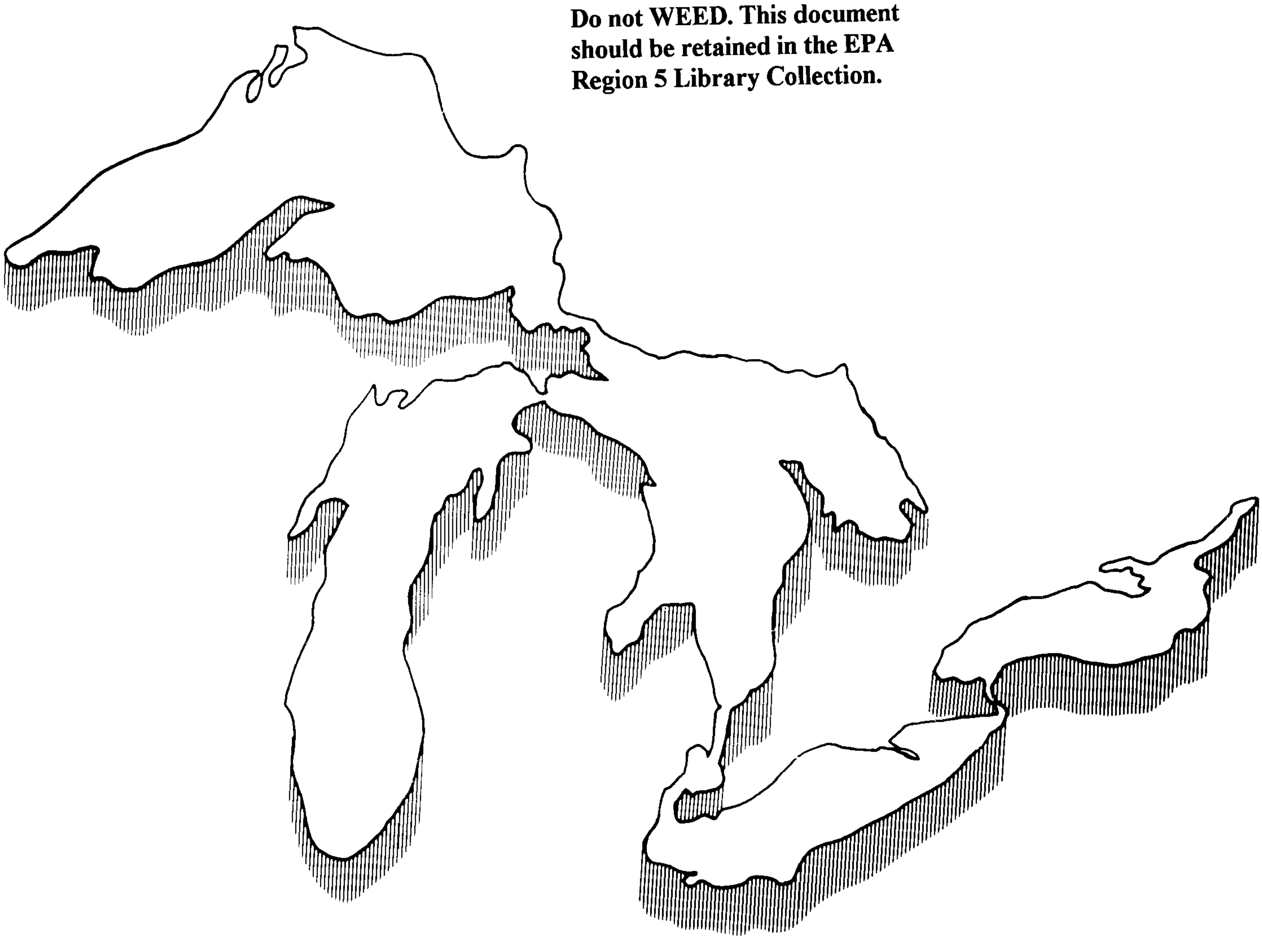
United States
Environmental Protection
Agency

Great Lakes National
Program Office
230 South Dearborn Street
Chicago, Illinois 60604

EPA 905/2-87-005
GLNPO Report No 87-10
July 1987

EPA

Controlling Discharge And Storage in a Combined Interceptor Sewer - Cleveland, Ohio (Hydrobrakes)



FOREWORD

The U.S. Environmental Protection Agency (USEPA) was created because of increasing public and governmental concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimany to the deterioration of our natural environment.

The Great Lakes National Program Office (GLNPO) of the USEPA was established in Region V, Chicago, Illinois to provide specific focus on the water quality concerns of the Great Lakes. The Section 108(a) Demonstration Grant Program of the Clean Water Act (PL 92-500) is specific to the Great Lakes drainage basin and thus is administered by the Great Lakes National Program Office.

This report details the results of a recently completed three and one-half year Combined Sewer Overflow (CSO) study conducted in a residential/industrial area on the west side of Cleveland Ohio. The study involved the in-line storage and controlled discharge of combined sewage flow, generated during a rain event, utilizing a Hydrobrake as the control device.

The object of the study was three fold.

1. To eliminate the combined sewer overflow to Lake Erie.
2. To study the effectiveness of the Hydrobrake when utilized as a flow regulator in an in-line storage situation.
3. To provide an even flow to the Westerly Wastewater Treatment Facility in a rain event.

We hope the information and data contained herein will help planners and managers of pollution control agencies to make better decisions in carrying forward their pollution control responsibilities.

Valdas V. Adamkus
Administrator, Region V
National Program Manager for the Great Lakes

EPA-905/2-87-005
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Controlling Discharge and Storage In A Combined Interceptor Sewer - Cleveland, Ohio (Hydrobrakes)

by

Anthony S. Jordan

Northeast Ohio Regional Sewer District
Cleveland, Ohio

Section 108(a) Demonstration Project
Grant No. S005602

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October 1986

Disclaimer

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ABSTRACT

This report details the results of a recently completed three and one-half year Combined Sewer Overflow (CSO) study conducted in a residential/industrial area on the west side of Cleveland Ohio. The study involved the in-line storage and controlled discharge of combined sewage flow, generated during a rain event, utilizing a Hydrobrake as the control device.

The object of the study was threefold.

1. To eliminate the combined sewer overflow to Lake Erie.
2. To study the effectiveness of the Hydrobrake when utilized as a flow regulator in an in-line storage situation.
3. To provide an even flow to the Westerly Wastewater Treatment Facility in a rain event.

The study area was a 1,400 acre residential/industrial site in the District's Westerly Wastewater Treatment Plant's service area. The combined sewage flow from this area drains to the Northwest Interceptor (NWI). Because of the NWI location and its potential for in-line storage, the District chose to construct seven storage weirs in the Interceptor thereby capturing the first flush in a rain event. A Hydrobrake was installed in each weir wall to provide a uniform downstream discharge. The flow and storage conditions behind the weirs and the resultant uniform downstream discharge was monitored in real time by level sensors and the information was transmitted by telephone data lines to the District's central computer system.

The construction of the weir and the installation of the Hydrobrake resulted in a maximum stored flow of approximately four million (4,000,000) gallons of sewage during each rain event. Previously this is flow that would have been discharged to Lake Erie. The cost of construction including the Hydrobrakes was $155,363 or a cost of approximately $0.04 per gallon of sewage stored.

The Hydrobrake proved to be a cost effective device that when properly installed is capable of reliably and accurately throttling flows, creating storage and allowing a self-scouring drain down action without electrical or mechanical controls and very little human intervention.

This report is submitted as a final requirement of Grant No. S005602-01 by the staff of the Sewer Control Systems Department of the Northeast Ohio Regional Sewer District. The grant was jointly sponsored and funded by a

Section 108 Grant from the Great Lakes National Program Office, Region V U.S.E.P.A. and the Northeast Ohio Regional Sewer District. The report covers the period of September, 1980 to June, 1984. Work was completed with the submittal of this report April 30, 1986.

CONCLUSION:

The Northwest Interceptor is now being utilized as a combination of seven (7) incremental/in-line detention segments separately controlled for maximum effective use of each storage segment. The high efficiency of flow control has significantly reduced the number of combined sewer overflow events to Lake Erie. The reoccurring capture of first flush runoff has improved the efficiency of the Wastewater Treatment Plant as influent dilution is reduced and solids concentration is increased. In addition, the hydraulic effluent fluctuations normally associated with combined sewers has been dampened which aides the wastewater treatment plant performance.

The Hydrobrake has proven to be a self acting regulator that has no moving parts and does not require an outside source of power. It has performed within the boundaries of its predicted discharge rate using only the energy created by upstream flow and the depth of the stored flow at the weir. Maintenance of the sites has not been required, a major factor in determining the cost-effectiveness of the Hydrobrake is demonstrated by the adjoining table.

Storage Capacity gal.	Drainage area acre	Capital *Cost	Storage Cost $/gal.	Cost per Acre $/acre	Annual O&M $/year
3,800,000	1400	$156,363	0.041	111.68	0

*1983 pricing
$/acre x 2.47 = $/ha.
$/gal. x 0.264 = $/L
M gal. x 3785 = m

RECOMMENDATIONS

In conclusion, the District can recommend the use of the Hydrobrake as a safe, cost efficient, maintenance free flow regulator for use in those combined sewer systems with the capacity for in-line storage.

The District's long term experience from this large scale project has proven the use of the Hydrobrake to be a cost effective, viable and safe alternative in automatic flow control of sewers.

The relatively simple construction, installation and the low maintenance requirements are the major factors contributing to the District's recommendation of the use of Hydrobrakes for controlling discharge and storage conditions in a combined sewer.

The Hydrobrake regulators are custom designed to fit each installation. They also can be supplied segmented for assembly in the sewers facilitating installation in either small or large access manholes. The material used in the fabrication for this project was stainless steel with a service life of approximately twenty-five (25) years.

PART 1 INTRODUCTION

1.1 History:

The Northeast Ohio Regional Sewer District, formerly the Cleveland Regional Sewer District was formed by court order June, 1972. The court ruled that the water pollution problems affecting the City of Cleveland and the suburbs could best be solved by formation of a metropolitan or regional sewer district. This ruling transferred all wastewater treatment facilities and interceptor sewers then owned by the City of Cleveland to the new entity.

The Northeast Ohio Regional Sewer District has been established as an independent political subdivision of the State of Ohio. Its purpose is to provide for the environmentally safe collection, treatment and disposal of wastewater generated by homes, businesses and industry in a way conducive to the public health, convenience and welfare.

Today, the District's facilities serve all of the City of Cleveland and all or portions of 40 suburban communities. This area of approximately 178 square miles includes much of Cuyahoga County and part of northern Summit County. Nearly 1.1 million persons are served by the District's facilities.

As is the case with most Metropolitan Areas, the core community (Cleveland) is served by a combined sewer system. Combined sewer systems utilize combined sewer overflows (CSO's) to relieve the sewers when the capacity is exceeded during a rain event. While CSO's provide hydraulic relief to the system, they also often carry high concentrations of pollutants to the receiving waters. The protection afforded to the combined sewer system through the use of CSO is primarily with regard to downstream flooding. The protection in terms of pollution abatement has not been at the same level of intensity.

During the past two decades, numerous reports and studies have been done on CSO's to determine cost effective methods to control the pollution problem. Since its origin, the Northeast Ohio Regional Sewer District has carried on an aggressive pollution abatement program. The District has made major improvements to the three regional treatment plants and completed the construction of approximately thirteen miles of interceptor sewer. As a portion of the capital improvement program, the District has begun to consolidate and control the number of CSO's in the Cleveland area. In 1974 the Northeast Ohio Regional Sewer District began construction on three computer controlled regulators. This system incorporated the use of hydraulic gates on the dry weather outlet (DWO) and inflatable dams on the CSO, along with gauging and telemetry equipment to obtain and relay data to a central computer. This type of system allowed for storage and a reduction in the overflow occurrences. While the method is viable for controlling CSO, it requires a large capital outlay, and a considerable amount of operation and maintenance expense.

In an attempt to reduce the costs associated with controlling CSO, new methods were investigated. One device currently on the market is the Hydrobrake. Originally developed in Europe, it's primary function is to deliver flow to a downstream area at a nearly constant predetermined rate under varying head conditions (see Figure #1).

During July, 1977, the Northeast Ohio Regional Sewer District installed a Hydrobrake in the main diversion chamber for the upper portion of the Northwest Interceptor. This Hydrobrake served two functions. It relieved downstream flooding, and it diverted excess flow during rain events to the lower portion of the Northwest Interceptor. Due to hydraulic conditions in the main diversion chamber flow cannot surcharge enough to create storage in the upper portion of the Northwest Interceptor, but the Hydrobrake still acts as a regulating device to limit downstream flow to 25 cubic feet per second (cfs), (.708 liters per second L/S). Since the installation of this Hydrobrake, downstream flooding has not occurred. Details of the installation of this Hydrobrake will be found in Section 1.2.

In 1978 the Northeast Ohio Regional Sewer District and the City of Cleveland began to investigate further uses of the Hydrobrake. The two entities along with the EPA Great lakes Demonstration Program Office were willing to investigate the effectiveness of in-line and off-line storage using the Hydrobrake. A combined grant was offered by the USEPA to the City of Cleveland and the Northeast Ohio Regional Sewer District to perform this demonstration. The City of Cleveland was to investigate the Hydrobrakes' suitability for off-line storage and the Northeast Ohio Regional Sewer District for in-line storage. Prior to the commencement of the project individual grants were awarded to the City of Cleveland and the Northeast Ohio Regional Sewer District.

District for in-line storage. Prior to the commencement of the project individual grants were awarded to the City of Cleveland and the Northeast Ohio Regional Sewer District.

1.2 Installation of Hydrobrake - W. 117th St. & Detroit Ave.

Immediately downstream of the upper portion of the Northwest Interceptor is a large sidespill weir diversion chamber located at West 117th St. and Detroit Ave., Diversion Chamber No. 1 (see Figure #2). It is in this chamber that a Hydrobrake was installed in 1977. The chamber receives flow from the Northwest Interceptor, through a 108" diameter sewer, and the Detroit Ave. sewer, an egg shaped brick sewer (80" x 64"). Dry weather flow passes through the Hydrobrake to a 30" RCP on West 117th St. In the past, during a rain event, flow in this chamber would surcharge and be discharged eventually to Lake Erie. To reduce the number of discharges to the environment it was determined that storage and controlled discharge from the Northwest Interceptor would be necessary. The flow from the Detroit Road sewer during rain events cannot be stored and controlled for two reasons: 1) Shallow depth of profile; 2) Age and condition of sewer.

In a rain event the flow peaks from the Detroit Ave. sewer reach the Diversion Chamber before the flow peaks from the Northwest Interceptor. This is due to the fact that the drainage area tributary to the Detroit Ave. sewer is in close proximity to the chamber. The first flush being carried into the chamber from the east causes a surcharge condition and is discharged to the environment. This situation is unaffected by the Hydrobrake storage project. The dry weather flow from the Detroit Ave. sewer is approximately 5 cfs. As mentioned before, the Hydrobrake in the Diversion Chamber is rated at 25 cfs. The remaining 20 cfs is the acceptable contribution from the Northwest Interceptor to the Diversion Chamber, without an overflow occurrence. The Hydrobrake storage project gives the opportunity to store flow in the Northwest Interceptor during most rain events and deliver it to the Diversion Chamber at a predetermined rate (approximately 20 cfs) with a time lag sufficient to allow the flow in the Detroit Ave. sewer to return to near dry weather conditions.

The construction consisted of the forming and pouring of a reinforced concrete weir wall in the chamber, approximately 3 feet high, and the installation of a 30" Hydrobrake.

Access to the chamber was via a two foot (2'0") diameter manhole. This access was not large enough to permit entry of the Hydrobrake without extensive construction. As a result the regulator was installed through the outlet pipe at the lakefront through the overflow pipe to Diversion Chamber No. 1.

District personnel transported the Hydrobrake in a boat from a private lakefront property to the outlet and then carried it through the sewer to the Diversion Chamber. The entire operation took 3½ hours.

The procedure related above, was not used for the 7 Hydrobrakes installed in the Northwest Interceptor under this grant. All of the units installed in 1984 were custom designed and fabricated in segments for easy access through existing manholes and assembled in the sewers prior to installation in the weir walls.

1.3 Flow Gauging:

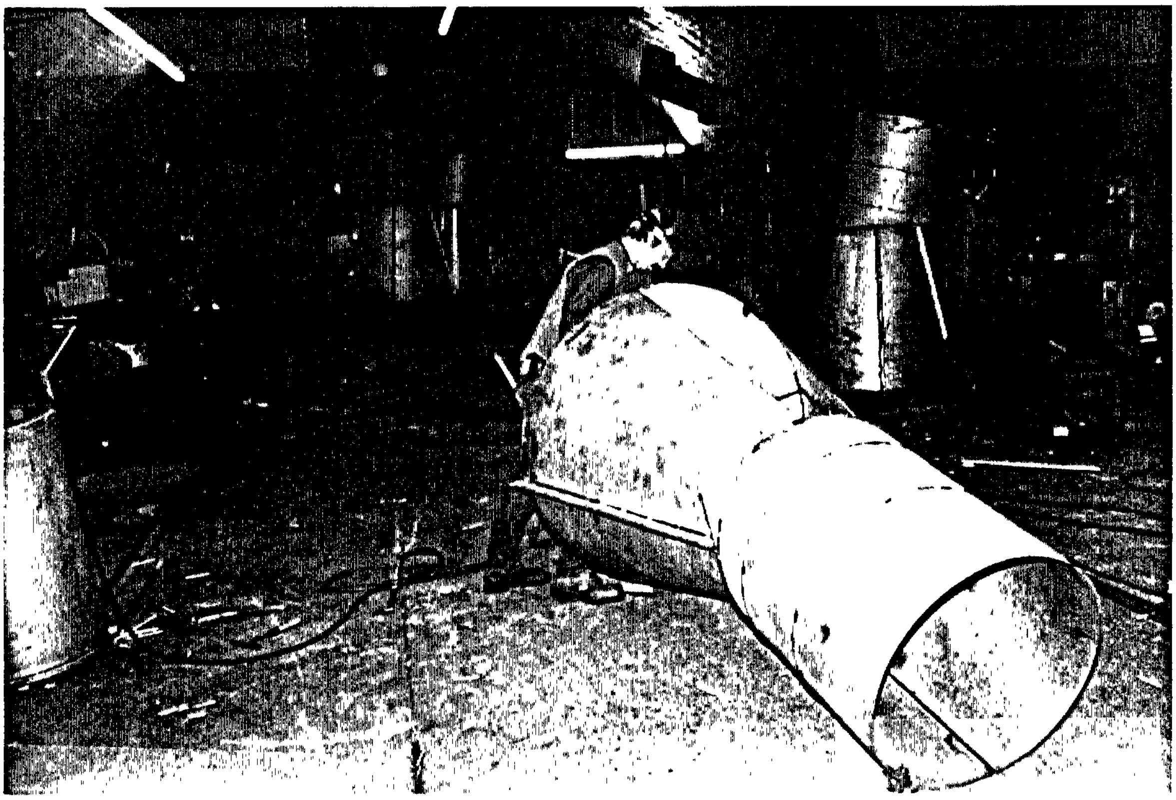
Prior to the construction of the Hydrobrake Project in the NWI, Northeast Ohio Regional Sewer District personnel performed gauging and sampling in the area of Diversion Chamber No. 1. The purpose of the gauging was to determine the pre-construction contribution from each of the areas tributary to the diversion chamber.

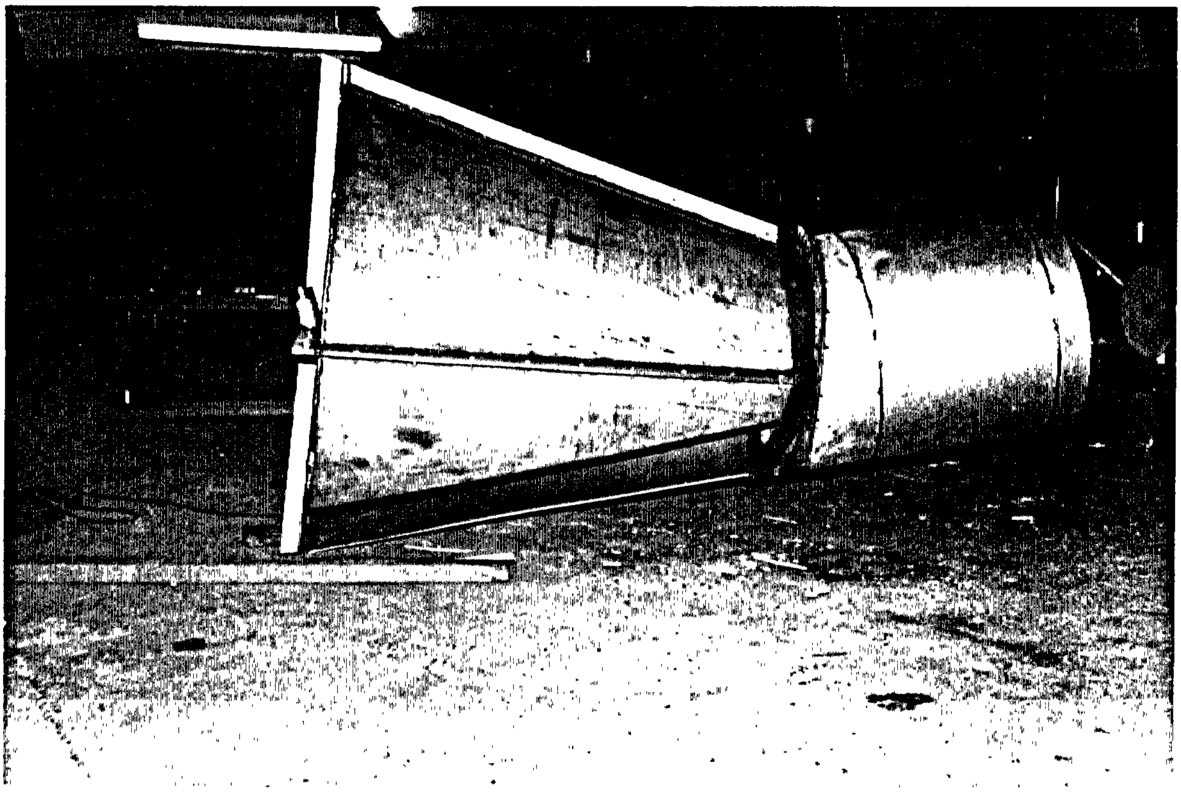
Flow level gauging was installed in this area in the form of permanent level gauges telemetered to the Northeast Ohio Regional Sewer District computer located at Sewer Control Systems. The gauging enabled the District to determine the dry weather and wet weather contributions to the chamber from each of the sewers.

A sampling device was also installed in the overflow pipe, downstream of the diversion chamber on the CSO. The device was equipped with a self actuating mechanism which enables the sampler to begin sampling when flow in the chamber exceeded the fixed weir height.

With this gauging and sampling information it was possible to determine the flow characteristics for the diversion chamber. Simply put, the wet weather flow from the Detroit Ave. tributary area that arrived at the chamber shortly after the start of a rain event. The Hydrobrake which had been installed in the diversion chamber in 1977, acted as a throttling device, but did not create storage due to the low height (approximately 3 ft. at downstream end) of the fixed weir. The flow that exceeded the weir height was therefore discharged to Lake Erie. The net result was that the Hydrobrake Project did not increase nor decrease the amount of flow which was discharged to the environment from the Detroit Ave. tributary area.

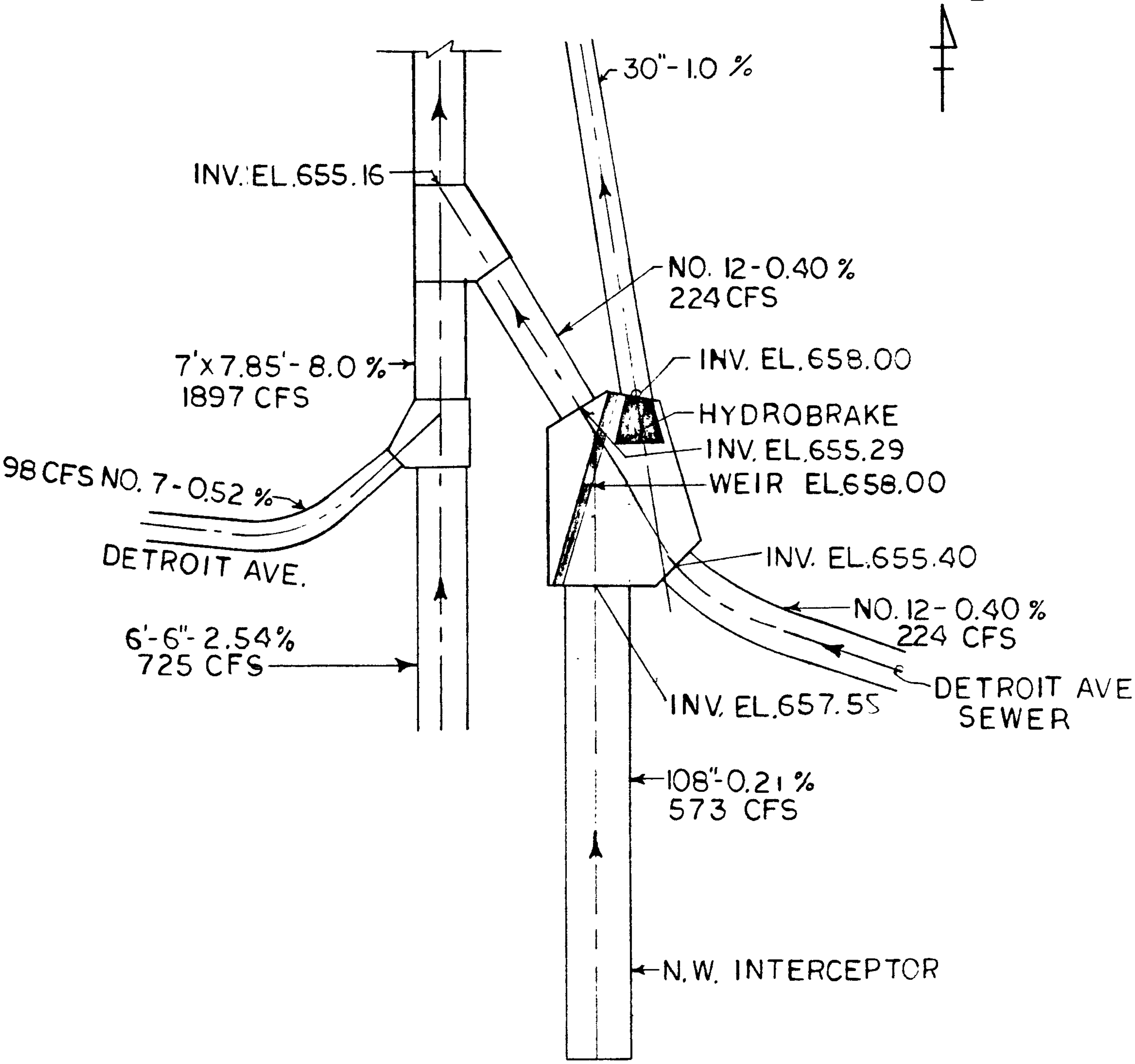
The Hydrobrake Project concerned itself with flow tributary to the upstream portion of the NWI area. As previously stated, due to the distance upstream of this tributary area, the flow arrives at the diversion chamber after the flow from the Detroit Ave. tributary area, even without the Hydrobrakes in place. The Hydrobrake Project is used to increase the time difference of arrival of the flows.





Photographic Views of Hydrobrakes During Factory Assembly

FIGURE #2



DIVERSION CHAMBER NO.1

DETROIT AVE. AT 117 ST.

PART 2 DESIGN METHOLOGY

2.1 Site Selection & Design Criteria:

In order to demonstrate the effectiveness of the Hydrobrake for in-line storage, a suitable location was necessary. Prior to grant application it was determined that the Northwest Interceptor would be ideal for the proposal, as the combined sewer interceptors in the City of Cleveland would not be applicable in this case, due to the large amounts of existing dry weather flow in the sewers.

The Northwest Interceptor is a combined sewer Interceptor that was built in the early 1970's. The sewer varies in size from 24" circular to a 9' x 20' rectangular box. The interceptor approximately parallels the western corporation line of the City of Cleveland from Puritas Ave. and Rocky River Dr. to West 117th St. and Edgewater Dr. At this point it flows east along Lake Erie to Westerly Wastewater Treatment Plant (see figure #3).

The Northwest Interceptor is discontinuous at a point in the area of West 117th St. and Detroit Ave. As mentioned before, a Hydrobrake was installed in this chamber prior to the project. This Hydrobrake could not take advantage of the storage available in the Northwest Interceptor upper portion due to the height of the bypass weir. The upper portion of the Northwest Interceptor offered a suitable location for in-line storage due to its large diameter, low grade, long length, and few connections.

The upper portion (west of 117th St. & Detroit Ave.) of the Northwest Interceptor is approximately 30,000 feet in length. The majority of the pipe is 108" diameter at .21% grade. The length, diameter and grade of this pipe along with the low flow conditions during dry weather made it an excellent candidate for in-line storage.

Seven Hydrobrake locations were chosen to maximize the use of available grant money. The major criteria used for selecting Hydrobrake locations was:

- Manhole locations
- Distance between Hydrobrake locations
- Chamber or manhole configuration

Since the Northwest Interceptor was not fully in service, the first step in the Hydrobrake project was writing specifications, developing plans, and awarding a contract to perform the Northwest Interceptor opening. When the Northwest Interceptor was constructed, several sewer pipes that would be contributing flow to the interceptor remained bulkheaded and flow continued to be received by the local sewers. The Northwest Interceptor opening consisted of removing these bulkheads and abandoning the existing lines. In addition, short lengths of sewer were constructed to connect some of the larger combined sewers to the Interceptor. Original plans for the Northwest Interceptor ended at Puritas and Rocky River Dr. which would have allowed the Northwest Interceptor to carry flow from Grayton Road Pump Station to Westerly Wastewater Treatment Plant. This last leg of the Interceptor was not constructed under the original Northwest Interceptor contract and; therefore, required completion prior to the Hydrobrake Project. This stretch of sewer was completed as a part of the Northwest Interceptor opening. After the construction of the Northwest Interceptor and prior to the Hydrobrake Project the City of Cleveland constructed the Triskett Road Relief Sewer. This sewer connects directly to the Northwest Interceptor in the area of West 140th St. and South Marginal Rd. These two major connections along with twelve other smaller connections contribute all the flow to the upper portion of the Northwest Interceptor.

The Northwest Interceptor opening provided several benefits to the southwest portion of the City of Cleveland. Placing the Interceptor in operation relieved an overloaded local system along Rocky River Dr. All flow from this area of the City of Cleveland is now tributary to a District Treatment Facility. Prior to this time, part of the flow from this area was tributary to the Lakewood Treatment Plant. Also the flow being pumped by the Grayton Road Pump Station was tributary to the District's Southerly Wastewater Treatment Facility. The route that this flow had taken prior to the opening of the N.W.I. did have the possibility of discharging to the environment through a CSO in any rain event. The flow from Grayton Road Pump Station is now in an express route to Diversion Chamber No. 1, and this has significantly reduced the possibility of pump station overflows to the environment.

The possibility of surcharging the Northwest Interceptor to the point where basement flooding would occur is non-existent. There are seven storage locations (Hydrobrake sites) along the length of the Northwest Interceptor (see Figure #4 for the Hydrobrake locations and the project drainage area). The total storage available is approximately 500,000 cubic feet.

In order to install the Hydrobrakes in the NWI, it was necessary to construct storage walls (weirs) for two reasons: to fully take advantage of the storage space in the large diameter sewer; and to act as the installation frame for the Hydrobrake. The storage wall with the hydrobrake installed will cause a back up in the interceptor during rain events. The Hydrobrakes used on this project have a manufacturers discharge rate of 20 cubic feet per second (cfs). When flow in the sewer exceeds this rate it becomes stored behind the wall and the discharge from the Hydrobrake remains relatively constant at 20 cfs even during varying head conditions behind the wall. When storage capacity of the weir walls is exceeded the flow will top the wall with the chance of being stored at a location further downstream.

Seven locations along the NWI were chosen for installation sites. Two of the manholes at these sites are chambers which allowed the construction of a larger weir wall (10 ft. in height) and still have sufficient distance between the top of the wall and the top of the chamber to permit excess flow to continue unobstructed. With the higher weir wall more storage was attained. The remaining five locations are normal tee style manholes. The height of the wall in these locations was limited to six (6) feet. This was to assure sufficient space for excess flow to pass without obstruction.

The four Hydrobrakes in this last upstream section are working in parallel, that is they are all storing flow at the same time. The three sites closer to Diversion Chamber No. 1 work in series. After storage is exceeded at the furthest Hydrobrake from the chamber, it will overflow and begin to store at the next downstream Hydrobrake. When the next sites storage is exceeded it overflows to the final storage site (see figure #5).

Construction of the storage walls and installation of the Hydrobrakes was performed in January and February of 1983. The construction contract for this project was competitively bid and awarded to the lowest and best bid received.

One main contractor was used for approximately 90% of the construction. The remaining 10% was performed by an approved minority business enterprise (MBE) acting as a subcontractor to the main contractor. Construction of this project was intentionally performed during the winter months to take advantage of the reduced chance of experiencing a rain event while working in a live combined interceptor. The project remained on schedule throughout the construction phase.

2.2 Design Solution:

During the design phase it was decided to conduct the in-line detention and controlled discharge study in the Northwest Interceptor. The major factors contributing to this decision were the location of the Northwest Interceptor, its flow capacity, and the relative ease of access to the Interceptor. The actual construction of the weir walls and the installation of the Hydrobrakes was relatively simple and proved to be the most cost effective solution.

2.3 Project Data:

Total area: 1,400 acre (566 ha.)
Type of drainage: Combined sewer
Total length of sewer: approximately 6 miles (10 kilometers)
Difference in elevation: approximately 100 feet (30 meters)
Smallest pipe diameter: 66 inches (1.67 meters)
Intermediate pipe diameter: 84 inches (2.13 meters)
Largest pipe diameter: 108 inches (2.74 meters)
Available Detention Volume: 3,795,000 gal. (14.217m)

2.4 Preliminary Work:

Prior to actual construction of the retaining walls and installation of the Hydrobrakes in the Northwest Interceptor, it was determined that the volume of dry weather flow present in the sewer was excessive for the contractor to perform the necessary construction safely and expediently. In an effort to reduce this dry weather flow, the District diverted flow from the Northwest Interceptor at five (5) locations along Rocky River Drive. Flow presently entering the Northwest Interceptor was temporarily diverted to the Lakewood sewer system at the following locations.

1. Rocky River Drive at Lucille Avenue
2. Rocky River Drive at Marquis Avenue
3. Rocky River Drive at Munn Avenue
4. Rocky River Drive at Fischer Avenue

The contractor accomplished this flow diversion in the following manner. The existing bulkhead in the 24" sanitary sewer running north along Rocky River Drive was removed. A temporary bulkhead was then installed in the 24" sanitary connection to the Northwest Interceptor. This resulted in a surcharge condition in the manhole causing flow to enter the existing 24" sanitary sewer and flow to the Lakewood Wastewater Treatment Plant.

This flow diversion work was initiated on December 29, 1982. During the time period between December 29, 1982 and February 24, 1983, the City of Lakewood was compensated by the District at a rate of $5.24/mcf for treatment of the diverted sewage. Total amount expended by the District for sewage treatment was $65,237. For location of the diversion sites (see Figure #6).

At the Rocky River Dr. and Puritas Rd. site the contractor inserted a 24" inflatable sewer plug into the 24" sanitary sewer connection to the Northwest Interceptor. This diverted flow to the Southerly Wastewater Treatment Plant via the Puritas Road combined sewer. This was completed on January 3, 1983.

During the course of the entire Hydrobrake Project, dry weather flow was not permitted to enter the environment. This flow diversion project reduced the dry weather flow in the Northwest Interceptor from approximately 10" to 4", a more manageable amount of flow for the contractor to work with.

2.5 Description of Hydrobrakes:

A Hydrobrake is a self regulating flow controller fabricated from 1/4" stainless steel. It has a conical shape resembling a space capsule. Each Hydrobrake used for this demonstration project consisted of five separate segments. Each segment weighted approximately 130 lbs. The effluent sleeve which is cylindrical in shape constitutes one segment. The vortex cone was divided into four equal sections. The assembly was performed inside the sewer. The Hydrobrake requires no electrical power but uses static head of stored water to create its own "energy" to retard flow. The movement of water through a Hydrobrake involves a swirl action, dissipating energy to control the rate of discharge. The unit has no moving parts and is virtually maintenance free (see Figure #1).

Two Hydrobrakes had an outlet diameter of:	554mm (21.8")
Five Hydrobrakes had an outlet diameter of:	613mm (24.1")
Largest outside diameter:	1219mm (48")
Largest unit, including sleeve:	1981mm (78")

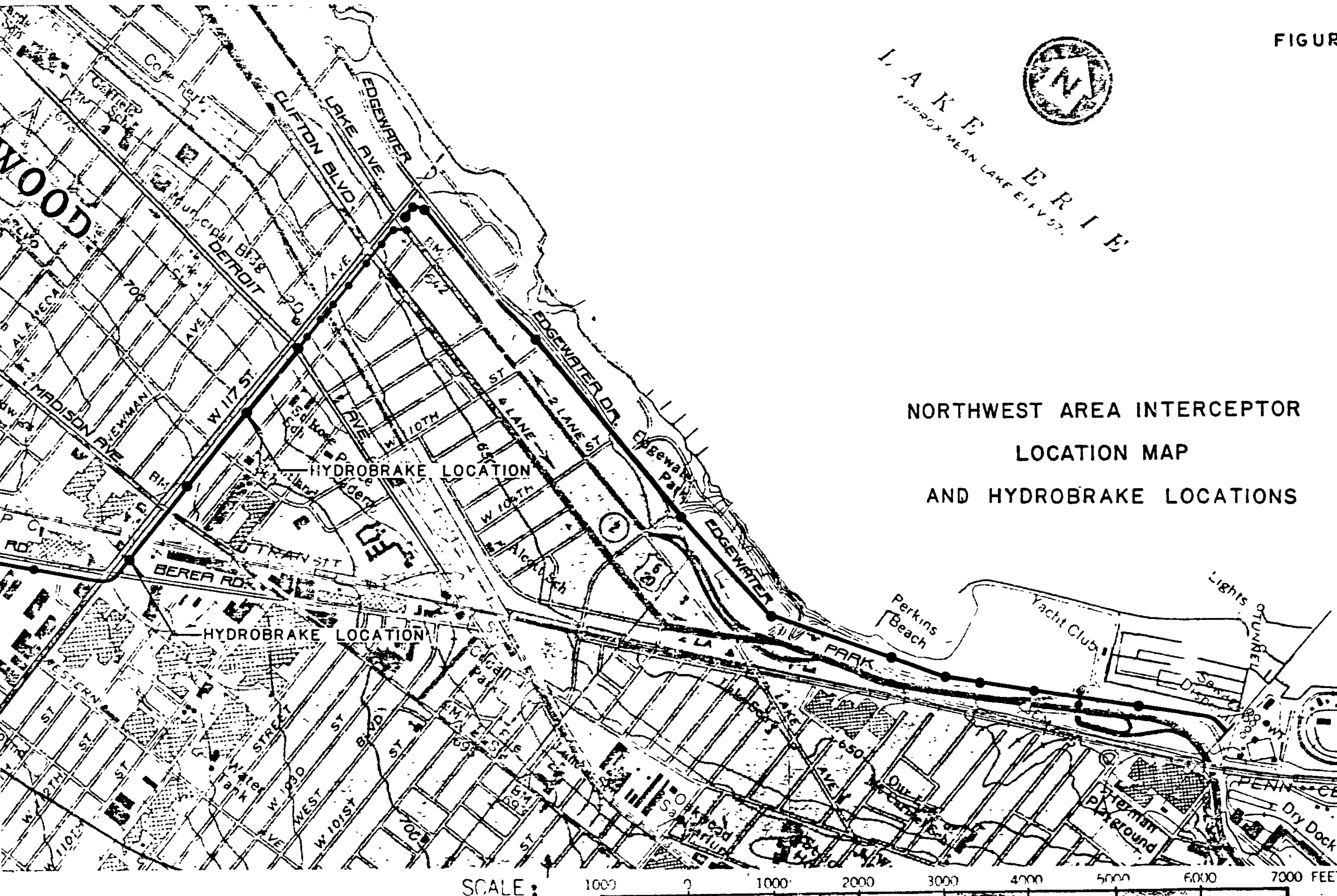
2.6 Description of Hydrobrake Installation:

Each Hydrobrake installation consists of constructing a reinforced concrete retaining wall with either a 30" or 24" stainless steel sleeve in the upstream side of the manhole.

The Hydrobrake was delivered to each site in five segments. The segments were then lowered into the sewer separately and placed on the upstream side of the retaining wall. After the segments were bolted together an "O" ring was installed on the effluent sleeve and the entire unit was inserted into the stainless steel sleeve cast into the retaining wall. The vortex cone came equipped with an anchor bracket which was attached to the sewer invert by means of an anchor bolt with an expansion shield. Installation was then completed.

Figures No. 7 and 8 show the theoretical head/discharge characteristics for the two sizes of Hydrobrakes installed on the project. Figure Number 9 shows the Hydrobrake flow storage data, including the volume of detention at each of the seven sites.

FIGURE 3



NORTHWEST AREA INTERCEPTOR LOCATION MAP AND HYDROBRAKE LOCATIONS

Figure #4

NORTHWEST INTERSEPTOR DRAINAGE AREA HYDROBRAKE AND RAIN GUAGE LOCATIONS

Numbers 1 through 7 denote Hydrobrake locations.

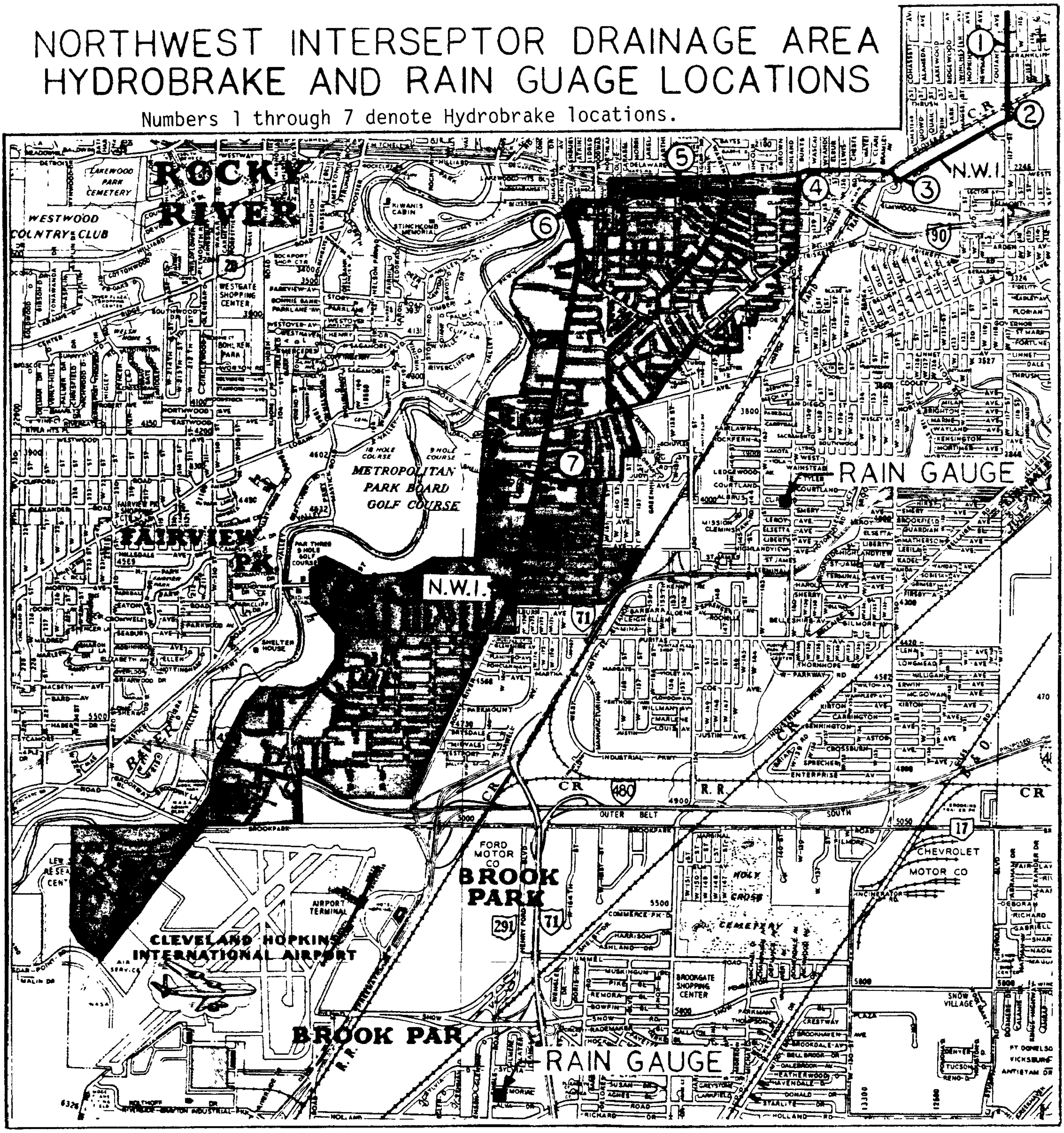


FIGURE 5

NORTHWEST INTERCEPTOR HYDROBRAKE AREA PROFILE WITH STORAGE CAPABILITIES

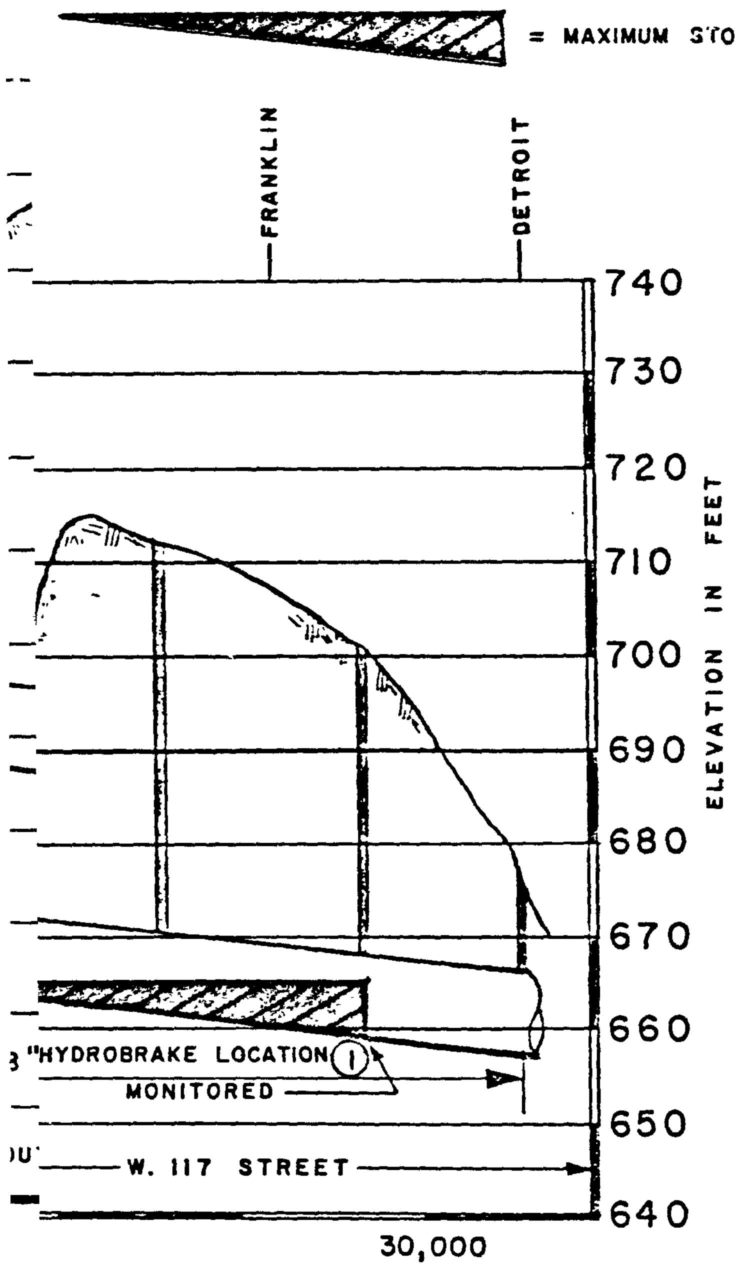


Figure #6

N.W.I. FLOW DIVERSION LOCATIONS

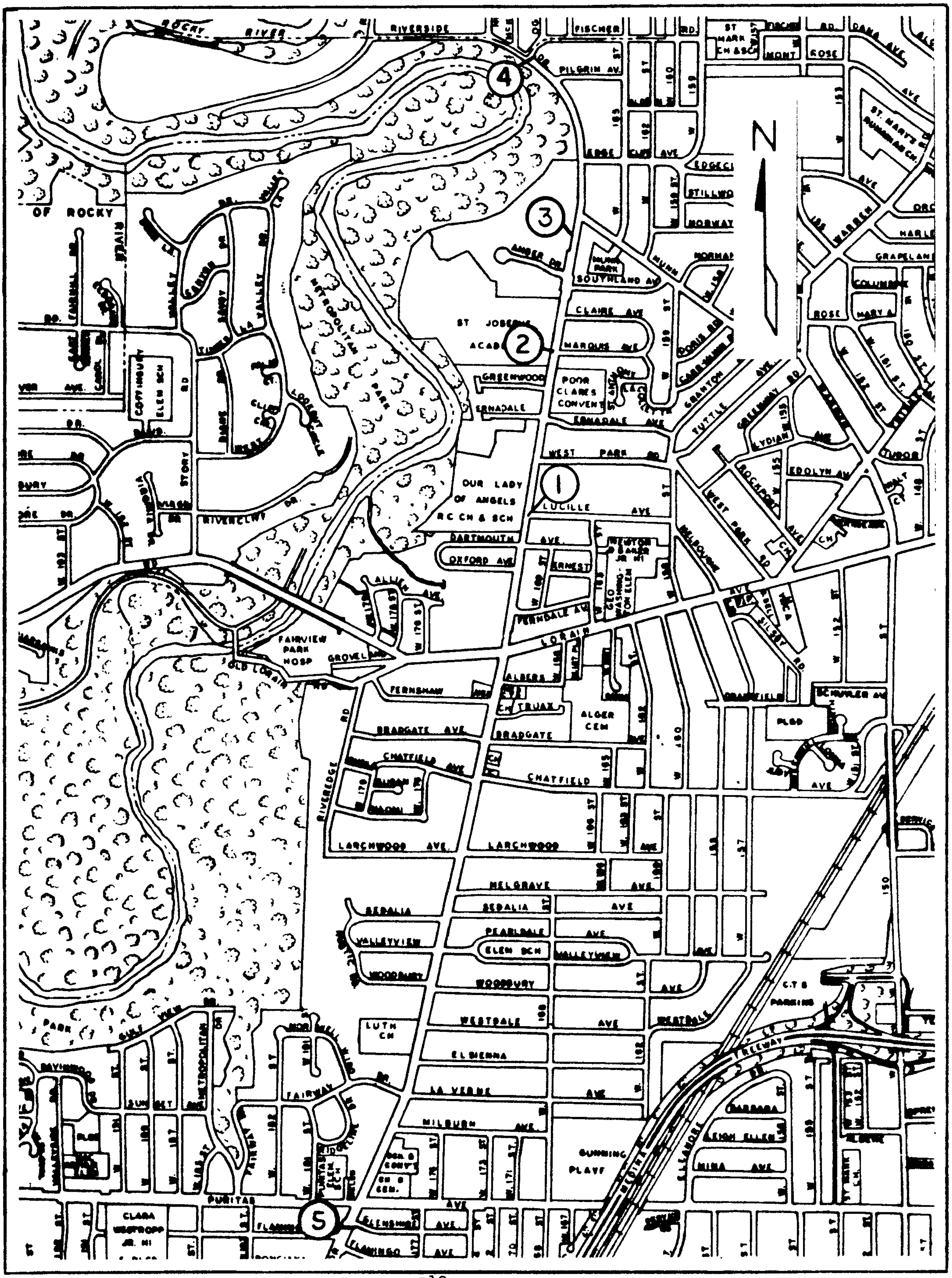
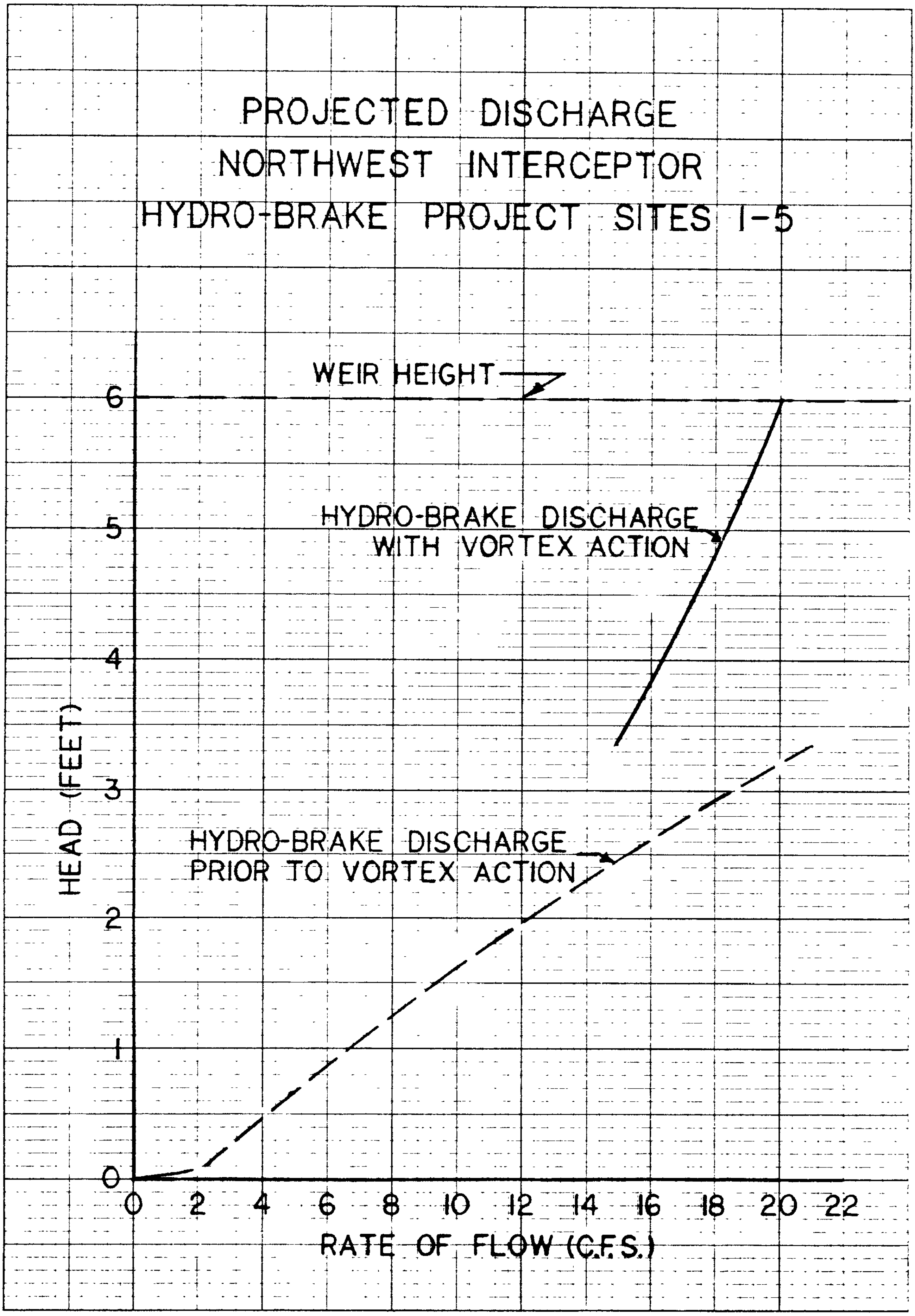
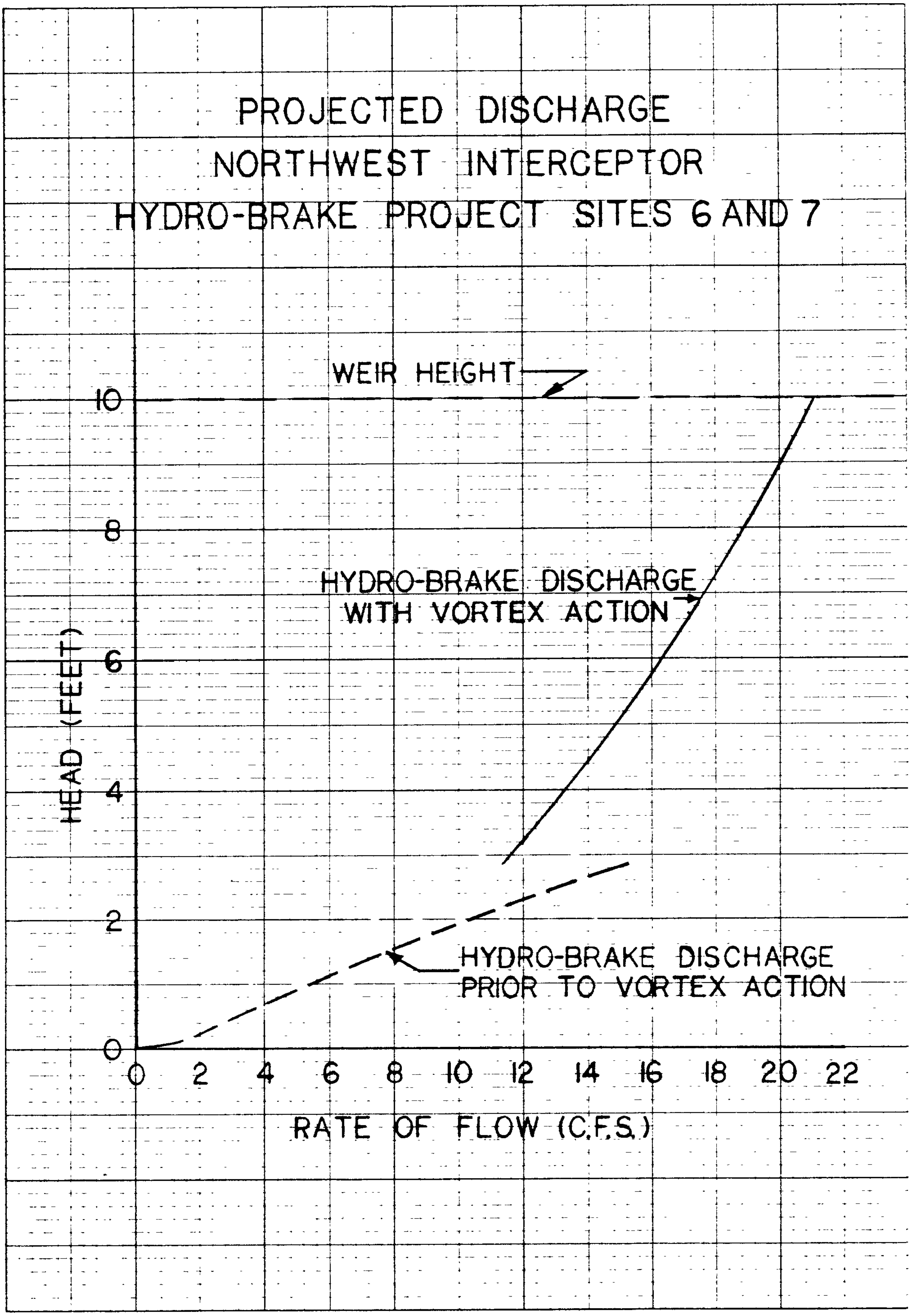


Figure #7


PROJECTED DISCHARGE
NORTHWEST INTERCEPTOR
HYDRO-BRAKE PROJECT SITES 1-5
WEIR HEIGHT
HYDRO-BRAKE DISCHARGE WITH VORTEX ACTION
HYDRO-BRAKE DISCHARGE PRIOR TO VORTEX ACTION
HEAD (FEET)
0
1
2
3
4
5
6
0
2
4
6
8
10
12
14
16
18
20
22
RATE OF FLOW (C.F.S.)


PROJECTED DISCHARGE
NORTHWEST INTERCEPTOR
HYDRO-BRAKE PROJECT SITES 6 AND 7
WEIR HEIGHT
HYDRO-BRAKE DISCHARGE
WITH VORTEX ACTION
HYDRO-BRAKE DISCHARGE
PRIOR TO VORTEX ACTION
HEAD (FEET)
10
8
6
4
2
0
0 2 4 6 8 10 12 14 16 18 20 22
RATE OF FLOW (C.F.S.)

HYDRO-BRAKE FLOW STORAGE DATA

LOCATION	WALL HEIGHT	PIPE DIA.	GRADE	DETENTION VOLUME
#1 - 1497 West 117th St.	6 ft. 1.83 meter	108 in. 2.74 meter	0.21%	53,000 cu. ft. 395,000 gal. 1,500 m^3
#2 - West 117th Street, north of Berea Road	6 ft. 1.83 meter	108 in. 2.74 meter	0.21%	53,000 cu. ft. 395,000 gal. 1,500 m^3
#3 - 12920 Berea Rd.	6 ft. 1.83 meter	108 in. 2.74 meter	0.21%	53,000 cu. ft. 395,000 gal. 1,500 m^3
#4 - Lakewood Heights Blvd.	6 ft. 1.83 meter	108 in. 2.74 meter	0.21%	53,000 cu. ft. 395,000 gal. 1,500 m^3
#5 - West 153rd St. & S. Marginal Rd.	6 ft. 1.83 meter	108 in. 2.74 meter	0.21%	53,000 cu. ft. 395,000 gal. 1,500 m^3
#6 - Rocky River & Fischer Rd.	10 ft. 3.05 meter	108 in. 2.74 meter	0.21%	167,000 cu. ft. 1,300,000 gal. 4,730 m^3
#7 - Rocky River & Chatfield Rd.	10 ft. 3.05 meter	84 in. 2.13 meter	0.36%	70,000 cu. ft. 520,000 gal. 1,893 m^3
TOTAL				502,000 cu. ft. 3,795,000 gal. 14,217 m^3

Figure #9

PART 3 CONSTRUCTION

3.1 Hydrobrake Construction Sites:

PROJECT #1	1497 West 117th Street
PROJECT #2	West 117th Street, north of Berea Road
PROJECT #3	12920 Berea Road
PROJECT #4	Lakewood Hts. Blvd., 80' west of West 139
PROJECT #5	West 153rd Street and South Marginal Road
PROJECT #6	Rocky River Drive at Fischer Road
PROJECT #7	Rocky River Drive at Chatfield Avenue

Figures #3 and #4 shows the geographic location of each Hydrobrake site. Figure #9 pertains to the site specific details including the total detention volume 3,795,000 gallons.

3.2 Project Construction - Typical:

Construction at all project sites included opening a section of pavement/treelawn approximately 10 feet square around the access manhole, excavation and removal of the conical manhole section and casting. A temporary precast manhole riser was then set in place to provide safe manhole entry and exit. A temporary bulkhead was also installed into any drop pipe entering the Northwest Interceptor chambers, when applicable. Throughout the course of the Hydrobrake Project two-way traffic was maintained at all sites located on a designated street, in compliance with the Ohio Department of Transportation specifications. During non-working hours, all areas of construction were covered with steel street plates and identified with appropriate barricades and flashers.

At all sites, in sewer work commenced with installation of sufficient lighting to safely illuminate the work area within the manhole. Work then began on flow control within the interceptor. This was accomplished by means of a prefabricated temporary plywood weir. The weir was secured in place with sandbags and positioned a satisfactory distance upstream of the chamber as not to interfere with construction of the retaining wall. A 24" orifice was built into the weir into which a 24" flexible plastic pipe was inserted to act as a flume. This flume effected a dry work area for the contractor's personnel.

In compliance with the contract specifications, work began on the receiving channel preceding construction of the retaining wall. Saw cuts were made 4" deep prior to chipping out the channel. Minimum depth of saw cuts were 4" in the area of the orifice in the retaining wall and 1½" depth in other areas. Concrete forms were erected for the retaining wall and placement of the reinforcing steel completed. All forms were mortar tight and conformed to proper dimensions and elevations. Reinforcing steel used at all sites was grade 40 and installed in compliance with Item 509 of ODOT specifications. At project sites 1, 2, 3, 4 and 5 a 30" stainless steel sleeve was positioned within the retaining wall. A 24" sleeve was used at project site 6 and 7. A concrete adhesive was then applied to the receiving channel to bond the new concrete wall to the old concrete in the existing sewer. At each site, while the wall was being poured, the concrete in the wall was mechanically vibrated to insure an uniform pour. Concrete used for all retaining walls was 4000 lbs. Type II (ASTMC150). Concrete test for moisture slump and temperature were performed at each site. Concrete compression tests were done at a local testing laboratory. The dimension of the retaining wall at projects 1, 2, 3, 4 and 5 is 6' x 9' x 1'. A retaining wall 10' x 14' x 1'4" was constructed at projects 6 and 7. After removal of the concrete forms, the Hydrobrake was installed in each retaining wall. Figure #10 shows the typical weir construction and Hydrobrake placement.

The Hydrobrakes were fabricated from 1/4" stainless steel. The segments were lowered into the manhole and assembled on the upstream side of the retaining wall. Assembly completed, the unit was inserted into the stainless steel sleeve cast into the retaining wall and bolted to the sewer invert (see figure #10). All facets of the Hydrobrake installation were supervised by the manufacturer's representatives.

Restoration for all project sites included removal of the temporary manhole riser and replacement with the conical manhole section section and casting. Backfill consisted of a coarse interlocking aggregate placed in layers not exceeding 4", loose depth. The aggregate was then compacted by a mechanical device to 95 proctor density. A concrete sub-base was poured to within 3" of the existing pavement and conformed to Item 499 of ODOT. The remaining 3" of concrete needed to return the area to grade was poured over a layer of plastic. Final asphalt paving was performed by the contractor when weather conditions permitted. At Project 6, restoration included sidewalk replacement and the placement of sod to the damaged treelawn.

Figure #11 is a photographic reproduction of the above ground facilities at site #6 - Rocky River & Fischer Ave.

3.3 Construction Problems:

3.3.1 Manhole Depth:

Problems encountered throughout the construction period were minimal. At all seven project sites the manhole depth posed the greatest difficulty, particularly at projects #3 and #4. However, excessive manhole depth was negated to some extent by incorporating a temporary manhole riser for easy access. Proper safety procedures were pursued at each site, with special attention directed towards hazardous gases in the Northwest Interceptor chambers. Oxygen deficiency/hydrogen sulfide/explosion meters were required at each site, and kept in sewer during working hours. By following accepted safety regulations, manhole access was considered an inconvenience, rather than a hindrance.

3.3.2 Infiltration:

Excessive infiltration was experienced at projects #5 and #6 access manholes. Prior to manhole ingress sit was necessary to alleviate this inflow of water to insure a safe work area. This was accomplished by applying hydraulic cement to affected areas. Abnormal amounts of calcium were also detected on a number of rungs at project #5. The calcium deposits had to be chipped away before personnel could safety enter the manhole.

3.3.3 Existing Concrete Encasement:

During routine manhole excavation at projects #2, #3 and #4 it was discovered that the conical manhole sections at each site were encased in concrete. It was necessary for the contractor to use jack hammers to remove this concrete before the conical manhole sections could be removed. The concrete was considered an "unknown condition differing materially from those ordinarily encountered." The concrete encasement added an extra work day at the affected project sites and it resulted in an extra work order submitted by the contractor. Also, project #1 access manhole was encased in a compact granular material which required minor jack hammering.

3.3.4 Flow Control:

Flow control within the interceptor was accomplished by means of a temporary weir with a 24" flume. The weir was held in place with sand bags at all project sites, with the exception of project #4. Extra precautions were employed at this site due to its proximity to the Triskett Road trunk sewer. It was necessary to protect the weir from a greater volume of flow by using 2' x 4' braces.

3.4 Total Cost:

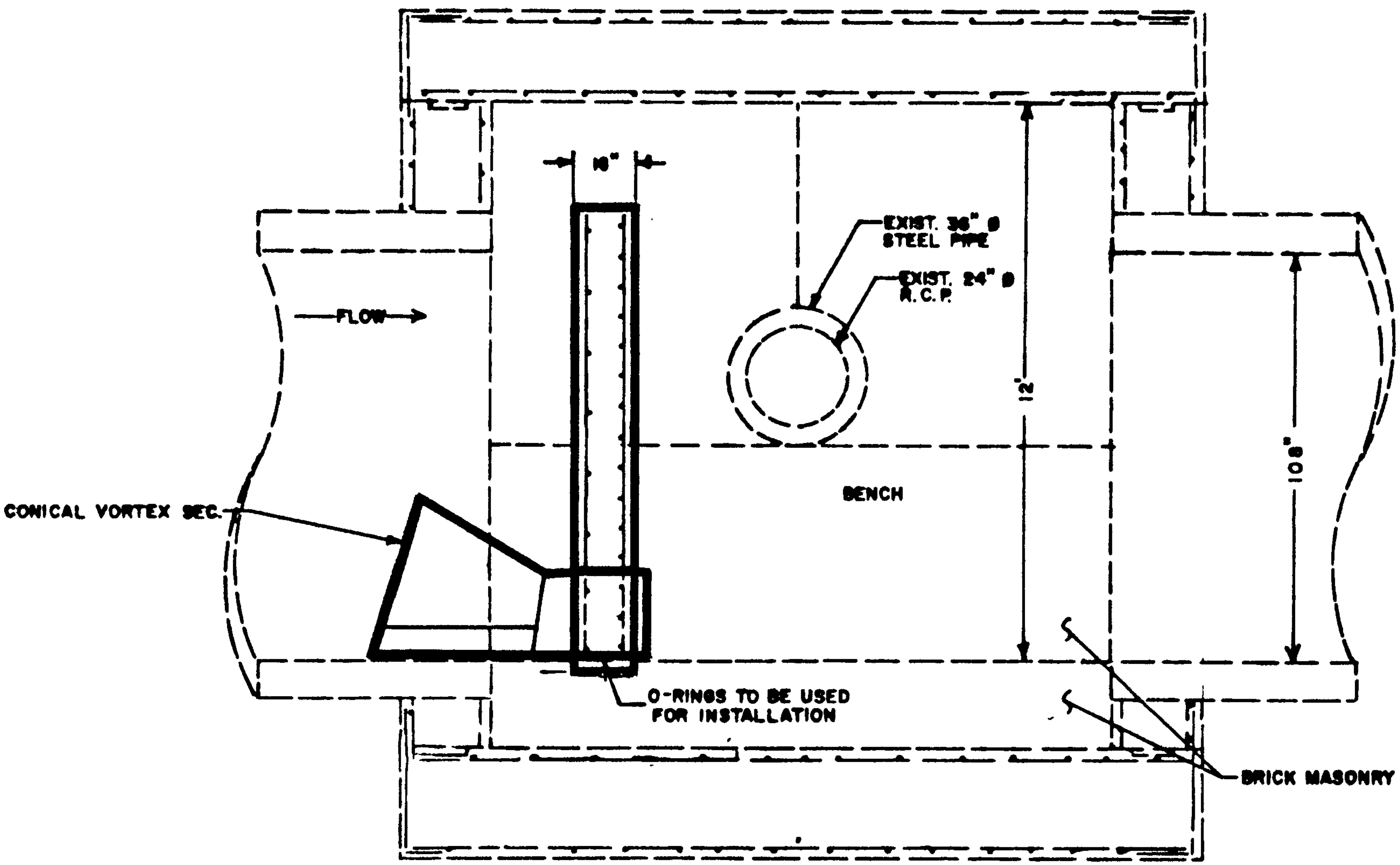
The contract awarded for all necessary manhole modifications, construction of the weirs, Hydrobrake, Hydrobrake installation and site restoration was $155,363. The total broken down by site is as follows:

Site	
#1	$21,183.00
#2	$21,183.00
#3	$21,183.00
#4	$21,183.00
#5	$21,183.00
#6	$22,224.00
#7	$27,224.00

3.5 Final Inspection:

Final restoration was concluded at all seven project sites on February 22, 1983. Before contract completion could be achieved by the contractor, removal of the temporary flow diversion devices was essential. At diversion locations 1 through 4, the temporary bulkhead in the Northwest Interceptor connection was removed and a permanent bulkhead with cleanout was installed in the existing 24" sanitary sewer along Rocky River Drive. Flow was then diverted back into the Northwest Interceptor. Flow previously going to the Lakewood system was rerouted to the District's Westerly Wastewater Treatment Plant. The 24" inflatable sewer plug was removed from the Northwest Interceptor at Rocky River Drive and Puritas Road. Flow temporarily being diverted to Southerly Wastewater Treatment Plant was returned to the Westerly system. A minor diversion device was also removed from project 7 at this time.

An on site inspected was performed by the contractor prior to final inspection by the District Engineer. This finalized all site work on the Hydrobrake Demonstration Project. Figures #12 and #13 are photographic reproductions of the flow upstream and downstream of the weir wall at Site #6, Fischer & Rocky River Drive and Site #7, Rocky River Drive & Chatfield Avenue.



Side View Existing Chamber Showing Weir Construction & Hydrobrake Installation

Figure #10

Photographic Reproduction Above Ground Facilities
Rocky River Dr. & Fischer Ave.

Figure #12

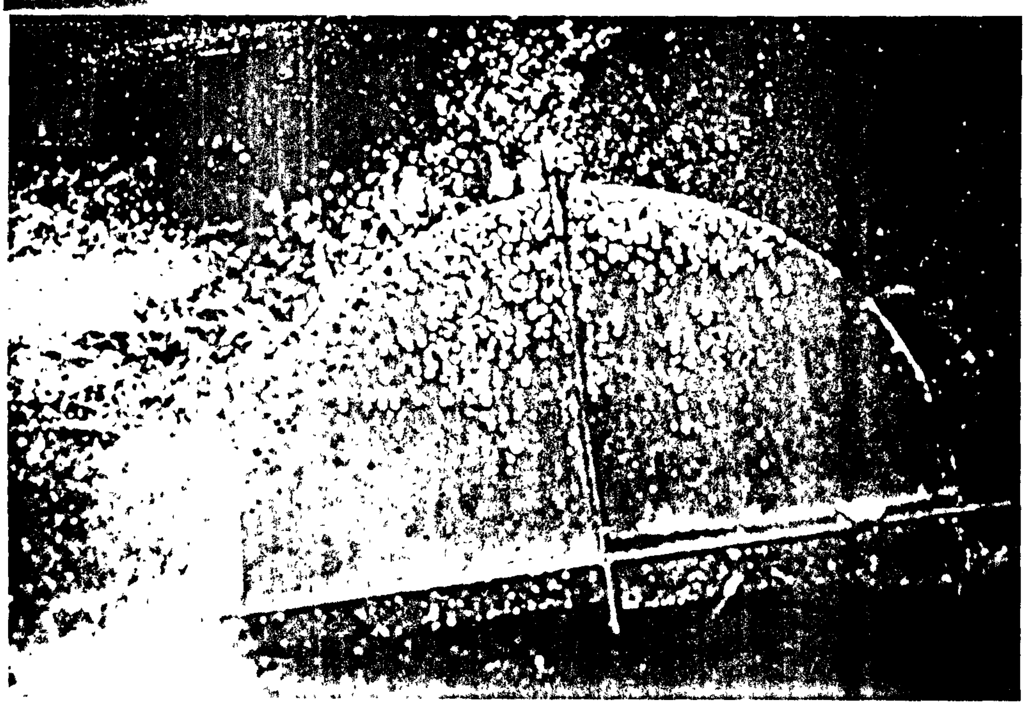
SITE #6

TOP VIEW

Showing both upstream & downstream of weir and Hydrobrake

DOWNSTREAM SIDE

of the weir showing discharge end of the Hydrobrake

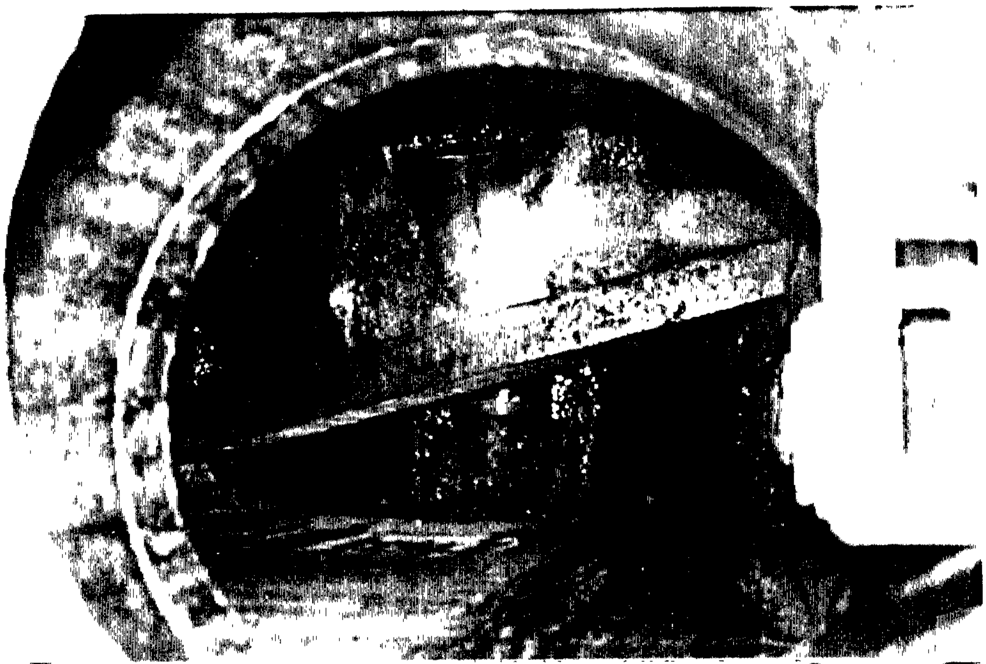


UPSTREAM SIDE

of the weir showing the entrance end of the Hydrobrake

Figure #13

SITE #7



TOP VIEW

showing both upstream & downstream sides of the weir and Hydrobrake

DOWNSTREAM SIDE

of the weir showing the discharge end of the Hydrobrake

UPSTREAM SIDE

of the weir showing the entrance end of the Hydrobrake

PART 4 HYDROBRAKE FLOW MONITORING:

4.1 Computer Control Facility:

The Northeast Ohio Regional Sewer District operates and maintains an extensive computer based combined sewer overflow (CSOC) control system. The system as implemented provides for significant reductions in overflows to the environment by utilizing excess transport capacity within the combined sewer collection system for in-line storage. This distributed process control system provides the ability to control and monitor each control site from a central station and to store data for later analysis. This central station is equipped with an operations console which allows for the observation of control actions and the trending of data in real time. Figure #14 is a photographic reproduction of the computer console showing the real time monitoring of a Hydrobrake site in a rain event. The red line represents the flow storage upstream of the weir and the yellow line depicts the flow downstream of the weir.

4.2 Monitoring Facilities:

This distributed process control system provides the capability for monitoring sewer levels at various locations within the wastewater collection system. In addition to the level monitors that are a part of each control site, several individual level monitors are available for installation at various locations on a temporary basis. This provides the ability to observe the operational characteristics of the wastewater collection system in real time from a central location and compile a comprehensive archive of historical data useful for planning purposes and maintenance activities.

The sewer level monitors are of the bubbler type that convert air pressure to an electrical voltage that is proportional to the depth of flow. This 105 volt signal is then transmitted on a continual basis to the central station via leased telephone data circuits using frequency shift keying telemetry. In turn, each signal is available for computer reading. The central sewer control facility located at 3090 Broadway Ave. in central

Cleveland in turn scans each individual signal on a round robin basis approximately every 2 minutes. The computer converts each signal to proper engineering units and stores the data for archives every 5 minutes.

4.3 Rain Gauges Facilities:

Another feature of the system is an extensive rain gauge network implemented to cover watersheds of the Cleveland Metropolitan area. This rain gauge network provides for the collection of real time rainfall data that, when utilized with the sewer level monitors, provides a comprehensive data base showing the response of the wastewater collection system to rain events.

The rain gauges are of the weighting type that convert the weight of total rainfall to an electrical signal much the same as the level monitors. Rainfall data is collected and stored in a manner similar to the sewer level monitors.

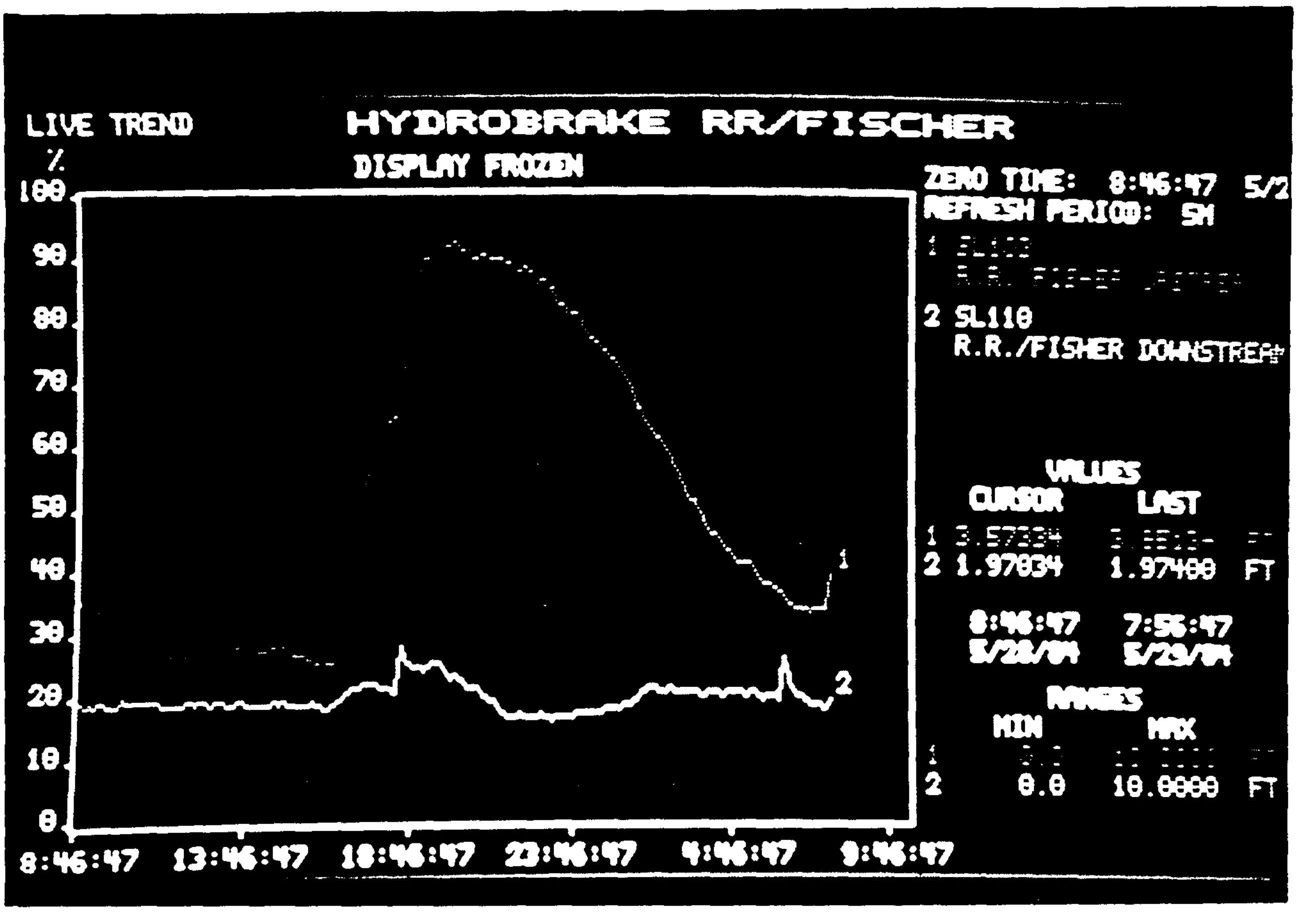
4.4 Monitoring Hydrobrake Locations:

In order to determine the effectiveness of the Hydrobrake storage system installed under this grant, two sewer level monitors were installed at each of the three weir Hydrobrake locations. One level monitor was installed upstream of the weir to measure the depth of stored flow. The second level monitor was installed downstream of the storage weir to measure the level of flow that was discharged from the Hydrobrake or topped the weir. Another level monitor was installed in the 30" conduit located at the downstream end of the storage system and conveys all dry weather flow and all the stored flow to the Westerly Interceptor and then to the Westerly Wastewater Treatment Plant for treatment prior to discharge to Lake Erie. The Profile Map (figure #15) shows the location of each monitor.

4.5 Monitoring Results:

The performance records collected from the computer data file at three monitored locations indicates the efficiency achieved by comparison of the Inflow Hydrograph, the Outflow Hydrograph and the individual weir level. It can be seen that the outflow is very constant despite high fluctuation of the inflow. The detention utilization rate is 100% as an overtopping of the weirs occurs from time to time, depending on the rain event.

The following flow charts should be compared in combination starting at Location #6, then Location #5 downstream, and finally Location #1 at the end of the Northwest Interceptor. The storage/detention volume behind the weir and the downstream flow for each rain event becomes very pronounced as witnessed by the flow charts. Figures #16 - #18 depict the storage and flow conditions during a rain storm June 18, and 19, 1984 at sites #1, #5 and #6. Figures #19 - #21 show similar storage and flow conditions for a rain event July 6, and 7, 1984 for the same three sites. Figures #22 - #24 show the storage and flow conditions for the same three sites during a rain event August 3, and 4, 1984. It should be noted the storage behind the weir varied with the rainfall intensity; however, the depth of the downstream flow remained relatively constant during each storm. Figures #25 - #33 show the same three storms at the same sites. The storm duration is only 24 hours and we have super imposed the rainfall intensity data. Again it should be noted the depth of the downstream flow is relatively constant except when the stored flow topped the weir.



Photographic Reproduction Computer Console
Monitoring Hydrobrake Site in a Rain Event

NORTHEAST OHIO REGIONAL SEWER DISTRICT

HYDRO-BRAKE DEMONSTRATION GRANT

ROCKY RIVER / FISHER LOCATION #6 RAIN EVENT MONITORING 6-18&19-84 G.U.

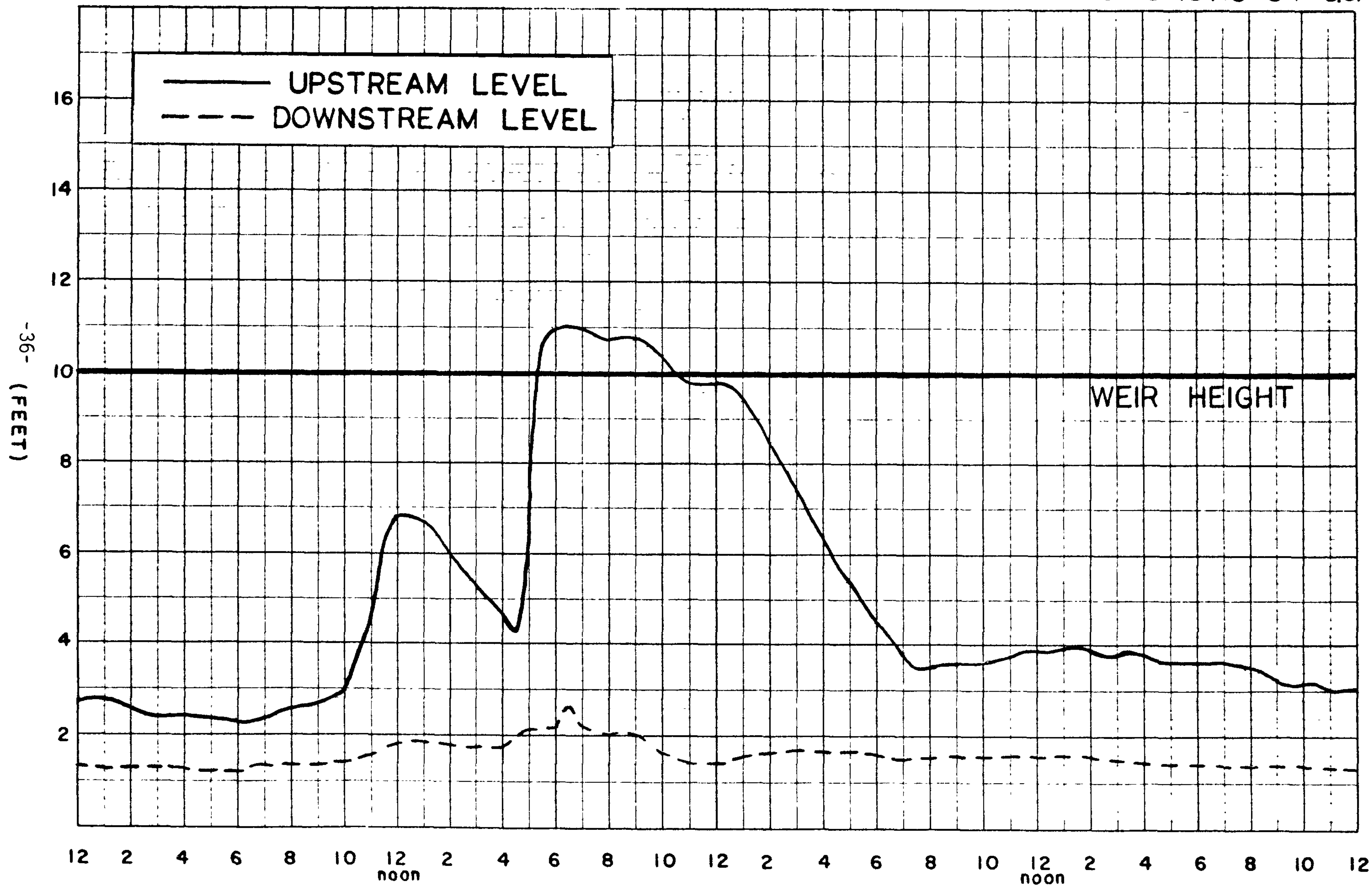


Figure #16

NORTHEAST OHIO REGIONAL SEWER DISTRICT

HYDRO-BRAKE DEMONSTRATION GRANT

W.153 / FERNWAY LOCATION #5 RAIN EVENT MONITORING 6-18&19-84 GU.

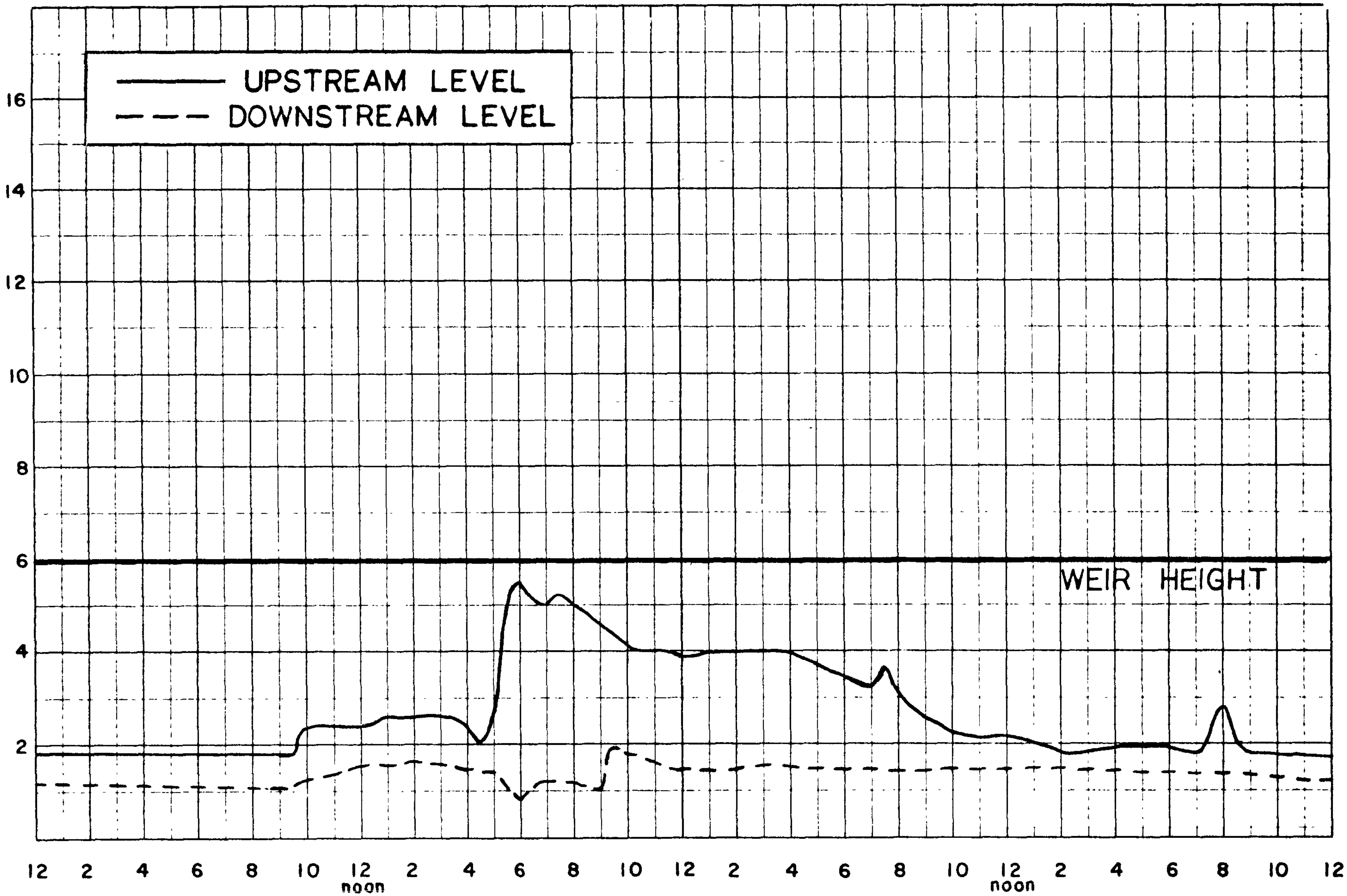


Figure #17

NORTHEAST OHIO REGIONAL SEWER DISTRICT

HYDRO-BRAKE DEMONSTRATION GRANT

W.117 / FRANKLIN LOCATION #1 RAIN EVENT MONITORING 6-18 & 19-84 GU.

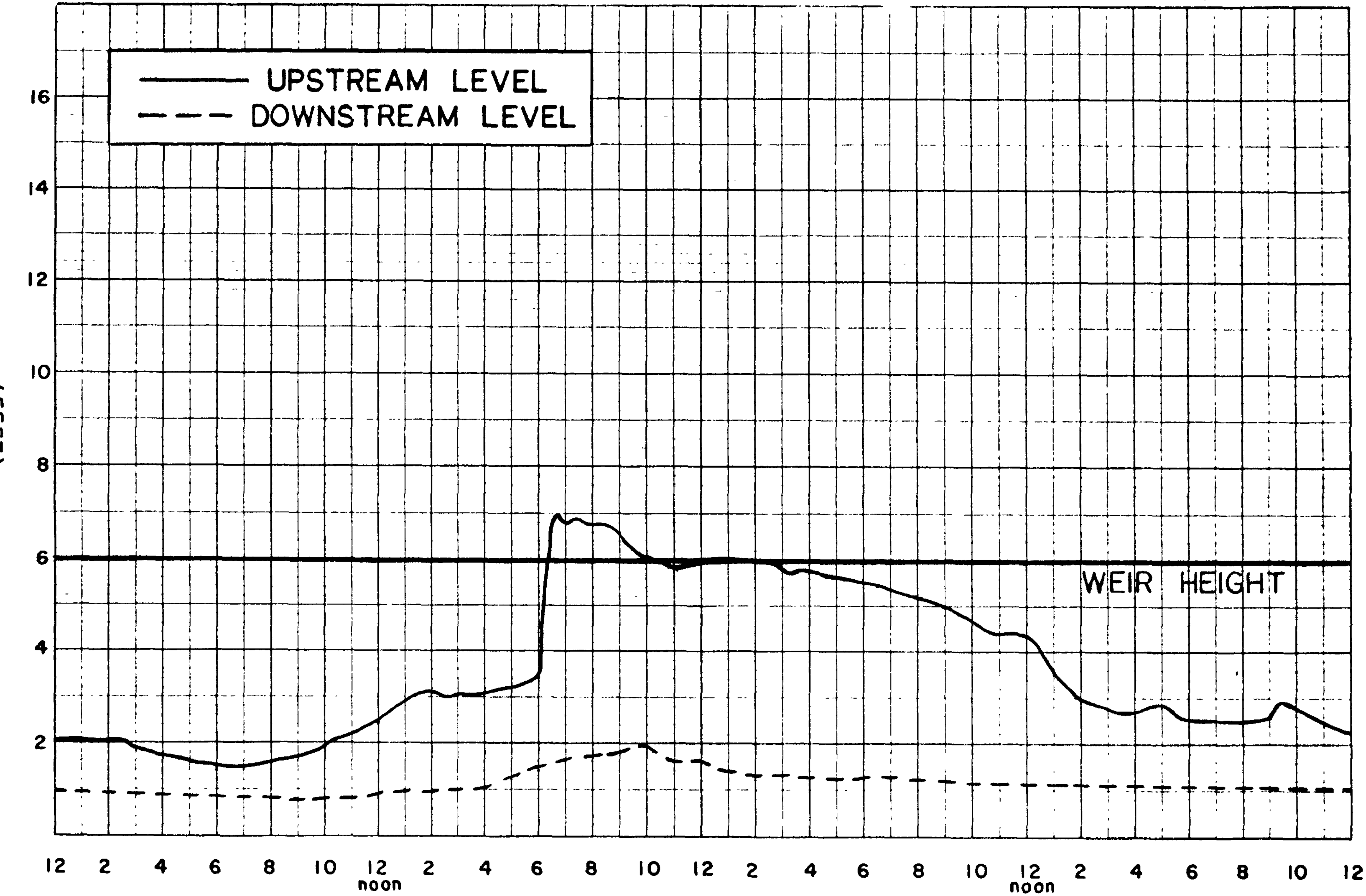


Figure #18

NORTHEAST OHIO REGIONAL SEWER DISTRICT

HYDRO-BRAKE DEMONSTRATION GRANT

ROCKY RIVER / FISHER LOCATION #6 RAIN EVENT MONITORING 7-6&7-84

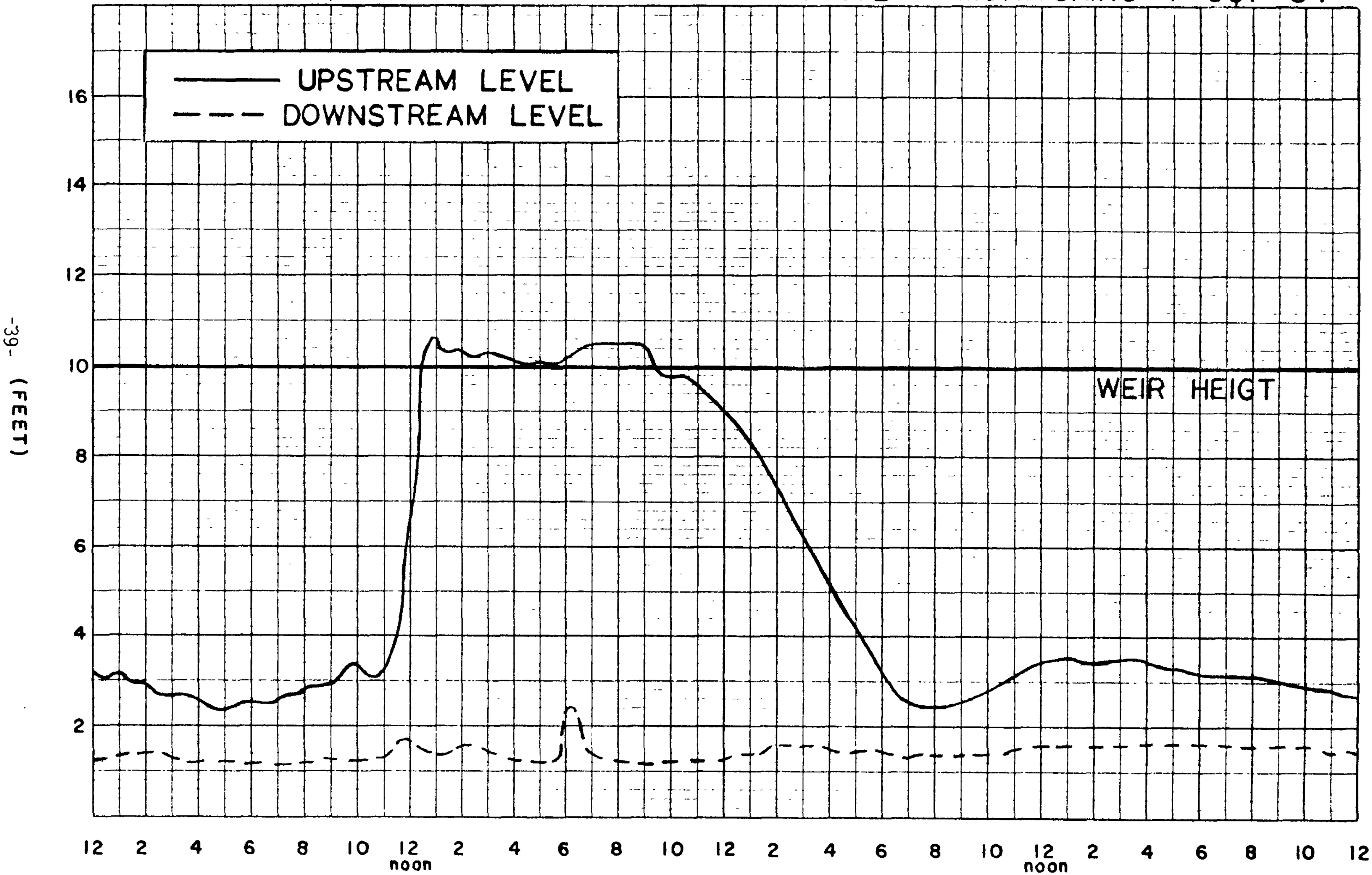
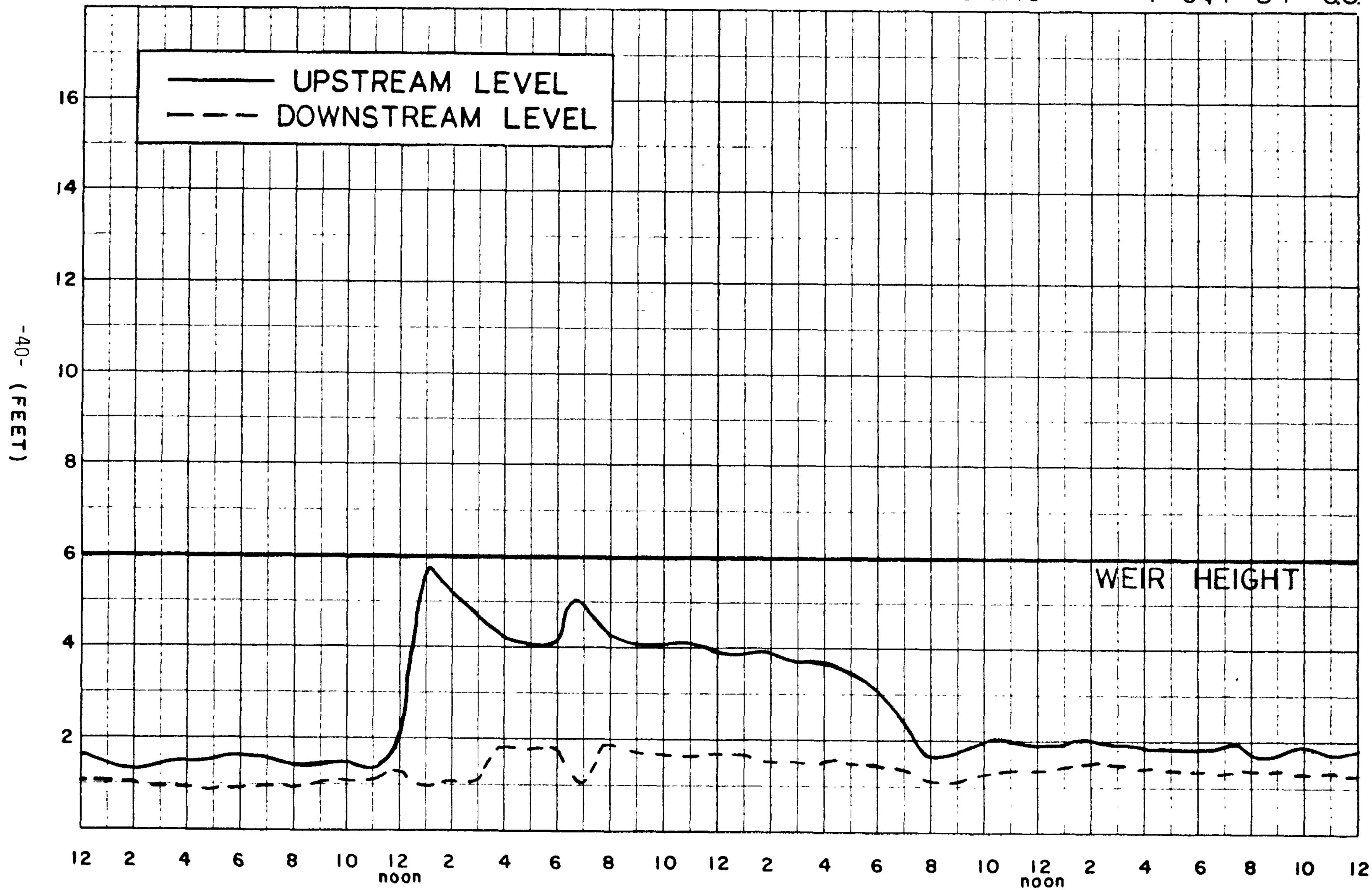


Figure #19

NORTHEAST OHIO REGIONAL SEWER DISTRICT

HYDRO-BRAKE DEMONSTRATION GRANT

W.153 / FERNWAY LOCATION #5 RAIN EVENT MONITORING 7-6 & 7-84 GU.



-40-

Figure #20

NORTHEAST OHIO REGIONAL SEWER DISTRICT

HYDRO-BRAKE DEMONSTRATION GRANT

W.117 / FRANKLIN LOCATION #1 RAIN EVENT MONITORING 7-6 & 7-84 GU.

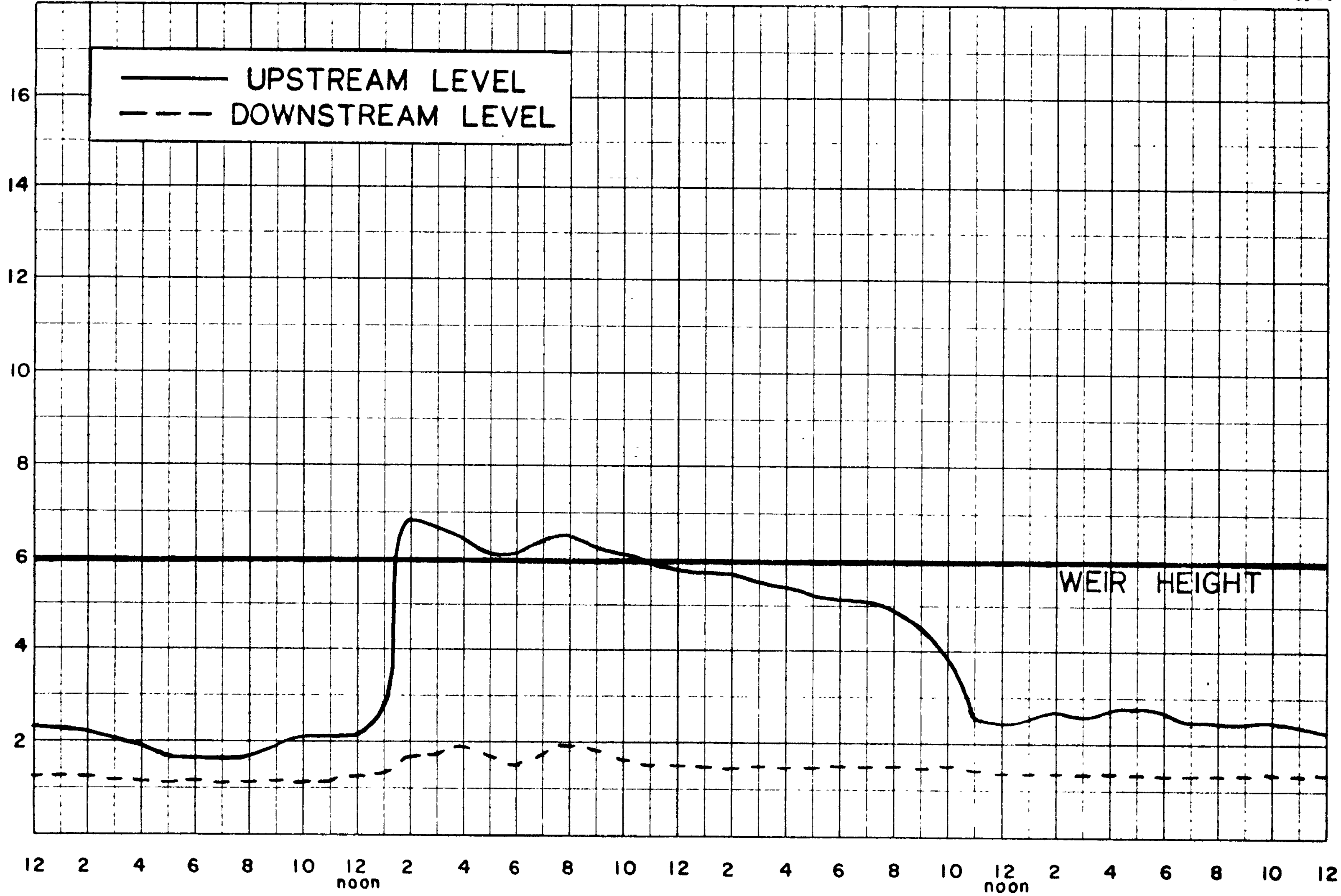


Figure #21

NORTHEAST OHIO REGIONAL SEWER DISTRICT

HYDRO-BRAKE DEMONSTRATION GRANT

ROCKY RIVER / FISHER LOCATION #6 RAIN EVENT MONITORING 8-3&4-84

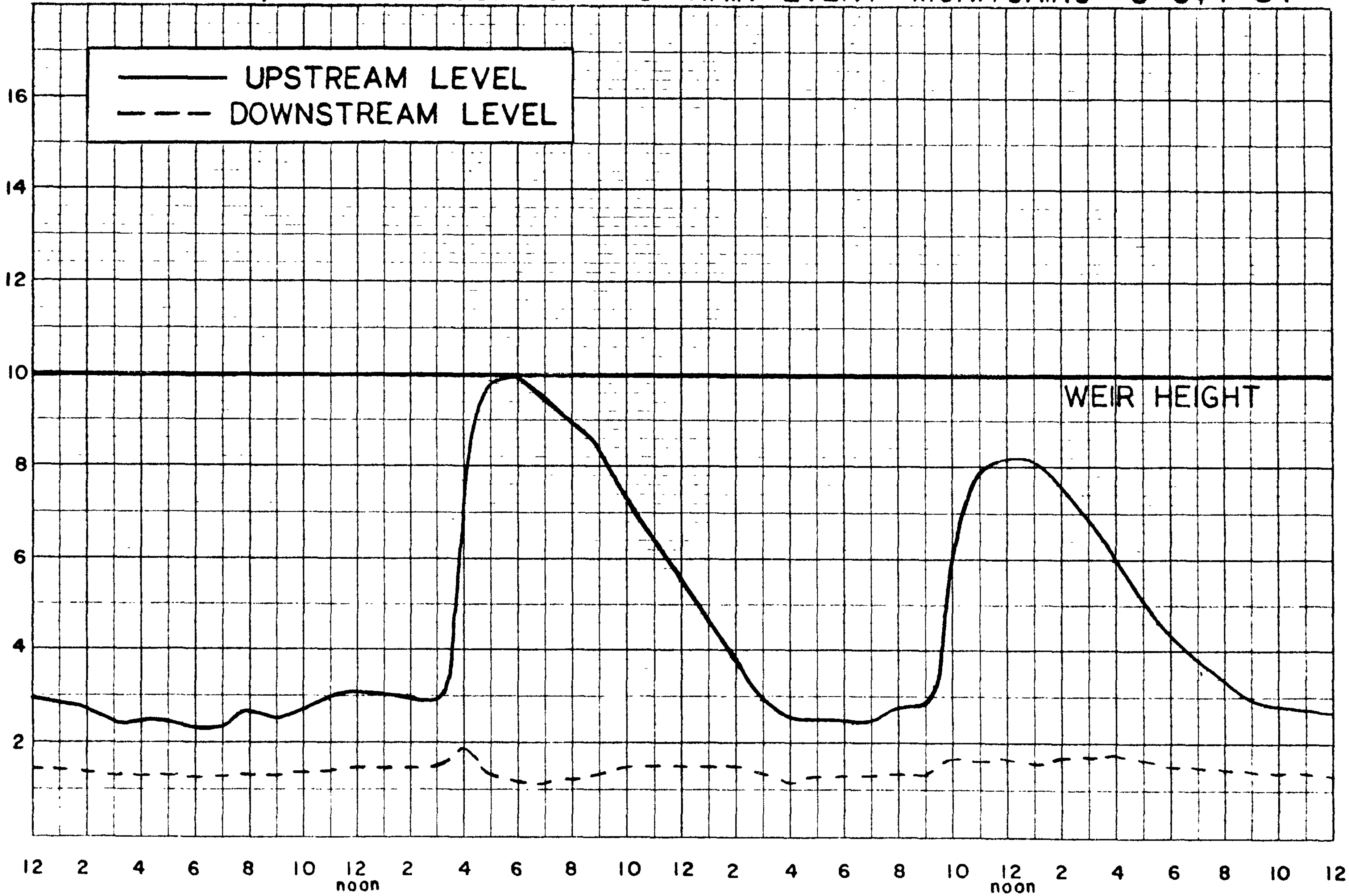


Figure #22

NORTHEAST OHIO REGIONAL SEWER DISTRICT

HYDRO-BRAKE DEMONSTRATION GRANT

W. 153 / FERNWAY LOCATION 5 RAIN EVENT MONITORING 8-3 & 4-84 G.U.

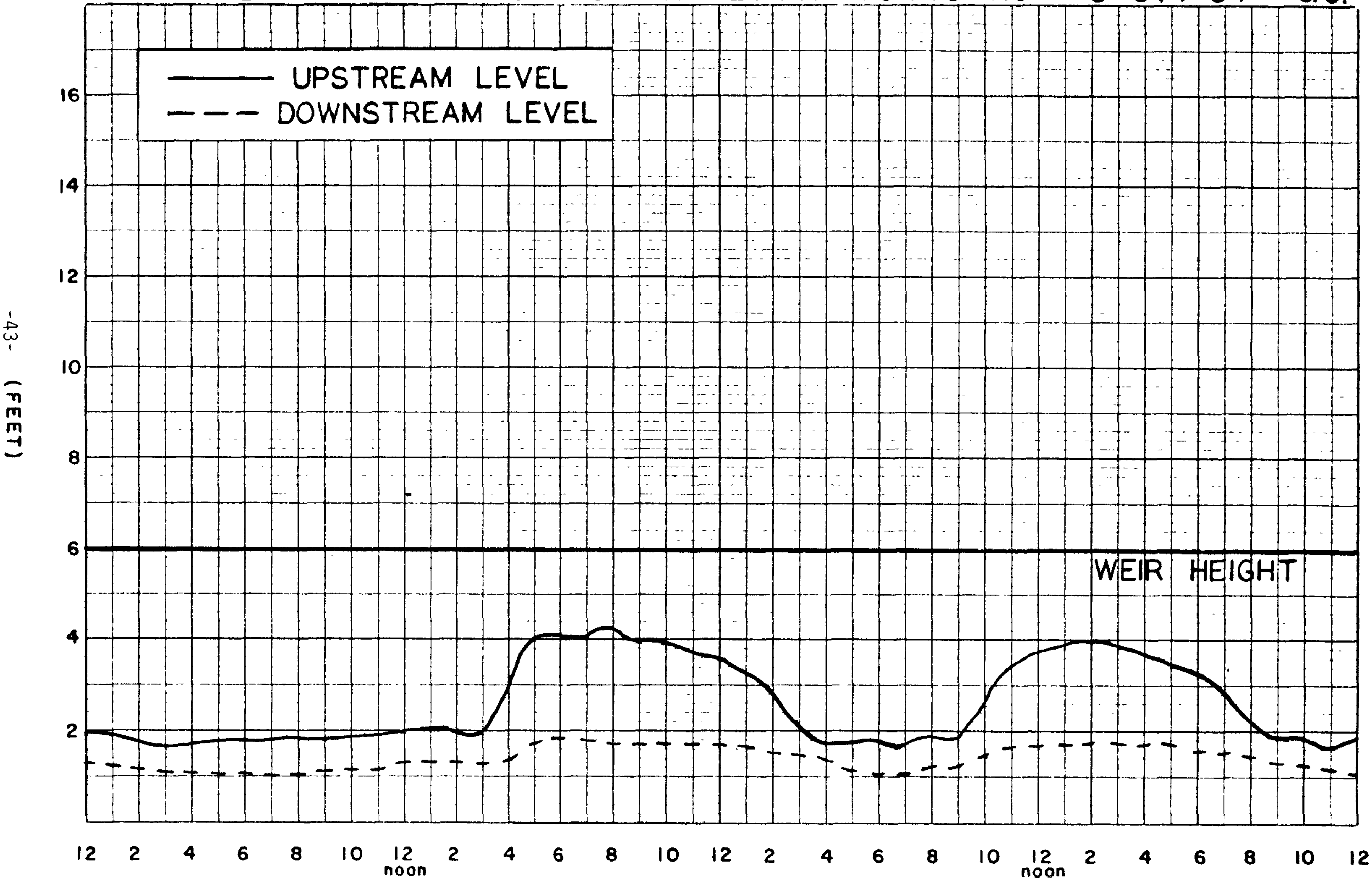


Figure #23

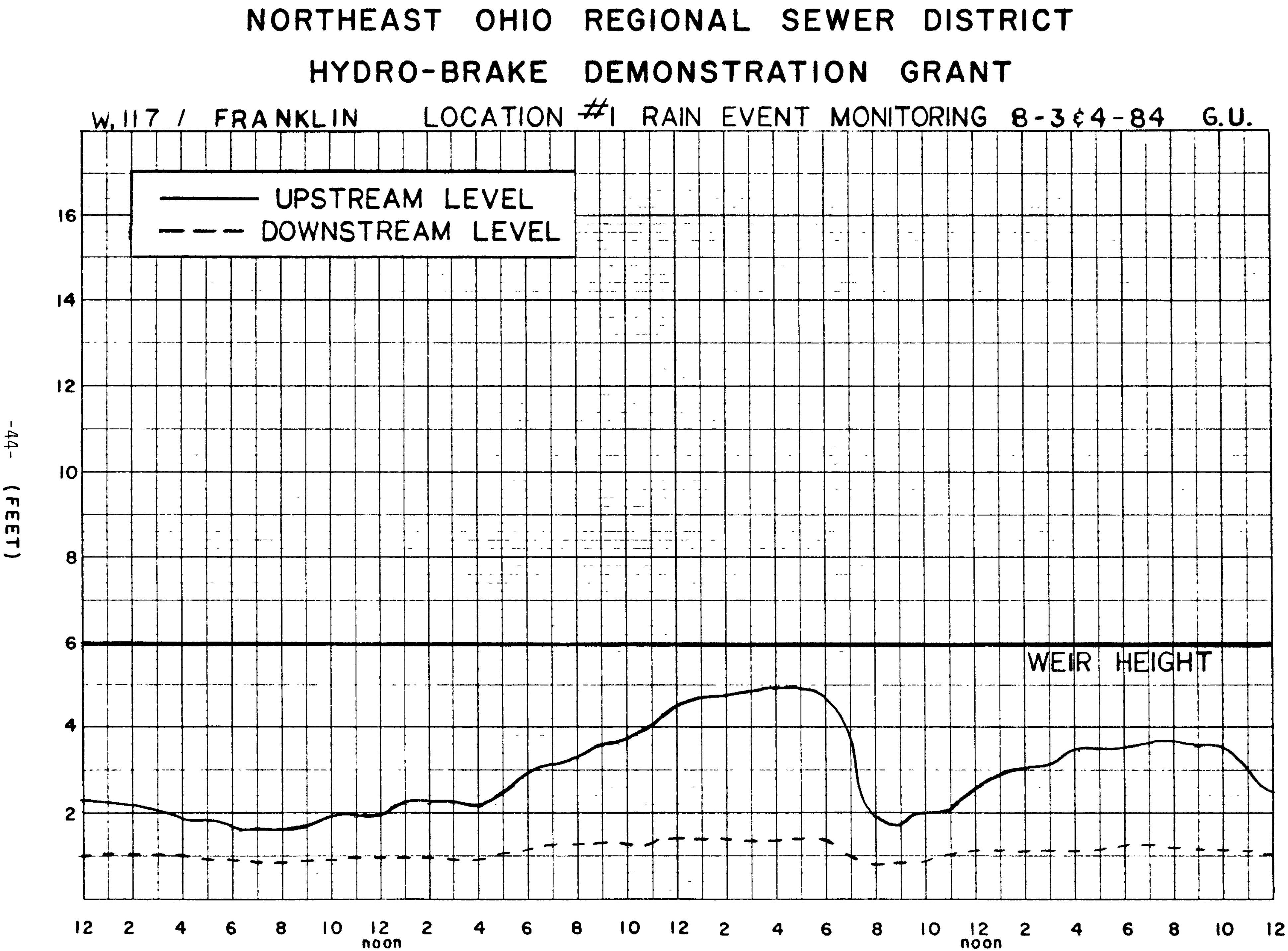

NORTHEAST OHIO REGIONAL SEWER DISTRICT
HYDRO-BRAKE DEMONSTRATION GRANT
W. 117 / FRANKLIN LOCATION #1 RAIN EVENT MONITORING 8-3 & 4-84 G.U.
UPSTREAM LEVEL
DOWNSTREAM LEVEL
WEIR HEIGHT
(FEET)
16
14
12
10
8
6
4
2
12 2 4 6 8 10 12 noon 2 4 6 8 10 12 2 4 6 8 10 12 noon 2 4 6 8 10 12

Figure #24

NORTHEAST OHIO REGIONAL SEWER DISTRICT
HYDRO-BRAKE DEMONSTRATION GRANT

ROCKY RIVER / FISHER LOCATION #6 RAIN EVENT MONITORING 6-18 & 19-84

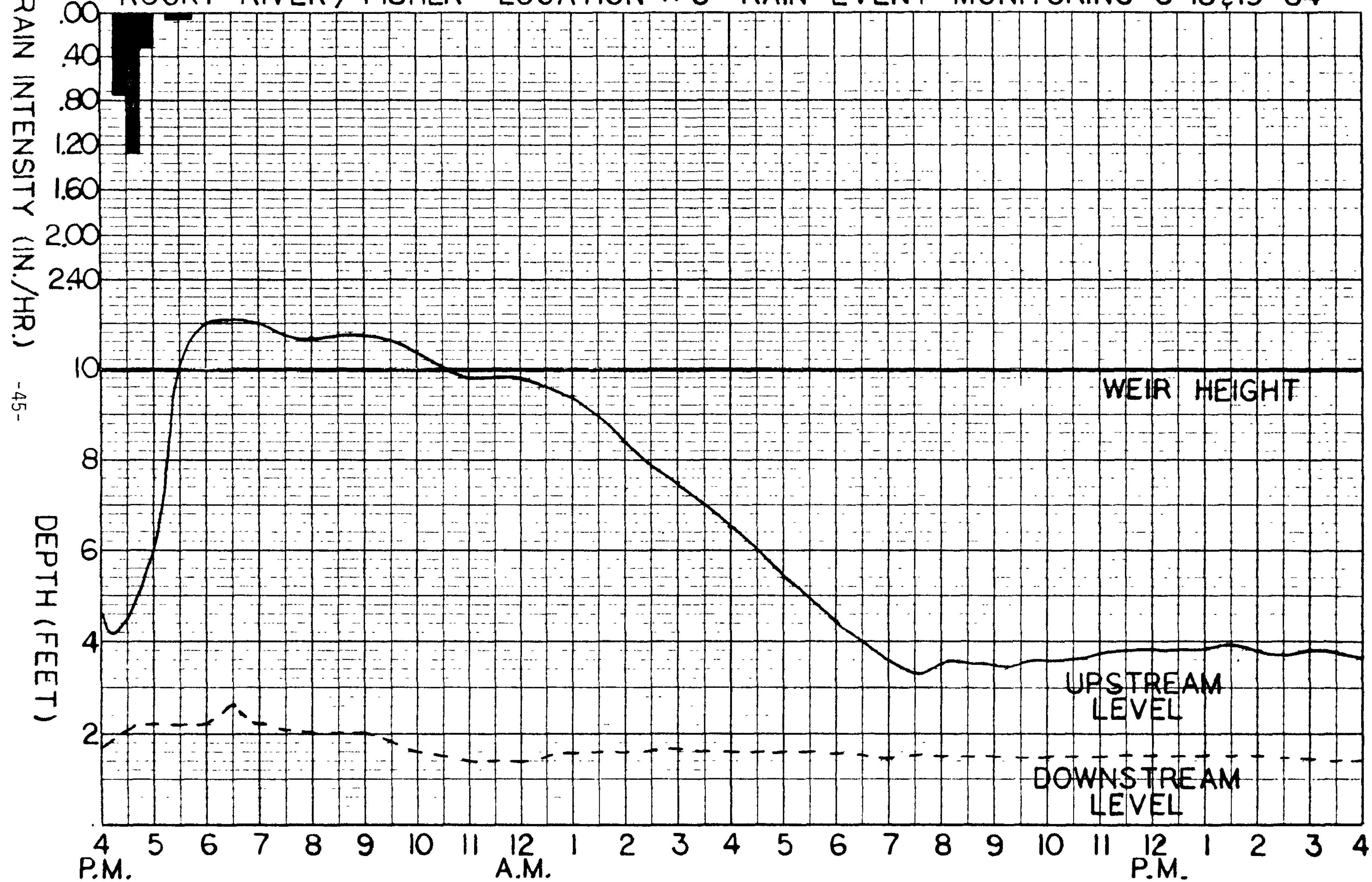


Figure #25

NORTHEAST OHIO REGIONAL SEWER DISTRICT
HYDRO-BRAKE DEMONSTRATION GRANT

W. 153/FERNWAY LOCATION #5 RAIN EVENT MONITORING 6-18 & 19-84

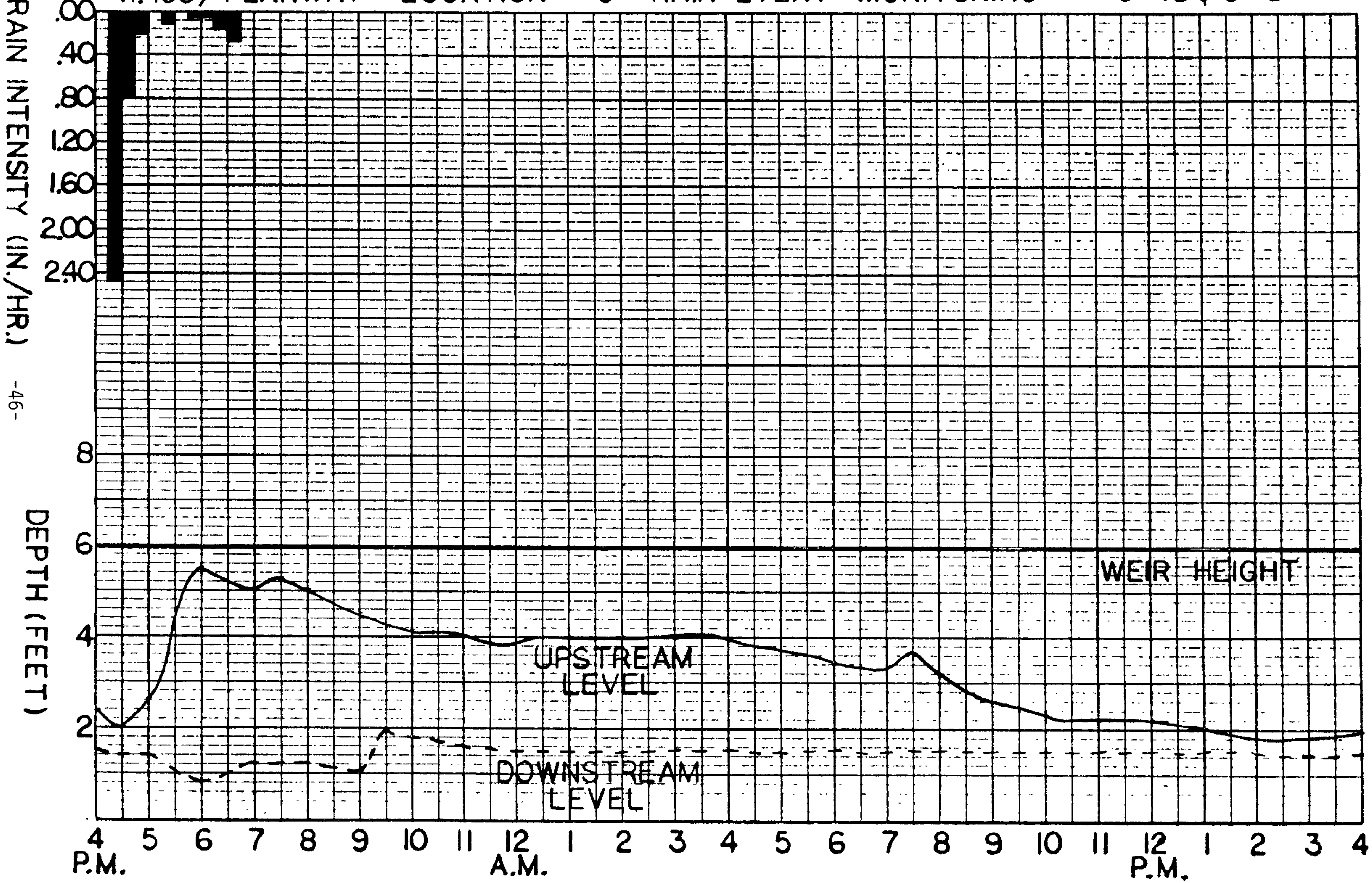


Figure #26

NORTHEAST OHIO REGIONAL SEWER DISTRICT
HYDRO-BRAKE DEMONSTRATION GRANT

W. 117 / FRANKLIN LOCATION #1 RAIN EVENT MONITORING 6-18 & 19-84

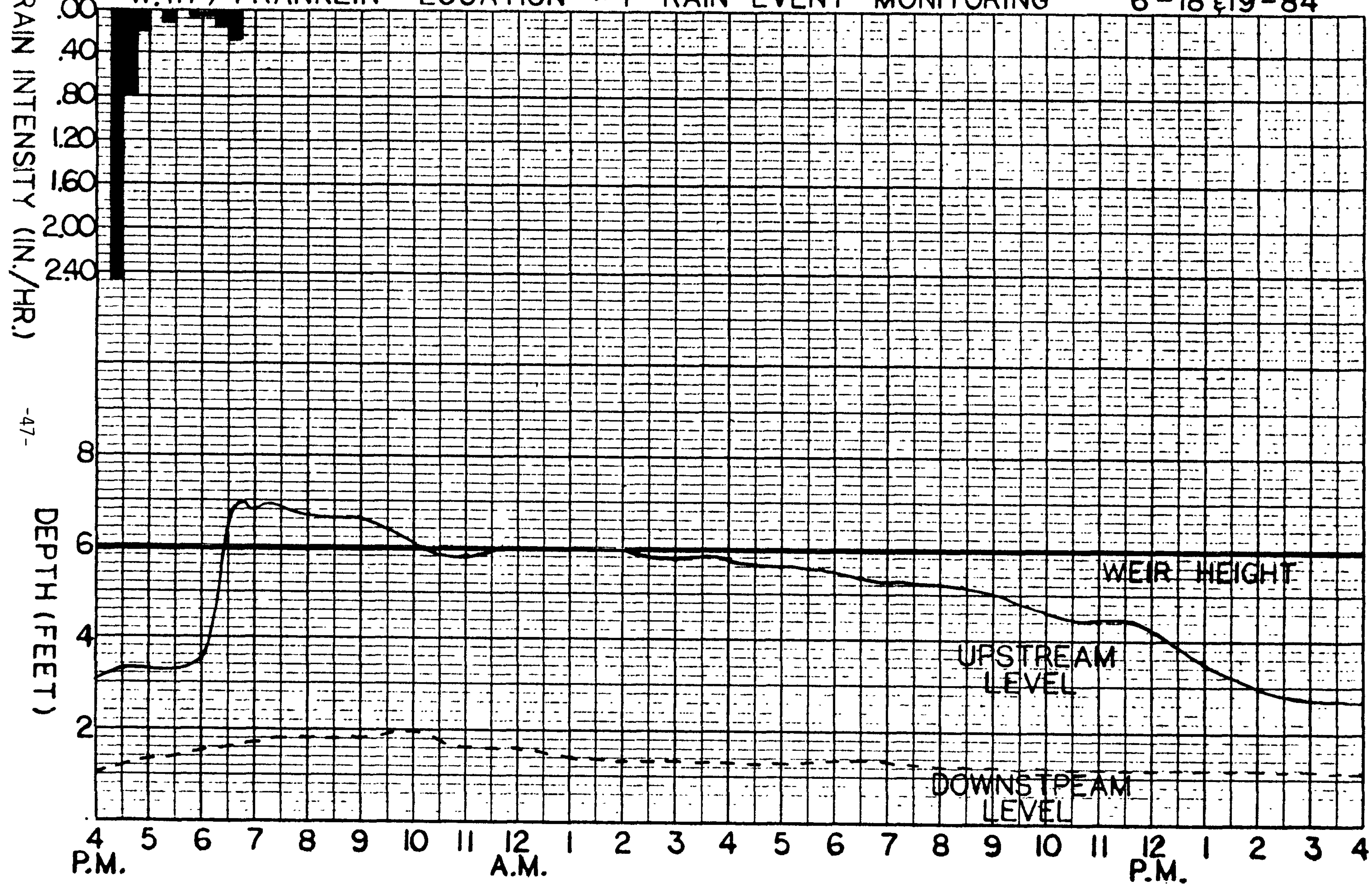


Figure #27

NORTHEAST OHIO REGIONAL SEWER DISTRICT
HYDRO-BRAKE DEMONSTRATION GRANT

ROCKY RIVER / FISHER LOCATION #6 RAIN EVENT MONITORING 7-6&7-84

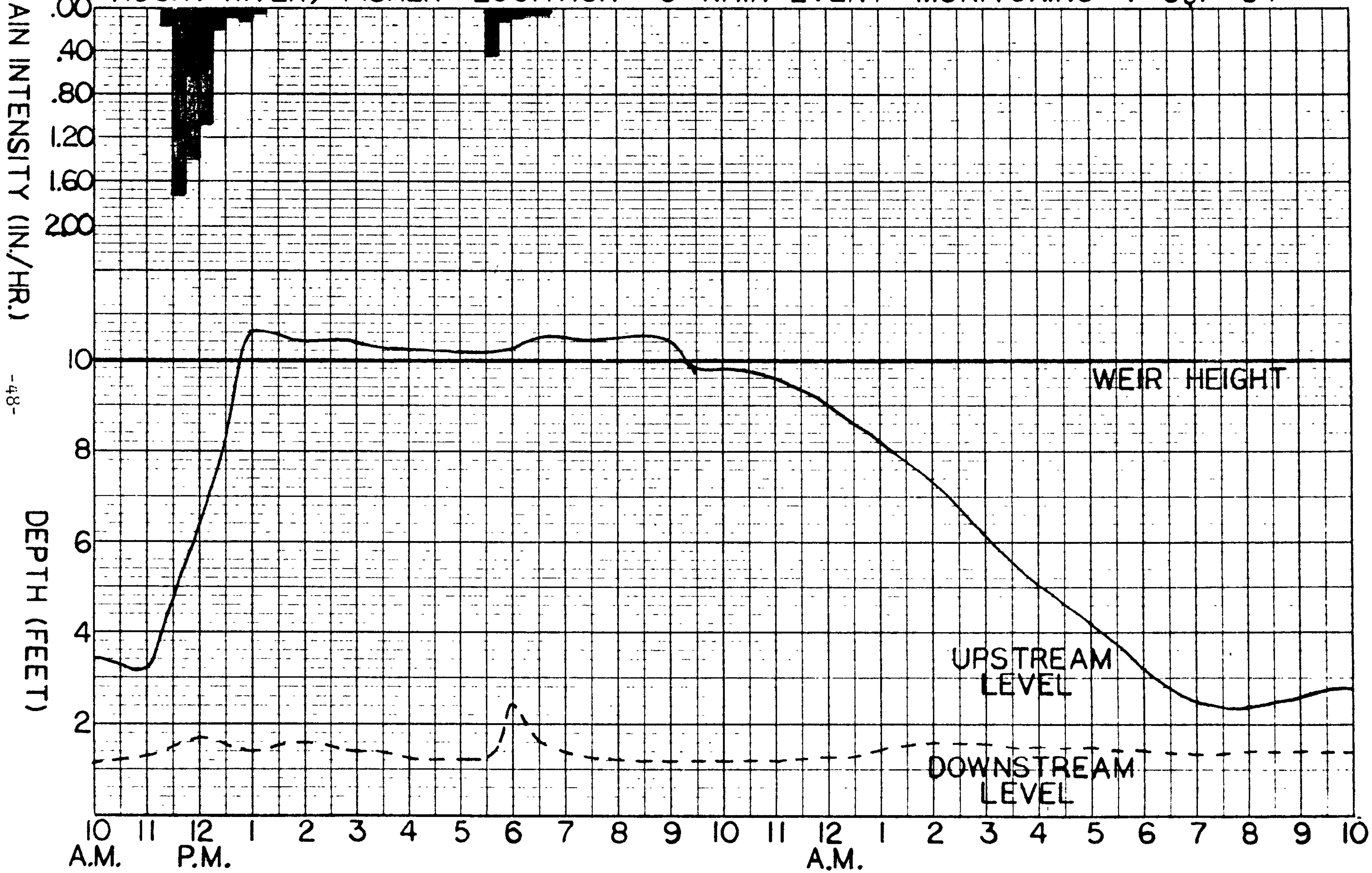


Figure #28

NORTHEAST OHIO REGIONAL SEWER DISTRICT
HYDRO-BRAKE DEMONSTRATION GRANT

W. 153/FERNWAY LOCATION #5 RAIN EVENT MONITORING 7-6&7-84

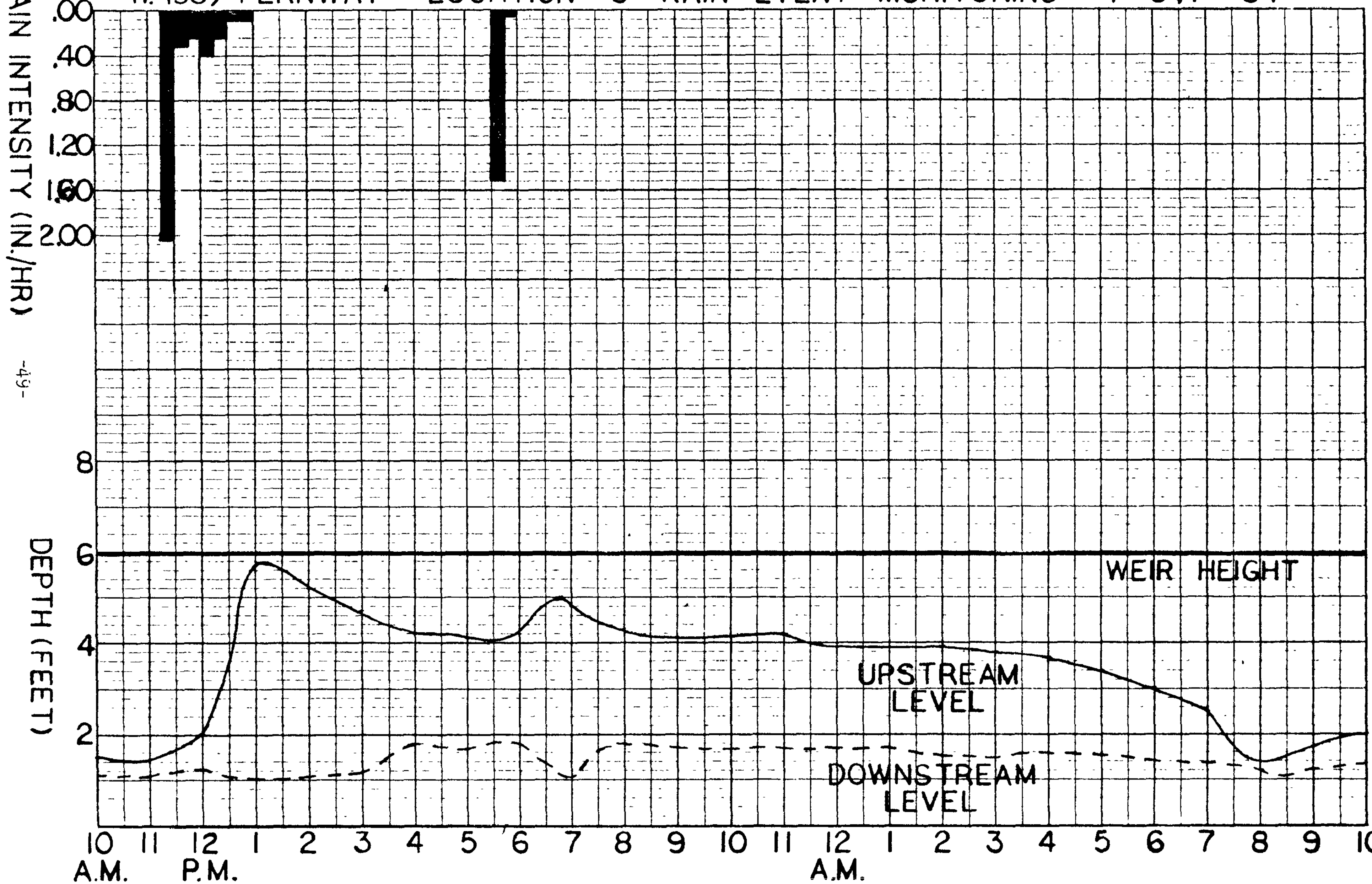


Figure #29

NORTHEAST OHIO REGIONAL SEWER DISTRICT
HYDRO-BRAKE DEMONSTRATION GRANT

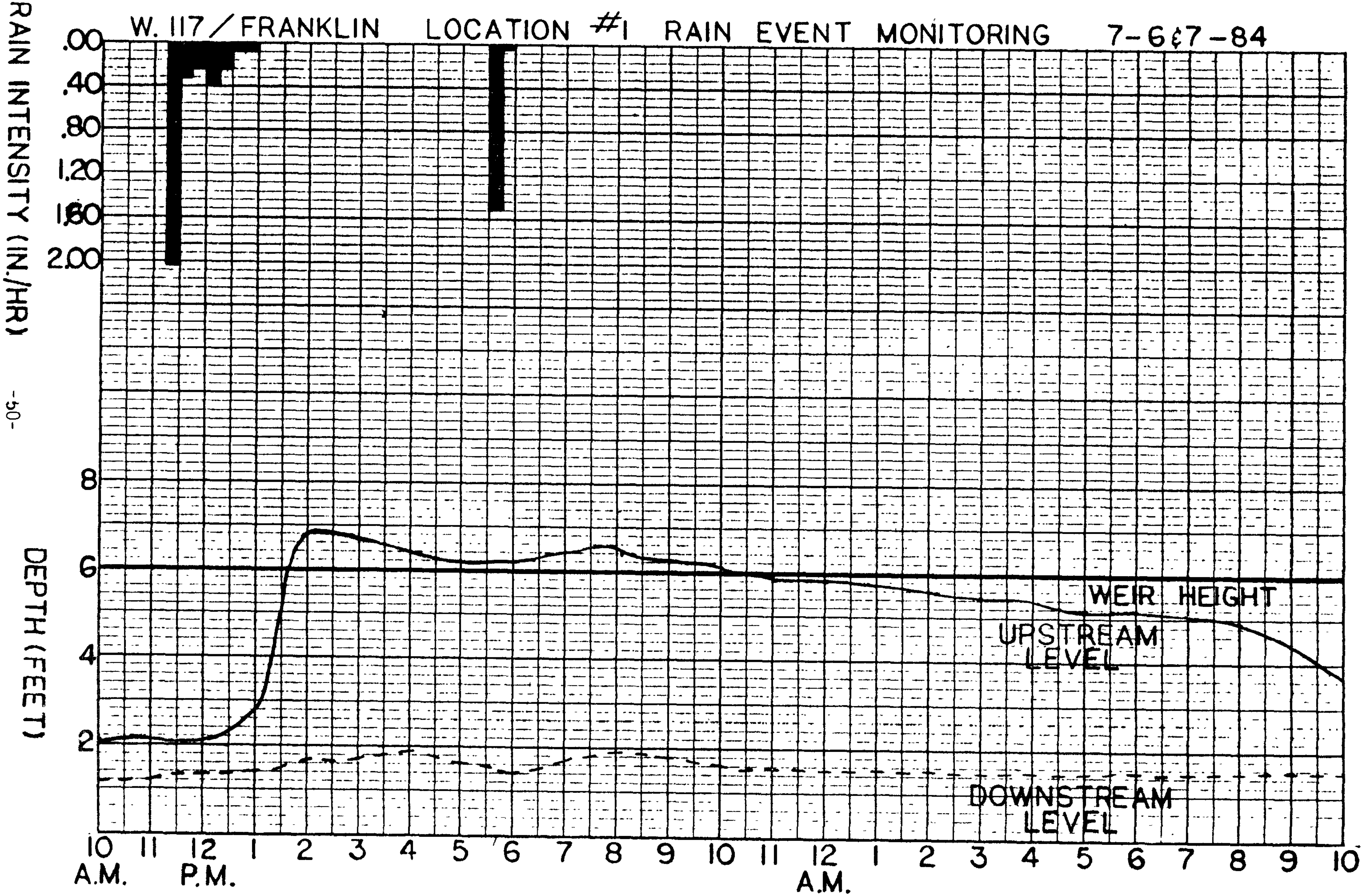


Figure #50

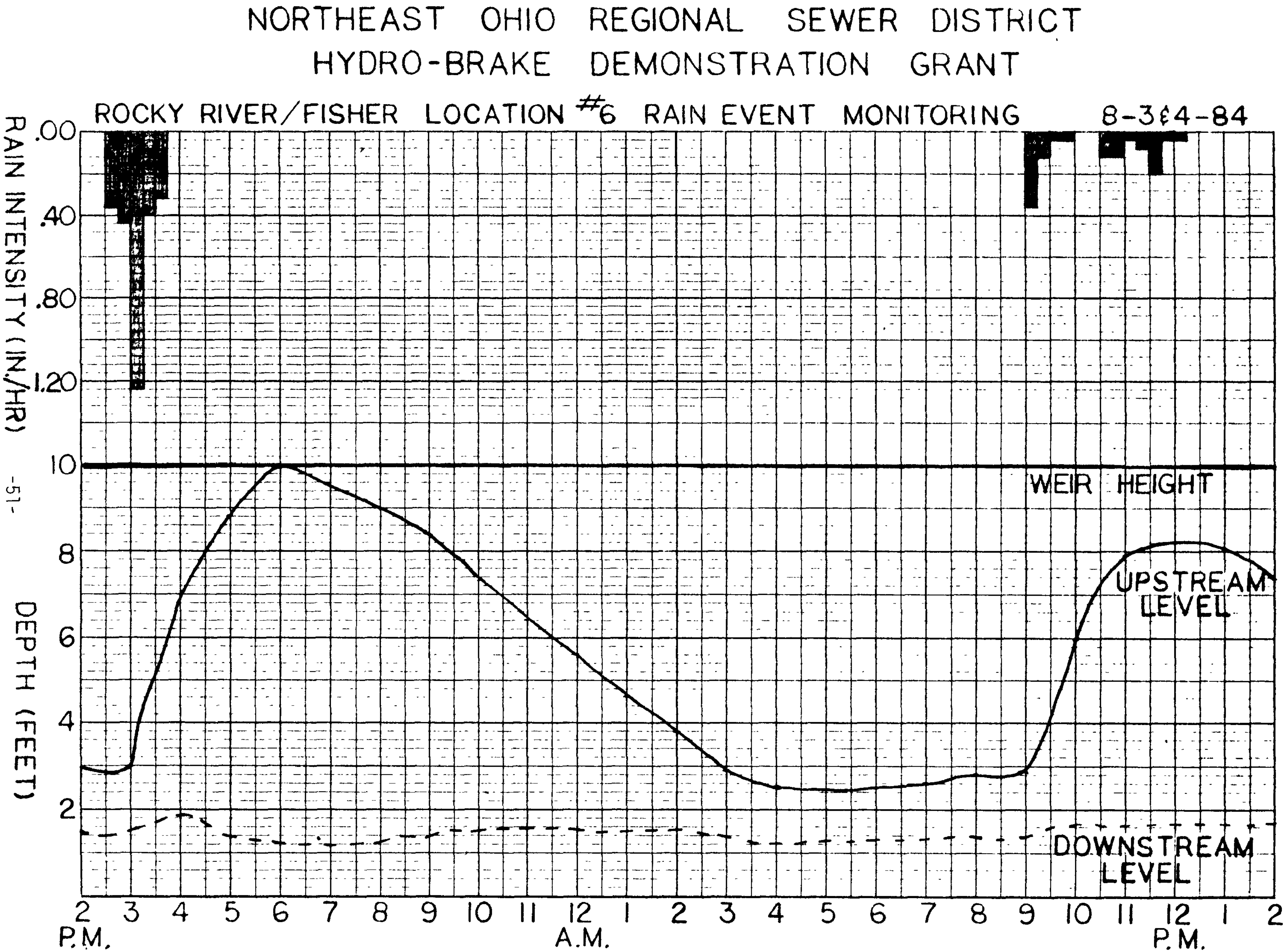

NORTHEAST OHIO REGIONAL SEWER DISTRICT
HYDRO-BRAKE DEMONSTRATION GRANT
ROCKY RIVER/FISHER LOCATION #6 RAIN EVENT MONITORING 8-3&4-84
RAIN INTENSITY (IN./HR)
.00
.40
.80
1.20
DEPTH (FEET)
10
8
6
4
2
WEIR HEIGHT
UPSTREAM LEVEL
DOWNSTREAM LEVEL
2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2
P.M.
A.M.
P.M.

Figure #31

NORTHEAST OHIO REGIONAL SEWER DISTRICT
HYDRO-BRAKE DEMONSTRATION GRANT

W.153/FERNWAY LOCATION #5 RAIN EVENT MONITORING 8-3&4-84

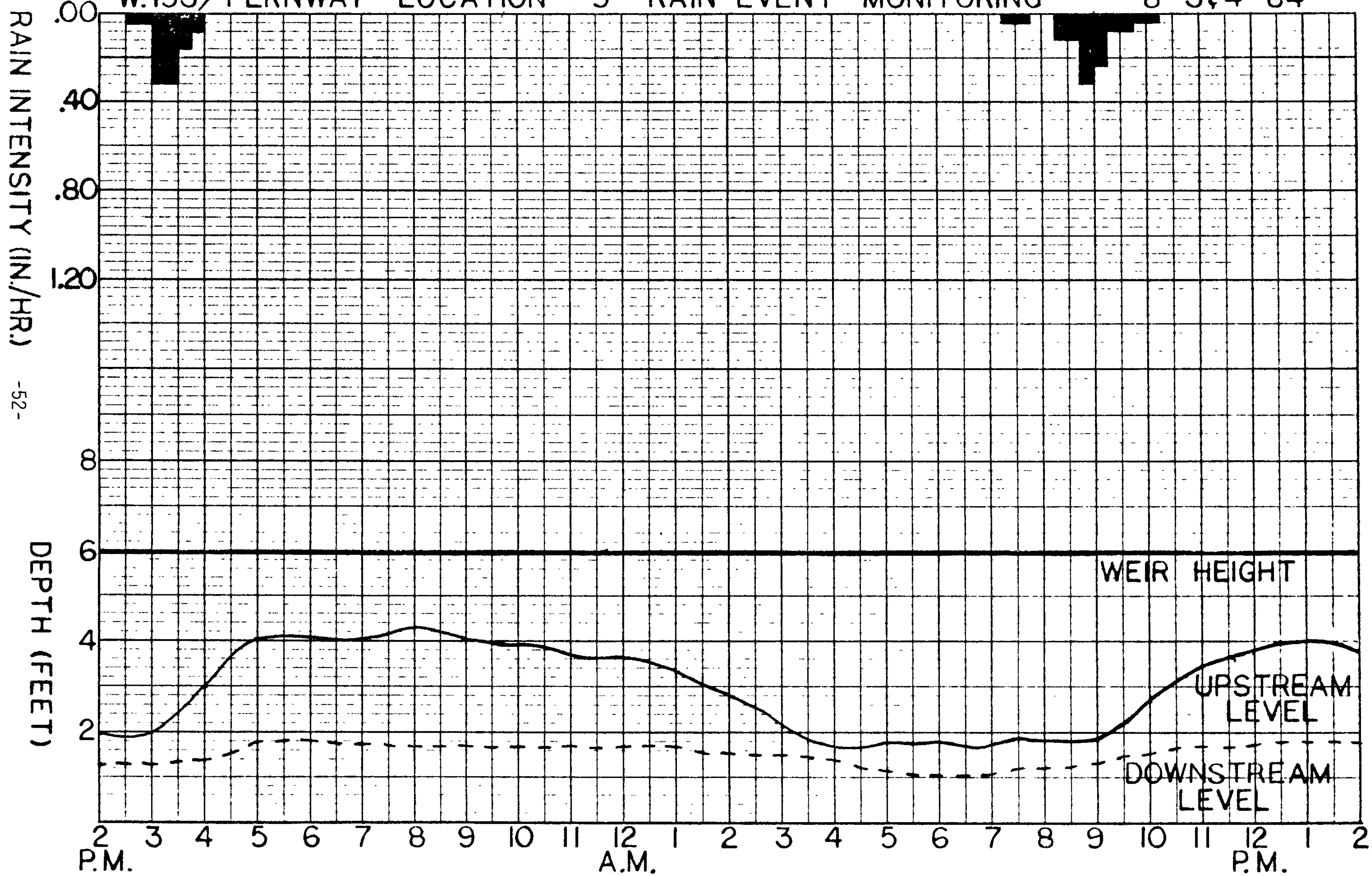


Figure #32

NORTHEAST OHIO REGIONAL SEWER DISTRICT
HYDRO-BRAKE DEMONSTRATION GRANT

W.117 / FRANKLIN LOCATION #1 RAIN EVENT MONITORING 8-3¢4-84

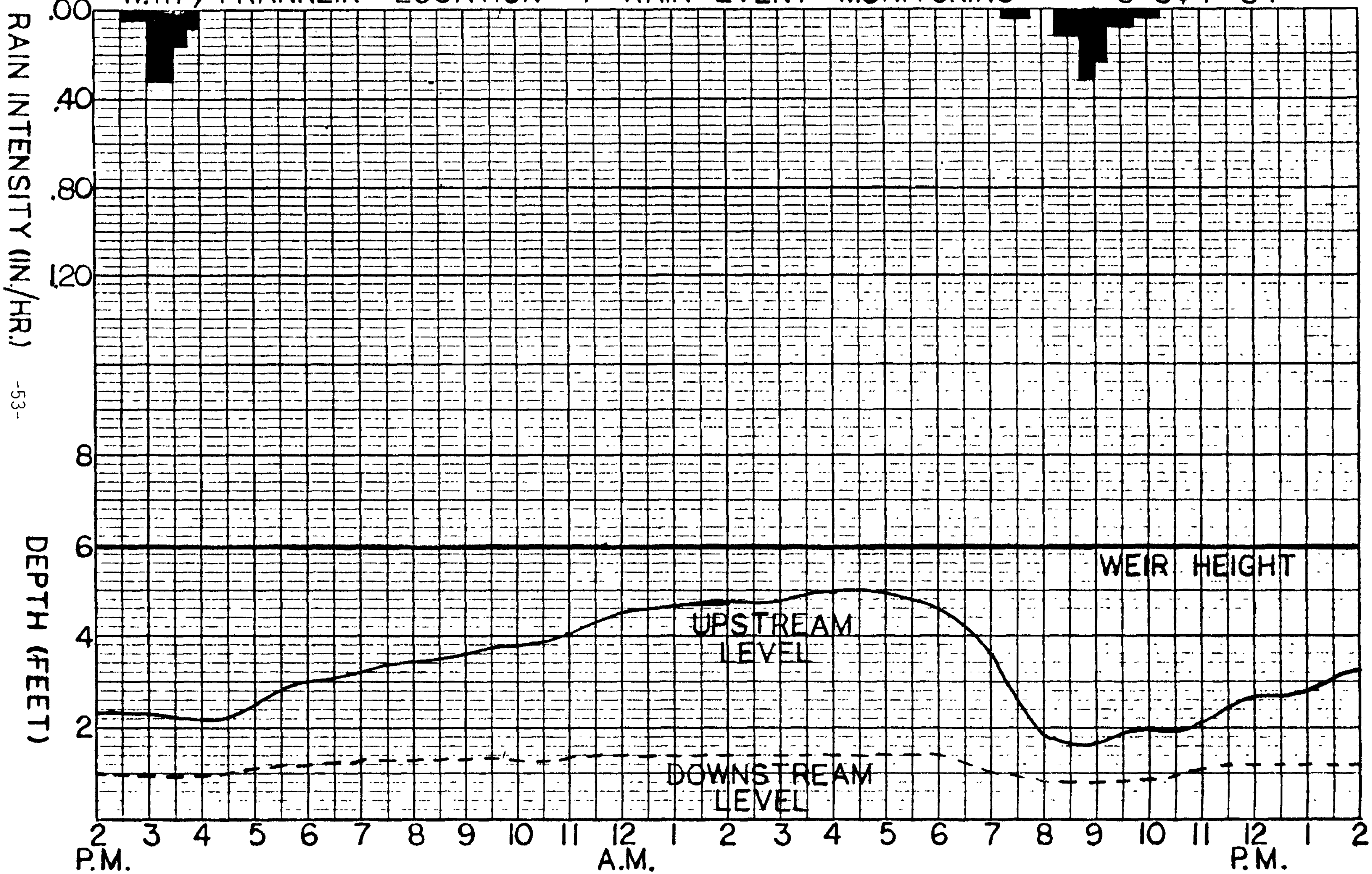


Figure #33

PART 5 ENVIRONMENTAL CONSIDERATIONS

5.1 Objectives:

One of the major objectives of the Hydrobrake Project was to reduce pollutant loading to the environment by controlling the surges of sewage flow that results in overflows of the combined sewer system. The control or reduction of combined sewer overflows is growing in importance. As the hundreds of millions of dollars in sewage treatment plant expansion and improvements are placed into operation, the pollution caused by combined sewer overflows is becoming the major source of urban water degradation. In fact, based upon a USEPA generated report entitled, CSO Loadings Inventory for the Great Lakes Basin, Final Report, March 1983 combined sewage overflows are estimated to contribute as much as:

258,895 lbs. per year of phosphorus
3,862,000 lbs. per year of BOD
9,933,000 lbs. per year of suspended solids

These loadings are equivalent to 35% of the total phosphorus loadings, 43% of the BOD loadings and 66% of the total suspended solids loadings to the water of the Cuyahoga River and near shore waters of Lake Erie in Cleveland. Because of the significance of the CSO pollutant loading to the environment, the Northeast Ohio Regional Sewer District has implemented many programs to reduce combined sewer overflow, including in automated regulators to reduce combined sewer overflows and aggressive program to inspect, clean, or repair blocked sanitary outlets which could result in a dry weather discharge of sanitary sewage. The awareness of the problems of combined sewer overflows led to this Hydrobrake Projects.

5.2 Sampling:

Prior to and after the installation of the Hydrobrakes, samples of the sewage in Diversion Chamber No. 1 (see figure #2) were collected. Four twenty-four hour composite samples were collected in order to determine the background strength of the sewage during dry weather flow. The sampling was performed using a Manning Model 4040 automatic sampler which collected two 250 ml samples per hour over a twenty-four hour period. The analytical results of these four samplings are presented in Table 1 below.

TABLE 1 DRY WEATHER POLLUTANT CONCENTRATIONS OF SEWAGE IN HYDROBRAKE PROJECT AREA, MG/L

Pollutant	6-23-1981	6-24-1981	5-2-1984	5-3-1984	Average
BOD	118	77	100	145	110
COD	424	106	186	237	238
TSS	30	42	120	108	75
Ammonia, as N	13.5	11.1	9.69	16.7	12.7
Phosphorus, as P	4.77	4.45	4.41	4.54	4.54
Chlorides	88	71	136	117	103
Sulfates	75	74	97	102	106
Alkalinity	185	174	184	193	184
Solids (TTL)	452	408	589	573	506
pH	7.28	7.2-7.6	8.0	7.6	-
Nickel	0.04	0.03	0.08	0.06	0.04
Copper	0.09	0.07	0.08	0.09	0.08
Chromium (TTL)	0.02	0.0	0.04	0.06	0.04
Zinc	0.12	0.11	0.42	0.46	0.28
Cadmium	0.01	0.01	0.03	0.01	0.02
Iron	1.0	1.2	2.8	1.9	0.02
Lead	0.01	0.01	0.04	0.1	0.02
Oil & Grease	10	22	28	21	20

Eight combined sewer overflow events were also sampled. Five samplings prior to the Hydrobrake installation and three afterward. These samplings were also performed in Diversion Chamber 1. The samples collected were from the combined sewage as it flowed over the weir enroute to the storm sewer. An ISCO Model 1680 automatic sampler was used in conjunction with a liquid level actuator. The sampler collected two 500 ml discrete samples every five minutes for the first twenty-five minutes of the rainstorm/combined sewer overflow event. Sampling in this manner, it was hoped that the effects of the first flush could be measured. The eight rain/combined sewage overflow events were sampled and analyzed at the Northeast Ohio Regional Sewer District laboratory. The data presented in Table 2, below, are the average concentrations of pollutants in the five rain/overflow events monitored.

TABLE 2. AVERAGE CONCENTRATION OF POLLUTANTS IN COMBINED SEWAGE OVERFLOW, MG/L

Time	BOD	COD	TSS	Phosphorus	T.S.	*D.S.
1st 5 min	129	704	344	4.06	1267	924
2nd 5 min	179	536	467	4.64	1228	761
3rd 5 min	236	709	441	4.86	1277	836
4th 5 min	244	788	644	5.54	1549	904
5th 5 min	285	787	534	6.32	1067	532
Average	215	705	486	5.08	1278	792

* D.S. is Dissolved Solids by difference between Total Solids (T.S.) and Suspended Solids (TSS)

The analytical data presented in Table 2 shows clearly that substantial concentrations of pollutants exited the sewer system during rain events and combined sewage overflow conditions.

The data, however, fails to show a "first flush effect" wherein the highest concentration of pollutants are flushed within the first few minutes of a rain event. This situation could be explained by the fact that overflow was caused by increased flows from two catchment areas. The Detroit Avenue catchment area is smaller and closer in proximity to the sampling point than is the Northwest Interceptor catchment area. The blending of the wastewater from these two separate catchment areas masked the scouring effect of the initial surge of stormwater in the combined sewers.

Flow gauging was attempted in order to calculate the pollutant loadings to the environment. Due to problems caused by the complexity of the sewer system at Diversion Chamber No. 1, the enormous volume and pressure of the flow during storm events, and in general, lack of a suitable and accessible flow monitoring point the flows could not be determined.

5.3 Estimation of Pollutant Reductions:

Although the pollutant loading reductions could not be calculated by actual measurement, these reductions can be estimated by considering the concentration of pollutants and volume of wastewater that is or could be stored by the Hydrobrakes. The Hydrobrakes throttle the flow in the Northwest Interceptor to 20 cfs. Flows in the Northwest Interceptor of greater than 20 cfs would cause an overflow condition at Diversion Chamber No. 1. Any volume of water stored behind the hydrobrake which regulates the flow at 20 cfs is essentially the volume of wastewater that is prevented from overflowing to the environment. This volume could range from zero to a maximum of 3,800,000 gallons depending upon the duration and severity of the particular rain event. For purposes of this report, the maximum storage volume will be used. The data therefore will represent the maximum loading of pollutants that would be removed from the environment as a result of the Hydrobrake installations. The concentration of pollutants used to determine the loading of the pollutants removed from the environment are the average concentrations of the first 25 minutes of the overflow events presented in Table 2. With this as a basis, the Hydrobrakes prevent the following pounds of pollutants from entering the environment:

TABLE 3. MAXIMUM POLLUTANT REDUCTIONS, LBS

Pollutant Parameter	For rain/overflow event	Annual Reduction*
BOD	7,172	502,040
COD	23,519	1,646,330
TSS	16,213	1,134,910
Phosphorus	169	11,830

* Using the average of 70 overflow events annually

Based upon USEPA's estimates of pollutant loadings from combined sewer overflows, the Hydrobrake Project is responsible for controlling as much as 13% of the BOD, 11% of the suspended solids, and 5% of the phosphorous that are discharged to the environment of Greater Cleveland.

PART 6 OTHER HYDROBRAKE PROJECTS

Several projects using Hydrobrakes have been implemented over the past years for various applications.

6.1 City of Cleveland, Ohio:

Most common use has been Inlet Control where Hydrobrakes are used to control street sewers to capacity so basement flooding can be eliminated in all heavy rain events.

Off line storage of excess runoff from the surface has been directed to underground stormwater tanks for controlled discharge by self acting Hydrobrake Flow Regulators.

This type of application was investigated by the City of Cleveland as reported in EPA publication EPA - 600/S2-B3-097, January, 1984.

6.2 City of Euclid, Ohio:

This City, having a separate sewer system, experienced very heavy infiltration/inflow during rain storms pressurizing the sanitary sewer to a point where basement flooding became a severe problem.

The City officials approved testing a small area using heavy runoff. The results convinced the City officials that the Hydrobrake Inlet Control was the most cost effective solution for the City.

During the period from 1978 through 1984 the City has installed more than 1,000 Hydrobrake Inlet Controls city-wide (approximately 4 square miles).

The City claims to have solved all basement back-up problems, reduced the overflows at the Wastewater Treatment Plant and reduced the overall infiltration volume. No off line storage tanks have been necessary as the natural topography could be used for excess runoff without creating any problems.

Experience over more than 7 years has proved that frequencies exceeding 5, 10, 25 and 50 year storms have been totally controlled. No extra operation or maintenance has been experienced.

6.3 City of Portland, Maine:

Portland started its first installations as early as 1977 and has continued the implementation of Inlet Control on a City-wide scale. (Approximately 400 units at present.)

The objectives have been to reduce the risk of sewer backups, blowing of manhole covers, and minimizing or eliminating the combined sewer overflow to the Back Cove from the existing combined sewer system.

The Superintendent of Sewers, Charles Perry, claims no increase in maintenance, the elimination of basement flooding and all first flush events are retained by the sewer. Only storm water will overflow to the Back Cove in the future.

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Finally, we wish to express our gratitude to Carl Maegaard, Hydro Storm Sewage Corporation, Portland, Maine, the supplier of the Hydrobrakes, for his assistance and technical direction throughout the study.

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15. SUPPLEMENTARY NOTES
Richard Traver, Douglas Ammon and John English-MERL Cincinnati.
Ralph G. Christensen - Project Officer-Region V, Chicago, Illinois

16. ABSTRACT

This report details the results of a recently completed three and one-half year Combined Sewer Overflow (CSO) study conducted in a residential/industrial area on the west side of Cleveland, Ohio. The study involved the in-line storage and controlled discharge of combined sewage flow, generated during a rain event, utilizing a Hydrobrake as the control device.

The object of the study was three fold.

1. To eliminate the combined sewer overflow to Lake Erie.
2. To study the effectiveness of the Hydrobrake when utilized as a flow regulator in an in-line storage situation.
3. To provide an even flow to the Westerly Wastewater Treatment Facility in a rain event.

The Hydrobrake proved to be a cost effective device that when properly installed is capable of reliably and accurately throttling flows, creating storage and allowing a self-scouring drain down action without electrical or mechanical controls and very little human intervention.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
CSO Pollution Storm Water Phosphorus Load Combined Sewer Hydrobrakes Storage Water Quality		

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