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In-System Storage Controls For Reduction Of Combined Sewer Overflow - Saginaw, Michigan

Executive Summary

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September 1985

IN-SYSTEM STORAGE CONTROLS FOR REDUCTION of COMBINED SEWER OVERFLOW SAGINAW, MICHIGAN

by

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for

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FOREWORD

This report overviews the results of a recently completed five-year combined sewer overflow (CSO) control program in Saginaw, Michigan (10,000 acres, pop. 85,000) funded by City of Saginaw/U.S. EPA 108 Great Lakes National Program and conducted by the engineering contractor, Environmental Design and Planning, Inc., Hanover, Mass. The implemented control program entailed modification of 13 combined sewer regulation chambers together with construction of one new in-line control chamber to maximize transient system storage of wet weather combined sewerage for later bleedback to a well-operated Wastewater Treatment Plant (WWTP) having phosphorous removal and ample treatment capacity. These improvements, "the reduced Best Management Practices (BMP) plan", represent a partial completion of the first of two phases of the City's CSO Facility Plan. The objective of Phase I was to maximize WWTP processing of wet weather combined sewage generated using inexpensive transient system storage (less than $1/cu.ft.) so as to minimize the extent, scale and cost of satellite CSO treatment facilities (Phase II). The swirl concentrator technology was recommended to treat residual overflows remaining after Phase I improvements. Six major facilities were recommended and adopted as part of the CSO Facility Plan.

The total cost of the implemented program including engineering was $.504 million (1984). A post construction evaluation measurement/modeling program was conducted in the Fall, 1984 to verify preproject design conditions. It has been determined that implementation of the reduced BMP plan has increased the percentage of total annual wet weather flow directed to the WWTP by 14.6% (from a previous "as is" level of 37.7%) and has incrementally reduced (beyond "as is" levels) suspended solids loadings to the Saginaw River by 16%, BOD by 20% and total phosphorous by 8.5% (secondary treatment). During periods of advanced wastewater treatment (AWT)(pickling liquor addition) at the WWTP, total phosphorous removals have increased to 12.6% above pre-implementation levels. Implementation of the remaining elements of the complete BMP plan (Phase I) will produce an overall incremental wet weather flow increase of 30% (increasing the total wet weather flow treated at the WWTP to 67.7%).

This project was funded by U.S. EPA in part, to demonstrate new innovative full scale approaches for mitigating CSO impacts on the Great Lakes. The primary project justification was to develop and document an innovative, inexpensive and cost-effective management approach for mitigating wet weather phosphorous loadings to Saginaw Bay (Lake Huron). The results are currently being used as part of U.S. EPA's joint efforts with Canada to develop phosphorous limitation management strategies.

In addition, the results of this demonstration project will provide valuable insights for a number of projects in the formative preliminary phase investigating in-system storage management to "clip" or eliminate CSO from small intensity, high frequency events as an inexpensive and cost effective control measure.

This report was submitted in partial fulfillment of Grant No. S005359 by Environmental Design & Planning, Inc. sponsored by a Section 108 grant from the Great Lakes National Program Office, Region V, U.S. EPA with funds also from the City of Saginaw. This report covers a period of September, 1979 to December, 1984 and work was completed as of April, 1985.

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The authors would like to commend the EDP staff who worked so hard to make this program a success. Through the diligent efforts of many, a study has been prepared assessing the viability of a relatively new technology for solving a complex combined sewer management problem in the City of Saginaw.

We would like to thank the City of Saginaw Public Utilities Department for their extreme cooperation and good will, including Robert Dust, Executive Director of Public Utilities, Mr. Jim Anderson, Superintendent and Fred Schulze, Assistant Superintendent, Wastewater Treatment Division.

We would like to also thank Mr. Ralph G. Christensen, U.S. EPA Region V, Great Lakes National Program Office, for his support and assistance. The Great Lakes Program provided funds for this project. In addition, Mr. Richard P. Traver, U.S. EPA, Edison, New Jersey was extremely helpful in coordinating the early phases of the project.

Finally, we would like to express our sincerest appreciation to Ms. Eunice Harris for her patience in typing this report.

Environmental Design & Planning, Inc. was the engineering contractor for his project. Dr. William C. Pisano, P.E., President, EDP, was the principal investigator. Mr. Daniel J. Connick, Sr. Design Engineer, was the project manager. Mr. Gerald L. Aronson, Executive Vice President, EDP, supervised field monitoring and evaluation efforts.

CHAPTER 1

DESCRIPTION OF CITY OF SAGINAW SEWERAGE CONVEYANCE AND TREATMENT FACILITIES

Section 1.1 Introduction

Saginaw is located in the eastern part of central Michigan, north of Detroit, as shown in Figure 1. The Saginaw River is a short section of a major drainage area leading to Saginaw Bay, Lake Huron. The topography of the area is flat. The Saginaw River about evenly divides the 10,437 acre area of the City of Saginaw. The Saginaw River drainage basin above the City has an area of 6,200 sq. mi.

The area which is surrounded by the Great Lakes, has a quasi-marine environment. Saginaw's normal annual precipitation is about 28.6 in., over 50% of which falls during the summer between March and September. Beginning in March or April, melting snow combined with rainfall can produce high overflow volumes to the river. Most of the storms that occur are of low average intensity. Over 90% of the time, the average intensity of rainfall which produces runoff is less than 0.10 in./h.

The City of Saginaw is serviced by a combined sewer system. Combined sewer overflows (CSO) during rain events are contributors of pollutants to the Saginaw River. Overflows may occur at 34 regulator chambers. Five pump stations are designed to relieve the system during flooding conditions. See Figure 2. It is estimated that over 60 overflows occur per year.

Impacts on the Saginaw River from CSO include dissolved oxygen depletion in the downstream segments of the river and floatable material may create visual problems. Nutrient emissions, particularly dissolved phosphorous, are critical concerns to Saginaw Bay and Lake Huron.

Section 1.2 Sewerage System Overview

The intercepting sewer shown in Figure 3 runs along both banks of the Saginaw River. The West Side Interceptor crosses the river at Weiss Street to join the East Side Interceptor, which continues to the WWTP at the northeast limits of the City.

Because a number of the sewers are below flood river stage, the problem of collecting sewage may involve stormwater pumping during periods of high river level. During flood river levels, storm flows will discharge over the regulator chamber weirs into the intercepting system. Backwater gates prevent

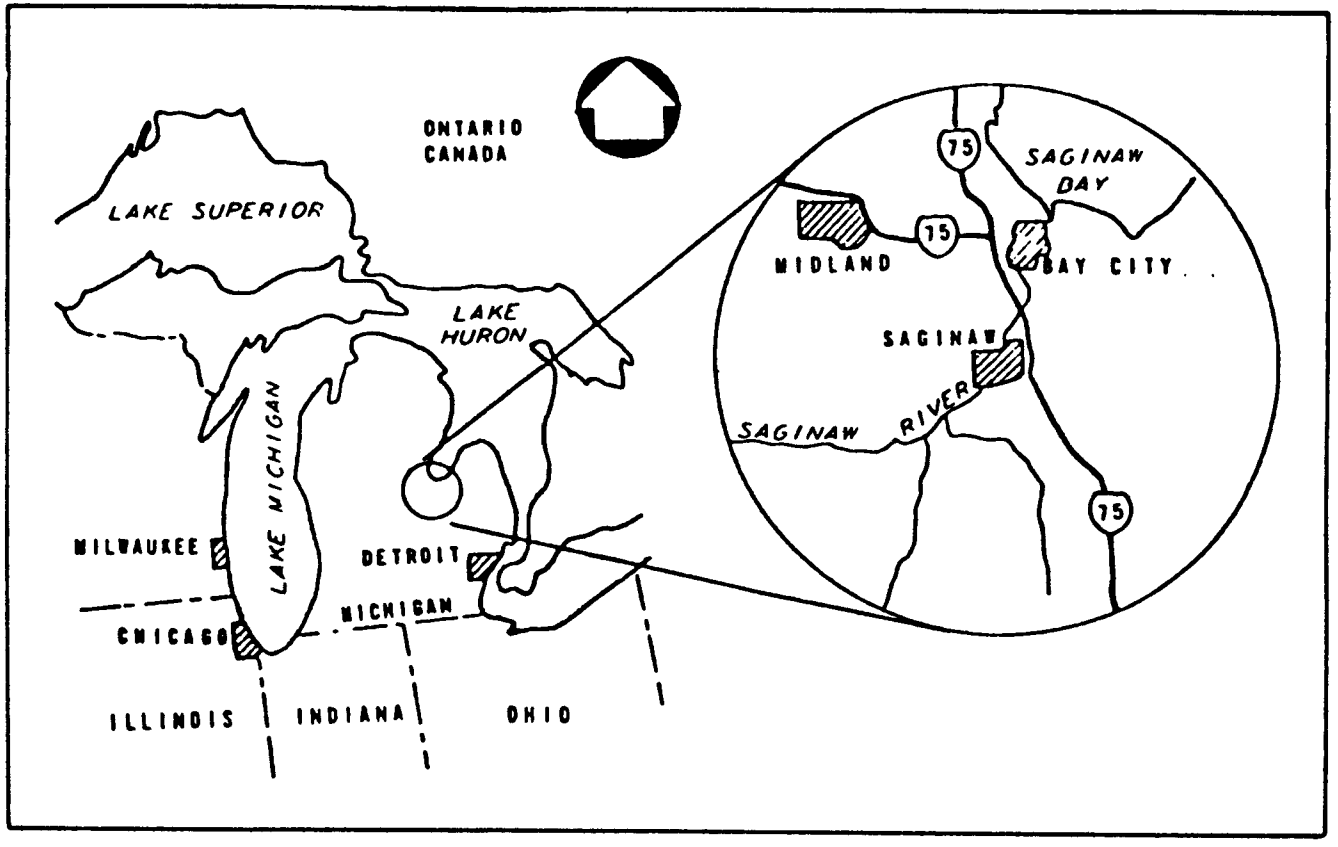

Figure 1 Location of Saginaw, Michigan.

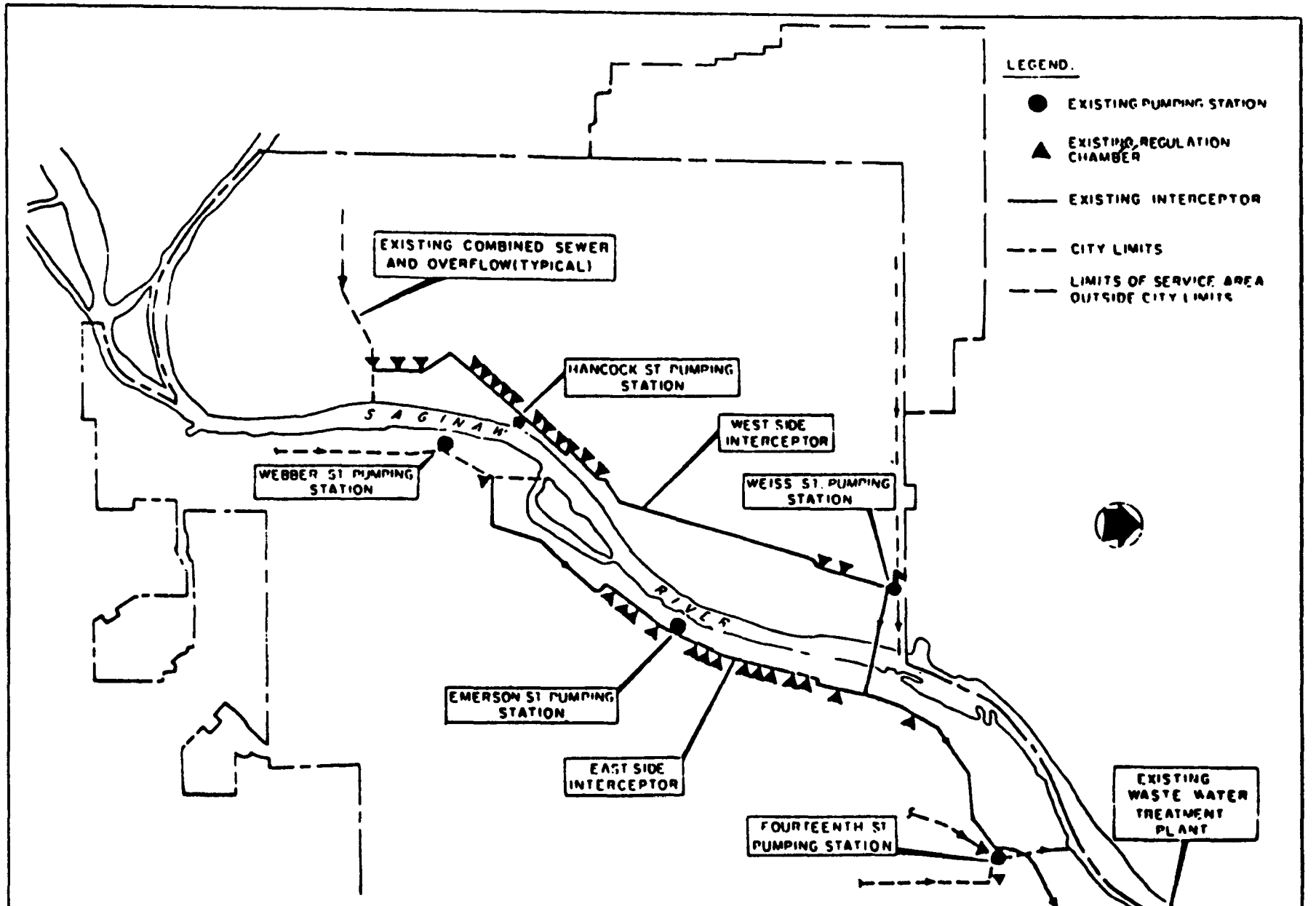

Figure 2 Saginaw combined sewer service area.

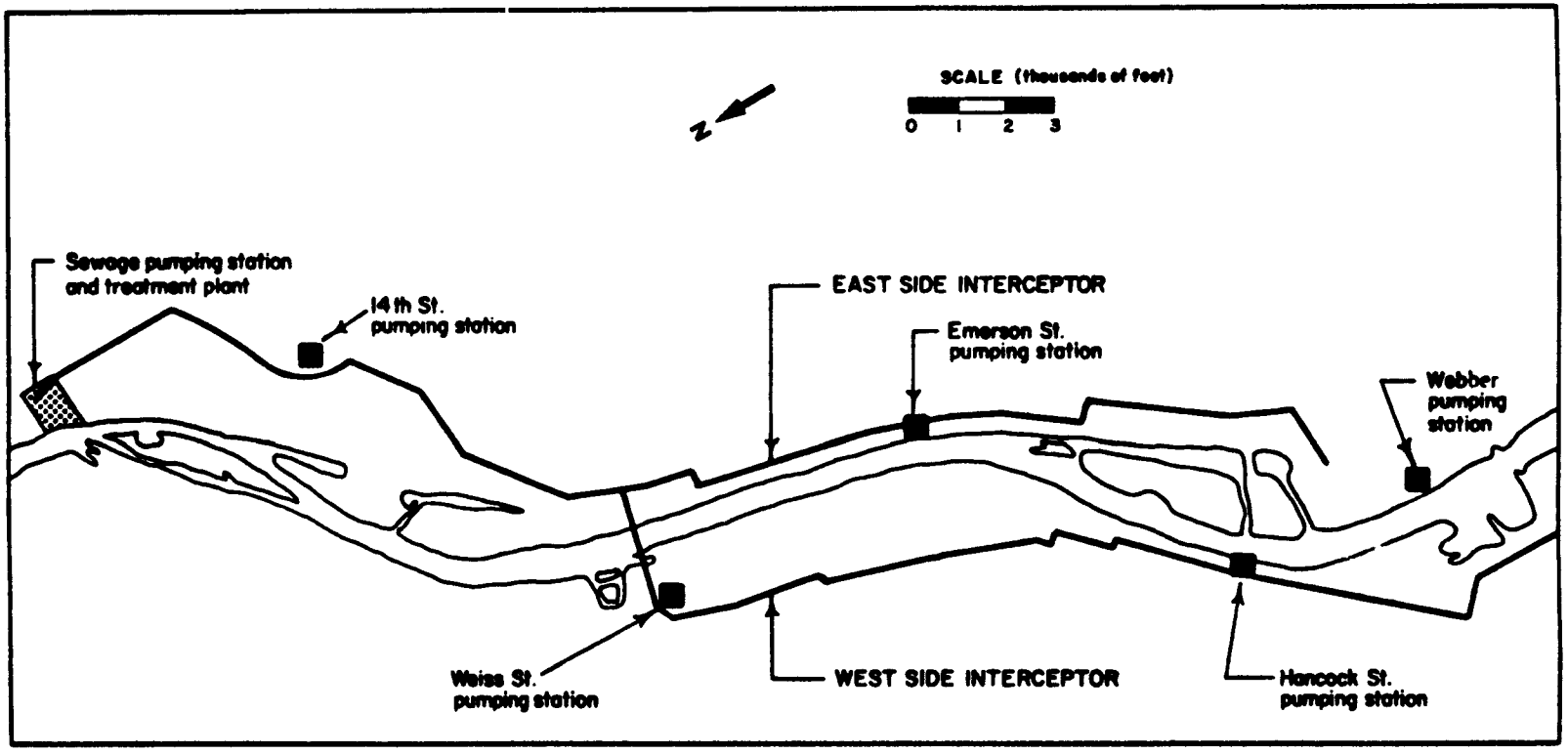

Figure 3 General plan of interceptor sewer system.

discharge of flood river water into the sewerage system. Flood pumping stations are located at Webber, Emerson, and Fourteenth Streets on the East Side, and Hancock and Weiss Streets on the West Side.

The interceptor system serves the dual purpose of collecting sewage and carrying storm flows and consists of tunnel sewers ranging from 42 to 78 inches in diameter. The tunnels are approximately 40 feet below ground level.

Section 1.3 Wastewater Treatment Plant (WWTP) Details

The City's 32.7 mgd secondary WWTP is located on the east bank of the Saginaw River. Wastewater enters the plant in a 72-inch interceptor sewer. After screening and grit removal, the wastewater is settled in four primary sedimentation tanks. Primary effluent passes into the conventional activated sludge system where ferrous sulfate or waste pickle liquor can be added, for phosphorus removal as necessary to meet effluent discharge standards. Final effluent is chlorinated before discharge to the Saginaw River. The current NPDES permit for the plant requires that monthly average BOD and suspended solids concentrations not exceed 25 and 30 mg/l, respectively. Effluent total phosphorous concentrations must be less than 1 mg/l.

Prior to 1968 sewage discharging from the City of Saginaw was given primary treatment with chlorination. The primary plant was then upgraded to secondary treatment including biological activated sludge with phosphorous removal. Although the modified plant is designed for a nominal flow of 50 cfs and an estimated maximum flow of 128 cfs, the secondary treatment unit operations are sized for about 160 cfs discharge. All storm flows entering the WWTP in excess of 108 cfs are split at the grit chamber with bypass receiving only chlorination. Currently, bypass beyond 108 cfs occurs at a spillover weir such that increasing influent flow rates results in simultaneous increased flow through the plant and increased bypass. The average dry weather flow is about 32 cfs.

All flow beyond the grit chambers receives full treatment. There are four secondary aeration tanks following the primary clarifiers. Normally two aeration basins are used for dry weather flow and wet weather discharges up to about 84 cfs. The two other aeration basins are used as storage (0.5 million cubic feet) for wet weather discharges above 84 cfs. If these basins are filled, flow- through conditions result. The storage contents after an event (or when influent rate significantly decreases) of these two tanks containing primary treated wastes then receive full primary/secondary treatment as these volumes are pumped back to the headworks. Any flows beyond 84 cfs and in

excess of the two aeration tank storage volume will receive primary treatment, limited aeration with phosphorous removal (if necessary), secondary clarification and disinfection.

Average suspended solids and BOD influent concentrations are reduced by 93% and 89% respectively. Total phosphorous effluent concentrations do not exceed 1 mg/l. Analysis of long-term plant efficiency records indicate little deviation from average removals during wet periods.

CHAPTER 2

COMBINED SEWER OVERFLOW CONTROL (1960-1978)

Section 2.1 Prior CSO Facility Plan

Abatement of CSO pollution was required to comply with order issued by State of Michigan Water Resources Commission (1960). Several studies focusing on the CSO problems were completed (1) to meet the requirements of the order. A control plan was accepted in 1969. The basic concept consisted of utilizing to its maximum the existing system together with seven new storage and treatment facilities at locations determined by the hydraulics of the system. See Figure 4. The intent was to make the best use of existing facilities, and to preserve the flood protection function of the existing interecepting and flood pumping system. The storage and treatment concept was considered to be the state-of-the-art CSO technology at that time.

The CSO control plan entailed the following design parameters: a) every overflow would be disinfected; b) the proposed facilities would provide the equivalent of primary treatment for events up to design storm (1 year) conditions; c) after storms the stored sewage and settled solids would slowly be bledback to the WWTP for final treatment; and d) the entire system would revert to its normal flood protection function during river flood stage.

The plan focused on utilizing in-line and off-line storage. Approximately 18 million gallons (mg) of in-system storage was determined to be available for retention/attenuation of combined sewage through modification of regulators, construction of weirs, restraining of tide gates and other means. In addition, over 18 mg of off-line storage at seven locations was recommended to be constructed to retain and treat wet weather flows in excess of the collection and transmission system's hydraulic capacity. Disinfection was recommended to be provided by injection of chlorine into the influent conduits of each storage basin with a minimum contact time of 15 minutes. Costs for construction of seven off-line storage/treatment facilities (excluding multi-purpose use considerations) and including in-line storage control improvements are estimated to equal $80.6 million (ENR=4500)(2).

Section 2.2 Hancock Street Storage/Treatment Facility

During the mid 70's the first element of the CSO plan was implemented. In 1977 the existing Hancock Street Flood Pumping Station was modified to include a 3.6 mg storage/treat-

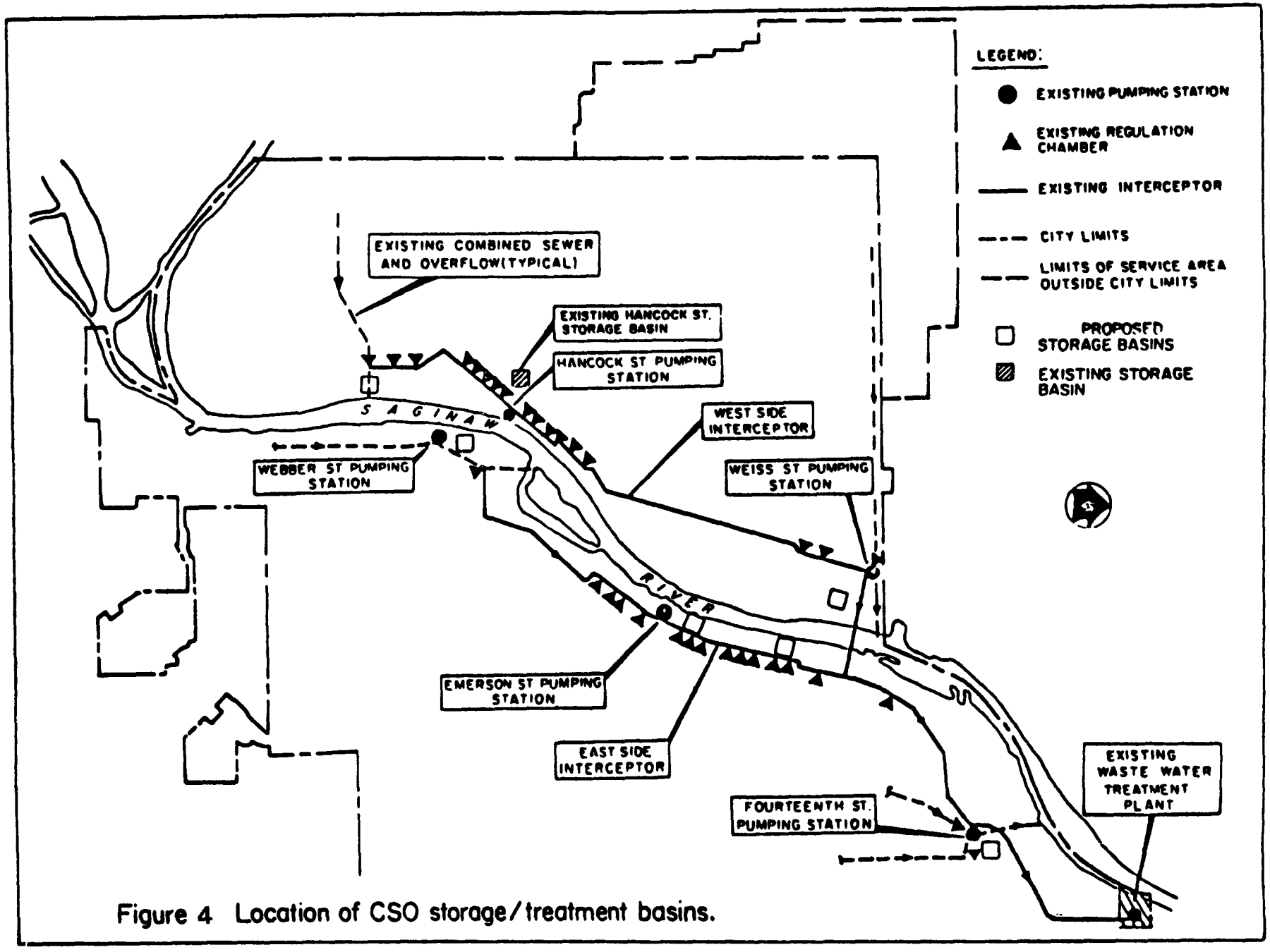

Figure 4 Location of CSO storage/treatment basins.

ment facility. The existing pumping station was upgraded to include electric-driven pumps. A multi-purpose underground storage/treatment facility with above ground municipal parking was constructed. Excluding garage and in-system modification improvements, the capital costs (ENR=4500) of the facility equalled $10.4 million. In-line storage potential of the combined sewers in the Hancock Street area was increased by modifying the existing static regulators in the system. Capital costs (ENR=4500) of the in-line control improvements in the Hancock Street catchment area equalled $.56 million. See Figure 5. Modifications to the regulators included replacing the tide gates at the outfall with motor-operated sluice gates to increase the maximum storage capacity of the system.

During the storm events, combined flows diverted to the interceptor by the regulators activate the Hancock Street pumping station as the interceptor flow level increases. Sluice gates between the interceptor and the pumping station wet well open automatically and pumping is sequentially controlled by sensing the wet well water elevations. All flows to the storage/treatment basins are pumped. During extreme river flooding, the station can be pumped directly to the river bypassing the retention basin.

Combined flows pumped to the Hancock Street facility sequentially fill a series of paired basins. The facilities operate under two types of storm flow conditions: a) for 1 year design storm, the flow will be captured and totally stored, with subsequent release to the interceptor as capacity becomes available; and b) for storm events producing flow exceeding the basin storage capacity, the system will store and treat the combined flow by sedimentation with disinfection of overflow before discharge to the river.

To date, the success of the overall detention/chlorination facility concept has been mixed. Construction costs for the Hancock Street facility exceeded estimates by roughly one million dollars. Suspended solids treatment efficiencies have ranged from 35 to 92%. Chlorination equipment has been inoperative since construction. Recently, severe operating difficulties during intense rainstorms have arisen due to the motor-operated sluice gates in the Hancock Street catchment area. The sluice gates open or close in a finite period of time. If the gates do not open to permit rapidly developing peak flows to overflow, then severe surcharge problems result.

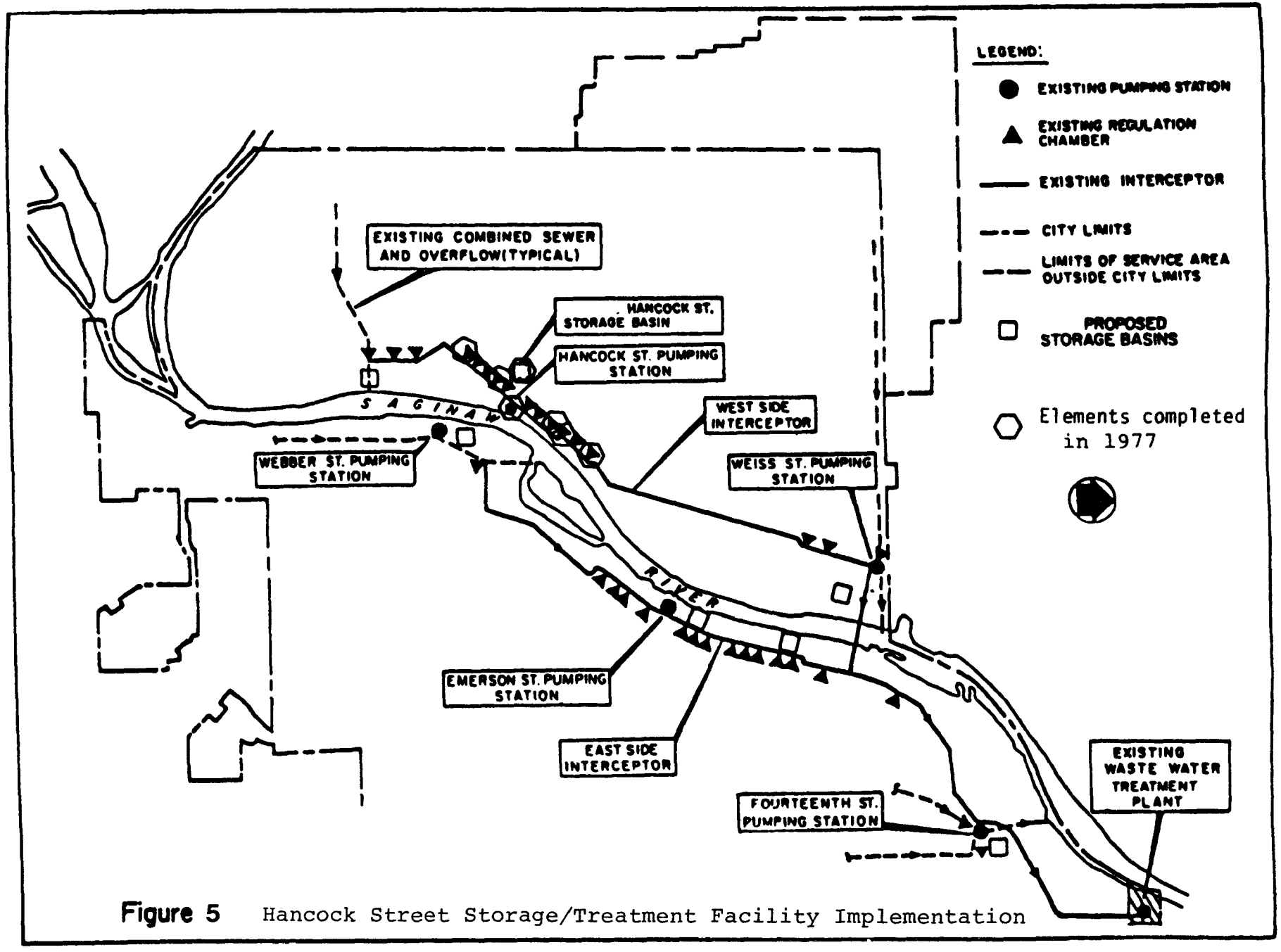

Figure 5 Hancock Street Storage/Treatment Facility Implementation

CHAPTER 3

COMBINED SEWER OVERFLOW CONTROL: 1979 - 1985

Section 3.1 Rationale for Replacement of CSO Facility Plan

During the late 70's developments in CSO abatement technology indicated the potential for treatment of excess wet-weather flows through application of high-rate processes. These high-rate processes were shown to result in the removal of pollutants (especially solids) at an efficiency equivalent to "low end" primary treatment at a fraction of the cost of conventional facilities. One such device is the swirl concentrator, which has been demonstrated to achieve over 40% "first flush" suspended solids removal and a significantly larger fraction of floatables (3).

In view of these new technological developments and the rising inflationary costs of both the envisioned storage and treatment construction programs and the ensuing high degree of operational requirements already experienced, the City of Saginaw applied for, and received a Section 108 grant from the U.S. EPA 108 Great Lakes National Program, Region V. The grant is entitled, "Demonstration Grant for Control and Treatment of Stormwater from Combined Sewer Overflows in Saginaw" and was funded to implement and evaluate on a full-scale basis new innovative low-cost technologies for mitigating CSO discharging from the City of Saginaw sewerage system into the Saginaw River. The 108 Program and subsequent funding was established when Public Law 92-500 came into existence for the purpose of demonstrating promising technologies for abating CSO and stormwater pollution impacting the Great Lakes. Approximately $1.1 million was allocated to the project. Environmental Design & Planning, Inc. (EDP) was the engineer for the project.

Section 3.2 Overview: 108 Demonstration Grant

The project progressed from 1979 until 1985, culminating with implementation and evaluation of a number of system improvements. The overall work effort consisted of three separate phases. Within Phase 1 EDP prepared a feasibility study in which the most cost effective means of treating CSO using new state-of-the-art technology were established. During this phase a CSO Facility Plan was developed and adopted as well as recommendations for implementing a demonstration project. Several promising demonstration projects were proposed and detailed but the costs exceeded available grant monies. In 1983 (Phase 2) a further investigation was prepared due to a lack of supportive 201 funds to implement several elements of the adopted

CSO Facility Program. Phase 2 efforts were directed at optimizing a reduced scope of work plan for implementation using available funds. In Phase 3 these proposed improvements were designed, implemented and evaluated.

Section 3.3 Phase 1: 108 Demonstration Project

The objectives of the Phase 1 (1979-1981) EDP study were twofold: a) preparation of an alternative overall framework plan for the management of CSO from the City of Saginaw considering, but not limited to, the existing concepts of storage/treatment/chlorination facilities; and b) preparation of a detailed preliminary plan for a portion of the envisioned city-wide plan, entailing implementation of a full-scale demonstration treatment facility devised in such a way that it would form a logical element of the overall CSO Facility Plan.

Runoff simulation studies indicated that the two most effective measures for handling CSO were increased wet weather loadings to the City's WWTP and inclusion of actions termed, "Best Management Practices" (BMP). The BMP program consists of extensive in-line storage and system modifications to increase hydraulic capacity so that the WWTP can handle more wet weather combined sewage. Roughly 2 million cubic feet of new in-line system storage would be generated as a result of this plan. Estimated capital cost of BMP plan equalled $2.7 million ENR=4500).

After implementation of the complete BMP plan, CSO's for heavy to moderate storm events would still remain at six locations: Weiss Street Pump Station, Weiss Street gravity line, Emerson Street Pump Station, Fourteenth Street Pump Station and gravity line (handled as a composite), Webber Street Pumping Station and the Fraser Street Regulator. Swirl solids concentrating facilities were recommended at these locations as the most cost-effective technology for treating these overflows. Optimization analysis of various swirl configurations/sizes at the various overflow points (after implementing the BMP program) resulted in pin-pointing the Weiss Street area as the most significant location for a major swirl concentrator facility.

Although the proposed BMP program elements were the most cost-effective means for abating CSO in Saginaw (see Figure 6), U. S. EPA desired at that time to implement and to conclusively evaluate the effectiveness of the swirl concentrator technology for reducing CSO pollutant loadings. The 24-foot diameter swirl concentrator (design flow - 40 cfs) in Lancaster, Penn. showed significant promise as a new inexpensive technology in comparison to sedimentation/detention for reducing CSO settleable solids and floatables. Although the suspended solids removal results,

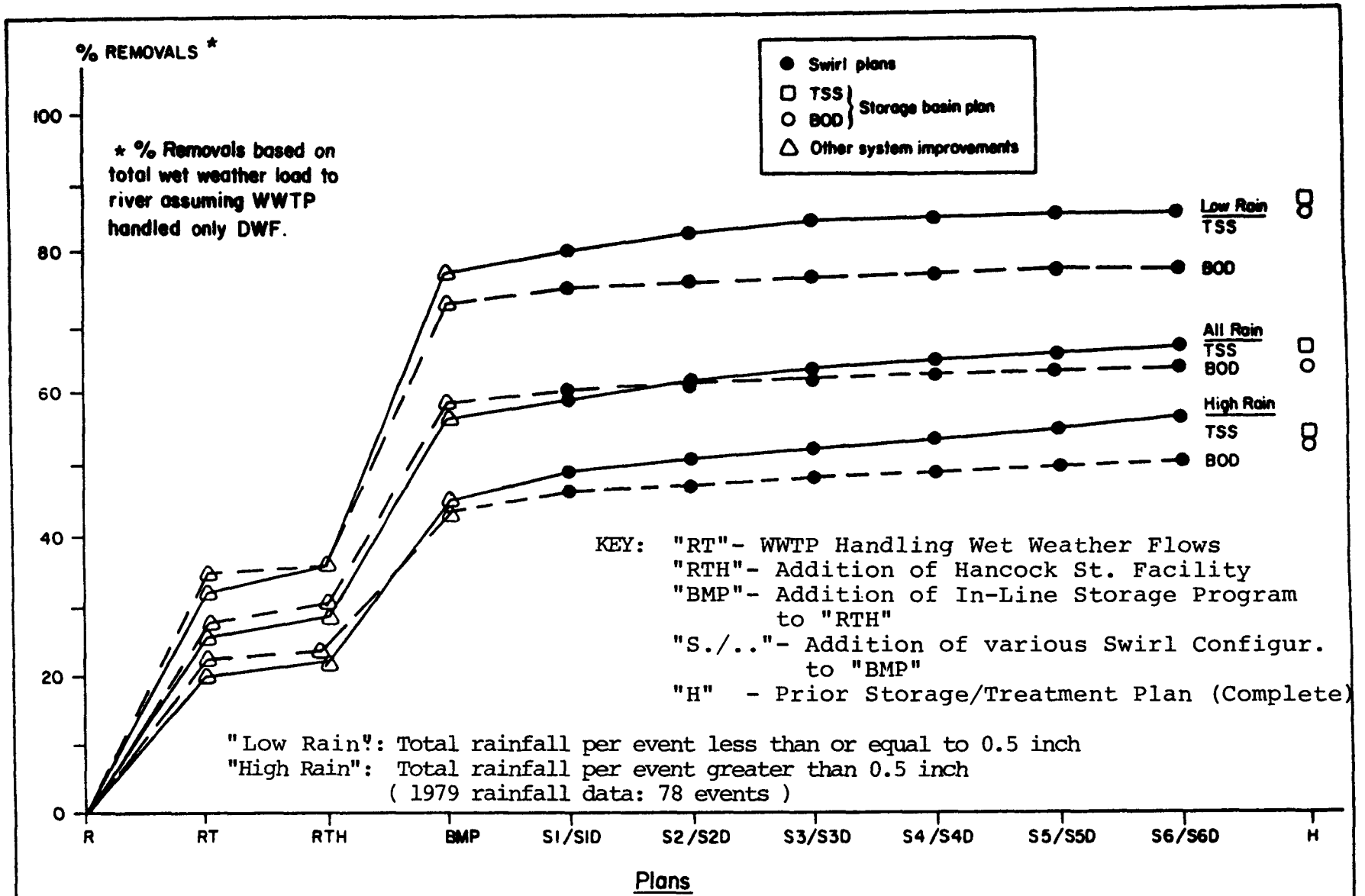

Figure 6 Effectiveness of overall preliminary plans.

particularly during "first flush" conditions, were extremely favorable the evaluation program was plagued with numerous flow measurement instrumentation problems. Since a number of swirl concentrators were being incorporated into designs throughout the U. S. at that time, U.S. EPA believed that the proposed evaluation program at Saginaw would answer any unresolved questions remaining from the Lancaster experience. It was also desired by U.S. EPA at that time to construct and evaluate a swirl concentrator of larger physical dimensions than the device at Lancaster to expand the evaluation experience for this emerging technology.

The Phase 1 study (4) recommended three alternative swirl concentrator demonstration facilities located at the Weiss Street gravity overflow, at the Weiss Street Pump Station discharge and at the gravity discharge at Fourteenth Street. The facility at the Weiss Street gravity overflow was preferred.

Section 3.3.1 New CSO Facility Plan - Phase 1

Because of the significant cost savings associated with the City-wide CSO control program reported during the Phase 1 feasibility study and as a mechanism to facilitate Section 201 Construction Grants funding to partially support the costs of the proposed demonstration project at Weiss Street, EDP was instructed in mid 1980 to expand the Phase 1 study into a proposed CSO Facility Plan for the City of Saginaw (5). In January, 1981 the proposed CSO Facility Plan was adopted by the City of Saginaw and is depicted in Figure 7. A comparative overview of the new CSO Facility Plan with the prior storage/treatment program is depicted in Table 1.

The major components of the adopted CSO Facility abatement program are as follows:

A: BMP program implementation

B: Swirl Concentrator Facilities at:

	Design Capacity
Weiss Street Pump Station	300 cfs
Weiss Street Gravity Line	100 cfs
Emerson Street Pump Station	300 cfs
Fourteenth Street Pump Station*	50 cfs
Webber Street Pump Station	50 cfs
Fraser Street	50 cfs

* Also Gravity Discharge Line

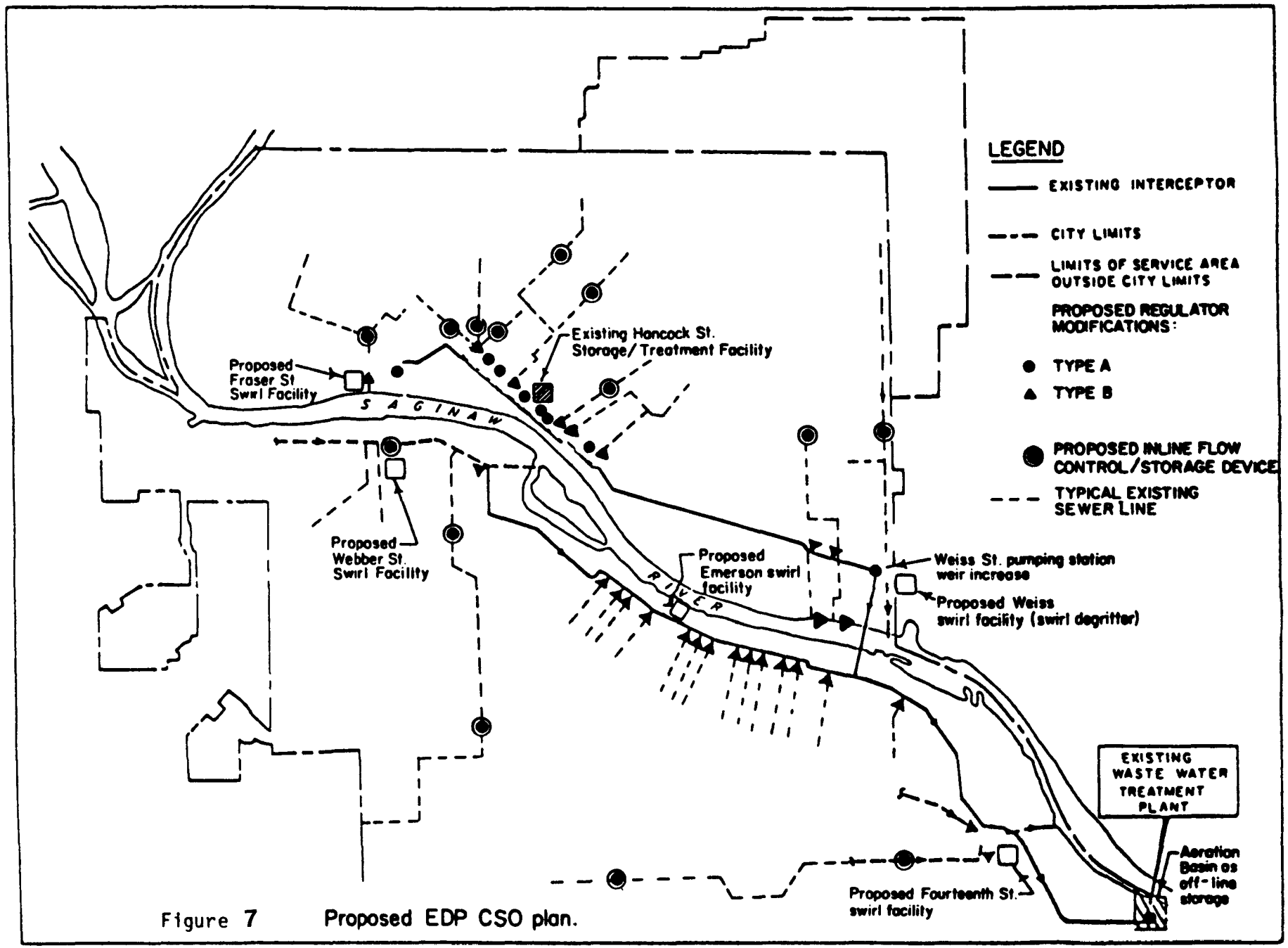

Figure 7 Proposed EDP CSO plan.

TABLE 1

COMPARISON OF RECOMMENDED PLAN
AND ALTERNATIVE PLAN

Basic Technologies	Swirl Concentrator Swirl Degritter Chlorine/Chlorine doioxide Sequential Disinfection In-line Flow Control for In-system Storage	Storage/Sedimentation Basin Chlorine In-line Flow Control for In-system Storage
Description	BMP Plan (1980) Management practices System modifications In-line storage Swirl/Disinfection Facilities at 6 overflow locations Swirl Degritter at Weiss Complex (contingency)	In-line storage (1974) Storage Basins/Disinfection facilities at 7 overflow locations
Effectiveness	56% TSS removal 50% BOD removal Significant floatables removal Greater than 90% settleable solids removal	52% TSS removal 55% BOD removal Significant floatables removal Greater than 90% settleable solids removal
Capitol Costs (Million $) (ENR=4500) TOTAL	23.7	80.6 (w/Hancock) 70.2 (w/out Hancock)
Operation and Maintenance (Annual, 1985 Million)	.49	.76

A. Description of Complete BMP Program

The BMP program concept is to maximize in-line storage already available in the system conduits and conveyance of storm flows to the WWTP. To actualize this plan, the existing regulators were to be modified and new "second tier" in-line control structures were to be installed to increase in-system storage.

It was envisioned to alter 24 regulators with vortex valves to yield a constant discharge during initial storage filling, with excess flows beyond available storage (for small to moderate storms) diverted to the interceptor rather than the river. In addition, the five modified Hancock area regulators (modified as part of the Hancock Street Detention Facility Implementation in 1977) were to be replaced with constant underflow discharge devices (vortex flow valve regulators) to increase the "first flush" diversion to the interceptor and maximize the use of the interceptor throughout the storm event. Furthermore, five other regulators of smaller size were to be altered with weirs to divert all flows to the interceptor. Existing weirs at all 34 regulators were to be modified to enhance in-system storage and to maximize flow to interceptor. Fourteen upstream structures with vortex valve flow regulators were to be constructed to yield additional in-line flow control for storage upstream of the regulator chambers. The resulting changes to the regulator operations would achieve the maximum useable in-line storage potential of the system.

An increased weir elevation of five feet was to be imposed at the Weiss Street Pumping Station to reduce pumped overflows at that point and increase the flow across the river crossing and into the East Side Interceptor. This improvement would maximize West Side "first flush" passage to the WWTP.

B. Description of Swirl Concentrator Complexes

Swirl concentrator facilities were proposed at each of the six major overflow points. The facilities were to be tailored to the particular needs of each site. Pumping stations to drive the swirls were considered necesssary at each site. New lift stations were to be included for the Weiss Street gravity overflow and for the Fraser Street overflow. A battery of various size fixed speed pumps were considered for these stations. The existing 100-cfs fixed speed pumps were to be used (after revamping/turning) for all other stations as required. New low capacity (25-40 cfs) fixed speed pumps were to be included in all revamped stations to provide variable pumping range using the revamped fixed speed 100-cfs pumps. The

Fourteenth Street swirl facility was to handle combined gravity line and pump station discharge (subject to further hydraulic and locational studies).

A swirl degritter at the Weiss Street complex may be necessary if the proposed City-wide system of swirl concentrators were implemented and pending a careful review of WWTP grit removal capacity under sustained wet weather high flow conditions. This degritter contingency was proposed to ensure that the WWTP's solids handling capacity would not be overtaxed.

Section 3.4 Description of Three Efforts to Develop the Demonstration Project - Phase 1

Three alternative CSO treatment configurations were investigated in detail so as to provide a suitable demonstration project. It was anticipated that the 201 program might lend partial financial support for the project given that a Facility Plan had been developed and that program elements had been placed on a priority list for funding. Unfortunately, 201 funding never materialized and final selection of a demonstration program occurred in Phase 2.

Alternative 1: Weiss Street Swirl Concentration Demonstration Project

Although the magnitude of the overflow at Weiss Street greatly exceeded those at other locations, City-owned land space to construct the proposed facility (see Figure 8) was extremely limited. Design of the proposed swirl concentrator facility at Weiss Street was curtailed due to the envisioned long and protracted period required to acquire the necessary land. Estimated construction costs and evaluation equalled $3.1 million (ENR=4500).

Alternative 2: Proposed Weiss Street Demonstration Project: Dunker's Floating Tank System

In December, 1980, U.S. EPA introduced Karl Dunkers to EDP as he was touring the United States marketing a new innovative, extremely cost-effective, flow-storage technology. Karl Dunkers is an independent Swedish research engineer and inventor and was commissioned by the National Swedish Board for Technical Development. In the mid-70's Dunkers experimented with and obtained an international patent for a pontoon tank system to equalize inflow in a two fluid media system using plug flow principles.

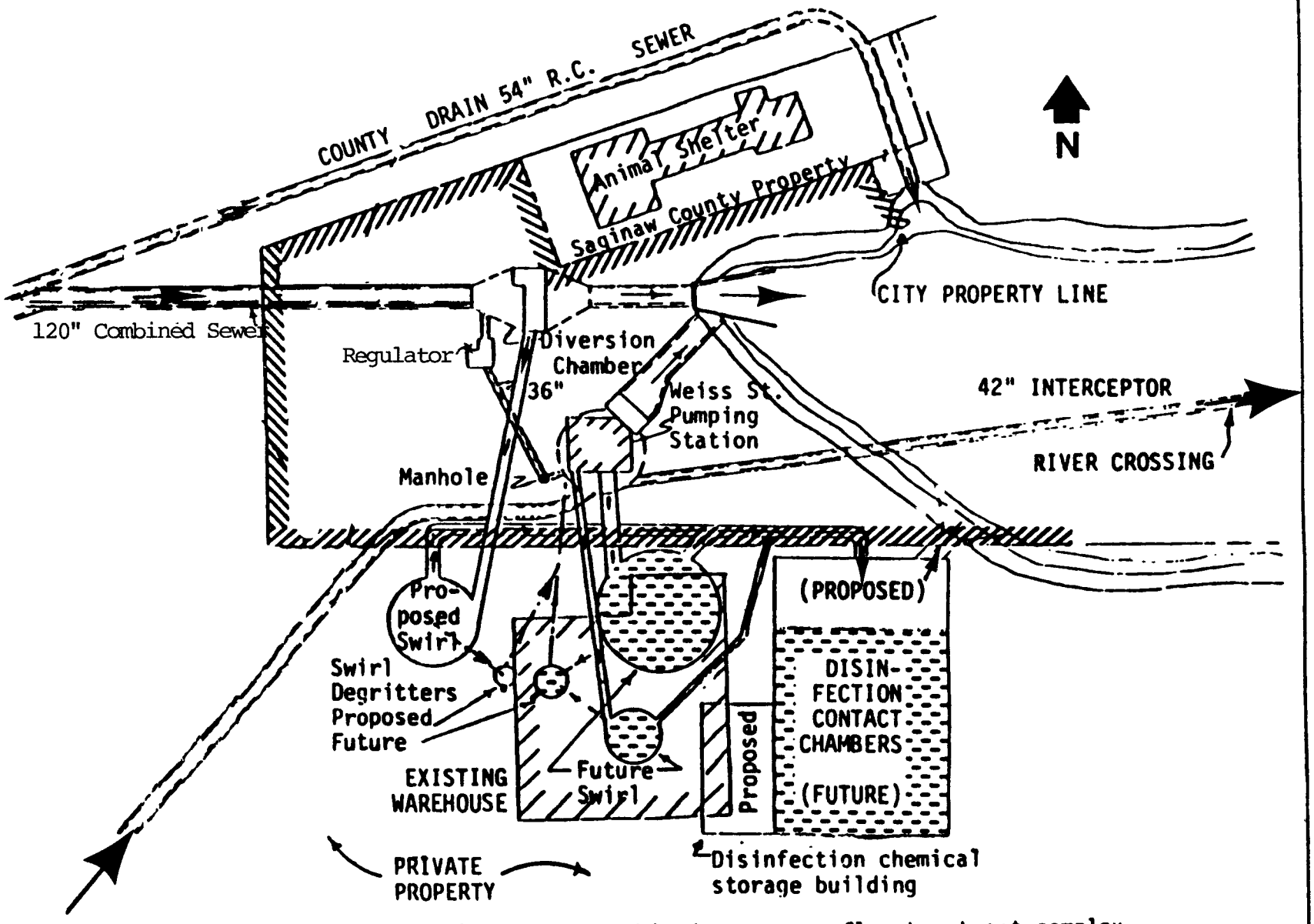

Figure 8 Layout of Weiss Street combined sewer overflow treatment complex.

During the course of discussions with Dunkers, EDP was initiating contract work for plans and specifications for the section 108 swirl technology demonstration project designated for the Weiss Street area. At that time EDP was informed by the City of the adverse unresolvable land problem at Weiss Street, effectively precluding this site from consideration as a swirl demonstration site. The Dunker's approach minimizes dry land requirements and its application for the Weiss Street area was obvious as a means of storing CSO with later bleedback to WWTP. EDP was immediately directed to investigate this technology as a potential demonstration project.

In principal, Dunkers' device creates in a fluid, through a pontooned celled system, a means of inputting extraneous fluid (stormwater/CSO) while displacing currently stored fluid (lakewater) in a plug flow manner. After the storm event the reverse pattern is created. For a small runoff event, only one or more of the cells are used and since the device is finite, it can be overflowed during a large event. The relative efficiency in transferring flows through plug flow operation is determined by the number of cells and relative placement.

A conceptual plan view layout of the Dunkers' pontoon tank system in the (900 foot long, 100-200 foot wide, 6-10 feet deep) man-made channel connecting the Weiss Street CSO to the Saginaw River is depicted in Figure 9. The present channel was formed in the mid 50's when the interceptor river crossing was constructed. Low, average high river elevations are 79.0, 81.0 and 84.0 feet, respectively. The channel volume up to elevation 79.0 is estimated to be 0.8 million cubic feet under present alignment conditions (6).

The project concept would be as follows. CSO discharging from both the Weiss Street pumping station and the gravity trunk are to be captured in Dunkers' system subject to the volumetric limitations of the channel (as improved) during a given storm event. Discharge (volume) from both the Weiss gravity/pumped discharge would be automatically monitored and total volume discharged into the pontoon system noted. Following the event, the stored overflows would be pumped back into the interceptor river crossing during suitable dry weather flow conditions.

Total estimated construction cost including extensive channel improvements (excluding evaluation) is about $1.6 million (ENR=4500). It was estimated that the Dunker's storage system would capture on the average, about 62% of all CSO from Weiss Street with subsequent bleedback to high-performance WWTP. Overall, this approach was more cost effective than the earlier land based storage /treatment facility programmed for this location and the swirl concentrator complex proposed in the new facility

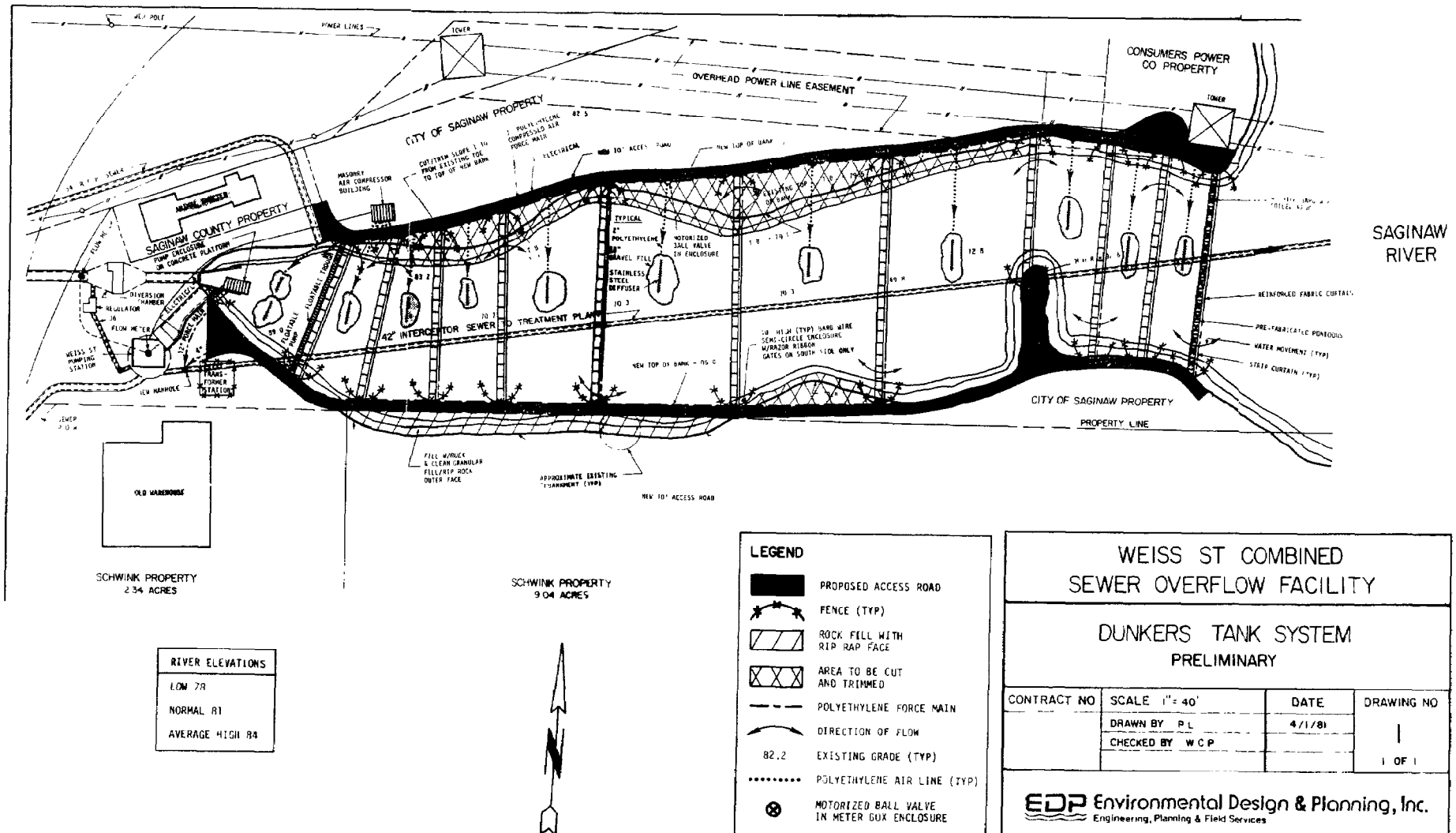
POWER LINES
TOWER
OVERHEAD POWER LINE EASEMENT
CONSUMERS POWER CO PROPERTY
CITY OF SAGINAW PROPERTY
SAGINAW COUNTY PROPERTY
PUMP ENCLOSURE ON CONCRETE PLATFORM
DIVERSION CHAMBER
REGULATOR
FLOW METER
WEISS ST PUMPING STATION
NEW MANHOLE
MASONRY AIR COMPRESSOR BUILDING
ELECTRICAL
TYPICAL
STAINLESS STEEL DIFFUSER
MOTORIZED BALL VALVE IN ENCLOSURE
42" INTERCEPTOR SEWER TO TREATMENT PLANT
NEW TOP OF BANK
REINFORCED FABRIC CURTAIN
PRE-FABRICATED PONTOONS
WATER MOVEMENT (TYP)
STRIP CURTAIN (TYP)
SAGINAW RIVER
CITY OF SAGINAW PROPERTY
PROPERTY LINE
FILL W/ROCK & CLEAN GRANULAR FILL/RIP ROCK OUTER FACE
APPROXIMATE EXISTING EMBANKMENT (TYP)
NEW 10' ACCESS ROAD
OLD WAREHOUSE
SCHWINK PROPERTY 2.34 ACRES
SCHWINK PROPERTY 9.04 ACRES
RIVER ELEVATIONS
LOW 78
NORMAL 81
AVERAGE HIGH 84
LEGEND
PROPOSED ACCESS ROAD
FENCE (TYP)
ROCK FILL WITH RIP RAP FACE
AREA TO BE CUT AND TRIMMED
POLYETHYLENE FORCE MAIN
DIRECTION OF FLOW
82.2 EXISTING GRADE (TYP)
POLYETHYLENE AIR LINE (TYP)
MOTORIZED BALL VALVE IN METER BOX ENCLOSURE
WEISS ST COMBINED SEWER OVERFLOW FACILITY
DUNKERS TANK SYSTEM
PRELIMINARY
CONTRACT NO
SCALE 1" = 40'
DATE
DRAWING NO
DRAWN BY P L
4/1/81
CHECKED BY W C P
1
1 OF 1
EDP Environmental Design & Planning, Inc.
Engineering, Planning & Field Services

FIGURE 9

plan. This concept was proposed as a demonstration project but did not proceed due to the level of available funding.

Alternative 3: Webber Street Swirl Concentrator Facility

In mid 1981 it appeared that 201 funding support seemed probable and EDP was instructed to re-direct efforts for placement of the proposed swirl concentrator facility at an alternative location within the City. The alternative facility was nevertheless to be constructed as a logical and congruent element of the overall adopted CSO Facility Plan. The Webber Street Pumping Station area was chosen as the new location to place the proposed demonstration facility. An analysis of this catchment was conducted supported by detailed field measurement programs so as to increase the technology scale of the swirl concentrator (80 cfs) from the scale (50 cfs) proposed in the CSO Facility Plan (7).

In 1981-1982 EDP prepared construction plans, specifications and bid documents for a new treatment complex consisting of an in-line diversion structure controlled by vortex flow regulation devices to direct flow to the existing pump station, with lift by a new 80-cfs pumping plant, on to a 38 foot diameter swirl concentrator. See Figure 10. The cost of the facility was estimated to be approximately $2.0 million (ENR=4500).

Approximately $.75 million was remaining from the 108 grant and additional 201 funding became unavailable. It was forcasted that this low status would remain for the next several years and it was finally decided by U.S. EPA to indefinitely postpone the proposed demonstration swirl concentrator project.

Section 3.5 Phase 2, 108 Demonstration Project

In early 1983, U.S. EPA and the International Joint Commission (IJC) (U.S. and Canada) became interested in developing phosphorous limitations for the Great Lakes revolving around a number of promising BMP practices controlling agricultural and urban runoff phosphorous loadings. Sewerage system management employing system controls to inexpensively maximize transient in-line storage with bleedback to WWTP's with high performance treatment was identified and viewed by U.S. EPA as a promising management prospect in view of the continuing low federal funding profile for the next several years. Since a number of the major sewerage systems impacting the Great Lakes are combined, relatively flat and discharge to high performance WWTPs, the notion of evaluating inexpensive system storage and hydraulic optimization in Saginaw was attractive, feasible and

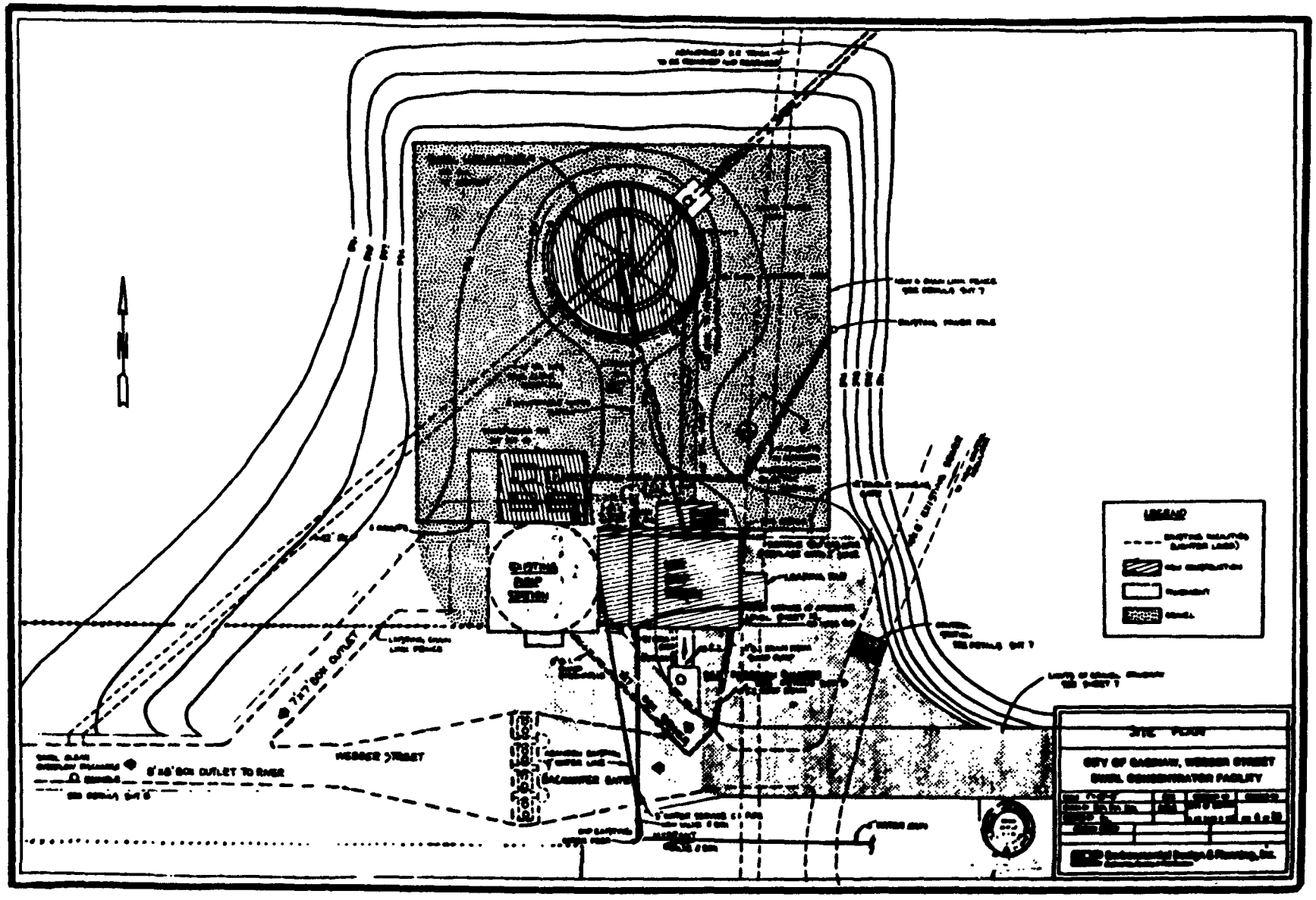

Figure 10 Webber Street Swirl Facility

logically extendable to other areas within the Great Lakes region, if proven to work.

On instruction in April, 1983, EDP embarked on Phase 2. The objective of the Phase 2 evaluation was to determine the optimum implementation plan for the reduction of CSO impacts to the Saginaw River based on available money and the elements of the overall CSO Facility Plan. Optimization included cost estimation of each plan element followed by a series of model simulations using various combinations of elements within the total allotted project budget.

As a first step, additional field evaluations of flow patterns at various regulator chambers were performed allowing further calibration of the simulation model. A limited field investigation was performed including continuous water elevation recording at several regulators on each side of the Saginaw River. This data was combined with information routinely collected by City personnel at the Weiss Street and Hancock Street Pump Stations and at the WWTP to estimate area wide hydraulic conditions. Simulations then indicated the optimum configuration for the "Reduced BMP" implementation plan. This plan consisted of modifications to the Saginaw sewerage system only on the West Side of the Saginaw River. See Figure 11 for locations controlled as part of the "Reduced BMP" plan.

Since the entire BMP plan was not to be implemented at this time, it was important that all elements of the "Reduced BMP" plan be designed and implemented such that no modifications will be required in the future. Furthermore, the concept of the total BMP plan was to control the system such that overflows (except for extreme events) would occur only at major pumped discharge points. Since it was not envisioned to modify the Emerson Street Pumping Station at this time (for automatic "turn-on"), the "Reduced BMP" plan was designed such that no additional capital expenditure for pumpage and/or adverse operational problems would occur as a result of the implementation. It was for these reasons that improvements were only programmed for the West Side.

As part of the "Reduced BMP" plan, 13 of 34, of the City of Saginaw's combined sewer regulators were to be modified in accordance with the CSO Facility Plan Concept. One of the 14 upstream in-system type structures was also to be constructed. See Figure 12. The Weiss Street Pumping Station weir/wet well operation was to be modified to increase river crossing discharge so that more of the West Side "first flush" is transmitted to the WWTP.

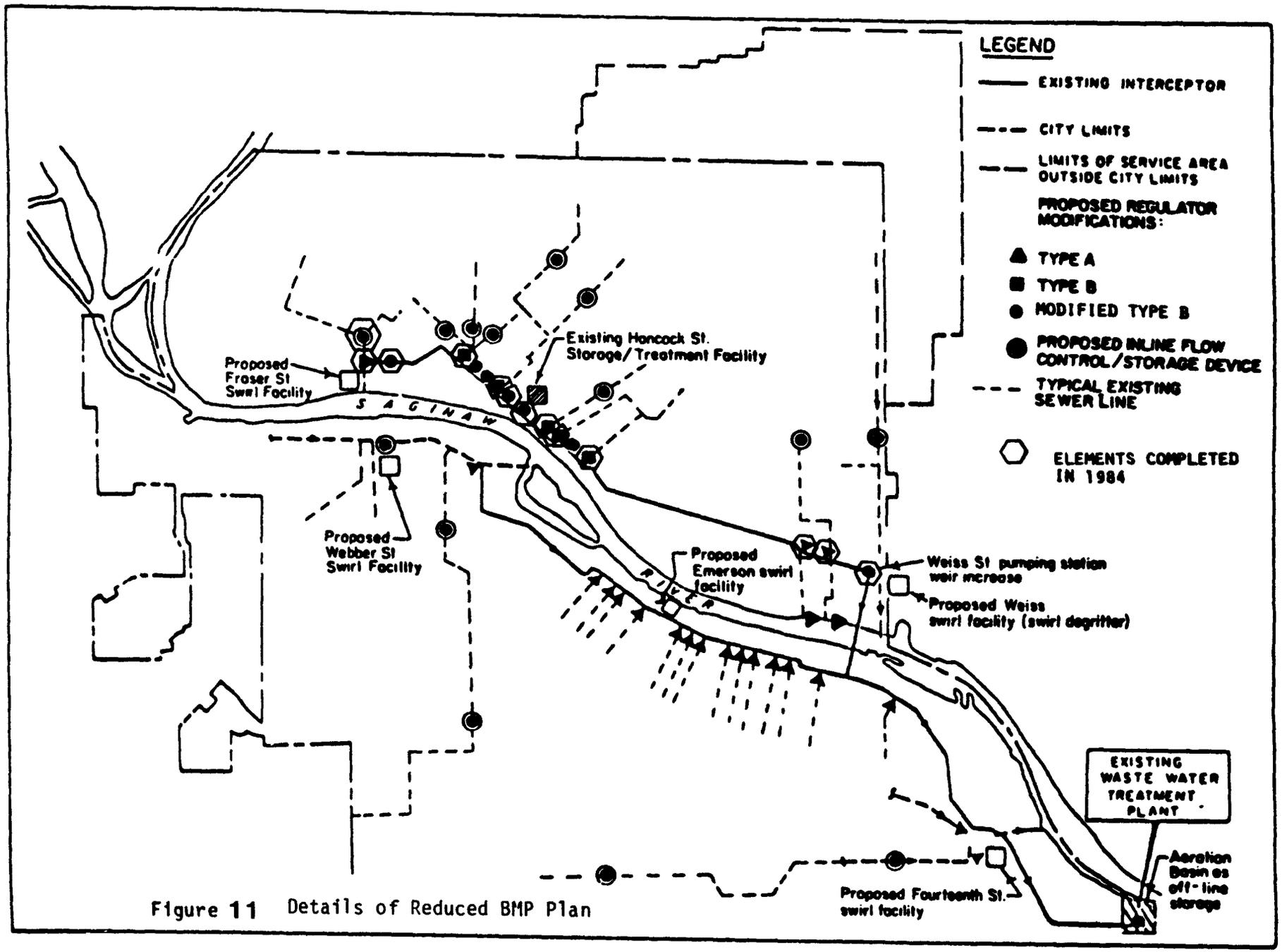

Figure 11 Details of Reduced BMP Plan

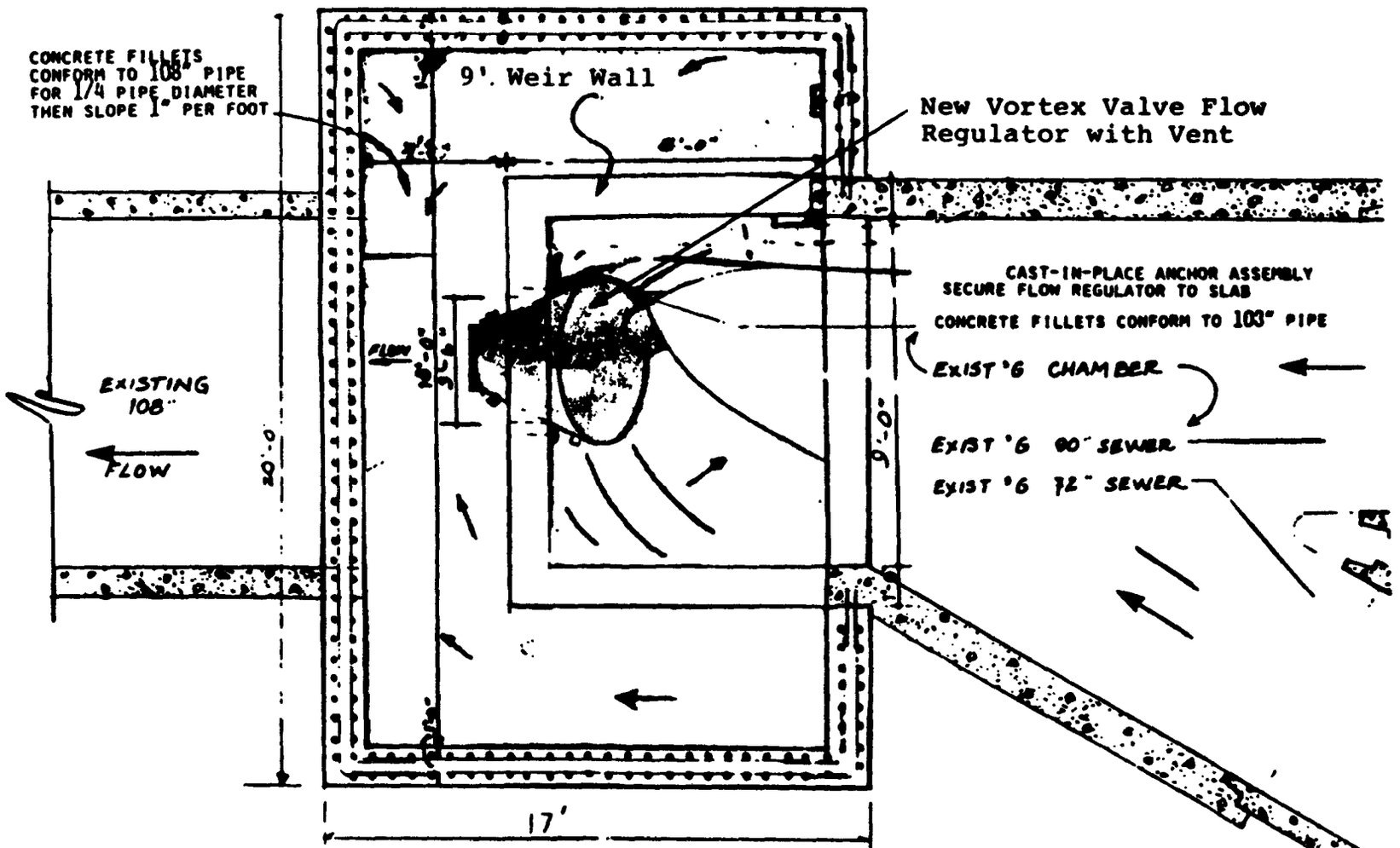

Figure 12 Salt and Vermont Streets Chamber - Plan View

Section 3.6 Phase 3, 108 Demonstration Project

In April, 1983, EDP was instructed to proceed with an implementation program for the "Reduced BMP" Plan and to prepare construction plans and specifications. In March 1984, the construction contract was awarded to Gary D. Steadman, of Bay City, Michigan. Advanced Fluidics, Inc. supplied the vortex valves for the project. The construction began in April, 1984 and was completed in September, 1984.

The Phase 1 EDP sewerage system simulation model was used to estimate City-wide emissions pre/post "Reduced BMP" plan implementation. Flow measurements using automatic equipment were made at a number of representative regulators as part of the Phase 3 preproject conditions. After the "Reduced BMP" plan project was implemented, flow measurements were conducted to document the effectiveness of the implemented controls on a representative basis. A limited post-implementation water quality sampling program was conducted using automatic sampler techniques.

Detailed observations were also noted by City maintenance personnel during routine post storm inspection of regulator chambers to determine physical conditions. One aspect of the "reduced BMP" plan was to include low maintenance flow regulating devices to replace the existing float-operated type. These existing devices required frequent maintenance and were subject to failure. The new vortex valve flow regulating devices performed satisfactorily and have reduced maintenance problems.

Structural changes to regulator chambers were intended to improve system storage capacities and flow hydraulics without causing excessive surcharge or in-system sedimentation. Degree of backwatering was noted at numerous locations upstream in the sewerage system. Debris accumulations in all regulator areas and sedimentation in dry weather flow channels were particularly noted. These observations served to document the reduction in maintenance labor provided by "Reduced BMP" plan implementation.

The post implementation documentary effectiveness of the "Reduced BMP" plan improvements in terms of increased wet weather pollutant loadings to the WWTP was close to pre implementation predictions. Expenditures of $.504 million (1984 ENR=4500) under the "Reduced BMP" plan for low level sewerage system modifications (entailing a significant portion of proposed controls for one-half of the City) resulted in decreasing the average annual system-wide total phosphorous wet weather loadings to the river by about 10%. Annual reductions for solids and organic loadings to the river averaged about 20%. No adverse conditions resulted from the plan.

Detailed conclusions and specific recommendations deriving from the Phase 3 program are presented in Appendices A and B, respectively.

In sum, the concept of inexpensive system controls to maximize transient in-line storage of combined sewage with bleedback to a high performance WWTP worked well and is recommended as a management practice.

APPENDIX A

108 DEMONSTRATION PROGRAM CONCLUSIONS

EDP has completed a five year 3 Phased study of CSO pollution from the City of Saginaw, Michigan and concludes that CSO pollution in Saginaw is controllable at reasonable costs. Pertinent conclusions associated with the BMP program are detailed in the following order:

PLANNING & DESIGN

A. Combined Sewer System Data Reduction Analysis

IMPLEMENTATION & EVALUATION

B. Implementation of Reduced BMP Plan
C. Evaluation of Implemented Reduced BMP Plan

A. Combined Sewer System Data Reduction Analysis

Wastewater Treatment Plant

(1) The secondary WWTP had the capacity to handle combined sewage volumes greater than generally flowing to the plant. An analysis of operating records indicated that both hydraulic and treatment capacity for additional loadings were available without impairment of overall WWTP treatment efficiency. Increasing the flow of combined sewage to the WWTP was a primary goal of this study. Pollutant loads to the river are expected to be significantly reduced by increasing flow to the WWTP and storing excesses within the system until throughput capacity becomes available.

(2) Review of daily operating records for 1978-1979 indicated that the BOD removal for the WWTP averages approximately 89% for both wet days and dry days.

(3) Review of WWTP data indicate wet weather total phosphorous removal of 50% without AWT. Non-soluble phosphorous removals are 95% but no soluble phosphorous removal is achieved. The non soluble fraction averages 54% of the total phosphorous.

(4) Advanced Wastewater Treatment (AWT) (pickling liquor or $FeSO_4$ addition) is used, as required at the WWTP to meet effluent standards. Phosphorous removals average 75% with AWT and the

entire additional level removed beyond secondary treatment rates is attributable to a 50% reduction of soluble phosphorous.

Interceptor Sewer Data

(5) The junction of the West Side Interceptor river crossing and the East Side Interceptor was identified as a hydraulic bottleneck. The Weiss Street Pumping Station relieves backwater-/surcharge at the crossing and together with the Weiss Street gravity overflow constitute the dominant CSO in the system.

(6) The intercepting system's major hydraulic bottleneck is the river crossing. Application of additional head to the crossing by raising the weir level at the Weiss Street Pump station would increase flows across the river. A five foot weir height increase was estimated to be optimum.

Regulator Data

(7) Regulators (earlier modifed as part of the Hancock Street Detention Facility improvements (mid 1970's)) had been altered to cause the underflow orifices to close rapidly, limiting flows to the interceptor and thus committing the "first flush" of a rain event to in-line storage created at the chamber. EDP considered it more advisable to maintain higher underflow discharges to the interceptor, limited only to what the interceptor can maximally handle. Operation in this manner will commit the "first flush" of a rain event, generally carrying the highest concentration of pollutants, to the interceptor, and eventually to the WWTP.

(8) It appeared during the EDP inspection program that the mechanical float-operated mechanisms used to regulate flow at the regulation chambers were slow in responding to rising water levels. The City reported that the devices required constant surveillance to maintain operation.

(9) New vortex flow throttling devices having no-moving parts, large aperture openings (in comparison to conventional orifices) constructed of durable material (stainless steel) and reported to be nearly clog-free were envisioned to replace the existing mechanical float operated mechanisms in the regulators.

In System Storage Data

(10) Potential in-line storage capacity in the Saginaw sewer network is extensive. A total storage volume (including interceptors and WWTP aeration tanks) of 3.93 million cubic feet

(29.4 million gallons) has been estimated as available without threatening basement flooding.

B. Implementation of Reduced BMP Plan

(11) Implementation of the "Reduced BMP" plan including modifications of 12 of 34 combined sewer regulators, construction of one upstream in-system storage structure and increasing the effective head at the Weiss Street crossover was completed for the construction price of $315,000.

(12) Modification of regulator chambers was accomplished under controlled conditions such that no dry weather sewage or wet weather combined sewage impacted the river during construction.

(13) Vortex valve flow regulators were constructed and installed in variable arrangements to conform to existing conditions within the regulator chambers. The devices were segmented for ease of installation particularly where access space is limited.

C. Evaluation of Implemented BMP Plan

(14) With the exception of limited pollutant removal at the Hancock Street Facility, all reduction of CSO impact to the Saginaw River is attributable to increased in-system transient storage coupled with increased flow to the WWTP. Prior to this program, it is estimated that on an annual basis, 37.7% of all wet weather related flow would be handled by the WWTP. For "Low Rainfall" events (total rain less than 0.5 inches), 53% of the system wide wet weather flow would be handled by the WWTP.

(15) Implementation of the "Reduced BMP" plan is estimated to have increased the percentage of total annual wet weather flow directed to the WWTP by 14.6% (from a previous "as is" level of 37.7%). For "Low Rainfall" events, this incremental increase in flow directed to the WWTP would be 19%. Implementation of the remaining elements of the complete BMP plan could produce an overall incremental increase of 30% (increasing the total wet weather flow treated at the WWTP to 67.7%). For "Low Rainfall" events, this incremental increase in flow directed to WWTP would be 34.6%.

(16) Implementation of the "Reduced BMP" plan is estimated to have incrementally reduced (beyond "as is" levels) suspended solids loadings to the Saginaw River by 16%, BOD by 20% and total phosphorous by 8.5%. During periods of AWT (pickling liquor addition) at the WWTP, total phosphorous removals will increase

12.6% above pre-implementation levels.

(17) On a weight basis, the "Reduced BMP" plan implementation is estimated to have reduced wet weather suspended solid pollutant loads to the river by 1.4 million pounds per year, BOD by 0.47 million pounds per year and total phosphorous by 3000 pounds per year. Wet weather related total phosphorous loadings are estimated to be reduced by 3000 to 4000 lbs. per year depending on application of AWT.

(18) Incremental TSS and BOD removals of total wet weather loadings to river attributable to implementation of the complete BMP program (when completed) are estimated to equal about 29% and 30%, respectively. Total phosphorous reduction with secondary treatment is estimated to equal 16.7% and with AWT would equal 25% above pre BMP conditions. Mass removals due to implementation of the complete BMP plan (when completed) are estimated as 2.5 million pounds of SS, 0.68 million pounds of BOD and 7000 to 10,000 pounds of total phosphorous (latter estimate when AWT used).

(19) WWTP TSS and BOD removal levels noted during the post construction evaluation period (late 1984) have not diminished, confirming earlier Phase 1 and Phase 2 projections.

(20) It has been determined that the modification of the Weiss Street Station spillover weir level has increased the crossover rate by about 20 cfs under all conditions.

(20) With the exception of a few minor reported incidences of large stick debris cloggage and grease blockage of device handling small flows (0.2 cfs), the flow and solids handling performance of the new vortex valve flow throttling devices replacing the mechanical float-operated controllers within the regulation chambers was satisfactory. No adverse flow backup or sedimentation problems were reported. On one occasion the devices were visually observed to pass "first flush" and scoured solids on draindown. Limited flow calibration measurements indicated that the devices generally operated as per manufacturer's specifications.

(21) The performance of the new in-line control chamber at Salt & Vermont Streets which generated at maximum capacity a transient storage volume of 175,000 cubic feet ($0.57/cubic foot storage) was satisfactory. The new vortex valve flow throttling device which controlled the wet weather discharge from this facility as well as permitting passage of normal dry weather sewage worked extremely well. No blockages, sediment buildup nor adverse backups were reported.

APPENDIX B

108 DEMONSTRATION RECOMMENDATIONS

The conclusions stated in Appendix A clearly indicate the effective use of elements of the BMP plan in reducing CSO to the Saginaw River. To date, the entire BMP plan has not been scheduled for completion as the the funding for implementation of complete facility plan elements is not available. In addition, the 1984 investigation of the system hydraulics during the construction and post evaluation phases indicated areas of system operation where additional review and "fine-tuning" may be necessary in the future due to hydraulic changes induced by implemented elements of the BMP plan.

The following recommendations are presented in order of importance:

1) The "Reduced BMP" plan included modification of only 12 of 34 regulator chambers. All other regulation chambers should be updated to include new vortex flow regulating devices as necessary, and appurtenances designed to maximize storage and minimize bypass to the river.

2) One of 14 proposed upstream in-line storage chambers was completed. Facilities for the remaining locations should be designed and constructed. The recommended order of priority for implementation of these locations is as follows:

In-line Storage Priority List

1. River & Cambrey Streets
2. Birch & Harris Streets
3. Gratiot & Michigan Avenue
4. Cass & Woodbridge Streets
5. Hamilton & Williams Streets
6. Union Avenue & Delaware Street
7. Jackson & Mason Streets
8. MacKinaw Street & Michigan Avenue
9. Troy & Boxwood Streets
10. 17th & Perkins Streets
11. 14th & Norman Streets
12. Hayes Street & Michigan Avenue
13. Weiss & Delaware Streets

The in-line storage facility at Weiss Street and Delaware Street should be completed as part of the CSO abatement program work at the Weiss Street Pump Station complex.

3) Existing gate opening and pump "turn-on" sequencing at the Hancock Street Pump Station should be reviewed to ascertain whether the operation is optimal. The existing monitoring equipment at the Hancock Street Pump Station should be upgraded, if necessary, for the purpose of monitoring station operation in compliance with optimization recommendations.

4) The pump initialization equipment at the Weiss Street Pump Station should be reviewed to optimize turn-on/shut-off elevations and to ascertain whether supplemental operating controls are necessary due to the weir modification performed as part of "Reduced BMP" plan.

5) The operations of the Hancock Street Facility and the Weiss Street Pump Station should be reviewed to ensure that the Hancock Street Station operates prior to the Weiss Street Station during a storm event. During areawide storms, detention storage/treatment currently available at Hancock Street will thus be utilized prior to untreated bypass at Weiss Street.

6) The CSO control facility for the Weiss Street area should be implemented as overflows at this location are still the dominant source of wet weather pollutant load to the Saginaw River.

7) Under extremely high rate conditions, wet weather flow pumped to the WWTP grit chamber is split with partial overflow to the WWTP bypass. Overflow commences at a total rate less than the existing WWPT flow-through capacity. Possible replacement of the WWTP overflow bypass weirs with other equipment may allow initial storm flow containing "first flush" materials to pass to the aeration basins for storage. Later cleaner flows would be bypassed, if necessary due to full basin conditions.

8) Currently potential pump cavitation conditions prevent maintaining WWTP wet well levels at the initial design elevation. Although the City WWTP personnel maintain maximum wet weather throughput whenever possible to the WWTP, the elevations currently maintained, reduce the hydraulic capacity of the interceptor system during major events causing overflow at upstream pump stations. Hydraulic conditions of influent pump intakes at the WWTP wet well should be investigated to determine if baffles, spoilers or intake vanes could reduce cavitation and allow lower operating levels, and result in lesser upstream overflow magnitudes.

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16. ABSTRACT

This report overviews the results of a recently completed five-year combined sewer overflow (CSO) control program in Saginaw, Michigan (10,000 acres, Pop. 85,000) funded by City of Saginaw/U.S. EPA 108 Great Lakes National Program. The implemented control program entailed modification of 13 combined sewer regulation chamber to maximize transient system storage of wet weather combined sewerage for later bleedback to a well-operated Wastewater Treatment Plant (WWTP) having phosphorous removal and ample treatment capacity. These improvements, "the reduced Best Management Practices (BMP) plan", represent a partial completion of the first of two phases of the City's CSO Facility Plan. The objective of Phase I was to maximize WWTP processsing of wet weather combined sewage generated using inexpensive transient system storage (less than $1/cu.ft.) so as to minimize the extent, scale and cost of satellite CSO treatment facilities (Phase II). The swirl concentrator technology was recommended to treat residual overflows remaining after Phase I improvements. Six major facilities were recommended and adopted as part of the CSO Facility Plan. In-system storage is controlled with vortex valve regulators.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
CSO Pollution Suspended solids Stormwater Phosphorus loadings Swirl concentrator Combined sewer Total phosphorus		

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