J.O.No. 12536

FINAL REPORT
INDIAN POINT FLUME STUDY
CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.

JULY 1976

STONE & WEBSTER ENGINEERING CORPORATION
BOSTON, MASS.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SECTION 1

INTRODUCTION

In April 1974, Stone & Webster Engineering Corporation (S&W) submitted a proposal to Consolidated Edison Company of New York, Inc. (Con Edison), for designing test facilities and conducting an experimental program. The purpose of this program was to evaluate the effectiveness and applicability of various fish diversion devices in alleviating the problem of fish impingement at Indian Point and other Hudson River sites. Alden Research Laboratories (ARL) in Holden, Massachusetts was chosen as the site for the study program to make use of existing facilities.

The objectives of the study program were as follows:

1. Determine the feasibility of transporting and holding Hudson River fish species at ARL.

2. Review available literature pertaining to fish protection at water intakes, fish diversion studies, and life histories and behavioral characteristics of key Hudson River species commonly impinged at Indian Point.

3. Evaluate the prototype engineering feasibility of various fish diversion structures for application at Indian Point.

4. Utilizing information obtained from 2 and 3, determine fish diversion structures to be tested. In addition, determine the water quality parameters which can be obtained in the test flume and investigate the effect of control limitations on the results of the study.

5. Test the applicability of specified fish diversion devices on Hudson River species and optimize the effectiveness of protection systems found to be effective and feasible.

The results of objectives 1 through 4, as summarized in Section 2, are discussed in detail in a separate progress report issued in August 1975 (Stone & Webster 1975b). The procedures, results, and conclusions of the study program to test the applicability of specified fish guidance devices (objective 5) are summarized in this final report.

SECTION 2

PROGRAM DEVELOPMENT

The studies described in this report were designed to evaluate the applicability of various fish diversion devices for alleviating fish impingement at the Indian Point Generating Station and the proposed Cornwall Pumped Storage Project. A description of these facilities and a brief summary of the information obtained and utilized in the development of the study program are given below.

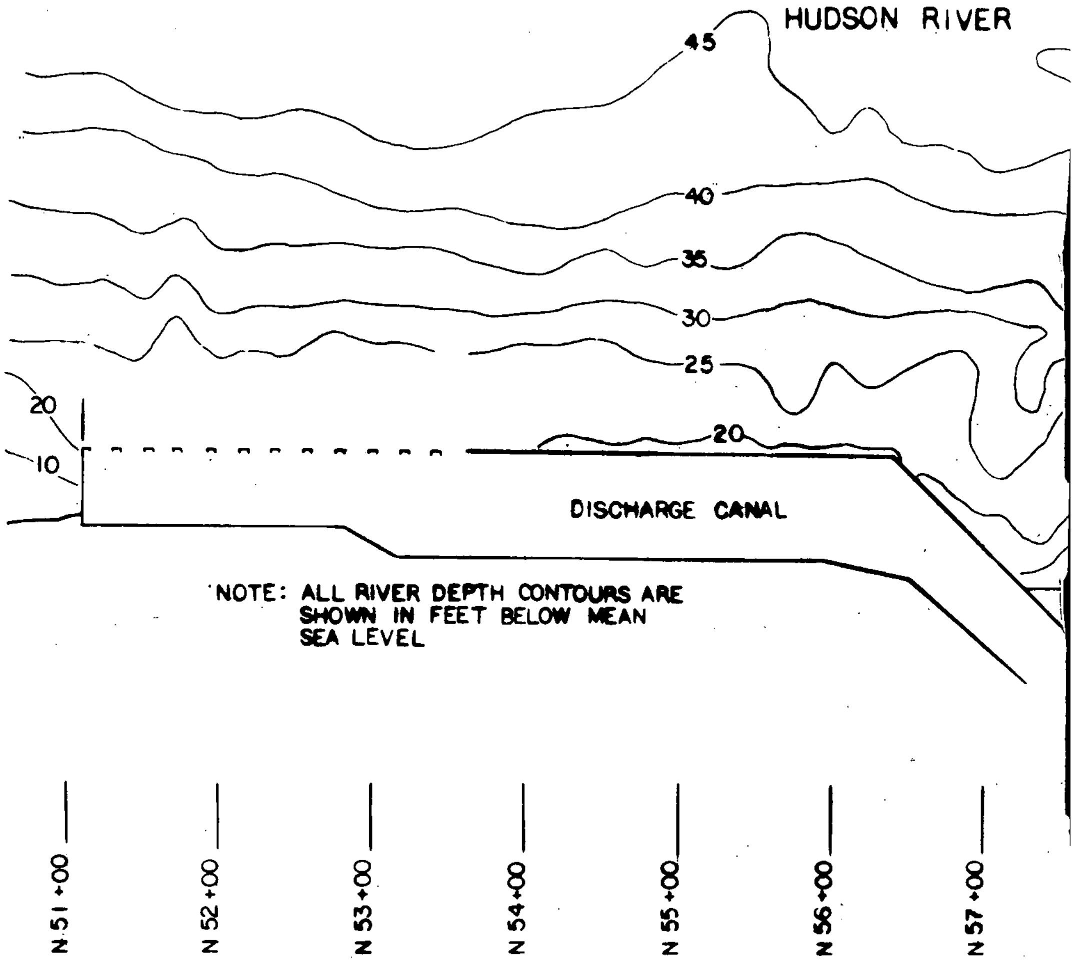
2.1 INDIAN POINT GENERATING STATION - UNITS 1, 2 AND 3

The intakes of Units 1, 2 and 3 are located on the shoreline of the Hudson River between river miles 42 and 43, as shown in Figure 2.1-1. The combined flow rate into the intakes is 2,058,000 gpm (4,589 cfs). Tidal fluctuations in the Hudson River influence the river currents in the vicinity of the intakes and the approach velocities to the intakes.

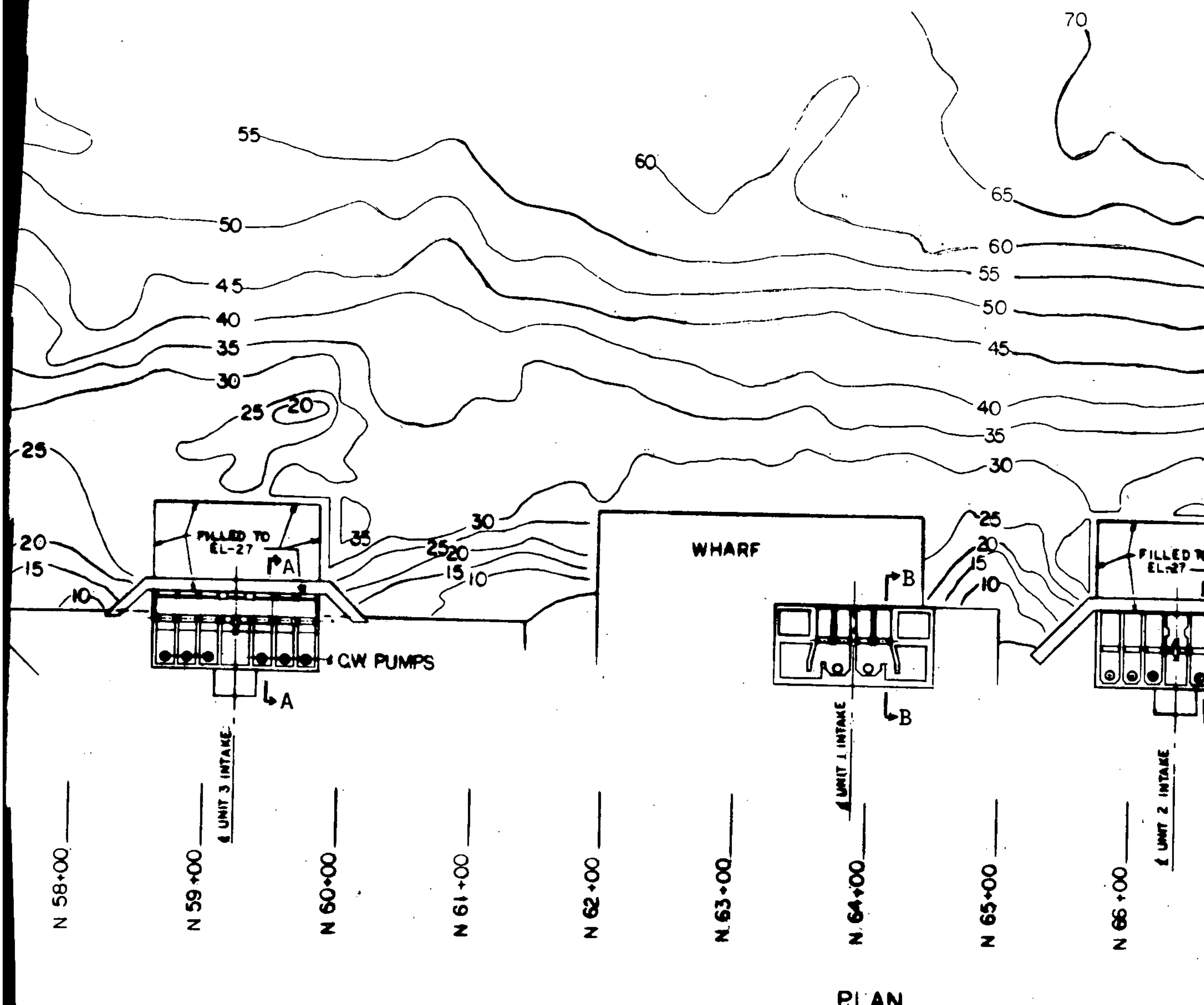
The Unit 1 intake is located between the Units 2 and 3 intakes and behind a barge wharf. The intake structure houses service water pumps and two circulating water pumps, as shown in Figure 2.1-1. The flow rate into the intake is normally 318,000 gpm (709 cfs), resulting in a design velocity approaching the screens of 0.7 fps. When the ambient river temperature drops below 40°F, the flow rate into the intake is reduced to 60 percent of the normal flow, resulting in an approach velocity of 0.42 fps. The intake structure is equipped with a fixed fine screen with 3/8-inch-square openings placed flush with the face of the intake, vertical trash racks with guided rakes, and traveling water screens with 3/8-inch-square openings, as shown in Figure 2.1-2. A skimmer wall and a warm-water recirculation pipeline upstream of the trash racks provide protection from floating and frazil ice.

The Unit 2 intake is located north of the intakes of Units 1 and 3. The intake structure houses service water pumps and six circulating water pumps, as shown in Figure 2.1-1. The flow rate into the intake is 870,000 gpm (1,940 cfs), resulting in an approach velocity of approximately 1 fps. At the reduced flow rate of 60 percent of normal flow, the approach velocity is approximately 0.6 fps. The Unit 2 intake structure is similar to the Unit 1 structure, with fixed fine screens flush with the intake face, a trash rack, a traveling water screen, a skimmer wall, and a warm-water recirculation line, as shown in Figure 2.1-2.

The Unit 3 intake is located south of the intakes of Units 1 and 2. The intake structure houses service water pumps and six circulating water pumps, as shown in Figure 2.1-1. The flow rate is 870,000 gpm (1,940 cfs) and the design approach velocity to the screens is approximately 1 fps. At the reduced flow rate of 60 percent of normal flow, the approach velocity is approximately 0.5 fps. The intake arrangement differs slightly from that of Units 1 and 2 in that the traveling water screens are set flush with the shoreline and the trash racks protrude into the river allowing a lateral passageway for fish upstream of the traveling screens, as shown in Figure 2.1-2. A skimmer wall in front of the trash racks and a warm-water recirculation line between the trash racks and screens are provided for protection from ice. Trash racks are also placed at both ends of the lateral passageway.



[COURTESY OF CONSOLIDATED EDISON CO. OF N.Y., INC.]



[SEE FIGURE 2.1-2 FOR ELEVATION VIEWS A-A, B-B & C-C]

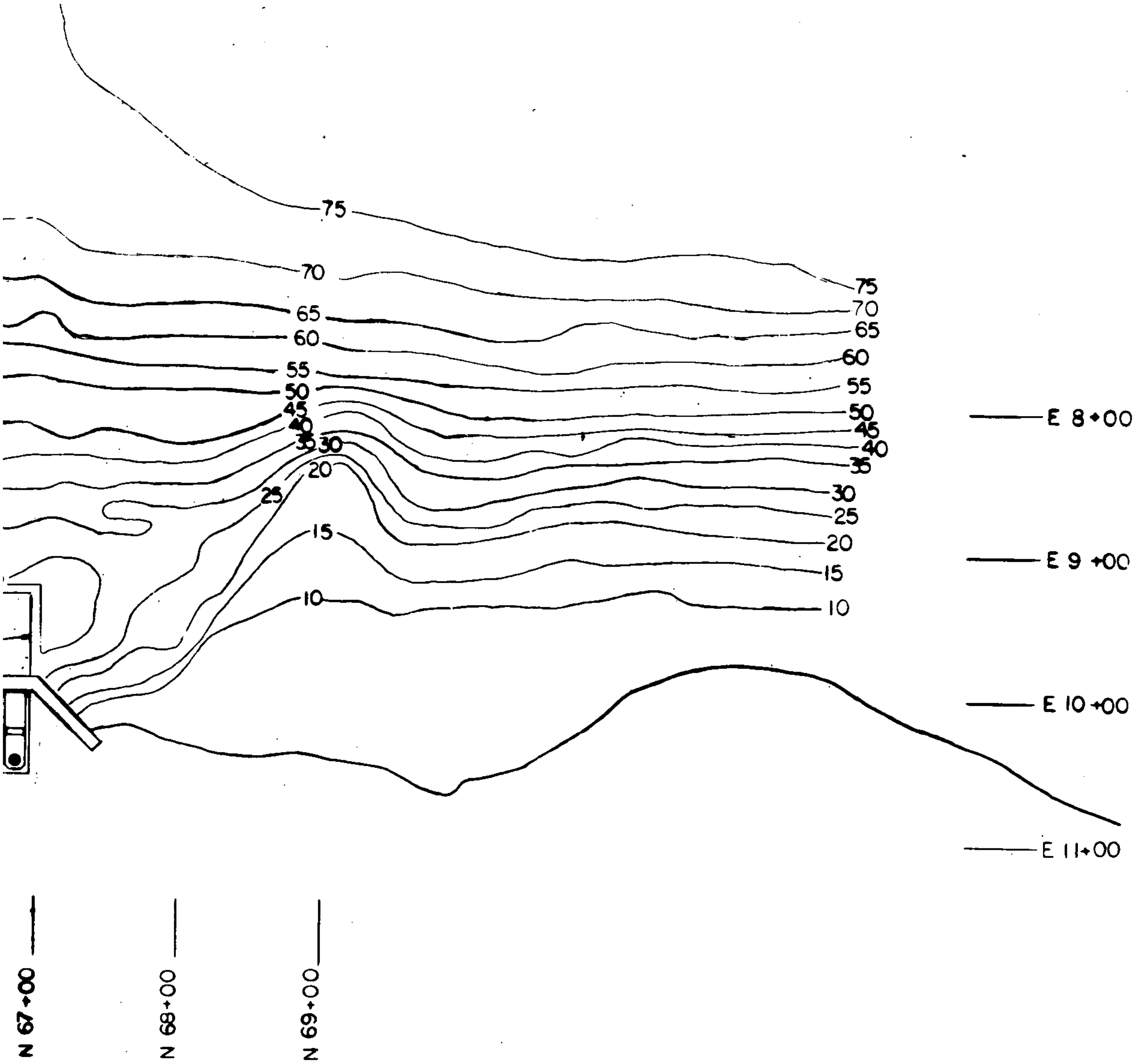


FIGURE 2.1-1

PLAN OF EXISTING INTAKES

INDIAN POINT FLUME STUDY
CONSOLIDATED EDISON CO. OF NEW YORK, INC.
STONE & WEBSTER ENGINEERING CORPORATION

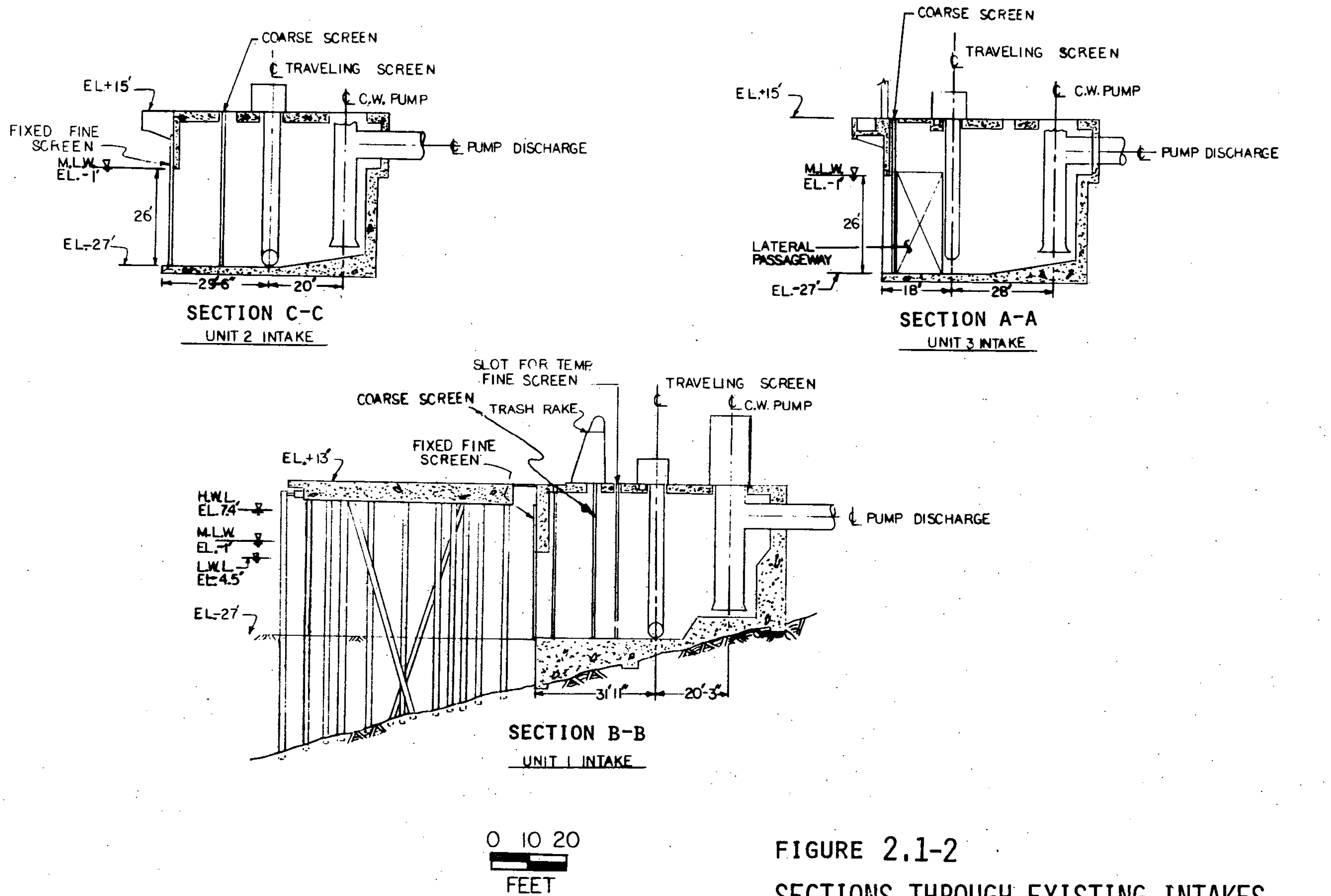


FIGURE 2.1-2

SECTIONS THROUGH EXISTING INTAKES

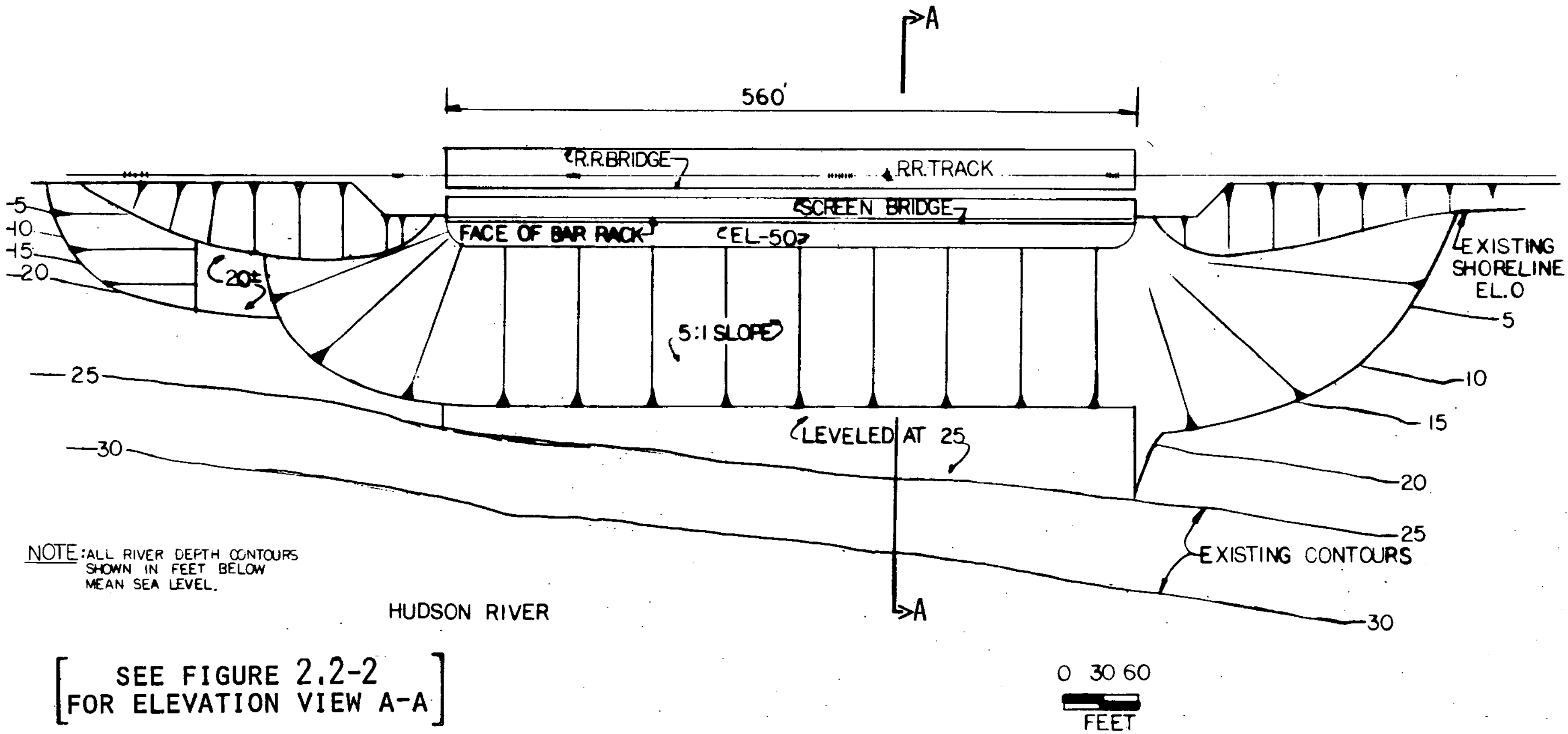
INDIAN POINT FLUME STUDY
CONSOLIDATED EDISON CO. OF NEW YORK, INC.

STONE & WEBSTER ENGINEERING CORPORATION

[COURTESY OF CONSOLIDATED EDISON CO. OF N.Y., INC.]

2.2 CORNWALL PUMPED STORAGE PROJECT

The proposed Cornwall intake will be located on the shoreline of the west bank of the Hudson River, as shown in Figure 2.2-1. The total intake flow rate with eight units operating during the pumping mode ranges between 9,335,040 gpm (20,800 cfs) maximum and 8,976,000 gpm (20,000 cfs) minimum, and the total discharge flow rate during the generating mode ranges between 12,925,440 gpm (28,800 cfs) maximum and 10,412,160 gpm (23,200 cfs) minimum. The intake opening is about 560 feet wide and extends from elevation -50 feet MSL depth to an ice baffle or curtain wall at elevation -6 feet MSL, as shown in Figure 2.2-2. The design velocity approaching the screen is approximately 1 fps. The screen will be set flush with the river shoreline and will consist of 1/4-inch-thick bars with 3/8-inch-wide clear spacings to which is attached 3/8-inch woven-wire mesh. If operational experience shows a need for bar rack cleaning, manual cleaning or a system of traveling water jets will be used. A tailrace bay extends between the screens and the tailrace tunnels.



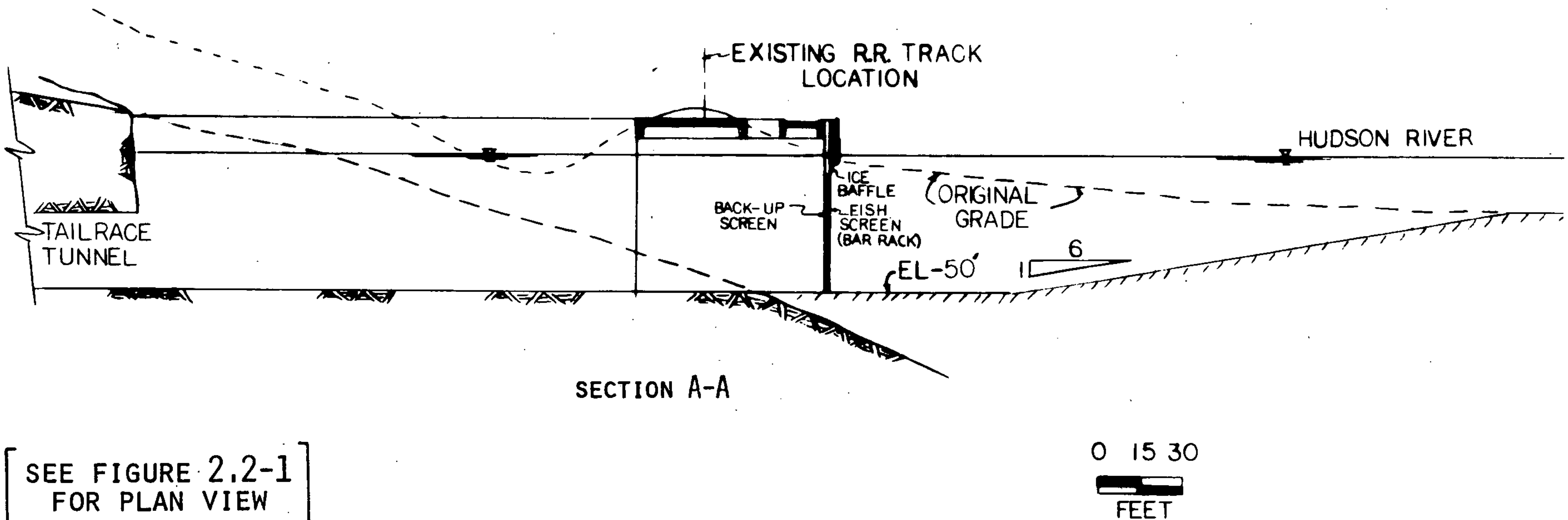
[SEE FIGURE 2.2-2 FOR ELEVATION VIEW A-A]

[COURTESY OF CONSOLIDATED EDISON CO. OF N.Y., INC.]

FIGURE 2.2-1
PLAN OF CORNWALL INTAKE

CORNWALL PUMPED STORAGE PROJECT
INDIAN POINT FLUME STUDY
CONSOLIDATED EDISON CO. OF NEW YORK, INC.

STONE & WEBSTER ENGINEERING CORPORATION



SECTION A-A

[SEE FIGURE 2.2-1 FOR PLAN VIEW]

[COURTESY OF CONSOLIDATED EDISON CO. OF N.Y., INC.]

FIGURE 2.2-2

SECTION THROUGH CORNWALL INTAKE

CORNWALL PUMPED STORAGE PROJECT
INDIAN POINT FLUME STUDY
CONSOLIDATED EDISON CO. OF NEW YORK, INC.
STONE & WEBSTER ENGINERING CORPORATION

2.3 LITERATURE REVIEW AND PROTOTYPE ENGINEERING FEASIBILITY EVALUATION

A literature review and prototype engineering feasibility evaluation were conducted as part of the study program. These provided a basis for selecting test devices which appeared to have the greatest potential for successful application and which were considered feasible for installation at Indian Point and Cornwall. The literature review included the impingement history at Indian Point, the life histories and behavioral characteristics of selected fish species, and the results of past studies with various diversion devices. The engineering evaluation was developed by S&W to determine the feasibility of utilizing specific devices at Indian Point and Cornwall relative to potential installation and operational problems. The results of each of these tasks are discussed in detail in a seperate report (Stone & Webster 1975b) and are summarized below.

2.3.1 Impingement History at Indian Point

Various regulatory agencies have been concerned with fish impingement at Indian Point since Unit 1 began operation in 1962. In an effort to alleviate fish impingement, various behavior-influencing diversion devices and intake design modifications have been evaluated or implemented at Indian Point since 1963.

Behavioral systems include air bubble curtains, sound, lights, and reduced intake velocity. Design modifications include installation of fixed screens, extending the warm-water discharge canal farther downstream from the intakes to minimize recirculation, removing the sheet pilings on the wharf of Unit 1, and moving the hypochlorite discharge downstream of the traveling water screens. Evaluation of these systems showed them to be, at most, only partially effective in reducing impingement (Con Edison 1973).

In June 1972, Texas Instruments Incorporated (TI) was contracted by Consolidated Edison to conduct an impingement monitoring program at Indian Point Units 1 and 2. The purpose of the study was to collect and analyze data on the seasonal occurrence, species composition, and size distribution of fish impinged by Units 1 and 2. These data were then related to various physical-chemical parameters associated with the plant's operation and its location on the Hudson River. The effectiveness of various fish-handling and fish-protective devices was also evaluated. Results of the impingement-monitoring program and associated studies through December 1973 have been published (Texas Instruments 1974).

During the course of the monitoring program (June 1972 through December 1973), 230,480 fish were collected from the Units 1 and 2 intake screens. Of the fish collected, six species made up over 90 percent of the fish impinged: white perch (Morone americana), Atlantic tomcod (Microgadus tomcod), bay anchovy (Anchoa mitchilli), striped bass (Morone saxatilis), blueback herring (Alosa aestivalis), and alewife (Alosa pseudoharengus). White perch and tomcod were the most abundant species and comprised over 75 percent of all fish impinged. Striped bass, an important commercial and recreational species in New York State, made up 1.5 percent of the fish impinged. These three species, white perch, tomcod, and striped bass, were selected for detailed study because of their numbers and/or their commercial and recreational value.

2.3.2 Life Histories of Test Species

Much information is available on the habits, distribution, and biology of the test species, which include tomcod, white perch, and striped bass, as they occur in waters along the eastern coast of North America. The information gathered for evaluation in the study program was specific to those life stages which are subject to impingement by the Indian Point facility. During the course of the previously mentioned TI study (Texas Instruments 1974), 105,892 white perch were collected from Unit 1 and 2 intake screens. This is 45.9 percent of the total number of fish impinged during the 18-month study. These fish were mainly young-of-the-year white perch averaging 83.3 mm in length.

Adult white perch spawn in fresh and brackish water areas of the Hudson River during the spring. Spawning generally occurs at temperatures of 50° to 60°F (Thoits 1973; Mansueti 1964). Young-of-the-year spend the summer in shallow water areas, such as Haverstraw Bay. During the fall, they migrate to deep-water areas to overwinter. This fall migration may account for the increase in white perch impingement at this time of year (Texas Instruments 1974). As temperatures drop during the winter, the movements and swimming ability of the perch become reduced, and consequently, they would be less likely to avoid impingement. This coincides with the period of peak impingement for this species which occurs from January through April (Texas Instruments 1974).

During the TI study, 76,958 tomcod were impinged, accounting for 33.4 percent of the total impingement. The fish impinged averaged 91.3 mm in length.

Tomcod begin moving up the Hudson River to freshwater spawning grounds in December. The migration continues through February and spawning occurs from January through April (Texas Instruments 1972). After spawning, the adults move downstream; some remain in the lower Hudson and others leave the river completely. Larvae and juveniles tend to remain near their spawning grounds. Young tomcod are usually of impingeable size (50 to 60 mm) by the end of the summer, as reflected in a rise in the impingement rate at this time. There is also a rise in the impingement rate during December and January. This coincides with the spawning run of adult tomcod, as indicated by length-weight statistics of impinged fish (Texas Instruments 1974).

During 18 months of sampling, 3,368 striped bass were impinged on Units 1 and 2 intake screens. Although this represents only 1.5 percent of all the fish impinged, striped bass were chosen for study because of their importance to commercial and sport fisheries.

During the winter, the majority of the impinged striped bass were young-of-the-year. Some yearling bass were impinged during the summer months. The average length of the fish impinged was 111.8 mm.

Adult striped bass enter the Hudson River during the spring and swim upstream to spawn mainly in fresh water areas of the river. The majority of the spawning occurs at temperatures generally between 58°and 70°F (Raney 1954).

Rathjen and Miller (1957) reported that major spawning of the bass probably takes place upstream of Indian Point. Young-of-the-year fish are, at times, common downstream of Poughkeepsie, in the general vicinity of Indian Point. In the fall, juvenile striped bass migrate downstream to the Haverstraw Bay area to overwinter.

Peak impingement occurs during the winter months but is noticeably dependent upon movement of the salt wedge past Indian Point. Trawling data obtained during the impingement monitoring program show markedly higher densities of striped bass in the immediate vicinity of the salt wedge interface than in areas upstream or downstream of the salt wedge. This indicates that high rates of impingement during the passage of the salt wedge past Indian Point are caused by an increase in the density of fish associated with the salt wedge, and that they are not caused by salinity changes and resultant stress.

2.3.3 Literature Review of Past Studies and Prototype Engineering Feasibility Evaluation

Two of the objectives of the study program were to review all literature pertaining to various fish diversion devices and to evaluate the prototype engineering feasibility of such devices for potential application at Indian Point and Cornwall. The devices chosen for study included vertical angled screens and louvers, an inclined plane screen, a lift basket collection system, an underwater wall, and an air bubble curtain. The following is a brief summary of the findings and conclusions of these investigations.

2.3.3.1 Vertical Fish Diversion Devices

Two vertical diversion devices were chosen for consideration; a louver system and an angled screen. Both could be stationary or traveling, depending on the extent of operational problems which might occur at a particular site. Most of the research on vertical diversion devices has been concerned with developing louver systems for bypassing fish in river systems of the Pacific Northwest. More recently, however, encouraging results have been obtained with a flush-mounted, traveling screen set at an angle to the flow and leading to a bypass (Taft et al 1976).

Louvers

All louver systems developed and operating to date have been stationary. A louver system is simply a row of evenly spaced, vertical slats which are aligned across a channel at a specified angle and lead to a bypass. The system works on the principle that fish avoid areas of high turbulence and will not cross through a vertical line of high differential velocity (Cal. Dept. Water Res. 1967; Hallock, Iselin, and Fry 1968; Pavlov 1969). Instead, they will seek out areas of relatively low velocity. The louvers act to establish a vertical line of high velocity crossflow (Kerr 1953).

It has been found that fish tend to orient themselves facing into a current, even if they are moving with it, in order to facilitate respiration and feeding (Kerr 1953). This means that they cannot see obstructions or barriers downstream. Therefore, fish rely mainly on their other senses to guide them around obstacles. The louver system takes advantage of this behavior. As fish approach the louvers, they sense the turbulence created by the system and move laterally away from it (Hallock, Iselin, and Fry 1968). As they are carried downstream, their lateral movement and the current eventually direct them into a bypass and then to a collecting area where they can be removed by various methods.

Louver systems have proven to have many advantages over other systems which are presently in use or under study. Model and prototype studies, as summarized in Table 2.3-1, have shown greater than 90 percent efficiency under many different experimental conditions with a large variety of fish species. Further, since the system relies on the natural ability of fish to sense velocity gradients, there is a minimum amount of handling involved, thus avoiding the injury and stress that can be caused by other systems (Riesbol and Gear 1972). Finally, because there are no moving parts, the cost of construction is substantially less than it is for some mechanical systems, such as horizontal traveling screens, and louvers are much easier to maintain. However, close-spaced stationary louvers have a potential for clogging, a condition which could affect guidance efficiency. Flush-mounted traveling louvers, which can be easily

TABLE 2.3-1

LIST OF PAST AND PRESENT LOUVER STUDIES

INDIAN POINT FLUME STUDY
CONSOLIDATED EDISON CO. OF NEW YORK, INC.
STONE & WEBSTER ENGINEERING CORPORATION

Study Site	Test Species	Test Facilities	References
Mayfield Dam, Washington for the City of Tacoma	Cutthroat and steelhead trout, chinook and coho salmon, whitefish	Prototype System	Thompson and Paulik 1967.
Redondo Beach, Cal., for Southern California Edison	Northern anchovy, queenfish, white croaker, walleye sunperch, shiner perch	50- x 6- x 4-ft redwood test flume	Schuler 1973; Schuler and Larson 1974; Downs and Meddock 1974
Robertson Creek, British Columbia Department of Fisheries of Canada	Juvenile chinook, sockeye and coho salmon	8- x 10- x 6-ft wooden test flume	Ruggles and Ryan 1964
Tracy Fish Collection Facilities, California Dept. of Water Resources	Striped bass, King salmon, shad, catfish, smelt, crappie, and others	36- x 5- x 2-ft test flume, followed by a 60- x 6- x 2-ft flume, then a prototype system	Bates and Vinsonhaler 1956; Bates, Logan, and Personen 1960; California Department of Water Resources 1967
Delta Pumping Plant, California Department of Water Resources	Striped bass	Test flume and prototype system	California Dept. of Fish and Game, Dept. of Water Resources, Annual Reports 1962-1967
Ruth Falls, Nova Scotia for Nova Scotia Power Commission	Atlantic salmon	Prototype system	Ducharme 1972
Nine Mile Point Nuclear Station, for Niagara Mohawk Power Corporation	Alewife, smelt, and coho salmon	70- x 3- x 3-ft test flume	Stone & Webster Engineering Corporation 1975a

maintained and cleaned, have recently been developed. Consequently, a traveling system can be utilized where clogging is deemed to be a potential problem with a stationary louver system. A louver device would then be a feasible alternative for fish guidance from an engineering viewpoint.

Based on the data from the literature review and a prototype engineering design evaluation, louvers were selected for evaluation in the study program.

In order to design a louver system for a certain area, model tests must be conducted so that the best design for the species present can be developed. Design criteria which were considered in this study are listed below:

(a) Maximum and minimum flow velocity approaching the louvers,
(b) Flow patterns,
(c) Angle and length of the line of louvers,
(d) Angle and dimensions of individual slats and spacing of the slats,
(e) Number and dimensions of bypasses, and
(f) Ratio of approach velocity to bypass velocity.

The experience gained from past studies was used to establish the initial design criteria to be evaluated during the study program; these criteria are discussed in Section 3.

<u>Screens</u>

Fixed and traveling screens have been used extensively at electric generating facilities for many years. The primary function of such screens is to block the passage of water-borne debris to protect condenser tubing from clogging. Recently, attention has been turned to protecting aquatic organisms which are also screened in cooling water systems. As a result, various screen designs and orientations have been researched in an attempt to establish conditions which prevent fish impingement.

Much of the research on screening techniques has been involved with designing screenwells to have screens mounted flush with the shoreline and to provide low intake velocities. While such an arrangement can act to reduce fish impingement, experience at Indian Point has pointed out the need for additional modification to reduce impingement. Recent studies by S&W, and discussions with other researchers, have led to the concept of utilizing flush-mounted traveling screens, angled to the flow and leading to a bypass.

Based on data presented in the literature and results obtained in other studies by Stone & Webster (1975a), the angled traveling screen was selected for evaluation during the study program.

As discussed below, other diversion devices were not selected for study due to poor effectiveness at other installations or engineering design problems. Vertical angled louvers and screens, however, were determined to be potentially effective and feasible from a prototype engineering viewpoint.

The criteria used in the engineering evaluation included the feasibility of construction, the capacity for creating the required hydraulic flow conditions, and the potential for minimizing clogging. It was determined from this evalution that flush-mounted traveling screens or louvers could be installed at Indian Point or Cornwall. Suitable flow conditions could be established through the use of appropriately sized approach sections or guide vanes, if deemed necessary. Clogging of louvers would not create a problem since traveling louver arrays can be rotated and washed and fixed louvers can be mechanically raked except in the vicinity of the bypass. Angled traveling screens can also be rotated and washed, thereby minimizing clogging potential.

Based on data from the literature review and prototype engineering feasibility evaluation, a number of different conceptual designs of a louver or screen diversion system for Indian Point were developed. Two examples are shown in Figures 2.3-1 and 2.3-2.

2.3.3.2 Other Diversion Devices Considered for Study

In addition to vertical louvers and screens, inclined plane louvers and screens, a screenwell lift basket collection system, and an underwater wall, or bottom sill, were considered for evaluation during the study program. However, on the basis of a literature review and engineering considerations, it did not appear that any of these systems offered as great a potential for reducing fish impingement as vertical screens and louvers. Therefore, it was decided that these devices would be tested only if the screens and louvers were found to be ineffective (Stone & Webster 1975b).

2.3.3.3 Air Bubble Curtain

Following a literature review, it was concluded that although an air bubble curtain may not be an effective fish diversion device when used alone, it could be used in conjunction with other systems, such as screens or louvers, to improve their effectiveness. Therefore, it was decided that an air bubble curtain would be tested together with the most effective diversion device at the end of the study program to determine its potential for improving the efficiency of that device.

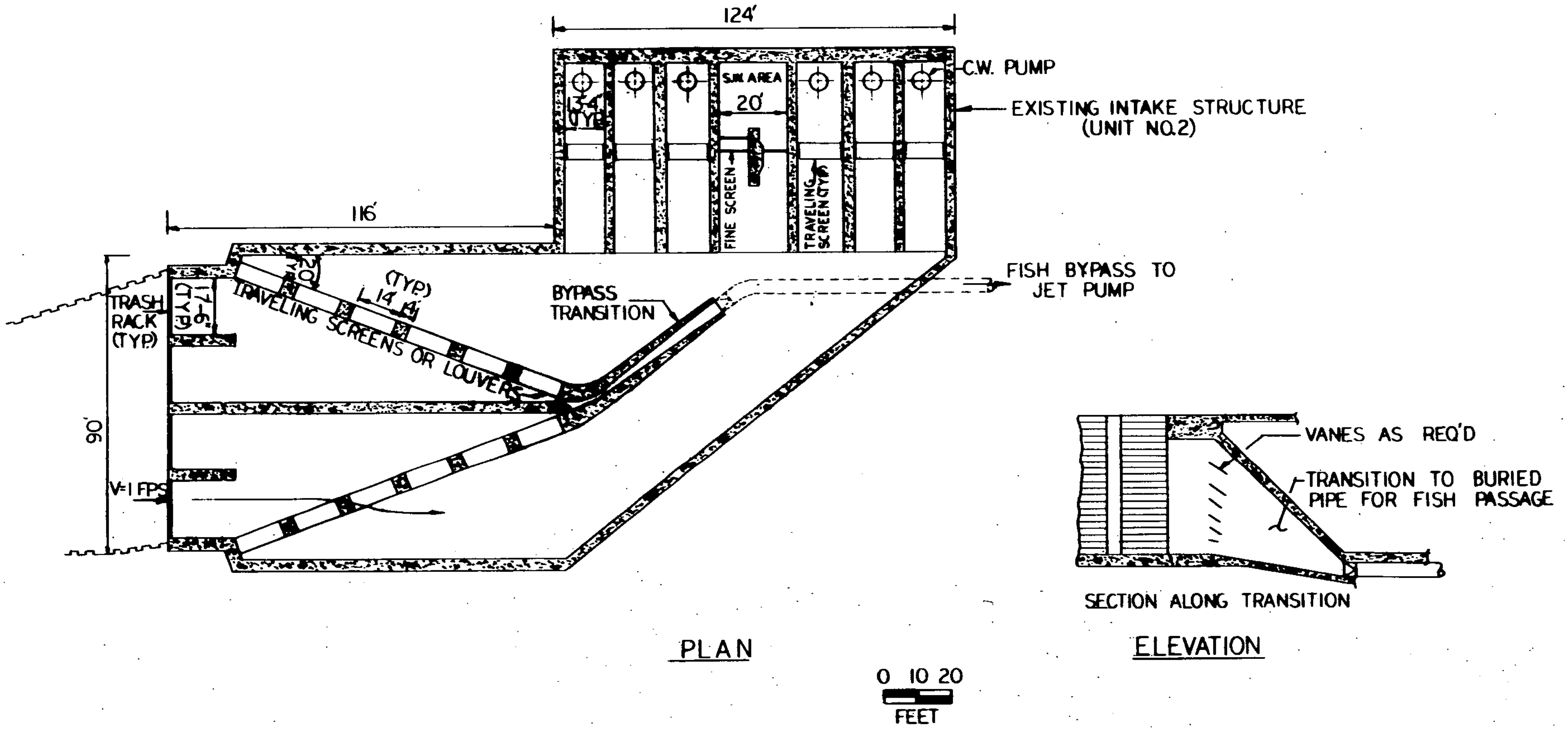


FIGURE 2.3-1

CONCEPTUAL INTAKE MODIFICATION, LOUVERS OR SCREENS WITH A V-ARRANGEMENT, INDIAN POINT GENERATING STATION

INDIAN POINT FLUME STUDY
CONSOLIDATED EDISON CO. OF NEW YORK, INC.
STONE & WEBSTER ENGINEERING CORPORATION

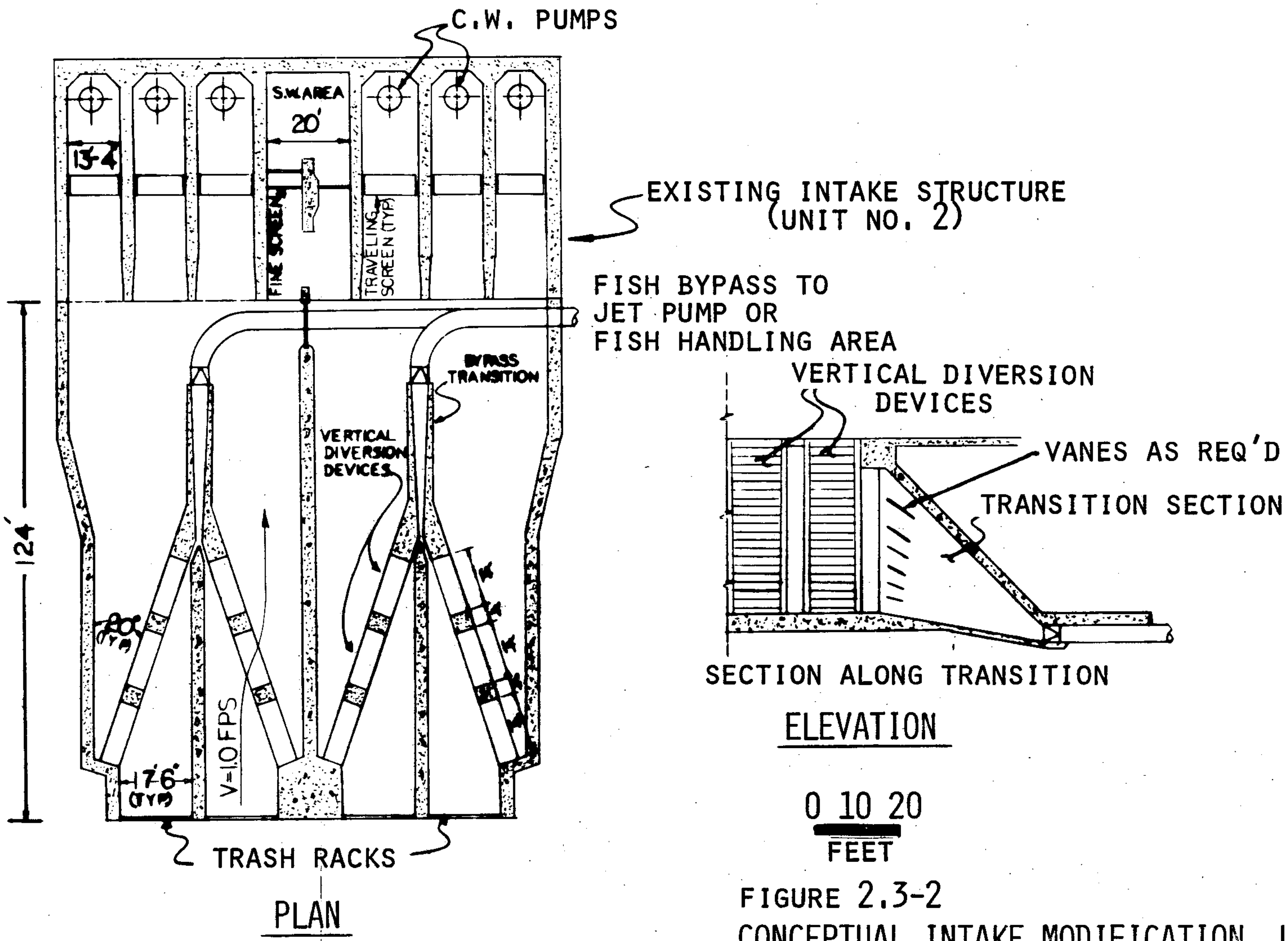


FIGURE 2.3-2

CONCEPTUAL INTAKE MODIFICATION, LOUVERS OR SCREENS WITH A CHEVRON ARRANGEMENT, INDIAN POINT GENERATING STATION

INDIAN POINT FLUME STUDY
CONSOLIDATED EDISON CO. OF NEW YORK, INC.
STONE & WEBSTER ENGINEERING CORPORATION

SECTION 3

FISH DIVERSION STUDY PROGRAM

As previously discussed, angled vertical screens and louvers were selected for evaluation during the study program. Based on data from the literature review, an initial test device angle of 25 degrees to the flow was selected. A bypass width of 6 inches was maintained throughout the study.

Before the flume testing was started in May 1975, a series of experiments were conducted by S&W to determine the feasibility of holding Hudson River species at ARL. Early experiments are discussed in detail in a separate report (Stone & Webster 1975b). Additional studies which led to the development of a suitable fish holding facility are described below.

3.1 FISH COLLECTION, TRANSPORT, AND HOLDING STUDIES

To ensure a sufficient supply of fish throughout the testing program conducted at ARL, S&W personnel collected fish from the Hudson River and transported them to ARL. In addition, hatchery-reared striped bass were procured from Consolidated Edison's Striped Bass Hatchery at Verplanck, N.Y. when available.

3.1.1 Fish Collection and Transport

Eight Hudson River fish collections were made, beginning the week of May 12, 1975 and ending the week of October 27, 1975. The success of each trip depended on such variables as water temperature, tides, and storms, and on boating and seining conditions. Boxtraps were set in areas known to have a high density of white perch. Catches from boxtraps were good for large white perch (6 to 9 inches), but poor for the 1- to 3-inch yearlings. Beach seining with a 100-foot seine was very successful in catching yearling white perch and striped bass, as summarized in Table 3.1-1.

Beach seining was conducted from Croton Bay (river mile 33) to Denning Point (river mile 60). The Croton Bay shallows, which have excellent cover for small fish, yielded the highest catches of yearlings (40-80 mm). Therefore, S&W personnel directed most of their efforts to the Croton Bay region, since the smaller fish were desirable for test purposes.

Tomcod were collected by TI personnel in boxtraps at Garrison, N.Y. (river mile 51) and transported to ARL on December 29, 1975, by S&W personnel.

Fish were transported to ARL in 200-gallon, oval-shaped, galvanized steel tanks. This method was highly successful throughout the year with very low mortality. Dissolved oxygen levels were maintained by the use of electric agitators, and temperature increases caused by trips in hot weather were controlled by adding blocks of ice to the tanks en route to ARL.

3.1.2 Fish Holding Studies

Preceding the present method of holding fish, a multitude of closed, recirculating systems utilizing water from the Hudson river, the ARL pond and stream system, and the town water system were evaluated. Tanks with capacities of 30, 50, and 400 gallons were used at salinities of 0 to 5 ppt with a suitable charcoal-floss filter for each tank. Striped bass and white perch were distributed among the tanks, and their behavior and mortality were observed.

It was determined that the high mortality was due to crowding in the small tanks and high ammonia levels. To correct these problems, a 2,500-gallon cylindrical swimming pool (3 by 12 feet) was assembled and outfitted with a biological sand filter for ammonia removal, and a chemical filter for the removal of dissolved organics. A rapid speed sand filter provided sufficient flow to aid in orientation of the fish and the removal of solid fish waste.

The fungus Saprolegnia continued to be a problem until it was discovered that this fungus could be controlled by maintaining salinities above 7 ppt.

Town water was chosen over ARL pond water because it was free from detritus that could clog the biological sand filter and also free from excessive amounts of dissolved organics that would neutralize the chemical filter. Ample aeration supplied by the filter airlifts maintained dissolved oxygen levels at or near the 100 percent saturation level at all times.

When ammonia-nitrogen levels approached 1.0 ppm, the water was changed so that undue stress would not burden the fish. The pH of the tap water was adjusted from its normal level of 5.5 to approximately 7.2 to aid in the nitrification of ammonia in the biological filter. The water temperature was ambient and had a seasonal range of approximately 35°F to 80°F.

3.1.3 Conclusions

As a result of these past studies, a highly successful method of holding fish was derived. The combination of the large holding pool and filters, as illustrated in Figure 3.1-1, in use with town water at salinities ranging from 7 to 8 ppt, proved to be highly successful in holding fish over long periods regardless of season.

Three holding pools (Figure 3.1-2) made it possible to segregate the hatchery-reared striped bass from the Hudson river striped bass, white perch, and tomcod. The fish were maintained in good

TABLE 3.1-1

FISH COLLECTION DATA, MAY - OCTOBER 1975

INDIAN POINT FLUME STUDY
CONSOLIDATED EDISON CO. OF NEW YORK, INC.
STONE & WEBSTER ENGINEERING CORPORATION

Date Week of	Water Temperature Range (°F)	Total No. of Fish Taken in Beach Seine			Total No. of Fish Taken in Boxtrap			Total No. of Fish For Week		
		SB[1]	WP[2]	Size, mm	SB	WP	Size, mm	SB	WP	Combined
5/12/75	62-64	0	0	-	0	30	125-180	0	30	30
5/19/75	64-86	75	1,300	25-100	0	55	150-230	75	1,355	1,430
6/2/75	70-79	0	715	25-75	0	340	50-125	0	1,055	1,055
6/16/75	72-91	20	1,830	25-75	0	0	-	20	1,830	1,850
7/21/75	83-85	0	0	-	0	0	-	0	0	0
9/8/75	76-78	1,000	800	25-75	0	0	-	1,000	800	1,800
10/6/75	59-65	1,200	300	25-100	0	0	-	1,200	300	1,500
10/27/75	54-58	0	0	-	0	0	-	0	0	0
					Total No. of Fish Collected From Hudson River			2,295	5,340	7,635

[1] SB = Hudson River striped bass

[2] WP = Hudson River white perch

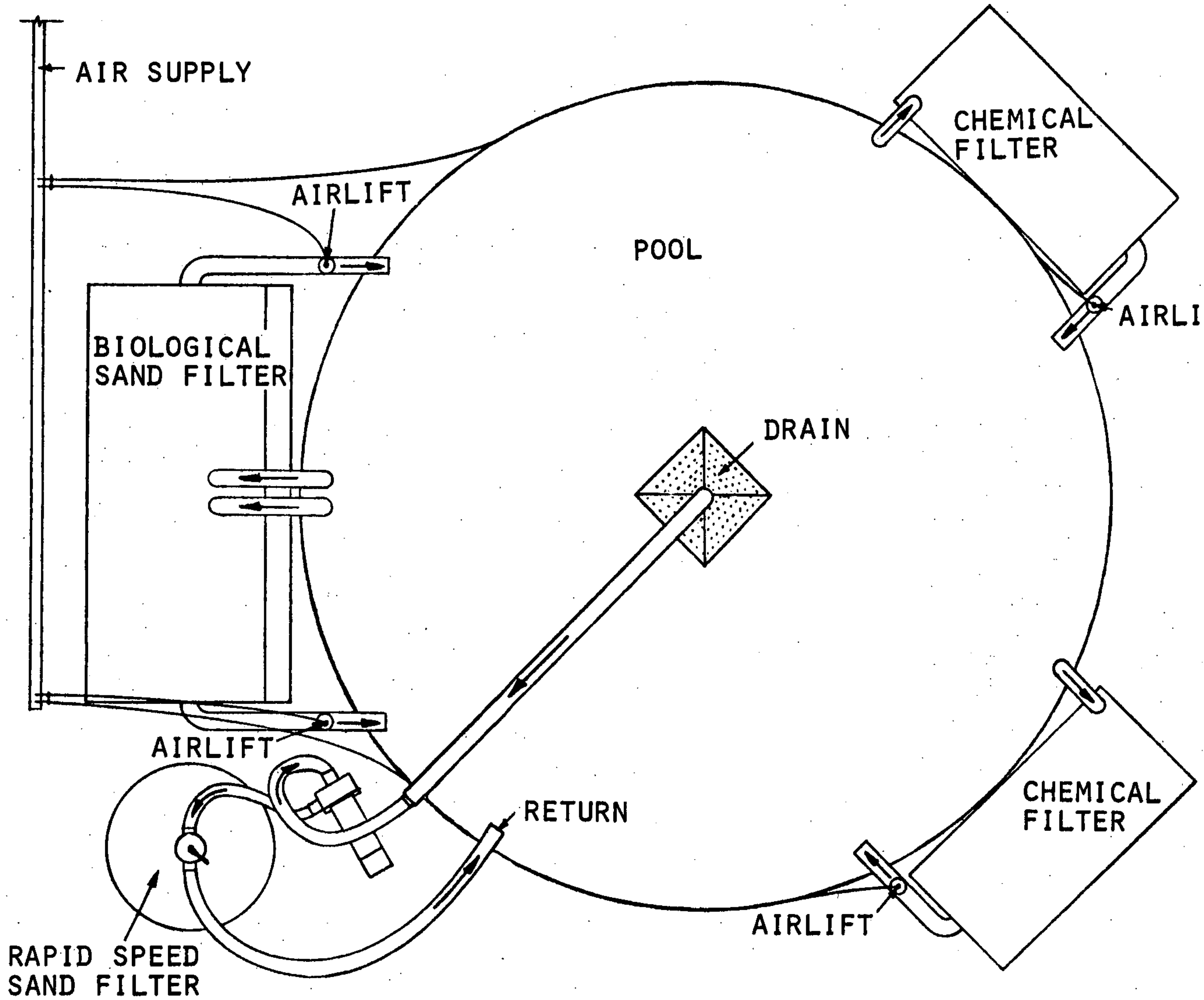


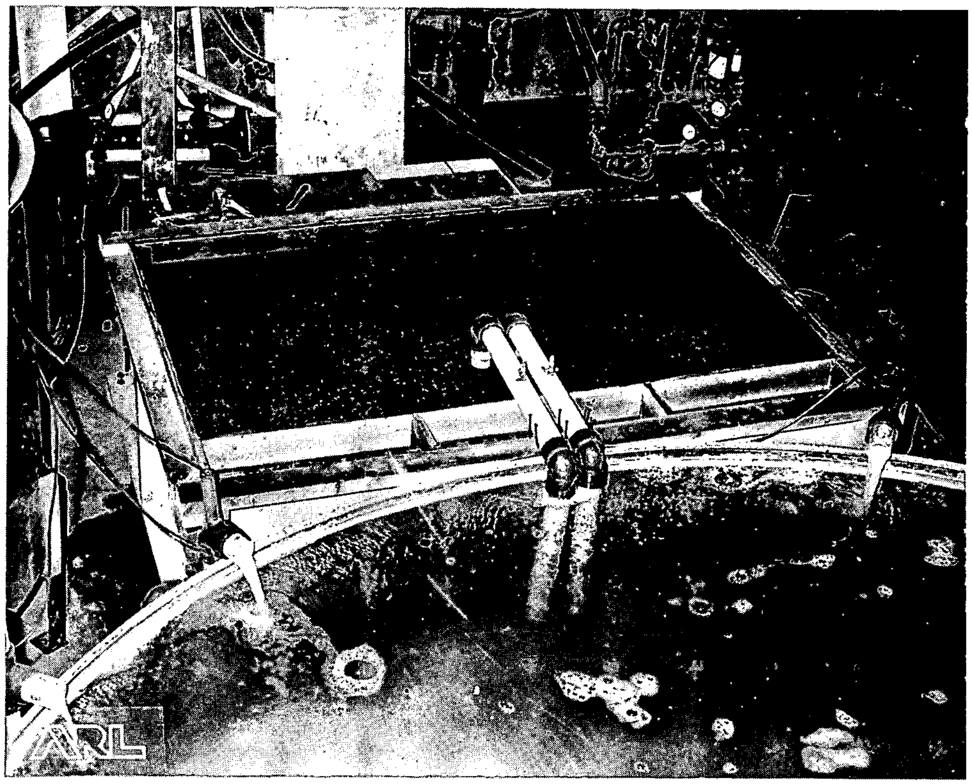
FIGURE 3.1-1

LAYOUT OF FISH HOLDING POOL WITH FILTRATION SYSTEM

INDIAN POINT FLUME STUDY
CONSOLIDATED EDISON CO. OF NEW YORK, INC.

STONE & WEBSTER ENGINEERING CORPORATION

HOLDING POOLS LOCATED ADJACENT TO FLUME



HOLDING POOL WITH BIOLOGICAL FILTER

FIGURE 3.1-2

FISH HOLDING FACILITY

INDIAN POINT FLUME STUDY
CONSOLIDATED EDISON CO. OF NEW YORK, INC.

STONE & WEBSTER ENGINEERING CORPORATION

condition and the minimal mortality that occurred can presumably be attributed to those individuals that were not able to feed successfully with the more aggressive fish.

3.2 TEST FLUME DESIGN

The test flume layout was developed by Con Edison, ARL, and S&W and was designed for the necessary flexibility to incorporate any of the devices proposed for the study. A detailed description of the flume and its flow capabilities is given in Appendix A. The following is a brief description of the flume as it relates to the fish testing program.

Figure 3.2-1 shows a plan view of the flume. The overall length is 80 feet and the depth is 7 feet. Three sections are designated: a 39-foot-long by 6-foot-wide approach section in which the flow is straightened to achieve a uniform flow distribution and into which the test fish are introduced; a 24-foot-long by 12-foot-wide test section in which the fish diversion test devices and bypass are installed, and an 8-foot-long by 7-foot-wide fish collection area where test fish are removed with a bypass lift basket system (Figure 3.2-2). The flume has a closed-loop recirculating system. A 42-inch bow thruster powered by a 300-hp marine engine drives the flow. Velocities up to 3 fps in the approach section and an approach-to-bypass velocity ratio of 1:2 can be attained. The flow through the test device and the bypass is controlled by adjustable gates.

The test devices were designed to simulate prototype structures in as much detail as possible. The louver and screen panels and associated support structures were constructed so that they are easily removable and interchangeable. This permitted testing of both devices under similar, non-controllable environmental parameters, particularly temperature.

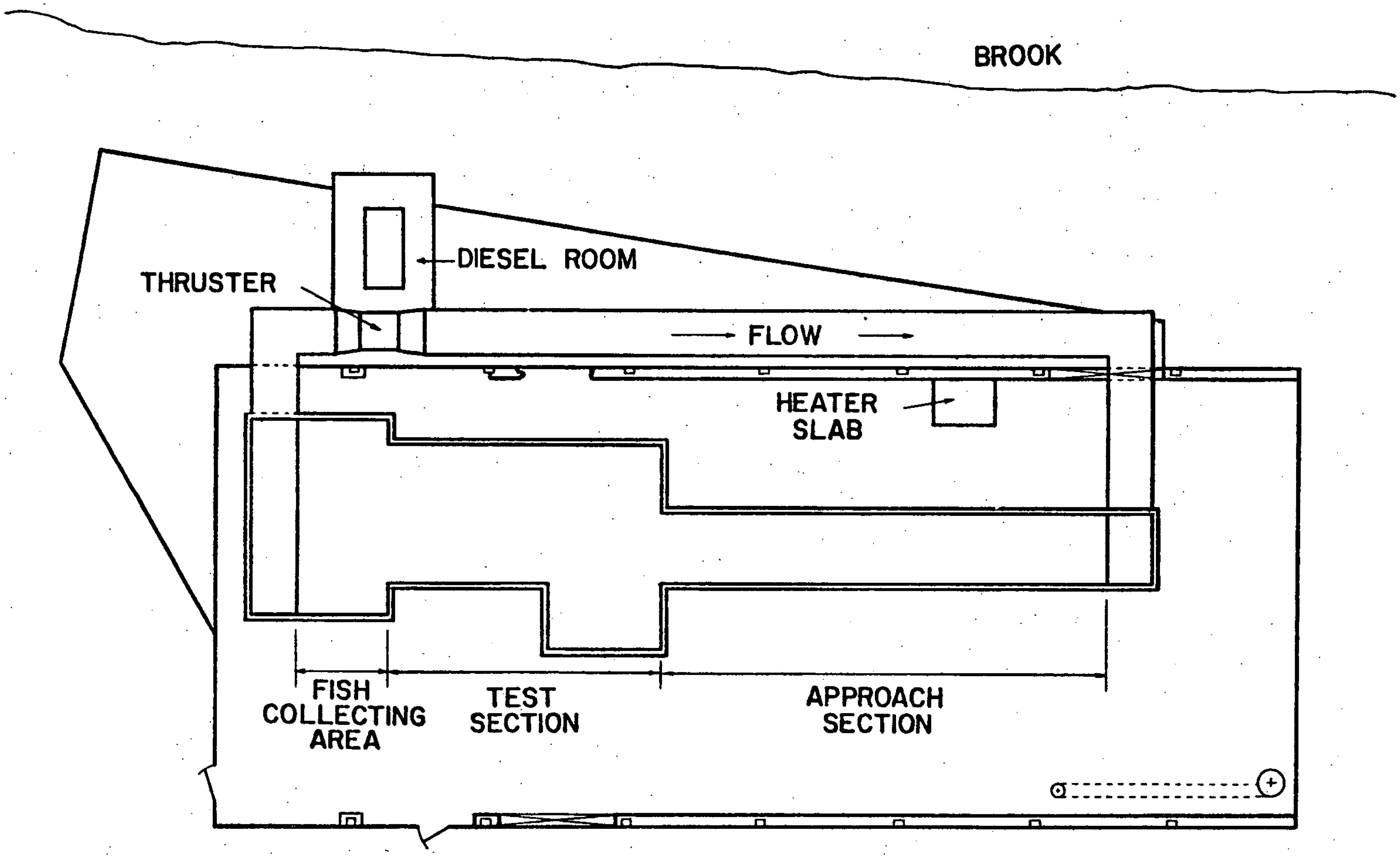
Details of the angled louver and screen test devices are shown in Figures 3.2-3 and 3.2-4, respectively, and their orientation in the flume is shown in Figures 3.2-5 and 3.2-6. The louver test device consisted of 1/4-inch-thick by 2-inch-wide wooden slats, spaced 1-1/4 inches apart on centers (1-inch clear openings). The louver slats were set in rigid steel frames 24 inches high and 13 feet long. This size frame was required to facilitate handling of the device within the test flume. Therefore, to create the 6-foot-deep louver array needed for testing, three of these frames were stacked above each other to make one complete louver unit.

To permit easy collection of fish that passed through the louver array during testing, an inclined plane, 1/4-inch perforated plate with a surface collection trough was located downstream of the test device (Figure 3.2-5). The plate was set at an approximate 30-degree angle to the flume bottom and had an effective open area of 40 percent. The surface collection trough was made of 1/4-inch-mesh nylon netting.

Two angled screen test structures were evaluated during the study program. The first structure was constructed from 3/8-inch-mesh wire screen attached to two rectangular wooden frames, each 13 feet long by 3 feet deep, resulting in a 6-foot-deep diversion device. The area of flow blockage due to the frame was comparable to the area of blockage expected from a conventional prototype traveling screen. This screen was installed in the test section at 25 degrees to the flow so that preliminary tests could be conducted with fish to determine the feasibility of the angled screen as a fish diversion device and to become familiar with the operation of the facility. Concurrently, S&W was working with Envirex on the design modifications necessary to adapt a conventional traveling screen to an angled application.

The second angled screen test device, based on the Envirex design, consisted of 11-gauge, 3/8-inch clear opening screen cloth, tack-welded to rigid steel frames 24 inches high by 13 feet long. Three of these frames, stacked above each other, were required to make one complete 6-foot-deep screening structure. Steel frames of similar design but of shorter lengths (approximately 8 feet) were also constructed for testing of an angled screen at a 45-degree orientation to the flow.

As mentioned in Section 2, an air bubble curtain was evaluated in conjunction with both test devices to determine its potential for improving system efficiency. The air bubble curtain test device consisted of four 1/2-inch PVC tubes set at a 25-degree angle to the flow and located 15 feet upstream of the 25-degree angled screen or louver. The tubes were drilled with 1/32-inch-diameter holes on 1-inch centers. The diffuser ports were aligned vertically downward and the tubes positioned in offset pairs, as shown in Figure 3.2-7. The tubes were supplied with air by an air compressor with an adjustable capacity. Each tube was equipped with adjustable valves and air flow meters.



FISH FLUME TEST FACILITY

[COURTESY OF ALDEN RESEARCH LABORATORIES]

FIGURE 3.2-1
PLAN VIEW OF TEST FLUME
INDIAN POINT FLUME STUDY
CONSOLIDATED EDISON CO. OF NEW YORK, INC.
STONE & WEBSTER ENGINEERING CORPORATION

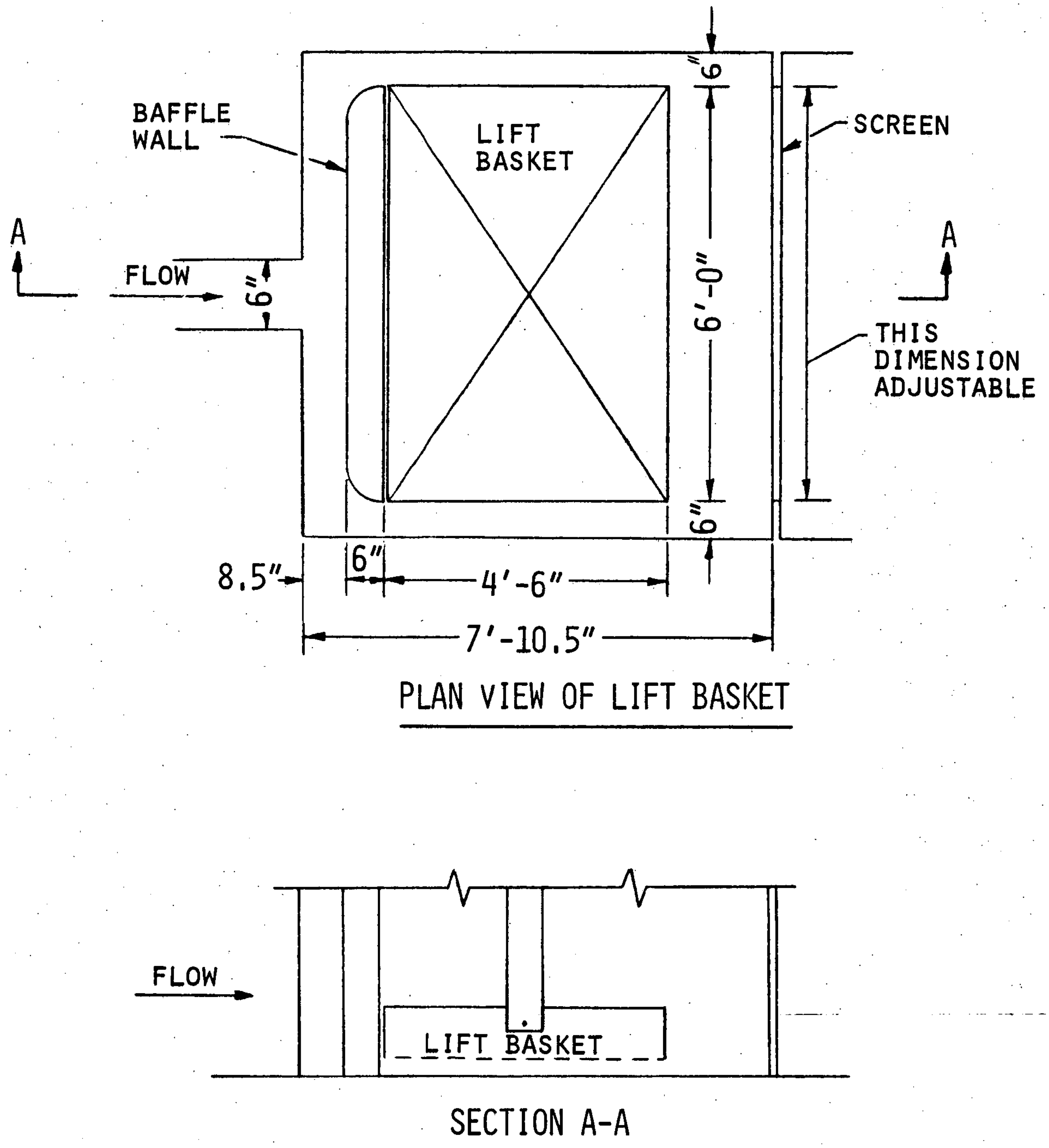
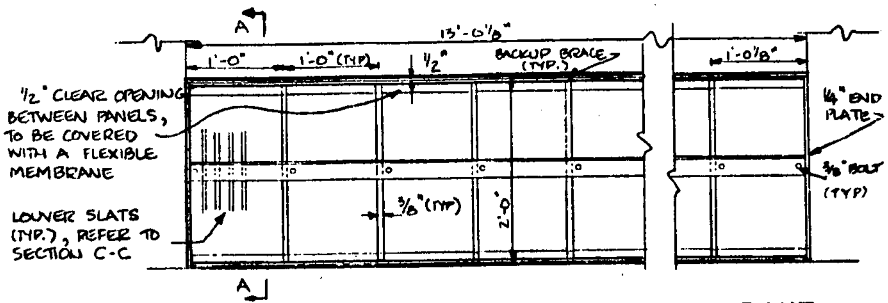


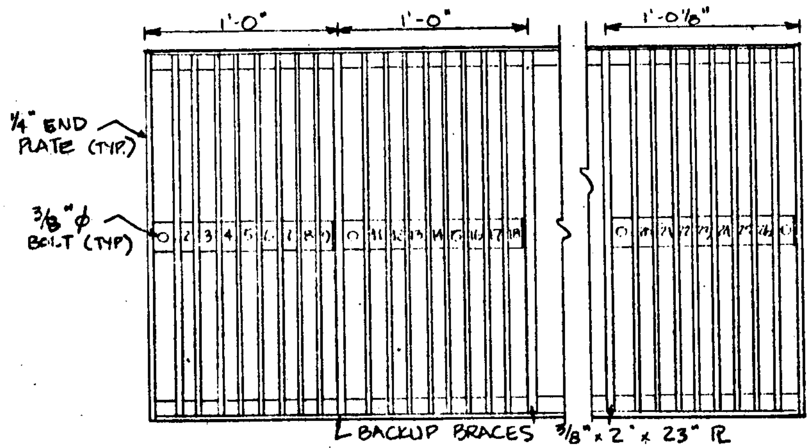
FIGURE 3.2-2
BYPASS LIFT BASKET SYSTEM

INDIAN POINT FLUME STUDY
CONSOLIDATED EDISON CO. OF NEW YORK, INC.

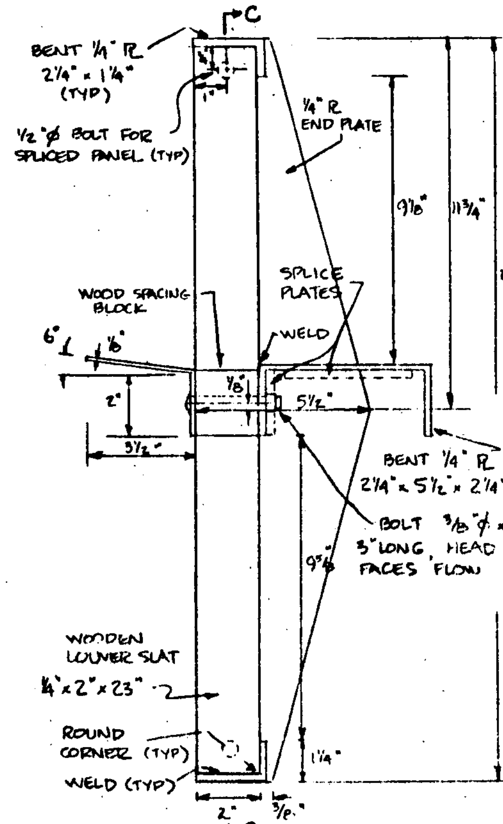
STONE & WEBSTER ENGINEERING CORPORATION



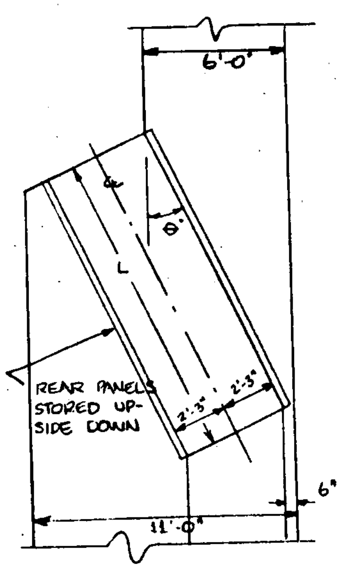
FRONT VIEW - UNBROKEN LOUVER PANEL



SECTION C-C - LOUVER SLAT DETAILS



SECTION A-A



FLUME LAYOUT

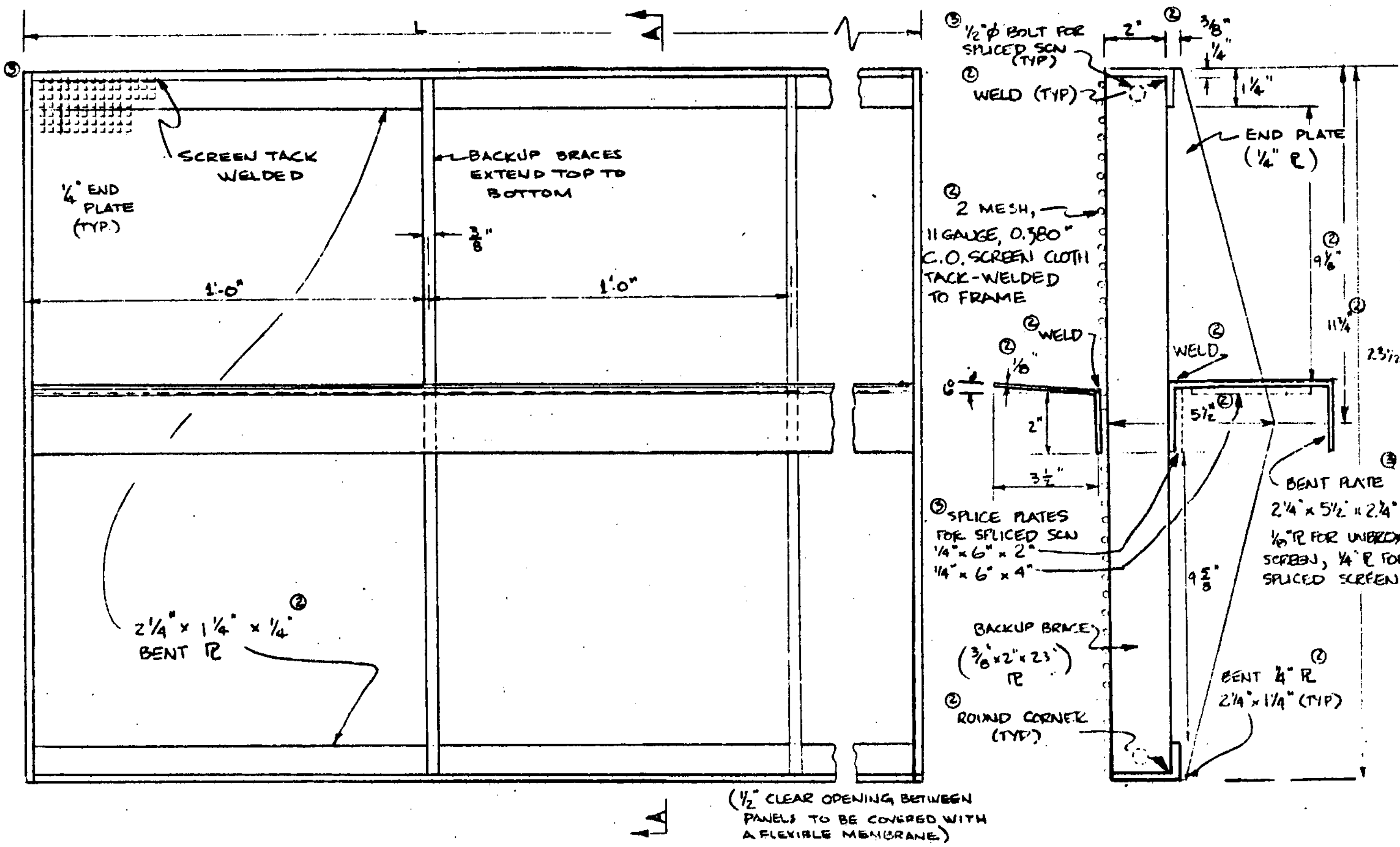
NOTES:

1. FOR INITIAL TEST, θ = 25°
2. LOUVER DESIGN COURTESY OF ENVIREX
3. EACH LOUVER CONSISTS OF 3 PANELS
4. WOODEN SLATS AND SPACING BLOCKS ARE CONSTRUCTED IN REMOVABLE 12" x 23" SECTIONS, HELD IN PLACE BY LIFTING LIP.

FIGURE 3.2-3
DETAILS OF ANGLED LOUVER

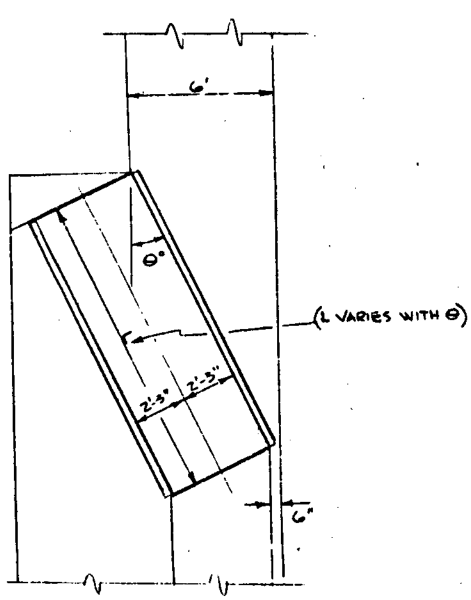
INDIAN POINT FLUME STUDY
CONSOLIDATED EDISON CO. OF NEW YORK, INC.

STONE & WEBSTER ENGINEERING CORPORATION



FRONT VIEW - TYPICAL SCREEN PANEL

SECTION A-A



FLUME LAYOUT

FIGURE 3.2-4

DETAILS OF ANGLED SCREEN

INDIAN POINT FLUME STUDY
CONSOLIDATED EDISON CO. OF NEW YORK, INC.

STONE & WEBSTER ENGINEERING CORPORATION

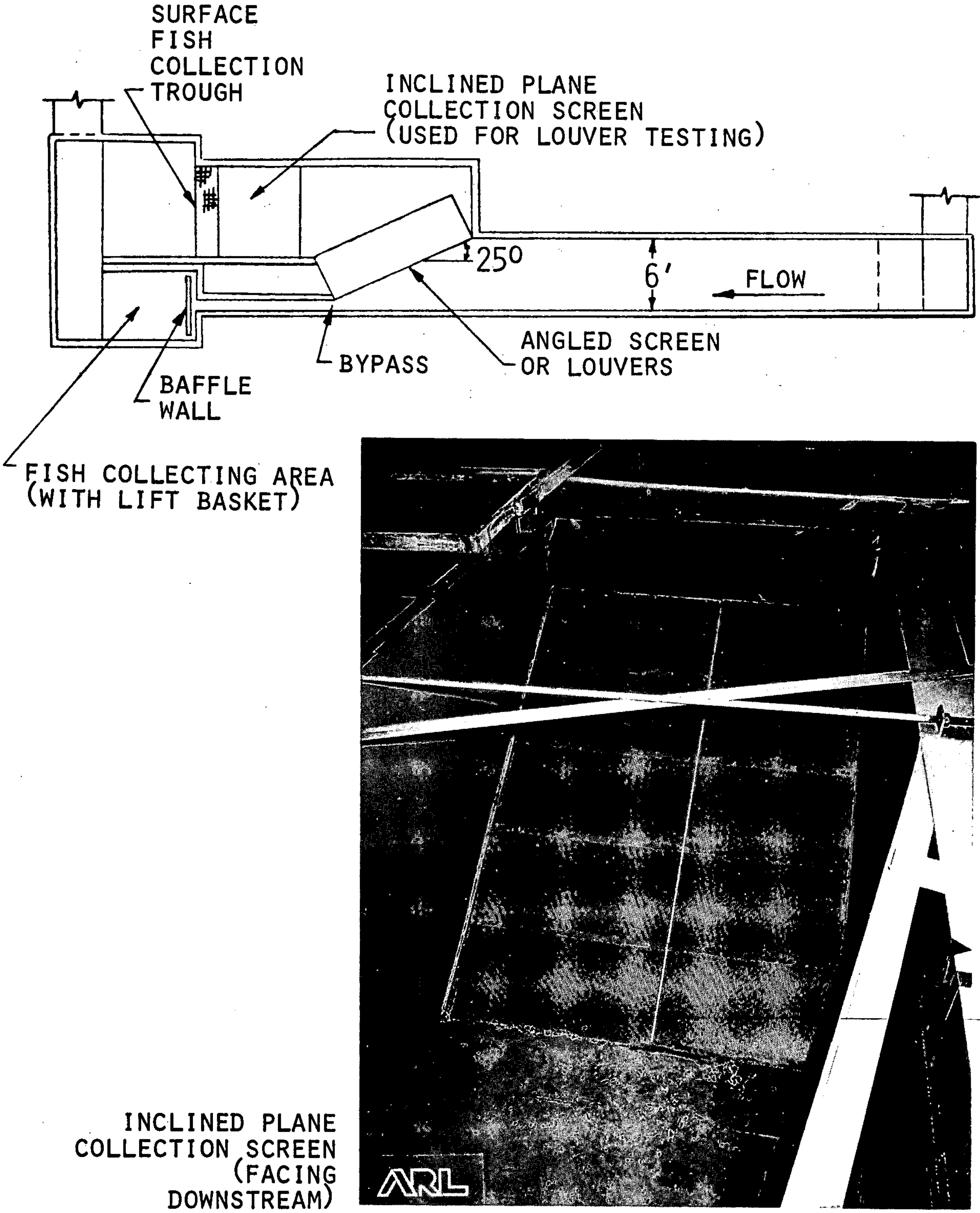
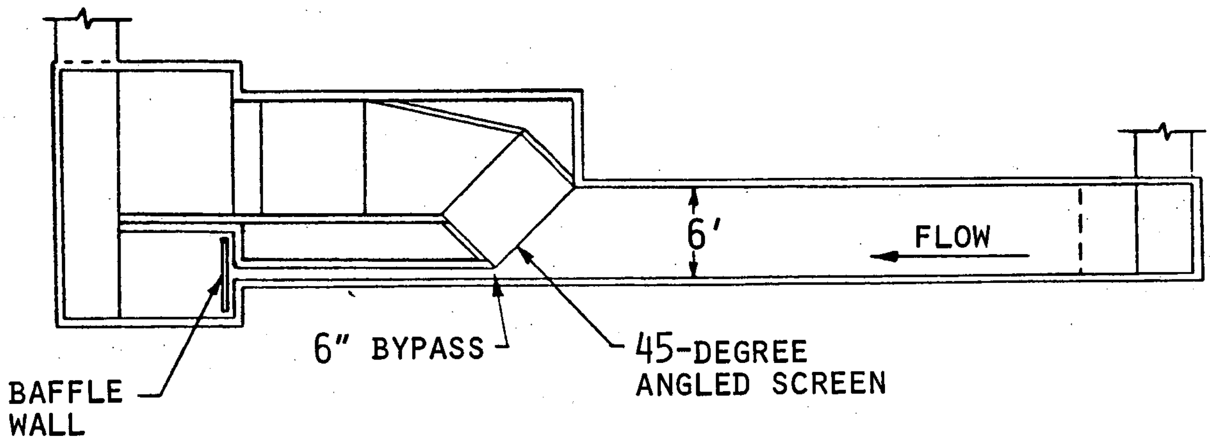


FIGURE 3.2-5

25-DEGREE ANGLED SCREEN OR LOUVER TEST ARRANGEMENT

INDIAN POINT FLUME STUDY
CONSOLIDATED EDISON CO. OF NEW YORK, INC.

STONE & WEBSTER ENGINEERING CORPORATION



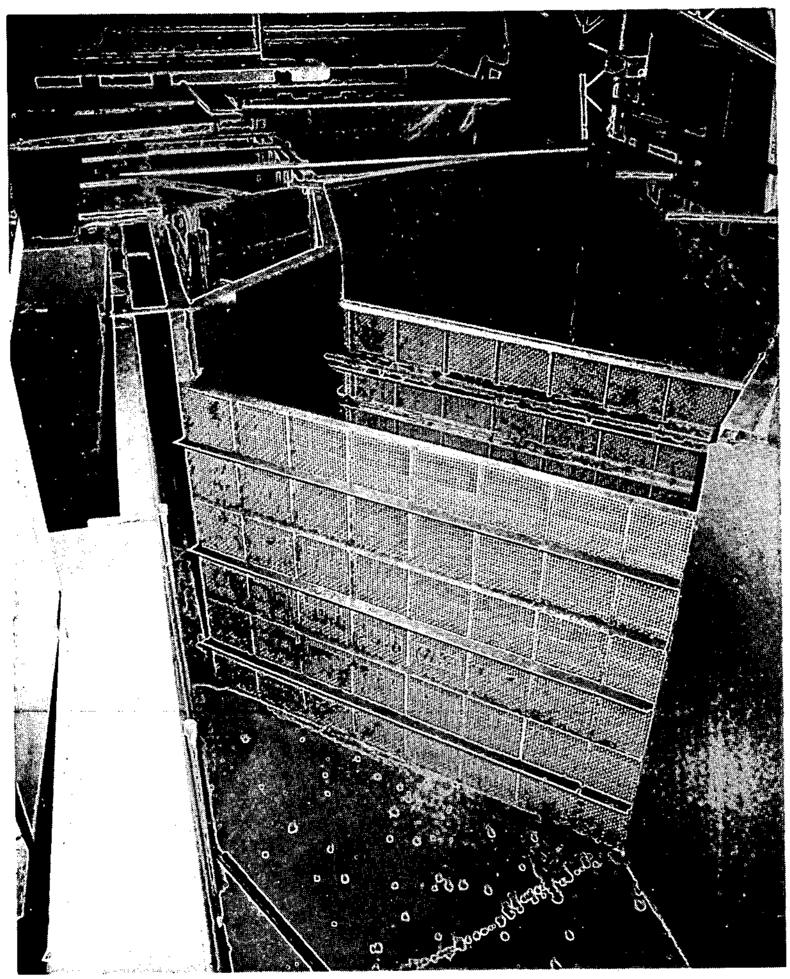
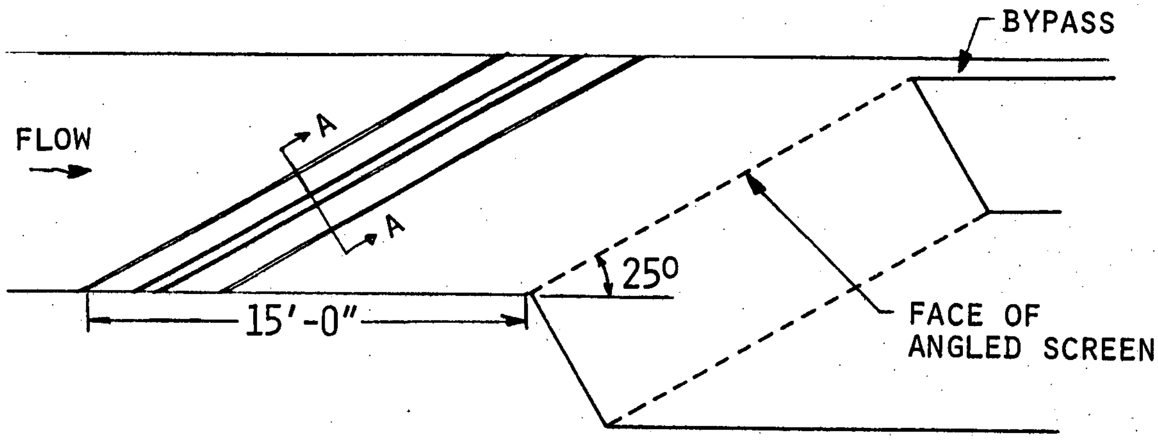
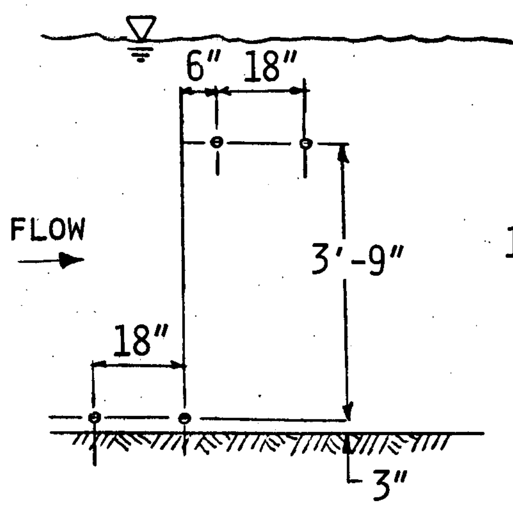


FIGURE 3.2-6
45-DEGREE ANGLED
SCREEN ARRANGEMENT

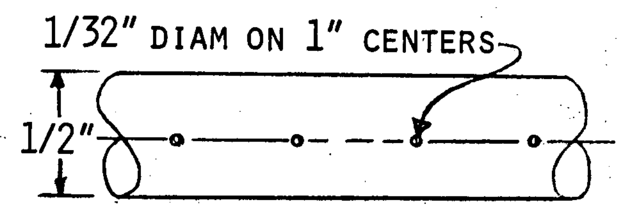
INDIAN POINT FLUME STUDY
CONSOLIDATED EDISON CO. OF NEW YORK, INC.
STONE & WEBSTER ENGINEERING CORPORATION



PLAN VIEW



SECTION A-A



DIFFUSER PIPE AIR HOLES

FIGURE 3.2-7
AIR BUBBLE CURTAIN

INDIAN POINT FLUME STUDY
CONSOLIDATED EDISON CO. OF NEW YORK, INC.

STONE & WEBSTER ENGINEERING CORPORATION

3.3 TEST PROCEDURE

3.3.1 Biological Testing

Both diversion devices studied were similar in that their efficiency depended upon the ability of fish to guide along a structure. Therefore, it was possible to utilize essentially the same test procedure for both devices.

Test parameters were determined and established for each test. Engineering design variables, such as diversion device angle and test velocity, were selected on the basis of a literature review and prototype engineering feasibility evaluation, as discussed in a separate report (Stone & Webster 1975b). Variable environmental factors recorded at the beginning and end of each test included test flume and holding pool temperatures, dissolved oxygen concentration, pH, salinity, conductivity, ammonia-nitrogen level, time of day, and lighting conditions. At the end of each test, the approach velocity and bypass velocity were measured, as discussed in Section 3.3-2.

When the desired test conditions were established, the fish were transferred directly from the holding pool to the flume, and an appropriate number of control fish were simultaneously placed in a holding tank.

Before the introduction of fish to the flume, a removable fish crowder was placed approximately 5 feet downstream of the upstream inflow screen to restrict fish movements during acclimation (Figure 3.3-1). The fish were transferred directly from the holding pools to the flume and allowed approximately 15 minutes for acclimation. As the flow was initiated, the crowder was simultaneously removed so that the fish could orient to the flow without contact with the crowder. Observations under light conditions indicated that the fish immediately oriented to the flow, and, in general, few fish moved downstream towards the test devices before maximum test velocity was reached.

During angled screen tests, the fish collection area was checked hourly and, under light conditions, the screen was checked for impingement. Fish were removed from the bypass collection area with a lift basket device, netted into buckets, and transferred to a holding tank for observation of 1-week mortality. When tests lasted longer than 24 hours, fish collected during each 24-hour period were held in separate tanks. At the end of a test, the fish remaining in the flume (non-bypassed fish) were also removed and held for observation of 1-week mortality.

The tanks that were used to hold the test, control, and non-bypassed fish for mortality studies consisted of rectangular wooden frames (4 by 3 by 2.5 feet deep) with nylon netting covering the sides and bottoms. The tanks were placed in the holding pools and submerged to a depth of at least 2.0 feet.

For 7 days following each angled screen test, all test and control tanks were checked daily. Dead fish were removed, weighed and measured to the nearest 0.01 gm and 1.0 mm, and recorded by tank. At the end of each mortality experiment, a subsample of remaining live fish were sacrificed for length/weight measurement. During a louver test, the fish that entered the bypass collection area, and those fish that passed through the louvers were removed hourly. The bypassed fish were held for a 6-hour period before a subsample of up to 20 fish was sacrificed for length/weight measurement. At the same time, all the fish from the louver collection area were immediately sacrificed for length/weight measurement. Length/weight measurements were utilized to calculate condition factors of test and control fish to determine whether the test devices had an effect on fish condition over a 1-week period.

3.3.2 Hydraulic Testing

The purpose of the testing program was to provide information on the hydraulic characteristics of the flow approaching the screens and louvers and along the face of the screens since these characteristics affect fish guidance. The hydraulic test program was designed to achieve the following objectives:

1. Determine the magnitude of the average velocity approaching the test section and exiting the bypass, so that combinations of the approach and bypass average velocities may be identified and reproduced for subsequent biological testing, if required; identify any nonuniformities in the approach velocity distribution which could affect a test by directing fish toward the bypass side of the flume; and document the velocity distributions associated with the efficiencies of fish guidance for the prototype application reference.

2. Study the variation of velocity magnitude and direction in the horizontal plane approaching the test device, the bypass, and along the face of the test device in order to gain an understanding of the role of the horizontal velocity vector in successful fish guidance and bypassing with an angled screen, an angled louver, and air bubble curtain and to document the flow patterns associated with fish guidance for prototype application reference.

3. Study the variation of water surface elevation upstream and downstream of the test device for use as input to the hydraulic design of the angled screen and angled louver in prototype installations.

During the biological test program, hydraulic measurements were taken after the completion of each test. Velocity distributions were taken by measuring point-velocities at prescribed locations

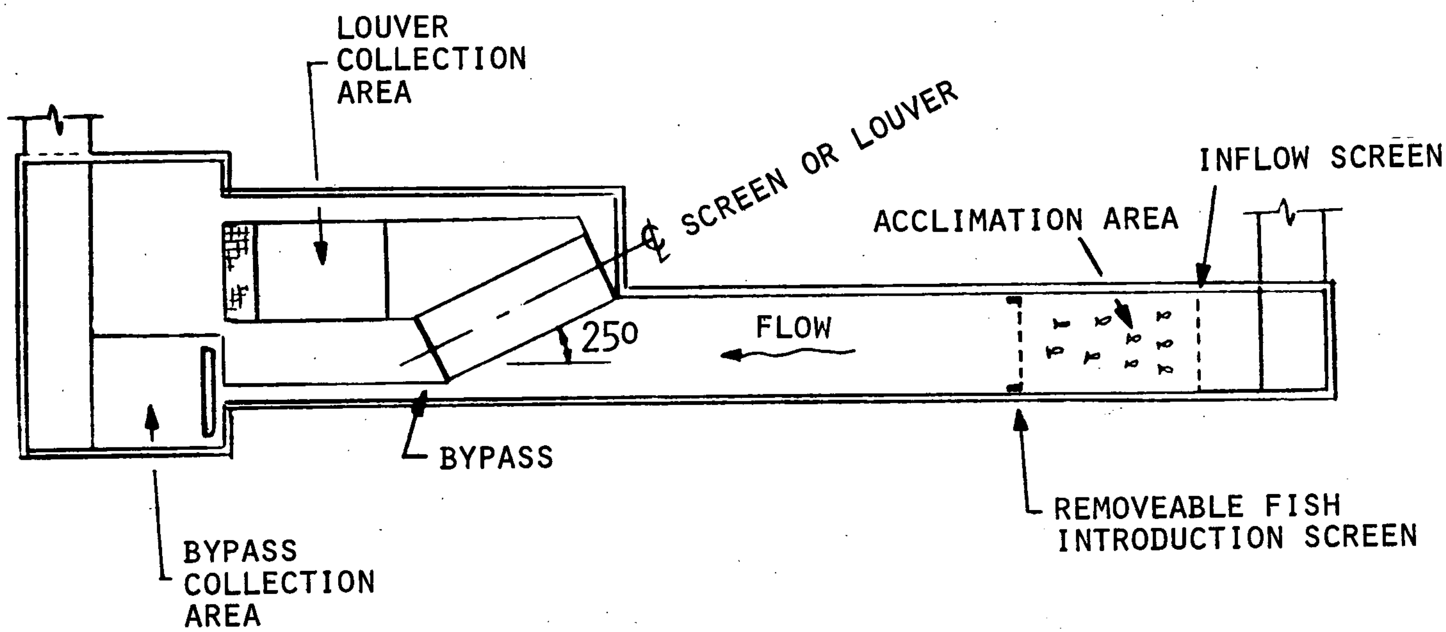


FIGURE 3.3-1

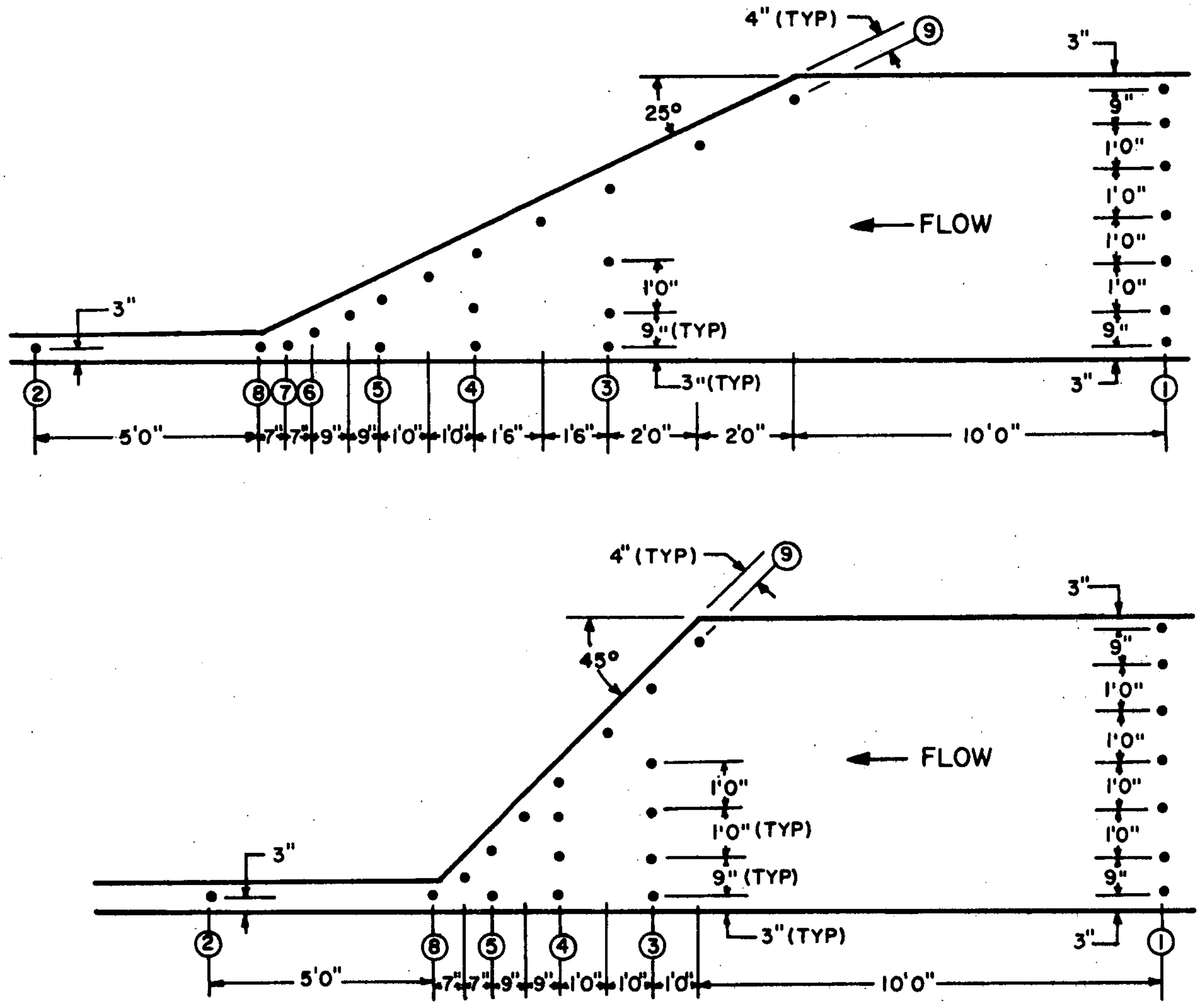
METHOD OF FISH INTRODUCTION
TO THE TEST FLUME

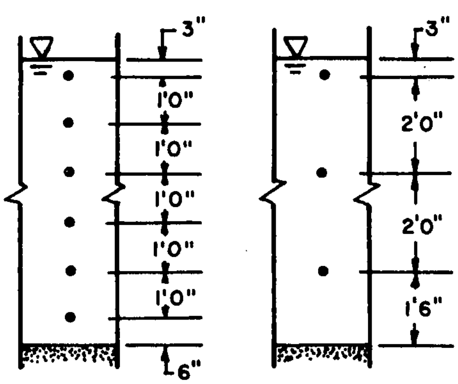
INDIAN POINT FLUME STUDY
CONSOLIDATED EDISON CO. OF NEW YORK, INC.
STONE & WEBSTER ENGINEERING CORPORATION

along two transects; one 10 feet upstream of the test device; and one 5 feet downstream of the bypass entrance.

After completion of the entire biological program, additional hydraulic measurements were taken to further document the flow conditions in the flume. Velocity distributions were taken along the face of each test device for both the 25- and 45-degree angled screens and 25-degree louvers and along other transects perpendicular to the flow, as shown in Figure 3.3-2. The direction in the horizontal plane of the velocity approaching the test device and bypass was determined using drogues. Photographs were taken of lighted candles attached to floats which were connected to cruciforms at two depths. The direction of the velocity through the test devices and downstream of the test devices were measured to determine head losses through the devices.

Detailed hydraulic data is presented in ARL's report in Appendix A.





TRANSECTS ①,②,⑧ & ⑨

TRANSECTS ③,④,⑤,⑥ & ⑦

DEPTH OF MEASUREMENTS

FIGURE 3.3-2
LOCATIONS OF HYDRAULIC MEASUREMENTS

INDIAN POINT FLUME STUDY
CONSOLIDATED EDISON CO. OF NEW YORK, INC.

STONE & WEBSTER ENGINEERING CORPORATION

3.4 TEST RESULTS

3.4.1 Biological Testing

Angled screen test parameters and results are summarized in Tables 3.4-1 and 3.4-2, respectively; louver test parameters and results are summarized in Tables 3.4-3 and 3.4-4, respectively. The angled screen was tested at angles of 25 and 45 degrees to the flow under a variety of environmental and hydraulic conditions described below. The louver device was tested only at an angle of 25 degrees to the flow with louver slat spacings of 1-inch clear opening. The bypass width was maintained at 6 inches in all tests.

The results of tests conducted with the angled screen and louver devices were subjected to statistical analysis. The analysis was an analysis of covariance (ANCOVA) which enables the inclusion of categorical independent variables and continuous independent variables. This analysis is, therefore, a blend of an analysis of variance (ANOVA) and a regression analysis. This type of analysis was chosen to conform to the experimental design. Some of the independent variables, such as illumination (light vs dark), were of a categorical nature while others, such as water temperature, were of a continuous nature. The simultaneous hypothesis testing for all independent variables, therefore, necessitated the use of the analysis of covariance model. The computer program used for these analyses was a general least-squares procedure which allows an unequal number of observations per cell (Kemp 1972).

The independent variables were divided into environmental variables, or those which would naturally fluctuate during the operation of the diversion device, and hydraulic design variables. The hydraulic design variables are those which can be altered to maximize the performance of the diversion device. The environmental variables consisted of the species of fish tested, the illumination during the test (light or dark), and the temperature and conductivity of the water. The hydraulic design variables included the approach velocity, the bypass velocity, the presence or absence of an air curtain upstream of the diversion device, and the angle of the device (tested only for angled screens).

The results of the analysis of covariance are presented in tabular form. The α level of rejection of the null hypothesis for each independent variable is presented. The establishment of the level of significance level is arbitrary. For the purposes of discussion, independent variables and/or interactions at an $\alpha \leq 0.05$ are considered as significant. Those effects which have an $\alpha \leq 0.10$ are also mentioned in the discussion.

The criterion for success of the device in diverting fish without damage or stress is called total efficiency (E_T). It is a combination of the efficiency (E) of the device in diverting fish into the 6-inch bypass, and the mortality of those fish which are bypassed that is attributable to the passage through the system (m). The functional relationship may be summarized as:

$$E_T = E\ (1-m)$$

The mortality attributable to the system must be determined by comparing the mortality of those test fish which were diverted (M_T) to a control group of fish (M_C). The only difference between the test fish and the control fish was the passage of the test fish through the system which also involved some additional handling during collection. Therefore, the system mortality (m) is calculated as:

$$m = E_T - E_C.$$

For louver tests, where the probability that fish would come in contact with the diversion device and then be bypassed was assumed to be small, the system mortality was assumed to be zero for purposes of comparison with the angled screen. The result of this assumption was to bias the comparison in favor of the louver device. Therefore, to achieve a conservative estimate of the predicted efficiency of the louver system, a separate estimate was made in which mortality of the angled screens was factored into the calculation of total louver efficiency.

The fish condition factor (coefficient of condition K) was computed from the length and weight measurements of test and control fish that died during each test ("dead fish"). Also, at the end of the test holding period, randomly selected test and control fish were sacrificed for length and weight measurements ("sacrificed fish"). Condition factors (K) were calculated using the equation:

$$K = \frac{W \times 10^5}{L^3}$$

where

W = weight in grams, and
L = length in millimeters.

Data from the angled screen and louver tests were combined into a single analysis to compare the total efficiencies (as previously defined) of the devices and the effect of other independent variables on device efficiency (refer to Table 3.4-5). The differences which are discussed below are those effects which had significance levels below 0.10. Assuming best survival conditions for louvers, the predicted total efficiency of the angled screen [95.4 percent; standard error (SE) = 2.18] was higher than for louvers (86.6 percent; SE = 2.29). Total efficiency differed by species ($\alpha \leq 0.043$); tomcod was the most

TABLE 3.4-1

SUMMARY OF ANGLED SCREEN TEST PARAMETERS

INDIAN POINT FLUME STUDY
CONSOLIDATED EDISON CO. OF NEW YORK, INC.
STONE & WEBSTER ENGINEERING CORPORATION

Test Number	Date	Screen Angle, Degree	Mean Water Temp, °F	Mean D.O., ppm	Salinity, ppt	Mean Conductivity, umho	Lighting Condition	Air Curtain	Velocity, fps Approach	Velocity, fps Bypass	Hours of Test
1	5/28/75	25	71.0	-	0	-	Light	no	1.00	1.15	4.50
2	6/9/75	25	62.0	9.80	0	-	Light	no	0.96	1.22	10.75
3	6/11/75	25	64.0	9.20	0	-	Light	no	1.95	2.13	5.75
4	6/12/75	25	66.0	8.80	0	-	Light	no	2.42	2.45	4.50
5	6/17/75	25	-	-	0	-	Light	no	1.47	1.63	7.00
6	6/18/75	25	71.2	-	0	-	Light	no	0.53	0.63	7.30
7	6/19/75	25	73.5	-	0	-	Light	no	1.42	1.60	4.50
8	6/24/75	25	77.8	8.40	0	-	Light	no	1.46	1.57	50.0
9	8/18/75	25	73.5	8.30	0	117	Light	no	1.01	1.16	91.5
10	8/26/75	25	70.0	8.85	0	119	Dark	no	1.07	1.16	18.00
11	8/27/75	25	73.5	8.55	0	125	Dark	no	1.94	2.08	41.75
12	9/2/75	25	71.5	8.95	0	125	Light	no	1.93	2.05	71.25
13	9/8/75	25	72.5	9.05	0	132	Dark	no	1.92	2.10	46.50
14	9/10/75	25	75.0	9.20	0	137	Light	no	1.89	2.03	42.00
15	9/15/75	25	73.0	9.60	0	140	Light	no	3.02	3.24	45.00
16	9/17/75	25	76.8	9.15	0	144	Light	no	1.91	1.98	38.00
17	9/22/75	25	68.0	9.30	0	139	Light	no	0.50	0.60	48.00
18	10/7/75	25	59.9	9.70	0	126	Light	no	1.02	1.34	18.00
19	10/8/75	25	59.8	9.70	0	127	Dark	no	0.94	1.20	19.00
20	11/3/75	25	52.4	10.65	3	3,680	Light	no	0.97	1.32	45.00
21	11/5/75	25	55.5	10.35	3	3,820	Light	no	1.87	2.39	3.00
22	11/5/75	25	55.9	10.20	3	3,865	Dark	no	1.09	1.39	2.50
23	11/6/75	25	55.6	10.20	3	3,845	Dark	no	1.94	2.44	1.00
24	12/17/75	25	41.0	12.20	0	77	Dark	yes	0.93	1.15	1.50
25	12/17/75	25	41.0	12.30	0	78	Dark	yes	0.97	1.18	10.00
26	12/18/75	25	41.0	12.40	0	79	Dark	yes	0.97	1.23	4.50
27	12/18/75	25	41.0	12.40	0	80	Dark	no	0.98	1.22	1.50
28	12/18/75	25	41.0	12.50	0	80	Dark	no	0.96	1.15	1.50
29	12/18/75	25	41.0	12.60	0	79	Dark	no	1.00	1.13	1.50
30	12/29/75	25	34.7	12.60	0	74	Light	yes	0.93	1.27	22.50
31	12/30/75	25	34.9	11.80	0	79	Dark	no	0.90	1.18	10.50
32	12/31/75	25	35.7	12.10	0	81	Dark	yes	0.98	1.20	12.50
33	1/27/76	45	36.2	12.80	0	120	Dark	no	1.04	0.88	6.50
34	1/28/76	45	37.2	12.65	0	124	Dark	no	1.00	0.66	6.50
35	1/28/76	45	37.6	12.70	0	128	Dark	no	1.03	1.05	5.50
36	1/28/76	45	38.3	12.80	0	128	Dark	no	1.03	1.07	3.50
37	1/29/76	45	38.8	12.80	0	128	Dark	no	1.95	1.88	0.50
38	1/29/76	45	38.9	12.80	0	128	Dark	no	1.98	1.88	0.50
39	1/29/76	45	38.9	12.80	0	128	Dark	no	1.99	1.92	1.50

TABLE 3.4-2

SUMMARY OF ANGLED SCREEN TEST RESULTS

INDIAN POINT FLUME STUDY
CONSOLIDATED EDISON CO. OF NEW YORK, INC.
STONE & WEBSTER ENGINEERING CORPORATION

Test	Fish Lost			Fish Bypassed			Efficiency, %		
Number	R.P.	R.B.	H.B.	R.P.	R.B.	H.B.	R.P.	R.B.	H.B.
1	0	-	-	78	-	-	100	-	-
2	0	-	-	68	-	-	100	-	-
3	1	-	-	66	-	-	98.4	-	-
4	2	-	-	63	-	-	96.9	-	-
5	13	-	-	168	-	-	92.8	-	-
6	0	-	-	24	-	-	100	-	-
7	1	-	-	42	-	-	97.7	-	-
8	3	-	-	248	-	-	98.8	-	-
9	-	-	2	-	-	167	-	-	98.8
10	-	-	0	-	-	121	-	-	100
11	-	-	0	-	-	171	-	-	100
12	-	-	0	-	-	94	-	-	100
13	-	0	-	-	132	-	-	100	-
14	-	-	0	-	-	27	-	-	100
15	-	-	0	-	-	76	-	-	100
16	0	1	-	202	46	-	100	97.8	-
17	0	0	-	153	18	-	100	100	-
18	-	-	0	-	-	105	-	-	100
19	-	-	0	-	-	138	-	-	100
20	0	1	-	27	83	-	100	98.8	-
21	0	1	-	56	115	-	100	99.2	-
22	0	0	-	55	139	-	100	100	-
23	-	-	0	-	-	192	-	-	100
24 P	-	-	0	-	-	194	-	-	100
25	-	-	0	-	-	175	-	-	100
26	-	-	0	-	-	96	-	-	100
27	-	-	0	-	-	173	-	-	100
28	-	-	0	-	-	185	-	-	100
29 P	-	-	0	-	-	195	-	-	100
30	-	-	0	-	-	49	-	-	100
31*									
32*									
33	-	-	0	-	-	119	-	-	100
34	-	-	0	-	-	116	-	-	100
35	-	-	0	-	-	101	-	-	100
36	-	-	0	-	-	131	-	-	100
37	-	-	0	-	-	200	-	-	100
38	-	-	0	-	-	200	-	-	100
39	-	-	0	-	-	193	-	-	100

Key:
R.P. - River Perch
R.B. - River Bass
H.B. - Hatchery Bass
P - Fish previously tested (tests 24 and 29)

*Tomcod used as test species in tests 31 and 32

Test Number	Fish Lost	Fish Bypassed	Efficiency, %
31	0	67	100
32	0	47	100

TABLE 3.4-2 (CONT'D)

Test Number	5-day Test Mortality, %			5-day Control Mortality, %			Differential Mortality, %			Total Efficiency, %		
	R.P.	R.B.	H.B.	R.P.	R.B.	H.B.	R.P.	R.B.	H.B.	R.P.	R.B.	H.B.
1	–	–	–	–	–	–	–	–	–	100	–	–
2	–	–	–	–	–	–	–	–	–	100	–	–
3	–	–	–	–	–	–	–	–	–	98.4	–	–
4	–	–	–	–	–	–	–	–	–	96.9	–	–
5	–	–	–	–	–	–	–	–	–	92.8	–	–
6	–	–	–	–	–	–	–	–	–	100	–	–
7	–	–	–	–	–	–	–	–	–	97.7	–	–
8	–	–	–	–	–	–	–	–	–	98.8	–	–
9	–	–	44.4	–	–	30.7	–	–	13.7	–	–	85.1
10	–	–	46.3	–	–	64.0	–	–	-17.7	–	–	100
11	–	–	1.8	–	–	2.0	–	–	-0.2	–	–	100
12	–	–	8.9	–	–	1.0	–	–	7.9	–	–	92.1
13	–	2.5	–	–	4.0	–	–	-1.5	–	–	100	–
14	–	–	23.1	–	–	3.0	–	–	20.1	–	–	79.9
15	–	–	24.7	–	–	13.0	–	–	11.7	–	–	88.3
16	3.5	35.4	–	2.2	35.8	–	1.3	-0.4	–	98.7	98.2	–
17	6.1	13.8	–	5.0	7.5	–	1.1	6.3	–	98.9	93.7	–
18	–	–	17.4	–	–	9.0	–	–	8.4	–	–	91.6
19	–	–	18.8	–	–	7.0	–	–	11.8	–	–	88.2
20	22.2	9.6	–	13.0	13.0	–	9.2	-3.4	–	90.8	100	–
21	19.6	7.8	–	5.5	5.5	–	14.1	2.3	–	85.9	96.9	–
22	7.3	18.0	–	5.5	5.5	–	1.8	12.5	–	98.2	87.5	–
23	–	–	24.5	–	–	18.0	–	–	6.5	–	–	93.5
24 P	–	–	0	–	–	0	–	–	0	–	–	100
25	–	–	0.6	–	–	0	–	–	0.6	–	–	99.4
26	–	–	0	–	–	0	–	–	0	–	–	100
27	–	–	0.5	–	–	0	–	–	0.5	–	–	99.5
28	–	–	0.5	–	–	0	–	–	0.5	–	–	99.5
29 P	–	–	0	–	–	0	–	–	0	–	–	100
30	–	–	0	–	–	1.0	–	–	-1.0	–	–	100
31*												
32*												
33	–	–	0	–	–	0	–	–	0	–	–	100
34	–	–	0	–	–	0	–	–	0	–	–	100
35	–	–	2.0	–	–	1.0	–	–	1.0	–	–	99
36	–	–	8.0	–	–	1.0	–	–	7.0	–	–	93
37	–	–	0	–	–	1.0	–	–	1.0	–	–	100
38	–	–	0	–	–	1.0	–	–	-1.0	–	–	100
39	–	–	0	–	–	1.0	–	–	-.10	–	–	100

Key:
R.P. – River Perch
R.B. – River Bass
H.B. – Hatchery Bass
P – Fish previously tested (tests 24 and 29)

*Tomcod used as test species in tests 31 and 32

Test Number	5-day Test Mortality, %	5-day Control Mortality	Differential Mortality, %	Total Efficiency
31	0	0	0	100
32	0	0	0	100

TABLE 3.4-3

SUMMARY OF LOUVER TEST PARAMETERS

INDIAN POINT FLUME STUDY
CONSOLIDATED EDISON CO. OF NEW YORK, INC.
STONE & WEBSTER ENGINEERING CORPORATION

Test Number	Date	Mean Water Temp, °F	Mean D.O., ppm	Salinity, ppt	Mean Conductivity, umho	Lighting Condition	Air Curtain	Mean Velocity, fps Approach	Mean Velocity, fps Bypass	Hours of Test
1	9/30/75	61.9	9.4	0	129	Light	No	1.11	1.60	61.0
2	10/6/75	60.6	9.7	0	129	Dark	No	1.00	1.50	21.0
3	10/14/75	59.2	9.7	0	129	Light	No	1.91	2.95	24.0
4	10/15/75	63.9	9.5	0	134	Dark	No	1.96	3.19	13.0
5	10/20/75	59.9	9.8	0	160	Light	No	2.89	4.54	1.0
6	10/21/75	55.4	10.6	0	129	Dark	No	2.89	4.54	1.0
7	11/10/75	57.5	9.9	3	3,800	Light	No	1.00	1.45	47.5
8	11/12/75	55.8	10.1	3	3,800	Light	No	2.09	3.09	6.5
9	11/13/75	55.4	9.7	3	4,000	Dark	No	2.00	3.10	0.5
10	11/13/75	55.4	9.7	3	4,000	Dark	No	1.03	1.39	3.5
11	12/15/75	43.2	12.2	0	78	Dark	No	1.04	1.28	3.5
12	12/15/75	43.2	11.7	0	79	Dark	No	0.96	1.22	4.5
13	12/15/75	43.7	11.2	0	80	Dark	No	1.02	1.15	2.5
14	12/16/75	44.7	11.2	0	80	Dark	No	1.04	1.34	5.5
15	12/16/75	45.1	11.3	0	80	Dark	Yes	1.01	1.27	4.5
16	12/16/75	44.8	11.9	0	81	Dark	Yes	1.02	1.17	4.5
17	12/16/75	44.6	12.1	0	82	Dark	Yes	1.06	1.30	3.5
18	1/5/76	34.3	13.4	0	78	Dark	Yes	0.98	1.47	12.0
19	1/6/76	34.3	13.5	0	80	Dark	No	0.94	1.50	3.0
20	1/6/76	34.3	13.6	0	78	Light	No	1.03	1.50	5.5
21	1/6/76	34.5	13.5	0	78	Light	Yes	1.01	1.52	14.0

TABLE 3.4-4

SUMMARY OF LOUVER TEST RESULTS

INDIAN POINT FLUME STUDY
CONSOLIDATED EDISON CO. OF NEW YORK, INC.
STONE & WEBSTER ENGINEERING CORPORATION

Test Number	Fish through Louvers R.P.	Fish through Louvers R.B.	Fish through Louvers H.B.	Fish Bypassed R.P.	Fish Bypassed R.B.	Fish Bypassed H.B.	Efficiency, % R.P.	Efficiency, % R.B.	Efficiency, % H.B.
1	-	-	6	-	-	98	-	-	94
2	40	13	-	104	35	-	72	73	-
3	6	4	-	31	128	-	84	97	-
4	10	13	-	24	144	-	71	92	-
5	5	31	-	25	133	-	83	81	-
6	19	55	-	19	94	-	50	63	-
7	-	-	26	-	-	126	-	-	83
8 P	3	8	-	9	56	-	75	88	-
9 P	2	14	-	5	84	-	71	86	-
10	-	-	28	-	-	60	-	-	68
11	-	4	2	-	5	175	-	56	99
12	-	-	1	-	-	193	-	-	99
13	-	-	3	-	-	194	-	-	98
14	-	-	4	-	-	189	-	-	98
15 P	-	-	1	-	-	174	-	-	99
16	-	-	15	-	-	163	-	-	92
17	-	-	1	-	-	185	-	-	99
18*									
19*									
20	-	-	1	-	-	148	-	-	99
21	-	-	8	-	-	68	-	-	89

Key:

R.P. - River Perch
R.B. - River Bass
H.B. - Hatchery Bass
P - Fish previously tested (tests 8, 9, and 15)

*Tomcod used as test species in tests 18 and 19

Test Number	Fish through Louvers	Fish Bypassed	Efficiency, %
18	3	69	96
19	1	82	99

TABLE 3.4-5

RESULTS OF COMBINED ANALYSIS OF COVARIANCE FOR LOUVER AND ANGLED SCREEN TESTS

INDIAN POINT FLUME STUDY
CONSOLIDATED EDISON CO. OF NEW YORK, INC.
STONE & WEBSTER ENGINEERING CORPORATION

Source	Degrees of Freedom	Sums of Squares	Mean Squares	F-Ratio	Probability
Device	1	0.0603	0.0603	7.417	0.0088
Species	3	0.0709	0.0236	2.907	0.0433
Light/Dark	1	0.0141	0.0141	1.733	0.1938
Device x Species	3	0.0726	0.0242	2.977	0.0398
Device x Light/Dark	1	0.0364	0.0364	4.475	0.0392
Approach Velocity	1	0.0013	0.0013	0.161	0.6895
Conductivity	1	0.0257	0.0257	3.155	0.0815
Mean Temperature, °F	1	0.0079	0.0079	0.966	0.3303
Residual	52	0.4228	0.0081		
Total	64	1.0244			

effectively diverted species (96.7 percent; SE = 5.04) and white perch was the least effectively diverted species (83.5 percent; SE = 2.94). Striped bass were intermediate and hatchery-reared bass were apparently more effectively diverted than were native bass.

These conclusions are confounded by the interaction of several of the independent variables. For example, it appears ($\alpha \leq 0.039$) that the angled screen was more efficient in the dark than in the light (96.4 percent; SE = 2.77 vs 94.3 percent; SE = 3.09), but louvers were more efficient in the light (91.2 percent; SE = 3.40 vs 82.0 percent; SE = 2.37). It also appears ($\alpha \leq 0.040$) that all species were successfully bypassed by the angled screen, but not by the louvers. There is also an indication that conductivity may influence total efficiency, with efficiency decreasing at the higher conductivity tested (salinity equivalent 3 ppt). The slope of this linear relationship from the ANCOVA was –0.00015 with a probability less than or equal to 0.08. Interpretation of the relationship between efficiency and conductivity is limited due to the unbalanced nature of the testing program. Only four of the 39 tests were conducted at the higher conductivities.

Each device was then analyzed separately to determine which factors affect the total efficiency of the devices. Angled screens were so highly efficient in bypassing fish that there was very little variability in the data (refer to Table 3.4–2). The inclusion of 5–day differential mortality with the bypass efficiency (i.e., total efficiency) led to several conclusions (Table 3.4–6). Screens were predicted ($\alpha \leq 0.016$) to be more efficient in the dark (100 percent; SE = 2.74) than in the light (92 percent; SE = 3.44), and were more efficient at lower conductivities ($\alpha \leq 0.041$; refer to above-mentioned relationship between conductivity and efficiency). Three variables approached significance (probability <0.10; refer to Table 3.4–6): species, previous use, and mean condition factor. It appears that native striped bass and tomcod were the most effectively diverted species with predicted efficiencies of 100 percent (SE = 3.88) and 99.7 percent (SE = 7.7), respectively. Efficiencies were also higher among fish tested once only as compared to fish which were tested a second time (99.7; SE = 2.10 vs 9.25 percent; SE = 4.21). It also appears that fish with higher condition factors were more effectively diverted. The linear relationship between total efficiency and mean condition factor for a test was 0.26 with a probability of less than or equal to 0.10. Within the range of variables studied, screen angle, velocity, and temperature had no effect on total efficiency.

Louver efficiency appears to be influenced by more independent variables than angled screen efficiency (refer to Table 3.4–7). The efficiency of louvers in bypassing fish was species-specific ($\alpha \leq 0.001$) and the device was apparently more efficient ($\alpha \leq 0.077$) in the light (95.3 percent; SE = 4.39) than in the dark (88.0 percent; SE = 3.49). Fish were predicted to be bypassed more efficiently if they had previously experienced the device (100;SE = 5.90 vs 82 percent; SE = 3.01). It appears (≤0.091) that efficiencies are lower at higher conductivities (refer to above-mentioned relationship). Condition factor was not important, although all other variables were more significant when condition factor was added to the analysis. It also appears that, within the range of the independent variables examined, velocity and temperature had no effect on efficiency.

Based on the data obtained during the study program, the angled screen showed higher total efficiencies (96.4, 95 percent Confidence Interval (CI) = ±2.5 percent) than louvers (84.7, 95 percent CI = ±5.4 percent) even though the louver results were biased in the favorable direction by assuming that the test mortality was zero. If the average test mortality observed for screens (3.4, 95 percent CI = ±2.5 percent) is assumed to be appropriate for louvers as a worst-case condition, the predicted average total efficiency would be 81.3 percent.

The statistical tests for the angle of the screen relative to flow velocities did not reveal any difference in the performance between the 25- and 45-degree orientations. It was subjectively observed, however, that fish suffered more physical damage in tests conducted with the angled screen at 45 degrees than they did in tests with the screen at 25 degrees, as discussed in Section 3.5.2.

The presence of the air curtain did not demonstrate any difference in the performance of the test devices. However, since only a small number of tests were conducted to evaluate both the 45-degree screen angle and the air bubble curtain, the power of the analysis to detect the effect of these design conditions is somewhat limited.

Test results indicate that the effectiveness of the angled screen appears to be less dependent on the species of fish tested than does the effectiveness of the louver device.

3.4.2 Hydraulic Testing

The results of hydraulic testing, described in Section 3.3.2, are summarized below:

1. The velocity distribution data and streamline measurements verified that the approach velocity was uniform. Uniform flow patterns were achieved in the model by providing a relatively long approach section and using an upstream flow straightening device. Uniform flow patterns upstream of and along the screens or louvers are desirable to maintain high fish guidance efficiencies. Tidal conditions at Hudson River sites, which were not simulated in the model, could cause non-uniform approach velocities. Testing of skewed

TABLE 3.4-6

RESULTS OF ANALYSIS OF COVARIANCE FOR ANGLED SCREEN TESTS

INDIAN POINT FLUME STUDY
CONSOLIDATED EDISON CO. OF NEW YORK, INC.
STONE & WEBSTER ENGINEERING CORPORATION

Source	Degrees of Freedom	Sums of Squares	Mean Squares	F-Ratio	Probability
Species	3	0.0001	0.0000	0.369	0.7757
Previous Use	1	0.0000	0.0000	0.298	0.5898
Light/Dark	1	0.0000	0.0000	0.768	0.3887
Conductivity	1	0.0000	0.0000	0.455	0.5057
Mean Condition Factor	1	0.0000	0.0000	0.489	0.4902
Temperature Change, °F	1	0.0000	0.0000	0.392	0.5365
Residual	27	0.0013	0.0000		
Total	35	0.0017			

System Differential Mortality(m)

Source	Degrees of Freedom	Sums of Squares	Mean Squares	F-Ratio	Probability
Species	3	0.0282	0.0094	2.413	0.0886
Previous Use	1	0.0143	0.0143	3.684	0.0655
Light/Dark	1	0.0245	0.0245	6.284	0.0185
Conductivity	1	0.0170	0.0170	4.363	0.0463
Mean Condition Factor	1	0.0124	0.0124	3.174	0.0861
Temperature Change, °F	1	0.0005	0.0005	0.132	0.7193
Residual	27	0.1051	0.0039		
Total	35	0.1913			

Total Efficiency

Source	Degrees of Freedom	Sums of Squares	Mean Squares	F-Ratio	Probability
Species	3	0.0271	0.0090	2.308	0.0990
Previous Use	1	0.0135	0.0135	3.440	0.0746
Light/Dark	1	0.0262	0.0262	6.675	0.0155
Conductivity	1	0.0180	0.0180	4.602	0.0411
Mean Condition Factor	1	0.0115	0.0115	2.927	0.0986
Temperature Change, °F	1	0.0004	0.0004	0.092	0.7644
Residual	27	0.1058			
Total	35	0.1973			

TABLE 3.4-7

RESULTS OF ANALYSIS OF COVARIANCE FOR LOUVER TESTS

INDIAN POINT FLUME STUDY
CONSOLIDATED EDISON CO. OF NEW YORK, INC.
STONE & WEBSTER ENGINEERING CORPORATION

Source	Degrees of Freedom	Sums of Squares	Mean Squares	F-Ratio	Probability
Species	3	0.2393	0.0798	9.165	0.0005
Previous Use	1	0.0686	0.0686	7.880	0.0109
Light/Dark	1	0.0303	0.0303	3.481	0.0768
Conductivity	1	0.0274	0.0274	3.152	0.0910
Temperature Change, °F	1	0.0339	0.0339	3.898	0.0623
Mean Condition Factor	1	0.0051	0.0051	0.583	0.4542
Residual	20	0.1741	0.0087		
Total	28	0.5700			

approach velocity distributions was not performed and therefore, the effect on non-uniform flow on bypassing efficiency was not determined. Detailed hydraulic tests results are given in the ARL report (Appendix A).

2. Water surface elevation measurements revealed relatively small head losses across both test devices. However, these measurements were taken with "100 percent clean" screens and louvers. Clogging due to trash loading would almost certainly alter the velocity distribution along the face of the diversion devices and increase the head losses through the devices.

3. Streamline photography indicated that the flow approaching the screens and louvers was parallel to the flume walls. This flow pattern would cause all debris in a prototype approach channel to be impinged on the screening device, except for a small proportion of the debris which floats directly into the bypass. Trash forced into a bypass could cause clogging in the fish return system. The bypass entrance could be constructed of removable steel sections, so that debris trapped inside could be cleaned manually, when required.

3.5 SUMMARY AND DISCUSSION

3.5.1 Program Summary

The Indian Point Flume Study is summarized below:

1. Stone & Webster (S&W) has conducted a study program for Consolidated Edison Co. of New York, Inc. to evaluate the effectiveness and applicability of various fish diversion devices for their potential in alleviating the problem of fish entrapment at Indian Point and other Hudson River sites.

2. The studies were conducted at Alden Research Laboratories (ARL). Striped bass, white perch, and tomcod, which are native Hudson River fish, as well as hatchery-reared striped bass, were procured by S&W. Experiments were conducted which led to the development of suitable facilities for these test species at ARL.

3. Based on the conclusions from an extensive literature review and the results of prototype engineering evaluation, angled flush-mounted traveling screens and louvers were selected for evaluation. Other devices, such as inclined plane screens and louvers and a lift basket collection system, were to be tested only if angled screens and louvers did not yield high diversion efficiencies.

4. A 6- by 7- by 80-foot flume was constructed by ARL. An angled screen test device was evaluated in the flume at angles of 25 and 45 degrees to the flow. Louvers were tested at 25 degrees only. A bypass width of 6 inches was maintained throughout the study.

5. The environmental variables investigated included test species, illumination (light or dark), water temperature, and conductivity. The hydraulic design variables included approach velocity, bypass velocity, test device angle (screen only), and presence or absence of an air bubble curtain upstream of the device.

6. In addition to evaluating the diversion efficiency of the devices, 1-week mortality studies were conducted during angled screen tests to determine the effect of swimming and guidance on the survival of the test fish. These data were included in the analysis of the data to determine total efficiency (E_T). Condition factors of fish that died during the 1-week holding period, and a sacrificed subsample of remaining test and control fish were also determined and were included in the analysis of the data.

7. Thirty-nine angled screen and 21 louver tests were conducted between May 1975 and January 1976. The results were subjected to an analysis of covariance using a general least-squares procedure.

8. Angled screens were found to be more effective than louvers. For angled screens, mean E_T = 96.4 percent, 95 percent confidence interval (CI) = ±2.5 percent; for louvers, mean E_T = 84.7 percent, 95 percent CI = ±5.4 percent. In general, the angled screen was 100 percent effective in guiding fish to the bypass. The lower E_T value for screens is, therefore, a function of resultant 1-week mortality. Mortality studies were not conducted with louvers, so the 84.7 percent E represents the actual diversion efficiency of the device.

9. Angled screens showed higher efficiencies under dark conditions but louvers were more effective in the light.

10. Conductivity appeared to influence efficiency, with E_T decreasing as conductivity increased.

11. Velocity, temperature, and the presence of an air bubble curtain had no effect on the efficiency of either screen or louvers. In addition, the angle of the screen (25 vs 45 degrees) did not appear to affect E_T.

12. Results of hydraulic testing showed that a uniform approach velocity distribution was provided in the test section of the flume throughout the biological test program.

3.5.2 Discussion of Test Results

Angled screens and louvers were both shown to be effective in guiding fish to a bypass. Several factors have been considered in the interpretation of the results relative to the relationships between certain hydraulic and environmental variables and the device efficiency.

Of primary importance is the relationship between angle of the angled screen test device and E_T. Analysis of the data did not show a significant difference in E_T between 25- and 45-degree screen orientations. However, a substantial number of fish (hatchery-reared striped bass) diverted at the 45-degree angle were observed to be scaled and bruised. Further, due to limitation in fish availability, testing with a 45-degree screen orientation was conducted with hatchery-reared striped bass which were larger than the native striped bass tested with a 25-degree angle at warmer temperatures. Therefore, the ability of smaller native fish to guide along a 45-degree angled screen at reduced water temperatures with low mortality is uncertain and could only be determined through further testing under those conditions. However, since the larger fish were injured at the 45-degree screen orientation, smaller native Hudson River fish could be more seriously affected.

The results of the analyses also showed a negative relationship between increasing conductivity (i.e., salinity) and E_T. This was somewhat unexpected since the fish holding facilities at the laboratory were maintained at 7 ppt salinity. Therefore, it would be expected that, if stress were to occur due to a difference in salinity between the holding pools and the test flume, the effects on E_T would be greater during tests run at low conductivities (0 ppt salinity). Since this effect was not observed, the biological significance of the relationship between conductivity and E_T is uncertain. There was also an uneven distribution of experiments over the range of conductivities tested (4 tests at high conductivity with each device compared to 35 angled screen tests and 17 louver tests conducted a low conductivity). Although the relationship between conductivity and E_T is unclear, the actual decrease in E_T at higher conductivities was small.

Results of hydraulic measurements showed that a relatively uniform velocity distribution was maintained during biological testing. The closer the velocity distribution in the prototype is to the velocity distribution in the test flume, the higher the confidence that can be applied in using the results of the biological testing to predict the effectiveness of a prototype angled screen or louver. If, due to design limitations, it is deemed impractical to construct a screenwell that incorporates uniform approach velocities, consideration should be given to the effect of skewed velocities on fish behavior.

The potential exists for debris clogging in a prototype fish bypass and transport system. The nature of the flow distribution could be such that some debris would pass directly into the fish bypass without first encountering the screening device. The magnitude or nature of this clogging cannot be predicted from the results of the study program. In designing a prototype bypass, consideration should be given to incorporating devices or procedures that would minimize the clogging potential. Possible devices include trash racks with narrow spacings and removeable bypass sections which could be cleaned manually.

The results of these studies have shown that, under the environmental and engineering conditions evaluated, angled screen and louver diversion devices are highly effective in guiding striped bass, white perch, and tomcod to a bypass with low resultant mortality. The results further indicate that such devices may be effective in reducing fish impingement at Hudson River power plant intakes.

REFERENCES

Bates, D.W.; Logan, O.; and Personen, E. 1960. Efficiency Evaluation, Tracy Fish Collecting Facility, Central Valley Project.

Bates, D.W., and Vinsonhaler, R. 1956. Use of Louvers for Guiding Fish. Trans. Am. Fish Soc., 86, 1956.

California Department of Fish and Game, Department of Water Resources. 1962-1967. Delta Fish and Wildlife Protection Study. Annual Reports Nos. 1–6. The Resources Agency of California.

California Department of Water Resources. 1967. Fish Collection Facilities Bypass Intake Passage Spacing Tests at Tracy Fish Collecting Facility 1963, 1964. The Resources Agency of California.

Consolidated Edison Company of New York, Inc. 1973. The Biological Effects of Fish Impingement on the Intake Screens at Indian Point (January 15, 1973).

Downs, D.I., and Meddock, K.R. 1974. Design of Fish Conserving Intake System. Jour. Power Div. ASCE, Vol. 100, No. PO2.

Ducharme, L.J.A. 1972. An Application of Louver Deflectors for Guiding Atlantic Salmon (Salmo salar) Smolts from Power Turbines J. Fish Res. Bd. Canada, 29: 1397–1404.

Hallock, R.J.; Iselin, R.A.; and Fry, Jr., D.H. 1968. Efficiency Tests of the Primary Louver System. Tracy Fish Screen, 1966-67, Marine Resources Branch, California Department of Fish and Game.

Kemp, K.E. 1972. Least Squares Analysis of Variance, a Procedure, a Program and Examples of their Use. Kansas Agricultural Experiment Station, Contribution 168, Res. Paper 7, 26pp.

Kerr, J.E. 1953. Studies on Fish Preservation at the Contra Costa Steam Plant of the Pacific Gas and Electric Co. California Fish and Game, Bulletin No. 92.

Mansueti, R. J. 1964. Eggs, Larvae, and Young of the White Perch, Roccus americanus, with Comments on Its Ecology in the Estuary. Chesapeake Science, 5(1–2): 3–45 (March–June 1964).

Pavlov, D.S. 1969. Entrapment of Fish Fingerlings in Pumping Installations as Related to Features of Their Behavior and Orientation to the Stream of Water. Problems in Ichthyology, American Fisheries Society, 9(2): 237–243.

Raney, Edward C. 1954. The Striped Bass in New York Waters. N.Y. State Conservationist 8(4): 14–16.

Rathjen, W.F., and Miller, L.C. 1957. Aspects of the Early Life History of the Striped Bass (Roccus saxatilis) in the Hudson River. N.Y. Fish and Game Jour. 4(1): 43–60.

Riesbol, H.S., and Gear, P.J.L. 1972. Application of Mechanical Systems to Alleviation of Intake Entrapment Problems. Presented at Atomic Industrial Forum Conference on Water Quality Considerations, Washington, D.C.

Ruggles, C.P., and Ryan, P. 1964. Louvers for Guiding Pacific Salmon. Can. Fish. Cult., 33: 1–68.

Schuler, V. 1973. Experimental Studies in Guiding Marine Fishes of Southern California with Screens and Louvers. Ichthyol. Assoc., Bulletin 8 (February 1973).

Schuler, V., and Larson, W.E. 1974. Experimental Studies Evaluating Aspects of Fish Behavior as Parameters in the Design of Generating Station Intake Systems. Southern California Edison Company and Ichthyological Associates, Inc., Middletown, Delaware.

Stone & Webster Engineering Corporation. 1975a. Studies To Alleviate Potential Fish Entrapment Problems – Summary Report, 1973–1974 Efforts, Nine Mile Point Nuclear Station Unit 2. Prepared for Niagara Mohawk Power Corporation (February 1975).

__________. 1975b. First Progress Report. Indian Point Flume Study. Prepared for Consolidated Edison Co. of N.Y., Inc. (August 1975).

Taft, E. P.; Hofmann, P.; Eisele, P.J.; and Horst, T.J. 1976. An Experimental Approach to the Design of Systems for Alleviating Fish Impingement of Existing and Proposed Power Plant Intake Structures. Presented at the Third National Workshop on Entrainment and Impingement, New York City, February 1976.

Texas Instruments, Inc. 1972. Literature Survey of Fish Behavior to Screening and Guiding Devices at Water Intakes and a Recommended Future Testing Program. Prepared for Consolidated Edison Co. of New York, Inc. (December 28, 1972).

__________. 1974. Hudson River Ecological Study in the Area of Indian Point. 1973 Annual Report. Prepared for Consolidated Edison Co. of N.Y., Inc.

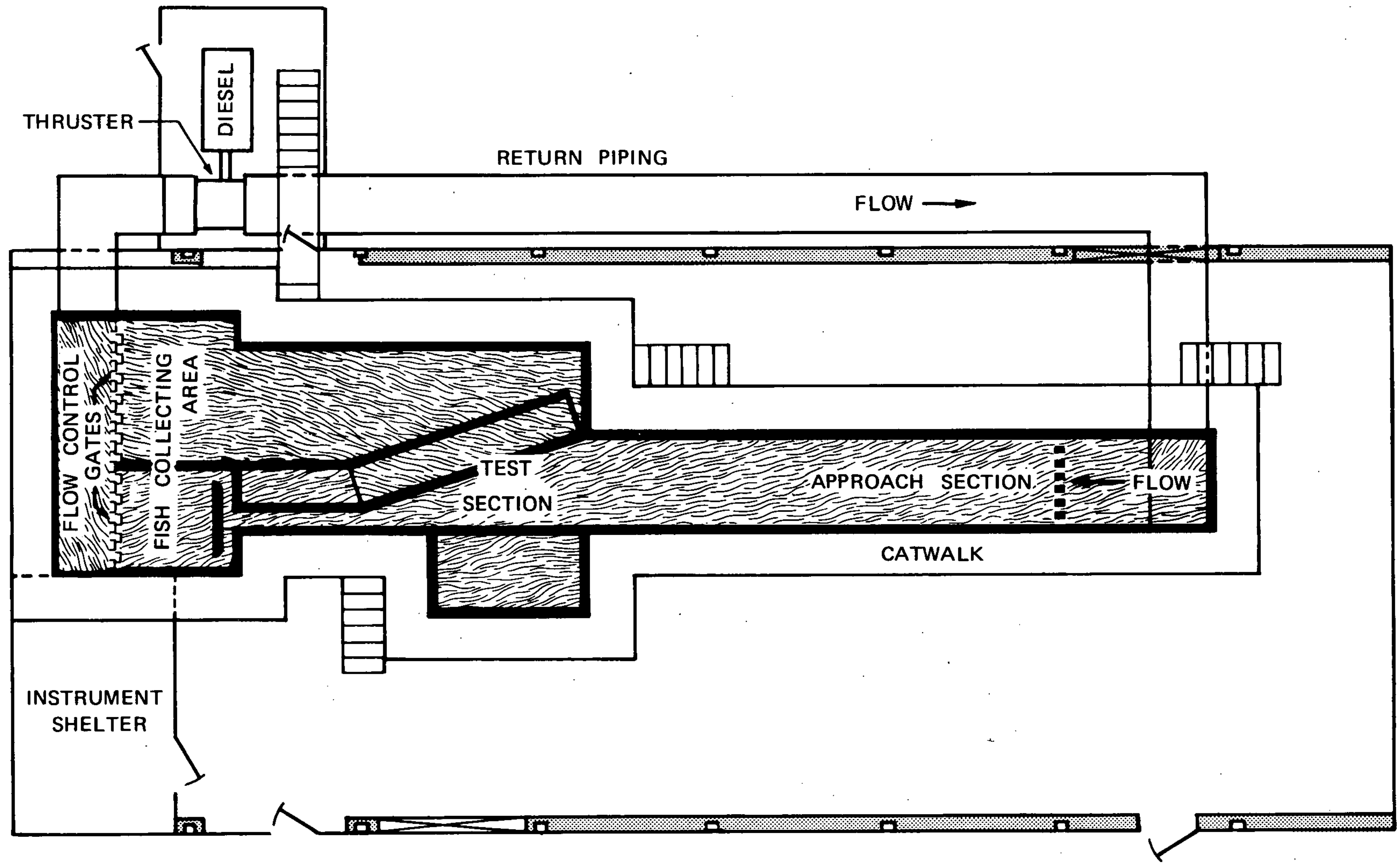
Thoits, C. F. 1973. A Compendium of the Life History and Ecology of the White Perch, Morone americana. Massachusetts Division of Fisheries and Game, Fisheries Bulletin No. 24, February 1973.

Thompson, J.S., and Paulik, G.J. 1967. An Evaluation of Louvers and Bypass Facilities for Guiding Seaward Migrant Salmonid Past Mayfield Dam in West Washington. Washington Department of Fisheries, Olympia, Washington.

APPENDIX A

INDIAN POINT FLUME STUDY

HYDRAULIC TEST PROGRAM



CONSOLIDATED EDISON FISH FLUME

(PLAN VIEW)

INDIAN POINT FLUME STUDY

HYDRAULIC TEST PROGRAM

FOR

STONE AND WEBSTER ENGINEERING CORPORATION

AND

CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.

Jonathan W. Leavitt

George E. Hecker, Director

ALDEN RESEARCH LABORATORIES
WORCESTER POLYTECHNIC INSTITUTE
HOLDEN, MASSACHUSETTS 01520

TABLE OF CONTENTS

INTRODUCTION

The entrapment of fish in the circulating water systems of electric generating stations has become a prime concern. Studies are being conducted by various researchers to determine what can be done to prevent fish from entering circulating water intakes and how entrapped fish can be returned to their natural habitat.

Consolidated Edison Company of New York, Inc. contracted the Alden Research Laboratories of Worcester Polytechnic Institute and Stone & Webster Engineering Corporation to design, construct and test an experimental flume facility that would evaluate fish diversion and bypass devices.

Specifically, the ARL designed and fabricated a flume facility that was capable of producing a velocity of up to 3 feet per second in a 6 foot wide channel with a water depth of 6 feet. The flume was sufficiently long to provide an approach section, a test section and a fish collecting section. ARL also fabricated and hydraulically tested fish diversion devices that S&W designed, and provided support personnel to assist S&W during testing that evaluated fish reaction to the devices.

The velocity data obtained during the hydraulic and fish testing, as well as water surface elevations and flowlines approaching and leaving the devices are presented in this appendix. The results of fish diversion studies conducted by S&W are presented in Section 3 of this report.

The frontispiece illustrates the flume test facility.

DESCRIPTION OF FLUME FACILITY

The facility consisted of a steel recirculating flume that is 7 feet high, 79 feet long and 18 feet wide at its widest point (the test section), a diesel powered pump located in a 4 foot diameter pipe that returned the water from the downstream end of the flume to the upstream end of the flume, a concrete storage tank to hold salt water and a fish holding facility.

Flume

The flume was fabricated of steel to the dimensions shown in Figure 1. The elevation of the bottom of the flume in the approach and test section was established at 3 feet above the floor of the building in which the facility was located. This feature provided the potential for access to the bottom of the facility for visual observation as well as space to allow withdrawal of flow through the floor. Neither provision has been utilized for this study. The bottom of the flume in the fish collecting area was 2 feet lower than the approach and test sections with a false wooden bottom installed to match the other two sections as shown in Figure 2. This provided space in the event a lift basket was installed below the wooden bottom in the fish collecting area. The height of the walls was 7 feet above the bottom.

The entire wetted surface of the facility was painted with an epoxy paint to minimize corrosion and to prevent the leaching of toxic materials. The length of the approach section allowed the flow distribution to become nearly uniform before it reached the test section. As the flow entered the flume from the 4 foot diameter pipe at the side, a series of baffles and turning vanes guided the flow to the flow straightener. The flow straightener can be seen in the lower portion of Photograph 1.

The fish used for the biological test program were introduced into the flume downstream of the flow straighteners in the approach section.

The test section was expanded to a width of 18 feet, centered on the 6 foot wide approach section, for a length of 10 feet. This feature provided versatility in orienting test devices to the flow direction. The section was then narrowed to 12 feet wide by placing the left wall, looking downstream, in line with the left wall of the approach section. Several test devices were installed in this section of the flume during the test program. For the particular devices tested during this study, the 6 foot by 10 foot left hand section was partitioned off, as shown in Figure 1.

A wooden partition was also installed parallel to the left wall to divide the flow into two portions, flow through the test device and bypass flow. The width of the bypass was set at 6 inches. The bypass provided a way of segregating the fish in an area away from the through flow where they could be collected.

The bypass flow discharged into the fish collection area as shown in Figure 3. The baffle wall caused the flow to split around both ends of the wall and form a quiescent area behind the wall where the fish would gather. A lift basket type device was used to remove fish from the bypass collection area.

During louver tests, an inclined screen was used to collect any fish that passed through the diversion device. Figure 2 shows the details at the screen while Photograph 4 illustrates the screen as one would view it looking upstream towards the diversion device.

The bypass flow and the through flow were regulated by individual flow control gates installed near the end of the flume, as shown in Figure 1. Each gate had a fixed section and a movable section. Both sections were fabricated from 8 inch channel iron installed vertically in the flume with 8 inch clearances between members, as detailed in Figure 3. The upstream movable sections were hung from dolly wheels and were operated by turning an adjusting screw.

Recirculating System

The flume, designed as a closed loop, utilized a 4 foot diameter steel pipe to return the water from the downstream end of the flume to the upstream end. The pump, installed in the pipe near the downstream end of the flume, was a model BT20 Harbormaster Bow Thruster. The thruster is a four blade, 42 inch diameter Kaplan type propeller mounted to a right angle gear reducer in a 42.75 inch inside diameter pipe. It is rated as 200 HP at 1200 RPM input operating at 473 RPM. This was sufficient to produce a flow in excess of the 108 cubic feet per second required to produce the desired 3 foot per second velocity in the 6 foot wide approach section in a water depth of 6 feet. Photograph 2 shows the thruster being installed in the 4 foot diameter pipe by means of dresser couplings.

A Caterpillar Model 334 Marine Engine with a 2:1 reducing marine gear was coupled to the thruster as the driver. This engine was rated at 240 continuous (flywheel) Brake HP at 2200 RPM. Photograph 3 shows the engine and thruster in place.

Fish Diversion Devices

Several fish diversion devices were tested "hydraulically" by taking velocity measurements and "biologically" by observing the reaction of fish to the devices. The emphasis of the study was concentrated on two devices, an angled screen and an angled louver. Both of these devices were modifications of the standard traveling screen commonly found in electric generating station screenwells. An angled screen was installed in the test section at 25° to the flow so that preliminary tests could be conducted with fish to determine the feasibility of the angled screen as a fish diversion device and to become familiar with the operation of the facility. Meanwhile, S&W was working with Envirex on the design modifications necessary to adapt a conventional traveling screen. When the new design was available, new support frames were fabricated and installed. Figure 4 shows the sectional details of the support frame of one panel of a traveling louver or screen. The frames for the louver and the screen were identical. Figure 5 shows the front view of the frame with screening illustrated in one section and louvers illustrated in another section. The two overall length dimensions on Figure 5 indicate the lengths used when the frames were installed in the test section at 25° and 45° to the flow. The angled screen was tested at both angles while louvers were only tested at 25°. The details of a typical wooden louver insert are shown in Figure 6.

An air bubble curtain was tested in conjunction with both screens and louvers at the 25° orientation. The curtain consisted of four diffuser pipes with 1/32 inch diameter holes drilled through the wall at the bottom of each pipe on 1 inch centers. The last 13 inches of each pipe on the bypass side of the flume did not have holes so that the fish would have an area to swim by the bubbles to the bypass. The curtain was installed upstream of and parallel to the louver and screen devices, as shown in Figure 7. The lines that supplied air to the diffusers had orifice meters to measure the flow rate. The coefficients for the orifice meters were obtained from the American Society of Mechanical Engineers' Power Test Code on flow measurement.

Figure 8 illustrates the relative positions of the devices installed at 25° to the flow while Figure 9 illustrates the devices at 45° to the flow.

Salt Water Storage Tank

A concrete storage tank was constructed near the facility to hold 125% of the volume of water (6200 cubic feet) contained in the flume in the event water from the Hudson River was used for the study. The storage tank was required to hold water of particular quality and salt concentration when the flume had to be drained. A 6 inch diameter pipe line and a pump connecting the flume to the storage tank were installed for this purpose. Photograph 5 shows the salt water storage tank. Fresh water was used for the majority of the test program, and only one series of tests was conducted with water of 3 ppt salinity.

Fish Holding Facility

Three 12 foot diameter by 3 foot deep swimming pools each having a water capacity of 2550 gallons were used as holding tanks near the flume. A number of fiberglass aquariums obtained from Consolidated Edison, ranging in size up to 400 gallons were also used. The pools were each equipped with biological, chemical and high-rate sand filters. The water in each holding tank was aerated by means of air stones supplied from a 3 horsepower, 25 cfm at 10 psi oiless compressor. Two smaller compressors were coupled into the air supply system as a back-up to the primary compressor.

Several instruments were used by S&W to monitor the water quality in the holding tanks and in the flume. The water quality parameters measured, included salinity, conductivity, temperature, dissolved oxygen, pH, and ammonia.

TEST PROCEDURE

Preliminary hydraulic tests were conducted and several modifications were made in the inlet end of the flume to produce a uniform velocity distribution 10 feet upstream of the test section. The final arrangement of baffles, guide vanes and flow straighteners resulted in a distribution that was nearly uniform.

The flume was calibrated for each test device and each test configuration. The calibration consisted of measuring the approach velocity and relating it to the rpm of the diesel. The original test velocities were established as being a velocity in the approach section of 1, 2, or 3 feet per second and a ratio of the velocity in the bypass to the velocity of approach of 1:1 for the screen device and 1.5:1 for the louver device.

Velocity Measurements

After each test device was installed in the flume, a velocity survey was conducted using an OTT propeller type current meter. Figures 10 and 11 show the locations specified by Stone and Webster for velocity measurements with the diversion devices installed at 25° and 45° to the flow, respectively. When the average velocities of transects 1 and 2 matched the desired velocities for the biological test, the diesel speed was noted and a more detailed survey was then conducted. The velocity measurements were recorded on data sheets that indicated the positions of each point along with other information such as test number, date, diversion device and test condition. The arithmetic average of each section was then determined and recorded in the space provided.

Water Surface Elevations

Piezometer taps were installed along the front and rear of the upstream louver and screen panels, along the rear of the downstream louver and screen panels and in the bypass. Flexible tubing was installed from each tap to a central manometer board on the outside of the flume to allow easy measurement of the water surface at these locations. Figures 12 and 13 show the measuring locations specified by S&W for the diversion devices installed at 25° and 45° to the flow, respectively. The flow in the flume was increased until the desired test velocities were achieved and allowed to stabilize before the measurements were taken. Water surface elevations were measured with the louvers and screens at 25° to the flow and the screens at 45° to the flow.

Flowlines

Lighted candles set on styrofoam floats supporting submerged cruciforms were placed in the flow and photographed using a time-lapse technique to determine the flowlines in the approach section, the bypass section, between the louver and screen devices and the section downstream of these devices. The screen was installed at both 25° and 45° to the flow while the louvers were installed only at 25° to the flow. The cruciforms were set at depths of 1 foot-6 inches and 3 feet-6 inches from the bottom.

Air Bubble Curtain

For the series of tests that involved the air bubble curtain, the air control valves were opened until the desired visual effect was achieved as determined by Stone and Webster personnel. Manometer readings were recorded, control valve positions were noted, and the flow rate was determined to be 3 cfm per pipe. Subsequently, the main valve in the air supply line was the only valve used to turn the air on and off for each test. As the air was turned on for each test, the manometers were checked to assure the flow rate had not changed.

Fish Diversion Studies

The biological testing program was conducted by Stone & Webster with the support of ARL personnel. The fish were introduced into quiet, non-flowing water in the approach section of the flume and allowed to acclimate. A segregating screen was then removed and the velocity was slowly increased until the rpm of the diesel indicated that the desired velocity conditions were set, as based on the detailed velocity measurements.

At regular intervals during the test, both fish collecting areas were checked for fish and any that were found were removed and placed in holding facilities. When the test had ended, velocity measurements were taken at transects 1 and 2 as shown in Figures 10 and 11. Upon completion of the velocity survey, the flow was reduced to zero and any remaining fish were removed.

HYDRAULIC TEST RESULTS

The preliminary velocity data indicated that the flow in the approach section was distributed nearly uniformly at a cross-section 10 feet upstream of the test section. Figures 14 and 15 indicate how individual velocities in localized areas varied from the average velocity.

The ratio of the bypass velocity to the approach velocity was set at 1:1 for the screen devices and 1.5:1 for the louver device. Velocity data for the screen tests indicated that the velocity distribution remained relatively unchanged as the flow approached the screen. Data from the louver tests indicated that the velocity along the bypass side of the flume increased as the flow approached the louver. The data from these tests are included at the end of this appendix.

The water surface measurements indicated a slight drop of the water surface along the first few feet of the screens and a gradual increase to nearly the original elevation as the flow neared the bypass. The louvers, however, produced a gradual decrease in elevation along the device as the flow approached the bypass. A head loss across the devices could not be determined as velocities were not measured downstream of the devices. The water surface elevation measurements are included at the end of this appendix.

Photographs of the candle floats illustrated the flowlines as the water approached, passed through, and left the devices. With the screens installed, the flowlines in the approach section were parallel to the walls of the flume up to the screens. After the flow had passed through the downstream screen, separation on the left side, looking downstream, occurred and a slow eddy was formed on the right side.

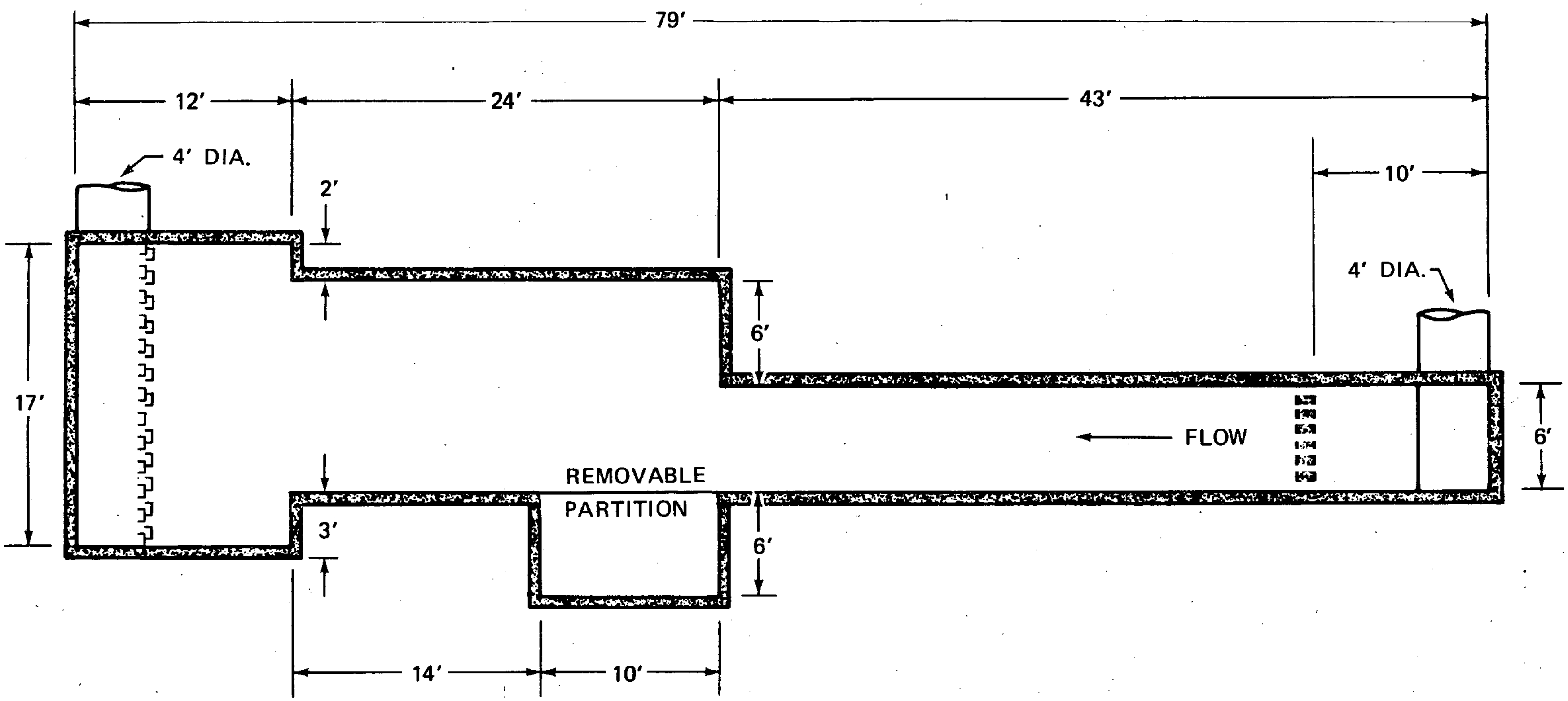
The approach flowlines for the louver device tended to angle towards the bypass as the flow reached the device, at which point they were deflected almost perpendicular to the louver as the flow passed through the device. A greater separation on the right side, looking downstream, was indicated as the flow left the louver. The photographs are included at the end of this appendix.

CONCLUSIONS

Hydraulic and fish behavioral tests were conducted on several fish diversion devices to determine their flow characteristics and fish guidance capabilities. The velocity data supporting these efforts is included at the end of this appendix.

The results of the fish behavioral studies are presented by Stone & Webster Engineering Corporation elsewhere in this report.

FIGURES

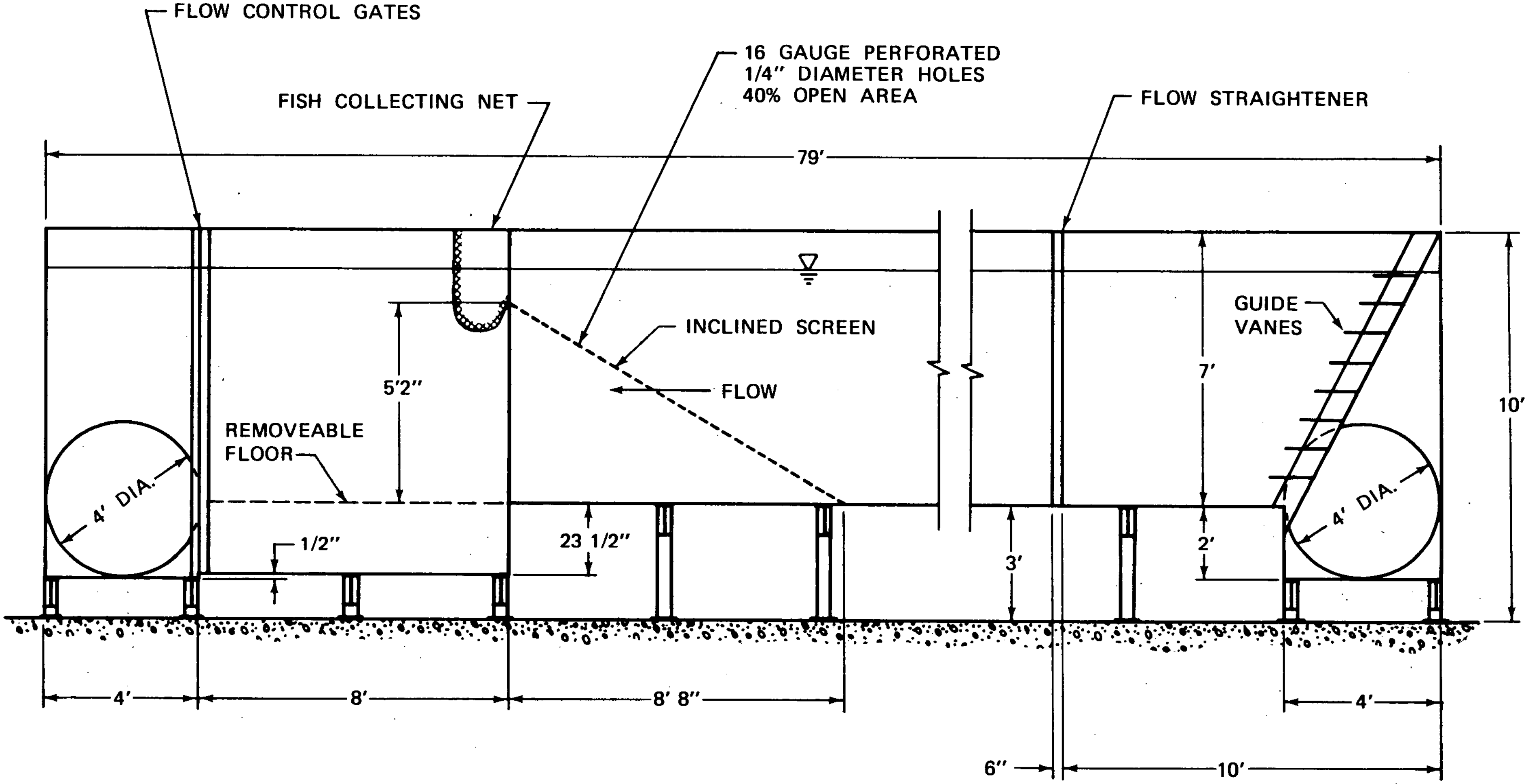


PLAN VIEW OF FLUME

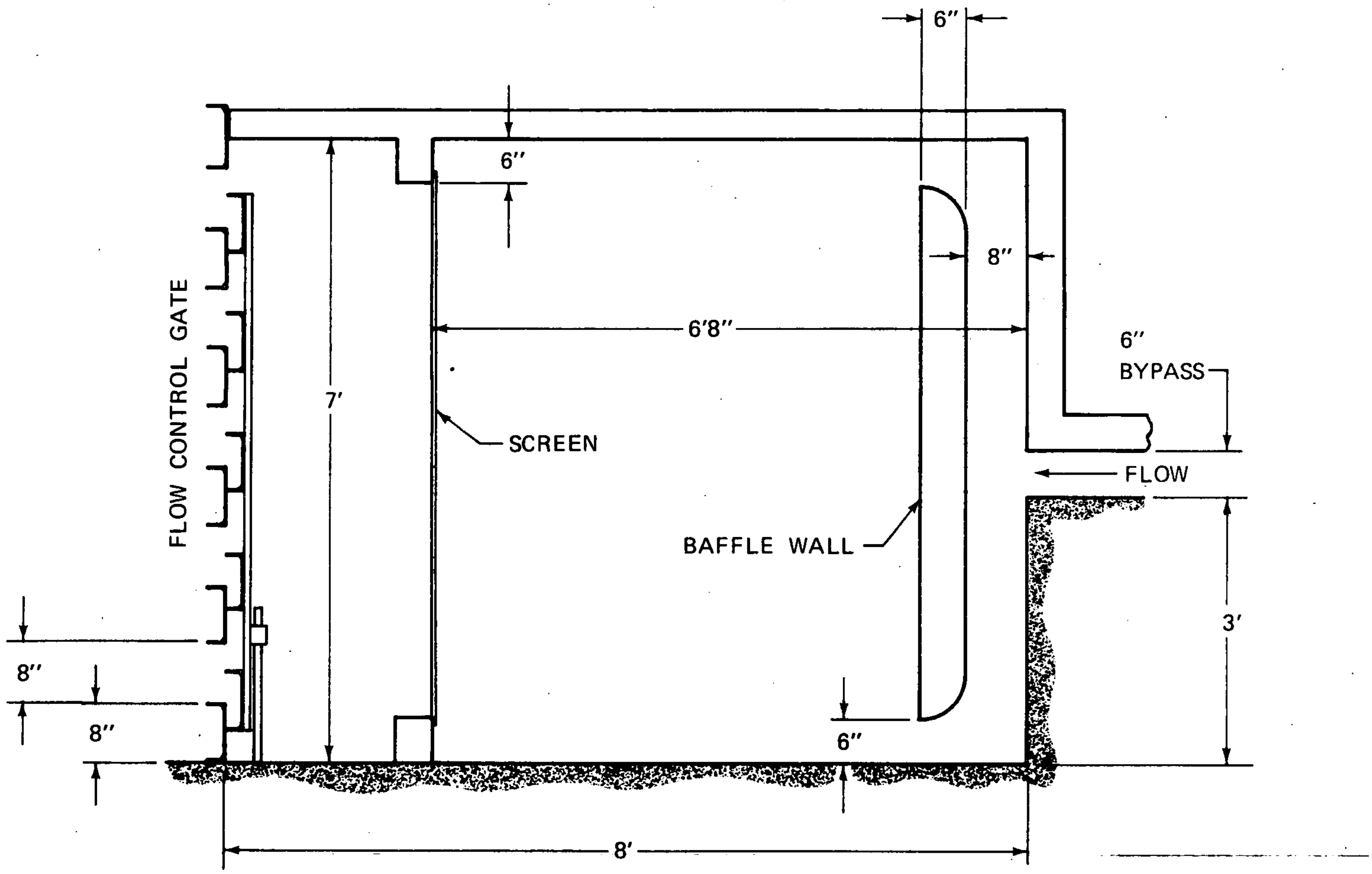
ARL

FIGURE 1

FIGURE 2



ELEVATION VIEW OF FLUME
(SECTIONAL)



NOTE: SEE FRONTISPIECE FOR RELATIVE LOCATION

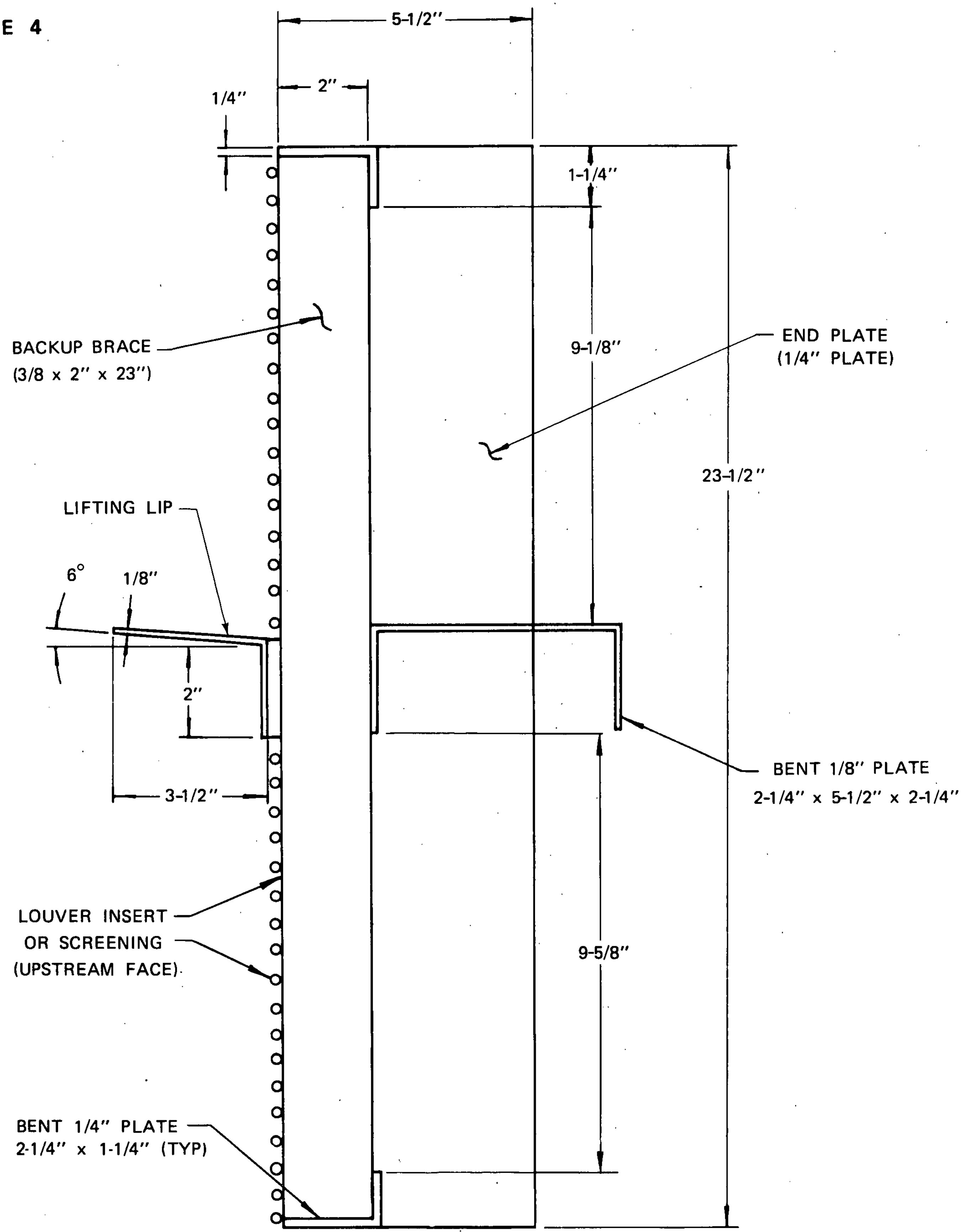
FISH COLLECTING AREA

(PLAN VIEW)

BAFFLE WALL AND SCREEN
SPECIFIED BY
STONE & WEBSTER ENGINEERING CORPORATION

ARL

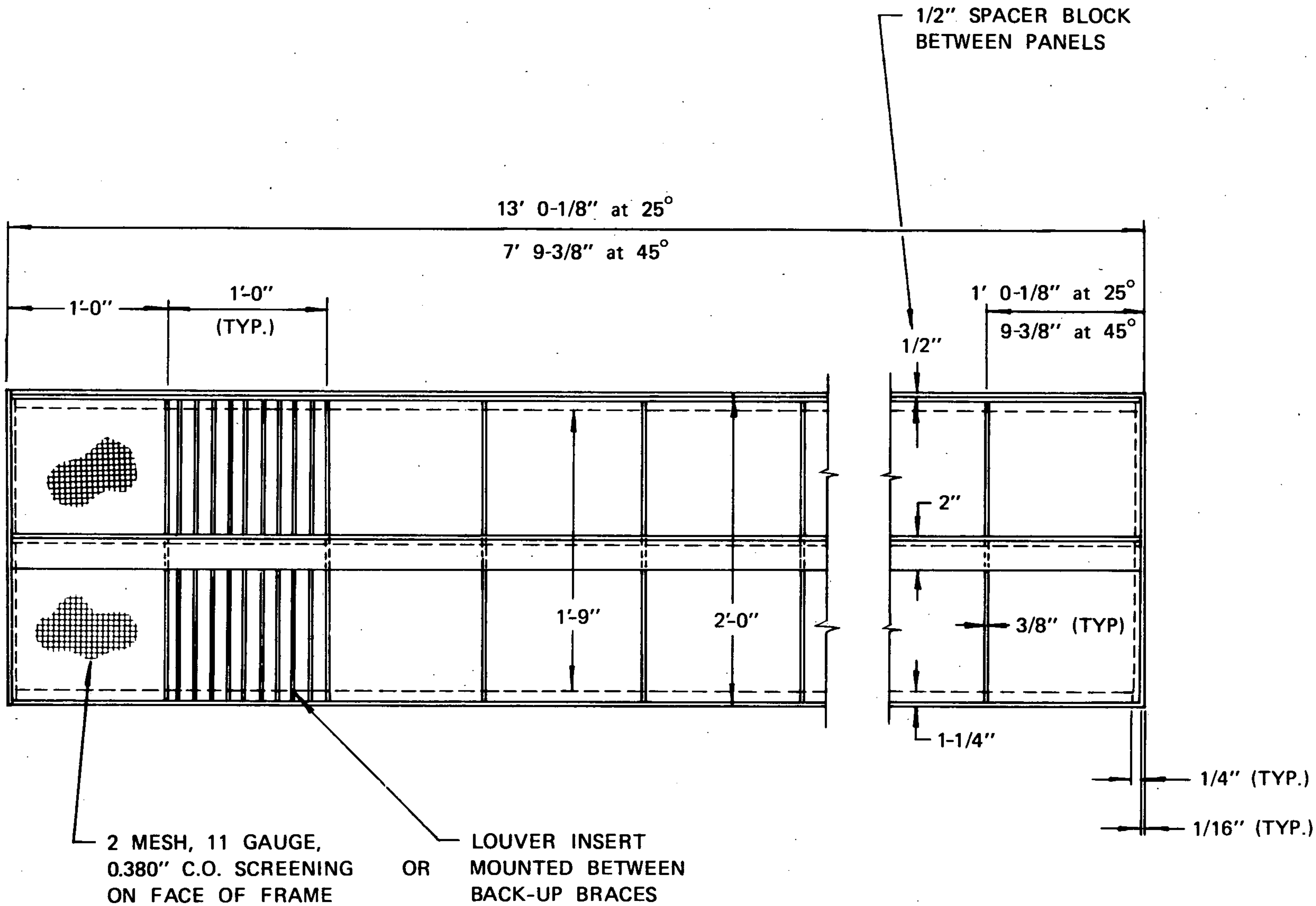
FIGURE 4



DESIGN COURTESY OF
ENVIREX AS MODIFIED
FOR MODEL CONSTRUCTION
BY ARL & S and W

LOUVER/SCREEN FRAME DETAIL

ARL



DESIGN COURTESY OF
ENVIREX AS MODIFIED
FOR MODEL CONSTRUCTION
BY ARL & S and W

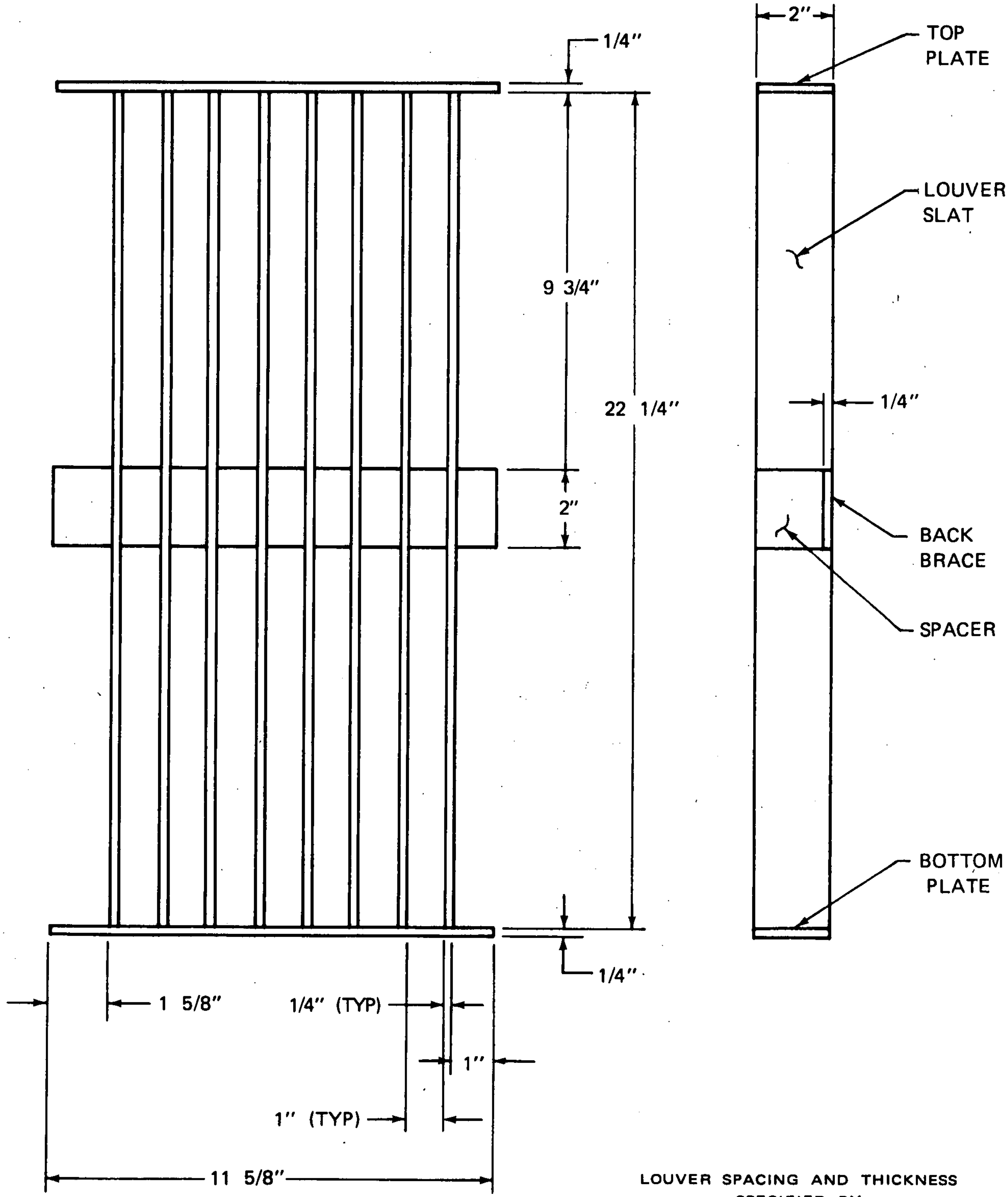
FRONT VIEW OF LOUVER/SCREEN FRAME

(SINGLE PANEL)

ARL

FIGURE 5

FIGURE 6

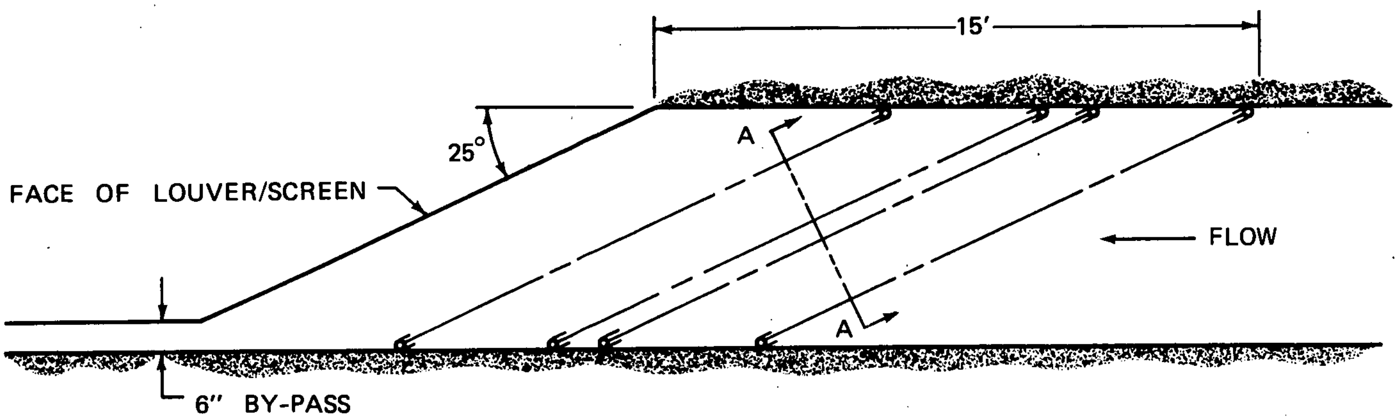


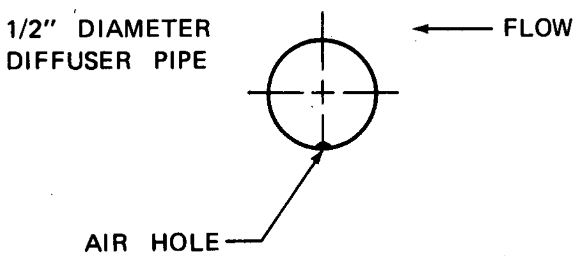
LOUVER SPACING AND THICKNESS
SPECIFIED BY
STONE & WEBSTER ENGINEERING CORPORATION

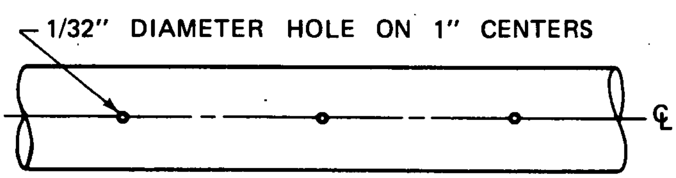
TYPICAL WOODEN LOUVER INSERT

ARL

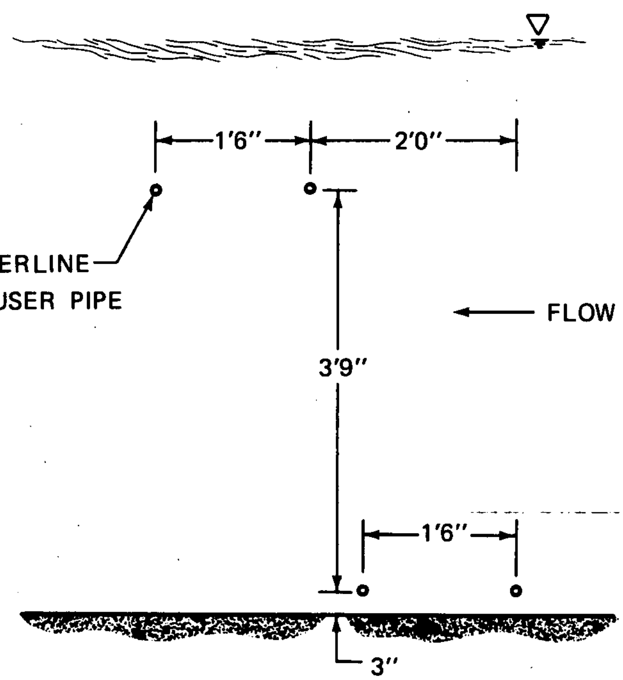
FIGURE 7







BOTTOM VIEW - DIFFUSER PIPE

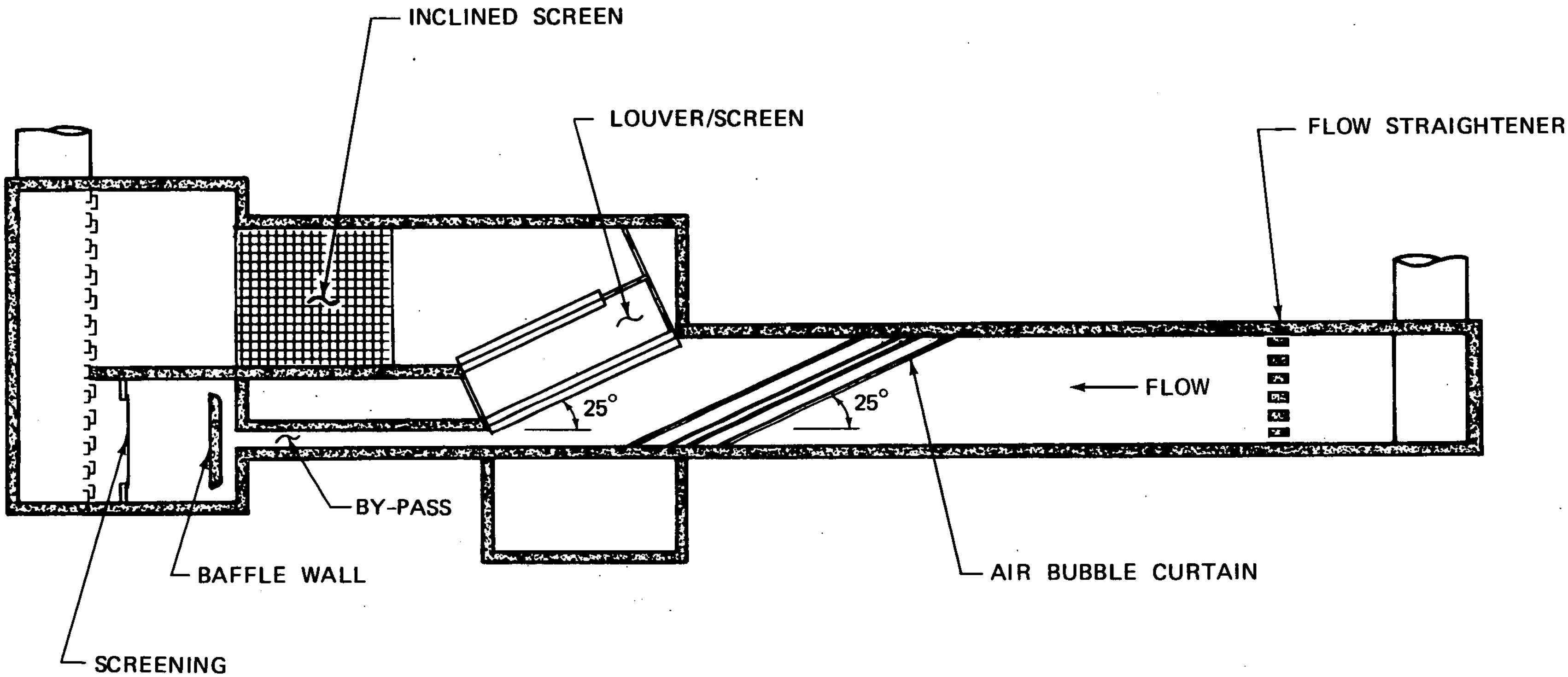


SECTION A-A

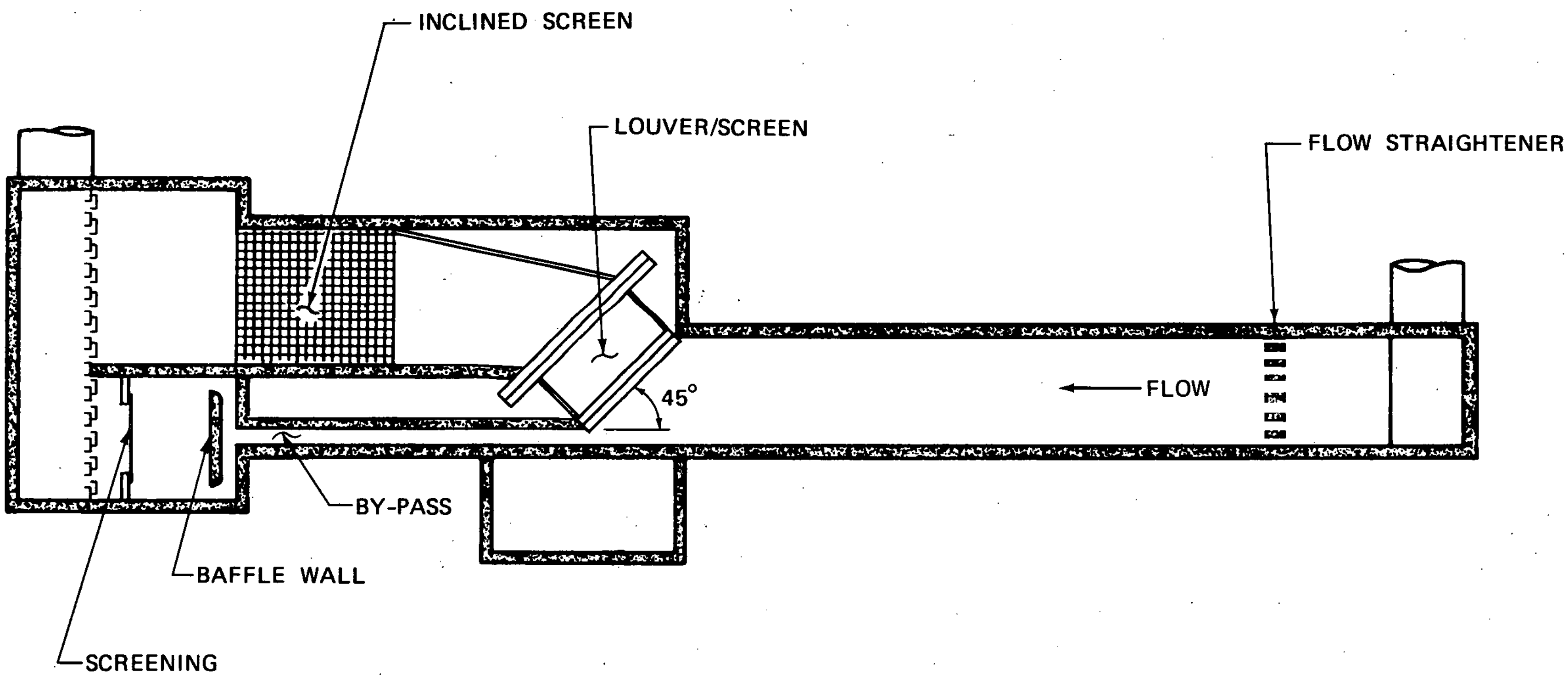
AIR BUBBLE CURTAIN AT 25° TO FLOW

DIFFUSER PIPE DESIGN
SPECIFIED BY
STONE & WEBSTER ENGINEERING CORPORATION

FIGURE 8



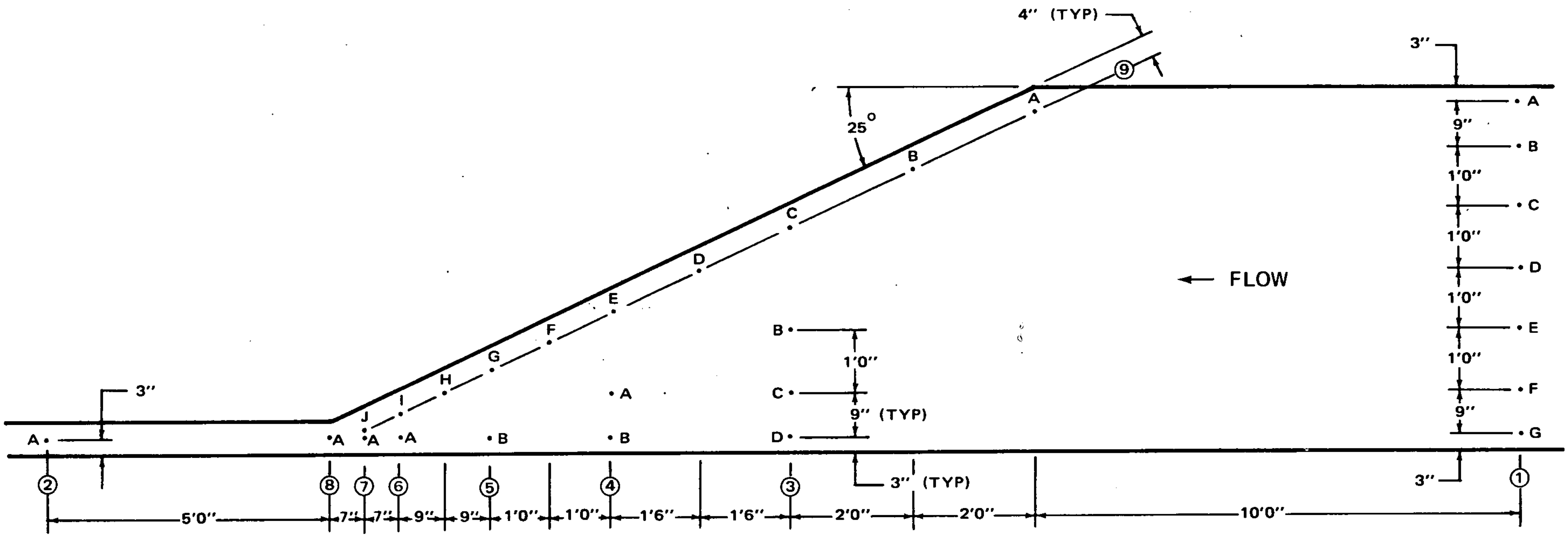
TEST DEVICES AT 25° TO FLOW



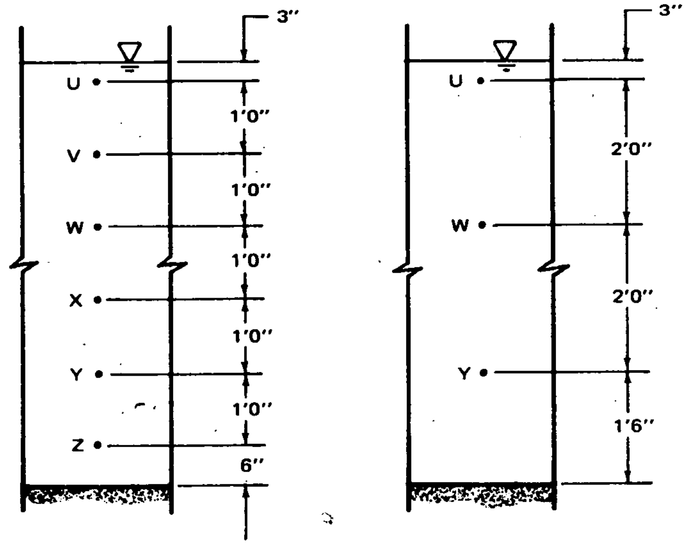
TEST DEVICES AT 45° TO FLOW

FIGURE 9

FIGURE 10



DEPTH OF MEASUREMENTS



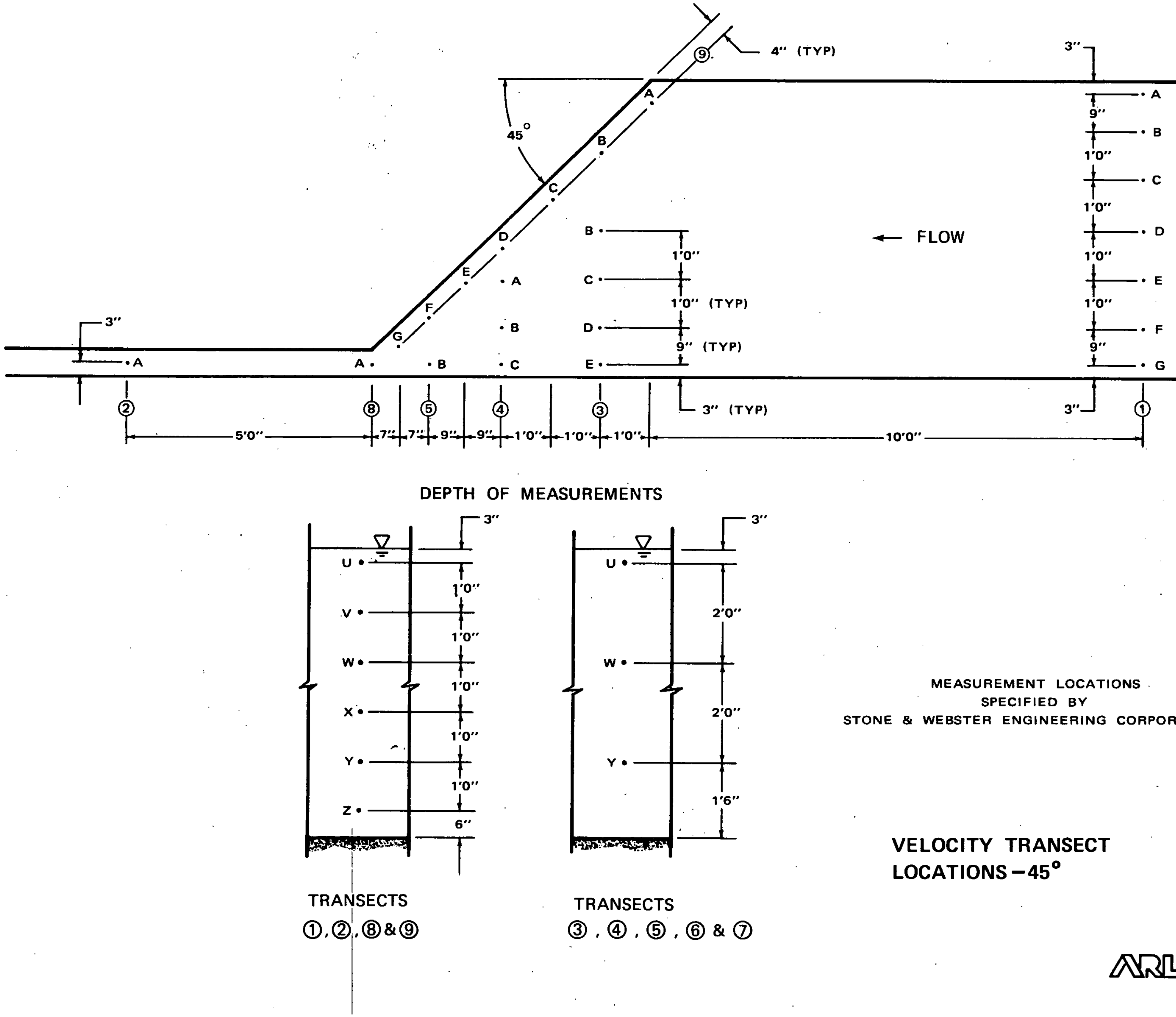
TRANSECTS ①,②,⑧&⑨

TRANSECTS ③ , ④ , ⑤ , ⑥ & ⑦

MEASUREMENT LOCATIONS
SPECIFIED BY
STONE & WEBSTER ENGINEERING CORPORATION

VELOCITY TRANSECT LOCATIONS – 25°

ARL



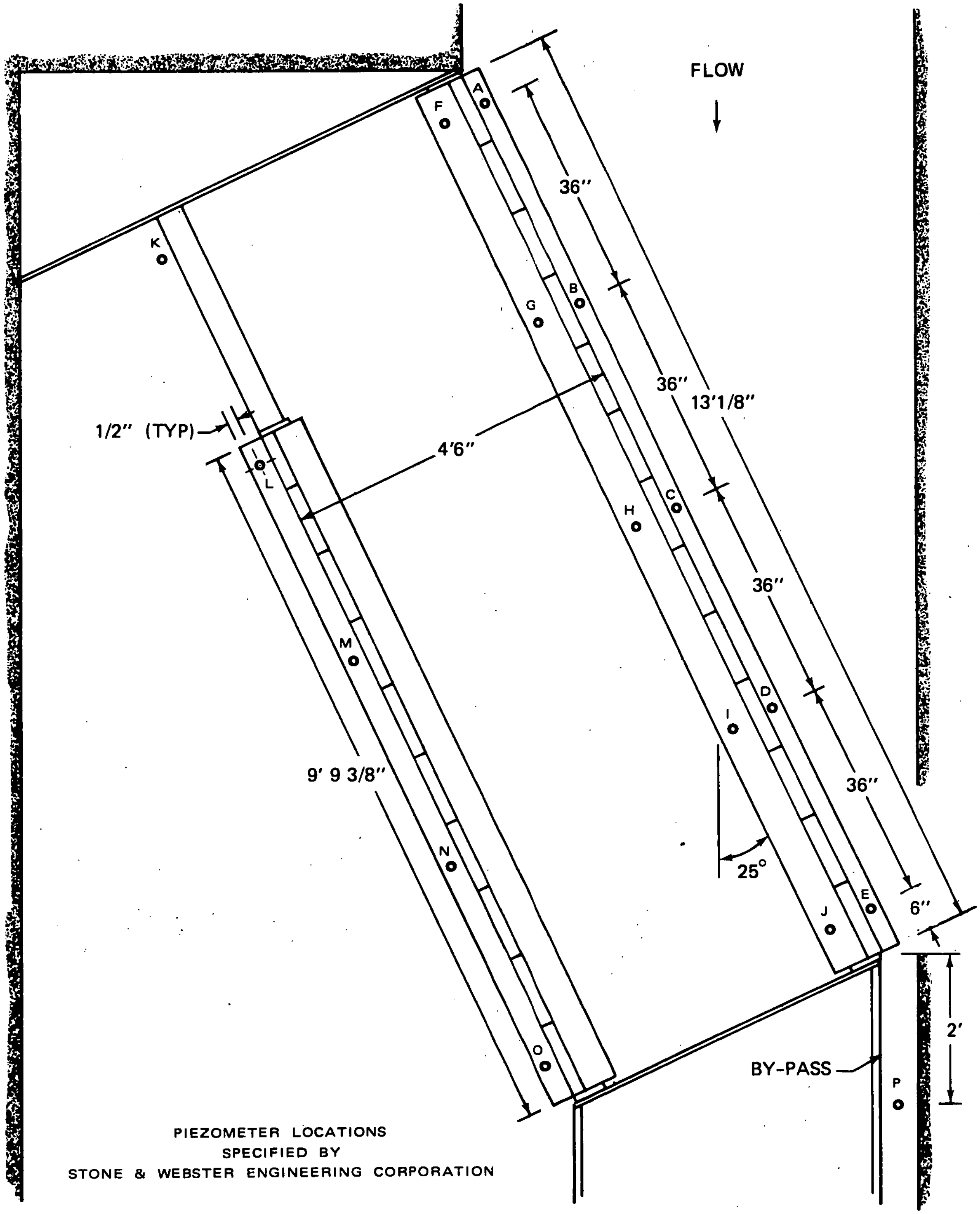
MEASUREMENT LOCATIONS SPECIFIED BY STONE & WEBSTER ENGINEERING CORPORATION

VELOCITY TRANSECT LOCATIONS – 45°

FIGURE 11

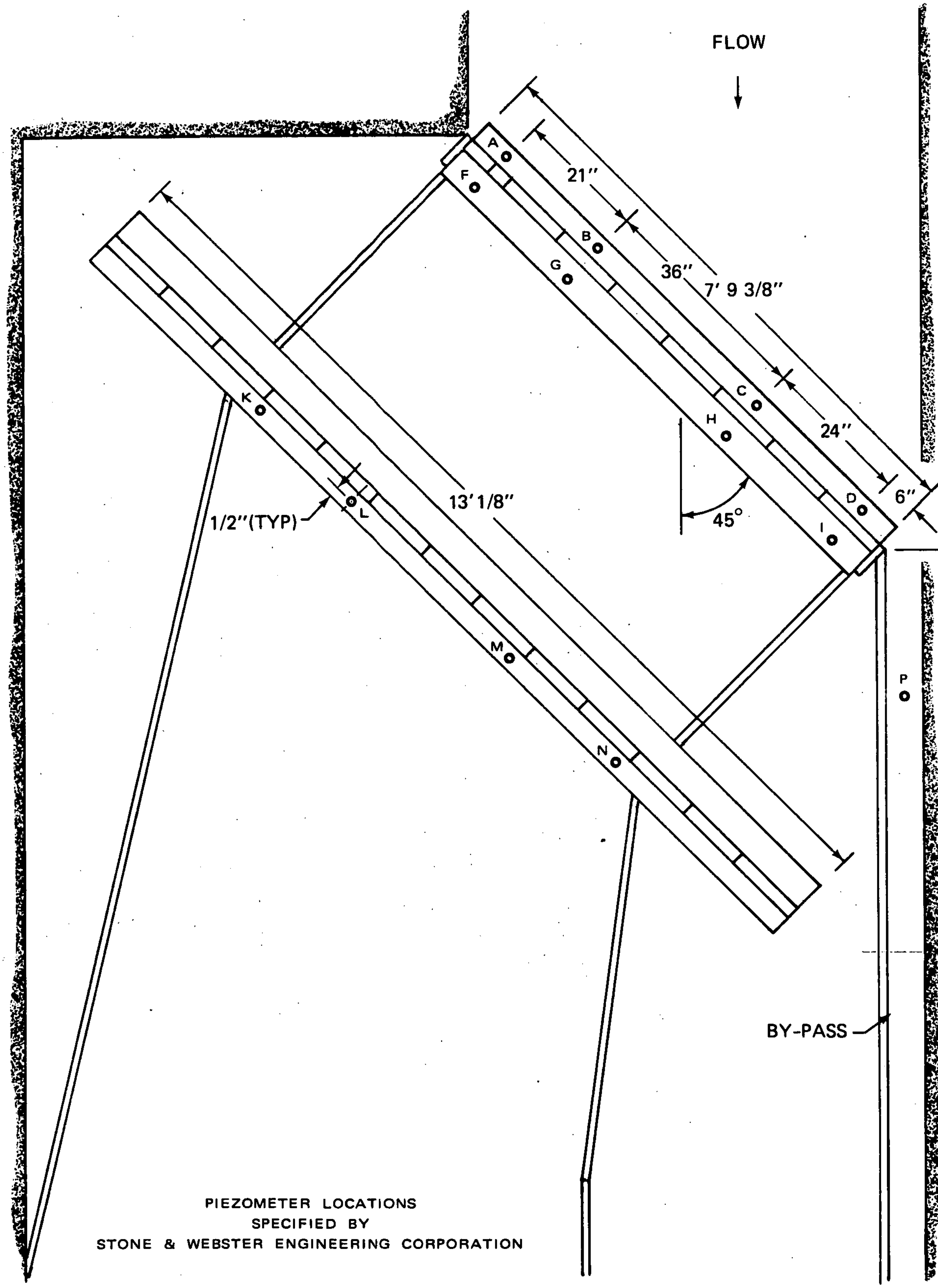
ARL

FIGURE 12



PIEZOMETER LOCATIONS FOR MEASURING
WATER SURFACE ELEVATIONS
DEVICE 25° TO FLOW

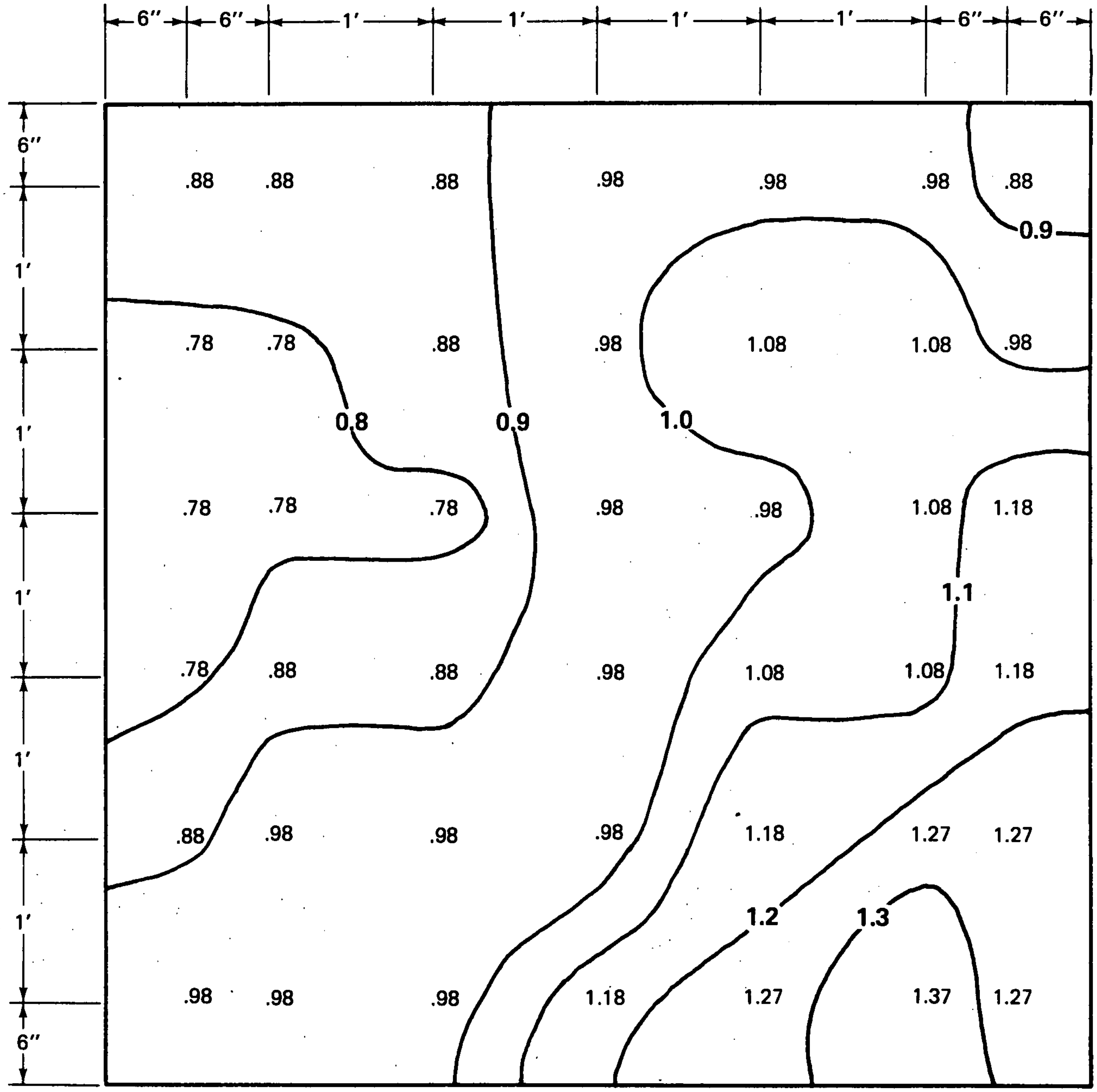
FIGURE 13



PIEZOMETER LOCATIONS FOR MEASURING
WATER SURFACE ELEVATIONS
DEVICE 45° TO FLOW

ARL

FIGURE 14

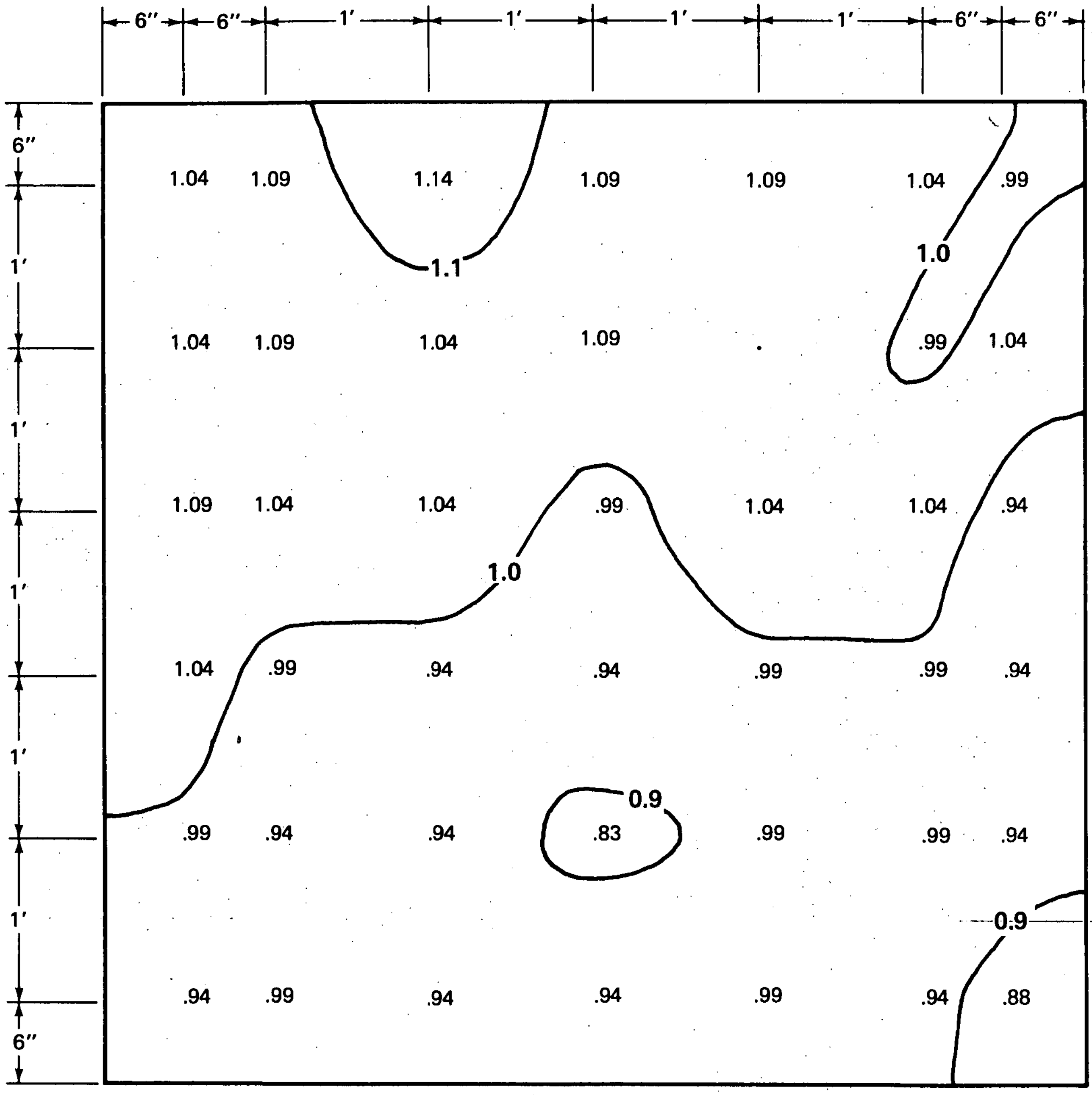


NORMALIZED VELOCITIES
10 FT. UPSTREAM OF TEST DEVICE
$\overline{V}$ = 1.02 FT/SEC

TEST DATE: 9 MAY 1975
TEST DEVICE: PRELIMINARY SCREEN
25° TO FLOW

FLUME CALIBRATION

ARL

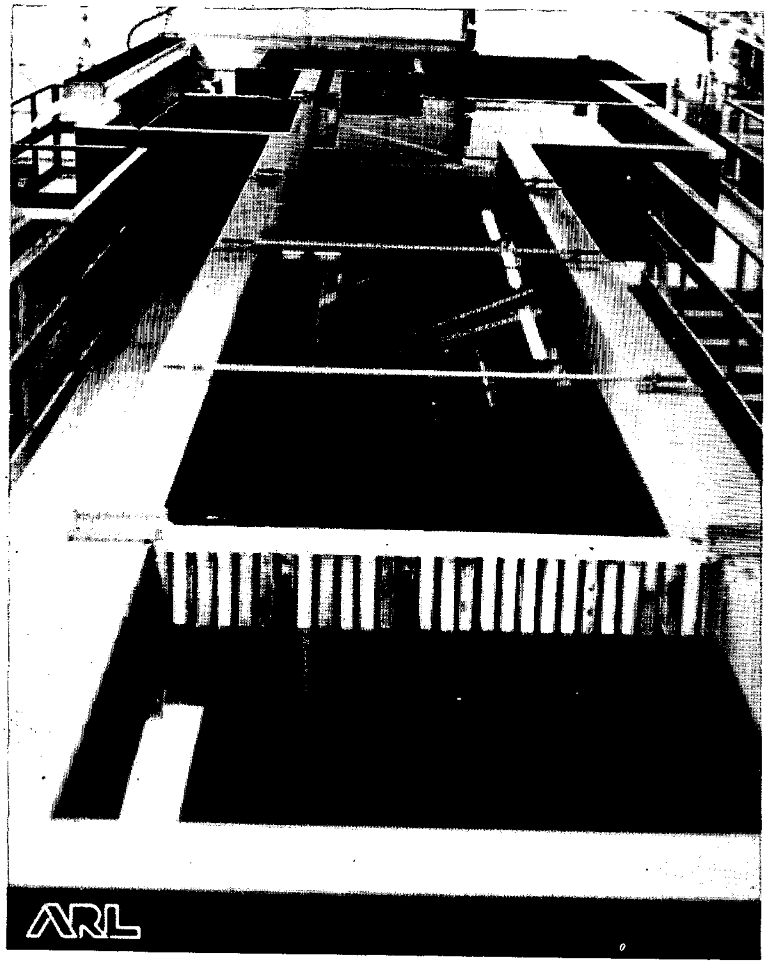


NORMALIZED VELOCITIES
10 FT. UPSTREAM OF TEST DEVICE
$\overline{V}$ = 1.92 FT/SEC

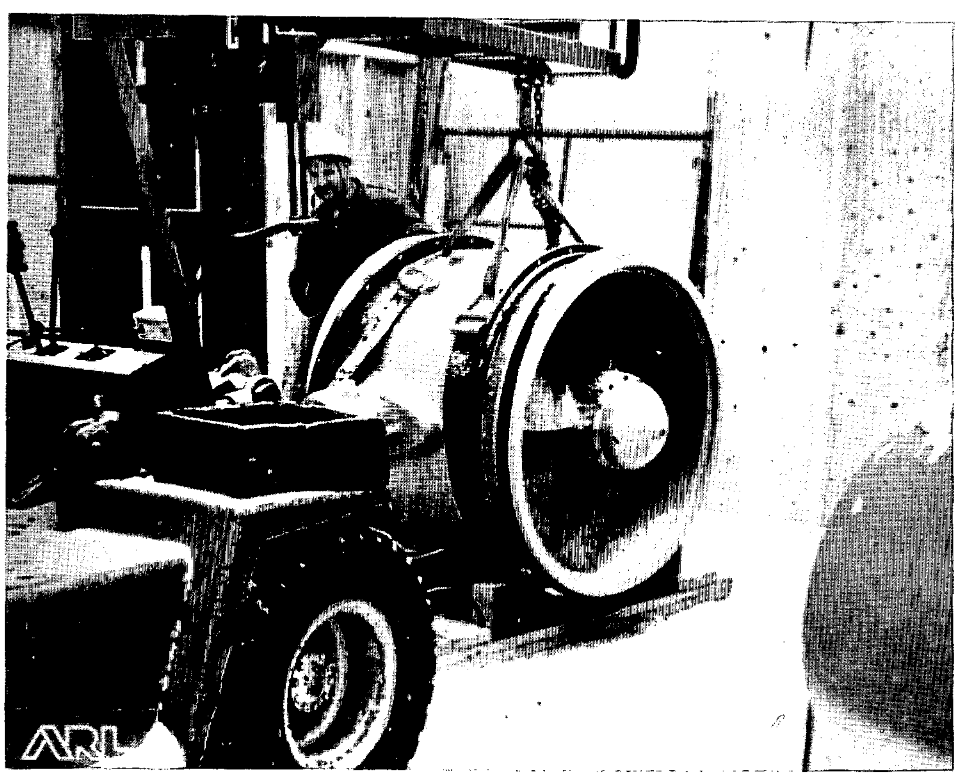
TEST DATE: 16 MAY 1975
TEST DEVICE: PRELIMINARY SCREEN
25° TO FLOW

FLUME CALIBRATION

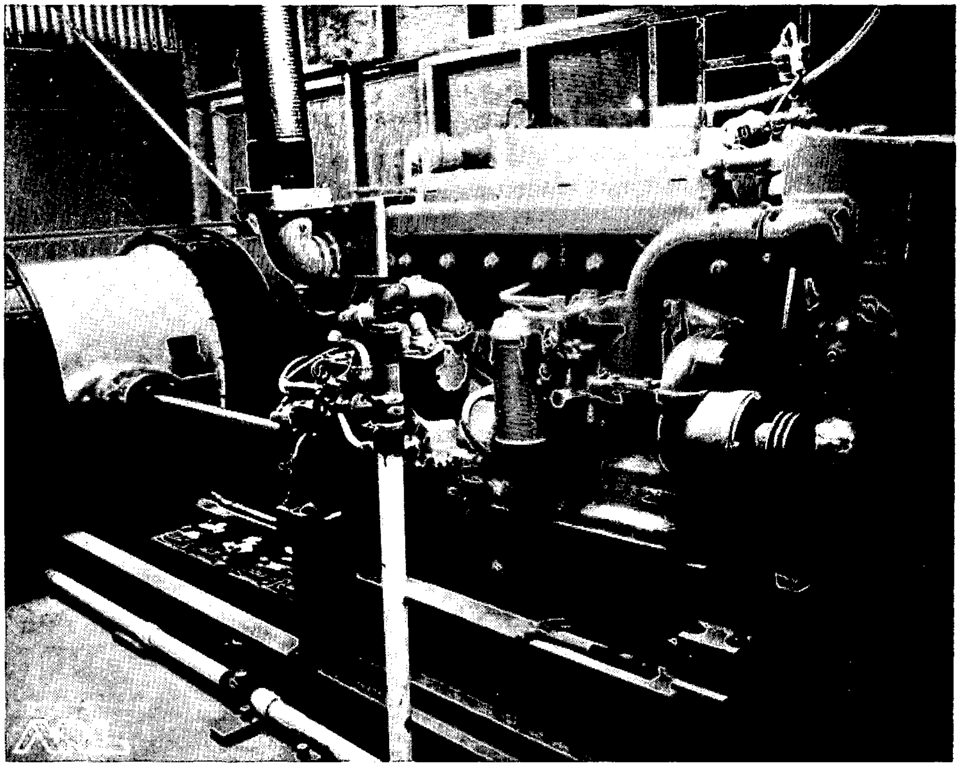
PHOTOGRAPHS



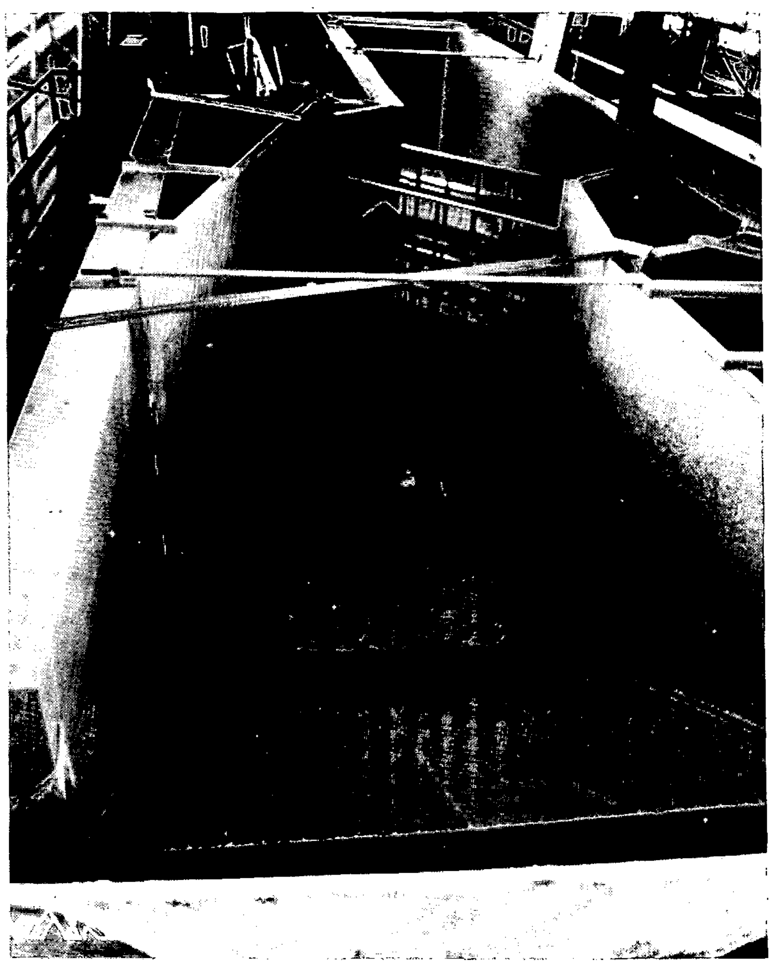
PHOTOGRAPH 1 Overall View of Flume



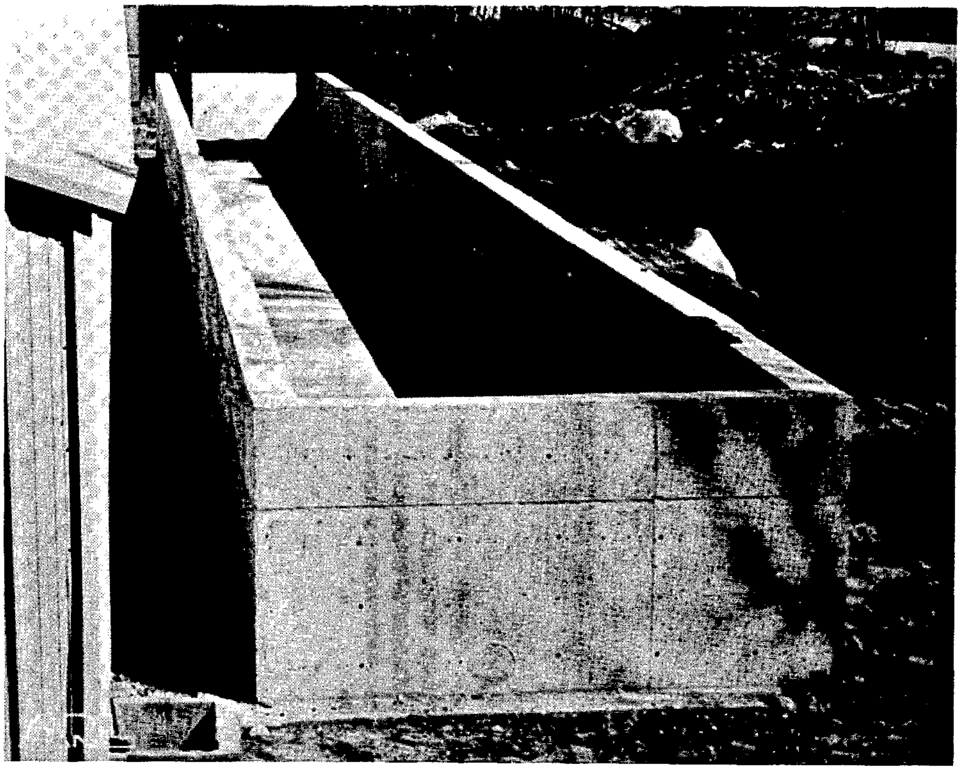
PHOTOGRAPH 2 Bow Thruster



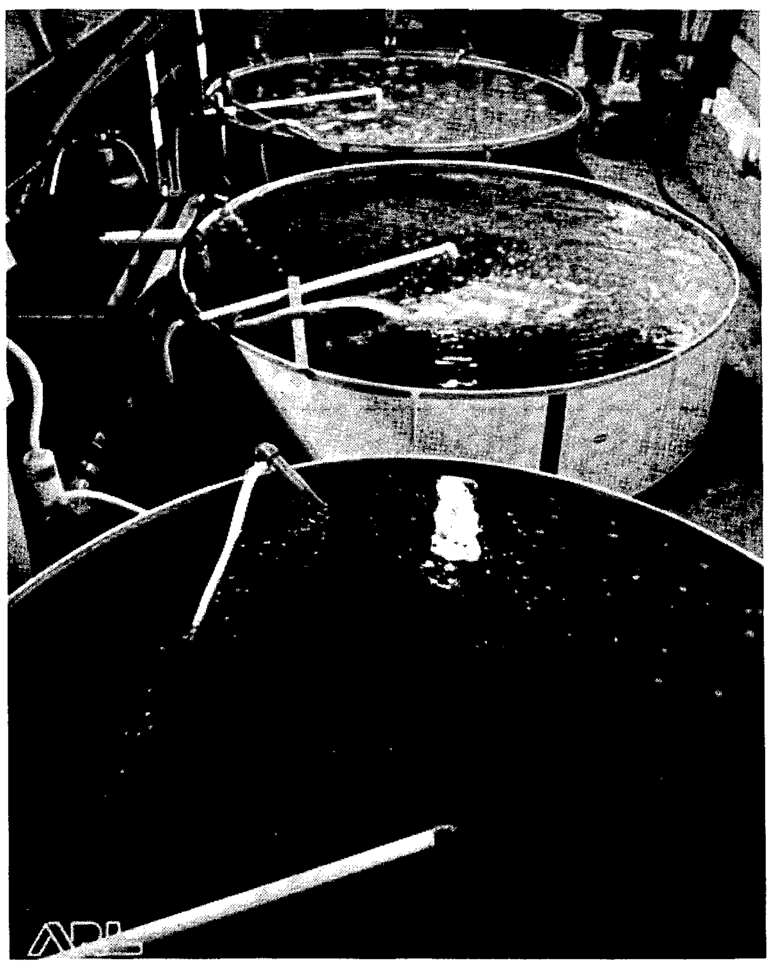
PHOTOGRAPH 3 Bow Thruster and Diesel Engine



PHOTOGRAPH 4 Inclined Screen



PHOTOGRAPH 5   Salt Water Storage Tank



PHOTOGRAPH 6   Fish Holding Facility

DATA ADDENDUM

VELOCITY DATA

TRANSECT 1

	G	F	E	D	C	B	A
U	1.6	1.8	1.8	1.8	1.8	1.8	1.7
V	1.7	1.5	1.6	1.6	1.7	1.7	1.6
W	1.7	1.5	1.5	1.5	1.4	1.4	1.4
X	1.4	1.5	1.4	1.3	1.4	1.5	1.5
Y	1.3	1.4	1.4	1.1	1.1	1.4	1.5
Z	1.1	1.3	1.3	1.1	1.0	1.4	1.3

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.47 FT/SEC

TRANSECT 2 / TRANSECT 8

	TRANSECT 2 A	TRANSECT 8 A
U	1.6	1.6
V	1.7	1.6
W	1.8	1.7
X	1.7	1.6
Y	1.6	1.6
Z	1.5	1.4

Transect 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.65 FT/SEC

Transect 8: BYPASS ENTRANCE

$\bar{V}$ = 1.58 FT/SEC

TEST NO.	1
TEST DATE	7/14/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	– – –

FLUME VELOCITY DATA

ARL

TRANSECT 3

D	C	B	9C
1.8	1.8	1.8	1.8
1.5	1.5	1.5	1.4
1.5	1.4	1.3	1.4

4 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.56 FT/SEC

TRANSECT 9

	D
U	1.8
V	1.7
W	1.4
X	1.2
Y	1.3
Z	1.4

5'6" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.41 FT/SEC

TRANSECT 9

	A
U	1.5
V	1.5
W	1.6
X	1.4
Y	1.4
Z	1.4

AT DEVICE EDGE
0 FOOT MARK

$\bar{V}$ = 1.47 FT/SEC

TRANSECT 9

	B
U	1.9
V	1.8
W	1.6
X	1.2
Y	1.2
Z	1.2

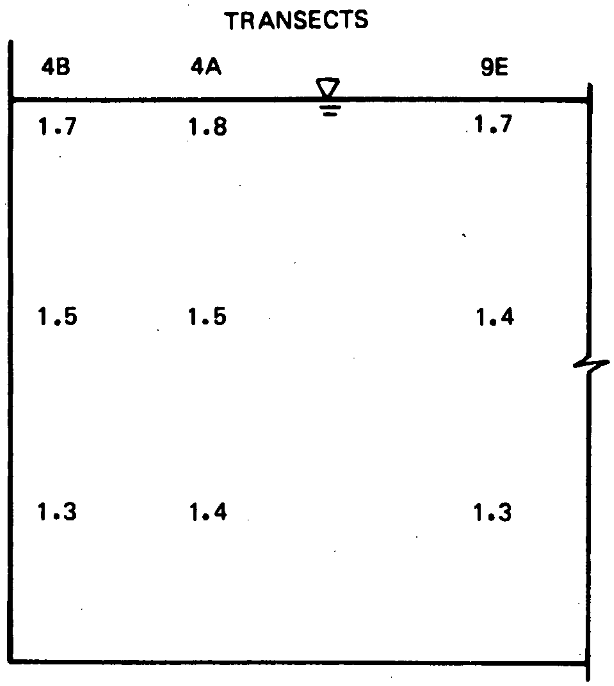
2 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.48 FT/SEC

TEST NO.	1
TEST DATE	7/14/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	– – –

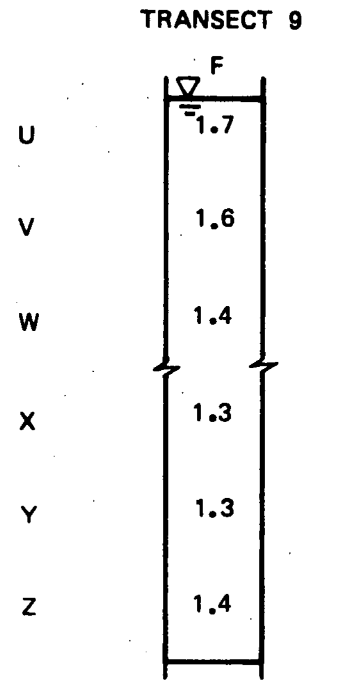
FLUME VELOCITY DATA

ARL



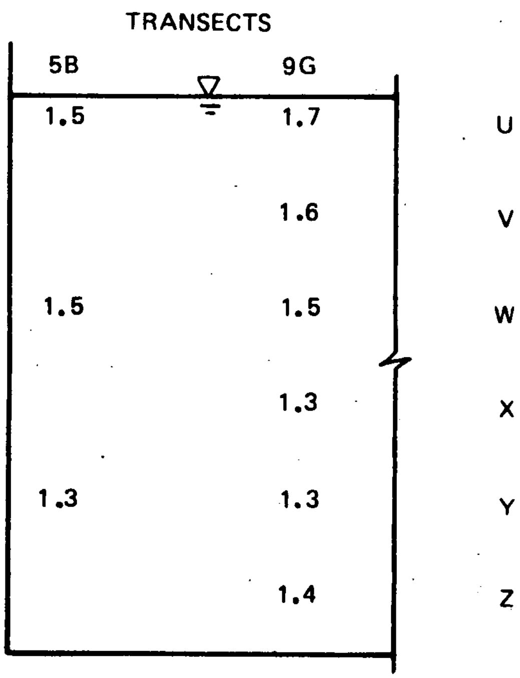
7 FT DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.51 FT/SEC



8 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.45 FT/SEC



9 FT DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.45 FT/SEC

TEST NO. 1

TEST DATE 7/14/75

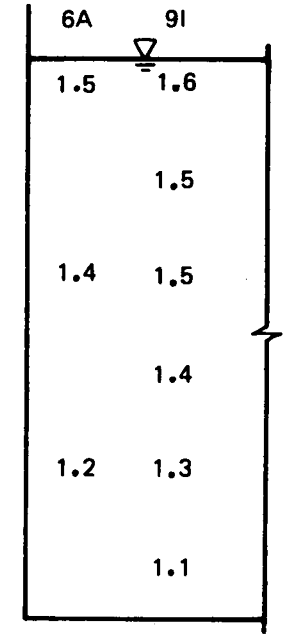
TEST DEVICE: SCREENS @ 25°

TEST CONDITION: ---

FLUME VELOCITY DATA

ARL

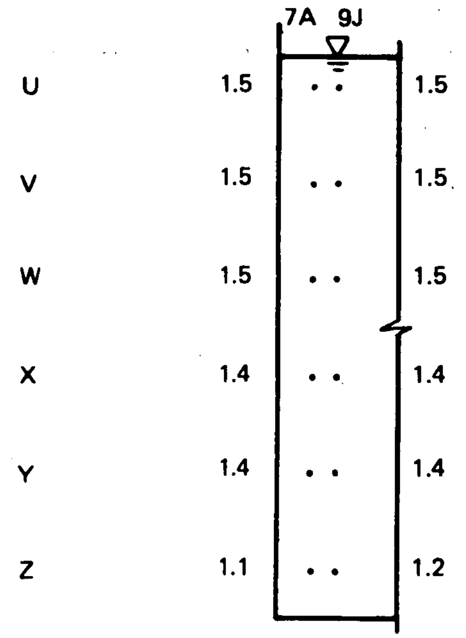
TRANSECTS



10'6" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.39 FT/SEC

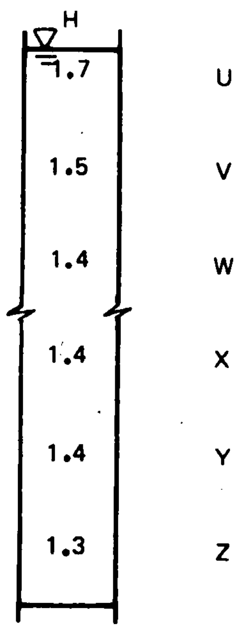
TRANSECTS



11'1" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.41 FT/SEC

TRANSECT 9



9'9" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.45 FT/SEC

TEST NO.	1
TEST DATE	7/14/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	– – –

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	2.9	3.1	3.4	3.2	3.1	3.0	2.7
V	2.8	2.9	2.8	2.9	2.8	2.7	2.5
W	2.6	2.4	2.4	2.4	2.4	2.5	2.4
X	2.4	2.3	2.3	2.2	2.1	2.4	2.4
Y	2.4	2.3	2.3	2.1	1.7	2.1	2.3
Z	2.1	2.3	2.2	2.0	1.6	2.0	2.1

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 2.46 FT/SEC

	TRANSECT 2 A	TRANSECT 8 A
U	2.6	2.7
V	2.7	3.1
W	2.5	3.5
X	2.5	3.1
Y	2.5	2.8
Z	2.3	2.4

TRANSECT 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 2.52 FT/SEC

TRANSECT 8: BYPASS ENTRANCE

$\bar{V}$ = 2.93 FT/SEC

TEST NO. 2
TEST DATE 7/15/75
TEST DEVICE: SCREENS @ 25°

TEST CONDITION: ---

FLUME VELOCITY DATA

ARL

TRANSECT 3

	D	C	B	9C
U	2.6	2.9	3.3	3.3
W	2.7	2.7	2.6	2.4
Y	2.4	2.3	2.2	2.2

4 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 2.63 FT/SEC

TRANSECT 9

	D
U	3.3
V	2.9
W	2.4
X	2.1
Y	2.1
Z	2.2

5'6" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 2.50 FT/SEC

TRANSECT 9

	A
U	3.0
V	2.9
W	2.6
X	2.4
Y	2.2
Z	2.4

AT DEVICE EDGE
0 FOOT MARK

$\bar{V}$ = 2.58 FT/SEC

TRANSECT 9

	B
U	3.2
V	2.9
W	2.6
X	2.1
Y	2.1
Z	2.2

2 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 2.17 FT/SEC

TEST NO.	2
TEST DATE	7/15/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	---

FLUME VELOCITY DATA

ARL

TRANSECTS

	4B	4A	9E
U	2.5	2.8	3.2
V			
W	2.6	2.5	2.5
X			
Y	2.3	2.2	2.1
Z			

7 FT DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 2.52 FT/SEC

TRANSECT 9

	F
U	2.9
V	2.7
W	2.5
X	2.3
Y	2.1
Z	2.0

8 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 2.42 FT/SEC

TRANSECTS

	5B	9G
U	2.2	2.8
V		2.7
W	2.5	2.5
X		2.2
Y	2.0	2.1
Z		2.1

9 FT DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 2.34 FT/SEC

TEST NO.	2
TEST DATE	7/15/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	– – –

FLUME VELOCITY DATA

ARL

TRANSECTS

	6A	9I
U	2.2	2.6
V		2.6
W	2.3	2.3
X		2.3
Y	2.0	2.2
Z		1.9

10'6" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 2.27 FT/SEC

TRANSECTS

	7A	9J
U	2.1	2.4
V	2.4	2.2
W	2.1	2.3
X	2.3	2.3
Y	2.2	2.2
Z	1.7	1.9

11'1" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 2.18 FT/SEC

TRANSECT 9

	H
U	2.7
V	2.7
W	2.5
X	2.3
Y	2.2
Z	2.2

9'9" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 2.43 FT/SEC

TEST NO.	2
TEST DATE	7/15/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	---

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	0.5	0.6	0.7	0.7	0.8	0.8	0.6
V	0.6	0.6	0.6	0.6	0.6	0.7	0.5
W	0.6	0.6	0.6	0.6	0.6	0.5	0.5
X	0.6	0.7	0.7	0.7	0.5	0.5	0.4
Y	0.5	0.5	0.5	0.6	0.6	0.5	0.4
Z	0.4	0.3	0.4	0.4	0.4	0.5	0.4

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 0.54 FT/SEC

	TRANSECT 2 (A)	TRANSECT 8 (A)
U	0.7	0.8
V	0.7	0.7
W	0.7	0.7
X	0.6	0.8
Y	0.7	0.7
Z	0.6	0.6

BYPASS ENTRANCE

$\bar{V}$ = 0.72 FT/SEC

5 FT. DOWNSTREAM
OF BYPASS ENTRANCE

$\bar{V}$ = 0.67 FT/SEC

TEST NO.	3
TEST DATE	7/16/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	– – –

FLUME VELOCITY DATA

ARL

TRANSECT 3

D	C	B	9C
0.5	0.6	0.6	0.7
0.4	0.6	0.6	0.6
0.4	0.5	0.5	0.6

4 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 0.56 FT/SEC

TRANSECT 9

	D
U	0.7
V	0.6
W	0.6
X	0.6
Y	0.6
Z	0.5

5'6" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 0.60 FT/SEC

TRANSECT 9

	A
U	0.7
V	0.6
W	0.5
X	0.5
Y	0.5
Z	0.5

AT DEVICE EDGE
0 FOOT MARK

$\bar{V}$ = 0.55 FT/SEC

TRANSECT 9

	B
U	0.7
V	0.7
W	0.7
X	0.6
Y	0.6
Z	0.5

2 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 0.63 FT/SEC

TEST NO.	3
TEST DATE	7/16/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	---

FLUME VELOCITY DATA

ARL

Transects — 7 FT DOWNSTREAM OF TEST DEVICE

	4B	4A	9E
U	0.6	0.5	0.7
V			
W	0.5	0.6	0.6
X			
Y	0.4	0.5	0.5
Z			

7 FT DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 0.54 FT/SEC

Transect 9 — 8 FT. DOWNSTREAM OF TEST DEVICE

	F
U	0.6
V	0.6
W	0.6
X	0.5
Y	0.5
Z	0.4

8 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 0.53 FT/SEC

Transects — 9 FT DOWNSTREAM OF TEST DEVICE

	5B	9G
U	0.5	0.6
V		0.5
W	0.4	0.6
X		0.6
Y	0.5	0.5
Z		0.4

9 FT DOWNSTREAM OF TEST DEVICE

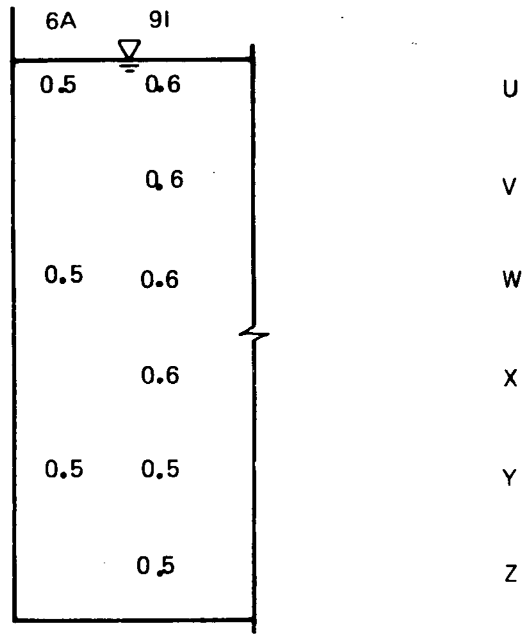
$\bar{V}$ = 0.51 FT/SEC

TEST NO.	3
TEST DATE	7/16/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	---

FLUME VELOCITY DATA

ARL

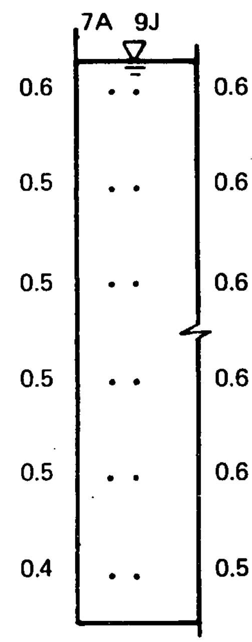
TRANSECTS



10'6" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 0.54 FT/SEC

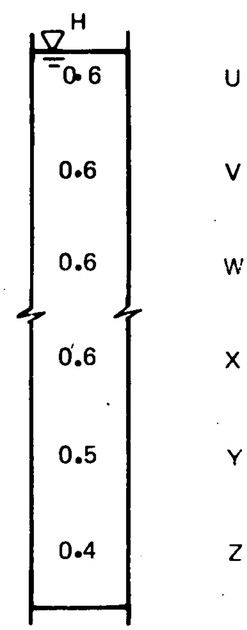
TRANSECTS



11'1" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 0.54 FT/SEC

TRANSECT 9



9'9" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 0.55 FT/SEC

TEST NO. 3
TEST DATE 7/16/75
TEST DEVICE: SCREENS @ 25°

TEST CONDITION: ---

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	4.0	4.2	4.1	3.4	3.4	3.3	3.1
V	3.3	3.1	3.1	3.3	3.4	3.2	3.0
W	3.0	2.7	2.8	2.8	2.9	2.9	2.7
X	2.6	2.5	2.6	2.5	2.5	2.8	2.8
Y	2.5	2.4	2.6	2.5	2.1	2.5	2.6
Z	2.2	2.0	2.5	2.5	2.2	2.3	2.5

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 2.78 FT/SEC

	TRANSECT 2 A	TRANSECT 8 A
U	5.1	4.4
V	4.9	4.6
W	4.8	4.6
X	4.3	4.1
Y	4.1	4.2
Z	4.0	4.4

TRANSECT 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 4.53 FT/SEC

TRANSECT 8: BYPASS ENTRANCE

$\bar{V}$ = 4.38 FT/SEC

TEST NO. 4
TEST DATE 10/27/75
TEST DEVICE: LOUVERS @ 25°

TEST CONDITION: ---

FLUME VELOCITY DATA

ARL

TRANSECT 3

	D	C	B	9C
	3.8	3.8	3.9	3.8
	3.1	3.1	3.1	3.0
	2.9	2.8	2.7	2.7

4 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 3.22 FT/SEC

TRANSECT 9

	D
U	3.9
V	3.4
W	3.1
X	2.8
Y	2.9
Z	2.8

5'6" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 3.15 FT/SEC

TRANSECT 9

	A
U	•
V	•
W	•
X	•
Y	•
Z	•

AT DEVICE EDGE
0 FOOT MARK

$\bar{V}$ = FT/SEC

TRANSECT 9

	B
U	3.6
V	3.3
W	2.9
X	2.4
Y	2.6
Z	2.7

2 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 2.92 FT/SEC

TEST NO.	4
TEST DATE	10/27/75
TEST DEVICE:	LOUVERS @ 25°
TEST CONDITION:	– – –

FLUME VELOCITY DATA

ARL

TRANSECTS

	4B	4A	9E
U	3.7	3.7	3.9
V			
W	3.3	3.3	3.3
X			
Y	3.0	3.0	2.8
Z			

7 FT DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 3.33 FT/SEC

TRANSECT 9

	F
U	4.1
V	3.6
W	3.1
X	3.1
Y	3.0
Z	3.0

8 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 3.32 FT/SEC

TRANSECTS

	5B	9G
U	3.8	4.0
V		3.6
W	3.6	3.5
X		3.2
Y	3.4	3.2
Z		3.2

9 FT DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 3.50 FT/SEC

TEST NO. 4
TEST DATE 10/27/75
TEST DEVICE: LOUVERS @ 25°

TEST CONDITION: ---

FLUME VELOCITY DATA

ARL

TRANSECTS

	6A	9I
U	4.0	4.1
V		3.8
W	3.7	3.5
X		3.3
Y	3.4	3.5
Z		3.4

10'6" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 3.63 FT/SEC

TRANSECTS

	7A	9J
U	3.8	4.1
V	3.9	4.0
W	3.7	3.9
X	3.8	3.8
Y	3.8	3.8
Z	4.0	3.8

11'1" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 3.87 FT/SEC

TRANSECT 9

	H
U	4.2
V	3.8
W	3.7
X	3.6
Y	3.4
Z	3.3

9'9" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 3.67 FT/SEC

TEST NO.	4
TEST DATE	10/27/75
TEST DEVICE:	LOUVERS @ 25°
TEST CONDITION:	---

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.3	1.3	1.2	1.2	1.2	1.2	1.1
V	1.2	1.1	1.1	1.1	1.1	1.1	1.1
W	1.1	1.0	1.0	1.0	1.1	1.1	1.1
X	1.0	1.0	1.0	1.0	1.0	1.1	1.1
Y	1.1	1.0	1.0	1.0	0.9	1.0	1.1
Z	0.9	1.0	1.0	0.8	0.7	0.9	1.0

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.07 FT/SEC

TRANSECT 2 / TRANSECT 8

	TRANSECT 2: A	TRANSECT 8: A
U	1.4	1.5
V	1.5	1.5
W	1.4	1.4
X	1.4	1.4
Y	1.5	1.2
Z	1.4	1.2

Transect 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.43 FT/SEC

Transect 8: BYPASS ENTRANCE

$\bar{V}$ = 1.36 FT/SEC

TEST NO.	5
TEST DATE	10/28/75
TEST DEVICE:	LOUVERS @ 25°
TEST CONDITION:	– – –

FLUME VELOCITY DATA

ARL

TRANSECT 3

D	C	B	9C
1.3	1.3	1.3	1.2
1.2	1.2	1.1	1.1
1.1	1.1	1.1	1.1

4 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.18 FT/SEC

TRANSECT 9

	D
U	1.3
V	1.2
W	1.1
X	1.1
Y	1.1
Z	1.1

5'6" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.15 FT/SEC

TRANSECT 9

	A
U	•
V	•
W	•
X	•
Y	•
Z	•

AT DEVICE EDGE
0 FOOT MARK

$\bar{V}$ = FT/SEC

TRANSECT 9

	B
U	1.2
V	1.2
W	1.1
X	0.9
Y	0.9
Z	0.9

2 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.03 FT/SEC

TEST NO.	5
TEST DATE	10/28/75
TEST DEVICE:	LOUVERS @ 25°
TEST CONDITION:	– – –

FLUME VELOCITY DATA

ARL

TRANSECTS

	4B	4A	9E
U	1.3	1.4	1.3
V			
W	1.3	1.2	1.2
X			
Y	1.2	1.2	1.2
Z			

7 FT DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.26 FT/SEC

TRANSECT 9

	F
U	1.3
V	1.2
W	1.2
X	1.2
Y	1.2
Z	1.2

8 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.22 FT/SEC

TRANSECTS

	5B	9G
U	1.3	1.4
V		1.3
W	1.4	1.3
X		1.2
Y	1.3	1.2
Z		1.2

9 FT DOWNSTREAM OF TEST DEVICE

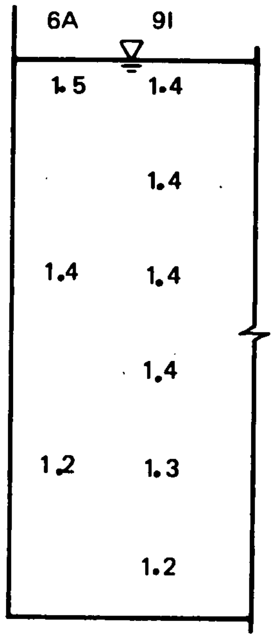
$\bar{V}$ = 1.29 FT/SEC

TEST NO.	5
TEST DATE	10/28/76
TEST DEVICE:	LOUVERS @ 25°
TEST CONDITION:	– – –

FLUME VELOCITY DATA

ARL

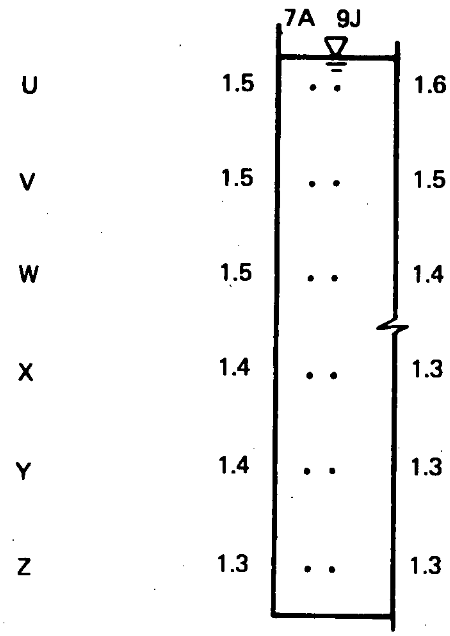
TRANSECTS



10'6" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.36 FT/SEC

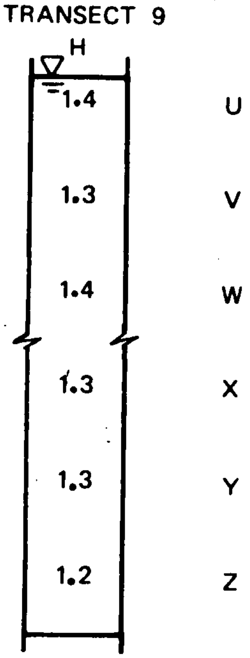
TRANSECTS



11'1" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.42 FT/SEC

TRANSECT 9



9'9" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.32 FT/SEC

TEST NO.	5
TEST DATE	10/28/76
TEST DEVICE:	LOUVERS @ 25°
TEST CONDITION:	– – –

FLUME VELOCITY DATA

TRANSECT 1

	G	F	E	D	C	B	A
U	2.2	2.5	2.6	2.5	2.4	2.4	2.1
V	2.4	2.2	2.2	2.2	2.2	2.2	2.1
W	2.2	1.9	1.9	2.0	2.1	2.1	2.0
X	2.1	1.9	1.9	1.8	1.8	2.1	2.0
Y	2.0	1.9	1.9	1.8	1.5	1.8	2.0
Z	1.7	1.9	1.9	1.8	1.4	1.9	2.0

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 2.04 FT/SEC

	TRANSECT 2 (A)	TRANSECT 8 (A)
U	3.2	2.6
V	3.3	3.5
W	3.2	3.4
X	3.2	3.1
Y	3.1	3.1
Z	2.7	2.6

TRANSECT 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 3.12 FT/SEC

TRANSECT 8: BYPASS ENTRANCE

$\bar{V}$ = 3.05 FT/SEC

TEST NO. 6
TEST DATE 10/28/75
TEST DEVICE: LOUVERS @ 25°

TEST CONDITION: ---

FLUME VELOCITY DATA

ARL

TRANSECT 3

	D	C	B	9C
	2.4	2.6	2.6	2.5
	2.3	2.2	2.1	2.0
	2.1	2.1	2.0	2.0

4 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 2.24 FT/SEC

TRANSECT 9

	D
U	2.5
V	2.4
W	2.1
X	1.9
Y	2.0
Z	2.0

5'6" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 2.15 FT/SEC

TRANSECT 9

	A
U	•
V	•
W	•
X	•
Y	•
Z	•

AT DEVICE EDGE
0 FOOT MARK

$\bar{V}$ = FT/SEC

TRANSECT 9

	B
U	2.3
V	2.2
W	2.0
X	1.7
Y	1.7
Z	1.7

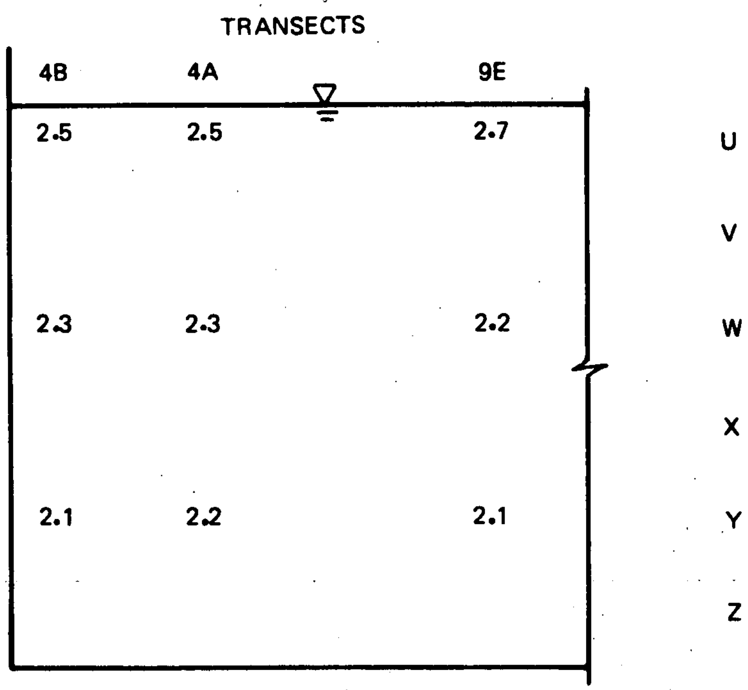
2 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.93 FT/SEC

TEST NO.	6
TEST DATE	10/28/75
TEST DEVICE:	LOUVERS @ 25°
TEST CONDITION:	---

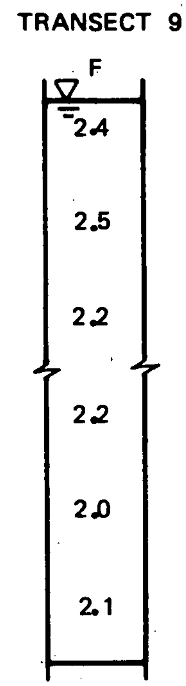
FLUME VELOCITY DATA

ARL



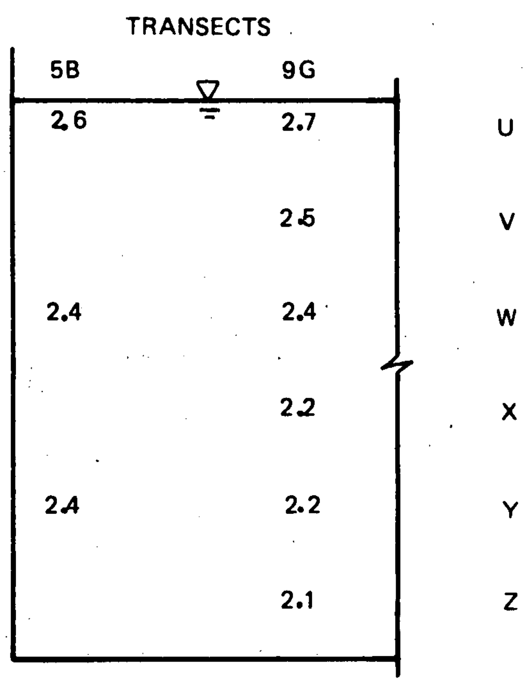
7 FT DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 2.32 FT/SEC



8 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 2.23 FT/SEC



9 FT DOWNSTREAM OF TEST DEVICE

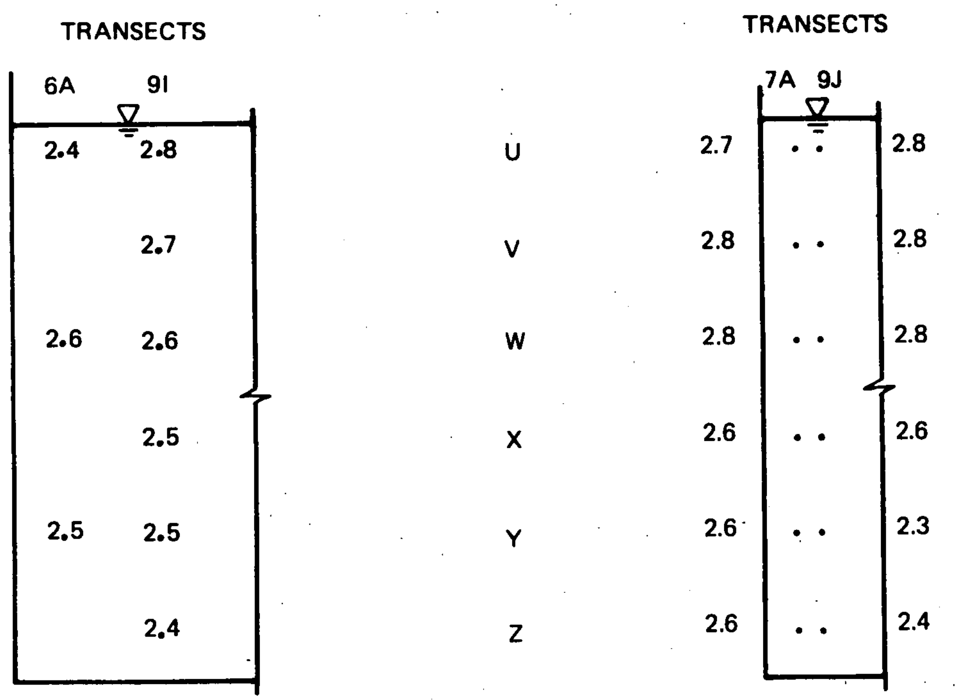
$\bar{V}$ = 2.39 FT/SEC

TEST NO. 6
TEST DATE 10/28/75
TEST DEVICE: LOUVERS @ 25°

TEST CONDITION: – – –

FLUME VELOCITY DATA

ARL

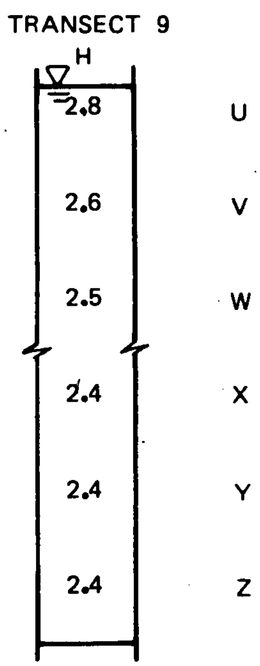


10'6" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 2.56 FT/SEC

11'1" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 2.65 FT/SEC



9'9" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 2.52 FT/SEC

TEST NO. 6
TEST DATE 10/28/75
TEST DEVICE: LOUVERS @ 25°

TEST CONDITION: ---

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.2	1.2	1.1	1.1	1.1	1.1	1.1
V	1.1	1.0	1.0	1.0	1.1	1.0	0.9
W	1.1	0.9	0.9	1.0	1.0	1.0	1.0
X	1.0	0.9	0.9	0.9	0.9	0.9	0.9
Y	0.9	0.9	1.0	0.9	0.8	1.0	0.9
Z	0.8	0.9	0.9	0.9	0.7	0.8	0.9

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 0.97 FT/SEC

	TRANSECT 2 A	TRANSECT 8 A
U	1.3	1.4
V	1.3	1.4
W	1.3	1.3
X	1.3	1.2
Y	1.2	1.1
Z	1.1	0.9

Transect 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.25 FT/SEC

Transect 8: BYPASS ENTRANCE

$\bar{V}$ = 1.22 FT/SEC

TEST NO. 7
TEST DATE 10/31/75
TEST DEVICE: SCREENS 25°

TEST CONDITION: ---

FLUME VELOCITY DATA

ARL

TRANSECT 3

D	C	B	9C
1.0	1.1	1.1	1.1
1.0	1.0	0.9	1.0
0.9	0.9	0.9	0.9

4 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 0.98 FT/SEC

TRANSECT 9

	D
U	1.1
V	1.0
W	0.8
X	0.8
Y	0.9
Z	0.8

5'6" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 0.90 FT/SEC

TRANSECT 9

	A
U	•
V	•
W	•
X	•
Y	•
Z	•

AT DEVICE EDGE
0 FOOT MARK

$\bar{V}$ = FT/SEC

TRANSECT 9

	B
U	1.2
V	1.0
W	1.0
X	0.9
Y	0.9
Z	0.8

2 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.02 FT/SEC

TEST NO.	7
TEST DATE	10/31/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	– – –

FLUME VELOCITY DATA

ARL

TRANSECTS

	4B	4A	9E
U	1.0	1.0	1.1
V			
W	0.9	0.9	0.9
X			
Y	0.9	0.9	0.8
Z			

7 FT DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 0.93 FT/SEC

TRANSECT 9

	F
U	1.1
V	1.0
W	0.9
X	0.8
Y	0.8
Z	0.8

8 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 0.90 FT/SEC

TRANSECTS

	5B	9G
U	1.0	1.1
V		1.0
W	1.0	0.9
X		0.8
Y	0.8	0.8
Z		0.8

9 FT DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 0.91 FT/SEC

TEST NO. 7

TEST DATE 10/31/75

TEST DEVICE: SCREENS @ 25°

TEST CONDITION: ---

FLUME VELOCITY DATA

ARL

TRANSECTS

	6A	9I
U	1.0	1.0
V		1.0
W	1.0	1.0
X		0.9
Y	0.9	0.9
Z		0.8

10'6" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 0.94FT/SEC

TRANSECTS

	7A	9J
U	1.0	1.0
V	1.0	1.1
W	0.9	1.0
X	1.0	0.9
Y	0.9	0.9
Z	0.9	0.8

11'1" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 0.95 FT/SEC

TRANSECT 9H

	9H
U	1.1
V	1.0
W	0.9
X	0.9
Y	0.9
Z	0.8

9'9" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 0.93 FT/SEC

TEST NO. 7
TEST DATE 10/31/75
TEST DEVICE: SCREENS @ 25°

TEST CONDITION: ---

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	2.3	2.5	2.5	2.4	2.3	2.2	2.0
V	2.2	2.2	2.1	2.2	2.1	2.1	2.0
W	2.1	2.0	1.9	2.0	2.1	2.1	1.9
X	2.0	1.8	1.8	1.7	1.8	2.0	2.0
Y	2.0	2.0	1.9	1.6	1.3	1.8	1.9
Z	1.9	1.9	2.0	1.6	1.4	1.6	1.8

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.98 FT/SEC

	TRANSECT 2 A	TRANSECT 8 A
U	2.3	2.3
V	2.5	2.7
W	2.4	2.6
X	2.3	2.3
Y	2.3	2.3
Z	2.2	2.0

TRANSECT 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 2.33 FT/SEC

TRANSECT 8: BYPASS ENTRANCE

$\bar{V}$ = 2.37 FT/SEC

TEST NO.	8
TEST DATE	11/7/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	— — —

FLUME VELOCITY DATA

ARL

TRANSECT 3

D	C	B	9C
2.0	2.2	2.3	2.3
1.8	1.9	1.9	1.9
1.8	1.7	1.6	1.6

4 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.92 FT/SEC

TRANSECT 9

	D
U	2.3
V	2.0
W	1.9
X	1.6
Y	1.6
Z	1.6

5'6" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.83 FT/SEC

TRANSECT 9

	A
U	
V	
W	
X	
Y	
Z	

AT DEVICE EDGE
0 FOOT MARK

$\bar{V}$ = FT/SEC

TRANSECT 9

	B
U	2.2
V	2.1
W	2.0
X	1.8
Y	1.7
Z	1.6

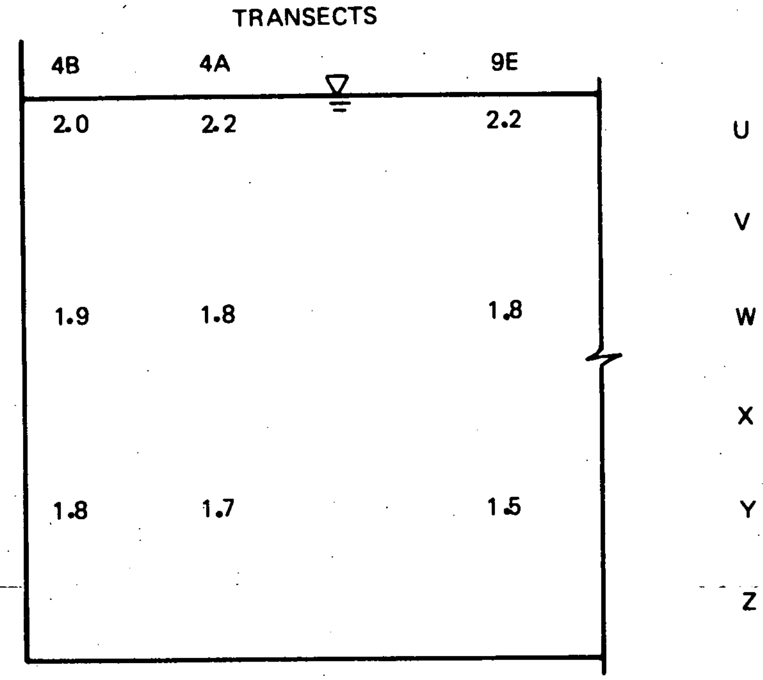
2 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.90 FT/SEC

TEST NO.	8
TEST DATE	11/7/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	---

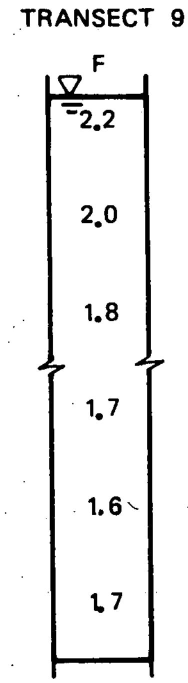
FLUME VELOCITY DATA

ARL



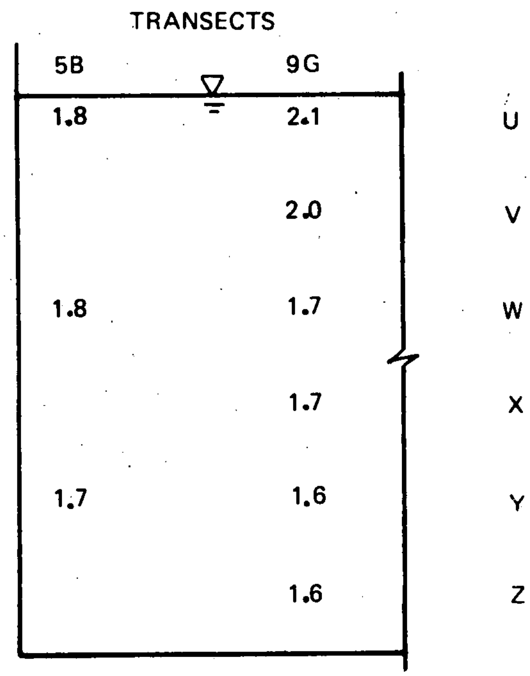
7 FT DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.88 FT/SEC



8 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.83 FT/SEC



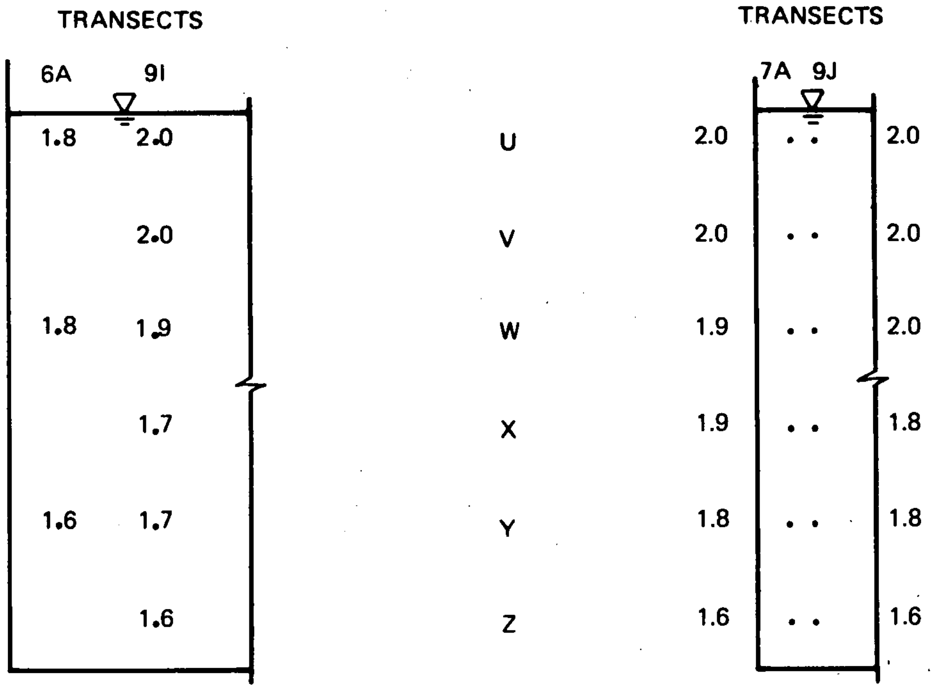
9 FT DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.78 FT/SEC

TEST NO.	8
TEST DATE	11/7/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	---

FLUME VELOCITY DATA

ARL

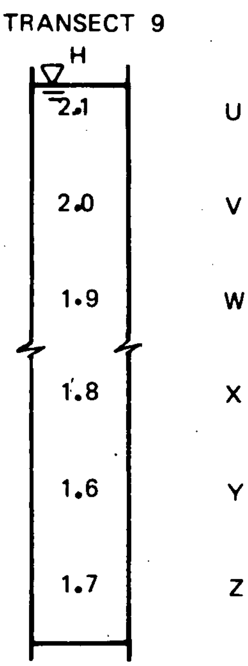


10'6" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.79 FT/SEC

11'1" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.87 FT/SEC



9'9" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.85 FT/SEC

TEST NO.	8
TEST DATE	11/7/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	– – –

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	3.4	3.8	4.0	3.8	3.6	3.2	3.0
V	3.2	3.2	3.3	3.4	3.4	3.2	3.0
W	2.9	2.8	2.8	3.0	3.0	2.9	2.7
X	2.8	2.7	2.7	2.5	2.6	2.8	2.7
Y	2.7	2.6	2.8	2.2	2.2	2.7	2.7
Z	2.5	2.6	2.5	2.4	2.0	2.3	2.5

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 2.88 FT/SEC

	TRANSECT 2 A	TRANSECT 8 A
U	3.4	3.1
V	3.5	3.5
W	3.5	3.7
X	3.3	3.2
Y	3.3	3.3
Z	3.1	3.1

5 FT. DOWNSTREAM
OF BYPASS ENTRANCE
$\bar{V}$ = 3.35 FT/SEC

BYPASS ENTRANCE
$\bar{V}$ = 3.32 FT/SEC

TEST NO. 9
TEST DATE 11/7/75
TEST DEVICE: SCREENS @ 25°

TEST CONDITION: ---

FLUME VELOCITY DATA

TRANSECT 3

D	C	B	9C
2.9	3.3	3.5	3.5
2.8	2.9	2.8	2.9
2.5	2.4	2.4	2.2

4 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 2.84 FT/SEC

TRANSECT 9

	D
U	3.4
V	3.1
W	2.9
X	2.5
Y	2.4
Z	2.4

5'6" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 2.78 FT/SEC

TRANSECT 9

	A
U	•
V	•
W	•
X	•
Y	•
Z	•

AT DEVICE EDGE
0 FOOT MARK

$\bar{V}$ = FT/SEC

TRANSECT 9

	B
U	3.5
V	3.2
W	2.9
X	2.4
Y	2.4
Z	2.6

2 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 2.83 FT/SEC

TEST NO.	9
TEST DATE	11/7/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	---

FLUME VELOCITY DATA

ARL

TRANSECTS

	4B	4A	9E
U	2.8	3.2	3.4
V			
W	2.7	2.8	2.8
X			
Y	2.5	2.4	2.3
Z			

7 FT DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 2.77 FT/SEC

TRANSECT 9

	F
U	3.2
V	3.0
W	2.8
X	2.4
Y	2.4
Z	2.1

8 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 2.65 FT/SEC

TRANSECTS

	5B	9G
U	2.7	3.1
V		2.9
W	2.6	2.7
X		2.4
Y	2.4	2.3
Z		2.3

9 FT DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 2.60 FT/SEC

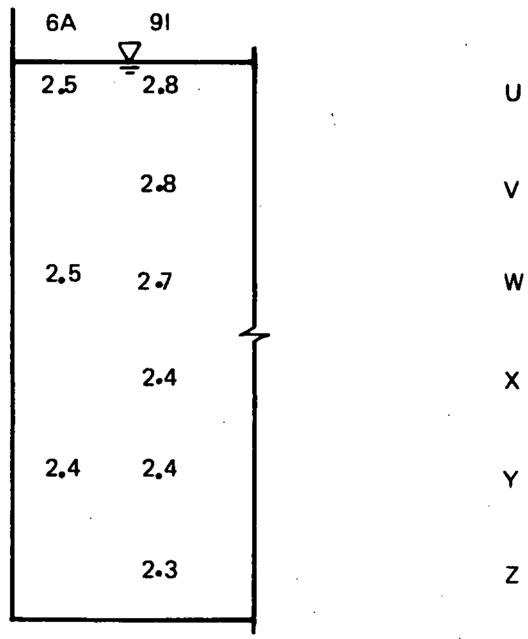
TEST NO. 9
TEST DATE 11/7/75
TEST DEVICE: SCREENS @ 25°

TEST CONDITION: ---

FLUME VELOCITY DATA

ARL

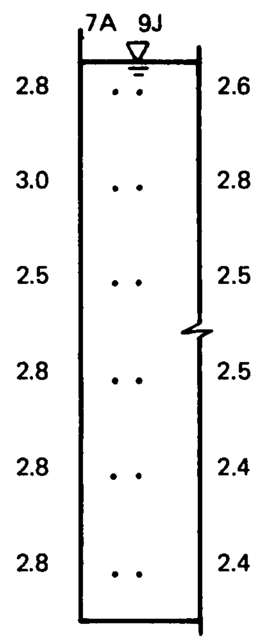
TRANSECTS



10'6" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 2.53 FT/SEC

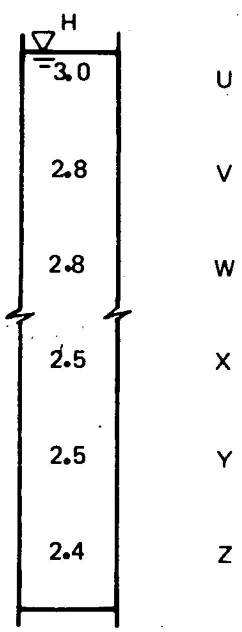
TRANSECTS



11'1" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 2.66 FT/SEC

TRANSECT 9



9'9" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 2.67 FT/SEC

TEST NO.	9
TEST DATE	11/7/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	---

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.1	1.3	1.3	1.2	1.2	1.2	1.1
V	1.2	1.2	1.1	1.0	1.1	1.1	1.1
W	1.2	1.0	0.8	0.8	0.9	1.0	0.9
X	1.1	0.9	0.7	0.8	1.0	1.0	1.0
Y	1.1	1.0	0.8	0.7	0.8	1.1	1.1
Z	0.8	0.9	0.9	0.8	0.8	1.0	1.1

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.00 FT/SEC

	TRANSECT 2 A	TRANSECT 8 A
U	1.4	1.5
V	1.3	1.4
W	1.2	1.3
X	1.2	1.2
Y	1.2	1.1
Z	1.0	0.9

Transect 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.22 FT/SEC

Transect 8: BYPASS ENTRANCE

$\bar{V}$ = 1.23 FT/SEC

TEST NO. 10
TEST DATE 12/19/75
TEST DEVICE: SCREENS @ 25°

TEST CONDITION: – – –

FLUME VELOCITY DATA

ARL

TRANSECT 3

D	C	B	9C
1.0	1.1	1.0	1.1
1.1	1.1	0.9	0.9
0.8	1.0	0.8	0.8

4 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 0.96 FT/SEC

TRANSECT 9

	D
U	1.1
V	0.9
W	0.9
X	0.8
Y	0.8
Z	0.8

5'6" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 0.88 FT/SEC

TRANSECT 9

	A
U	1.0
V	1.0
W	1.0
X	0.9
Y	0.9
Z	0.8

AT DEVICE EDGE
0 FOOT MARK

$\bar{V}$ = 0.93 FT/SEC

TRANSECT 9

	B
U	1.1
V	1.1
W	1.0
X	0.9
Y	0.8
Z	0.7

2 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 0.93 FT/SEC

TEST NO. 10
TEST DATE 12/19/75
TEST DEVICE: SCREENS @ 25°

TEST CONDITION: ---

FLUME VELOCITY DATA

ARL

TRANSECTS

	4B	4A	9E
U	1.2	1.1	1.1
V			
W	1.0	1.0	0.8
X			
Y	0.8	1.0	0.8
Z			

7 FT DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 0.98 FT/SEC

TRANSECT 9

	F
U	1.1
V	1.0
W	0.9
X	0.9
Y	0.9
Z	0.8

8 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 0.93 FT/SEC

TRANSECTS

	5B	9G
U	1.1	1.1
V		1.0
W	1.1	0.9
X		0.8
Y	0.9	0.9
Z		0.9

9 FT DOWNSTREAM OF TEST DEVICE

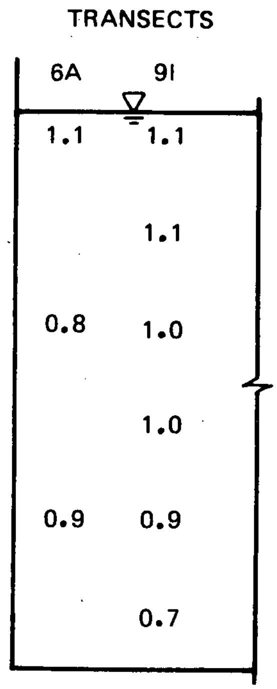
$\bar{V}$ = 0.97 FT/SEC

TEST NO. 10
TEST DATE 12/19/75
TEST DEVICE: SCREENS @ 25°

TEST CONDITION: ---

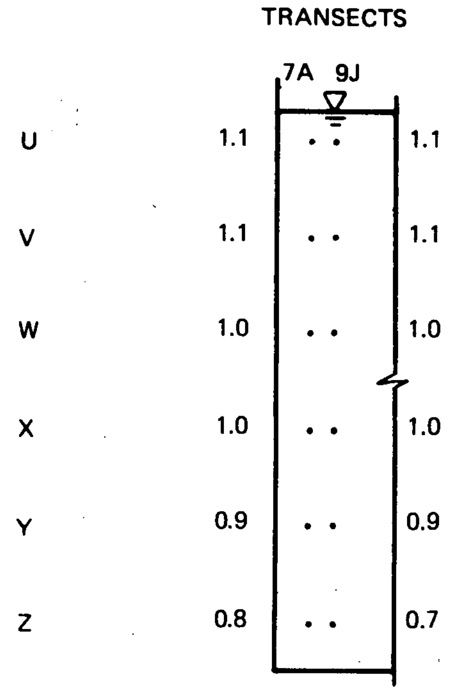
FLUME VELOCITY DATA

ARL



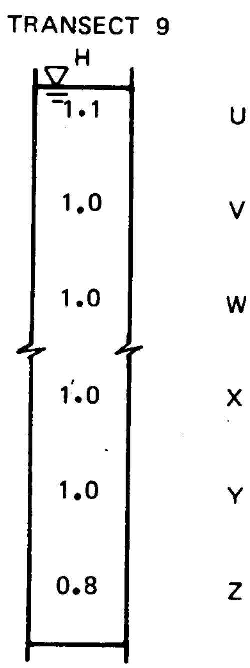
10'6" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 0.96 FT/SEC



11'1" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 0.98 FT/SEC



9'9" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 0.98 FT/SEC

TEST NO.	10
TEST DATE	12/19/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	– – –

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	2.3	2.5	2.5	2.3	2.3	2.2	2.0
V	2.4	2.3	2.0	2.0	2.2	2.2	2.0
W	2.2	1.9	1.4	1.6	1.9	1.9	1.9
X	2.0	1.6	1.4	1.4	1.7	2.0	1.9
Y	1.8	1.6	1.3	1.2	1.7	2.1	2.1
Z	1.8	1.7	1.6	1.4	1.6	1.9	2.1

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.90 FT/SEC

TRANSECT 2 / TRANSECT 8

	TRANSECT 2 A	TRANSECT 8 A
U	2.2	2.4
V	2.4	2.5
W	2.4	2.4
X	2.2	2.3
Y	2.2	2.0
Z	2.0	1.9

Transect 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 2.27 FT/SEC

Transect 8: BYPASS ENTRANCE

$\bar{V}$ = 2.25 FT/SEC

TEST NO. 11
TEST DATE 1/2/76
TEST DEVICE: SCREEN @ 25°

TEST CONDITION: BUBBLE CURTAIN IN OPERATION

FLUME VELOCITY DATA

ARL

TRANSECT 3

D	C	B	9C
1.9	2.4	2.3	2.2
1.9	1.8	1.8	1.9
1.6	1.7	1.5	1.5

4 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.88 FT/SEC

TRANSECT 9

	D
U	2.2
V	1.9
W	1.8
X	1.6
Y	1.5
Z	1.5

5'6" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.75 FT/SEC

TRANSECT 9

	A
U	2.0
V	1.9
W	1.8
X	1.9
Y	2.0
Z	1.9

AT DEVICE EDGE
0 FOOT MARK

$\bar{V}$ = 1.92 FT/SEC

TRANSECT 9

	B
U	2.1
V	2.0
W	1.9
X	1.8
Y	1.7
Z	1.5

2 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.83 FT/SEC

TEST NO.	11
TEST DATE	1/2/76
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	BUBBLE CURTAIN IN OPERATION

FLUME VELOCITY DATA

TRANSECTS

	4B	4A	9E
U	1.8	2.3	2.2
V			
W	1.9	1.8	1.7
X			
Y	1.6	1.5	1.5
Z			

7 FT DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.81 FT/SEC

TRANSECT 9

	F
U	2.1
V	1.9
W	1.7
X	1.6
Y	1.5
Z	1.5

8 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.72 FT/SEC

TRANSECTS

	5B	9G
U	1.6	2.2
V		1.9
W	1.8	1.7
X		1.6
Y	1.6	1.6
Z		1.4

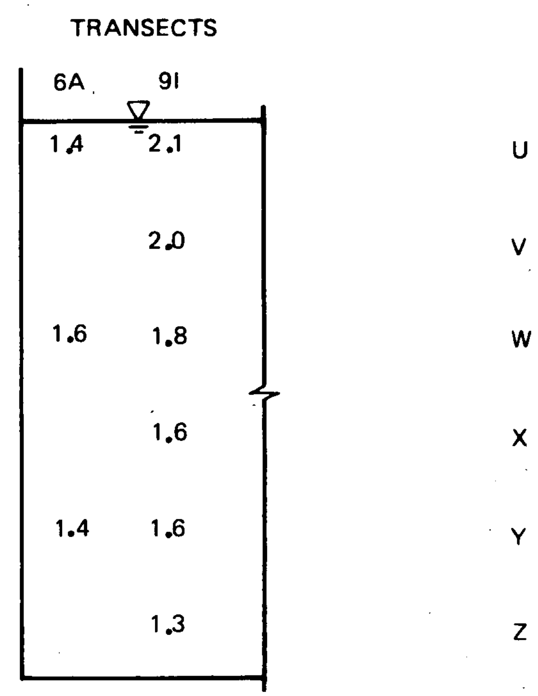
9 FT DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.71 FT/SEC

TEST NO.	11
TEST DATE	1/2/76
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	BUBBLE CURTAIN IN OPERATION

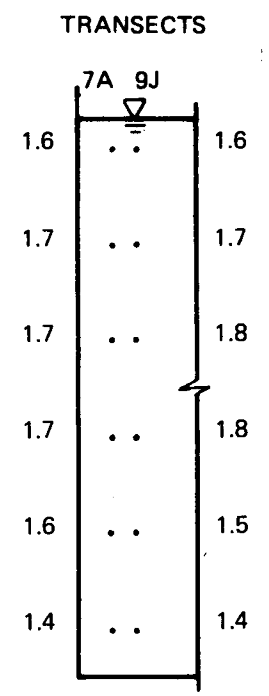
FLUME VELOCITY DATA

ARL



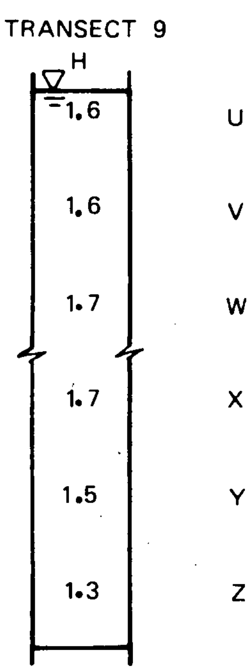
10'6" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.64 FT/SEC



11'1" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.62 FT/SEC



9'9" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.57 FT/SEC

TEST NO.	11
TEST DATE	1/2/76
TEST DEVICE:	SCREEN @ 25°
TEST CONDITION:	BUBBLE CURTAIN IN OPERATION

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.4	1.4	1.5	1.5	1.6	1.5	1.3
V	1.3	1.2	1.2	1.1	1.3	1.3	1.2
W	1.2	1.0	0.7	0.7	1.0	1.1	1.1
X	1.1	0.8	0.6	0.5	0.7	0.9	1.0
Y	0.9	0.8	0.5	0.5	0.7	1.1	1.1
Z	0.6	0.7	0.5	0.5	0.8	1.1	1.2

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.00 FT/SEC

	TRANSECT 2 (A)	TRANSECT 8 (A)
U	1.2	1.4
V	1.2	1.4
W	1.1	1.2
X	1.0	0.9
Y	0.9	0.8
Z	0.7	0.5

TRANSECT 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.02 FT/SEC

TRANSECT 8: BYPASS ENTRANCE

$\bar{V}$ = 1.03 FT/SEC

TEST NO. 12
TEST DATE 1/30/76
TEST DEVICE: SCREENS @ 45°

TEST CONDITION: ---

FLUME VELOCITY DATA

ARL

TRANSECTS

	3E	3D	3C	3B	9B
U	1.3	1.3	1.4	1.2	1.4
W	1.2	1.0	0.7	0.8	0.9
Y	1.0	0.9	0.6	0.6	0.7

1 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.00 FT/SEC

	TRANSECT 9 A	TRANSECT 9 C
U	1.2	1.3
V	1.2	1.0
W	0.9	0.9
X	0.9	0.6
Y	1.0	0.6
Z	1.1	0.6

Transect 9 A: AT DEVICE EDGE
0 FOOT MARK

$\bar{V}$ = 1.05 FT/SEC

Transect 9 C: 2 FT. DOWNSTREAM
OF TEST DEVICE

$\bar{V}$ = 0.83 FT/SEC

TEST NO. 12
TEST DATE 1/30/76
TEST DEVICE: SCREENS @ 45°

TEST CONDITION: – – –

FLUME VELOCITY DATA

ARL

	4C	4B	9D
U	1.2	1.3	1.3
V			
W	1.0	1.1	0.8
X			
Y	0.8	0.9	0.7
Z			

TRANSECTS

3 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.01 FT/SEC

	5B	9F
U	1.2	1.2
V		1.0
W	1.0	1.0
X		1.0
Y	0.7	0.9
Z		0.8

TRANSECTS

4'6" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 0.98 FT/SEC

TRANSECT 9

	E
U	1.3
V	1.0
W	0.9
X	0.7
Y	0.8
Z	0.8

3'9" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 0.92 FT/SEC

TRANSECT 9

	G
U	1.2
V	1.1
W	0.9
X	0.8
Y	0.7
Z	0.5

5'1" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 0.86 FT/SEC

TEST NO.	12
TEST DATE	1/30/76
TEST DEVICE:	SCREENS @ 45°
TEST CONDITION:	---

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	2.7	3.2	3.3	2.8	2.9	2.9	2.5
V	2.7	2.4	2.1	2.2	2.6	2.7	2.5
W	2.3	2.0	1.4	1.5	1.8	2.3	2.2
X	2.2	1.7	1.1	1.1	1.6	1.8	2.0
Y	1.9	1.6	1.0	0.9	1.5	2.1	2.1
Z	1.6	1.5	1.0	1.0	1.6	2.0	2.2

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.99 FT/SEC

	TRANSECT 2: A	TRANSECT 8: A
U	2.1	2.7
V	2.3	2.4
W	2.1	2.2
X	1.9	1.8
Y	1.8	1.5
Z	1.5	1.3

TRANSECT 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.95 FT/SEC

TRANSECT 8: BYPASS ENTRANCE

$\bar{V}$ = 1.98 FT/SEC

TEST NO. 13
TEST DATE 2/2/76
TEST DEVICE: SCREENS @ 45°

TEST CONDITION: – – –

FLUME VELOCITY DATA

ARL

TRANSECTS

	3E	3D	3C	3B	9B
U	2.3	2.6	2.5	2.5	2.6
W	2.1	1.7	1.6	1.7	2.0
Y	1.8	1.7	1.1	1.2	1.5

1 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.93 FT/SEC

	TRANSECT 9 A	TRANSECT 9 C
U	2.3	2.5
V	2.4	2.0
W	2.1	1.7
X	1.8	1.3
Y	2.0	1.4
Z	2.1	1.5

Transect 9 A: AT DEVICE EDGE 0 FOOT MARK

$\bar{V}$ = 2.12 FT/SEC

Transect 9 C: 2 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.73 FT/SEC

TEST NO. 13
TEST DATE 2/2/76
TEST DEVICE: SCREENS @ 45°

TEST CONDITION: ---

FLUME VELOCITY DATA

ARL

	4C	4B	9D
U	2.1	2.7	2.4
V			
W	2.2	1.8	1.6
X			
Y	1.7	1.5	1.2
Z			

TRANSECTS

3 FT. DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.91 FT/SEC

	5B	9F
U	2.1	2.4
V		2.1
W	1.8	2.0
X		1.8
Y	1.4	1.7
Z		1.5

TRANSECTS

4'6" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.87 FT/SEC

	TRANSECT 9 E	TRANSECT 9 G
U	2.5	1.9
V	2.0	2.0
W	1.9	1.9
X	1.7	1.7
Y	1.5	1.4
Z	1.7	1.0

Transect 9 E: 3'9" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.88 FT/SEC

Transect 9 G: 5'1" DOWNSTREAM OF TEST DEVICE

$\bar{V}$ = 1.65 FT/SEC

TEST NO. 13
TEST DATE 2/2/76
TEST DEVICE: SCREENS @ 45°

TEST CONDITION: ---

FLUME VELOCITY DATA

WATER SURFACE ELEVATIONS

WATER SURFACE ELEVATIONS

TEST DEVICE: LOUVERS - 25° TO FLOW

TEST DATE: 1/9/76

AVERAGE APPROACH VELOCITY: 1 fps

Location (Ref. Fig. 12)	Average Reading Ft. of H_2O	Datum Ft. of H_2O	Water Surface Elevation
A	+0.005	5.75	5.755
B	-0.005	5.75	5.745
C	-0.010	5.75	5.745
D	-0.020	5.75	5.730
E	-0.020	5.75	5.730
F	+0.015	5.75	5.765
G	0.000	5.75	5.750
H	0.000	5.75	5.750
I	-0.012	5.75	5.738
J	-0.020	5.75	5.730
K	+0.005	5.75	5.755
L	+0.007	5.75	5.757
M	0.000	5.75	5.750
N	-0.013	5.75	5.737
O	-0.020	5.75	5.730
P	-0.040	5.75	5.710

WATER SURFACE ELEVATIONS

TEST DEVICE: LOUVERS - 25° TO FLOW

TEST DATE: 1/9/76

AVERAGE APPROACH VELOCITY: 2 fps

Location (Ref. Fig. 12)	Average Reading Ft. of H_2O	Datum Ft. of H_2O	Water Surface Elevation
A	0.000	5.75	5.750
B	-0.027	5.75	5.723
C	-0.047	5.75	5.703
D	-0.064	5.75	5.686
E	-0.056	5.75	5.694
F	+0.040	5.75	5.790
G	+0.001	5.75	5.751
H	-0.015	5.75	5.735
I	-0.044	5.75	5.706
J	-0.066	5.75	5.684
K	+0.020	5.75	5.770
L	+0.025	5.75	5.775
M	+0.001	5.75	5.751
N	-0.038	5.75	5.712
O	-0.074	5.75	5.676
P	-0.157	5.75	5.593

WATER SURFACE ELEVATIONS

TEST DEVICE: SCREENS - 25° TO FLOW

TEST DATE: 1/21/76

AVERAGE APPROACH VELOCITY: 1 fps

Location (Ref. Fig. 12)	Average Reading Ft. of H_2O	Datum Ft. of H_2O	Water Surface Elevation
A	-0.016	5.75	5.734
B	-0.031	5.75	5.719
C	-0.029	5.75	5.721
D	-0.019	5.75	5.731
E	-0.021	5.75	5.729
F	-0.017	5.75	5.733
G	-0.029	5.75	5.721
H	-0.031	5.75	5.719
I	-0.022	5.75	5.728
J	-0.018	5.75	5.732
K	-0.023	5.75	5.727
L	-0.026	5.75	5.724
M	-0.020	5.75	5.730
N	-0.039	5.75	5.711
O	-0.049	5.75	5.701
P	-0.046	5.75	5.704

WATER SURFACE ELEVATIONS

TEST DEVICE: SCREENS - 25° TO FLOW

TEST DATE: 1/21/76

AVERAGE APPROACH VELOCITY: 2 fps

Location (Ref. Fig. 12)	Average Reading Ft. of H_2O	Datum Ft. of H_2O	Water Surface Elevation
A	+0.004	5.75	5.754
B	-0.033	5.75	5.717
C	-0.027	5.75	5.723
D	+0.001	5.75	5.751
E	+0.001	5.75	5.751
F	-0.001	5.75	5.749
G	-0.029	5.75	5.721
H	-0.024	5.75	5.726
I	-0.002	5.75	5.748
J	+0.021	5.75	5.771
K	-0.013	5.75	5.737
L	-0.020	5.75	5.730
M	-0.038	5.75	5.712
N	-0.061	5.75	5.689
O	-0.110	5.75	5.640
P	-0.085	5.75	5.665

WATER SURFACE ELEVATIONS

TEST DEVICE: SCREENS - 45° TO FLOW

TEST DATE: 1/30/76

AVERAGE APPROACH VELOCITY: 1 fps

Location (Ref. Fig. 12)	Average Reading Ft. of H_2O	Datum Ft. of H_2O	Water Surface Elevation
A	+0.011	5.75	5.761
B	-0.009	5.75	5.741
C	+0.020	5.75	5.770
D	+0.006	5.75	5.756
F	-0.013	5.75	5.737
G	+0.021	5.75	5.729
H	+0.010	5.75	5.760
I	0.000	5.75	5.750
K	-0.014	5.75	5.736
L	-0.040	5.75	5.710
M	-0.039	5.75	5.711
N	-0.040	5.75	5.710
P	+0.020	5.75	5.770

WATER SURFACE ELEVATIONS

TEST DEVICE: SCREENS - 45° TO FLOW

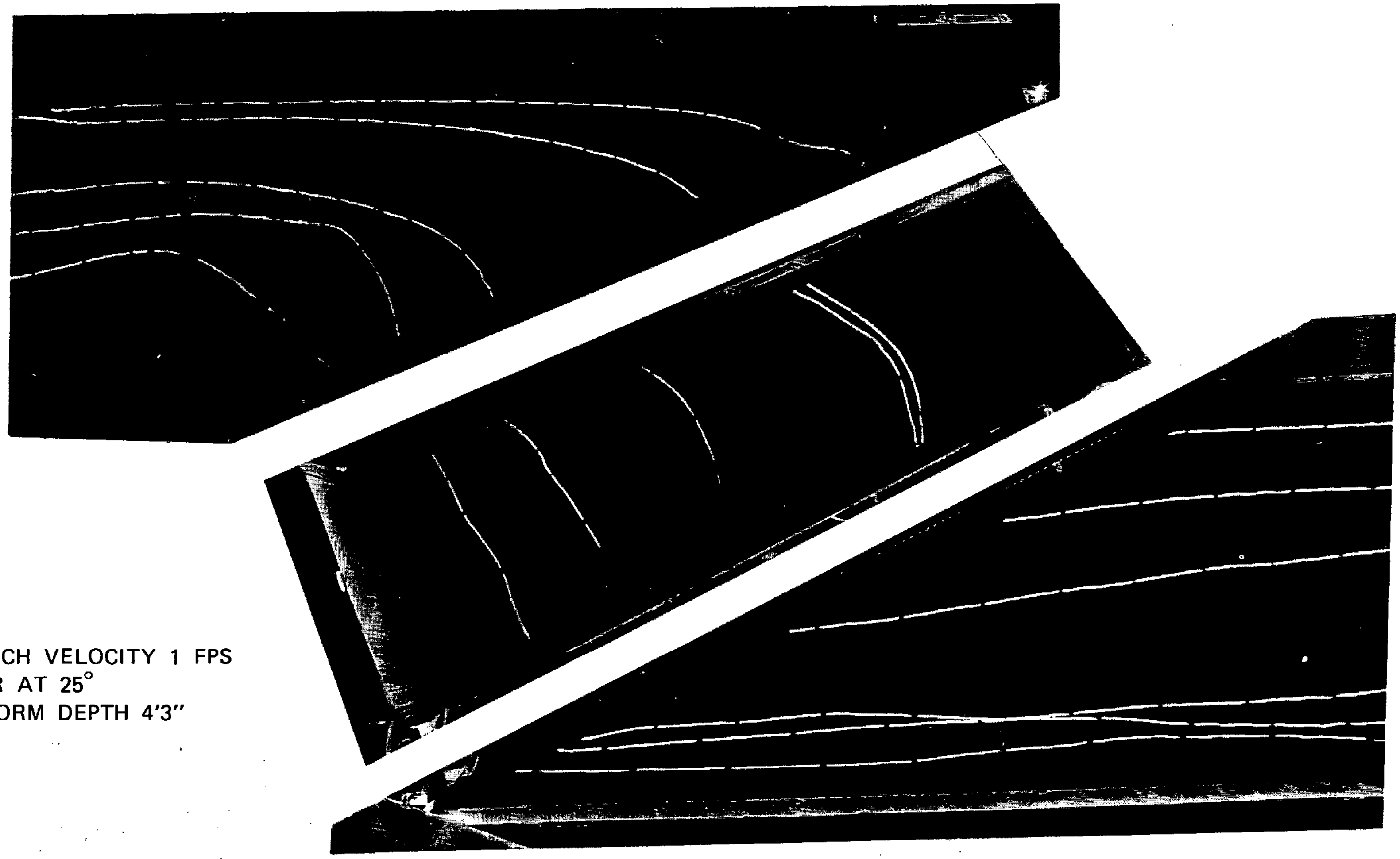
TEST DATE: 2/3/76

AVERAGE APPROACH VELOCITY: 2 fps

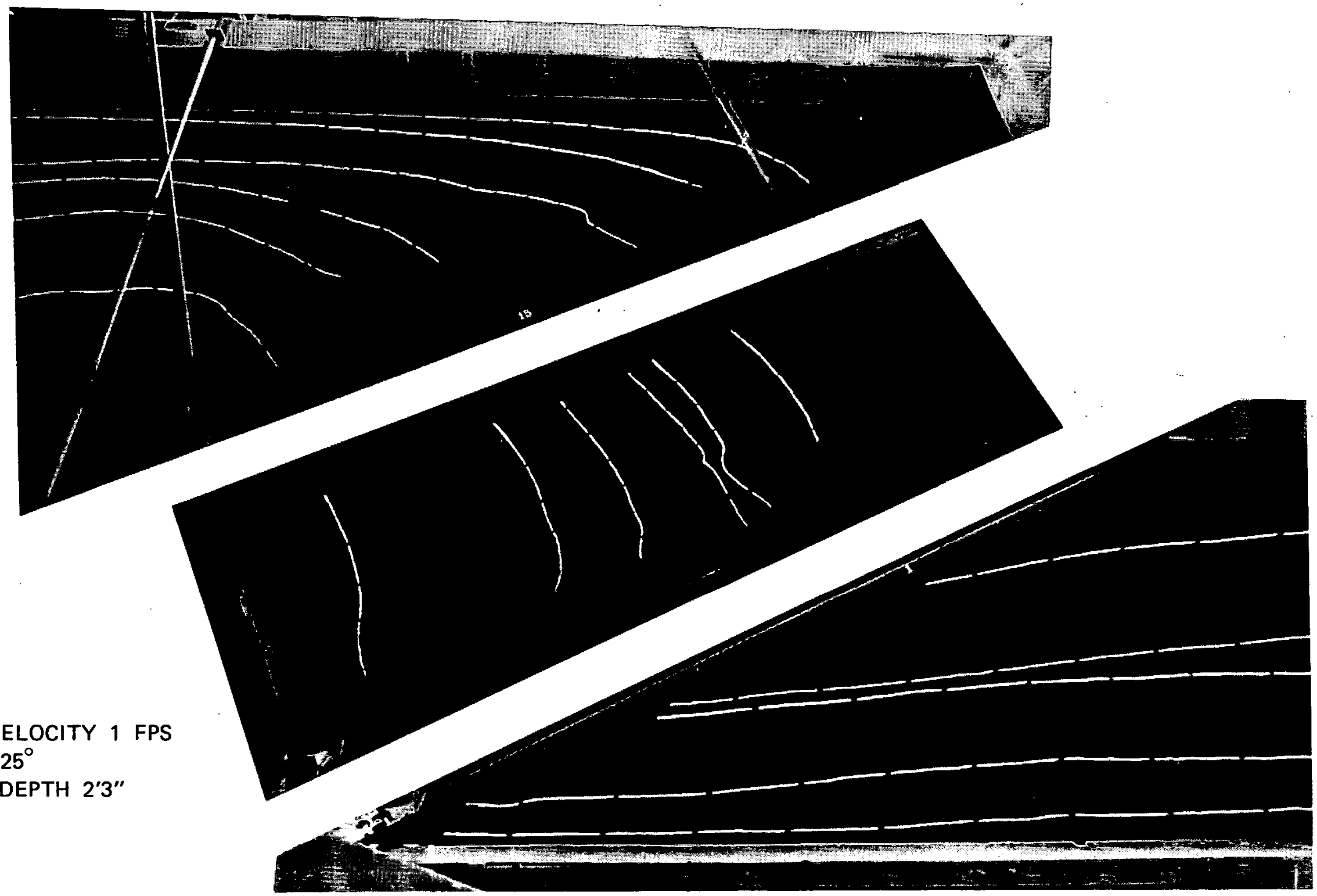
Location (Ref. Fig. 12)	Average Reading Ft. of H_2O	Datum Ft. of H_2O	Water Surface Elevation
A	+0.018	5.75	5.768
B	-0.012	5.75	5.738
C	+0.011	5.75	5.761
D	+0.050	5.75	5.800
F	-0.082	5.75	5.668
G	-0.064	5.75	5.686
H	-0.008	5.75	5.742
I	+0.017	5.75	5.767
K	-0.028	5.75	5.722
L	-0.082	5.75	5.668
M	-0.107	5.75	5.643
N	-0.118	5.75	5.632
P	+0.032	5.75	5.782

FLOWLINE PHOTOGRAPHS

APPROACH VELOCITY 1 FPS
LOUVER AT 25°
CRUCIFORM DEPTH 4'3"



FLOWLINES



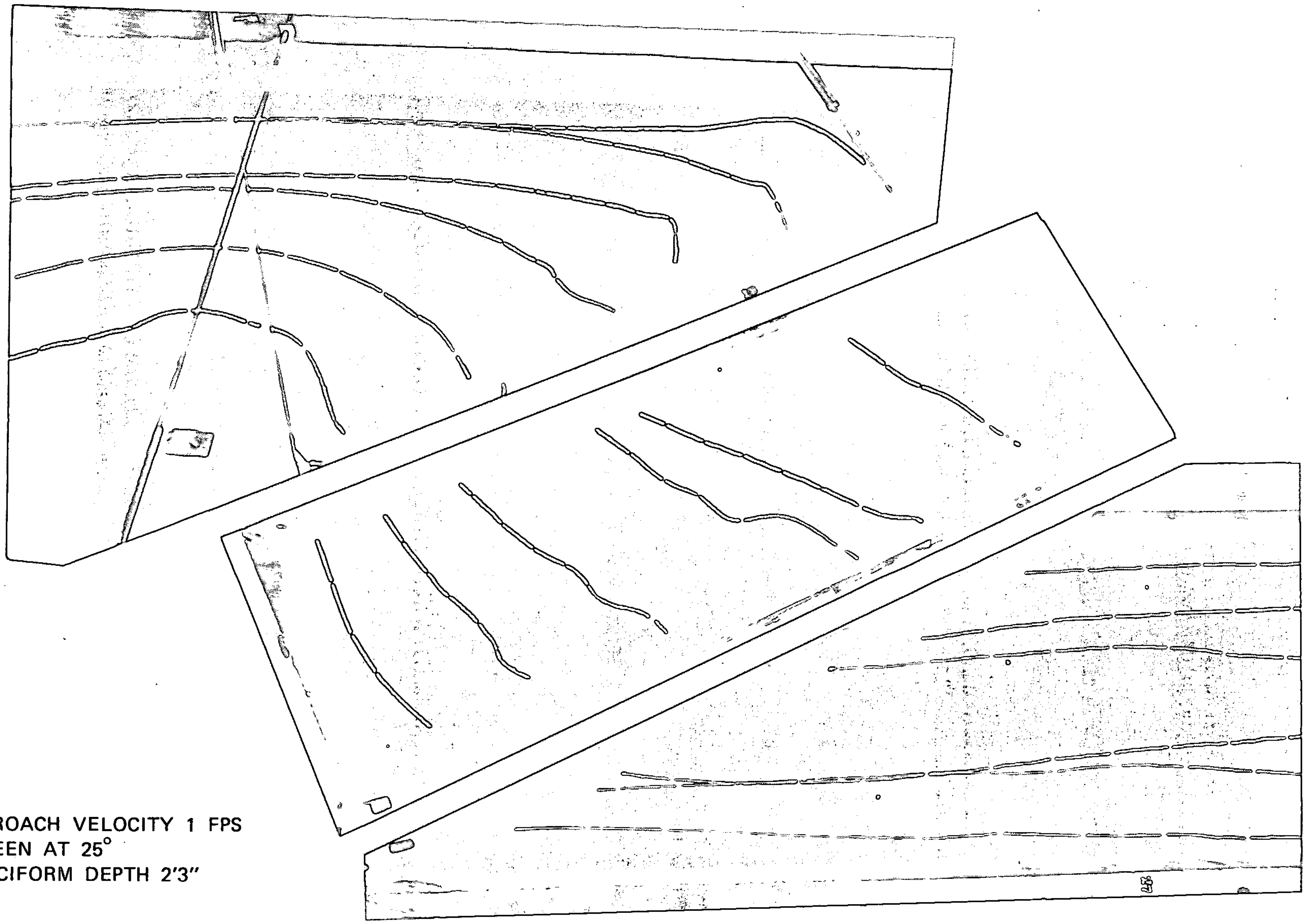
APPROACH VELOCITY 1 FPS
LOUVER AT 25°
CRUCIFORM DEPTH 2'3"

FLOWLINES

ARL

APPROACH VELOCITY 1 FPS
SCREEN AT 25°
CRUCIFORM DEPTH 4'3"

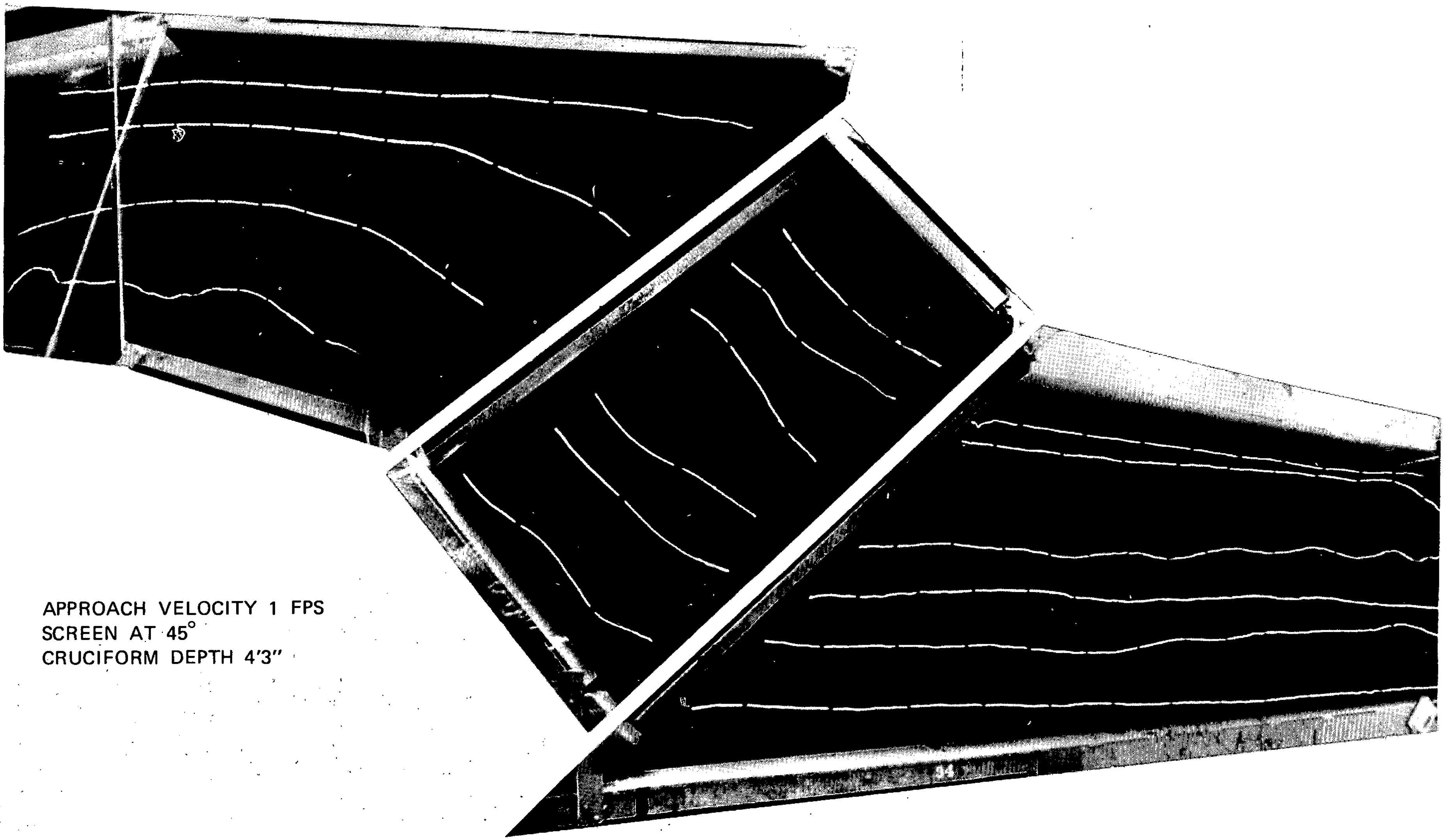
FLOWLINES



APPROACH VELOCITY 1 FPS
SCREEN AT 25°
CRUCIFORM DEPTH 2'3"

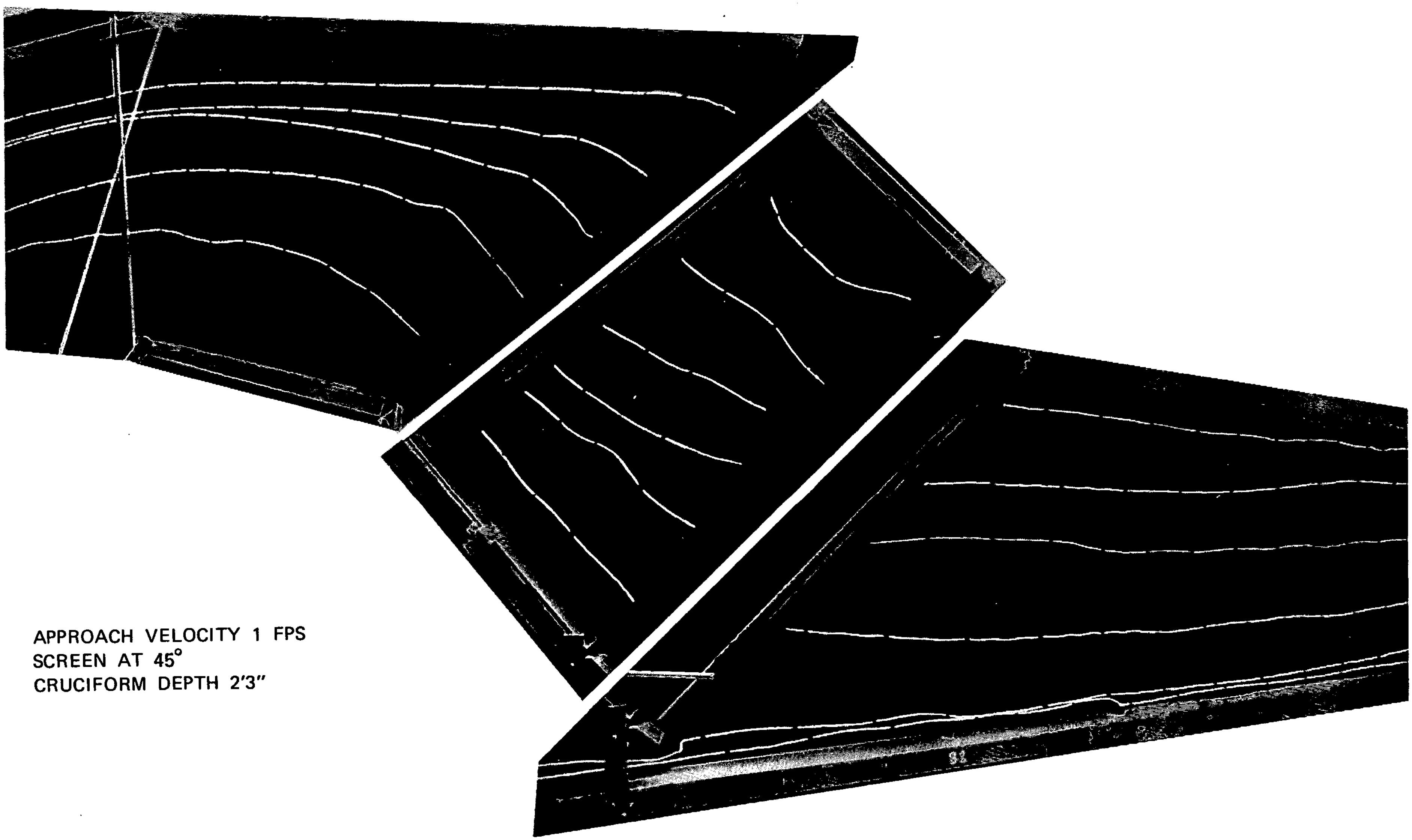
FLOWLINES

ARL



APPROACH VELOCITY 1 FPS
SCREEN AT 45°
CRUCIFORM DEPTH 4'3"

FLOWLINES



APPROACH VELOCITY 1 FPS
SCREEN AT 45°
CRUCIFORM DEPTH 2'3"

FLOWLINES

VELOCITY DATA IN SUPPORT OF BIOLOGICAL TESTING

TRANSECT 1

	F	D	B
U	0.9	1.0	1.0
V	1.0	1.0	1.0
W	1.0	1.0	1.0
X	0.9	1.0	0.9
Y	0.9	0.9	0.9
Z	•	•	•

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 0.96 FT/SEC

TRANSECT 8

	A
U	1.1
V	1.2
W	1.2
X	1.2
Y	1.2
Z	•

BYPASS ENTRANCE

$\bar{V}$ = 1.22 FT/SEC

TEST NO.	2
TEST DATE	6/10/75
TEST DEVICE:	PRELIMINARY SCREENS @ 25°
TEST CONDITION:	— — —

FLUME VELOCITY DATA

ARL

TRANSECT 1

	F	D	B
U	2.0	2.1	1.9
V	2.2	2.1	2.0
W	2.0	2.1	2.0
X	1.9	2.0	2.0
Y	1.8	1.8	1.9
Z	1.7	1.8	1.8

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.95 FT/SEC

TRANSECT 8

	A
U	2.0
V	2.3
W	2.4
X	2.1
Y	2.2
Z	1.8

BYPASS ENTRANCE

$\bar{V}$ = 2.13 FT/SEC

TEST NO.	3
TEST DATE	6/11/75
TEST DEVICE:	PRELIMINARY SCREENS @ 25°
TEST CONDITION:	— — —

FLUME VELOCITY DATA

TRANSECT 1

	F	D	B
U	2.5	2.7	2.6
W	2.4	2.5	2.4
Y	2.2	2.3	2.2

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 2.42 FT/SEC

TRANSECT 8

	A
U	2.5
V	2.5
W	2.6
X	2.5
Y	2.4
Z	2.2

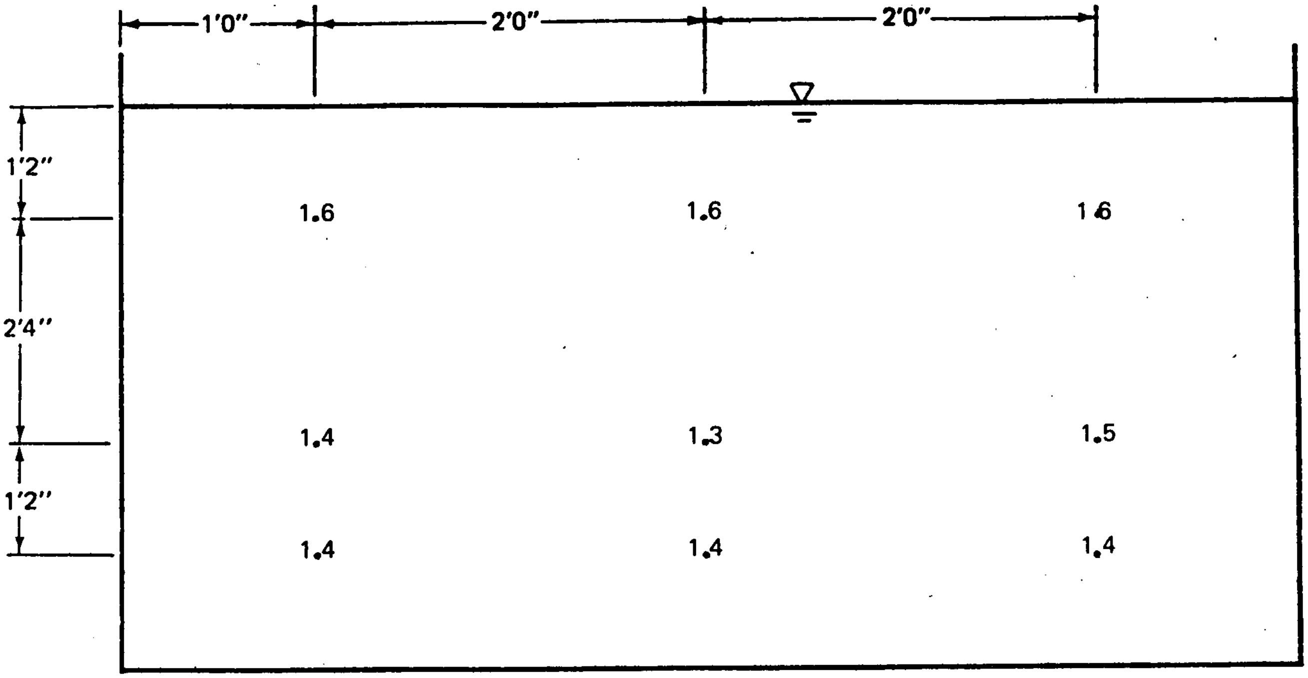
BYPASS ENTRANCE

$\bar{V}$ = 2.45 FT/SEC

TEST NO.	4
TEST DATE	6/12/75
TEST DEVICE:	PRELIMINARY SCREENS @ 25°
TEST CONDITION:	– – –

FLUME VELOCITY DATA

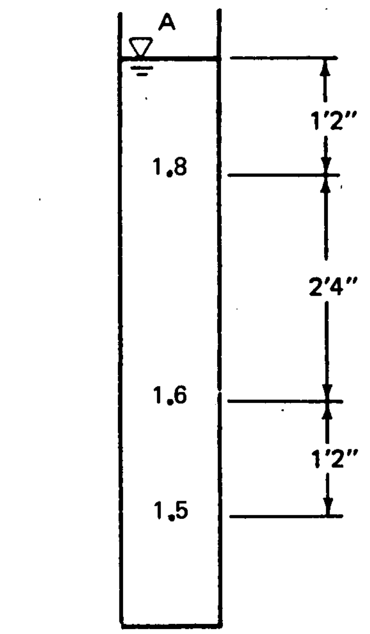
TRANSECT 1



10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.47 FT/SEC

TRANSECT 8



BYPASS ENTRANCE

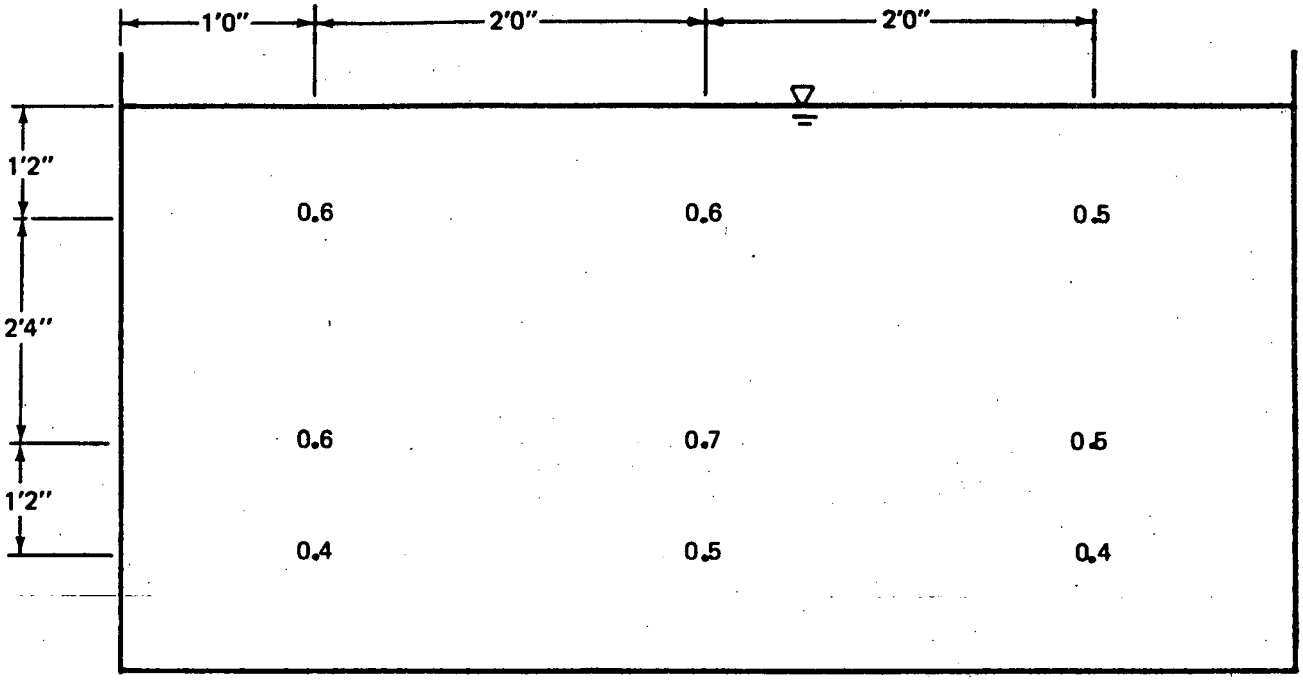
$\bar{V}$ = 1.63 FT/SEC

TEST NO.	5
TEST DATE	6/17/75
TEST DEVICE:	PRELIMINARY SCREENS @ 25°
TEST CONDITION:	– – –

FLUME VELOCITY DATA

ARL

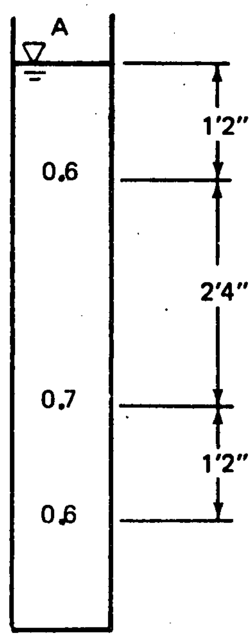
TRANSECT 1



10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 0.53 FT/SEC

TRANSECT 8



BYPASS ENTRANCE

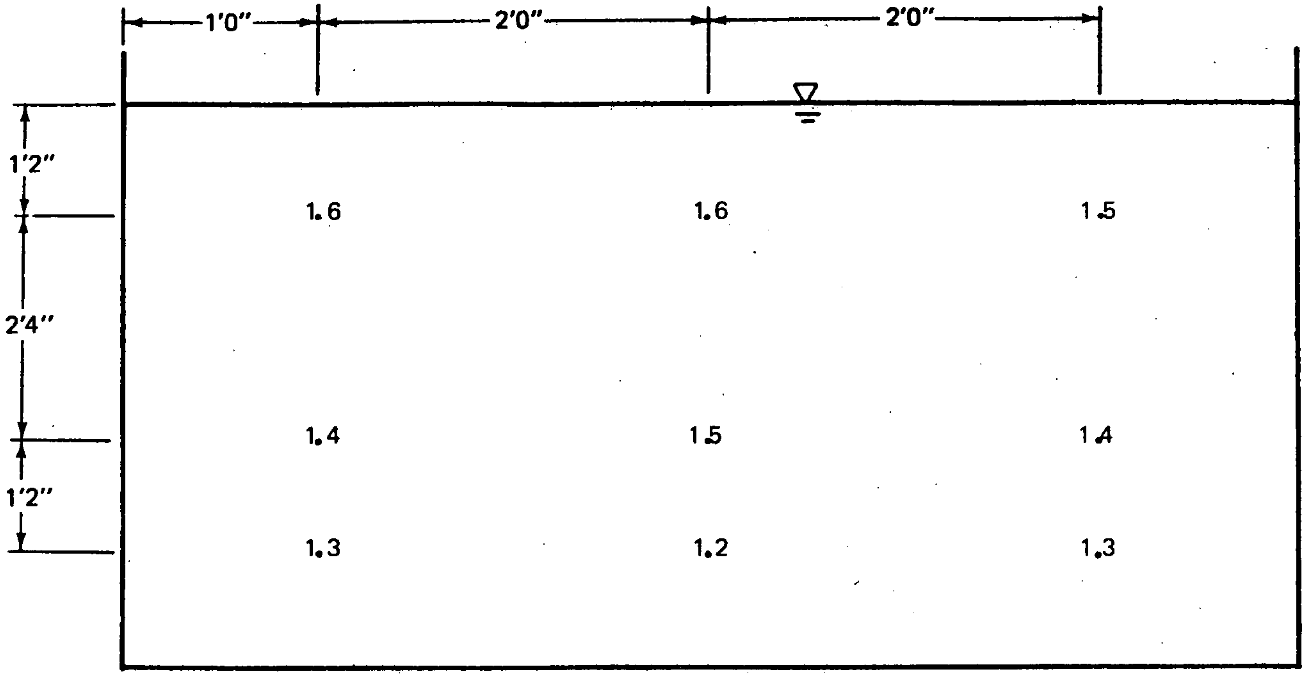
$\bar{V}$ = 0.63 FT/SEC

TEST NO.	6
TEST DATE	6/18/75
TEST DEVICE:	PRELIMINARY SCREENS @ 25°
TEST CONDITION:	– – –

FLUME VELOCITY DATA

ARL

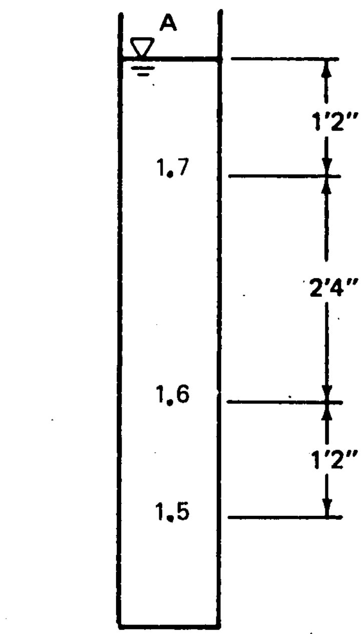
TRANSECT 1



10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.42 FT/SEC

TRANSECT 8



BYPASS ENTRANCE

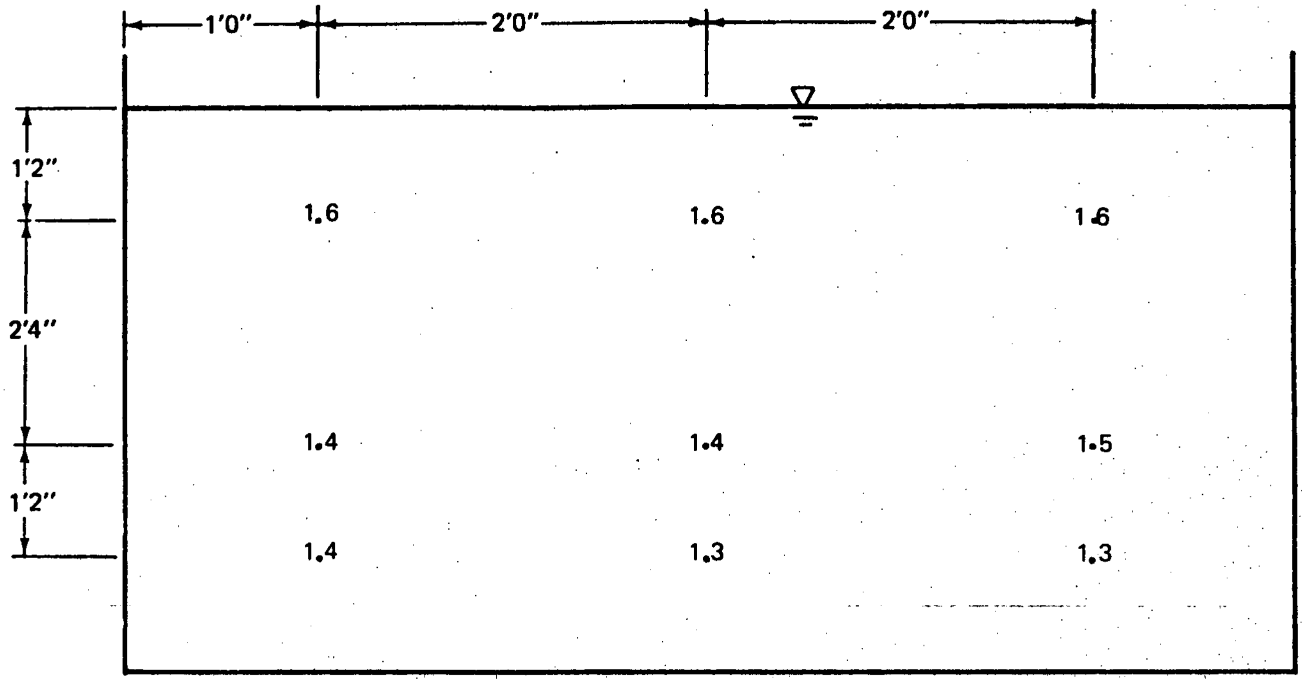
$\bar{V}$ = 1.60 FT/SEC

TEST NO.	7
TEST DATE	6/19/75
TEST DEVICE:	PRELIMINARY SCREENS @ 25°
TEST CONDITION:	— — —

FLUME VELOCITY DATA

ARL

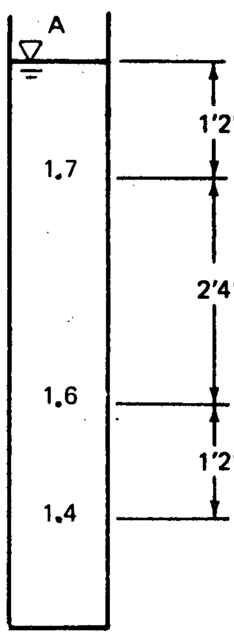
TRANSECT 1



10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.46 FT/SEC

TRANSECT 8



BYPASS ENTRANCE

$\bar{V}$ = 1.57 FT/SEC

TEST NO.	8
TEST DATE	6/24/75
TEST DEVICE:	PRELIMINARY SCREENS @ 25°
TEST CONDITION:	— — —

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.1	1.1	1.1	1.1	1.0	1.0	0.9
V	1.0	1.1	1.1	1.1	1.0	0.9	0.9
W	1.1	1.1	1.0	1.1	1.0	1.0	0.9
X	1.0	1.0	1.1	1.1	1.1	1.0	0.9
Y	1.0	1.0	1.0	1.0	1.1	0.9	1.0
Z	0.7	1.0	0.9	1.0	1.0	0.9	1.0

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.01 FT/SEC

	TRANSECT 2 (A)	TRANSECT 8 (A)
U	1.2	1.2
V	1.2	1.2
W	1.1	1.2
X	1.2	1.2
Y	1.1	1.2
Z	1.1	1.0

TRANSECT 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.15 FT/SEC

TRANSECT 8: BYPASS ENTRANCE

$\bar{V}$ = 1.17 FT/SEC

TEST NO. 9
TEST DATE 8/18/75
TEST DEVICE: SCREENS @ 25°

TEST CONDITION: – – –

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.2	1.2	1.2	1.1	1.1	1.0	1.0
V	1.1	1.1	1.1	1.1	1.1	1.0	0.9
W	1.2	1.1	1.1	1.1	1.1	1.1	1.0
X	1.1	1.1	1.0	1.1	1.1	1.1	1.1
Y	1.0	1.0	1.0	1.0	1.0	1.1	1.1
Z	0.7	0.8	0.9	1.0	1.0	1.1	1.0

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.07 FT/SEC

	TRANSECT 2 A	TRANSECT 8 A
U	1.2	1.3
V	1.2	1.4
W	1.2	1.2
X	1.2	1.1
Y	1.0	1.1
Z	1.0	1.1

TRANSECT 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.13 FT/SEC

TRANSECT 8: BYPASS ENTRANCE

$\bar{V}$ = 1.20 FT/SEC

TEST NO. 10
TEST DATE 8/26/75
TEST DEVICE: SCREENS @ 25°

TEST CONDITION: ---

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	2.4	2.5	2.5	2.3	2.4	2.2	2.0
V	2.2	2.1	2.2	2.1	2.1	1.8	1.8
W	2.1	2.0	1.8	2.0	1.9	2.0	1.8
X	1.9	1.8	1.8	1.8	1.8	1.9	1.9
Y	1.9	1.9	1.8	1.8	1.8	1.7	1.8
Z	1.7	1.8	1.7	1.6	1.7	1.6	1.7

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.94 FT/SEC

	TRANSECT 2 A	TRANSECT 8 A
U	2.0	2.4
V	2.4	2.2
W	2.0	2.3
X	2.1	2.1
Y	2.0	1.9
Z	1.8	1.8

5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 2.05 FT/SEC

BYPASS ENTRANCE

$\bar{V}$ = 2.12 FT/SEC

TEST NO. 11
TEST DATE 8/29/75
TEST DEVICE: SCREENS @ 25°

TEST CONDITION: ---

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	2.2	2.4	2.4	2.4	2.4	2.3	2.1
V	2.2	2.1	2.1	2.1	2.1	2.1	1.8
W	2.1	1.8	1.8	1.8	1.8	1.9	1.8
X	2.1	1.9	1.9	1.7	1.7	1.8	1.8
Y	1.9	1.9	1.9	1.8	1.6	1.6	1.7
Z	1.8	1.9	1.8	1.7	1.6	1.6	1.7

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.93 FT/SEC

	TRANSECT 2 (A)	TRANSECT 8 (A)
U	2.0	2.3
V	2.1	2.4
W	2.1	2.3
X	2.0	2.1
Y	1.8	1.8
Z	1.9	1.8

TRANSECT 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.98 FT/SEC

TRANSECT 8: BYPASS ENTRANCE

$\bar{V}$ = 2.12 FT/SEC

TEST NO.	12
TEST DATE	9/5/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	– – –

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	2.1	2.4	2.4	2.4	2.3	2.2	2.1
V	2.2	2.2	2.1	2.1	2.0	2.0	1.9
W	2.1	1.9	1.7	1.7	1.7	1.8	1.8
X	2.0	1.9	1.8	1.7	1.7	1.8	1.8
Y	2.0	2.0	1.9	1.5	1.7	1.8	1.7
Z	1.8	2.0	1.8	1.6	1.6	1.7	1.7

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.92 FT/SEC

	TRANSECT 2 A	TRANSECT 8 A
U	2.1	2.2
V	2.3	2.4
W	2.2	2.2
X	2.1	2.2
Y	1.9	2.0
Z	1.8	1.7

TRANSECT 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 2.07 FT/SEC

TRANSECT 8: BYPASS ENTRANCE

$\bar{V}$ = 2.12 FT/SEC

TEST NO. 13
TEST DATE 9/10/75
TEST DEVICE: SCREENS @ 25°

TEST CONDITION: ---

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.8	2.0	2.1	2.2	2.2	2.0	2.2
V	1.8	1.8	1.9	1.9	2.0	2.1	2.2
W	1.8	2.0	1.8	1.9	1.8	2.0	2.1
X	1.8	2.0	1.7	1.6	1.8	1.9	2.1
Y	1.8	1.9	1.6	1.5	1.9	1.8	1.8
Z	1.8	1.8	1.5	1.7	1.8	1.9	2.0

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.89 FT/SEC

	TRANSECT 2 (A)	TRANSECT 8 (A)
U	2.1	2.1
V	2.2	2.2
W	2.0	1.9
X	2.0	1.9
Y	2.0	2.0
Z	1.9	1.8

5 FT. DOWNSTREAM
OF BYPASS ENTRANCE
$\bar{V}$ = 2.03 FT/SEC

BYPASS ENTRANCE
$\bar{V}$ = 2.03 FT/SEC

TEST NO. 14
TEST DATE 9/12/75
TEST DEVICE: SCREENS @ 25°

TEST CONDITION: ---

FLUME VELOCITY DATA

TRANSECT 1

	G	F	E	D	C	B	A
U	2.9	3.4	3.6	4.0	4.1	3.9	3.6
V	3.0	3.3	3.5	3.5	3.6	3.8	3.6
W	3.1	3.2	3.0	2.9	2.9	2.9	3.3
X	3.0	2.9	2.3	2.5	2.8	2.8	2.8
Y	2.9	2.8	1.9	2.6	2.9	3.0	2.8
Z	2.8	2.7	2.0	2.2	2.7	2.6	2.7

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 3.02 FT/SEC

	TRANSECT 2 A	TRANSECT 8 A
U	3.4	2.9
V	3.6	3.8
W	3.6	3.9
X	3.2	3.2
Y	2.8	3.0
Z	2.6	2.9

TRANSECT 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 3.20 FT/SEC

TRANSECT 8: BYPASS ENTRANCE

$\bar{V}$ = 3.28 FT/SEC

TEST NO. 15
TEST DATE 9/17/75
TEST DEVICE: SCREENS @ 25°

TEST CONDITION: ---

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	2.2	2.3	2.4	2.2	2.0	2.0	1.9
V	2.2	2.1	2.0	2.0	2.0	2.1	1.9
W	2.1	1.9	1.8	2.0	2.0	2.2	2.0
X	1.9	1.8	1.8	1.6	1.6	2.0	2.0
Y	1.8	1.8	1.8	1.7	1.4	1.8	2.0
Z	1.7	1.7	1.7	1.6	1.4	1.9	2.0

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.91 FT/SEC

	TRANSECT 2 — A	TRANSECT 8 — A
U	2.0	2.0
V	2.2	2.0
W	2.2	1.9
X	2.1	2.0
Y	2.0	2.0
Z	1.8	1.5

Transect 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 2.05 FT/SEC

Transect 8: BYPASS ENTRANCE

$\bar{V}$ = 1.90 FT/SEC

TEST NO. 16
TEST DATE 9/19/75
TEST DEVICE: SCREENS @ 25

TEST CONDITION: ---

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	0.4	0.6	0.6	0.5	0.6	0.6	0.6
V	0.7	0.5	0.5	0.5	0.5	0.6	0.6
W	0.6	0.6	0.5	0.5	0.5	0.5	0.5
X	0.5	0.5	0.6	0.5	0.4	0.5	0.4
Y	0.5	0.5	0.5	0.4	0.4	0.4	0.4
Z	0.4	0.3	0.4	0.4	0.4	0.4	0.4

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 0.50 FT/SEC

	TRANSECT 2 A	TRANSECT 8 A
U	0.6	0.6
V	0.7	0.7
W	0.5	0.6
X	0.6	0.6
Y	0.6	0.5
Z	0.6	0.6

TRANSECT 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 0.60 FT/SEC

TRANSECT 8: BYPASS ENTRANCE

$\bar{V}$ = 0.60 FT/SEC

TEST NO. 17
TEST DATE 9/24/75
TEST DEVICE: SCREENS @ 25°

TEST CONDITION: – – –

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.0	1.1	1.1	1.1	1.1	1.1	1.0
V	1.0	1.0	1.1	1.1	1.1	1.1	1.0
W	0.9	1.1	1.1	1.0	1.1	1.1	1.0
X	1.0	1.0	1.0	1.1	1.1	1.1	1.0
Y	1.0	0.9	1.0	1.1	1.1	1.1	1.0
Z	0.9	0.9	0.9	0.9	0.9	0.9	0.8

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.02 FT/SEC

	TRANSECT 2 A	TRANSECT 8 A
U	1.4	1.5
V	1.3	1.5
W	1.3	1.5
X	1.3	1.4
Y	1.2	1.2
Z	1.2	1.3

Transect 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.28 FT/SEC

Transect 8: BYPASS ENTRANCE

$\bar{V}$ = 1.40 FT/SEC

TEST NO.	18
TEST DATE	10/8/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	– – –

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.0	1.1	1.1	1.1	1.0	0.9	0.9
V	1.0	1.0	1.0	1.0	1.0	0.9	0.8
W	1.0	1.0	1.0	1.0	0.9	0.9	0.8
X	0.9	0.9	1.0	0.9	0.9	1.0	0.9
Y	0.8	0.9	1.0	1.1	0.9	0.9	0.9
Z	0.7	0.9	1.0	1.0	0.9	0.8	0.9

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 0.94 FT/SEC

	TRANSECT 2 (A)	TRANSECT 8 (A)
U	1.2	1.3
V	1.1	1.2
W	1.3	1.2
X	1.1	1.3
Y	1.3	1.2
Z	1.0	1.1

TRANSECT 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.17 FT/SEC

TRANSECT 8: BYPASS ENTRANCE

$\bar{V}$ = 1.22 FT/SEC

TEST NO.	19
TEST DATE	10/9/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	---

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.1	1.2	1.2	1.1	1.1	1.1	1.1
V	1.1	1.0	1.0	1.0	1.1	1.1	1.1
W	1.0	0.9	0.9	0.9	1.0	1.0	1.0
X	1.0	0.9	0.9	0.8	0.9	1.0	1.0
Y	0.9	0.9	0.9	0.9	0.8	1.0	1.0
Z	0.8	0.9	0.9	0.8	0.7	0.9	0.9

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 0.97 FT/SEC

	TRANSECT 2 A	TRANSECT 8 A
U	1.3	1.4
V	1.3	1.4
W	1.3	1.4
X	1.2	1.3
Y	1.2	1.2
Z	1.2	1.1

5 FT. DOWNSTREAM
OF BYPASS ENTRANCE
$\bar{V}$ = 1.25 FT/SEC

BYPASS ENTRANCE
$\bar{V}$ = 1.39 FT/SEC

TEST NO.	20
TEST DATE	11/5/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	SALINE WATER

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	2.1	2.1	2.1	2.3	2.3	2.3	2.3
V	2.0	2.1	2.1	2.1	2.0	2.1	2.1
W	1.8	1.9	2.0	1.9	1.9	1.9	2.1
X	1.9	1.9	1.7	1.6	1.8	1.8	1.9
Y	1.9	1.8	1.3	1.4	1.8	1.8	1.7
Z	1.8	1.6	1.3	1.4	1.5	1.6	1.7

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.87 FT/SEC

TRANSECT 2 TRANSECT 8

	TRANSECT 2 (A)	TRANSECT 8 (A)
U	2.4	2.6
V	2.4	2.7
W	2.4	2.6
X	2.2	2.5
Y	2.2	2.4
Z	2.1	2.2

5 FT. DOWNSTREAM
OF BYPASS ENTRANCE
$\bar{V}$ = 2.28 FT/SEC

BYPASS ENTRANCE
$\bar{V}$ = 2.50 FT/SEC

TEST NO.	21
TEST DATE	11/5/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	SALINE WATER

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.3	1.3	1.3	1.2	1.2	1.2	1.1
V	1.2	1.2	1.1	1.2	1.2	1.2	1.2
W	1.2	1.1	1.1	1.1	1.2	1.1	1.1
X	1.1	1.1	1.0	0.9	1.0	1.1	1.1
Y	1.0	1.1	1.0	0.8	0.8	1.0	1.1
Z	1.0	1.1	1.0	1.0	0.7	0.9	1.0

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.09 FT/SEC

	TRANSECT 2 A	TRANSECT 8 A
U	1.5	1.4
V	1.4	1.5
W	1.4	1.4
X	1.4	1.4
Y	1.4	1.4
Z	1.2	1.3

Transect 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.38 FT/SEC

Transect 8: BYPASS ENTRANCE

$\bar{V}$ = 1.40 FT/SEC

TEST NO.	22
TEST DATE	11/6/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	SALINE WATER

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	2.3	2.4	2.4	2.3	2.2	2.1	2.0
V	2.2	2.2	2.1	2.1	2.1	2.1	2.0
W	2.1	1.9	1.9	2.0	1.9	2.0	1.8
X	1.9	1.9	1.9	1.6	1.9	2.0	1.8
Y	1.9	1.9	1.9	1.6	1.4	1.8	1.9
Z	1.9	1.9	1.8	1.7	1.4	1.7	1.8

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.94 FT/SEC

	TRANSECT 2 (A)	TRANSECT 8 (A)
U	2.5	2.5
V	2.4	2.6
W	2.5	2.6
X	2.4	2.6
Y	2.4	2.4
Z	2.1	2.3

TRANSECT 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 2.38 FT/SEC

TRANSECT 8: BYPASS ENTRANCE

$\bar{V}$ = 2.50 FT/SEC

TEST NO.	23
TEST DATE	11/6/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	SALINE WATER

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.1	1.2	1.2	1.1	1.1	1.1	0.9
V	1.1	1.1	1.0	0.9	1.0	1.0	1.0
W	1.0	0.9	0.7	0.8	0.9	0.9	0.9
X	1.0	0.8	0.6	0.7	0.9	0.9	0.9
Y	1.0	0.8	0.7	0.7	0.8	1.0	1.0
Z	0.9	0.9	0.9	0.8	0.8	0.9	1.0

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 0.93 FT/SEC

	TRANSECT 2: A	TRANSECT 8: A
U	1.2	.
V	1.3	.
W	1.2	.
X	1.1	.
Y	1.1	.
Z	1.0	.

TRANSECT 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.15 FT/SEC

TRANSECT 8: BYPASS ENTRANCE

$\bar{V}$ = FT/SEC

TEST NO.	24
TEST DATE	12/17/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	BUBBLE CURTAIN IN OPERATION

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.1	1.2	1.2	1.2	1.1	1.1	1.0
V	1.1	1.2	1.0	1.0	1.1	1.1	1.0
W	1.0	0.9	0.8	0.9	1.0	1.0	1.0
X	1.0	0.8	0.8	0.8	0.9	1.0	1.0
Y	1.0	0.8	0.7	0.7	0.8	1.0	1.1
Z	0.9	0.9	0.9	0.8	0.8	1.0	1.1

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 0.97 FT/SEC

	TRANSECT 2 (A)	TRANSECT 8 (A)
U	1.3	
V	1.2	
W	1.2	
X	1.2	
Y	1.2	
Z	1.0	

5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.18 FT/SEC

BYPASS ENTRANCE

$\bar{V}$ = FT/SEC

TEST NO.	25
TEST DATE	12/18/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	BUBBLE CURTAIN IN OPERATION

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.2	1.3	1.3	1.2	1.2	1.2	1.0
V	1.2	1.1	1.0	1.1	1.1	1.1	1.1
W	1.1	0.9	0.7	0.8	0.9	1.1	1.0
X	1.1	0.8	0.6	0.7	1.0	1.0	1.0
Y	1.0	0.8	0.7	0.7	0.9	1.1	1.2
Z	0.9	0.9	0.9	0.8	0.8	1.0	1.1

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 0.97 FT/SEC

	TRANSECT 2 A	TRANSECT 8 A
U	1.4	.
V	1.3	.
W	1.3	.
X	1.2	.
Y	1.2	.
Z	1.0	.

5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.23 FT/SEC

BYPASS ENTRANCE

$\bar{V}$ = FT/SEC

TEST NO.	26
TEST DATE	12/18/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	BUBBLE CURTAIN IN OPERATION

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.1	1.3	1.2	1.2	1.2	1.1	1.0
V	1.2	1.2	1.1	1.0	1.1	1.1	1.0
W	1.2	0.9	0.8	0.8	1.0	1.0	0.9
X	1.1	0.9	0.6	0.8	1.0	1.0	1.0
Y	1.1	1.0	0.8	0.8	0.8	1.0	1.0
Z	1.0	1.0	0.9	0.8	0.9	1.0	1.1

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 0.98 FT/SEC

TRANSECT 2

	A
U	1.3
V	1.3
W	1.2
X	1.2
Y	1.2
Z	1.1

5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.22 FT/SEC

TRANSECT 8

	A
U	.
V	.
W	.
X	.
Y	.
Z	.

BYPASS ENTRANCE

$\bar{V}$ = FT/SEC

TEST NO.	27
TEST DATE	12/18/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	BUBBLE CURTAIN IN PLACE

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.1	1.2	1.2	1.2	1.1	1.1	1.1
V	1.2	1.2	1.0	1.0	1.1	1.1	1.0
W	0.9	1.0	0.8	0.8	0.9	0.9	0.9
X	1.1	0.9	0.7	0.8	1.0	1.0	0.9
Y	1.0	0.9	0.8	0.7	0.8	1.0	1.0
Z	1.0	0.8	0.8	0.8	0.9	1.0	0.8

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 0.96 FT/SEC

	TRANSECT 2 A	TRANSECT 8 A
U	1.2	.
V	1.2	.
W	1.2	.
X	1.2	.
Y	1.1	.
Z	1.0	.

TRANSECT 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.15 FT/SEC

TRANSECT 8: BYPASS ENTRANCE

$\bar{V}$ = FT/SEC

TEST NO.	28
TEST DATE	12/18/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	BUBBLE CURTAIN IN PLACE

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.0	1.3	1.1	1.2	1.2	1.2	1.1
V	1.2	1.2	1.0	1.0	1.1	1.0	1.1
W	1.2	0.9	0.8	0.8	1.0	1.0	0.8
X	1.2	0.9	0.7	0.8	1.0	1.0	0.9
Y	1.1	1.0	0.9	0.8	0.7	1.1	1.0
Z	1.0	1.0	0.8	0.8	0.9	1.0	1.0

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.00 FT/SEC

TRANSECT 2 / TRANSECT 8

	TRANSECT 2 A	TRANSECT 8 A
U	0.7	.
V	1.3	.
W	1.3	.
X	1.2	.
Y	1.2	.
Z	1.1	.

5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.13 FT/SEC

BYPASS ENTRANCE

$\bar{V}$ = FT/SEC

TEST NO.	29
TEST DATE	12/18/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	BUBBLE CURTAIN IN PLACE

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.2	1.3	1.3	1.3	1.2	1.2	1.1
V	1.2	1.1	1.0	0.9	1.1	1.1	1.0
W	1.1	1.0	0.7	0.8	0.9	1.0	0.8
X	1.1	0.7	0.6	0.6	0.9	1.0	0.9
Y	0.7	0.6	0.7	0.6	0.8	0.9	1.0
Z	0.6	0.6	0.7	0.7	0.9	1.1	1.1

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 0.93 FT/SEC

	TRANSECT 2 (A)	TRANSECT 8 (A)
U	1.4	.
V	1.4	.
W	1.3	.
X	1.2	.
Y	1.2	.
Z	1.1	.

TRANSECT 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.27 FT/SEC

TRANSECT 8: BYPASS ENTRANCE

$\bar{V}$ = FT/SEC

TEST NO.	30
TEST DATE	12/29/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	BUBBLE CURTAIN IN OPERATION

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.2	1.3	1.3	1.1	1.2	1.1	1.1
V	1.2	1.2	1.0	1.0	1.0	1.1	1.1
W	1.1	0.9	0.7	0.5	0.9	0.9	0.9
X	1.0	0.9	0.6	0.7	0.8	1.0	1.0
Y	1.0	0.8	0.6	0.6	0.9	1.1	1.1
Z	0.8	0.9	0.8	0.7	0.8	1.1	1.1

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 0.90 FT/SEC

	TRANSECT 2 A	TRANSECT 8 A
U	1.2	.
V	1.2	.
W	1.2	.
X	1.2	.
Y	1.2	.
Z	1.1	.

5 FT. DOWNSTREAM
OF BYPASS ENTRANCE
$\bar{V}$ = 1.18 FT/SEC

BYPASS ENTRANCE
$\bar{V}$ = FT/SEC

TEST NO.	31
TEST DATE	12/30/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	BUBBLE CURTAIN IN OPERATION.

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.2	1.3	1.3	1.1	1.2	1.2	1.0
V	1.2	1.1	1.0	0.9	1.1	1.1	1.0
W	1.2	0.9	0.7	0.8	0.9	0.8	0.9
X	1.1	0.9	0.7	0.7	1.0	1.0	1.0
Y	1.1	1.0	0.8	0.7	0.9	1.0	1.1
Z	0.9	0.9	0.8	0.8	0.9	1.1	0.9

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 0.98 FT/SEC

	TRANSECT 2 A	TRANSECT 8 A
U	1.4	.
V	1.4	.
W	1.3	.
X	0.9	.
Y	1.2	.
Z	1.0	.

TRANSECT 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.20 FT/SEC

TRANSECT 8: BYPASS ENTRANCE

$\bar{V}$ = FT/SEC

TEST NO.	32
TEST DATE	12/31/75
TEST DEVICE:	SCREENS @ 25°
TEST CONDITION:	BUBBLE CURTAIN IN OPERATION.

FLUME VELOCITY DATA

TRANSECT 1

	G	F	E	D	C	B	A
U	1.4	1.5	1.5	1.5	1.5	1.5	1.4
V	1.4	1.2	1.1	1.2	1.3	1.4	1.3
W	1.2	1.0	0.8	0.8	1.0	1.2	1.2
X	1.1	0.9	0.6	0.4	0.7	1.0	1.1
Y	1.0	0.8	0.5	0.4	0.7	1.1	1.2
Z	0.8	0.7	0.6	0.5	0.8	1.1	1.2

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.04 FT/SEC

	TRANSECT 2 (A)	TRANSECT 8 (A)
U	1.0	.
V	1.1	.
W	1.0	.
X	0.9	.
Y	0.7	.
Z	0.6	.

5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 0.88 FT/SEC

BYPASS ENTRANCE

$\bar{V}$ = FT/SEC

TEST NO.	33
TEST DATE	1/27/76
TEST DEVICE:	SCREENS @ 45°
TEST CONDITION:	– – –

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.3	1.5	1.5	1.4	1.4	1.4	1.3
V	1.3	1.3	1.0	1.1	1.3	1.3	1.2
W	1.3	1.1	0.7	0.7	1.1	1.2	1.0
X	1.1	0.9	0.6	0.6	0.7	1.0	1.1
Y	1.0	0.9	0.5	0.4	0.7	1.0	1.1
Z	0.6	0.7	0.5	0.4	0.8	1.1	1.1

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.00 FT/SEC

TRANSECT 2

	A
U	0.8
V	0.9
W	0.8
X	0.7
Y	0.5
Z	0.3

5 FT. DOWNSTREAM
OF BYPASS ENTRANCE

$\bar{V}$ = 0.66 FT/SEC

TRANSECT 8

	A
U	.
V	.
W	.
X	.
Y	.
Z	.

BYPASS ENTRANCE

$\bar{V}$ = FT/SEC

TEST NO.	34
TEST DATE	1/28/76
TEST DEVICE:	SCREENS @ 45°
TEST CONDITION:	---

FLUME VELOCITY DATA

TRANSECT 1

	G	F	E	D	C	B	A
U	1.3	1.4	1.5	1.4	1.5	1.4	1.3
V	1.4	1.3	1.1	1.2	1.1	1.4	1.3
W	1.2	1.0	0.8	0.8	1.1	1.2	1.1
X	1.2	1.0	0.6	0.5	0.8	1.0	1.0
Y	1.0	0.8	0.6	0.5	0.8	1.1	1.2
Z	0.6	0.6	0.4	0.5	0.8	1.1	1.2

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.03 FT/SEC

TRANSECT 2 / TRANSECT 8

	Transect 2 A	Transect 8 A
U	1.1	.
V	1.2	.
W	1.1	.
X	1.1	.
Y	1.0	.
Z	0.8	.

BYPASS ENTRANCE

$\bar{V}$ = FT/SEC

TEST NO.	35
TEST DATE	1/28/76
TEST DEVICE:	SCREENS @ 45°
TEST CONDITION:	---

5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.05 FT/SEC

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.3	1.4	1.4	1.4	1.4	1.4	1.3
V	1.3	1.2	1.1	1.2	1.4	1.3	1.3
W	1.2	1.0	0.8	0.8	0.8	1.2	1.1
X	1.1	1.0	0.7	0.5	0.8	1.0	1.1
Y	1.1	0.9	0.6	0.5	0.8	1.1	1.2
Z	0.7	0.7	0.6	0.5	0.7	1.0	1.2

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.03 FT/SEC

	TRANSECT 2 A	TRANSECT 8 A
U	1.2	.
V	1.2	.
W	1.2	.
X	1.0	.
Y	1.0	.
Z	0.8	.

5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.07 FT/SEC

BYPASS ENTRANCE

$\bar{V}$ = FT/SEC

TEST NO. 36
TEST DATE 1/28/76
TEST DEVICE: SCREENS @ 45°

TEST CONDITION: ---

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	2.7	3.0	2.9	2.8	2.8	2.9	2.2
V	2.7	2.2	2.1	2.2	2.5	2.3	2.2
W	2.4	2.0	1.4	1.6	2.0	2.2	2.1
X	2.2	1.8	1.1	1.0	1.5	1.8	1.9
Y	2.0	1.6	1.1	0.9	1.4	1.9	2.0
Z	1.6	1.6	1.2	1.1	1.2	1.9	2.1

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.95 FT/SEC

	TRANSECT 2 (A)	TRANSECT 8 (A)
U	2.1	.
V	2.3	.
W	2.0	.
X	1.9	.
Y	1.6	.
Z	1.4	.

5 FT. DOWNSTREAM
OF BYPASS ENTRANCE
$\bar{V}$ = 1.88 FT/SEC

BYPASS ENTRANCE
$\bar{V}$ = FT/SEC

TEST NO. 37
TEST DATE 1/29/76
TEST DEVICE: SCREENS @ 45°

TEST CONDITION: – – –

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	2.6	2.8	2.8	2.8	2.9	2.8	2.6
V	2.6	2.3	2.2	2.2	2.6	2.6	2.5
W	2.4	1.9	1.5	1.5	1.8	2.1	2.1
X	2.1	1.6	1.3	1.1	1.6	1.9	1.9
Y	1.9	1.6	1.2	1.0	1.3	2.0	2.1
Z	1.7	1.7	1.2	1.0	1.3	2.0	2.2

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.98 FT/SEC

	TRANSECT 2 A	TRANSECT 8 A
U	2.1	.
V	2.0	.
W	2.2	.
X	1.9	.
Y	1.7	.
Z	1.4	.

5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.88 FT/SEC

BYPASS ENTRANCE

$\bar{V}$ = FT/SEC

TEST NO.	38
TEST DATE	1/29/76
TEST DEVICE:	SCREENS @ 45°
TEST CONDITION:	— — —

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	2.5	2.8	2.7	2.8	2.8	2.8	2.6
V	2.7	2.4	2.1	2.2	2.6	2.6	2.3
W	2.4	1.8	1.5	1.6	2.0	2.3	2.1
X	2.1	1.6	1.1	1.2	1.7	2.1	1.9
Y	1.8	1.5	1.1	1.0	1.5	2.1	2.1
Z	1.7	1.5	1.2	1.0	1.5	2.0	2.2

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.99 FT/SEC

TRANSECT 2 / TRANSECT 8

	TRANSECT 2 A	TRANSECT 8 A
U	2.1	.
V	2.2	.
W	2.1	.
X	2.0	.
Y	1.7	.
Z	1.4	.

5 FT. DOWNSTREAM
OF BYPASS ENTRANCE
$\bar{V}$ = 1.92 FT/SEC

BYPASS ENTRANCE
$\bar{V}$ = FT/SEC

TEST NO. 39
TEST DATE 1/29/76
TEST DEVICE: SCREENS @ 45°

TEST CONDITION: ---

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.2	1.2	1.1	1.2	1.1	1.1	1.0
V	1.2	1.2	1.2	1.2	1.2	1.0	1.0
W	1.2	1.2	1.2	1.2	1.2	1.1	1.0
X	1.2	1.1	1.1	1.1	1.1	1.1	1.1
Y	1.1	1.1	1.1	1.1	1.0	1.1	1.1
Z	1.0	1.1	1.1	1.0	1.1	0.9	1.1

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.11 FT/SEC

	TRANSECT 2 A	TRANSECT 8 A
U	1.6	1.7
V	1.6	1.7
W	1.6	1.7
X	1.5	1.6
Y	1.6	1.5
Z	1.5	1.5

5 FT. DOWNSTREAM
OF BYPASS ENTRANCE
$\bar{V}$ = 1.57 FT/SEC

BYPASS ENTRANCE
$\bar{V}$ = 1.62 FT/SEC

TEST NO. 1
TEST DATE 10/3/75
TEST DEVICE: LOUVERS @ 25°

TEST CONDITION: ---

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	2.2	2.1	2.4	2.5	2.2	2.0	1.7
V	2.2	2.3	2.2	2.2	2.1	1.9	1.6
W	2.1	1.9	1.8	1.9	2.0	2.2	1.7
X	2.0	1.8	1.7	1.6	1.6	1.8	1.8
Y	2.0	2.0	1.9	1.8	1.5	1.6	1.8
Z	1.9	2.0	1.8	1.5	1.5	1.5	1.8

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.91 FT/SEC

	TRANSECT 2 (A)	TRANSECT 8 (A)
U	2.6	2.7
V	3.1	3.2
W	3.1	3.1
X	3.0	2.9
Y	3.1	3.1
Z	2.4	3.0

5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 2.90 FT/SEC

BYPASS ENTRANCE

$\bar{V}$ = 3.00 FT/SEC

TEST NO.	3
TEST DATE	10/15/75
TEST DEVICE:	LOUVERS @ 25°
TEST CONDITION:	– – –

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	2.1	2.3	2.3	2.1	2.0	2.0	1.9
V	2.1	2.2	2.1	2.1	2.0	2.0	1.8
W	2.2	2.1	2.1	2.1	2.0	2.0	1.9
X	1.9	2.0	2.0	1.9	1.9	1.9	2.0
Y	1.9	1.9	2.0	2.0	1.9	1.7	1.8
Z	1.7	1.9	1.8	1.8	1.8	1.7	1.6

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.96 FT/SEC

TRANSECT 2

	A
U	3.0
V	3.3
W	3.2
X	3.2
Y	3.2
Z	3.0

5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 3.15 FT/SEC

TRANSECT 8

	A
U	3.1
V	3.4
W	3.4
X	3.3
Y	3.2
Z	3.0

BYPASS ENTRANCE

$\bar{V}$ = 3.23 FT/SEC

TEST NO. 4
TEST DATE 10/16/75
TEST DEVICE: LOUVERS @ 25°

TEST CONDITION: – – –

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	3.1	3.4	3.7	3.7	3.5	3.1	2.9
V	3.2	3.3	3.3	3.3	3.2	3.0	2.8
W	3.1	2.9	2.9	3.0	3.0	2.8	2.7
X	3.0	2.7	2.8	2.6	2.7	2.8	2.8
Y	2.5	2.6	2.7	2.8	2.7	2.4	2.5
Z	2.7	2.6	2.6	2.6	2.5	2.4	2.4

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 2.89 FT/SEC

	TRANSECT 2 (A)	TRANSECT 8 (A)
U	5.0	4.1
V	4.9	4.8
W	4.9	5.0
X	4.8	4.6
Y	4.1	4.4
Z	4.0	3.9

TRANSECT 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 4.62 FT/SEC

TRANSECT 8: BYPASS ENTRANCE

$\bar{V}$ = 4.47 FT/SEC

TEST NO.	5
TEST DATE	10/20/75
TEST DEVICE:	LOUVERS @ 25°
TEST CONDITION:	– – –

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.2	1.2	1.2	1.1	1.2	1.2	1.1
V	1.1	1.0	1.0	1.1	1.1	1.1	1.0
W	1.0	1.0	0.9	1.0	1.0	1.0	1.0
X	1.0	1.0	1.0	0.9	1.0	1.0	1.0
Y	1.0	1.0	1.0	0.8	0.8	1.0	1.0
Z	0.9	1.0	0.8	0.7	0.8	1.0	1.0

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.00 FT/SEC

	TRANSECT 2 (A)	TRANSECT 8 (A)
U	1.3	1.4
V	1.4	1.5
W	1.5	1.5
X	1.5	1.5
Y	1.5	1.5
Z	1.4	1.4

TRANSECT 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.43 FT/SEC

TRANSECT 8: BYPASS ENTRANCE

$\bar{V}$ = 1.47 FT/SEC

TEST NO.	7
TEST DATE	11/12/75
TEST DEVICE:	LOUVERS @ 25°
TEST CONDITION:	SALINE WATER

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	2.2	2.4	2.5	2.6	2.7	2.7	2.4
V	2.3	2.4	2.4	2.3	2.4	2.4	2.4
W	2.1	2.2	2.1	2.0	1.9	2.0	2.0
X	2.0	2.1	1.8	1.7	1.8	1.9	2.1
Y	2.1	2.1	1.4	1.5	2.0	2.0	2.0
Z	1.9	2.0	1.7	1.4	1.9	2.0	2.0

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 2.09 FT/SEC

	TRANSECT 2 (A)	TRANSECT 8 (A)
U	2.9	3.1
V	3.3	3.4
W	3.1	3.2
X	3.2	3.1
Y	3.1	3.0
Z	2.9	2.8

TRANSECT 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 3.08 FT/SEC

TRANSECT 8: BYPASS ENTRANCE

$\bar{V}$ = 3.10 FT/SEC

TEST NO.	8
TEST DATE	11/12/75
TEST DEVICE:	LOUVERS @ 25°
TEST CONDITION:	SALINE WATER

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	2.2	2.3	2.5	2.5	2.6	2.6	2.4
V	2.1	2.3	2.4	2.1	2.1	2.1	2.3
W	2.0	2.1	2.2	2.1	2.0	2.0	2.1
X	2.0	2.0	1.6	1.5	1.7	1.8	1.9
Y	2.0	1.9	1.5	1.5	1.8	1.9	1.9
Z	1.9	1.9	1.3	1.5	1.8	1.9	1.6

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 2.00 FT/SEC

	TRANSECT 2 A	TRANSECT 8 A
U	3.0	4.2
V	3.3	3.3
W	3.1	3.0
X	2.4	3.2
Y	2.8	3.0
Z	2.9	3.0

5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 2.92 FT/SEC

BYPASS ENTRANCE

$\bar{V}$ = 3.28 FT/SEC

TEST NO.	9
TEST DATE	11/13/75
TEST DEVICE:	LOUVERS @ 25°
TEST CONDITION:	SALINE WATER

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.3	1.3	1.2	1.2	1.3	1.2	1.1
V	1.2	1.1	1.1	1.2	1.2	1.2	1.1
W	1.1	1.0	1.0	1.0	1.0	1.1	1.0
X	1.0	1.0	1.0	0.9	0.9	1.0	1.0
Y	1.0	1.0	1.0	0.8	0.7	1.0	1.0
Z	0.9	0.9	0.7	0.6	0.8	1.0	1.0

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.03 FT/SEC

	TRANSECT 2 (A)	TRANSECT 8 (A)
U	1.5	1.5
V	1.5	1.4
W	1.4	1.4
X	1.4	1.4
Y	1.4	1.4
Z	1.2	1.2

TRANSECT 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.40 FT/SEC

TRANSECT 8: BYPASS ENTRANCE

$\bar{V}$ = 1.38 FT/SEC

TEST NO.	10
TEST DATE	11/13/75
TEST DEVICE:	LOUVERS @ 25°
TEST CONDITION:	SALINE WATER

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.2	1.4	1.3	1.2	1.2	1.2	1.1
V	1.2	1.2	1.1	1.2	1.2	1.2	1.2
W	1.2	0.9	0.8	0.9	1.0	1.1	1.0
X	1.1	0.9	0.8	0.8	0.8	1.1	1.1
Y	1.1	1.0	0.9	0.9	0.8	1.0	1.1
Z	0.9	1.0	0.9	0.8	0.8	1.0	1.1

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.04 FT/SEC

	TRANSECT 2 A	TRANSECT 8 A
U	1.3	.
V	1.4	.
W	1.3	.
X	1.3	.
Y	1.2	.
Z	1.2	.

5 FT. DOWNSTREAM
OF BYPASS ENTRANCE
$\bar{V}$ = 1.28 FT/SEC

BYPASS ENTRANCE
$\bar{V}$ = FT/SEC

TEST NO.	11
TEST DATE	12/15/75
TEST DEVICE:	LOUVERS @ 25°
TEST CONDITION:	BUBBLE CURTAIN IN PLACE

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.2	1.2	1.2	1.2	1.2	1.2	1.1
V	1.2	1.1	1.1	1.0	1.1	0.9	1.0
W	1.0	0.9	0.8	0.8	1.0	1.0	0.8
X	0.9	0.8	0.7	0.7	0.8	1.0	1.0
Y	1.0	0.9	0.8	0.8	0.8	0.9	1.0
Z	0.8	0.9	0.9	0.8	0.8	1.0	0.9

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 0.96 FT/SEC

TRANSECT 2

	A
U	1.2
V	1.3
W	1.3
X	1.2
Y	1.2
Z	1.1

5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.22 FT/SEC

TRANSECT 8

	A
U	.
V	.
W	.
X	.
Y	.
Z	.

BYPASS ENTRANCE

$\bar{V}$ = FT/SEC

TEST NO.	12
TEST DATE	12/15/75
TEST DEVICE:	LOUVERS @ 25°
TEST CONDITION:	BUBBLE CURTAIN IN PLACE

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.3	1.3	1.3	1.2	1.2	1.2	1.1
V	1.2	1.2	1.1	1.1	0.9	1.1	1.1
W	1.2	1.0	0.8	0.9	1.0	1.0	1.0
X	1.1	0.9	0.8	0.7	0.8	1.0	1.0
Y	1.0	1.0	0.9	0.9	0.8	1.0	0.9
Z	0.9	1.0	0.9	0.8	0.8	1.0	1.0

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.02 FT/SEC

	TRANSECT 2 A	TRANSECT 8 A
U	1.0	.
V	1.2	.
W	1.3	.
X	1.3	.
Y	1.1	.
Z	1.0	.

TRANSECT 2: 5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.15 FT/SEC

TRANSECT 8: BYPASS ENTRANCE

$\bar{V}$ = FT/SEC

TEST NO.	13
TEST DATE	12/16/75
TEST DEVICE:	LOUVERS @ 25°
TEST CONDITION:	BUBBLE CURTAIN IN PLACE

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.3	1.3	1.3	1.3	1.2	1.2	1.2
V	1.3	1.2	1.2	1.2	1.2	1.2	1.2
W	1.2	1.0	0.8	0.9	1.0	1.0	1.0
X	1.1	0.9	0.7	0.8	0.8	1.1	1.0
Y	1.0	1.0	0.9	0.9	0.8	1.0	1.1
Z	0.8	0.9	0.9	0.8	0.8	1.0	1.1

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.04 FT/SEC

TRANSECT 2 / TRANSECT 8

	Transect 2: A	Transect 8: A
U	1.3	.
V	1.3	.
W	1.3	.
X	1.3	.
Y	1.2	.
Z	1.2	.

5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.34 FT/SEC

BYPASS ENTRANCE

$\bar{V}$ = FT/SEC

TEST NO.	14
TEST DATE	12/16/75
TEST DEVICE:	LOUVERS @ 25°
TEST CONDITION:	BUBBLE CURTAIN IN PLACE

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.2	1.3	1.3	1.3	1.2	1.2	1.1
V	1.2	1.2	1.1	1.1	1.1	1.1	1.0
W	1.2	1.0	0.8	0.8	1.0	1.1	0.9
X	1.1	0.9	0.8	0.7	0.8	1.0	1.0
Y	1.0	0.9	0.9	0.8	0.8	1.0	1.1
Z	0.9	1.0	0.9	0.8	0.8	1.0	1.1

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.01 FT/SEC

	TRANSECT 2 (A)	TRANSECT 8 (A)
U	1.4	.
V	1.3	.
W	1.3	.
X	1.3	.
Y	1.2	.
Z	1.1	.

5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.27 FT/SEC

BYPASS ENTRANCE

$\bar{V}$ = FT/SEC

TEST NO.	15
TEST DATE	12/16/75
TEST DEVICE:	LOUVERS @ 25°
TEST CONDITION:	BUBBLE CURTAIN IN OPERATION

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.3	1.4	1.3	1.2	1.3	1.2	1.1
V	1.2	1.2	1.0	1.0	1.1	1.2	1.0
W	1.0	0.9	0.8	0.9	1.0	1.1	0.9
X	1.2	0.9	0.7	0.7	0.8	1.0	1.0
Y	1.0	0.9	0.9	0.9	0.9	1.0	1.1
Z	1.0	1.1	0.8	0.9	0.9	1.1	1.1

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.02 FT/SEC

	TRANSECT 2 A	TRANSECT 8 A
U	0.8	·
V	1.4	·
W	1.2	·
X	1.1	·
Y	1.3	·
Z	1.2	·

5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.17 FT/SEC

BYPASS ENTRANCE

$\bar{V}$ = FT/SEC

TEST NO.	16
TEST DATE	12/16/75
TEST DEVICE:	LOUVERS @ 25°
TEST CONDITION:	BUBBLE CURTAIN IN OPERATION

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.4	1.4	1.4	1.3	1.3	1.3	1.2
V	1.4	1.3	1.1	1.0	0.9	1.3	1.2
W	1.3	0.8	0.8	0.9	0.9	1.1	1.0
X	1.1	0.9	0.7	0.7	1.0	1.1	1.0
Y	1.1	0.9	0.9	0.8	1.0	1.1	1.2
Z	0.8	0.8	1.0	0.9	1.0	1.0	1.2

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.06 FT/SEC

	TRANSECT 2 (A)	TRANSECT 8 (A)
U	1.3	.
V	1.4	.
W	1.4	.
X	1.2	.
Y	1.3	.
Z	1.2	.

5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.30 FT/SEC

BYPASS ENTRANCE

$\bar{V}$ = FT/SEC

TEST NO.	17
TEST DATE	12/17/75
TEST DEVICE:	LOUVERS @ 25°
TEST CONDITION:	BUBBLE CURTAIN IN OPERATION

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.3	1.3	1.3	1.3	1.3	1.2	1.1
V	1.2	1.1	1.1	1.0	1.1	1.1	1.1
W	1.2	0.9	0.7	0.7	1.0	1.0	1.0
X	1.1	0.8	0.6	0.6	0.8	1.0	1.1
Y	1.0	0.9	0.6	0.5	0.9	1.1	1.1
Z	0.8	0.8	0.7	0.7	0.8	1.1	1.2

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 0.98 FT/SEC

TRANSECT 2

	A
U	1.6
V	1.5
W	1.4
X	1.5
Y	1.4
Z	1.4

5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.47 FT/SEC

TRANSECT 8

	A
U	.
V	.
W	.
X	.
Y	.
Z	.

BYPASS ENTRANCE

$\bar{V}$ = FT/SEC

TEST NO.	18
TEST DATE	1/5/76
TEST DEVICE:	LOUVERS @ 25°
TEST CONDITION:	BUBBLE CURTAIN IN PLACE

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.2	1.3	1.3	1.3	1.2	1.2	1.1
V	1.2	1.2	1.0	1.0	1.1	1.2	1.0
W	1.2	0.9	0.7	0.8	0.9	1.0	0.8
X	1.1	0.9	0.7	0.6	0.8	1.1	1.1
Y	1.0	0.9	0.7	0.5	0.8	1.1	1.1
Z	0.8	0.9	0.7	0.7	0.8	1.1	1.2

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 0.94 FT/SEC

TRANSECT 2 and TRANSECT 8

	TRANSECT 2: A	TRANSECT 8: A
U	1.6	
V	1.5	
W	1.5	
X	1.5	
Y	1.5	
Z	1.4	

5 FT. DOWNSTREAM
OF BYPASS ENTRANCE
$\bar{V}$ = 1.50 FT/SEC

BYPASS ENTRANCE
$\bar{V}$ = FT/SEC

TEST NO.	19
TEST DATE	1/6/76
TEST DEVICE:	LOUVERS @ 25°
TEST CONDITION:	BUBBLE CURTAIN IN PLACE

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.3	1.4	1.4	1.3	1.3	1.3	1.2
V	1.3	1.1	1.0	1.0	1.2	1.3	1.1
W	1.2	0.9	0.7	0.8	1.0	1.1	1.1
X	1.1	1.3	0.6	0.6	0.9	1.0	1.1
Y	1.1	0.8	0.6	0.5	1.0	1.2	1.2
Z	0.9	0.8	0.6	0.7	0.9	1.0	1.2

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.03 FT/SEC

TRANSECT 2 | TRANSECT 8

	TRANSECT 2 A	TRANSECT 8 A
U	1.6	.
V	1.5	.
W	1.5	.
X	1.5	.
Y	1.5	.
Z	1.4	.

5 FT. DOWNSTREAM
OF BYPASS ENTRANCE
$\bar{V}$ = 1.50 FT/SEC

BYPASS ENTRANCE
$\bar{V}$ = FT/SEC

TEST NO.	20
TEST DATE	1/6/76
TEST DEVICE:	LOUVERS @ 25°
TEST CONDITION:	BUBBLE CURTAIN IN PLACE

FLUME VELOCITY DATA

ARL

TRANSECT 1

	G	F	E	D	C	B	A
U	1.3	1.4	1.4	1.4	1.3	1.3	1.1
V	1.2	1.2	1.0	1.1	1.1	1.2	1.1
W	1.2	0.9	0.7	0.8	1.0	1.1	1.0
X	1.1	0.9	0.6	0.6	0.8	1.1	1.1
Y	1.1	0.9	0.6	0.5	0.8	1.1	1.2
Z	0.8	0.8	0.7	0.7	0.8	1.1	1.2

10 FT. UPSTREAM OF TEST DEVICE

$\bar{V}$ = 1.01 FT/SEC

	TRANSECT 2 A	TRANSECT 8 A
U	1.6	.
V	1.6	.
W	1.5	.
X	1.5	.
Y	1.5	.
Z	1.4	.

5 FT. DOWNSTREAM OF BYPASS ENTRANCE

$\bar{V}$ = 1.52 FT/SEC

BYPASS ENTRANCE

$\bar{V}$ = FT/SEC

TEST NO.	21
TEST DATE	1/6/76
TEST DEVICE:	LOUVERS @ 25°
TEST CONDITION:	BUBBLE CURTAIN IN PLACE

FLUME VELOCITY DATA

19-6E