these high metal concentrations could be numerous (i.e., nonpoint sources, overflows, process discharges -- including LTV Steel Company operations, particularly the electrogalvanizing operation, with discharges to the river upstream of these sampling locations).

The results of the bacteriological quality analyses reveal coliform counts that can be highly variable. Although, in general, the concentrations have declined as compared to analyses from previous sampling efforts on the river, occasional episodic concentrations do occur. The sources of coliform bacteria are more consistently from human waste sources and less from mixed human and animal waste sources. Bacterial contamination due to non-human waste sources is very rare in the lower stretch of the river as only one sample showed a higher fecal streptococcus concentration than fecal coliform concentration (6/1/87 at location #20; FC/FS less than 0.7).

Analysis of the data from samples collected at location #'s 22.5-24, where Warmwater Habitat 30-day average criteria apply, shows that temperature maximum were never exceeded. Dissolved oxygen (D.O.) concentrations were also at acceptable levels and the summer concentrations were higher than those found at the downstream locations referred to earlier.

BOD and COD concentrations are similar to those at the downstream locations. The COD values, however, are noticeably higher on sample date 11/12/87 from location #24 down to location #23. Oil and grease data, which might compare with and explain the higher COD concentrations, are lacking at all locations on this date. With regard to BOD, the only noticeable extreme concentration occurred on 9/29/87 at location #22.51 (BOD = 24 ppm).

The concentrations of solids, ammonia-N (NH_3), total and soluble phosphorus (P), nitrates (NO_3), nitrites (NO_2), organic-N, total kjeldahl nitrogen (TKN), chlorides (Cl), sulfates (SO_4), hardness and alkalinity show no discernable differences across samples at any location nor between locations (including downstream data). Again, turbidity levels are highly variable. Also, there was a considerably high organic-N concentration at location #24 on 10/6/87 (organic-N = 16.63 ppm). The reason for this is unknown.

The average metals concentrations, except copper (Cu) at location #'s 22.51 and 24, are all within the applicable standards. Copper's exceedences of the standards here are very minor and are not the result of any episodic concentrations.

Fecal coliform violations occurred at all of the four upstream locations. Also, the average total coliform concentration is higher at these locations than at those downstream. Noticeably higher total coliform counts were found on 11/12/87 at location #'s 22.51-24. Coliform bacteria contamination is primarily from human waste sources and occasionally from mixed animal and human waste sources. On only one occasion was the fecal streptococcus count greater than the fecal coliform count (7/27/87 at location #23; FC/FS 0.7).

Seven locations were sampled qualitatively for macroinvertebrates one time each, except location #23 which was sampled two times. Sampling methods involved either the use of a core sampler (location #'s 20-22) or a surber sampler in conjunction with hand-picking (location #'s 22.51-24). At location #22.51 and #24, not all of the collections made with a surber sampler have been sorted. As a result, the species list is not totally complete for these locations. Close to 80% of the organisms collected over all of the locations have been identified. However, the level of identification (i.e., class, order, family, genus, species) is variable. At each location, and where possible, all sampling was conducted in and around each of the representative habitat types (i.e., riffles and shallow runs). Also, at the time of each sampling effort, the general characteristics of the river's physical environment were noted.

Sampling Location #'s 20-22 (7/29/87):

Indication	Organisms
(T)	Oligochaetes: Family Tubificidae

Sampling Location #22.5 (11/13/87):

Indication	Organisms
(T)	Oligochaetes: Family Tubificidae
(F)	Turbellarians: Dugesia tigrina
(T)	Hirudineans: Family Erpobdelliidae (cocoons with young)
(F)	Amphipods: Crangonyx gracilis
(F)	Isopods: Asellus communis
(F_2)	Odonata nymphs: Suborder Anisoptera Boyeria sp.
(F_2)	Odonata nymphs: Suborder Zygoptera; Agrion sp., Agria sp
(T_2)	Coleoptera adults: Laccophilus sp.
(T)	Gastropods: Physa sp., Helisoma sp., Gyraulus sp., Laevapex sp.

Sampling Location #22.51 (10/6/87):

Indication	Organisms
(T)	Oligochaetes: Family Tubificidae
(T)	Hirudineans: Family Erpobdelliidae
(F)	Turbellarians: Dugesia tigrina
(F_2)	Odonata nymphs: Suborder Zygoptera, Agria sp.
(F_2)	Coleoptera larvae: Stenelmis sp.
(F)	Coleoptera adult: Stenelmis vittipennis
(F_2)	Ephemeroptera nymphs: Stenonema pulchellum
(F_2)	Trichoptera larvae: Hydropsycne sp., Cheumatopsyche sp.
(T)	Gastropods: Physa sp., Laevapex sp.
(T)	Dipetera larvae: Family Chironomidae

Sampling Location #23 (7/27/87):

Indication	Organisms
(T)	Oligochaetes
(T)	Hirudineans
(F)	Nematoda
(F)	Amphipods: Family Gammaridae
(F)	Coleoptera larvae and adults: Stenelmis sp.
(F)	Ephemeroptera nymphs: Heptagenia sp.
(I)	Ephemeroptera nymphs: Baetis sp.
(F)	Trichoptera larvae: Hydropsyche sp., Cheumatopsyche sp.
(I)	Trichoptera larvae: Hydroptila sp.
(F)	Diptera larvae: Family Rhagionidae, Atherix variegata Family Simuliidae, Simulium sp. Family Tanypodinae, Pentaneura sp. Family Empididae
(T)	Diptera larvae: Family Chironomidae

Sampling Location #23 (11/24/87):

Indication	Organisms
(F)	Turbellarians: Curi formanii
(F)	Coleoptera adult: Stenelmis vittipennis
(F)	Gastropods: Ferrissia sp.
(F)	Ephemeroptera nymphs: Stenonema tripunctatum, Stenonema interpunctatum
(F)	Megaloptera larvae: Corydalus cornutus

Sampling Location #24 (8/21/87):

Indication	Organisms
(T)	Oligochaetes
(T)	Hirudineans
(F)	Nematoda
(F)	Coleoptera larvae and adults: Psephenus sp., Stenelmis s
(F)	Ephemeroptera nymphs: Stenacron sp.
(I)	Ephemeroptera nymphs: Baetis sp.
(F)	Trichoptera larvae: Hydropsyche sp., Cheumatopsyche sp.
(I)	Trichoptera larvae: Agraylea sp.
(F)	Megaloptera larvae: Corydalus cornutus
(F)	Diptera larvae: Family Rhagionidae, Atherix variegata Family Tanypodinae, Pentaneura sp.
(T)	Diptera larvae: Family Chironomidae

After the collected organisms were identified, species indication determinations (tolerant (T), tolerant of moderate to heavy organic pollution and periods of D.O. below 5 ppm (F_2), facultative (F), intolerant (I)) were based on a combination of physical habitat observations, macroinvertebrate classifications relating to species pollution tolerances and to a lesser extent on the results of water quality testing at each location.

The only benthic organisms which appear representative of the substrate type found through location #'s 20-22 are the oligochaetes, family Tubificidae (sludge worms). These organisms are highly tolerant of organic pollution and are generally found in silty, muck-like substrate, where they are often associated as clumps or groups of many individuals. The sole presence of Tubificid worms at these locations is certainly reflective of the associated water and sediment quality.

At location #22.5, an equal number of tolerant and facultative species were found. The only species of significant importance as forage for fish include Asellus communis (Isopoda) and Crangonyx gracilis (Amphipoda) (Pennak, 1978), though only a few individuals of these species were found. The Odonata nymphs may also serve as a forage base and relatively more individuals of these species were present. In general, substrate conditions in and around this location are not conducive to the existence of highly diverse, economically important macroinvertebrate communities. This is primarily due to the heavy deposition of silt and harmful organics (i.e., oily sludge) underneath occasional rocks, logs and debris. Analysis of a sediment sample obtained at this macroinvertebrate sampling location, which is on the east bank approximately 50 yards upstream of the Newburg and Southshore R.R. Bridge, revealed the following parameter concentrations: oil and grease = 0.37%, volatile solids = 4.08% (total = 58%; fixed = 95.92%) and total metals (Ni, Cu, Cr, Zn, Cd, Pb) = 0.9 mg/gm. These concentrations are fairly high and may prevent or interfere with the successful establishment of high quality benthic communities.

At location #22.51, where the river's physical habitat characteristics appear transitional, slightly more facultative species were found than tolerant species. The only organisms collected here which are of significant importance as forage for fish include the Trichoptera and Ephemeroptera insect larvae and to a lesser extent the Odonata nymphs (Pennak, 1978). However, relatively few numbers of these three groups were found. As a general observation, the Turbellarians appeared to be the most numerous benthic organisms present. Most of the sampling in this area was conducted in riffle and shallow run habitat where gravel, small rocks, bricks, concrete pieces and additional human artifacts situated over sand were the predominant substrate types. Silt depositional areas, which are fairly common near the lower bank, especially closer to the Lower Harvard Bridge, were not sampled. However, samples obtained close to the confluence of Big Creek, where the water is deeper, contained mostly Chironomid larvae. The riffle and shallow run habitat found at this location is the last of its kind as one moves downstream. As compared to upstream locations, the macroinvertebrate community found here is not highly diverse.

At location #23, the majority of the species collected were facultative. Relatively few tolerant species were found and for the first time at any one location, intolerant species were present. The organisms collected here, many of which are common in fish diets (i.e., Amphipods, Trichopterans, Ephemeropterans, Megalopterans), were associated with riffle and shallow run habitat and substrate types predominately of gravel, stones and rocks situated over course and fine sand. Also, dense mats of vegetation, with its associated micro-flora and -fauna, were typically covering the larger substrate materials. This condition was not as common downstream and represents an important source of forage for the macroinvertebrates. The Trichoptera larvae (caddisfly) were the most common organisms present at this location and were represented by three genera, one of which is intolerant (Hydroptila genus; micro-caddisfly). The Ephemeropteran larvae (mayfly) were also represented by three genera. The presence of intolerant organisms, the relatively higher species diversity and the higher quality physical characteristics of the instream habitat, as compared to downstream locations, suggests a good potential for continued and/or increased high quality macroinvertebrate assemblages to occur in the stretch of the river which runs through this location.

The sampling location furthest upstream, #24, is very similar with regard to the character of the instream physical habitat as sampling location #23. Again, a higher percentage of facultative species were present and intolerant as well as tolerant species continue to occur, though in low numbers. Trichopteran larvae were the dominant taxa collected at this location. Because location #23 was sampled twice, it is not surprising that additional numbers of species were found. If additional collections were to be made at this location, the actual differences between the two upstream locations with respect to macroinvertebrate diversity would probably be negligible.

Although there are no strong conclusive trends based on this initial sampling effort for macroinvertebrates, there are indications that macroinvertebrate diversity is decreasing as one goes downstream. This appears to be reflective of the instream physical habitat characteristics at the various sampling locations and to a lesser extent of the water quality characteristics. The results of future qualitative as well as quantitative benthic sampling, with seasonal as well as yearly comparisons, may be more enlightening in reference to the use of macroinvertebrates as indicators of disturbed aquatic habitats.

IV. ENVIRONMENTAL PROBLEMS AND REMEDIATION

The environmental problems associated with the Cuyahoga River are numerous and include, among others, problems with point source discharges to the river, nonpoint sources of pollution, sedimentation in the lower river channel and physical habitat limitations. Relatively little field work has been conducted under the IWS Stream Monitoring Program to closely examine the sources and effects of the river's pollution problems, while work has been done by other professionals that addresses the problems with the river as they relate to the AOC and the redesignated segment (SAIC, 1986; EA Sci and Tech., 1987). Below is a description of IWS efforts as well as a general discussion highlighting the work conducted by others and directed at the river's environmental problems.

During the river survey trips taken by IWS Investigators Zablotny and Nowac on 6/2/87-6/5/87, a total of 77 outlets were identified on the river, some with and some without a discharge, and are presented below. These outlets, which could be either small drain pipes, culverts, or small open waterways and ditches/trenches, are listed from upstream to downstream, starting at sampling location #24 and ending approximately near the location of the Superior Street Pump Station in the Flats. The size of the outlets as well as their location are given as approximations. The discharges that were measured at certain outlets were done with the bucket and stopwatch method. For those outlets which are asterisked, a grab sample of the discharge has been obtained and the results of the analyses on those samples are also presented (indexed by the number assigned to each outlet from upstream to downstream). A total of 20 grab samples were obtained at outlet discharges and in many cases, a grab sample was arbitrarily taken. Lastly, large tributaries (i.e., Tinkers Creek, Mill Creek, Big Creek) were not included in the listing and neither was the Southerly Treatment Plant discharge and the location of the canal overflow approximately near RM 8. Also, due to the faster speed at which the current moves the boat in certain stretches of the river and the relatively large number of outlets, it is likely that not all of the outlets have been identified within the segment of the river that was traversed.

*1.) 12-inch outlet with discharge (10 gal/min.). Milky-white color. North corner of Station Road Bridge. West bank.

*2.) Culverted intermittent watercourse under railroad bridge with discharge (100 gal/min). Approximately 3/4 mile upstream of Fitzwater Road Bridge. West bank.

3.) 3-foot outlet with no discharge. Approximately 100 yards downstream of above-mentioned culverted watercourse. West bank.

*4.) Sagamore Creek. Approximately 1/2 mile upstream of Fitzwater Road Bridge. West bank.

5.) 4-foot outlet with discharge (2 gal/min.). Approximately 1/4 mile upstream of Fitzwater Bridge. West bank.

6.) Small creek just upstream of Riverview Road Bridge. West bank.

7.) Ohio Canal overflow. Approximately 1/4 mile upstream of Stone Road Bridge. East bank.

8.) Intermittent watercourse with discharge (10 gal/min.). Approximately 500 yards upstream of Stone Road Bridge. West bank.

9.) Open drain trench with discharge. Approximately 1/4 mile upstream of Rockside Road Bridge. East bank.

*10.) 4-foot outlet with discharge. Approximately 1/4 mile upstream of Rockside Road Bridge. West bank.

11.) 3-foot outlet (1/2 submerged). Just downstream of Rockside Road Bridge. East bank.

12.) Open drain trench with discharge. Approximately 1/4 mile upstream of I-480 Bridge. West bank.

13.) Open drain trench with discharge (5 gal/min.). Approximately 500 yards upstream of I-480 Bridge. West bank.

14.) 3-foot outlet with discharge (5 gal/min.). Just upstream of I-480 Bridge. East bank.

*15.) 6-inch outlet with no discharge. Under I-480 Bridge. West bank.

16.) 6-inch outlet with no discharge. Under I-480 Bridge. East bank.

17.) Open drain trench with discharge. Approximately 500 yards upstream of Granger Road Bridge. East bank.

18.) 1 1/2-foot outlet with discharge (1 gal/min). North corner of Granger Road Bridge. East bank.

19-20.) Two 3-foot outlets (approx. 30 feet apart) with discharges (1 gal/min). Approximately 1/4 mile downstream of Southerly Treatment Plant discharge. West bank.

21.) 2 1/2-foot outlet with discharge. Just upstream of Conrail railroad crossing. East bank.

22.) 5-foot outlet with discharge. Approximately 100 yards downstream of Conrail railroad crossing. West bank.

23.) 3-foot outlet with discharge (20 gal/min). Approximately 100 yards upstream of tank farm located on west side of river. East bank.

24.) 4-foot outlet with no discharge. Opposite tank farm located on west side of river. East bank.

*25.) 4-foot outlet with discharge (10 gal/min). Approximately 300 yards upstream of River Smelting Company. West bank.

*26.) 7-foot outlet with discharge (100 gal/sec). Approximately 100 yards upstream of River Smelting Company. West bank.

27.) 4-foot outlet with discharge (30 gal/min). Opposite River Smelting Company located on west side of river. East bank.

*28.) 6-foot outlet with discharge (50 gal/min). Approximately 1/4 mile downstream of River Smelting Company. West bank.

*29.) 1 1/2-foot outlet with discharge at the Harshaw Chemical Company. (2 gal/sec). Just downstream of Lower Harvard Bridge. West bank.

*30.) 10-inch outlet with no discharge. North corner of Lower Harvard Bridge. East bank.

31.) 2-foot outlet with discharge. Approximately 200 feet downstream of Lower Harvard Bridge. West bank.

32.) 3-foot outlet with no discharge. Just downstream of the Harvard-Denison Bridge. East bank.

33.) 4-foot outlet (1/2 submerged). Approximately 500 yards downstream of the Harvard-Denison Bridge. East bank.

34.) 3-foot outlet (1/2 submerged). Approximately 100 yards downstream of above-mentioned 4 foot drain pipe. East bank.

35.) 96-inch outfall (1/3 submerged). Approximately 100 yards downstream of the North and Western railroad crossing. West bank.

*36.) 4-inch outlet at LTV Steel Company's beige blockhouse with discharge (3 gal/sec). Approximately 1/4 mile downstream of the Harvard-Denison Bridge. West bank.

*37.) 4-inch outlet with discharge. Approximately 200 yards upstream of the #821 mark on the bank. Behind LTV Steel Company's slab yard on west bank.

*38.) 3-foot outlet with discharge. Approximately 175 yards upstream of the #821 mark on the bank. West bank.

*39.) Effluent distribution arm outlet with discharge. Just south of the #821 mark on the bank. East bank.

*40.) 3-foot outlet with discharge. Red-brown color. Approximately 100 feet south of the Newburgh and Southshore railroad bridge. West bank.

41.) 3-foot outlet (1/3 submerged). Near the #820 mark on the bank. East bank.

42.) 2 1/2-foot outlet (1/4 submerged). Across from the #819 mark on the bank. West bank.

43.) 2 1/2-foot outlet with no discharge. Across from the #815 mark on the bank. West bank.

44.) Burke Brook (3/4 submerged). Approximately 300 yards downstream of the Newburgh and Southshore railroad bridge. East bank.

45.) Morgana Run (3/4 submerged). Approximately 500 yards downstream of Burke Brook. East bank.

*46.) Y-shaped outlet with discharge. Approximately 60 yards downstream of LTV Steel Company's coke conveyor bridge (near the #784 mark on the bank). East bank.

*47.) 8-inch outlet with discharge. Approximately 50 yards downstream of LTV Steel Company's coke conveyor bridge (near the #783 mark on the bank). East bank.

48-50.) Three 3- to 5-foot outlets (3/4 submerged). Between the #774 and #775 marks on the bank. East bank.

51.) 1-foot outlet with no discharge. Near the #756 mark on the bank. East bank.

*52.) 7-foot outlet (3/4 submerged). Mary Street pumping station overflow. At the #086 mark. West bank.

*53.) Kingsbury Run. Approximately 150 yards downstream of the Mary Street pumping station overflow. East bank.

54.) 8-inch outlet with discharge (8 gal/min). Across from the #733 mark on the bank. West bank.

.55.) 2-foot outlet (1/2 submerged). Near green buoy marker in river. East bank.

56.) 3-foot outlet (1/2 submerged). Near the #716 mark on the bank. East bank.

57.) 1-foot outlet (3/4 submerged). Just downstream of the #710 mark on the bank. West bank.

58.) 1-foot outlet (1/4 submerged). Near the #703 mark on the bank. West bank.

59-61.) Three 4-foot outlets (1/2-3/4 submerged). Near the #675 mark on the bank. Just upstream of the Marathon Oil Company. East bank.

62.) 2-foot outlet with discharge (1 gal/min). South corner of West 3rd Street Bridge. East bank.

63.) 8-inch outlet with no discharge. At the #696 mark on the west bank.

64.) 8-inch outlet with no discharge. Near Cleveland Builders Supply Company. West bank.

65.) 6-foot outlet (3/4 submerged). At the #681 mark on the west bank.

66.) 3-foot outlet with no discharge. At the #673 mark on the west bank. Just below the I-90 Bridge.

67.) 8-inch outlet (1/2 submerged). At the #659 mark on the west bank.

68.) 8-inch outlet (1/2 submerged). At the #058 mark on the west bank.

*69.) Walworth Run with discharge. At the #080 mark on the west bank.

70.) 18-inch outlet (1/2 submerged). Just south of Cleveland Fire Station. West bank.

71.) 8-inch outlet with discharge (3 gal/sec). At Jim's Steakhouse on the west bank.

72.) 8-inch outlet with no discharge. At Riverfront Yacht Club on the West bank.

73-75) Three 3-foot outlets (3/4 submerged). Near the #598 mark on the bank. West bank.

76.) Open runoff (1-2 gal/min). Just south of Columbus Road Bridge. West bank.

77.) 3-foot outlet (1/2 submerged). Across from the Commodore's Club. West bank.

The results of the grab sample analyses, with considerable variation in the water quality parameters actually measured on the samples, generally reveal concentrations which would have minimal impact once an individual discharge is diluted by the river. However, in certain of the grab samples obtained, particular parameter concentrations appear to be high.

The analyses of the grab samples obtained from outlet #'s 1, 2, 4, 10, 25, 26 and 28 show no major problems with high parameter concentrations, although the discharge from outlet #1 located very near the Station Road Bridge was a milky-white color. The analysis of the grab sample obtained from the Harshaw Chemical Company's first discharge to the river (outlet #29) reveals a very low pH and relatively high concentrations of the metals Ni, Fe and Pb. In fact, all of the metal concentrations, except Cd, are higher than the estimated effluent concentrations obtained from the Form 2C Pretreatment Program Application for this company (SAIC, 1986). Outlet #'s 36, 37, 38, 39, 40, 46 and 47 are located in the LTV Steel Company "stretch" of the river. The analyses of the grab samples obtained from outlet #'s 36 and 40 show relatively high suspended solids (SS), COD and Fe concentrations in the discharge at #36 and relatively high SS, Zn and Fe concentrations in the discharge at #40. At outlet #40, the Zn and Fe concentrations were especially high and the discharge was a red-brown color. The grab sample associated with the discharge at outlet #52 was obtained from a manhole on Mary Street and represents the overflow from the Mary Street Pump Station as well as river surcharge. This pump station has not been operable for at least 6 months and it is estimated that it overflows at a rate of 4.32 MGD. The analysis of the grab sample obtained at the overflow manhole shows relatively high Ni, Cu, and coliform concentrations. Analyses of the grab samples obtained at outlet #53, Kingsbury Run, and at outlet #69, Walworth Run, show high coliform concentrations. High BOD, COD, ammonia-N (NH_3), total kjeldahl nitrogen (TKN) and phosphorus (P) concentrations were also noted in the discharge at outlet #69. At Walworth Run, there was a continuous overflow at the weir location under dry weather conditions at least during April and May 1987. Lastly, analyses of the grab samples obtained from outlet #'s 15 and 30, both of which are road/highway runoff drain pipes, show very high chloride (Cl) concentrations as compared to the instream concentrations. Both of these samples were obtained during wet weather and at a time when roads were being de-iced.

For those above-mentioned discharges which revealed high concentrations of certain water quality parameters, if they are continuous discharges to the river, they may contribute significantly to water quality degradation. At this time, however, for many of the outlets it is not known whether their associated discharges to the river are intermittent or continuous, or for that matter, whether they are from continuous point (industrial, municipal), intermittent point (CSO, sanitary overflows), though these often include diffuse sources as well, or from nonpoint/diffuse sources. In the future, the outlets that have been identified need to be further investigated in order to determine the discharge contributions "up the pipe" from whatever sources as well as to more closely characterize their associated outfalls.

Major industrial and municipal point source dischargers to the Cuyahoga River are closely regulated under the National Pollutant Discharge Elimination System (NPDES) permitting process. In the past, the contributions of these dischargers to the pollution problems of the river were significantly large. However, with the development of improved pretreatment technology and equipment, their contributions have since been significantly reduced. There are still effluent quality problems associated with occasional treatment plant malfunctions, plant upgrades and overflows and bypasses, but for the most part these are capable of being controlled. Continued revision and enforcement of industrial permits based on Best Available Technology (BAT) water quality standards should continue to offer adequate control of industrial discharges. On the other hand, contaminants from combined sewer overflows (CSO's), sanitary overflows, storm runoff discharges, and runoff from sources such as landfills (including hazardous waste sites), dumpsites and pesticide/herbicide treated areas may be a significant source of pollution to the Cuyahoga River and its tributaries and are less quantifiable than point source discharges. Also, in-place sediments contain contaminants from past or current discharges and will continue to act as a source of pollutants to the river (SAIC, 1986).

The problems associated with CSO's and sanitary overflows have been addressed through more efficient collection system flows control, treatment plant operations, and pumping station and overflow structure control. However, problems continue to exist (i.e., Walworth Run overflow and Mary Street Pump Station overflow) and in the future raw sewage overflows need to be completely eliminated and more comprehensive control measures need to be implemented in order to adequately reduce the contaminant load from CSO's.

The problems associated with stormwater runoff, which carries eroded soil, chemicals, oil and grease and probably a wide array of other pollutants, and runoff from agricultural areas, dumpsites and landfills have been addressed to a lesser extent than point source discharges, CSO's and sanitary overflows. The pollutant contributions from these sources are less quantifiable and may be highly significant (SAIC, 1986). In the future, considerations should be made with regard to the collection and treatment of storm runoff while Best Management Practices (BMP's) should be implemented at urban and suburban development sites, at farms and in high runoff potential areas.

Other miscellaneous sources of pollutants to the Cuyahoga River and its tributaries, all of which have the potential to negatively impact sediment and water quality, include atmospheric deposition, septic disposal facilities, hazardous waste spills, discharges from shipping vessels, dredging of contaminated sediments and the accumulation of floating debris, oil, scum, etc. on the water and near the banks. On occasion, the latter problem is still apparent as oil sheens have been identified during sampling periods and natural and manmade debris often accumulates in quieter waters, especially after heavy rains.

Out of all the environmental problems associated with the Cuyahoga River, the observed high erosion potential and associated silt and sediment load, the resultant channel instability and shifting substrate conditions as well as the high turbidity condition of the river would present a marked physical habitat limitation for the successful growth and reproduction of certain macroinvertebrate and fish species (EA Sci. and Tech., 1987). The Cuyahoga River has historically been subject to erosional and sedimentation problems as a natural condition because it is cut through unconsolidated till deposits.

Evidence of bank erosion is not uncommon on the river. The existence of many fallen trees along the shore and on the bottom is an indication of this problem. Although the erosion potential has been reduced along the banks in certain areas where steel, concrete and other rip-rap material has been installed, the constraint that this has on the river's movement and channel development limits the availability of high quality aquatic habitat (EA Sci. and Tech., 1987).

The high suspended solids loading in the river, as evidenced by the high turbidity condition, would allow for considerable deposition in slower waters and pooled areas. This is certainly the case in the navigation channel where annual maintenance dredging is necessary to keep up with the upstream sediment load so that large shipping vessels can traverse this segment of the river. This dredging practice, however, which is not unlike the resuspension of sediments further upstream under high flow conditions, releases organic matter and chemicals which may exert a high BOD or toxic effect on aquatic organisms (SAIC, 1986).

The high turbidity condition of the river is much more prominent after heavy rains as highly erodable upland and bank soil and instream sediment is carried downstream, and subsequently the river turns a darker brown color. This high turbidity condition is more apparent upon inspection of the transparency of the water in the Southerly Treatment Plant effluent discharge channel. Transparency in the effluent channel, prior to its waters mixing with the river mainstem, is close to three times that in the river. Also, as another example of the suspended solids problem, a non-uniform turbid condition was noted in the river near sampling location #24 at the Station Road Bridge on an occasion while surveying this area after a recent rain. At this time, the suspended floc material, which disappeared from the water column 1-2 days after the last rain, was seen settled out in shallow areas and blanketing the bottom and vegetation (EA Sci. and Tech., 1987). This condition is an impediment to substrate associated macroinvertebrate and spawning fish species and in conjunction with shifting substrate conditions, may limit the maintenance or development of the community structure and function typical of a warmwater habitat.

Continued control of point sources of pollution may maintain or improve water quality conditions in the river, however, the high erosion and associated turbidity and shifting substrate conditions as well as sedimentation problems may pose a more considerable threat to the river's biota.

V. THE STATE'S ASSESSMENT OF THE CUYAHOGA RIVER

The Cuyahoga River downstream of Akron to the shipping channel is designated by Ohio EPA as Warmwater Habitat (WWH) based upon the river's potential to attain this use designation. The segment of the Cuyahoga River from the effluent of the Southerly Wastewater Treatment Plant to the Newburgh and Southshore Railroad Bridge at the head of navigation received the designation of Warmwater Habitat in 1987. The Northeast Ohio Regional Sewer District challenged this designation on the basis that the river was not attaining its use designation for the 30 miles of reach upstream of the Southerly Wastewater Plant. It was the District's opinion that upstream conditions affecting both fish and macroinvertebrates were not clearly understood and were inadequately studied. The River was not attaining and the causative factor or factors were not known. Were point sources or nonpoint sources causing the river not to attain? Were there chemical, geological, bacteriological, or habitat problems affecting the River's fishery? How far downstream was affected by unknown upstream conditions? What is being done? What problems must be addressed? At what cost? Using what technology? Without some knowledge of the actual cause of the River's failure to attain with a program underway to address these problems it was reasoned that the designation of Warmwater Habitat based upon "potential" was premature and could, in fact, be detrimental to the river system. Once designated, the States focus becomes one of writing and enforcing NPDES Permits. There would be no further compelling reason for major research to determine the cause or causes of the failure of the river to attain its designated use. Permits that are being written may not address the actual cause of the River's failure to attain. The cause may not even be due to point sources.

In defense of the NEORSD challenge to the Use Designation of the Cuyahoga River as Warmwater Habitat, Ohio EPA opined that the principle reason that the Cuyahoga River is not achieving WWH is that this river is "effluent dominated." Ohio EPA, in fact, reported that the Cuyahoga River is 115% sewage effluent during low flow periods in the segment near the Southerly effluent. It is obvious to Ohio EPA that unidentified toxic properties of sewage treatment plant effluents are causing the river to not attain its designated use. Ironically, it was also reported by Ohio EPA that the chemistry of the water column in the reach of the Cuyahoga River between Akron and Southerly was no longer an impediment to attaining WWH.

The WWH designation is given if a river system has the "potential" to have a balanced reproducing population of warmwater fish and associated vertebrates and invertebrates on an annual basis. Ohio EPA is presently using an array of fish, macroinvertebrate, and habitat grading systems to evaluate river systems for use designations. The grading systems consist of a series of metrics or tests for the fish, macroinvertebrates, and habitat evaluations. The individual metrics or tests generate points. These points are summed and if the composite score is sufficiently high compared to certain reference sites then the river has attained WWH. The grading system for fish contains 12 individual metrics:

1. Total number of indigenous fish
2. Proportion of round-bodied Catostomidae (round-bodied suckers)
3. Number of sunfish species
4. Number of intolerant species
5. Number of sucker species
6. Percent abundance of tolerant species
7. Omnivores
8. Proportion of Insectivores
9. Top Carnivores

10. Number of individuals in a sample
11. Proportion of individuals as simple lithophilic spawners
12. Proportion of individuals with deformities

The fish community grading system is called the Index of Biotic Integrity (IBI). In addition to the IBI, Ohio EPA also uses another scoring method call the Modified Index of Well-being (Modified I_{wb}). This grading system utilizes three metrics:

1. Relative number of all species excluding those designated as "highly tolerant"
2. Relative weights of all species excluding species designates as "highly tolerant"
3. Shannon's Diversity Index

Electroshocking is the method employed by Ohio EPA to collect fish for the IBI evaluation.

WWH is also a function of the macroinvertebrate assemblage. Ohio EPA uses the Invertebrate Community Index (ICI) grading system to grade the array of macroinvertebrates collected by using modified Hester-Dendy samplers and qualitative sampling techniques. The ICI uses a series of ten metrics which include:

1. Total number of taxa
2. Total number of Mayfly taxa
3. Total number of Caddisfly taxa
4. Total number of Dipteran taxa
5. Percent Mayfly composition
6. Percent Caddisfly composition
7. Percent other Dipteran and Non-insect composition
8. Percent Tribe Tanytarsini Midge composition
9. Percent tolerant organisms
10. Total number of qualitative EPT taxa

To grade the physical habitat of a river, Ohio EPA uses a standardized grading system called the Qualitative Habitat Evaluation Index or the QHEI. This grading system scores the quality of a river's habitat in 7 categories:

1. Substrate
2. Instream cover
3. Channel morphology
4. Riparian zone and bank erosion
5. Pool/glide and riffle/run quality
6. Map gradient
7. Drainage area

The highest possible score is 95. Habitat scores noted by Ohio EPA for the Cuyahoga River downstream of Akron range from a high of 72 near the Akron Wastewater Treatment Plant to a low of 50 downstream of the Southerly Plant. A score of 50 is considered to be mediocre habitat. Charts 2 and 4, below, show a general decline in physical habitat from Akron to the head of navigation.

Charts 1 through 4, present the summary of Ohio EPA's grading of the Cuyahoga River for the four year period from 1984 through 1987. It observed that the Cuyahoga River fishery is in a poor condition from downstream of the Akron Sewage Treatment Plant. Although there is some recovery of the fishery since the discovery of a major toxic effect problem in 1984, the fish community as graded on the IBI system is generally in the "poor" category. The macroinvertebrate community, as graded on the ICI system, is also, generally, in the "poor" category. The 1987 evaluation of the macroinvertebrate community shows two locations where the macroinvertebrate community has achieved a "fair" rating.

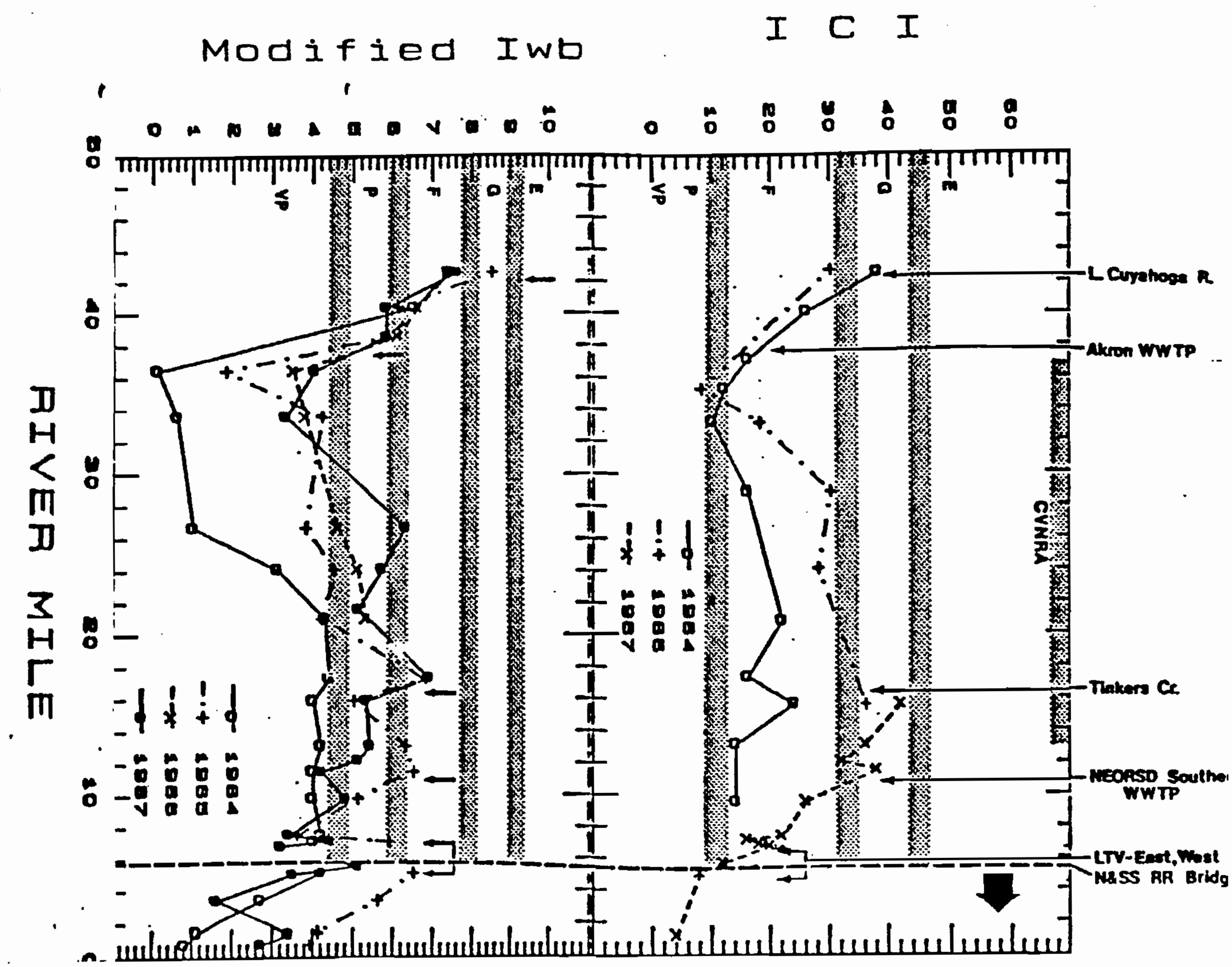


Chart 1. Longitudinal Assessment: Cuyahoga RM 50-0

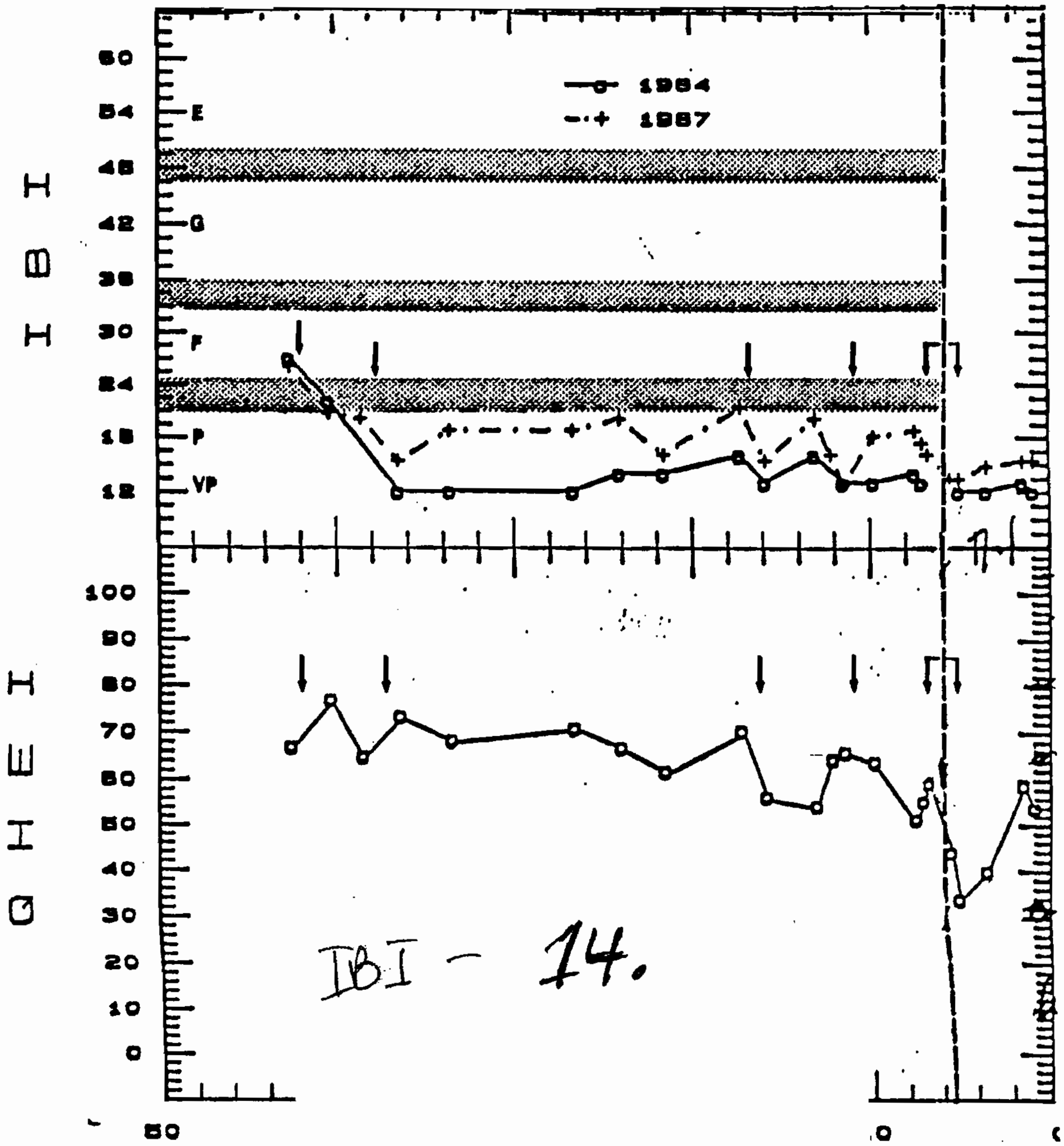


Chart 2. Longitudinal Assessment: Cuyahoga RM 50-0

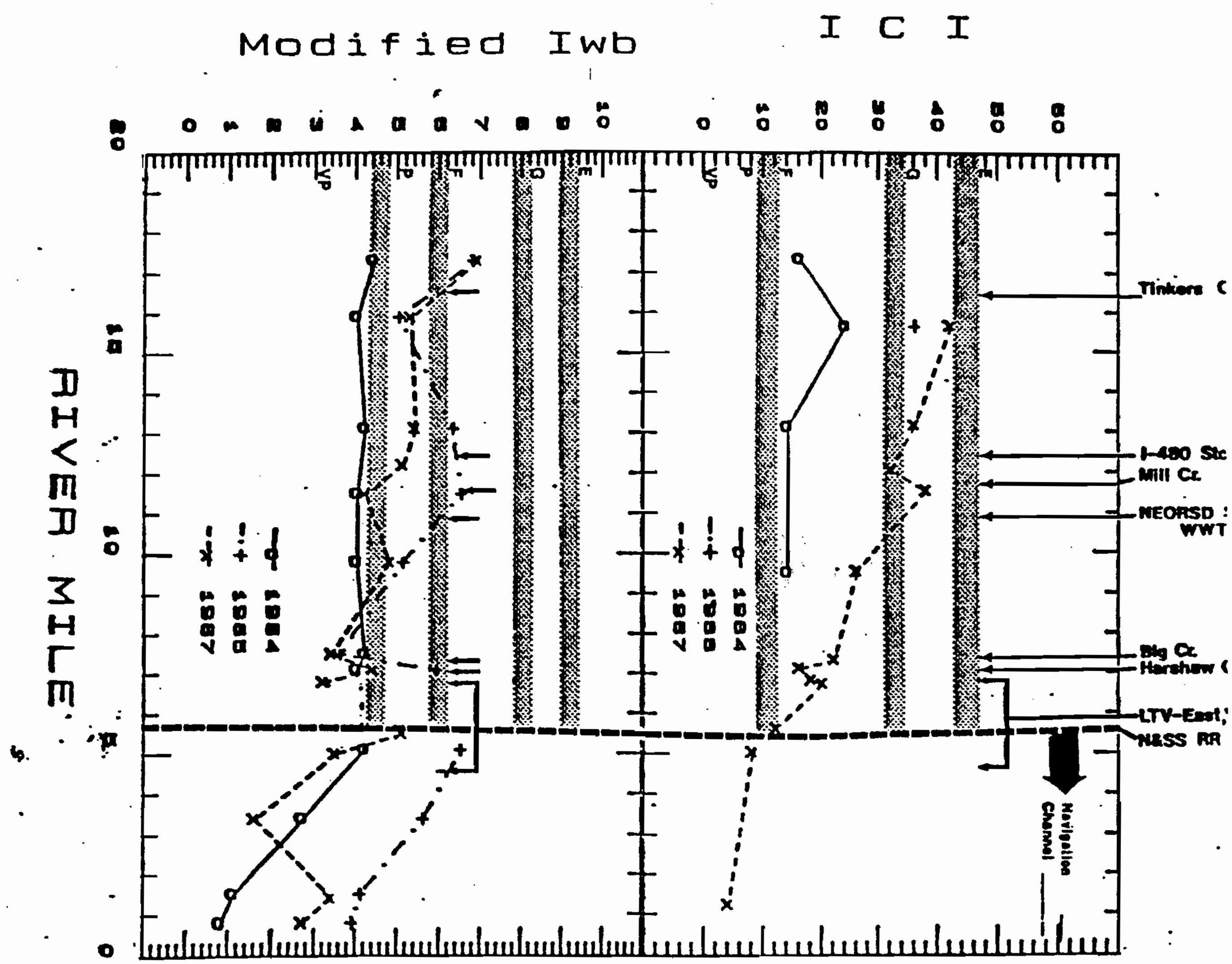


Chart 3. Longitudinal Assessment: Cuyahoga RM 20-0

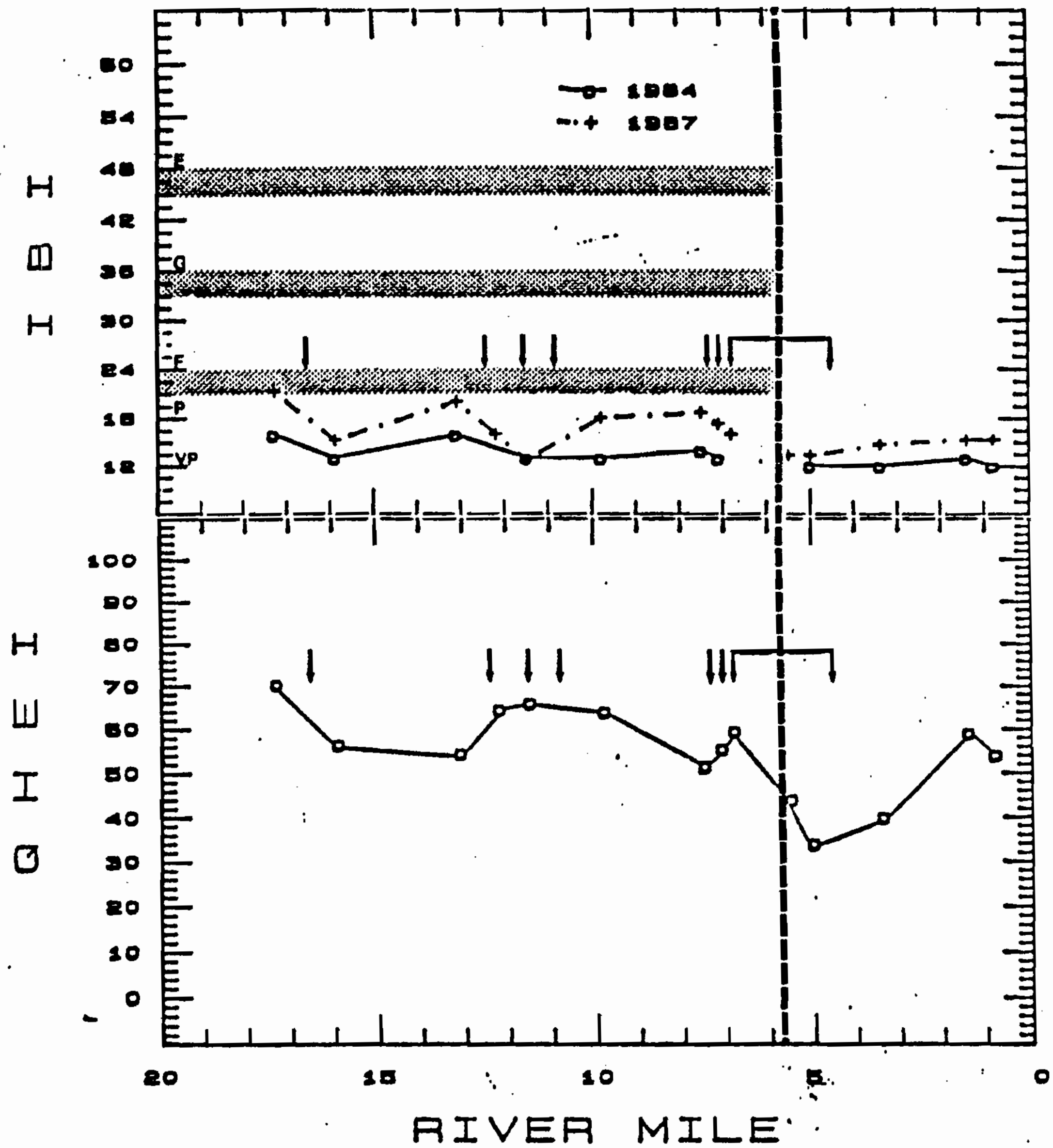


Chart 4. Longitudinal Assessment: Cuyahoga RM 20-0

BIG CREEK

I. COMMUNITIES SERVED

Big Creek drains southwestern Cleveland and the south and southwest suburbs. It has a total drainage area of 38.60 square miles and a total length of 12.0 miles (Havens & Emerson, 1968). Big Creek has two main branches: the East Branch, which originates in North Royalton south of Pleasant Valley Road, and flows north through Parma and Parma Heights into Brooklyn, and the West Branch, which originates in Brook Park and flows northeast through the west side of Cleveland into Brooklyn, where it combines with the east branch. From the confluence of the two main branches, Big Creek flows east through Brooklyn and Cleveland to the Cuyahoga River at River Mile 7.0. Additionally, each branch has a significant tributary stream: Stickney Creek, which originates in Parma and flows northwest through a section of Cleveland into Brooklyn, where it combines with the East Branch; and the "Chevrolet" branch, which originates in Parma south of Brookpark Road and flows north into Cleveland, where it combines with the West Branch.

II. PHYSICAL OBSERVATIONS

Under dry weather conditions, flow measurements obtained at Jennings Road indicated that Big Creek discharges approximately 11.3 million gallons per day (MGD) into the Cuyahoga River. About 7.0 MGD of the flow was from the East Branch, while 2.4 MGD of the flow was from the West Branch.

Most of Big Creek is open, with only two major portions culverted: approximately 0.4 miles underneath the Metroparks Zoo; and approximately 2.6 miles of the West Branch between West 117th St. and Puritas Avenue.

Along Interstate 71, from downstream of the East and West Branch confluence to Brookside Park, the creek has been relocated and channelized with concrete beds. Other than this 1.6 miles of channelization and the culverted portions, the creek's substrate is predominantly natural.

The creek's drainage area is largely residential but also includes significant portions of land used for industrial and recreational purposes. Big Creek's main stream and West Branch have been classified by the Ohio EPA as "Limited Warmwater Habitat." The East Branch has been classified as "Warmwater Habitat."

III. SUMMARY OF DATA

Big Creek has been assigned 6 locations for chemical, bacteriological, and benthic sampling and analysis. See Figure 2.

Stream Monitoring Program Sample Site #25 is located on the main stream downstream of Jennings Road and approximately 900 feet upstream of the confluence with the Cuyahoga River. This segment's substrate consists of large rocks, pieces of concrete and miscellaneous debris. The stream bed is about 20 feet wide and the water velocity was fast with many riffles present. This segment of the creek is located in an industrial area of the city.

Chemical data obtained at Sample Site #25 was relatively inconclusive. All chemical parameters checked were within Water Quality Standards for Limited Warmwater Habitat. However, bacteriological data indicated serious organic pollution with a fecal coliform concentration of 9000 counts per 100 mL. The fecal coliform/fecal streptococcus ratio was 2.2, suggesting the water contained organic wastes of mixed human and animal origins. The Cleveland Metroparks Zoo, which is less than 1.5 miles upstream of the sample site, may be the primary source of animal wastes in the creek at this point. Wastes of human origin may be attributed to upstream sanitary sewer overflows referred to later in this report.

Qualitative sampling of benthos by handpicking also indicated pollution at Site #25. The following organisms were found: oligochaetes (Tubificidae); turbellarians (*Dugesia tigrina*); hurudineans (*Placobdella* sp. and *Hellobdella* sp.); chironomids; and gastropods (*Physa* sp.). All species found at this site were tolerant of heavy organic pollution with the exception of *Dugesia tigrina*, which is tolerant of moderate to heavy organic pollution.

Sample Site #27 is located on the West Branch of Big Creek approximately 100 feet upstream of the confluence with the East Branch. It is in a portion of the Metroparks Big Creek Reservation North of Memphis Ave. and Tiedeman Road. The banks are surrounded by trees and much vegetation. This segment of the creek was obviously heavily polluted with sanitary sewage. The water had a gray tint and smelled septic. The substrate contained many large rocks, which were coated with slime. The flow velocity was moderate with some riffles and some pooled areas. Disturbance of the sediment revealed a black color.

Dissolved oxygen levels, when checked, were all above the Limited Warmwater Habitat lower limit of 4.0 p.p.m., but on several occasions were only slightly within this standard. Ammonia concentration exceeded the standards on two occasions. The iron concentration exceeded the water quality standard on one occasion.

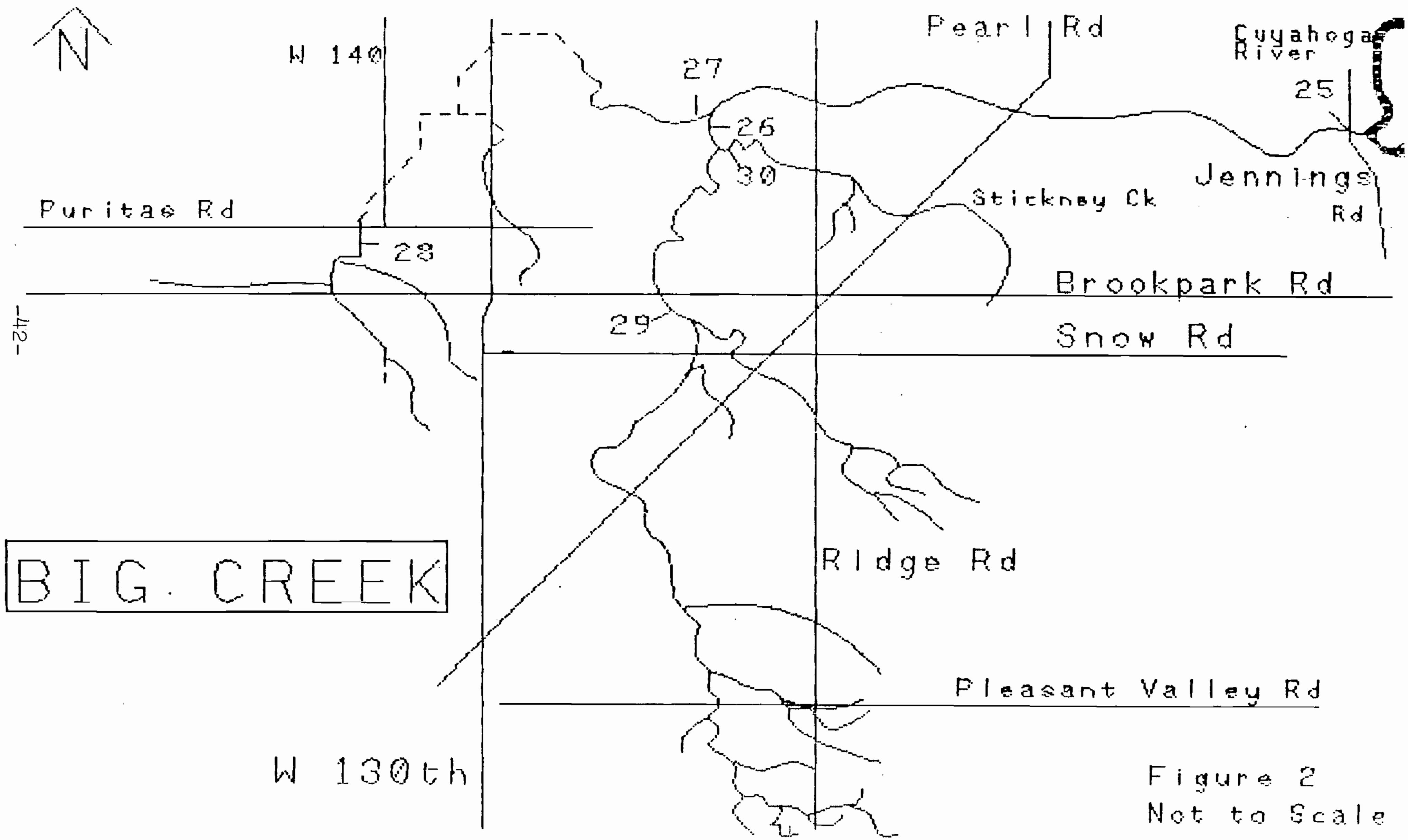


Figure 2
Not to Scale

Bacteriological data indicated extremely heavy organic pollution. Fecal coliform concentrations were as high as 3,200,000 counts per 100 mL and at no time lower than 9,000 count per 100 mL throughout 1986 and 1987. The sanitary sewer overflow at Cooley Avenue is known to be the primary source of this pollution and is discussed later in this report.

Qualitative sampling of benthos gave further evidence of the severely degraded condition of this segment of the West Branch. Handpicking only revealed one group of organisms - Tubificidae, which are tolerant of heavy organic pollution. This location had the lowest benthic diversity of any sample site inspected during the Stream Monitoring Program to date.

Sample Site #28 is located on the West Branch immediately upstream of the beginning of the "double-barrel culvert" south of Puritas Ave. The stream at this point is passing through a flat marshy area with high grass. Near the culvert, it has concrete beds which are covered with sand and a dense growth of green algae. The stream bed is approximately 8 to 10 feet wide. Flow measurements under dry weather conditions indicated a flow rate of 0.5 MGD.

Chemical data obtained was all within water quality standards for a Limited Warmwater Habitat at this location.

Bacteriological data varied from 100 counts to 5,400 counts per 100mL. Although periodically contaminated by human waste, as indicated by fecal coliform/fecal streptococcus ratios greater than 4.1, the bacteria counts at this location were far smaller than those obtained further downstream on the West Branch.

Qualitative sampling for benthos at Sample Site #28 produced: oligochaetes; hirudineans (of the family Erpobdella); isopods; damselfly nymphs (<u>Ischnura</u> sp.); chironomids (<u>Pentaneura</u> sp.); and gastropods (<u>Physa</u> sp. and <u>Bithinia</u> sp.). This is certainly much greater diversity than is found downstream on the West Branch, but all of these organisms are tolerant of heavy organic pollution, except <u>Pentaneura</u> sp., which is classified as "facultative."

Sample Site #26 is located on the East Branch of Big Creek approximately 100 feet upstream of its confluence with the West Branch. As is the case with Sample Site #27, this segment of the creek passes through a portion of the Metroparks Big Creek Reservation north of Memphis Ave. and Tiedeman Road. The banks are surrounded by trees. Many large rocks are scattered along the banks and in the creek. The substrate is composed of rocks, pebbles, and sand, and green and brown algae coat the rocks. The stream width was about 22 feet.

As far as chemical data is concerned, copper concentrations were noted in excess of the water quality standards for Warmwater Habitat.

Bacteriological data varied throughout 1986 and 1987 at Sample Site #26. With one exception, fecal coliform concentrations ranged from 390 counts to 21,000 counts per 100 mL. The exception occurred on May 5, 1987, when construction near Interstate 480 was responsible for the bypass of sanitary sewage to a storm sewer on Ridge Rd., which was tributary to Stickney Creek and eventually the East Branch of Big Creek. This was a one-time incident which was immediately corrected, but it resulted in a fecal coliform concentration at Sample Site #26 of 480,000 counts per 100 mL. Other than this particular event, the bacteriological data indicated that, although frequently greatly exceeding the Primary Contact Use Designation standards, the East Branch of Big Creek near the confluence is considerably less polluted by organic waste than is the West Branch.

Diversity of benthic macroinvertebrates in the East Branch was higher than in any other part of Big Creek. Qualitative sampling produced the following facultative organisms at Sample Site #26: turbellarians (Dugesia tigrina); isopods (Asellus communis); caddisfly larvae (Hydropsyche sp.); damselfly nymphs (Enallagma sp.); and gastropods (Ferrisia sp.). It also produced the following tolerant organisms: oligochaetes (Naididae); chironomids, and hirudineans (Helobdella sp.) However, no organisms intolerant of organic pollution were found anywhere in Big Creek.

Sample Site #29 is located upstream on the East Branch at the Fern Hill Picnic Area in the Metroparks Big Creek Reservation, south of Brookpark Road. Overhanging trees and sparse vegetation surround the creek, which is 30 feet wide at this location. The substrate consists of shale, rocks, logs, and mostly natural debris with riffles and some pooled areas. The flow under dry weather conditions was measured to be 6.5 MGD. Dense green and brown algae covered the substrate.

All chemical data obtained was within the water quality standards for Warmwater Habitat. (Hardness was not analyzed for, which prevented comparison of some metals data with the standards).

Bacteriological data was greatly in excess of the standard for Primary Contact Use Designation. The fecal coliform concentration was as high as 36,000 counts per 100 mL. This may be attributed to the sanitary sewer overflow at Snow Road which is less than one mile upstream of this point and is discussed later in this report.

Diversity of benthic macroinvertebrates at Sample Site #29 was high compared to other locations in Big Creek. However, as was the case with Sample Site #26, no organism intolerant of organic pollution were found. Facultative organisms found included: turbellarians (*Cura formanii*); isopods (*Asellus communis*); caddisfly larvae (*Hydropsyche* sp.); blackfly larvae (*Simulium* sp.); chironomids (*Pentaneura* sp.); gastropods (*Ferissia* sp.); and a nematode. Tolerant species found included: oligochaetes; hirudineans (*Hellobdella* sp.); gastropods (*Physa* sp.); and chironomids. Both sample sites on the East Branch have higher water quality than the West Branch but the data indicates the presence of significant organic pollution nevertheless.

Sample Site #30 is located on Stickney Creek about 100 feet upstream of its confluence with the East Branch of Big Creek south of Memphis Avenue. The creek is surrounded by many overhanging trees and thick vegetation. The stream's substrate consists of solid flat shale with some shale pieces and sand, and the segment has some pooled areas. Green algae was noted on rocks. Measurements indicated a dry weather flow of 0.6 MGD.

Chemical data was relatively inconclusive with none of the parameters tested for exceeding the Water Quality Standards for Warmwater Habitat.

As far as bacteriological data is concerned, fecal coliform concentrations varied from 100 counts to 5400 counts per 100 mL. Apparently, Stickney Creek periodically receives significant organic pollution.

Benthic macroinvertebrates collected at Sample Site #30 were relatively few, but this may reflect more the unsuitable nature of the substrate than be an indicator of the water quality. Facultative organisms collected included turbellarians (*Cura formanii*) and mayfly nymphs (*Baetis* sp. and *Callibaetis* sp.). Gastropods (*Physa* sp.) which are tolerant of organic pollution were also found.

IV. ENVIRONMENTAL PROBLEMS AND REMEDIATION

Surveys of Big Creek have uncovered four major dry weather sources of sanitary pollution. As of the date of this report all of these problems have continued unabated since their discoveries.

The most significant source of sanitary pollution in Big Creek is occurring at Cooley Avenue in Cleveland. A 24-inch sanitary sewer north of Bellaire Road and Kensington Avenue is partially blocked and the flow is severely restricted. The sanitary sewage is backing up the pipe to the overflow at Cooley Avenue, where it is entering the West Branch at a rate of 0.4 MGD in dry weather conditions. Bacteriological analyses of this influent to the creek have indicated fecal coliform concentrations as high as 3,400,000 counts per 100 mL. Daily BOD and suspended solids loadings were calculated to be 410 pounds and 417 pounds respectively. Based on dimensions, the 24-inch sanitary sewer has a capacity of 7.4 MGD. The entire dry weather flow on Cooley Ave., upstream of the 24-inch sewer was estimated to be considerably less, however, at 1.0 MGD. Nevertheless, manholes on the 24-inch sewer are surcharged upstream of Bellaire Road, and the overflow at Cooley Avenue continues to occur, resulting in severely degraded conditions downstream in Big Creek.

The second most significant dry weather source of pollution on the West Branch of Big Creek occurs at the "double-barrel" culvert between Puritas Avenue and West 130th Street in Cleveland. The culvert is divided by a median wall. Big Creek West Branch flows through the southeast side of the culvert. The northeast side of the culvert collects combined sewer overflows which travel to the perpendicular weir at West 130th Street, where the sewage flows through a sanitary outlet to the Big Creek Interceptor. The fecal coliform concentration in the creek upstream of this "double-barrel" culvert at Puritas Ave. was only 100 counts per 100 mL on May 6, 1987. However, at the same time, the fecal coliform concentration downstream in the creek side of the culvert at West 130th Street was 140,000 counts per 100 mL. Fluorescent dye injected into the sanitary sewage side of the culvert at Puritas Avenue appeared in the creek side of the culvert at West 130th Street, verifying that at some point between these two locations, sanitary sewage is crossing the dividing wall.

A third major dry weather source of pollution occurs on the East Branch of Big Creek under Snow Road at the border between Parma and Parma Heights. Flow measurements indicated that sanitary sewage is entering the creek through a pipe from the west at a rate of 0.2 MGD. Fecal coliform concentrations in this influent to the creek were as high as 6,400,000 counts per 100 mL. Daily BOD and suspended solids loadings were calculated to be 134 pounds and 106 pounds respectively. The cause of this continuous sanitary sewage overflow has not been determined.

Another dry weather discharge from a sewer pipe to the East Branch of Big Creek is occurring via a tributary stream at Evergreen Drive in Parma. According to nearby residents, there is a great variation in the concentration of sewage evident in this discharge, though the flow rate remains constant in dry weather. Significant visual evidence of sewage was noted on the substrate downstream. Measurements indicated that the flow rate from the pipe was approximately 0.1 MGD. Fecal coliform concentrations obtained in samples of the influent have been as high as 33,000 counts per 100 mL. However, the fecal coliform/fecal streptococcus ratio has been as low as 0.2, suggesting that the primary source of bacterial pollution may be non-human at this location.

In total, over 100 dry weather influents to Big Creek have been noted in N.E.O.R.S.D. - IWS surveys. The majority of these influents were either too insignificant in volume of flow or in concentration of pollutants to be mentioned in this report. If the four problems referred to above were corrected, a significant improvement in Big Creek's dry weather water quality conditions would occur. The local authorities in each community responsible for the correction of each of these problems have been contacted and are aware of their deleterious effect on the environment.

MILL CREEK

I. COMMUNITIES SERVED

Mill Creek drains southeastern Cleveland and the southeastern suburbs along the southern border of Cleveland. It has a total drainage area of 18.10 square miles and a total length of 9.0 miles (Havens & Emerson, 1968). Mill Creek originates in Warrensville Township, flows southwest through Warrensville Heights and a small section of Cleveland to near Broadway Avenue in Maple Heights, along which it flows northwest through Garfield Heights into Cleveland and then south along the border of Cuyahoga Heights and Garfield Heights to the Cuyahoga River at River Mile 11.8.

II. PHYSICAL OBSERVATIONS

Under dry weather conditions, flow measurements obtained at Canal Road indicated that Mill Creek discharges approximately 8.4 MGD into the Cuyahoga River.

Almost the entire creek is open, with the only significant culverted sections being short segments of the creek upstream of Garfield Park, under Interstate 480, and downstream of the Kerruish Park retention basin. Except for the concrete beds in the culverts, the creek's substrate is predominately natural.

Mill Creek's drainage area is mostly residential and industrial. The Ohio EPA has classified Mill Creek from its mouth to near Granger Road as "Limited Warmwater Habitat" and upstream of this point as "Warmwater Habitat."

III. SUMMARY OF DATA

Mill Creek has been assigned 6 locations for chemical, bacteriological, and benthic sampling and analysis. See Figure 3.

Sample Site #31 is located on Mill Creek, approximately 600 feet upstream of the confluence with the Cuyahoga River, between Canal Road and the Ohio Canal. The creek is about 25 feet wide at this point and the substrate consists of gravel, sand, small rocks, and miscellaneous debris. Many trees and dense vegetation surround the creek. The water appeared slightly turbid and the flow velocity was moderate. The water depth through this segment was around one foot during dry weather.

Chemical analyses of the water at Sample Site #31 revealed that ammonia, iron, and cadmium all exceeded the water quality standards for Limited Warmwater Habitat. The creek passes

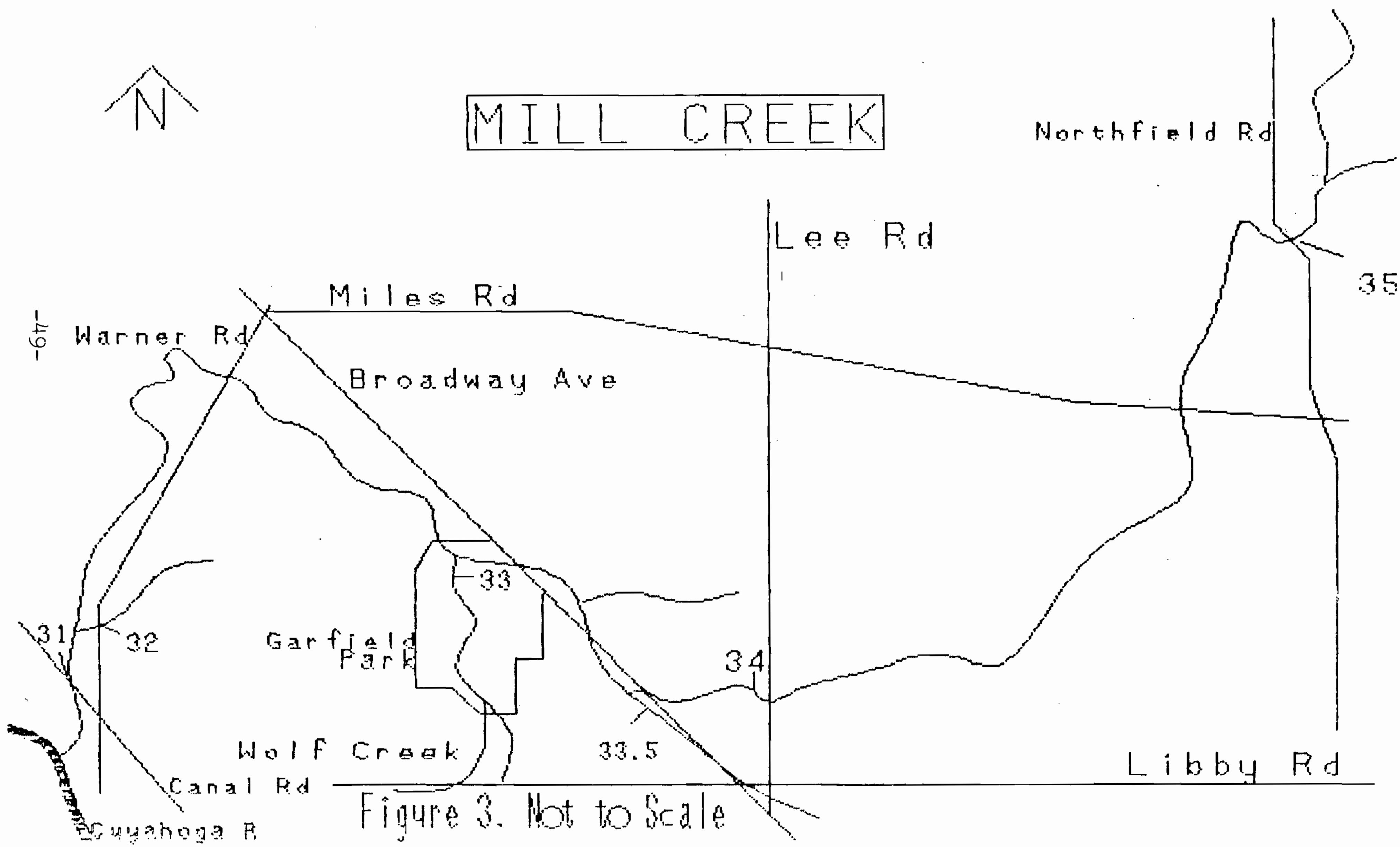


Figure 3. Not to Scale

through the a landfill less than one mile upstream of the location, and this could have an impact on some chemical parameters. Also noted was that the chlorides concentration was as high as 294 mg/L. Chlorides may be attributed to runoff from the application and accumulation of salt on roads and parking lots, as this sample was obtained in late winter 1987. High oil and grease concentrations (111 mg/L) may also be attributed to road/yard run-off in this highly industrialized area.

Bacteriological data indicated that Mill Creek at Sample Site #31 has rather severe organic pollution with fecal coliform concentrations as high as 300,000 counts per 100 mL. At the time of this sample, the interceptor break near Longbrook Road had not yet been repaired. Also contributing significantly to the pollution is the sewer overflow behind Mapletown Shopping Center and the tributary by Warner Road, all of which are discussed later in this report.

Biological data gave further evidence that the condition of Mill Creek has been seriously degraded at Sample Site #31. Qualitative sampling revealed a very low diversity of benthic macroinvertebrates, all of which were tolerant to heavy organic pollution: oligochaetes (Tubificidae); hirudineans (Placobdella sp.); chironomids; and gastropods (Physa sp.).

Sample Site #32 is located on a small tributary to Mill Creek which passes underneath Warner Road from the northeast. It enters the creek less than one mile upstream of Mill Creek's confluence with the Cuyahoga River. This tributary is about six feet wide and the substrate consists of large rocks, sand, and sludge. The rocks were coated with a grey slime, and the sediment became black and sulfurous when disturbed. The flow velocity was relatively slow with some riffles present. The creek is surrounded by moderate vegetation and some trees.

Chemical analysis at Sample Site #32 indicated that the mercury concentration in the flow exceeded the Limited Warmwater Habitat standard of 0.2 micrograms per liter. Mercury concentrations in the stream sediment were also high at 1.3 ug/L. Whether these concentrations may be associated with the Allied Chemical Corp. plant at 5000 Warner Rd. or a source further upstream on the tributary is yet to be determined.

Bacteriological data indicated the presence of severe organic pollution at Sample Site #32 with a fecal coliform concentration of 340,000 counts per 100 mL. Dissolved oxygen had a concentration as low as 0.3 parts per million. Further investigation is also required to determine the source of sewage in the tributary.

The presence of severe organic pollution was supported by a low benthic diversity. Only three types of benthic macroinvertebrates were found at this location: oligochaetes (tubificidae); chironomids (Chironomus sp.) and gastropods (Physa sp.). All of these organisms are tolerant of heavy organic pollution.

Sample Site #33 is located on the "Wolf Creek" tributary to Mill Creek in the Cleveland Metroparks Garfield Park Reservation, approximately 100 feet upstream of its confluence with Mill Creek. This tributary is about 6 to 8 feet in width with a depth of 4 to 6 inches in dry weather. The substrate is composed of stones, gravel and sand, and the creek has riffles and pools. The stones were covered with green algae.

All chemical parameters tested for were within the Limited Warmwater Habitat standards. Chlorides were as high as 766 mg/L on February 5, 1987 however.

Bacteriological data obtained in March 1987 indicated some organic pollution with a fecal coliform concentration of 4,500 counts per 100 mL. Periodic overflows from sewers on surrounding streets in Garfield Heights and storm sewers which may be contaminated by cross connections are known to be at least partially responsible for this organic pollution of Wolf Creek.

However, benthos samples collected in October 1987 at Sample Site #33 indicated an improvement in the water quality. Only two of the five types of macroinvertebrates found at the location are tolerant of organic pollution: gastropods (Physa sp.) and chironomids. Amphipods (Crangonyx gracilis) and turbellarians (Dugesia tigrina), which are facultative, and isopods (Asellus militaris), which cannot withstand adverse environmental conditions and are usually associated with recovery zones, were also found.

Sample Site #33.5 is on a tributary to Mill Creek, which flows in a northwest direction parallel with Broadway Avenue, known as the "Mapletown Branch." The sampling location is about thirty feet upstream of this tributary's confluence with Mill Creek, south of Interstate 480 and Broadway Avenue. The tributary is obviously grossly polluted with sanitary sewage for reasons discussed later in this report. The substrate, composed of slime-coated rocks, sand, and sludge, is colored black from septic conditions. Overhanging trees and thick vegetation surround the tributary.

Among the chemical parameters tested for at Sample Site #33.5, only the copper concentration exceeded the Water Quality Standard for Limited Warmwater Habitat.

Bacteriological analysis confirmed that this tributary to Mill Creek is suffering from gross organic pollution. The fecal coliform concentration was greater than 2,000,000 counts per 100 mL.

Qualitative sampling for benthic macroinvertebrates further supported this conclusion, as only one type of organism was found: oligochaetes (Tubidficidae), which are extremely tolerant of severe organic pollution.

Sample Site #34 is located on Mill Creek at Rex Avenue and Glenburn Avenue in Maple Heights. The stream is approximately 20 feet wide at this point and is surrounded by trees and thick vegetation. The substrate consists of rocks, shale-bits, sand, and miscellaneous debris. Slime coated the rocks and the creek had obvious visual evidence of contamination by sanitary sewage. The turbid flow had a relatively slow velocity and was about 6 inches deep.

The only chemical concentrations which were in excess of the Warmwater Habitat Water Quality Standards were those of copper and lead.

Bacteriological analysis revealed that considerable organic pollution has occurred in Mill Creek at Sample Site #34 with fecal coliform concentrations as high as 130,000 counts per 100 mL in March 1987.

The low diversity of benthic macroinvertebrates at Sample Site #34 also indicated significant organic pollution. Only two types of organisms were found during qualitative sampling: oligochaetes (Tubificidae); and gastropods (<u>Physa</u> sp.); both of which are tolerant of heavy organic pollution.

Two major sanitary sewer overflows to the creek upstream of this location may be entirely responsible for the degraded condition of this part of the creek. These two problems, near Longbrook Rd. in Warrensville Heights and near East 173rd Street in Kerruish Park, were both corrected and are discussed later in this report. Future sampling results should reflect improved water quality at Sample Site #34.

Sample Site #35 is located on Mill Creek about 100 feet upstream of Northfield Road in Warrensville Township. The creek at this point was about 6 to 12 inches deep and about 10 to 12 feet wide. The substrate consisted of fine gravel and pebbles. The creek was surrounded by many overhanging trees and dense vegetation. The water was clear and the flow velocity was moderate.

Although all other chemical parameters were within the Warmwater Habitat Water Quality Standards, the copper concentration slightly exceed its standard of 0.01 mg/L.

Bacteriological analysis indicated that there was less organic pollution at Sample Site #39 than at any of the other Mill Creek locations. The fecal coliform concentration was less than 100 counts per 100 mL, which is well within the Primary Contact Use Designation standard.

Qualitative sampling for benthic macroinvertebrates revealed a relatively high diversity. Tolerant organisms found included: oligochaetes (Tubificidae); chironomids; hirudineans (Erpobdella punctata); and an aquatic hempiteran. Facultative organisms found included: nematodes (Rhabdolaimus sp.); turbellarians (Cura formanii); and black fly larvae (Simulium sp.). Additionally, numerous minnows, tadpoles, and water striders were noted at this furthest upstream location on Mill Creek.

IV. ENVIRONMENTAL PROBLEMS AND REMEDIATION

During the 1987 survey of Mill Creek, two major sources of sanitary sewage were identified as being primarily responsible for the severely degraded conditions of Mill Creek.

On March 24, 1987, the Mill Creek Interceptor under Mill Creek just south of Longbrook Rd. in Warrensville Heights was found to be broken. Sanitary sewage was entering the creek from underground at this point at a rate of 1.8 MGD according to flow measurements. The fecal coliform concentration in Mill Creek downstream of the break was 1,500,000 counts per 100 mL. Daily BOD and suspended solids loadings were calculated to be 1524 pounds and 2190 pounds respectively.

The problem south of Longbrook Rd. was reported to Cuyahoga County officials, and by September 4, 1987, 600 feet of the Mill Creek Interceptor had been replaced by contractors, eliminating this source of pollution in Mill Creek. According to the contractors, tree roots were responsible for the sewer break, and all trees in the immediate vicinity of this new section of interceptor have been cleared.

Another, smaller, underground sanitary sewer break was also discovered on March 24, 1987 between Mill Creek and Mayfair Lane in Warrensville Heights. This 8" sanitary sewer break was also reported to County officials and was repaired by April 20, 1987.

The repair of these two problems has vastly improved the dry weather water quality in Mill Creek upstream of Broadway Avenue. However, the most serious source of pollution in Mill Creek has continued unabated, as of the date of this report: a dry weather sanitary sewage overflow to the "Mapletown Branch" tributary to Mill Creek is occurring west of Mapletown Shopping Center in Maple Heights. According to NEORSD records, this overflow is known to have been occurring for at least 12 years. Deterioration and overloading of the Broadway Avenue sewer has necessitated the opening of a regulator gate at Broadway Avenue and Maple Heights Boulevard, allowing the discharge of sanitary sewage to the creek through a relief sewer. The flow of sewage entering the creek was measured to be approximately 1.8 MGD. Fecal coliform concentrations in this influent have been as high as 7,100,000 counts per 100 mL. Daily loadings of BOD and suspended solids were calculated to be 1763 pounds and 875 pounds respectively. Supposedly, officials of the City of Maple Heights are to address the problem of this overflow in 1988.

On November 24, 1987, a sanitary sewage overflow was discovered at East 173rd Street, south of Elmer Avenue, in Kerruish Park. The apparent cause for overflow of the sidespill weir was blockage downstream in the 8" sanitary sewer. The condition of this NEORSD-maintained overflow, identified as No. MC-31, was reported to Sewer Control Systems on November 27, 1987. An inspection on December 10, 1987 revealed that the blockage had been removed and that the overflow was no longer occurring at this location.

On March 24, 1987, during the initial survey of Mill Creek, a discharge to the creek from the east, north of South Miles Road, had been found containing water soluble oil. Further upstream on the on the small tributary, was discovered considerable accumulation of dark brown oil. The source of the tributary was traced to a storm sewer behind Empire Die Casting Company, 19800 Miles Avenue. To the storm sewer, Empire Die Casting Company's process wastewater effluent was tributary through an underground oil separator. Subsequent NEORSD investigations indicated that this separator may not have been properly maintained. Furthermore, the company had no NPDES Permit for this direct discharge to the environment. Consequently, the Ohio EPA was notified and required that Empire Die Casting Co either obtain an NPDES Permit or redirect the wastewater discharge to the public sanitary sewer system. As of the end of 1987, the Ohio EPA requirement had not yet been met.

Finally, a source of untreated sanitary sewage exists west of Bancroft Avenue in Garfield Heights, where residences are inappropriately connected to a storm sewer. Sanitary sewage pools at the storm sewer outfall at this point. The pool's effluent flows westward across the Harvard Landfill's property to Mill Creek. This discharge does not result in severe contamination of the creek, due to the distance from its source and the relatively small volume of its flow. However, the pooling of raw sewage poses a potential health hazard to the nearby residential community. The City of Garfield Heights has been made aware of this problem, and remediation is expected to occur in 1988.

WEST CREEK

I. COMMUNITIES SERVED

West Creek drains the eastern section of Parma, and portions of Seven Hills, Brooklyn Heights and Independence. It has an approximate drainage area of 20 square miles and a total length of approximately 8 miles. West Creek has two branches: the "Main" branch, which originates in Parma just south of the intersection of Broadview and Pleasant Valley Roads and flows north through the eastern section of Parma, then east through Seven Hills, Brooklyn Heights and Independence; a smaller branch originating in Independence north of the Chestnut Road and Oakwood Drive intersection. The smaller branch joins the main stream by means of culvert under I-480 west of the I-77 interchange. From this confluence the creek flows north to the Cuyahoga River and joins it at river mile 11.0.

II. PHYSICAL OBSERVATIONS

Flow was measured at the furthest upstream sample site, location #38 near West Ridgewood Drive, during dry weather, and was found to be approximately 0.4 MGD.

Most of West Creek is open. The "Main" branch was estimated to be approximately 3% culverted. Along I-480 the "Main" branch has short channelization with concrete beds and sidewalls. The predominant substrate of the creek is natural.

The creek's drainage area is largely residential. The creek has been classified by the Ohio Environmental Protection Agency as a "Warmwater Habitat."

III. SUMMARY OF DATA

West Creek has been assigned three (3) locations for chemical, bacteriological, and benthic sampling and analysis. See Figure 4.

Stream monitoring program sample site #36 is located on the "Main" branch under the Granger Road Bridge approximately 1,000 feet upstream of the confluence with the Cuyahoga River. This segment's substrate consists of small pebbles, sand and silt. The stream bed is about 15 feet wide and the water velocity was slow.

Chemical data obtained at sample site #36 was relatively inconclusive. Chlorides were measured at 510 mg/L, which may be attributed to road salt runoff. Fecal coliform was less than 90 counts per 100 mL. This is well within the water quality standards for primary contact use designation.

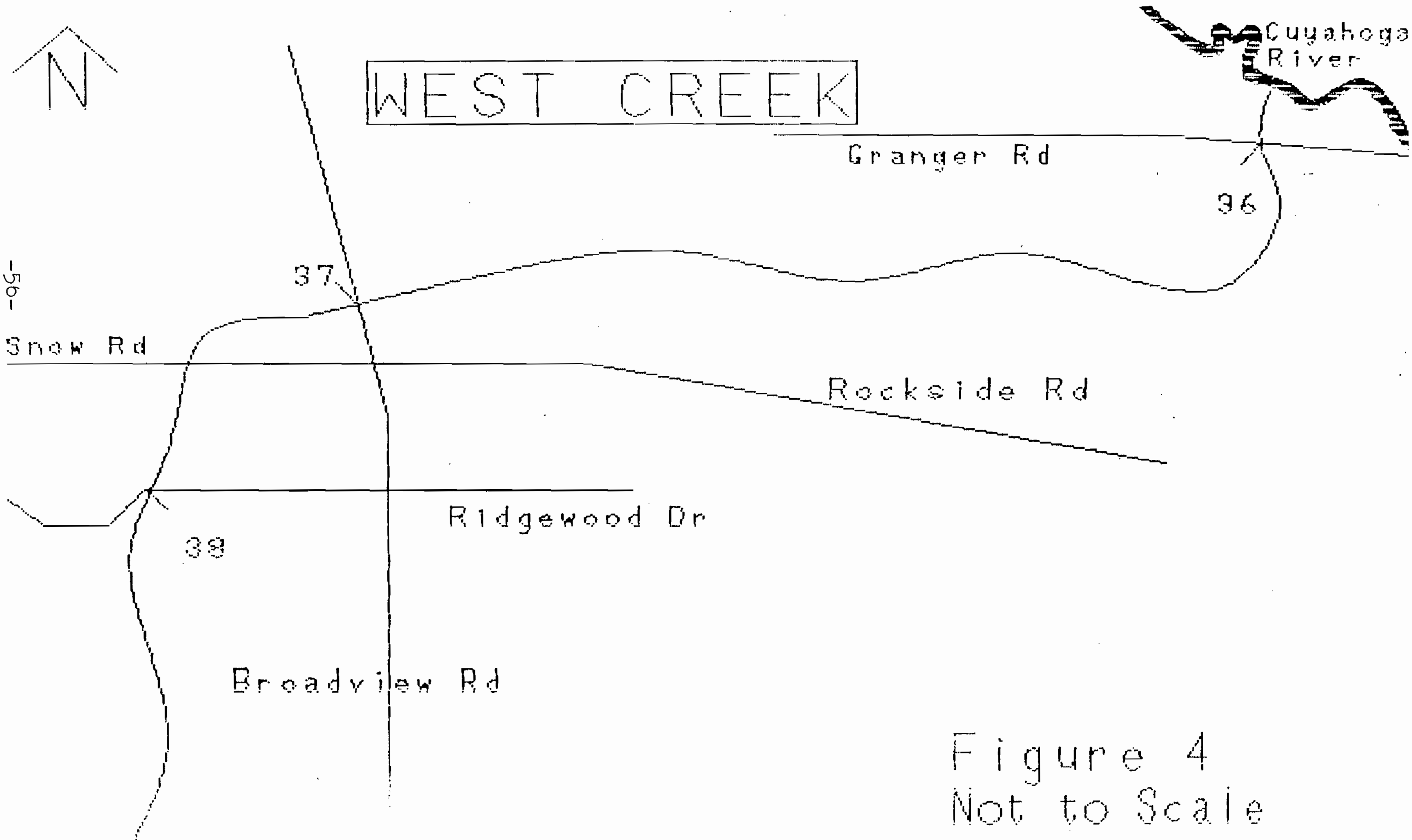


Figure 4
Not to Scale

Qualitative sampling of benthos by handpicking at site #36 found only the following organism: hirudinean (Erpobdella sp.) which is tolerant to pollution.

Sample site #37 is located under the Broadview Road Bridge in Parma. This area had large boulders, rocks, and concrete chunks in and around the creek. One section downstream of the sample site had a concrete bottom which was very shallow (1" deep). Here was noted evidence of a septic tank discharge from a nearby nursing home. The area under the bridge had many deep pools, some over 3 feet deep. Approximately 50 feet upstream was a man-made spillway about 30 feet wide. Just 20 feet upstream of the sample location was found city water tributary to the creek at a measured rate of 105,000 gallons per day. (At this point the creek is only 2 to 3 feet wide). Approximately 50 feet downstream of the sample location was the concrete-bottom area mentioned above where the width was about 20 feet.

Chemical data obtained at sample site #37 was relatively inconclusive. It should be noted that this chemical data includes the impact of the city water. Chlorides were measured at 536 mg/L, which may be attributed to road salt runoff. Fecal coliform was 180 counts per 100 mL, well within the water quality standards.

Qualitative sampling of benthos by handpicking at site #37 revealed the following organisms: gastropods (Physa sp. and Bithynia sp.), which are tolerant to heavy organic pollution. Other organisms found included: turbellarians (Cura formanii); amphipods (Crangonyx pseudogracilis); isopods (Asellus communis); and trichopteran larvae (Hydropsyche sp.), which are all classified as "facultative." Tipulidae larvae (Tipula sp.), which are classified as "intolerant," were also found. This site had much greater diversity than was found at sample site #36.

Sample site #38 is located 10 feet upstream of West Ridgewood Dr. Bridge in Parma in a residential area. There are steep slopes and lawns on one side, while the other side rises up about 3 feet from the creek bed and has many trees and thick vegetation. The creek contains many large rocks and some logs. The substrate was shale, sand, and poured concrete for anti-erosion purposes. The creek at this point is 4 to 9 inches deep and about 12 feet wide, with about 75% riffles and a moderately fast current. The water was clear and many fish were seen. Two fish were caught; one was a Northern Creek Chub, which is moderately tolerant to organic pollution.

Chemical data obtained at sample site #38 was relatively inconclusive. Chlorides were measured at 566 mg/L, which may be attributed to road salt runoff. Fecal coliform was 450 counts per 100 mL. This is well within the water quality standards.

Qualitative sampling of benthos by handpicking at site #38 revealed the following organisms classified as "facultative:" turbellarians (Dugesia tigrina); amphipods (Cragonyx gracilis, Crangonyx pseudogracilis); isopods (Asellus communis); emphemeropteran nymphs (Stenomema tripunctatum); odonatan nymphs (Agrion sp.); trichopteran larvae (Hydropsyche sp.); chironomid larvae (Pentaneura sp.); simuliidae larvae and pupae and orthocladiinae larvae. One organism classified as tolerant was found: an oligochaete of the family Tubificidae. One organism classified as intolerant was found: an ephemeropteran nymph (Baetis sp.). Also found were hirudinean cocoons, and chironomid larvae. Diversity of benthic organisms at sample #38 was higher than at any other part of West Creek.

IV. ENVIRONMENTAL PROBLEMS AND REMEDIATION

During the initial survey and following chemical and benthos sampling, noted were only three minor environmental disruptions: the impact of the city water; septic tank discharges; and "urban junk" in the creek.

1) On May 29, 1987, a City of Cleveland Water Department crew was assisted in the attempt to locate the source of city water entering Parma's storm sewer. The City crew was not able to find the source of this 105,000 gallons per day discharge to the creek at Broadview Road. The Parma Engineering Dept. has been made aware of this situation. Until the source is eliminated, this discharge will have a dilutive impact on data obtained at sample site #37.

2) Of the two septic tank discharges found, the discharge from Parma Nursing Home, 5553 Broadview Road, was tied into the sanitary sewer located on Sandpiper Drive in the fall of 1987. Continuing to be a source of septic tank effluents is a 42-inch Parma storm sewer, located south of West Pleasant Valley Road, which serves residences having septic tanks on Robert, Orchardview and Howard Drives.

3) Two separate locations with high concentrations of "urban junk" were found. Just north of the Pleasant Valley Shopping Center, located at West Pleasant Valley Road and Broadview Road, the stream becomes a marsh land where many grocery carts have been dumped. The second area where "urban junk," including a car, was found is located south of sample site #38 (Ridgewood Drive), adjacent to the Parma landfill.

During the survey along West Creek, wildlife observed included a fawn, turtles, geese, mallard ducks, frogs, water snakes, and minnows. No major industrial/commercial discharge of pollutants was noted entering the stream at any location.

TINKERS CREEK

I. COMMUNITIES SERVED

Tinkers Creek's tributary area includes: Solon, Glenwillow Township, Oakwood, Bedford Heights, Bedford (including the Metroparks Bedford Reservation), Walton Hills (including the Cuyahoga Valley National Recreation Area), Valley View, Twinsburg, Twinsburg Township, Reminderville, Aurora (including Aurora Lake and Tinkers Creek State Park), Streetsboro, and Hudson (including Hudson Spring Lake).

II. PHYSICAL OBSERVATIONS

Sample Site #39 is located approximately 500 feet upstream of Tinkers Creek's confluence with the Cuyahoga River at the west face of the Ohio Canal over the creek. See Figure 5. This site represents the total flow of Tinkers Creek, which, according to measurements, ranged from 26.5 to 35.2 MGD in dry weather. The width of the creek at this point is 65 feet. The substrate consists of mud, sand, and rocks covered with mostly brown and some green algae. The creek banks are 6 to 12 feet high, and vegetation, including grass, bushes, and trees surround the creek. A heavy laminar flow and clear water were noted at the time of investigation.

Sample Site #40 is located under the Northfield Rd. bridge off the Bedford Parkway near Broadway Avenue. According to flow measurements, Tinkers Creek at this point has a dry weather flow ranging from 22.7 to 32.4 MGD. The width of the creek is 49 feet. The substrate consists of smooth rock, covered with green algae. The banks are grassy with some trees. The flow was swift, 1 to 3 feet deep, and slightly turbid at the time of investigation.

Sample Site #41 is located east of Richmond Road behind the Inland Refuse service garage. According to flow measurements, the dry weather flow of Tinkers Creek at this location ranged from 8.9 to 27.3 MGD. The width of the creek at this point is 37 feet and the substrate consists of mud. The current was very slow at this location and the water was quite turbid at the time of investigation. Many septic tank effluents were noted in this vicinity of the creek.

Sample Site #42 is located at the north face of the Glenwood Drive bridge in Twinsburg. Flow measurements indicated that the dry weather flow at this site ranged from 10.2 to 19.1 MGD. The width of Tinkers Creek, which was 1 to 12 inches deep at this location, is 41 feet. The substrate consists of mud and the water was slightly turbid at the time of investigation. The banks are 4 feet high and covered with grass and trees.

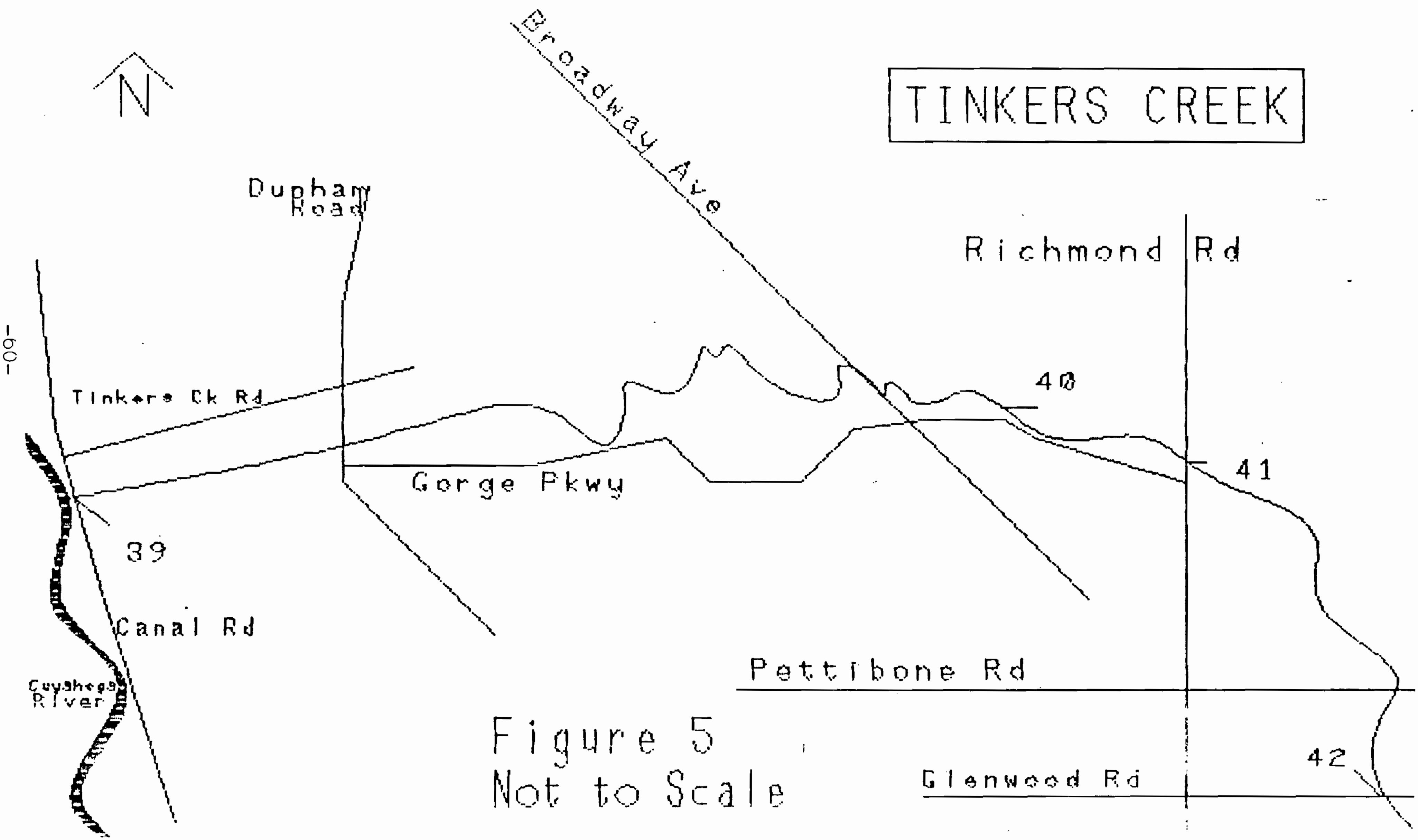


Figure 5
Not to Scale

Throughout the investigation of Tinkers Creek, numerous types of wildlife were noted, including: fingernail clams, crayfish, water striders, minnows (including a Stoneroller minnow, Campostoma anomalum), suckers, carp, frogs, a salamander, water snakes, a snapping turtle, kingfishers, a great blue heron, mallard ducks, Canada geese, bank swallows, and beavers.

III. SUMMARY OF DATA

All chemical parameters tested for were within the OEPA Water Quality Standards for Warmwater Habitat at all sampling locations, with the exception of Sample Site #42, where concentrations of zinc, copper, and iron slightly exceeded the standards. BOD, Total Solids, and other metals were all higher at Sample Site #42 than at the other three locations.

At Sample Site #39, fecal coliform concentrations were lower than at any other location on Tinkers Creek and were all within the standards for Primary Contact Use Designation. The fecal coliform/fecal streptococcus ratios at this site were indicative of combined human and non-human sources.

Qualitative sampling for benthic macroinvertebrates at Sample Site #39 revealed the following facultative organisms: decapods (Orconectes propinquus); ephemeropteran nymphs (Stenacron sp.); trichopteran larvae (Hydropsyche sp., Cheumatopsyche sp.); nematodes; chironomid larvae (Pentaneura sp.); dipterans (Simuliidae); and gastropods (Ferrissia sp., Somatogyrus sp.). The following tolerant organisms were found at this site: oligochaetes; chironomid larvae; and coleopteran larvae (Berosus sp.). Additionally, the following organisms which are intolerant of organic pollution were found: ephemeropteran nymphs (Baetis sp.); and trichopteran larvae (Agraylea sp., Hydroptila sp.) Also identified were odonatan nymphs (Zygoptera).

At Sample Site #40, fecal coliform concentrations slightly exceeded the standards for Primary Contact Use Designation on one occasion (1,700 counts per 100 mL on 5/6/87). Other than this occasion, the bacteriological data was within the standards. Fecal coliform/fecal streptococcus ratios indicated that the bacterial contamination was primarily of human origin.

Qualitative sampling for macroinvertebrates at Sample Site #40 revealed the following facultative organisms: turbellarians (Hymanella retenuova); odonatan nymphs (Hetaerina sp.); ephemeropteran nymphs (Stenacron sp.); trichopteran larvae (Hydropsyche sp.); chironomid larvae (Pentaneura sp.); dipteran larvae (Simuliidae); and gastropods (Ferrissia sp.). Tolerant organisms included: oligochaetes; and chironomid larvae. Organisms intolerant of organic pollution found included: ephemeropteran nymphs (Baetis sp.); and trichopteran larvae

(Hydroptila sp., Leucotrichia sp.). Also found were: hirudineans; isopods; collembolans (Isotomurus palustri); ceteopogonid larvae (Dasyhelea sp.); and pelecypods.

At Sample Site #41, fecal coliform concentrations were as high as 7,200 counts per 100 mL, exceeding the OEPA standards on two occasions. According to the fecal coliform/fecal streptococcus ratios, the bacterial contamination has both human and non-human origins.

Qualitative sampling for macroinvertebrates revealed the following facultative organisms at Sample Site #41: turbellarians, (Dugesia tigrina); hirudineans (Placobdella ornata); decapods (Orconectes propinquus), ephemeropteran nymphs (Stenacron sp.); trichopteran larvae (Hydropsyche sp., Cheumatopsyche sp.); coleopteran larvae (Stenelmis sp.); chironomid larvae (Pentaneura sp.); dipteran larvae (Simuliidae); and gastropods (Ferrissia sp.). Tolerant organisms found included: oligochaetes; and chironomid larvae. Ephemeropteran nymphs (Baetis sp.), which are intolerant of organic pollution, were identified at this location. Also found were: collembolans (Isotomurus palustris); coleopteran adults; and pelecypods.

At Sample Site #42, all bacteriological data exceeded the OEPA standards for Primary Contact Use Designation and the fecal coliform concentration was as high as 37,000 counts per 100 mL. This location had the most bacterial contamination of any of the sample sites on Tinkers Creek. The fecal coliform/fecal streptococcus ratios indicated this contamination was primarily from human sources.

Qualitative sampling for benthic macroinvertebrates revealed the following factultative organisms: hirudineans (Plaocbdella ornata); isopods (Asellus communis); ephemeropteran nymphs (Stenacron sp.); odonatan nymphs (Agria sp., Agrion sp.); trichopteran larvae (Hydropsyche sp., Cheumatopsyche sp.); and coleopteran larvae (Stenelmis sp.). The following tolerant organisms were found: oligochaetes; and chironomid larvae. The following organisms which are intolerant to organic pollution were found: ephmeropteran nymphs (Baetis sp.); and trichopteran larvae (Chimarra sp.). Other organisms at this location included: colepteran adults and pelecypods.

The high diversity of benthic macroinvertebrates found at all the Tinkers Creek sampling locations and the presence of some organisms intolerant of organic pollution indicate that the water quality is relatively high in this stream. However, the bacteriological data indicates that some organic contamination does occur, especially at Sample Site #42. This is further supported by the chemical data obtained at Sample Site #42.

Additionally, the City of Solon has submitted monthly to the NEORSD Stream Monitoring Program results of analyses of upstream and downstream of the Solon Central Wastewater Treatment Plant, the effluent of which flows to Beaver Creek, a tributary of Tinkers Creek. The parameters reported included temperature, dissolved oxygen, BOD, pH, total non-filterable residue, fecal coliform, ammonia, hexavalent chromium, and trivalent chromium. No significant environmental disruptions were indicated by these data in 1987. The analyses results are on file at the NEORSD Industrial Waste Section offices.

IV. ENVIRONMENTAL PROBLEMS AND REMEDIATION

On May 4, 1987, a grayish-white discharge to Tinkers Creek was discovered in Bedford. The contaminant appeared to be water-soluble cooling oil. It was traced eastward to a 24" storm pipe emanating from underneath railroad tracks west of Willis Street, between Whitaker Court and Brown Court. At this point was found a makeshift stone filter bed clogged with oily solids. The storm sewer was traced to a grated manhole on the property of D. Hamilton Trucking, Inc., 141 Willis Street. Due east from this location is Franklin Oil Corporation, 40 South Park. The Ohio E.P.A. was notified of this problem on May 11, 1987. After an investigation, the E.P.A. required Franklin Oil Corp. to sever storm sewer connections in the company's process area and improve housekeeping for spill prevention. Additionally, as of September 8th, D. Hamilton Trucking, Inc. had converted its connection to the storm sewer.

On May 5, 1987, a discharge which appeared to contain sanitary sewage was discovered flowing from a 4-foot concrete pipe to Tinkers Creek downstream of the Union Avenue bridge on the north bank by Taylor Road in Bedford. The Bedford Service Department was contacted and the problem was traced to a broken force main from Taylor Chair Co., 75 West Taylor Rd., to the Willis Street sewer. As of August 25, 1987, the break had been repaired, although a trickle remained, possibly due to residual contaminated groundwater.

On May 5, 1987, a discharge with evidence of sanitary sewage was found coming from a 2-foot vitreous clay pipe on the north bank of Tinkers Creek about 200 feet upstream of the Union Avenue bridge. The Bedford Service Department was notified about this problem, but, as of August 25, 1987, its source had not been identified.

On May 6, 1987, a 4-inch white PVC pipe from the property of Inland Refuse Transfer, Inc., 6705 Richmond Road, was discovered discharging oily water. Black oily solids could be seen accumulated in the creek at this point. The Ohio EPA was contacted, and they claimed that they had been aware of this problem and had given Inland Refuse Transfer, Inc. orders to eliminate the discharge. Additionally, a second pipe discharging sudsy and oily water from the property was discovered and reported to the EPA, who had been unaware of this pipe and would investigate.

On May 7, 1987, a bright orange-colored substance with an oily sheen was noted on the northeast bank of Tinkers Creek along the BFI landfill and reported to the Ohio EPA.

Finally, on May 7th, a contaminated tributary to Tinkers Creek was found upstream of the Glenwood Drive bridge. The source was identified as decaying building materials from a nearby new housing development. The problem had ceased as of August 24, 1987.

CHIPPEWA CREEK

I. COMMUNITIES SERVED

The tributary area of Chippewa Creek includes: Brecksville, including the Cuyahoga Valley National Recreation Area and the Metroparks Brecksville Reservation; Broadview Heights; Seven Hills; and North Royalton. See Figure 6.

II. PHYSICAL OBSERVATIONS

The lower Chippewa Creek valley is a relatively gently sloping basin that is is heavily wooded and sparsely populated. It includes Sample Site #43 on a ford about 1/4 mile upstream of the creek's confluence with the Cuyahoga River. The banks are mostly wooded and occasionally grassy. Flow measurements at Sample Site #43 during dry weather indicated that the flows ranged from 2.3 to 2.9 MGD. The substrate consists of mud, silt, and small stones. The flow is gentle with a few riffles. Numerous small tributaries appear to be clear and clean.

Upstream of the lower valley is a steep gorge with rocky cliffs and large boulders. Chippewa Creek is a turbulent rapid as it tumbles through the boulders.

Upstream of the gorge, the creek is situated in a wooded hollow and grassy meadows as it winds its way through the suburban communities. The banks are again occasionally wooded, occasionally grassy, and are generally gently sloped. Visual evidence of organic pollution became increasingly apparent as municipal wastewater treatment plants, either existing or recently abandoned, were approached. All of the environmental disruptions noted were in this upper region of Chippewa Creek and are discussed later in this report. The substrate in this area changed periodically from shale to large rocks and sand with many riffles.

Chippewa Creek has four significant tributary branches in this upper section. The first of these is the Bramblewood Branch, which is a major tributary near the intersection of Harris Road and Old Royalton Road. Since it is far downstream of the other major tributaries, an additional sampling location was selected to represent the Bramblewood Branch and designated Sample Site #43.5. This location is just upstream of the branch's confluence with the creek and is similar in its physical characteristics to the upper Chippewa Creek. The Bramblewood WWTP has been abandoned and the water in the Bramblewood Branch has, throughout the 1987 investigations, appeared to be clean. Measurements indicated that the dry weather flow of the branch ranged from 0.8 to 1.0 MGD.

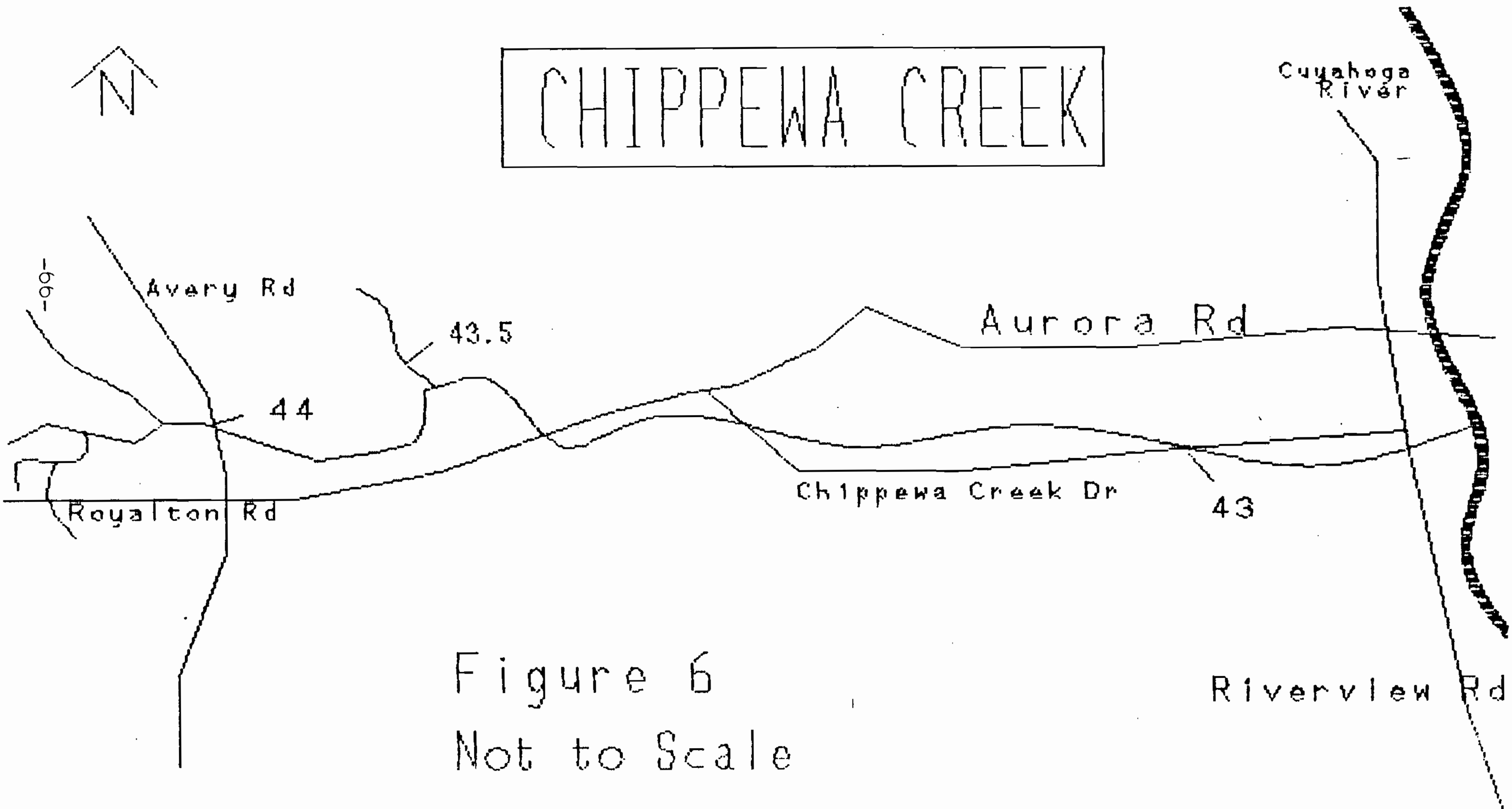


Figure 6
Not to Scale

Upstream of Avery Road, Chippewa Creek splits into three branches: the Seneca Branch, the Royalwood Branch, and the Briarwood Branch. The contributions of all three branches are reflected at Sample Site #44, which is just downstream of Avery Road. Measurements indicated that the dry weather flow in Chippewa Creek at this point ranged from 1.2 to 1.5 MGD.

The Seneca Branch is the southernmost of the three branches and passes through dense woods. The substrate consists of sand and rocks. The water became increasingly turbid as the Seneca WWTP was approached. Upstream of this plant, the water was clear.

The Royalwood Branch runs in a wooded hollow parallel to Royalwood Road. Upstream, it becomes a winding brook amidst briar patches and grassy logs. No visible effect on water quality could be noted from the Royalton Heights WWTP effluent, which is further upstream.

The Briarwood Branch, which is the northernmost of the three branches, appeared to be the most polluted. Five wastewater treatment plants, of which only one was still active as of the date of this report, are located along the Briarwood Branch. The effects of these plants on the creek's water quality are discussed later in this report.

Throughout the survey of Chippewa Creek, abundant wildlife, including fish, frogs, and crayfish, were noted.

III. SUMMARY OF DATA

Chemical data obtained at Sample Site #43, which represents the total flow of Chippewa Creek prior to its confluence with the Cuyahoga River, were all within Ohio EPA Water Quality Standards for Warmwater Habitat with the exceptions of iron, copper, and lead which, on one or two occasions, slightly exceeded the standards.

Bacteriological data obtained at Sample Site #43 were within the standards for Primary Contact Use Designation with the exception of on 10/13/87, when the fecal coliform concentration of 1,200 counts per 100 ml slightly exceeded the standard.

Qualitative sampling for benthic macroinvertebrates revealed the following organisms intolerant to organic pollution at Sample Site #43: ephemeropteran nymphs (_Baetis_ sp., _Isonychia_ sp.); and trichopteran larvae (_Agraylea_ sp., _Chimarra_ sp.). The following facultative organisms were found at this site: ephemeropteran nymphs (_Stenonema tripunctatum_); trichopteran larvae (_Hydropsyche_ sp.); and gastropods (Ferrissia sp.). Also found were the following organisms tolerant of organic pollution: oligochaetes; chironomid larvae; and gastropods (Ferrissia sp.). The relatively high diversity of benthos and the presence of pollution-intolerant organisms indicate good water quality in Chippewa Creek at this point.

Comparing the other two Chippewa Creek locations, Sample Site #43 is not as clear as the Bramblewood Branch but is significantly cleaner than the Avery Road site. Natural recovery and/or the dilutive effect of the Bramblewood tributary are probably responsible for the improved water quality conditions downstream.

Sample Site #43.5, at the Bramblewood Branch mouth, produced chemical data within the Ohio EPA Water Quality Standards for Warmwater Habitat, with the exception of one pH (9.16 S.U.), which slightly exceeded the standard. In fact, pH, alkalinity, hardness, and total dissolved solids are all significantly higher at this location than at the other two sites. This may be attributable to natural factors such as lime deposits and hard groundwater and/or it may be due to remaining septic tank effluents.

All bacteriological data obtained at Sample Site #43.5 were well within the standards for Primary Contact Use Designation. The fecal coliform/fecal streptococcus ratios showed that the minimal bacterial contamination could be attributed to combined human and non-human sources.

Qualitative sampling for benthic macroinvertebratess at Sample Site #43.5 revealed: ephemeropteran nymphs (Baetis sp.), and trichopteran larvae (Agraylea sp.), which are intolerant to organic pollution; trichopteran larvae (Hydropsyche sp.), dipteran larvae (Simuliidae), and anthomyiid larvae (Limnophora aequifrons), which are classified as facultative; and chironomid larvae and coleopteran adults. The presence of intolerant organisms, once again, is indicative of good water quality at this location.

Also noted at Sample Site #43.5 were fish, including a Blacknose Dace (Rhinichthys meleagris), which is described by Trautman (1957) as an extremely vulnerable species.

Chemical data obtained at Sample Site #44, downstream of Avery Road, were within Water Quality Standards for Warmwater Habitat with the exceptions of iron on 8/11/87 (22.0 mg/L), pH, and a slightly exceeding concentration of ammonia on 4/27/88.

Bacteriological data obtained at Sample Site #44 showed fecal coliform concentrations as high as 36,000 counts per 100 mL (10/13/87), which exceeded the standard for Primary Contact Use

Designation. The fecal coliform/fecal streptococcus ratios indicated that the bacterial contamination at this site was primarily from human sources.

Qualitative sampling for benthic macroinvertebrates at Sample Site #44 produced the following facultative organisms: ephemeropteran nymphs (Callibaetis sp., Heptageniidae); trichopteran larvae (Hydropsychidae); coleopteran larvae (Psephenus sp., Stenelmis sp.); chironomid larvae (Pentaneura sp.); and anthomyiid larvae (Limnophora aequifrons). Oligochaetes, which are tolerant, and emphemeropteran nymphs (Baetis sp.), which are intolerant of organic pollution were also found. Other organisms found included: gastropods; amphipods; ephemropteran nymphs (Cloen sp.); and empididae larvae and pupae (Hemerodromia sp.). The relatively high diversity of benthos indicates that the creek at this location is relatively unpolluted. However, the bacteriological data indicate greater pollution by sanitary waste at this site than at the other locations on Chippewa Creek.

IV. ENVIRONMENTAL PROBLEMS AND REMEDIATION

Five municipal wastewater treatment plants are located along the Briarwood Branch. The Tollis WWTP is the only one of the plants which had remained in service as of the date of this report. Increased turbidity and evidence of contamination by sanitary waste were noted for a short distance downstream of the plant's effluent.

The Avery Meadows WWTP was reported to be abandoned, but during spring 1987, sanitary waste was discovered emanating from it and evidence of sanitary contamination was found as far as 1000 feet downstream. Broadview Heights City Engineer Mr. Dick Allar explained that a bulkhead had given way and was responsible for the problem, which was later found to be corrected.

During the 1987 survey, the Vineyards WWTP effluent was found to be clean. However, this plant has since been abandoned.

High turbidity and solids concentrations were found downstream of the St. Sava's WWTP, despite the fact that it had been supposedly abandoned.

The Briarwood WWTP was found abandoned during the survey and no evidence of sanitary contamination was noted in its vicinity.

Privately owned septic tank effluents are probably responsible for contamination of Chippewa Creek by Harris Road (between Eagle Valley Court and Old Royalton Road) and under the Avery Road bridge.

A pipe discharge, apparently contaminated with sanitary waste was discovered in April 1987 at the north bank of Chippewa Creek, off Mill Road, just west of Brecksville Road. However, the source of this problem was not identified.

Also in April 1987, sanitary sewage was found surcharging through holes in a bolted manhole cover to Chippewa Creek, about 1000 feet west of the Avery Road Pump Station. Mr. Dick Allar of the City of Broadview Heights was notified and the problem was reportedly corrected.

Finally, a malodorous discharge with black solids from a 12" PVC pipe by the Avery Road Pump Station was identified as groundwater percolating through slag by City of Broadview Heights personnel.

Improvements in the water quality of the Chippewa Creek should be seen in the future as abandonments of municipal WWTP's and septic tanks continue due to the construction of the Cuyahoga Valley Interceptor.

EUCLID CREEK

I. TRIBUTARY AREA

Runoff from portions of Cleveland, Euclid, Highland Hts., Richmond Hts., and South Euclid is tributary to Euclid Creek. This encompasses about 15,500 acres. The length of the stream is 9.5 miles, and is unculverted. The average slope is 64 ft/mile, or 1.2%. Average daily flow is 16.1 MGD. (H & E, 1968).

II. PHYSICAL OBSERVATIONS

A concrete stream bed was built by the Army Corp. of Engineers from Lakeshore Blvd. to Nottingham Road to control flooding. This eliminated bottom fauna, and detracted from the aesthetic value of the area.

Site 1 is fairly steeply sloped, with average velocities approaching 2 ft/sec. The bottom consists of rock and pebbles, sand and silt (from backwash). A dam downstream of this site prevents any fish migration from the lake. Sites 2 and 3 are on branches in Euclid Creek Reservation Park. The water was reasonably clear in both branches, and fish were visible. Site 4 was clear, supporting fish.

Both branches and the main stream were walked. The stream remains in its natural setting throughout its length upstream of St. Clair Ave. The waters were clean and supported a fairly diverse fauna.

III. SUMMARY OF DATA

Four sample sites were selected on Euclid Creek as follows (See Figure 7.):

Site 1: Just south of the St. Clair Road Bridge
Site 2: Highland Park - South Branch - 100' upstream of confluence
Site 3: Highland Park - East Branch - 100' upstream of confluence
Site 4: South Branch at Mayfield Rd. - adjacent the library.

High suspended solids concentrations at Site 1 reflect the backwash from the Nottingham Water Filtration Plant (see Environmental Problems & Remediation). Bacteria concentrations at Sites 1 and 3 were high because of an environmental problem occurring on the east branch on 4/14/87 (see Environmental Problems & Remediations). Besides those two problems, the chemical analyses reflect

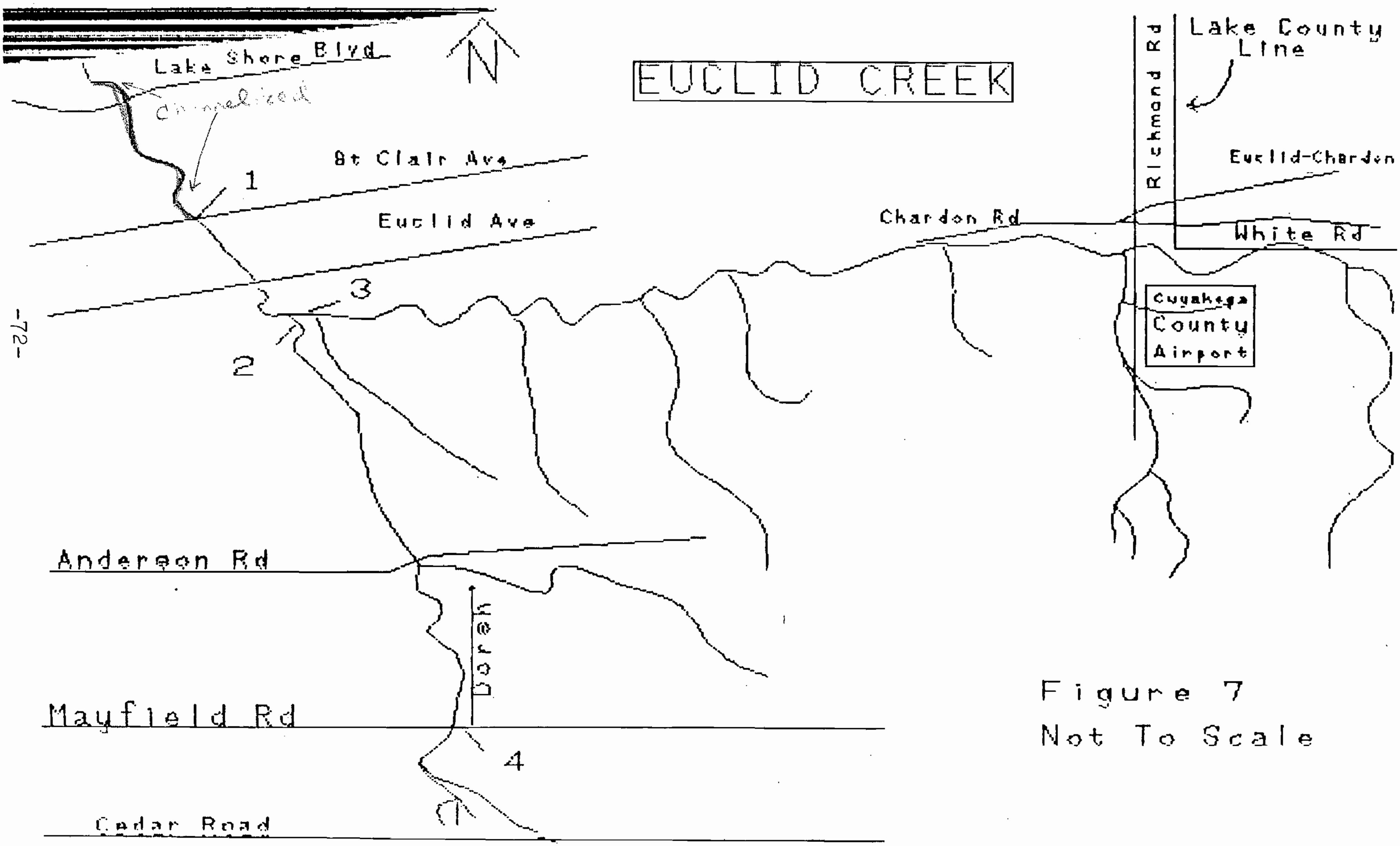


Figure 7
Not To Scale

what the physical observations concluded - that the stream is relatively clean and has minor amounts of sanitary or industrial sewage contributions.

Benthic macroinvertebrates found during qualitative sampling at Site 1 included: oligochaetes and chironomid larvae, which are tolerant of organic pollution; and ephemeropteran nymphs (Baetis sp.), which are facultative. The relatively low diversity of benthos found at the site may be due to high concentrations of suspended solids discharged upstream of this point as backwash from the Nottingham Filtration Plant.

Benthic macroinvertebrates found during qualitative sampling at Site 2 included: oligochaetes, and gastropods (Physa sp.), which are tolerant; and ephemeropteran nymphs (Baetis sp.), coleopteran adults (Stenelmis sp.), chironomid larvae (Pentaneura sp.), turbellarians (Dugesia formanii), and trichopteran larvae (Hydropsychidae), which are facultative. Also found at this site were amphipods and isopods. This location had a much higher benthic diversity, indicating fairly good water quality in the South Branch upstream of the confluence.

The location with the highest benthic diversity of all four sampling locations was Site 3 which had: oligochaetes, and gastropods (Physa sp.), which are tolerant; and turbellarians (Cura formanii), ephemeropteran nymphs (Stenonema tripunctatum and Baetis sp.), coleopteran adults (Stenelmis sp.), chironomid larvae (Pentaneura sp.), amphipods (Crangonyx gracilis), isopods (Asellus communis), trichopteran larvae (Hydropsyche sp.),and Simuliidae larvae, which are facultative.

Benthic macroinvertebrates found at Site 4 included: ephemeropteran nymphs (Calibaetis sp.), which are facultative; and chironomid larvae and a hirudinean.

Additionally, two species of fish were identified at the confluence of the South and East Branches: the Cenral Stoneroller Minnow (Compostoma anomalum pullum), which is rare or absent only where oxygen has been depleted or where pollution or siltation has decreased its food; and the Western Blacknose Dace (Rhinichthys atratulus meleagris), which is extremely vulnerable to pollution, turbidity, and siltation.

IV. ENVIRONMENTAL PROBLEMS AND REMEDIATION

The worst problem found was a City of Euclid pump station which was inoperative on 4/14/87. About 0.5 MGD of sewage was entering the east branch at Balmoral and

Brandywine Drs. Mr. Dennis Sustarcik of Euclid was notified of the problem. He was already aware of it, and had parts ordered. The pump station was repaired on 4/21/87. It had been out of operation since January 1987.

Scottish Highlands Sewage Plant at Royal Oak Blvd. on the east branch of the stream was contributing partially treated sewage.

Upstream of Site 1 at St. Clair Avenue, backwash from the Nottingham Water Filtration Plant was tributary to the creek until August 1987, when it was directed to a sanitary sewer. Prior to its removal, the backwash had loaded the stream with suspended solids.

Construction was occurring on Edgemont Dr., and a bulldozer had shoved substantial amounts of dirt, rocks, and trees over the 50 ft. embankment into the creek.

Additionally, investigators found iron concentrations as high as 230 mg/L downstream of a 42" storm sewer outfall entering Euclid Creek east of Cleveland Metal Cleaning Corp., 1423 Dille Rd., on June 4, 1987. There was no significant discharge containing iron from the storm sewer at that time, and the contribution of iron had apparently occurred at some time prior to the investigation. The 42" storm sewer originates on the property of the Inland Division of the General Motors Corp., 20001 Euclid Avenue, and flows northeast under Cleveland Metal Cleaning Corp. to the creek.

Finally, on November 17, 1987, investigators found a broken sanitary sewer underneath the Monticello Blvd. bridge at South Green Rd. Officials of Cuyahoga County, who owns and maintains this sewer line, and the City of South Euclid were made aware of this problem.

GREEN CREEK

I. TRIBUTARY AREA

Runoff from a small portion of South Euclid and Cleveland is tributary to this creek. The drainage area is approximately 660 acres, of which about 35% is impervious (H & E, 1968). The stream is 6.1 miles long, and is culverted for 2.3 miles, from Euclid Ave. to Lake Erie. Average slope is eighty feet/mile, or 1.5% (H & E, 1968). Average flow is 1.2 MGD.

II. PHYSICAL OBSERVATIONS

The open section of Green Creek was not walked. The appearance of the stream at Sample Site 7, south of Euclid Ave. on Upper Valley Drive, looked relatively clean. The stream bottom consisted of small pebbles. The Saranac Rd. location, Site 6, also appeared clean.

III. SUMMARY OF DATA

The three sample sites (Figure 8) on Green Creek were:

5. Manhole on Arcade Ave.
6. Small opening between the culvert and RR tracks at Saranac Rd. and E. 171st Street.
7. The end of the open stream just south of Euclid Ave. on Upper Valley Drive.

It is evident from the chemical and bacteriological data that sanitary sewage is tributary to the stream within the culvert. However, comparing H & E, 1968 samplings, much pollution has been removed from the open stream.

The only Green Creek benthos analysis done was at Site 7. The only organism found was an oligchaete of the family Tubificidae. The other locations were not amenable to benthos sampling.

IV. ENVIRONMENTAL PROBLEMS AND REMEDIATION

No environmental disruptions were noted while monitoring Green Creek.

Samples were collected on July 13, 1987 at all three locations. Sites 5 and 7 were sampled on April 14, while Site 6 was sampled on April 20, 1987. An additional sample was taken at Site 6 on November 13, 1987.

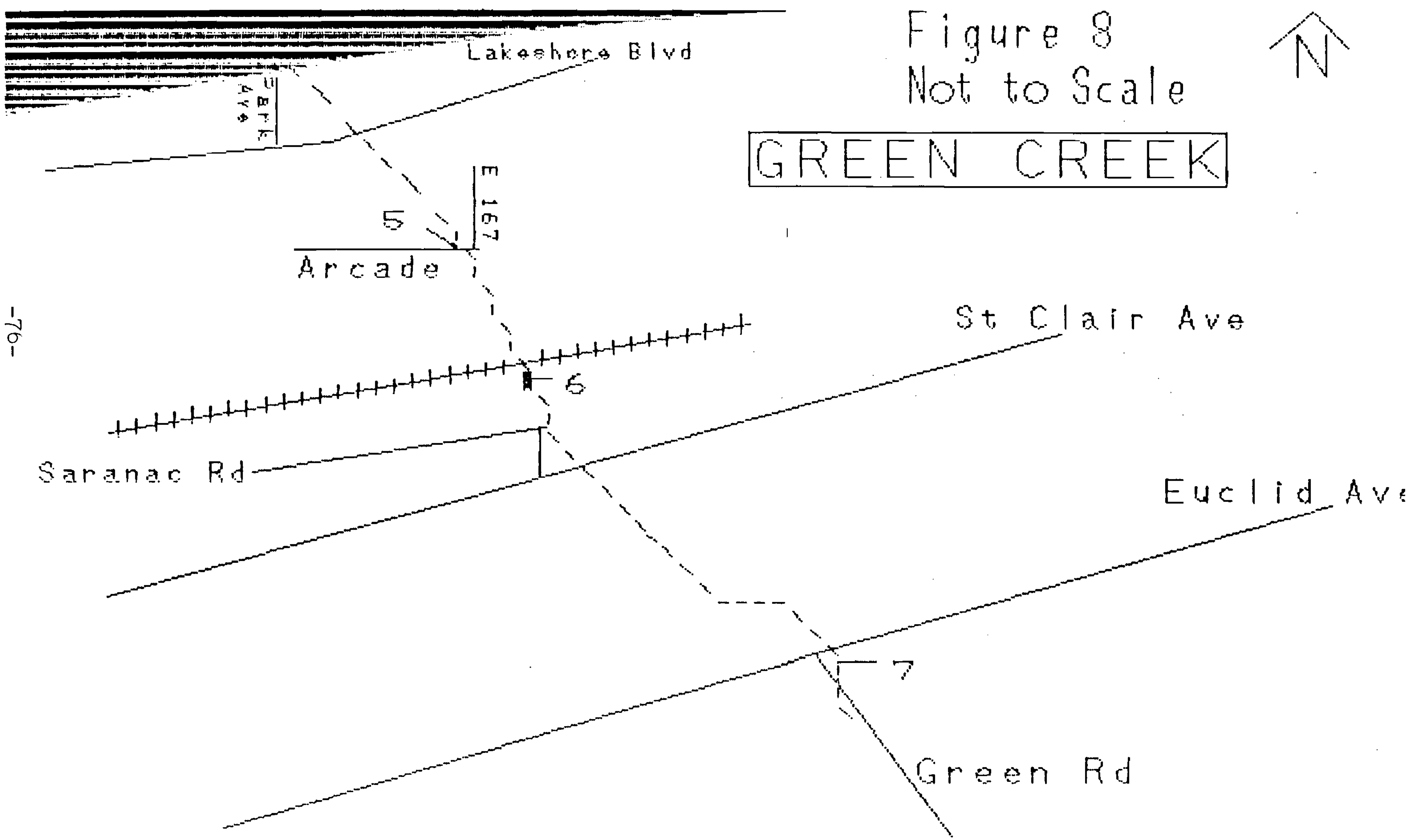


Figure 8
Not to Scale

NINE MILE CREEK

I. TRIBUTARY AREA

Runoff from portions of South Euclid, University Hts., Cleveland Hts., East Cleveland, Cleveland and Bratenahl is tributary to Nine Mile Creek. This drainage area is approximately 5000 acres, of which about half is impervious (H & E, 1968). Average daily flow is about eleven (11) MGD.

II. PHYSICAL OBSERVATIONS

Nine Mile Creek is culverted from near its mouth at Lake Shore Blvd. southeasterly to its branch tributaries at Belvoir Rd. Both branches upstream of the culvert were walked. These branches are set in a valley, with deep cut banks on either side of a small, meandering, heavily-wooded flood plain. Remnants of sanitary sewage (i.e., toilet paper, etc.) clung to tree branches twenty or thirty feet in the air. This occurs because the culvert will not accept flows exceeding a one-year storm event (H&E, 1968). The natural ravine, therefore, acts as a retention basin during high flow conditions.

The stream's branches cut through smooth shale rock at a fairly steep gradient. No life was observed within the water in April 1987, although birds, including mallard ducks and hawks, were seen utilizing the area. A sanitary sewage odor is present in both branches.

At Lake Shore Blvd., the stream was grossly polluted with sanitary sewage. Velocity was very low, and at times the stream was flowing backwards, probably because of high lake levels. Any disturbance of the bottom produced black septic plumes in all areas.

III. SUMMARY OF DATA

The Stream Monitoring Program called for three sample locations on Nine Mile Creek. These were modified, and an additional site was added at Ivanhoe to better interpret point sources of contamination.

The sampling locations (Figure 9) were:

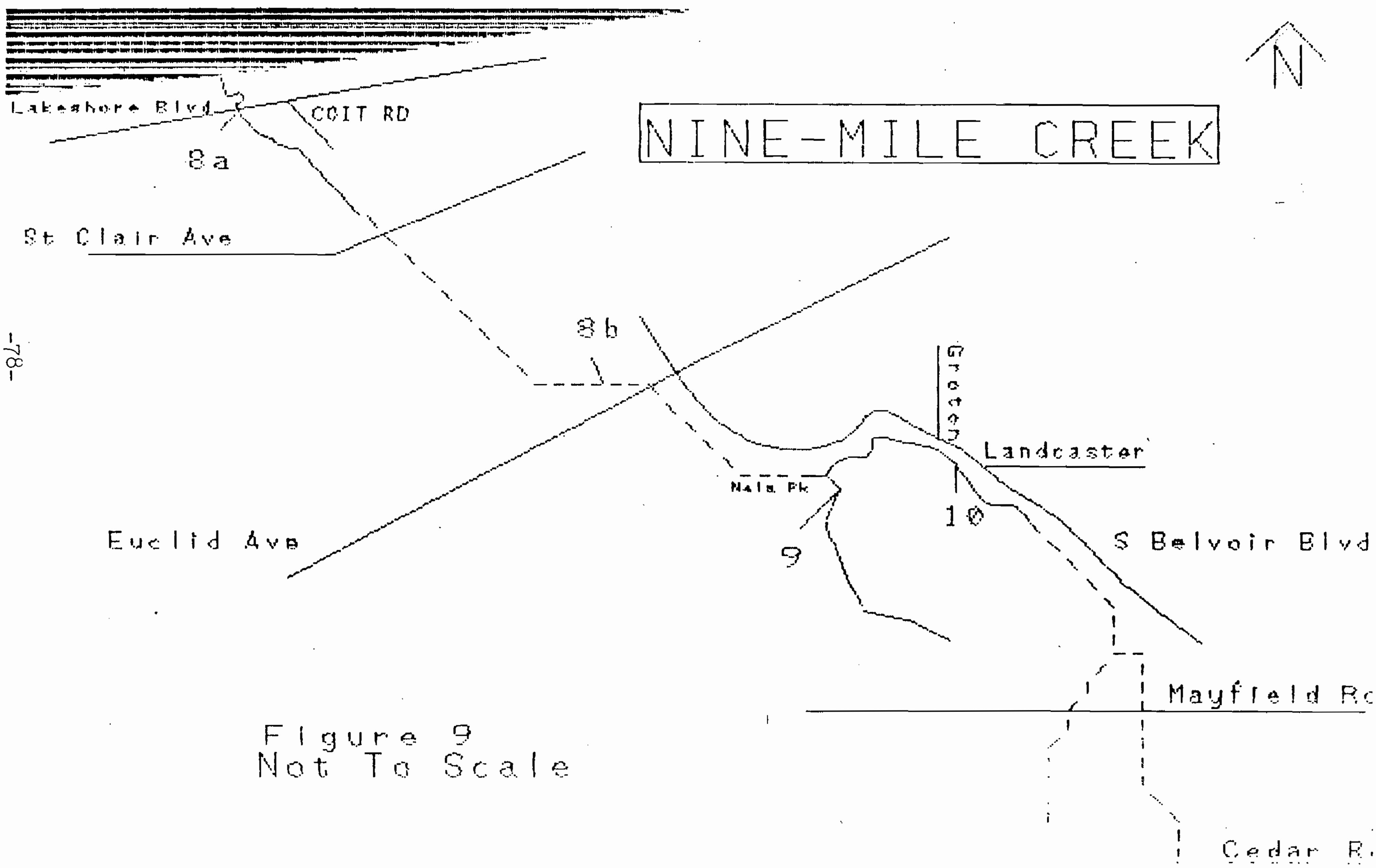


Figure 9
Not To Scale

8a) Main Branch - north of Lakeshore Blvd.
8b) Culverted major branch west of Ivanhoe, north of railroad tracks
9) Nela Branch upstream of confluence
10) Main Branch upstream of culvert at South Belvoir Blvd.

A comparison of H & E (1966) data and the 1987 chemical and bacteriological data at sites 8a and 10 show some reduction of sanitary sewage has occurred (probably the 5MGD from the Belvoir-Lancaster regulator) over the past 20 years. However, considerable amounts of sewage continue to degrade the stream to below acceptable levels, especially in the Nela Branch.

Nine Mile Creek is classified as limited warmwater habitat capable of supporting primary contact use.

The only macroinvertebrates identified in Nine Mile Creek were oligochaetes of the family Tubificidae, at Sites 8a and 9.

IV. ENVIRONMENTAL PROBLEMS AND REMEDIATION

The major problem found in April, 1987 was partial blockage of the influent line into the pumping station at Lakeshore Blvd., causing an overflow. The influent line was cleared, and subsequent investigations found the problem was not recurring.

Residential complaints of stream contamination caused an investigation conducted by Schuschu and Pavlik. 14 separate bootleg overflows were found in So. Euclid contributing sanitary sewage to the stream. Although none of these overflows were found to be bypassing during dry weather conditions in January 1988, evidence such as sanitary debris and surcharged sanitary sewers indicated that activation of these overflows had been occurring frequently. An investigation of the bootleg overflows in February 1988 revealed that discharges of sanitary sewage to the storm sewers had occurred at the following locations: 1106 Plainfield Rd; 1372 South Belvoir; 1956 South Belvoir; Acacia South Belvoir. Additionally, an overflow at Brookline & Rugby was found to be an occasional source of sewage to Nine Mile Creek in dry weather. The ultimate source of this overflow was not identified. However, most of the sanitary sewage discharges to Nine-Mile Creek may be attributed to the dry weather loading placed on these sanitary sewers by a growing population since their construction in 1920, as stated in the Dalton, Dalton and Newport Report of 1982.

SHAW BROOK

I. COMMUNITIES SERVED AND PHYSICAL OBSERVATIONS

Shaw Brook serves the cities of Bratenahl, Cleveland, and East Cleveland. Most of Shaw Brook is culverted, with the exception of the quarter mile segment from Lake Erie to the Memoral Shoreway. This open stretch's substrate consists of sand and medium sized rocks, tree branches, and debris from sanitary sewage. The waves from Lake Erie sometimes reverse the current, retaining sanitary waste debris at the mouth of the Brook.

Shaw Brook flows over the Easterly Interceptor between the New York Central Railroad and the Shoreway. At this location, a hole has been punched through the top of the Interceptor, to allow all dry weather flow to drop into the Interceptor. NEORSD Sewer Control Systems has recently installed a curb drain over the opening to capture any large pieces of debris. The S.C.S. also inspects and cleans the grate on a routine basis.

Shaw Brook's total length is 2.2 miles and drains a 1.3 square mile area. Approximately 0.4 MGD flows from this stream into the Easterly Interceptor during dry weather.

II. SUMMARY OF DATA

Two samples were taken from Shaw Brook, upstream of its entry into the Easterly Interceptor, during dry weather. See Figure 10. The first sample showed that the Brook was quite clean for an urban stream. No indication of industrial pollution was found. The second sample showed an increase in biological oxygen demand to 107 ppm. No reason for this rise in BOD could be identified.

Due to corrections in the collection system, Shaw Brook's water quality seems to be improving. Fecal coliform bacteria was measured during a rain event on April 6, 1987, and showed that the stream becomes extremely polluted during such an event. The fecal coliform concentration was 400,000 counts per 100 ml, and the fecal coliform/fecal streptococcus was 20, indicating a heavy load of human sanitary waste.

During dry weather, the fecal coliform concentration dropped to 700 counts per 100 ml on July 7, 1987 and to 300 counts per 100 ml on November 3, 1987. On both occasions the coliform/streptococcus ratio was indicative of mixed human and non-human sources.

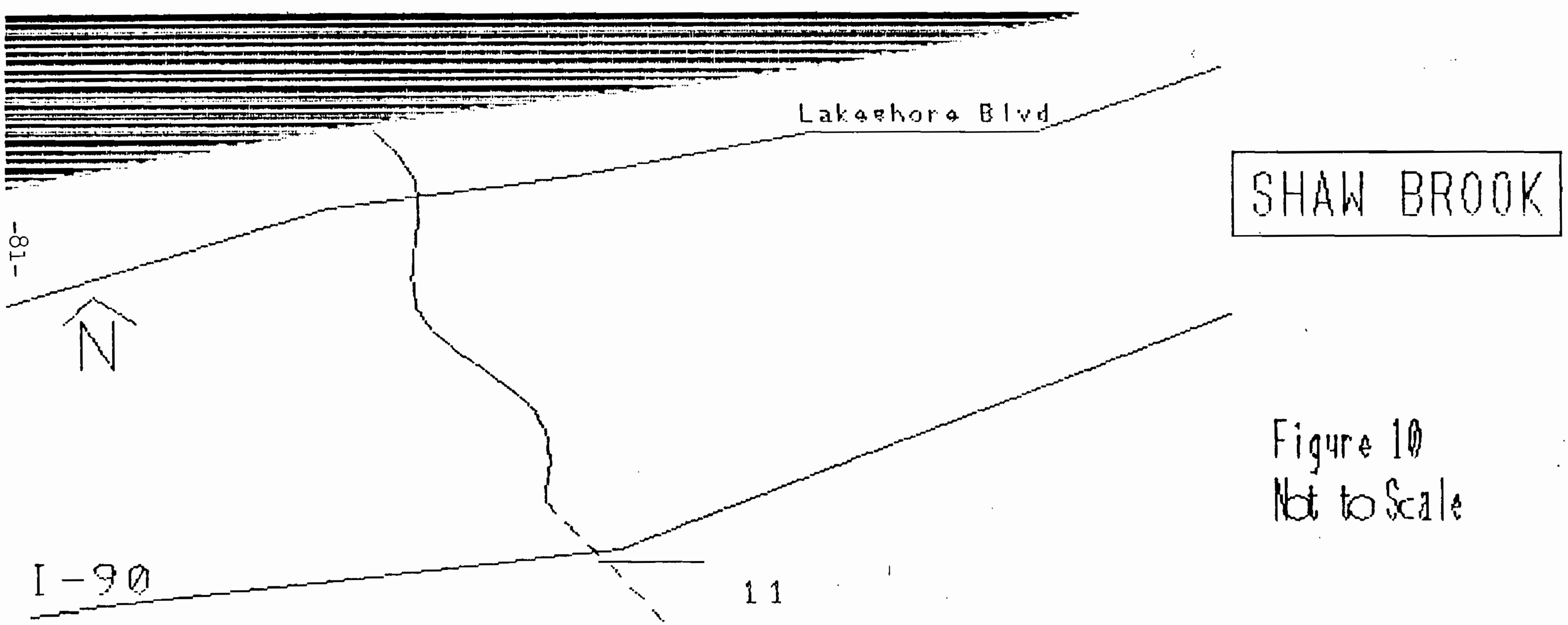


Figure 10
Not to Scale

The bacteriological data shows that, although the Brook is somewhat clean, during wet weather it becomes extremely polluted. The repair of an overflow regulator located at Hayden and Woodworth Avenues has improved the water quality. However, the vault continues to allow a small amount of overflow, and any increase in sanitary flow will cause an increase in sanitary loading to this Brook.

III. ENVIRONMENTAL PROBLEMS AND REMEDIATION

In the April 1987 inspection of Shaw Brook, it was found that the current origin of this stream as a culverted creek is a vault located at the corner of Hayden and Woodworth Avenues. At this vault, two five-foot combined sewers, which were heavily contaminated with sanitary sewage, converge. The waters are retained momentarily and then flow out of the vault through a 24" sanitary outlet or through the Brook's culvert.

Since a good amount of the sanitary wastewater was flowing down the Brook's culvert rather than into the sanitary sewer, it was suggested that a retaining wall be placed along the culvert's invert in order to retain more water in the vault and increase the amount of flow to the sanitary sewer. An inspection by Investigator Pavlik on November 3, 1987 showed that this suggestion was not followed up on.

The problem of dry weather overflow reaching Lake Erie has been eliminated by the installation of a curb drain in a hole in Easterly Interceptor, over which the Brook runs. All dry weather flow now flows to the interceptor through this drain. Constant cleaning of this grate is necessary to keep it open and free flowing. During the fall inspection in 1987, the grate was cleaned to prevent dry weather overflow from entering Lake Erie.

A retention wall, which was suggested in the F. Schuschu/M. Pavlik inspection memo of April 1987 and Tony Jordan's memo of May 8, 1987, has not been built. Such a wall would prevent overflow due to a small amount of debris on the grate and would capture more of the contaminated flow from overflows during a light rain.

DUGWAY BROOK

I. COMMUNITIES SERVED AND PHYSICAL OBSERVATIONS

Dugway Brook serves the cities of Cleveland, Cleveland Hts., University Hts., and Bratenahl. The Brook has two main branches, East and West, which drain the central Cleveland vicinity. See Figure 11. The Brook's total length is 7.9 miles and drains 9.53 square miles of area. Almost the entire length of the Brook is culverted.

The West Branch of the Brook is unculverted through the Lakeview Cemetery. The stream at this point is approximately 9' wide, and about 4" deep. The original creek bed consists mainly of shale, several waterfalls, and many small rocks. Many riffles were found at Sample Location #14, downstream of the Northeast Ohio Regional Sewer District's Lakeview Dam. All the rocks were covered with a dark green algae and light grayish slime. This open section drops approximately 110 feet in elevation. This sample location represents the west Branch upper stretches.

The East Branch opens in East Cleveland's Cumberland Park. The Brook in this area is approximately 6 to 8 feet wide and 4 to 6 inches deep. The open section drops approximately 60 feet in elevation. The creek bed consists primarily of shale bottom with small rocks. All the rocks were covered with a greenish brown algae and grayish white slime. This Sample Location #15 represents the upper reaches of the East Branch.

Dugway Brook discharges approximately 0.9 MGD into Lake Erie, one mile east of East 105th., according to flow measurements.

II. SUMMARY OF DATA

Using data collected since 1985 from Location #12, north of Lake Shore Boulevard, analysis of Dugway Brook's chemical data revealed problems of low dissolved oxygen, high chemical oxygen demand (COD), and high chlorides at various times.

The average D.O. at Location #12 was 5.9 ppm, and the lowest was measured during the July 1987 study at 3.5 ppm, at which time the high water temperature (20°C) may have had an effect on the results. However, the D.O. at this point has not exceeded 5.4 in 1987, with the lowest temperature reading being 17°C.

The average COD at this point was 85 ppm, but a 204 ppm COD concentration was noted on 11/3/87. (The biological oxygen demand (BOD) on this date was only 14 ppm.) This high COD may have been related to the high ammonia concentration of 11.7 ppm (almost

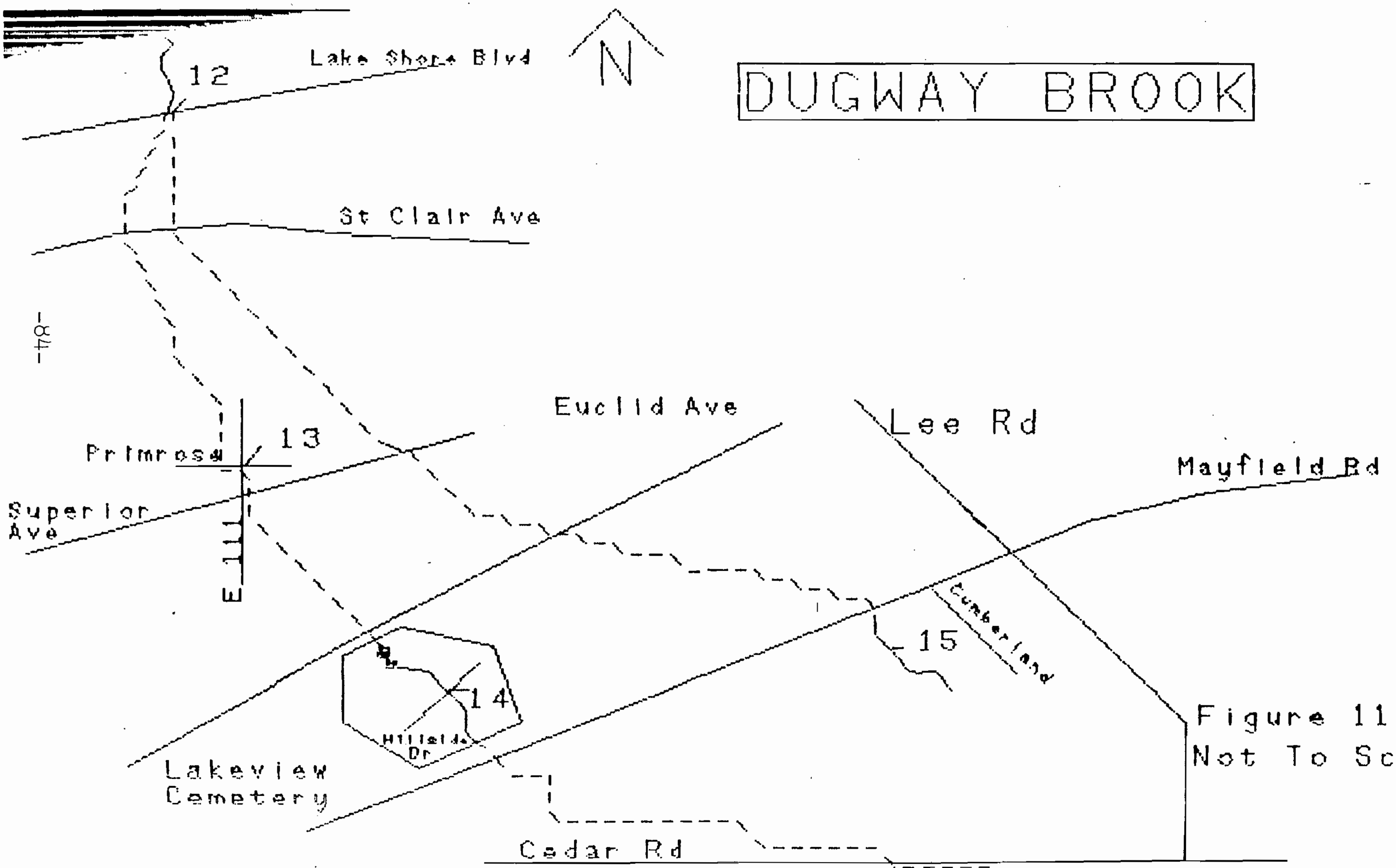


Figure 11
Not To Scale

double the average of 6.2 ppm) or to the coliform bacteria concentration of 10,000,000 counts per 100 ml on the same day. However, this does not account for the relatively low BOD.

The average chloride concentration at this point was 258 ppm. The highest concentration, 504 ppm, was found in February of 1986 and may be attributed to road salting.

At Location #13 on Dugway Brook's West Branch at Primrose Avenue, the average D.O. was 9.2 ppm, even with a temperature high of 21°C. This result may be attributed to the significant elevation change prior to this location causing aeration through turbulance.

A high COD concentration was noted at this location on the same day as the high was noted at Location #12 (11-3-87).

The average chloride concentration was 163 ppm, even though these samples were collected during non-road-salting seasons.

At Location #14, on Dugway's West Branch at Hillside Drive, the average D.O. was 11.1 ppm. This D.O. concentration was consistent throughout the year. The Brook flows down a number of falls and cascades, just prior to this sampling location. This may account for the high D.O. of the stream at this point.

A high COD concentration was also noted at Location #14 on the same day as the high COD was noted at Locations #12 & #13. The average chloride concentration was 178 ppm.

At Location #15 on Dugway Brook's East Branch at Cumberland Park, the average D.O. was 5.0 ppm with the lower concentration of 4.8 ppm being associated with the lowest temperature of 14°C. This may have been related to a high COD (254 ppm), a high coliform bacteria count (93 times higher than previous sampling) and/or a higher than normal ammonia concentration.

It is obvious that an environmental disruption has occurred upstream of Location #15 involving sanitary sewage. Until this sampling, no problems south of this location were known. Further investigation of this area will be done during future studies.

It is evident in the collected data that no heavy industrial pollution is occurring in this stream. The bulk of pollution is being caused by the contamination of these waters with sanitary sewage.

During 1987 three sets of bacteriological samples were taken from Dugway Brook. The first set taken in April 1987 was taken during a heavy rain event and was not used in the calculation of averages. These samples do point out that the Brook takes a heavy load of sanitary sewage during such an event. The fecal coliform/fecal streptococcus ratio was 6.4, with the fecal coliform concentration at 200,000 counts per 100 ml, indicating the presence of human fecal matter. This sample, taken at Lake Shore Boulevard, represents the discharge of Dugway Brook to Lake Erie.

During the July 1987 study, samples taken at this location showed an increase in the fecal coliform concentration to 330,000 counts per 100 ml, and a corresponding increase of fecal streptococcus concentration to 100,000 counts per 100 ml. The fecal coliform to fecal streptococcus ratio decreased to 3.3. These increases may be attributed to a decrease in the flow rate of the Brook due to low-rain conditions.

However, during the latest study, conducted in November 1987, a dramatic increase in the concentration of coliform bacteria has shown that this stream remains seriously polluted with sanitary sewage. The majority of the sewage seems to be coming from the East Branch between Lake Shore Boulevard and Cumberland Park and/or from the West Branch between Lake Shore Boulevard and Primrose Avenue. The fecal coliform/fecal streptococcus ratio of 5 indicates that this is human waste.

Also noted during the 1987 study was a sharp increase in bacteria at Sample Location #15, in Cumberland Park, south of Mayfield Road. A fecal coliform/fecal streptococcus ratio of 2.4 indicates that this may not be entirely due to contamination by sanitary sewage. Further investigation of the area south of this location will be done during future studies.

In July 1987, benthic samples were taken at Location #12 and Location #15. Only two types of organisms were found in these two locations: Tubificidae and chironomids. Both of these macroinvertebrates are pollution tolerant and, due to the lack of diversity, indicate heavy organic pollution in this stream.

III. ENVIRONMENTAL PROBLEMS AND REMEDIATION

This section will deal with specific sources of pollution on Dugway Brook, as they were seen in the F. Schuschu/M. Pavlik 1983 report and as they appear today. In the 1987 study some improvements were found but the major problem remains. Dugway Brook's East and West Branch act as an interceptor for the frequent dry weather overflow of overloaded sanitary sewers in Cleveland's eastern neighborhoods.

On any given day, raw sewage can be seen at the opening of the culvert downstream of the confluence of the two branches, north of Lake Shore Boulevard. Since the Brook is completely culverted through much of the problem area to this point, public attention has not been drawn to this extremely polluted stream.

1. Sample point #12 north of the confluence of the East and West branches, north of Lake Shore Boulevard. - As stated above, and supported with analytical data, raw sanitary sewage can be seen on any given day, flowing through this open section to Lake Erie, which lies about one mile north.

2. The total West Branch contribution. - This is no longer the major contributor to the Brook's problems due to the repair of two suspended sanitary lines, hanging in the culvert under St. Clair Avenue. However, other problems further upstream continue to pollute this Branch.

3. The second tie-in to the West Branch from the southeast. - This box culvert is a storm relief sewer for an overflow regulator located on East 110th Street, north of Glenview Avenue. In 1983 the manhole on this overflow regulator was located by Investigators Pavlik and Schuschu, paved over, in the southbound lane of East 110th Street. This cover has never been excavated but the overflow is routinely checked by Sewer Control System crews by entering the West Branch culvert and observing the storm sewer outlet. It has not been found to overflow during dry weather.

4. Overflow regulator #D-8 at East 106th Street and Glenville Avenue - In the past this overflow was seen overflowing frequently during dry weather. However, recent inspections by Sewer Control Systems and Industrial Waste Section personnel have shown that this overflow has remained in proper working order, without consistent dry weather overflow.

5. Suspended sanitary lines at East 106th Street and St. Clair Avenue. - In 1983 one of these two lines was broken and allowing a heavy load of sanitary sewage to flow to the West Branch. Both of these lines have been repaired and this is no longer a pollution problem.

6. Overflow regulators at Helana Avenue and East 107th Street - There are three overflow regulators at this intersection. In the past, they have been known as problem areas but recent inspections have shown that they are now blocked less frequently during dry weather.

7. Tuscora Avenue and Linn Drive, overflow regulator #D-35 - This regulator was found to be a problem during the 1985 study and was again found overflowing in 1987 by NEORSD Sewer Control System crews on October 22nd and 30th, and also on November 5th and 17th.

8. Overflow regulators #D-37 and #D-38, located at the intersection of Primrose Avenue and Linn Drive - Both these regulators were found to be overflowing in 1985 and 1987. The western overflow, #D-37, was found blocked by Sewer Control Systems on October 30, 1987 and again by Industrial Waste Section on November 24, 1987. The Eastern overflow, #D-38, was cleaned by Sewer Control Systems on November 11, 1987 to eliminate a dry weather overflow condition. Both these overflows are frequent causes of pollution due to small sanitary lines and high population density.

Another problem found during the 1987 study was that a sanitary sewer, which runs through the crown of the storm outlet from overflow regulator #D-38, is broken and allowing sanitary waste to enter the West Branch at this point.

It should also be noted that this area was picked as a permanent sampling point for water quality studies on the Brook. All samples are collected from a point just north of the tie-ins of storm outlets from these two regulators.

9. Overflow regulator #D-58 (East 1), located at Lakeview Road and Superior Avenue - This regulator has been a constant source of pollution since the 1983 study. Traffic, poor condition of the rungs and the amount of flow has made inspection and cleaning difficult. Also the sanitary outlet from the overflow structure is always running near capacity, even during the driest weather. Investigator Pavlik found the regulator overflowing intermittently during an inspection on November 3, 1987, allowing sanitary waste to the Brook's West Branch.

10. 48" Storm sewer at Mayfield Road - In 1983 this storm sewer was found to have sanitary sewage flowing through it to the Brook's West Branch. Since our 1985 inspection this situation has never been seen again. The sewer is now found to be dry during dry weather.

Since the water quality of Dugway Brook's West Branch has improved at the sampling location in Lakeview cemetery, study upstream of this point has been limited so as to concentrate our efforts on the problem areas downstream of this point. The West Branch of the Brook, upstream of Edghill Road appears to be as clean as any of the urban streams in the Cleveland area.

While the West Branch's water quality has improved slightly since 1983, the East Branch remains the same at best. Following is a list of the East Branch problems:

1. Overflow regulator #D-1 (east), located at Hazeldell Avenue and East 117th Street. - This regulator has been found since the 1983 inspection and is being maintained by Sewer Control Systems. An inspection in November of 1987 found the regulator in proper operating condition.

2. The practice of throwing trash down into the Brook's East Branch, by employees of Parkway Elementary School has been discontinued since the 1983 inspection.

3. Overflow regulator #D-68, located at Hart Avenue and Thornhill Road - A leak in the weir wall discovered during the 1983 inspection has been repaired and sanitary sewage is no longer leaking from this area to the Brook's East Branch. An inspection on November 25, 1987 has shown that this regulator is in proper operating condition.

4. Overflow regulator located at Rozell Avenue and Phillips Road - The cover on the access manhole to this overflow was not openable in 1983, and sanitary sewage was overflowing to the Brook's East Branch. Since then, Sewer Control Systems crews have removed the cover and repaired the manhole ring. This repair allowed them access to the regulator for cleaning and inspection. The 1987 inspection has shown that this regulator is now in proper operating condition.

5. Overflow regulator located on Eddy Road between Hayden and Emily Avenues - This overflow was inspected on November 25, 1987 and was found to be in the same condition as it was in 1983. Although the regulator was not overflowing, the flow on the sanitary side of the weir was within one quarter of an inch from overflowing.

6. A 4'9" Circular storm sewer which runs from south of Euclid Avenue to the Brook's East Branch north of the rapid transit tracks - In 1985 it was found that drivers in a garbage transfer depot, located on top of the Brook, were washing out the cargo areas of garbage trucks to a drain, tributary to the stream. Since chunks of garbage could be seen in this water it can be concluded that this practice is adding to the organic loading on the stream. During the 1987 inspections this was not seen being done.

7. Emily Avenue, where Dugway Brook's culvert passes underneath - Two 12" storm sewers were found tied into the Brook from the east and west. Both these lines were discharging sanitary sewage at a rate of about 5 gpm. Further investigation of the area in 1987 showed that the sanitary sewer east of the Brook's culvert is blocked and surcharged. There are no known overflows or cross connections in the area.

The East Cleveland Service Department has been alerted to this situation by a letter written December 3, 1987.

8. Overflow regulator #D-76, located at 13505 Euclid Avenue - This overflow was found overflowing due to a blocked sanitary sewer by Sewer Control Systems crews on the following dates: April 4, July 27, September 8, and November 5, 1987. This record illustrates the sanitary sewage contamination problem due to overflow regulators on this stream.

9. Overflow regulator #D-86, located south of Terrace Road and East of Superior Avenue, in Cleveland Hts. - This regulator has been found overflowing during every inspection since 1983. It appears that an entire apartment building is being serviced by this eight inch sanitary line.

A letter was written to Cleveland Hts. Service Department, requesting maintenance on this line, on November 27, 1987.

10. Two outfalls northwest of the intersection of Monticello and Lee Road - A 5' x 5' culvert and a 72" storm sewer project from the side of the hill in Forest Hill Park side by side and discharge their flows to form a sizeable stream which runs through the park to Dugway's East Branch. Both outlets are now discharging sanitary sewage to the Brook during dry weather.

The 5' x 5' culvert was found to have a tie-in at Lee Road which is the source of sanitary sewage. A corregated steel pipe of about 12 inches appears to be a make-shift sanitary relief system.

No source has yet been found for the sanitary sewage coming from the 72" line but further investigation is forthcoming.

11. At the study sample location in Cumberland Park, the final location on the study, definite signs of sanitary contamination exist and will be investigated in the future.

DOAN BROOK

I. COMMUNITIES SERVED AND PHYSICAL OBSERVATIONS

Doan Brook carries storm water from parts of Cleveland, Cleveland Hts., and Shaker Hts. See Figure 12. The Creek receives discharges from combined sewer overflows from Cleveland and some flow from sanitary relief in other communities. Doan Brook's total length is 8.1 miles and drains an 11.7 square mile area. A total of 1.3 miles of the Brook is culverted, while the rest is open channel. The Baldwin Filtration Plant's filter backwash process has left a large amount of settled solids from the culverted section to the mouth of the Brook. In addition, there are 44 combined sewer overflows from Ambler Park to Lake Erie discharging sanitary waste water nearly every rainfall. In December 1987 the Baldwin Filtration Plant discontinued its filter backwash discharge to the Brook. The facility has constructed holding tanks for the backwash, which is now diverted to the sewer system after solids removal.

The Brook upstream of Ambler Park was found to be relatively clean. The Brook has a predominantly rocky bottom and contains boulders and fallen trees. The Shaker Lakes upstream of Ambler Park act as a retention basin and tend to homogenize the quality and quantity of overflowing waters.

In April of 1987, the flow of this entire stream was measured to be 8 MGD, with great elevation change, between the Shaker Lakes area and the opening of the culvert north of the Art Museum.

II. SUMMARY OF DATA

Samples taken at Location #16, north of St. Clair Avenue, on Doan Brook have shown a decline in water quality throughout 1987. Samples taken on November 3, 1987 have shown an increase in the following chemical parameters: BOD has risen from 2 to 30 ppm, COD has risen from 14 to 192 ppm. This increase in oxygen demand and the resulting decrease in D.O. from 6 to 3.4 ppm, may be related to the rising ammonia and sulfate concentrations.

Also the chlorides in this stream increased from 94 ppm in July 1987 to 306 ppm in November 1987. This was not a road salting period.

Samples taken at Location #17, north of the Art Museum, on Doan Brook, have also shown a decline in water quality, indicating that the pollution source is upstream of this location. The following parameters have increased in

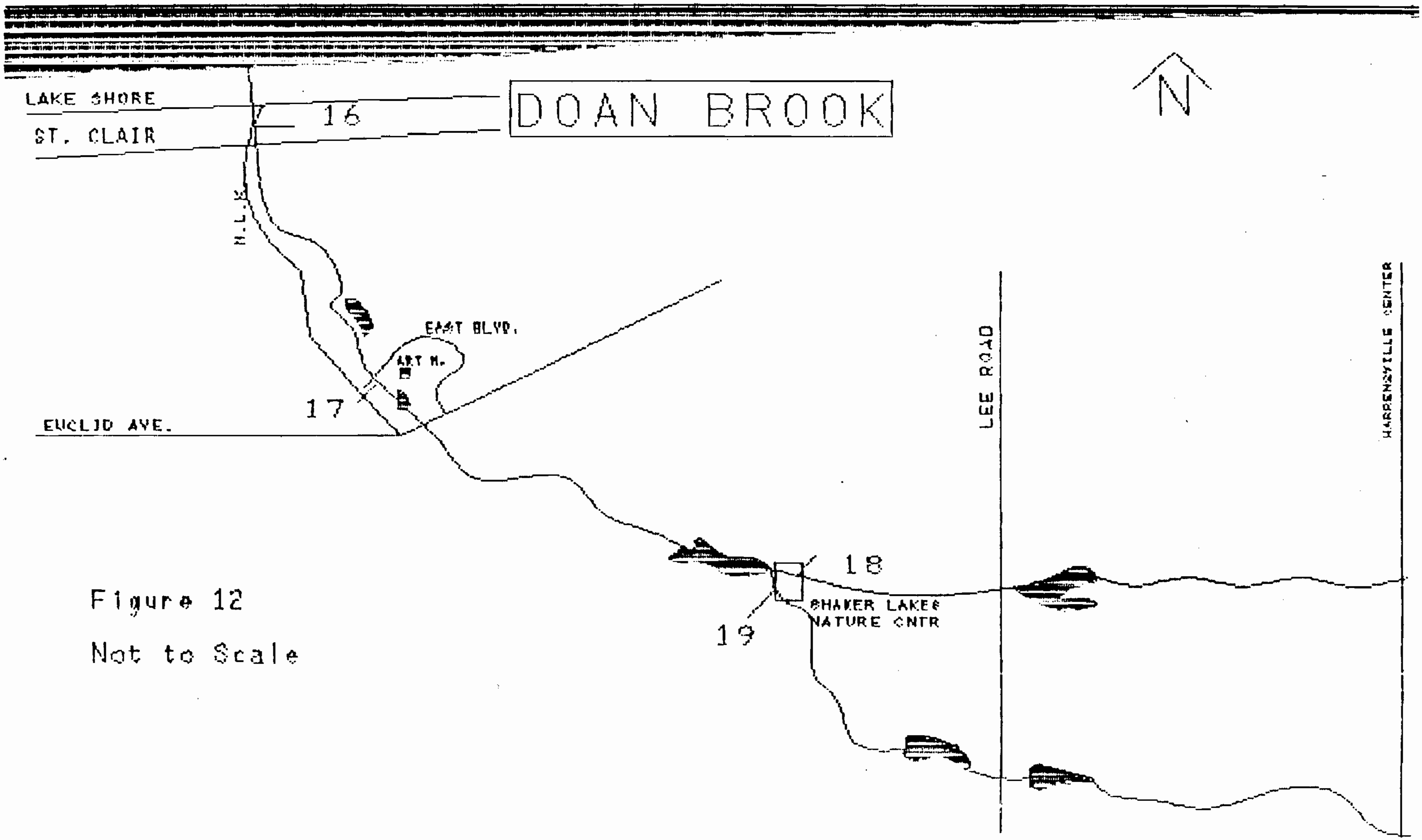


Figure 12

Not to Scale

concentration since the July 1987 study: BOD has risen from 4 to 10 ppm; COD has risen from 13 to 166 ppm. This increase in oxygen demand was not accompanied by a corresponding decline in

D.O., probably due to aeration from the elevation drop upstream of this sampling location. It may be due to a dramatic increase in bacterial contamination, which is discussed below.

Ammonia also increased from 0.02 to 1.37 ppm and chlorides rose from 38 to 116 ppm at this location through the year.

Samples taken at Locations #18 and #19 on Doan Brook's North and South Branches, at the Shaker Lakes Nature Preserve, have shown that this area of the Brook is in good condition, meeting the Water Quality Standards for Warmwater Habitat.

Biological data collected from Doan Brook throughout 1987 has shown a great increase in bacterial contamination. The fecal coliform/fecal streptococcus ratio of 52 at Location #16 and the rise in fecal coliform from 720 to 220,000 counts per 100 ml at Location #17, shows that the blocked overflow downstream of the Margret Wagner Nursing Facility is having a serious detrimental effect on this stream.

At Locations #18 and #19, the stream appears to be relatively clear of sanitary sewage contamination during dry weather. Samples indicate that a slight amount of contamination does occur during rain events.

In July 1987, benthic samples were obtained at all four locations on Doan Brook. At Locations #16 and #17 only two types of organisms were identified, Tubificidae and chironomids. Both these organisms are pollution tolerant and the low diversity indicates heavy pollution in this stream from upstream of Location #17 to Lake Erie.

Samples obtained at Location #18 and #19 showed a much greater diversity and the presence of facultative organisms, indicating that the water quality of Doan Brook is in relatively good condition in the Shaker Lakes area.

At Location #18, the following tolerant organisms were found: oligochaetes; hirudineans; chironomid larvae; and gastropods. Also found were Pentaneura sp., which is classified as facultative, and pelecypods.

At Location #19, the following tolerant organisms were identified: chironomid larvae; oligochaetes; hirudineans (Haemopis grandis, Haemopis marmarata). The following facultative organisms were identified: turbellarians (Dugesia *tigrina*); and ephemeropteran nymphs (*Baetis* sp.). Also found were gastropods (Lymaeidae, Planorbidae, Vivaparidae) and pelecypods.

III. ENVIRONMENTAL PROBLEMS AND REMEDIATION

In the April 1987 inspection of Doan Brook, Investigators Pavlik and Schuschu found three problems that pose a threat to the water quality. A 24" corregated steel pipe flowing to the creek from Fairhill Avenue and Kemper Road was found to be discharging sanitary sewage to an otherwise clean portion of the Brook. This outlet was traced back to an over/under separated sanitary and storm sewer system on North Moreland Road. At the address of 2539 was found a leaking inspection plate in the bottom of the storm sewer. Sanitary waste was backing up out of this plate to the storm sewer due to a partial blockage or an overloaded condition in the sanitary line.

The City of Cleveland Hts. Service Department was contacted by phone and during the July 1987 study it was found that this problem had been corrected. Only clear water was discharging from the outlet to the Brook and fresh cement could be seen around the inspection plate sealing it from leakage.

Also noted in the April 1987 report was the problem of solids and chlorine being discharged to the creek from Baldwin Filtration Plant. Investigations by the Industrial Waste Section has shown that this discharge to the creek has been eliminated due to the installation of a solids removal facility. This discharge is now directed to the sewer system. Though the solids removal system is operating, periodic discharge to the creek is possible due to debugging.

In the November 1987 study, sample data at the Art Museum location showed a dramatic increase in bacterial contamination. This increase may be due to the fact that overflow regulator #DV-15 has been overflowing since September 1987. This overflow is located downstream of the Margret Wagner Nursing Home at 2373 Euclid Hts. Blvd. This facility is primarily responsible for the blocking of this sanitary line. It is presently trying to screen all discharges to eliminate the discharging of cloth materials. The effectiveness of this procedure is unknown as NEORSD Sewer Control Systems lacks the proper equipment to clean the line due to equipment loss and failure.

ROCKY RIVER

I. COMMUNITIES SERVED

The Rocky River drainage area includes: North Royalton, Strongsville, Cleveland, Lakewood, Berea, Rocky River, Fairview Park, Brook Park, Middleburg Heights, Olmsted Falls, North Olmsted, Columbia Station, and Medina County.

II. PHYSICAL OBSERVATIONS AND SUMMARY OF DATA

Rocky River has been assigned 5 locations for chemical, bacteriological, and benthic sampling and analysis. See Figure 13.

Sample Site #49 is located on a field on a ford on the Rocky River Parkway, North of Bagley Road and about 200 yards downstream of the Berea Wastewater Treatment Plant effluent. On the east side of the ford, the water is pooled, and on the west side, the fast-flowing water is riffled. The river at this location is approximately 50 to 75 feet in width. The water was turbid and the substrate consists of shale bits and fine gravel. Vegetation on the banks, which rise up about 3 feet from the river, is heavy, with numerous types of trees. Flow measurements indicated a dry weather flow at this location of approximately 13.3 MGD.

All chemical and bacteriological data obtained at Sample Site #49 were within the EPA Water Quality Standards for Warmwater Habitat and Primary Contact Use Designation, with the exceptions of copper and iron, which slightly exceeded the standards. The fecal coliform/fecal streptococcus ratio indicated that organic pollution at this site was primarily from non-human sources and the bacteriological contamination was minimal.

Qualitative benthos sampling at Sample Site #49 revealed the following macroinvertebrates tolerant of organic pollution: chironomids, oligochaetes, and hirudineans. Macroinvertebrates classified as facultative included: amphipods (Crangonyx gracilis); isopods (Asellus communis); ephemeropteran nymphs (Stenacron sp., Stenonema sp., Baetis sp., Calibaetis sp.); trichopteran larvae (Hydropsyche sp.); coleopteran larvae (Dubiraphia sp.; Stenelmis sp.); blackfly larvae (Simuliidae); and gastropods (Ferrissia sp.). Additionally, an organism intolerant to organic pollution, a crane fly larva (Tipula sp.)

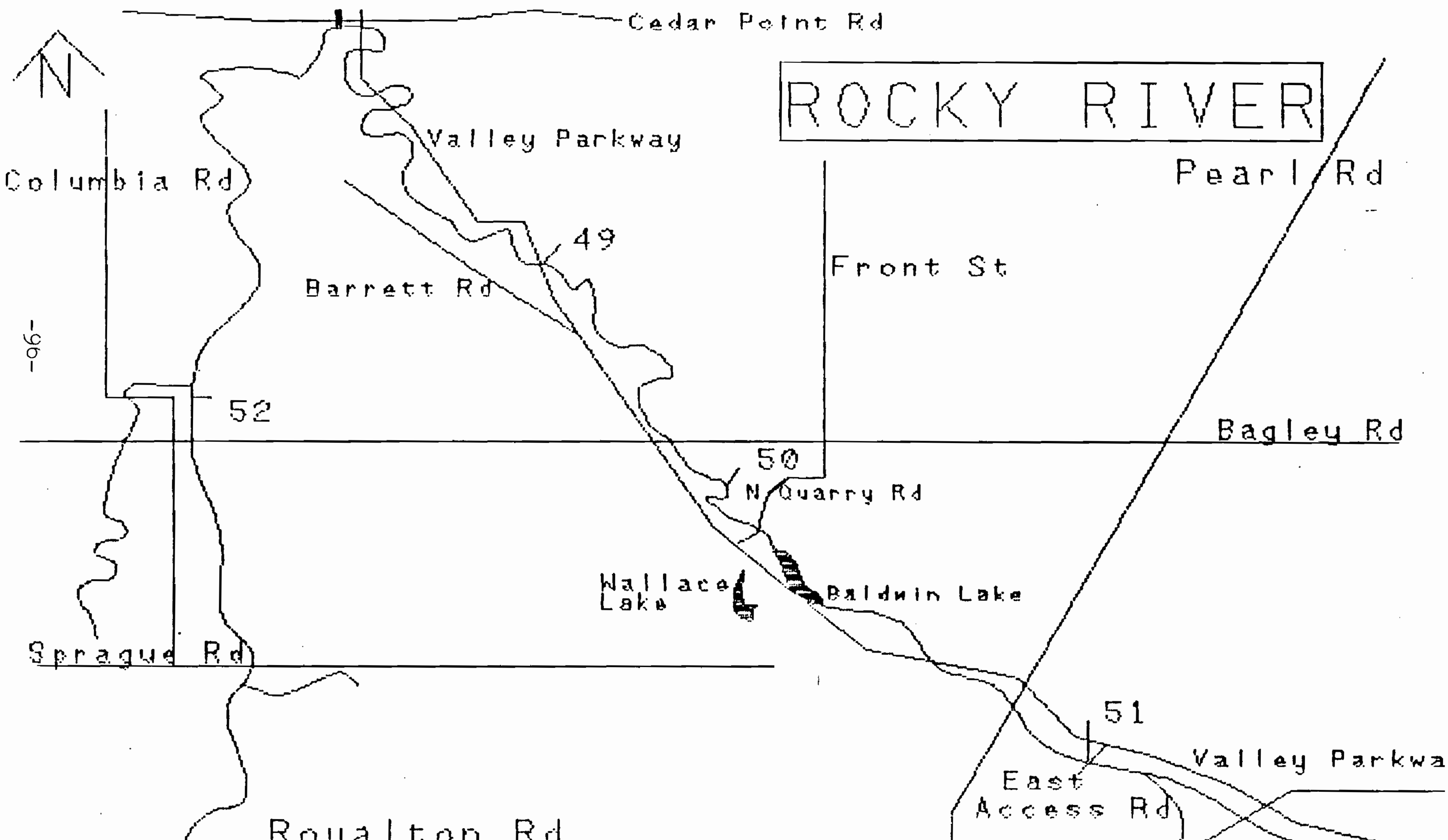


Figure 13. Not to Scale

was also found. The relatively high diversity of benthic macroinvertebrates and the presence of facultative and intolerant organisms at Sample Site #49 indicate that Rocky River at the location is relatively unpolluted.

Sample Site #50 is located at West Bridge Street in Berea, approximately 100 yards downstream of the Berea Water Purification Plant. Steep banks on both sides of the river rise 50 to 75 feet, and the river is about 40 feet wide and 6 to 30 inches deep at this location. The moderately fast-flowing water was very turbid at the time of the investigation. The substrate consists of very large rocks, shale bits, concrete, asphalt, sand, and gravel. No flow measurement was performed at this location.

All chemical and bacteriological data obtained at Sample Site #50 were within the E.P.A. Water Quality Standards, with the exceptions of copper, iron, and hexavalent chromium, which slightly exceeded the standards. The fecal coliform/fecal streptococcus ratio indicated that organic pollution at this site was from wastes of mixed human and animal sources, but the bacteriological contamination was minimal.

Qualitative benthos sampling at Sample Site #50 revealed the following facultative macroinvertebrates: isopods (Asellus sp.); ephemeropteran nymphs (Cloeon sp., Stenonema sp., Stenacron sp.); odonatan nymphs (Agria sp.); megalopteran larvae (Sialis sp., Nigronia sp.); trichopteran larvae (Cheumatopsyche sp.); coleopteran larvae (Psephenus sp., Stenelmis sp.); and gastropods (Ferrisia sp.). Tolerant organisms were also found, including oligochaetes and a hemipteran. The relatively high diversity of predominantly facultative macroinvertebrates indicates that Rocky River at Sample Site #50 is relatively unpolluted.

Sample Site #51 is located 75 feet upstream from East Access Road in the Metroparks Mill Stream Run Reservation. The river at this site is about 45 feet wide and 6 to 12 inches deep and, at the time of the investigation, the flow was moderately fast. The substrate consisted of shale bits, gravel, large rocks, and logs. The banks on both sides were about 4 to 5 feet high and covered with thick vegetation, including overhanging trees (maples, cottonwoods, oaks). A flow measurement indicated a dry weather flow at this location of approximately 12.9 MGD.

All chemical and bacteriological data obtained at Sample Site #51 were within the EPA Water Quality Standards, with the exceptions of copper and hexavalent chromium, which slightly exceeded the standards. The fecal coliform/fecal streptococcus ratio indicated that organic pollution at this site was from mixed human and animal sources, but the bacteriological contamination was minimal.

Qualitative benthos sampling at Sample Site #51 revealed the following facultative macroinvertebrates: turbellarians (Cura formanii); isopods (Asellus sp.); crayfish (Decapoda); plecopteran nymphs (Acroneuria sp.); ephemeropteran nymphs (Stenonema tripunctatum, Stenacron sp., Heptagenia sp.); megalopterans (Nigronia serricornis); coleopteran larvae (Psephenus sp., Stenelmis sp.); dipterans (Atherix variegata); chironomid larvae (Pentaneura sp.); and gastropods (Ferrissia sp.). Also found were chironomids, which are tolerant to organic pollution. The relatively high diversity of predominantly facultative organisms indicate that the river at Sample Site #51 is relatively unpolluted.

Sample Site #52 is located on the West Branch of Rocky River upstream of the Plum Creek confluence, north of Bagley Road. The location has a large pool which flows over a 6-foot drop at the downstream end and has smaller pools and riffles upstream. The river is about 75 feet wide at this point with a 100-foot steep bank on the east side and a public park on the west side. Vegetation with numerous trees are on the west bank. The water was slightly turbid and fast-flowing at the time of the investigation. The substrate consists of large boulders, sand, and gravel. No flow measurement was obtained.

All chemical and bacteriological data obtained at Sample Site #52 were within the EPA Water Quality Standards with the exception of copper, which slightly exceeded the standard of 0.008 mg/L. The fecal coliform/fecal streptococcus ratio indicated that organic pollution at this site was primarily from non-human sources, and the bacteriological contamination was minimal.

Qualitative benthos sampling at Sample Site #52 revealed the following facultative macroinvertebrates: amphipods (Crangonyx pseudogracilis); isopods (Asellus communis); ephemeropteran nymphs (Calibaetis sp., Caenis sp., Stenacron sp., Stenonema sp.); odonatan nymphs (Agria sp.); trichopteran larvae (Hydropsyche sp.), and coleopterans (Stenelmis sp.). Also found were oligochaetes, hirudineans, and coleopteran larvae (Berosus sp.), which are tolerant to organic pollution. The relatively high diversity of predominantly facultative organisms indicate that the river at Sample Site #52, like at all of the Rocky River Sample sites, is relatively unpolluted.

An additional sampling location, to be identified as Sample Site #52.5, was selected for Rocky River approximately 30 yards upstream of the Hilliard Road bridge and approximately 200 yards downstream of the sewer outfall at Riverside Drive and Hog's Back Lane, which is the northern most point of the NEORSD jurisdiction. This new sampling location was chosen to reflect the environmental impact on Rocky River from 7 upstream storm sewer outfalls, to which numerous combined sewer overflows are tributary. No sampling data has yet been obtained for this site.

III. ENVIRONMENTAL PROBLEMS AND REMEDIATION

On June 18, 1987, a 48" sewer discharging raw sanitary sewage into Rocky River was discovered between Pulaski Street and Depot Street in Berea. The flow was estimated at about 50 gallons per minute. The sewer was traced to an overflow from a partially blocked 12" sanitary sewer on North Rocky River Drive. Mr. Paul McCumbers of the City of Berea was notified of the problem, and on June 19, 1987, a maintenance crew removed rocks and grit from the sanitary sewer. Follow-up inspections showed that the sewage overflow had virtually ceased, although a trickle of overflow continued, due to the fact that the flow in the 12" sanitary sewer was at maximum capacity.

CONCLUSIONS

In 1987, a wide variation in water quality was noted in the streams within the NEORSD jurisdiction, from relatively clean, unpolluted streams, such as Euclid Creek, Chippewa Creek, and West Creek, to streams severely polluted by organic material, including Big Creek, Mill Creek, Dugway Brook, and Nine-Mile Creek. Fecal coliform concentration, which is the parameter most indicative of contamination by human waste, ranged from less than 100 counts per 100 ml, found on a couple of occasions on Chippewa Creek, to a high of 10,000,000 counts per 100 ml on Dugway Brook. Diversity of benthic macroinvertebrates also reflected the great variation in water quality, ranging from as many as 17 different types of organisms, identified at one site on Tinkers Creek, to as few as a single type of organism (Tubificidae, which are extremely tolerant of heavy organic pollution) found at sites on Nine-Mile Creek, Big Creek, and Mill Creek.

All of the identified major sources of pollution having serious impacts on receiving streams during dry weather conditions were due to sanitary sewerage system failures. Some of these problems may be solved by upcoming system improvements, such as the new interceptors being constructed. Others will require that community agencies perform necessary repairs in the existing sewer system. Some merely require better maintenance of the system.

Future stream studies should reflect whether improvements in water quality are being made. As the NEORSD stream monitoring program proceeds, upgrading of sampling may be possible. The 1987 studies were limited, due to time restrictions, to qualitative sampling of benthos and to grab samples for chemical and bacteriological parameters obtained on only a few occasions. In the future, quantitative benthos sampling, at least on a limited basis, may be initiated. Additionally, fish and periphyton sampling may be included in the biological assessments. To determine compliance with Ohio EPA Water Quality Standards, increased chemical/ bacteriological sampling would be required. The 1987 data are only sufficient for comparison purposes.

Sampling on the storm sewer "streams", such as Kingsbury Run, Morgana Run, and Burke Brook, which received minimal attention in 1987, will be increased, and they will be studied in much greater detail.

Finally, the Stream Monitoring Program should be able to focus its future efforts on known problem areas, many of which were identified during the stream studies of 1987. Future studies may also encompass some of the problems caused by factors not fully addressed in 1987, including the impacts of rain events and non-point sources.

REFERENCES

Brown, H. P. 1972. Biota of Freshwater Ecosystems: Aquatic Dryopoid Beetles (Coleoptera) of the United States. Water Pollution Control Research Series.

Dalton, Dalton and Newport. 1982. Easterly Separate Sewer Area: Sewer System Evaluation Survey. Submitted to Northeast Ohio Regional Sewer District.

EA Science and Technology. 1987. Evaluation of Warmwater Habitat and Primary Contact Recreation Use Attainability in the Lower Cuyahoga River, Ohio. Submitted to Northeast Ohio Regional Sewer District.

Environmental Review Board (State of Ohio). 1988. EBR No. 181434: Appellee's Exhibit Nos. 63 and 64.

Hart, C. W., Jr., and S.L.H. Fuller. 1974. Pollution Ecology of Freshwater Invertebrates. Academic Press, New York.

Havens and Emerson. 1968. Master Plan for Pollution Abatement, City of Cleveland, Ohio. Submitted to the City of Cleveland.

Hilsenhof, W. L. 1979. Aquatic Insects of Wisconsin. Revised Edition. Geological and Natural History Survey, Madison Wisconsin.

Holsinger, J. R. 1972. Biota of Freshwater Ecosystems: The Freshwater Amphipod Crustacean (Gammaridae) of North America. Water Pollution Control Research Series.

Hynes, H. B. N. 1966. The Biology of Polluted Waters. Liverpool University Press.

Krieger, Kenneth A., et. al. 1980. Environmental Quality of Upper Honey Creek: a Preliminary Assessment. Water Quality Laboratory, Heidelberg College, Tiffin, Ohio. Submitted to U.S. Army Engineer District, Buffalo.

Lewis, P. A. 1974. Taxonomy and Ecology of Stenonema Mayflies (Heptageniidae: Ephemeroptera). U. S. EPA.

Merritt, R.W., and K.W. Cummins. 1978. An Introduction to the Aquatic Insects of North America. Kendall/Hunt Publishing Company, Dubuque, Iowa.

Ohio Environmental Protection Agency (OEPA). 1985. Ohio Water Quality Standards. Ohio Administrative Code Title 3745.

Pennak, R. W. 1978. Freshwater Invertebrates of the United States. Second Edition. Ronald Press, New York.

Sawyer, R. T. 1972. North American Freshwater Leeches Exclusive of the Pisicolidae. University of Illinois Press, Urbana, Chicago.

Science Applications International Corporation (SAIC). 1986. Cuyahoga River Remedial Action Plan. Draft. Submitted to U. S. EPA Great Lakes National Program Office.

Standard Methods for the Examination of Water and Wastewater. Second Edition. 1985. American Public Health Association, Washington, D.C.

Trautman, M. B. 1981. The Fishes of Ohio. Revised Edition. The Ohio State University Press.

Ward, H. B., and G. C. Whipple. 1959. Freshwater Biology. Second Edition. John Wiley & Sons, Inc., New York.

Whipple, Timothy. 1986. Northeast Ohio Regional Sewer District Industrial Waste Section Stream Monitoring Program. Submitted to N.E.O.R.S.D.

APPENDICES

1987 Chemical and Bacteriological Data

(All data represented are arithmetic means from grab samples obtained under dry weather conditions, except bacteriological data, which are geometric means.*)

(Bacteriological data are in thousand counts/100 mL. Other data are in mg/L unless otherwise specified.)

*Individual data are on file by date of sampling and are available for review upon request at the NEORSD Industrial Waste Section offices.

APPENDIX A: Cuyahoga River

Sample Dates: 6/1, 7/27, 9/14-15, 9/28-29, 10/5-6, 11/12, 11/24/87

Sample Sites #	20	21	22	22.5
No. of samples	9	8	9	1
Temp. (°C)	20.4	20.4	20.7	9.0
D.O.	4.5	4.6	6.1	9.5
BOD	6	3	5	5
COD	26	28	37	17
SS	30	23	22	15
Tot. Solids(%)	0.05	0.06	0.06	0.07
TDS	464	535	486	742
Sp.Con.(umhos/cm)	796	697	647	849
Turbidity	19	16	12	8
NH_3	1.59	1.68	1.71	0.86
P	0.41	0.30	0.29	0.29
Soluble P	0.26	0.21	0.19	0.19
NO_3	3.06	3.59	3.61	0.62
NO_2	0.17	0.19	0.15	0.19
TKN	3.66	3.75	3.96	5.88
Cl	118	108	117	224
SO_4	88	89	103	122
Alkalinity	129	133	134	150
Hardness	192	200	214	182
Ni	0.03	<0.02	0.05	0.06
Cu	0.02	0.02	<0.02	0.02
Cr	<0.01	<0.01	0.01	0.01
Zn	0.14	0.36	0.45	0.12
Fe	1.5	1.2	1.2	0.60
Cd	<0.01	<0.01	<0.01	<0.01
Pb	<0.01	<0.02	<0.02	.02
Hg(ug/L)	<0.10	<0.05	<0.17	<0.10
Total Coli.	1.950	<1.816	9.631	33.000
Fecal Coli.	<0.544	<0.346	1.503	6.900
Fecal Strep.	<0.259	<0.136	0.283	-

APPENDIX B: Cuyahoga River (continued)

Sample Dates: 6/1, 7/27, 9/14-15, 9/28-29, 10/5-6, 11/12/87

Sample Sites #	22.51	23	24
No. of samples	9	4	4
Temp. (^{o}C)	18.0	17.2	17.5
D.O.	8.8	8.7	9.0
BOD	5	4	3.0
COD	31	31	30
SS	20	18	11
Tot. Solids(%)	0.06	0.05	0.05
TDS	496	474	486
Sp.Con.(umhos/cm)	679	674	676
Turbidity	8	9	10
NH_3	0.49	0.33	0.25
P	0.39	0.26	0.27
Soluble P	0.29	0.17	0.19
NO_3	4.02	2.52	2.53
NO_2	0.13	0.15	0.17
TKN	2.32	1.20	5.79
Cl	107	119	108
SO_4	84	75	76
Alkalinity	137	143	145
Hardness	203	238	265
Ni	$<$ 0.07	$<$ 0.01	$<$ 0.01
Cu	0.02	$<$ 0.01	0.02
Cr	$<$ 0.01	$<$ 0.01	$<$ 0.01
Zn	0.09	0.03	0.04
Fe	1.0	$<$ 0.4	0.62
Cd	$<$ 0.01	$<$ 0.01	$<$ 0.01
Pb	$<$ 0.02	$<$ 0.01	$<$ 0.01
Hg(ug/L)	$<$ 0.10	$<$ 0.05	$<$ 0.18
Total Coli.	21.650	15.690	10.968
Fecal Coli.	1.564	1.377	1.750
Fecal Strep.	0.785	0.310	0.276

APPENDIX C: Big Creek (Main Stream/West Branch)

Sample Dates: 5/5-6, 10/28/87

Sample Sites #	25	27	28
No. of samples	1	2	2
Temp. (^{o}C)	8.0	14.0	9.0
D.O.	11.0	9.9	8.6
BOD	4	10	2
COD	85	60	72
SS	6	8	7
Tot. Solids	-	762	-
TDS	-	869	-
Sp.Con.(umhos/cm)	508	965	660
Turbidity	7	11	14
NH_3	0.81	1.60	1.10
P	0.19	0.90	0.11
Soluble P	-	1.29	-
NO_3	0.70	0.68	0.94
NO_2	0.05	0.08	0.12
TKN	3.92	3.66	4.03
Cl	108	213	98
SO_4	91	101	116
Alkalinity	-	154	-
Hardness	-	230	-
Ni	0.02	0.01	$<$ 0.01
Cu	0.02	0.02	0.02
Cr	$<$ 0.01	$<$ 0.01	$<$ 0.01
Zn	0.05	0.15	0.09
Fe	0.50	0.40	0.60
Cd	$<$ 0.01	$<$ 0.01	$<$ 0.01
Pb	$<$ 0.01	$<$ 0.01	$<$ 0.03
Hg(ug/L)	$<$ 0.10	$<$ 0.01	$<$ 0.01
Total Coli.	27.000	334.963	2.683
Fecal Coli.	9.000	34.336	0.735
Fecal Strep.	4.100	3.020	0.232

APPENDIX E: Mill Creek

Sample Dates: 2/5, 3/19/87

Sample Sites #	31	32	33	33.5
No. of samples	1	1	2	1
Temp. (^{o}C)	6.0	6.0	5.0	9.0
D.O.	10.1	0.3	10.9	6.9
BOD	24	45	10	27
COD	34	39	28	33
SS	16	8	6	17
Tot. Solids	976	1650	845	730
TDS	925	1530	761	627
Sp.Con.(umhos/cm)	1600	2350	1350	1220
Turbidity	38	7	4	12
NH_3	4.06	5.04	1.30	3.78
P	0.72	-	0.42	1.18
Soluble P	0.45	0.73	0.10	0.98
NO_3	0.70	0.53	1.08	0.71
NO_2	0.10	0.03	0.04	0.06
TKN	6.44	6.72	1.40	9.80
Cl	294	324	549	292
SO_4	153	796	133	101
Alkalinity	182	212	134	197
Hardness	330	321	297	133
Ni	< 0.01	0.02	0.03	0.01
Cu	0.04	0.03	0.03	0.02
Cr	0.03	< 0.01	< 0.01	< 0.01
Zn	0.16	0.04	0.05	0.02
Fe	2.4	1.6	0.6	1.01
Cd	0.02	< 0.01	0.01	< 0.01
Pb	< 0.01	< 0.01	0.01	< 0.01
Hg(ug/L)	< 0.01	0.4	0.01	< 0.01
Total Coli.	2000.000	2200.000	200.000	> 2000.000
Fecal Coli.	300.000	340.000	4.500	> 2000.000
Fecal Strep.	-	-	-	-

APPENDIX F: Mill Creek (continued)

Sample Dates: 2/5, 3/19/87

Sample Sites #	34	35
No. of samples	2	1
Temp. (°C)	9.0	5.0
D.O.	9.6	13.9
BOD	14	8
COD	25	11
SS	19	3
Tot. Solids	792	846
TDS	747	745
Sp.Con.(umhos/cm)	1440	1430
Turbidity	3	3
NH_3^-	1.83	0.02
P	0.70	0.03
Soluble P	0.76	0.02
NO_3	0.81	0.54
NO_2	0.05	0.02
TKN	3.64	1.12
Cl	650	374
SO_4	84	87
Alkalinity	178	147
Hardness	130	230
Ni	< 0.01	< 0.01
Cu	0.02	0.02
Cr	< 0.01	< 0.01
Zn	0.02	0.01
Fe	0.5	0.40
Cd	< 0.01	< 0.01
Pb	< 0.03	< 0.01
Hg(ug/L)	0.2	< 0.10
Total Coli.	1000.000	1.900
Fecal Coli.	130.000	< 0.100
Fecal Strep.	-	-

APPENDIX G: West Creek

Sample Dates: 12/6, 12/14/87

Sample Sites #	36	37	38
No. of samples	1	1	1
Temp. (^{o}C)	4.0	3.1	3.0
D.O.	14.2	12.6	15.0
BOD	1	2	1
COD	22	22	26
SS	6	4	6
Tot. Solids	1204	1205	1244
TDS	1134	1108	1178
Sp.Con.(umhos/cm)	2020	2060	2120
Turbidity	8	6	4
NH_3	0.58	0.32	0.46
P	0.11	0.18	0.39
Soluble P	0.09	0.15	0.36
NO_3	1.14	1.64	2.01
NO_2	0.03	0.04	0.05
TKN	1.96	2.24	1.96
Cl	510	536	566
SO_4	119	105	114
Alkalinity	117	112	124
Hardness	261	357	185
Ni	< 0.01	< 0.01	< 0.01
Cu	0.01	0.01	0.01
Cr	< 0.01	< 0.01	< 0.01
Zn	0.03	0.02	0.04
Fe	0.6	0.30	0.30
Cd	< 0.01	< 0.01	< 0.01
Pb	0.02	< 0.01	< 0.01
Hg(ug/L)	36	< 0.1	0.1
Total Coli.	1.300	1.100	5.000
Fecal Coli.	0.090	0.180	0.450
Fecal Strep.	< 0.090	< 0.090	< 0.090

APPENDIX H: Tinkers Creek

Sample Dates: 5/6, 7/28, 10/13/87

Sample Sites #	39	40	41	42
No. of samples	3	3	3	3
Temp. (^{o}C)	15.7	17.2	16.2	16.4
D.O.	12.7	14.7	12.9	12.8
BOD	< 2	2	2	2
COD	24	23	25	21
SS	4	8	14	11
Tot. Solids(%)	0.06	0.06	0.05	0.60
TDS	545	548	535	546
Sp.Con.(umhos/cm)	698	744	702	637
Turbidity	9	10	11	18
NH_3	0.27	0.23	0.23	0.44
P	0.21	0.24	0.29	0.37
Soluble P	0.15	0.20	0.22	0.31
NO_3	3.24	3.57	2.77	1.33
NO_2	0.07	0.05	0.06	0.04
TKN	1.68	2.01	2.32	1.94
Cl	141	146	121	105
SO_4	73	71	65	58
Alkalinity	144	147	163	159
Hardness	177	159	131	152
Ni	< 0.02	0.03	< 0.04	0.06
Cu	0.01	< 0.01	< 0.02	< 0.07
Cr	< 0.01	< 0.01	< 0.01	< 0.03
Zn	0.04	0.06	0.07	0.64
Fe	0.1	0.2	1.0	0.7
Cd	< 0.01	< 0.01	< 0.01	< 0.02
Pb	0.02	< 0.01	< 0.01	< 0.01
Hg(ug/L)	< 0.1	< 0.1	< 0.1	< 0.01
Total Coli.	10.231	102.535	19.317	47.011
Fecal Coli.	0.715	7.990	1.048	6.540
Fecal Strep.	0.262	0.144	0.431	1.059

APPENDIX I: Chippewa Creek

Sample Dates: 4/27, 8/11, 10/13/87

Sample Sites #	43	43.5	44
No. of samples	3	3	3
Temp. (^{o}C)	15.1	12.6	13.8
D.O.	10.9	12.1	9.6
BOD	4	1	6
COD	14	8	14
SS	14	6	12
Tot. Solids(%)	0.06	0.10	0.06
TDS	571	950	522
Sp.Con.(umhos/cm)	700	1125	684
Turbidity	3	2	8
NH_3	0.25	0.23	0.33
P	0.17	0.42	0.64
Soluble P	0.14	0.16	0.61
NO_3	0.71	0.63	1.12
NO_2	0.02	0.03	0.09
TKN	1.59	1.00	1.19
Cl	103	98	100
SO_4	195	282	143
Alkalinity	140	220	164
Hardness	250	487	261
Ni	< 0.01	< 0.01	< 0.01
Cu	< 0.03	< 0.01	< 0.01
Cr	< 0.01	< 0.01	< 0.01
Zn	0.04	0.02	0.04
Fe	2.6	0.3	7.5
Cd	< 0.01	< 0.01	< 0.01
Pb	< 0.03	< 0.01	< 0.01
Hg(ug/L)	< 0.01	< 0.1	< 0.1
Total Coli.	1.716	0.251	24.974
Fecal Coli.	0.442	0.173	6.000
Fecal Strep.	0.290	0.114	1.390

APPENDIX J: Euclid Creek

Sample Dates: 4/14, 7/13, 11/13/87

Sample Sites #	1	2	3	4
No. of samples	3	3	3	3
Temp. (^{o}C)	7.5	6.5	6.5	7.4
D.O.	11.9	14.4	11.8	11.5
BOD	5	2	3	2
COD	60	17	13	19
SS	59	5	5	7
Tot. Solids	413	602	359	610
TDS	389	537	328	573
Sp.Con.(umhos/cm)	717	712	518	1062
Turbidity	6	3	4	3
NH_3	0.13	0.23	0.08	0.06
P	0.34	0.11	0.24	0.04
Soluble P	0.06	0.04	0.28	0.02
NO_3	0.68	0.26	1.11	0.20
NO_2	0.02	0.02	0.04	0.03
TKN	1.87	1.77	1.49	1.87
Cl	91	171	96	204
SO_4	74	85	57	72
Alkalinity	96	113	100	122
Hardness	158	189	217	195
Ni	$<$0.01	$<$0.01	$<$0.01	$<$0.01
Cu	$<$0.02	$<$0.01	$<$0.01	$<$0.01
Cr	$<$0.02	$<$0.01	$<$0.02	$<$0.01
Zn	0.04	0.02	0.01	0.01
Fe	3.4	0.1	0.17	0.25
Cd	$<$0.01	$<$0.01	$<$0.01	$<$0.01
Pb	$<$0.02	$<$0.13	$<$0.01	0.01
Hg(ug/L)	$<$0.10	0.08	$<$0.10	0.12
Total Coli.	1.012	1.120	3.461	0.696
Fecal Coli.	0.313	0.235	0.809	0.185
Fecal Strep.	0.141	$<$0.163	0.390	0.198

APPENDIX K: Green Creek

Sample Dates: 4/14, 4/20, 7/13, 11/13/87

Sample Sites #	5	6	7
No. of samples	2	2	2
Temp. (°C)	7.5	9.0	9.3
D.O.	10.5	10.5	11.9
BOD	4	6	4
COD	11	15	10
SS	7	7	8
Tot. Solids	407	293	315
TDS	381	252	271
Sp.Con.(umhos/cm)	798	394	400
Turbidity	3	2	5
NH_3	0.09	0.15	0.13
P	0.14	0.19	0.06
Soluble P	0.08	0.19	0.07
NO_3	0.60	0.34	0.57
NO_2	0.24	0.05	0.01
TKN	2.10	1.40	0.61
Cl	71	54	53
SO_4	70	57	53
Alkalinity	126	100	92
Hardness	280	207	125
Ni	$<$ 0.01	$<$ 0.01	$<$ 0.03
Cu	0.01	0.01	0.01
Cr	$<$ 0.01	$<$ 0.01	$<$ 0.05
Zn	0.21	0.02	$<$ 0.02
Fe	0.3	0.2	35.6
Cd	$<$ 0.01	$<$ 0.01	$<$ 0.01
Pb	$<$ 0.01	$<$ 0.01	$<$ 0.01
Hg(ug/L)	$<$ 0.01	$<$ 0.10	0.08
Total Coli.	33.166	22.978	0.894
Fecal Coli.	5.796	2.449	0.441
Fecal Strep.	2.846	0.640	0.360

APPENDIX L: Nine-Mile Creek

Sample Dates: 4/14, 7/13, 11/11/87

Sample Sites #	8a	8b	9	10
No. of samples	3	3	3	3
Temp. (^{o}C)	10.0	9.5	9.8	8.6
D.O.	4.8	10.3	8.8	11.3
BOD	7	3	8	< 5
COD	20	24	23	20
SS	4	6	5	6
Tot. Solids	606	542	898	504
TDS	538	47	763	500
Sp.Con.(umhos/cm)	826	788	1145	719
Turbidity	10	2	3	14
NH_3	0.64	0.31	3.57	< 0.14
P	0.38	0.28	0.52	0.23
Soluble P	0.33	0.25	0.41	0.19
NO_3	0.41	0.53	1.06	< 0.12
NO_2	0.10	0.08	0.11	0.03
TKN	2.77	2.57	5.09	< 0.84
Cl	140	146	171	127
SO_4	108	93	162	88
Alkalinity	150	124	154	127
Hardness	190	186	250	199
Ni	< 0.01	0.02	0.04	< 0.01
Cu	< 0.01	< 0.01	0.02	< 0.01
Cr	0.02	< 0.01	< 0.01	< 0.01
Zn	0.06	0.04	0.07	0.01
Fe	0.8	0.2	10.4	< 0.01
Cd	< 0.01	< 0.01	< 0.01	< 0.01
Pb	< 0.01	< 0.01	< 0.01	< 0.01
Hg(ug/L)	< 0.13	< 0.10	< 0.10	< 0.10
Total Coli.	22.610	113.000	329.221	1.485
Fecal Coli.	7.034	36.088	38.875	0.239
Fecal Strep.	3.642	9.727	14.848	0.271

APPENDIX M: Shaw Brook

Sample Dates: 7/7, 11/3/87

Sample Sites #	11
No. of samples	2
Temp. ($^{\circ}C$)	18.8
D.O.	7.5
BOD	17
COD	62
SS	10
Tot. Solids(%)	-
TDS	-
Sp.Con.(umhos/cm)	578
Turbidity	4
NH_3	0.78
P	0.32
Soluble P	-
NO_3	0.72
NO_2	0.05
TKN	-
Cl	89
SO_4	76
Alkalinity	-
Hardness	-
Ni	$<$0.02
Cu	0.02
Cr	$<$0.01
Zn	0.08
Fe	0.6
Cd	$<$0.01
Pb	$<$0.02
Hg(ug/L)	-
Total Coli.	4.572
Fecal Coli.	0.458
Fecal Strep.	0.173

APPENDIX N: Dugway Brook

Sample Dates: 7/7, 7/8, 11/3, 11/4/87

Sample Sites #	12	13	14	15
No. of samples	2	2	2	2
Temp. (^{o}C)	18.5	17.5	18.1	17.0
D.O.	4.4	9.2	11.1	5.0
BOD	14	10	5	42
COD	116	109	108	135
SS	19	5	22	6
Tot. Solids(%)	-	-	-	-
TDS	-	-	-	-
Sp.Con.(umhos/cm)	948	824	910	1040
Turbidity	4	4	2	3
NH_3	8.26	0.82	2.26	0.91
P	1.20	0.77	1.16	0.56
Soluble P	-	-	-	-
NO_3	0.29	1.46	0.28	0.45
NO_2	0.08	0.28	0.11	0.19
TKN	-	-	-	-
Cl	168	163	178	194
SO_4	93	102	100	74
Alkalinity	-	-	-	-
Hardness	-	-	-	-
Ni	$<$0.01	$<$0.01	$<$0.01	$<$0.01
Cu	0.02	0.02	0.01	0.01
Cr	$<$0.01	$<$0.01	$<$0.01	$<$0.01
Zn	0.04	0.05	0.02	0.04
Fe	1.2	1.0	0.7	0.8
Cd	$<$0.01	$<$0.01	$<$0.01	$<$0.01
Pb	$<$0.01	$<$0.01	$<$0.01	$<$0.01
Hg(ug/L)	-	-	-	-
Total Coli.	2258.318	17.709	14.142	66.453
Fecal Coli.	961.249	7.036	4.673	12.594
Fecal Strep.	238.747	1.775	1.581	7.099

APPENDIX O: Doan Brook

Sample Dates: 7/7, 7/8, 11/4/87

Sample Sites #	16	17	18	19
No. of samples	2	2	2	2
Temp. (^{o}C)	18.5	18.0	16.0	18.0
D.O.	4.7	7.8	6.1	8.3
BOD	16	7	3	2
COD	103	90	45	22
SS	17	22	6	4
Tot. Solids(%)	-	-	-	-
TDS	-	-	-	-
Sp.Con.(umhos/cm)	1010	410	535	242
Turbidity	4	12	2	2
NH_3	0.41	0.70	0.01	0.03
P	1.09	0.33	0.11	0.18
Soluble P	-	-	-	-
NO_3	0.32	0.32	0.34	0.08
NO_2	0.03	0.04	0.02	0.03
TKN	-	-	-	-
Cl	200	77	94	69
SO_4	87	50	40	36
Alkalinity	-	-	-	-
Hardness	-	-	-	-
Ni	$<$ 0.01	$<$ 0.01	$<$ 0.01	$<$ 0.01
Cu	0.01	0.01	0.02	0.02
Cr	$<$ 0.01	$<$ 0.01	$<$ 0.01	$<$ 0.01
Zn	0.04	0.12	0.06	0.05
Fe	0.1	0.6	0.3	0.2
Cd	$<$ 0.01	$<$ 0.01	$<$ 0.01	$<$ 0.01
Pb	$<$ 0.01	$<$ 0.02	$<$ 0.01	$<$ 0.02
Hg(ug/L)	-	-	-	-
Total Coli.	28.425	114.456	0.748	4.752
Fecal Coli.	20.838	29.374	0.386	1.466
Fecal Strep.	2.301	13.565	0.315	0.986

APPENDIX P: Rocky River

Sample Dates: 6/8, 6/15, 9/14/87

Sample Sites #	49	50	51	52
No. of samples	3	3	3	3
Temp. (^{o}C)	21.6	21.5	19.2	20.7
D.O.	8.1	7.8	8.0	8.0
BOD	6	2	4	2
COD	22	20	16	23
SS	21	49	14	13
Tot. Solids	555	506	477	566
TDS	473	421	411	455
Sp.Con.(umhos/cm)	680	651	566	594
Turbidity	36	53	16	32
NH_3	2.50	0.32	0.25	0.50
P	0.37	0.35	0.59	0.38
Soluble P	0.29	0.55	0.61	0.28
NO_3	2.32	2.17	3.44	1.56
NO_2	0.26	0.08	0.23	0.29
TKN	3.31	1.12	1.57	1.66
Cl	219	75	60	86
SO_4	98	90	141	105
Alkalinity	103	129	134	126
Hardness	146	170	140	186
Ni	< 0.02	< 0.02	< 0.01	0.04
Cu	0.02	0.02	< 0.01	0.01
Cr	< 0.01	< 0.01	< 0.01	< 0.01
Zn	0.02	0.02	0.02	0.09
Fe	1.2	2.4	0.6	0.8
Cd	< 0.01	< 0.01	< 0.01	< 0.01
Pb	0.02	< 0.02	< 0.01	< 0.02
Hg(ug/L)	< 0.01	< 0.10	< 0.05	< 0.05
Total Coli.	3.988	1.975	4.626	1.339
Fecal Coli.	0.261	0.439	1.236	0.529
Fecal Strep.	0.340	0.216	0.626	0.171

APPENDIX Q: Walworth Run, Kingsbury Run

Sample Dates: 6/8/87

Sample Sites #	45	46
No. of samples	1	1
Temp. (^{o}C)	-	-
D.O.	-	-
BOD	65	6
COD	145	35
SS	50	15
Tot. Solids	628	662
TDS	600	640
Sp.Con.(umhos/cm)	958	994
Turbidity	52	27
NH_3	11.40	2.28
P	1.93	0.31
Soluble P	1.74	0.37
NO_3	5.20	3.63
NO_2	0.02	0.38
TKN	17.42	4.62
Cl	136	156
SO_4	73	189
Alkalinity	222	160
Hardness	136	186
Ni	0.01	0.02
Cu	0.04	0.01
Cr	0.02	$<$ 0.01
Zn	0.08	0.22
Fe	1.0	0.9
Cd	$<$ 0.01	$<$ 0.01
Pb	0.02	0.01
Hg(ug/L)	0.4	$<$ 0.1
Total Coli.	2900.000	30.000
Fecal Coli.	2000.000	2.800
Fecal Strep.	1300.000	2.300