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DEPARTMENT OF HEALTH AND HUMAN SERVICES
U.S. PUBLIC HEALTH SERVICE
FOOD AND DRUG ADMINISTRATION

Yaquina Bay, Oregon
Comprehensive Sanitary Survey
May, 1984 and November-December, 1984

State of Oregon
Department of Health and
Department of Environmental Quality
and the
U.S. Food and Drug Administration

by
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Northeast Technical Services Unit
February, 1985

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Also assisting in the May study was trainee Mr. Kirk Cook of the State of Washington.

EXECUTIVE SUMMARY

During the periods May 14-23, 1984 and November 28 - December 9, 1984, the State of Oregon and the Food and Drug Administration cooperatively conducted comprehensive studies of the sanitary quality of the Yaquina Bay commercial shellfish areas. This report provides the results and conclusions of those studies with respect to the classification of the Bay.

The major thrust of the studies was to develop a management plan to assure safe shellfish. It was felt by the Oregon Departments of Health and Environmental Quality and the Region X, Senior Regional Shellfish Specialist that historical information showed sporadic poor water quality and that a conditionally approved area plan was needed.

The two studies, and additional works by Oregon in the summer, 1984, demonstrated that the area cannot be classified as approved for direct marketing. No station in the commercial oyster area met the national program criteria.
WINTER ONLY
Not only is water quality [redacted], microbiologically, but fecal coliform levels reached [redacted] levels at times.
???

The use of the conditionally approved area concept is not feasible during most of the year including the major oyster harvesting period of the fall and winter because of the following reasons:

1. Pollution sources including point and nonpoint human, and nonpoint animal were found to affect the microbiological levels of the area at any time. Additionally, rain events compound the problems even more. The Toledo sewage treatment plant does not have the reliability factors built in to the plant that are designed to protect shellfish waters.

2. The hydrographic factors are not conducive to the development of a management plan because of little dispersion, insufficient dilution, proximity of the pollution sources and short times of travel. Meteorlogical factors detrimental to a plan include frequent heavy rains and small hilly watersheds causing rapid runoff. However, numerous low lying areas with horses and animals, easily flood, causing pollution of the tributaries which discharge directly to the estuary.

3. Bacterial water quality of the commercial area degrades quickly i.e. within a day, and is slow to recover with average flushing times of 3 or more days. The fecal coliform levels persisted well above the national program criteria for several more days. At low tide, fecal

coliform levels, whether in drier seasons or wet seasons, do not meet the national program criteria.

Because of these reasons it cannot be recommended that Yaquina Bay remain open for direct marketing of shellfish either as an approved area or as a conditionally approved area. To develop a conditionally approved area management plan, certain long term solutions are possible with respect to abating the various pollution sources and increasing the reliability of the Toledo sewage treatment plant.

The feasible option available to the industry is the development of controlled shellfish purification systems. Inexpensive purification system components are readily available. The appendix of the report provides suggested equipment.

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INTRODUCTION

Yaquina Bay and River comprise a 12 mile long narrow estuary on the central Oregon coast. The City of Newport is located near the mouth and the City of Toledo near the head. The lower 3 miles are usually called Yaquina Bay and the remainder, Yaquina River: - for purposes of this report the entire system will be termed Yaquina Bay.

Pacific oysters have provided a viable industry for many years in Yaquina Bay, with one dealer having operated for over 70 years. The oysters are held on racks or rafts rather than on the bottom. Thus the pollution effects of surface water may affect the sanitary quality of the oysters.

For a number of years, the FDA Regional office has expressed concern about the sanitary quality of the commercial oyster area because there has never been a full comprehensive survey. The Oregon Department of Environmental Quality (DEQ) conducted its last major sampling in May, 1982 over a two day period. The data revealed a significant difference in fecal coliform levels from high to low tide from the middle of the approved commercial area (fecal coliform greater than 20/100ml) to Toledo (fecal coliform greater than 100/100ml). The DEQ report concluded that there was a need for further investigation. The report stated: "Past historical data support the findings of this survey and indicate a sustained high level of fecal contamination in the upper closure area influencing the commercial oyster growing area below."

The State of Oregon is a member of the National Shellfish Sanitation Program (NSSP) or as currently also named the Interstate Shellfish Sanitation Program (ISSP). Shippers located in Oregon who ship shellfish interstate are placed on the Interstate Shippers List by the State. By being on the list the shippers are certified and by belonging to the interstate program, the State agrees to adhere to the sanitation requirements of the program. It was in this regard that this study developed.

PURPOSE OF THE STUDY

The impetus for this study came from concerns expressed by the Region X annual reviews. These reviews concluded that insufficient work has been done to determine the adverse hydrographic and pollution conditions. In other words, a comprehensive sanitary survey had not been done. Whatever monitoring has been done in recent years indicated that there were high bacterial levels at certain times and that actual and potential pollution sources existed in the watershed.

Because of the existence of a sewage treatment plant, some industry, frequent rain in fall and winter, and sporadic high fecal coliform levels, there appeared to be a need to develop a <u>conditionally approved</u> area management plan. The need for this plan was fortified by the occurrence of a significant pollution event which occurred in November, 1984. Because of the lack of a definitive management plan, no action was taken to prevent harvesting.

The main purpose of the study was to develop sufficient pollution source information, hydrographic data, and bacteriological water quality data which would lead to a management plan.

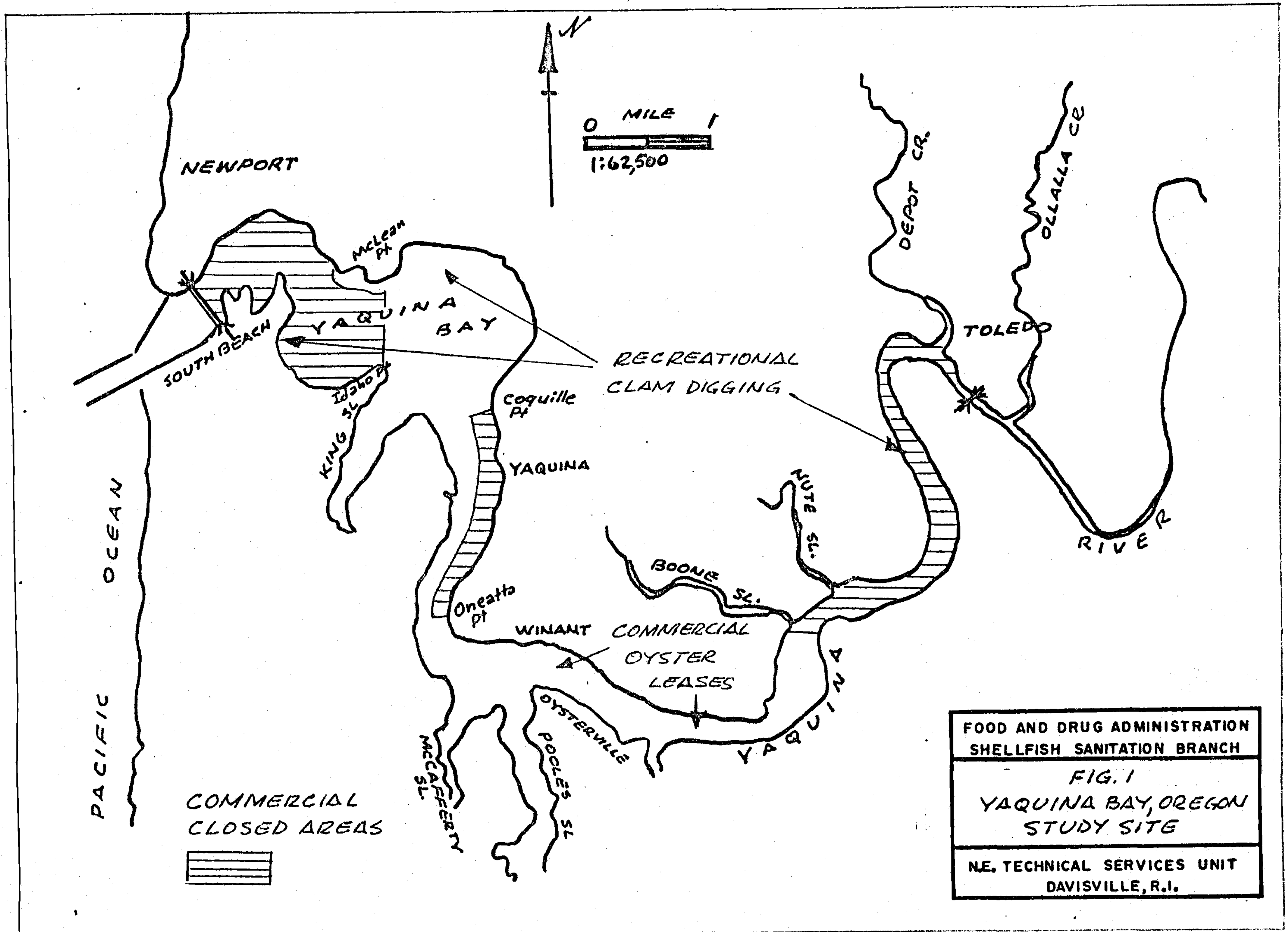
DESCRIPTION OF THE AREA

Figure 1 shows the estuary and the main tributaries. The City of Newport (population c.8000) is located at the coast. The industrial City of Toledo (population c.3000) is located 12 miles up the estuary. Newport is an active port area with fishing, seafood processing and tourism. Toledo is active in wood products including a large pulp and paper company.

The watershed is hilly with extensive forests with lumbering throughout. Along the Bay, there are houses along the shoreline, tidal marshes and foothills, camp sites, and boat docking facilities. Certain low lying areas along the tributaries and the main part of the river are used for pastures for cows and sheep.

Yaquina Bay is situated within the zone of typical Pacific Northwest weather; i.e. a wet, rainy season, November - March; and a drier season, April - October.

At Newport the mean tide range is 6.0 feet and the diurnal range is 8.1 feet. The times of the tides at Toledo lag those of Newport by about an hour. The fresh water portion of the Yaquina River is tidal for several miles above Toledo.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0 MILE 1
1:62,500
NEWPORT
McLean Pt
YAQUINA BAY
SOUTH BEACH
Idaho Pt
KING SL
RECREATIONAL CLAM DIGGING
Coquille Pt
YAQUINA
DEPOT CR.
OLLALLA CR
TOLEDO
RIVER
NUTE SL.
BOONE SL.
Oneatta Pt
WINANT
COMMERCIAL OYSTER LEASES
YAQUINA
OYSTERVILLE
POOLES SL
McCAFFERTY SL.
PACIFIC OCEAN
COMMERCIAL CLOSED AREAS
FOOD AND DRUG ADMINISTRATION
SHELLFISH SANITATION BRANCH
FIG. 1
YAQUINA BAY, OREGON
STUDY SITE
N.E. TECHNICAL SERVICES UNIT
DAVISVILLE, R.I.

The commerically approved growing area shown on Figure 1 is located mid-way between the two cities. This portion of the estuary with proper temperature and salinity apparently has been quite supportive of pacific oysters. However, the effects of siltation have prevented bottom culturing and the oysters grow on racks or rafts. Three oyster dealers were operating at the time of the study. In addition, the estuary supports active recreational harvesting of razor and softshell clams with tidal flats as close as two miles from Toledo being used.

SCOPE OF THE STUDY

This study can be considered a full comprehensive sanitary survey of the area. The survey entailed the identification and evaluation of actual or potential sources of pollution, hydrographic studies and an intensive bacteriological sampling program.

Identification of the actual or potential pollution sources is important because these are the sources of disease organisms and the bacterial indicators of pollution that are measured. The evaluation of these sources includes a certain amount of sampling. Hydrography is particularly important in Yaquina Bay since the site of the commercial oyster leases are in the middle reaches of the estuary. Times of travel of pollution sources can be short. Available estuarine dilution may not be adequate under certain circumstances.

Hydrographic work usually includes pollution tracing studies and salinity measurements.

An adequate sampling program for the bacteriological water quality is extremely important. Prevention of disease transmission from polluted shellfish means that applicable standards are adhered to. The sampling program must assure that water quality standards are or are not met.

The field studies of 1984 covered three periods: May, usually a dry period or a transition from the wet season to the dry summer; August, the dry period; and November - December, the rainy season. Additional data were available from the special research by the FDA Region X Seafood Products Research Center (SPRC) in September. The May and November-December studies involved intensive sampling for ten days. In May, estuarine stations were sampled twice a day for most of the study. In November-December, most stations were sampled only once per day, but generally close to the low tide period. This was found to be an adverse hydrographic situation with respect to water quality in the commercial area.

CONDITIONS OF THE SURVEYS

Table 1 gives the rainfall data for the two study periods. During May there were moderate amounts of rain. For the

TABLE 1

YAQUINA BAY

RAINFALL DATA

DATE MAY 1984	NEWPORT AIRPORT	TOLEDO WWTP	
10	.37	.77	
11	.05	.16	
12	.01	0	
13	.31	.34	
14	.16	.25	Study began
15	.21	.07	
16	.06	0	
17	0	.03	
18	0	0	
19	.95	.44	
20	0	.03	
21	Trace	.14	
22	.85	.94	
23	.03	-	Study ended

DATE	NEWPORT AIRPORT		TOLEDO STP
Nov. 1	1.20		2.58
2	1.34		0.64
3	0.15		0.66
4	0.45		0.0
5	0.0		0.47
6	0.73		0.95
7	0.60		0.50
8	1.01		0.76
9	0.56		1.05
10	0.55		0.30
11	0.77		1.00
12	0.68		0.71
13	0.91		0.31
14	0.03		0.0
15	0.06		0.14
16	0.0		0.0
17	0.60		0.81
18	0.42		0.18
19	0.59		1.18
20	0.96		0.04
21	0.02		0.00
22	0.0		0.68
23	1.30		1.57
24	0.56		0.48
25	0.31		0.07
26	0.12		1.90
27	2.43		2.82
28	0.60	Study began	0.41
29	1.66		1.22
30	.18		0.16
Dec. 1	.09		0.0
2	.10		0.13
3	.04		0.0
4	0.0		0.0
5	0.0		0.0
6	-	Study ended	-

November-December period, the study began with heavy rain. The month of November was extremely wet, but this is not too unusual for coastal Oregon. At the start of the November - December study the rivers and streams were swollen and the low-lying portions along the river and estuary banks were flooded. As the study progressed, however, the weather became sunny and bright with little rain. The rivers dropped in level and the fresh water in the Bay slowly began to flush out.

For both studies, stratification of the Bay was evident with the fresher water found at the surface. The stratification was found to within one mile down from Toledo.

The tides for the May survey were during an extreme period: i.e. at the beginning, low tides were as low as - 1.7 feet and high tide up to 8.8 feet at Toledo - for a range of 10.5 feet. At the end of the survey the range was about 6.3 feet. For November - December, the survey began with a tide range of about 7.5 feet and ended with a range of about 8.5 feet.

METHODS

SOURCES OF POLLUTION

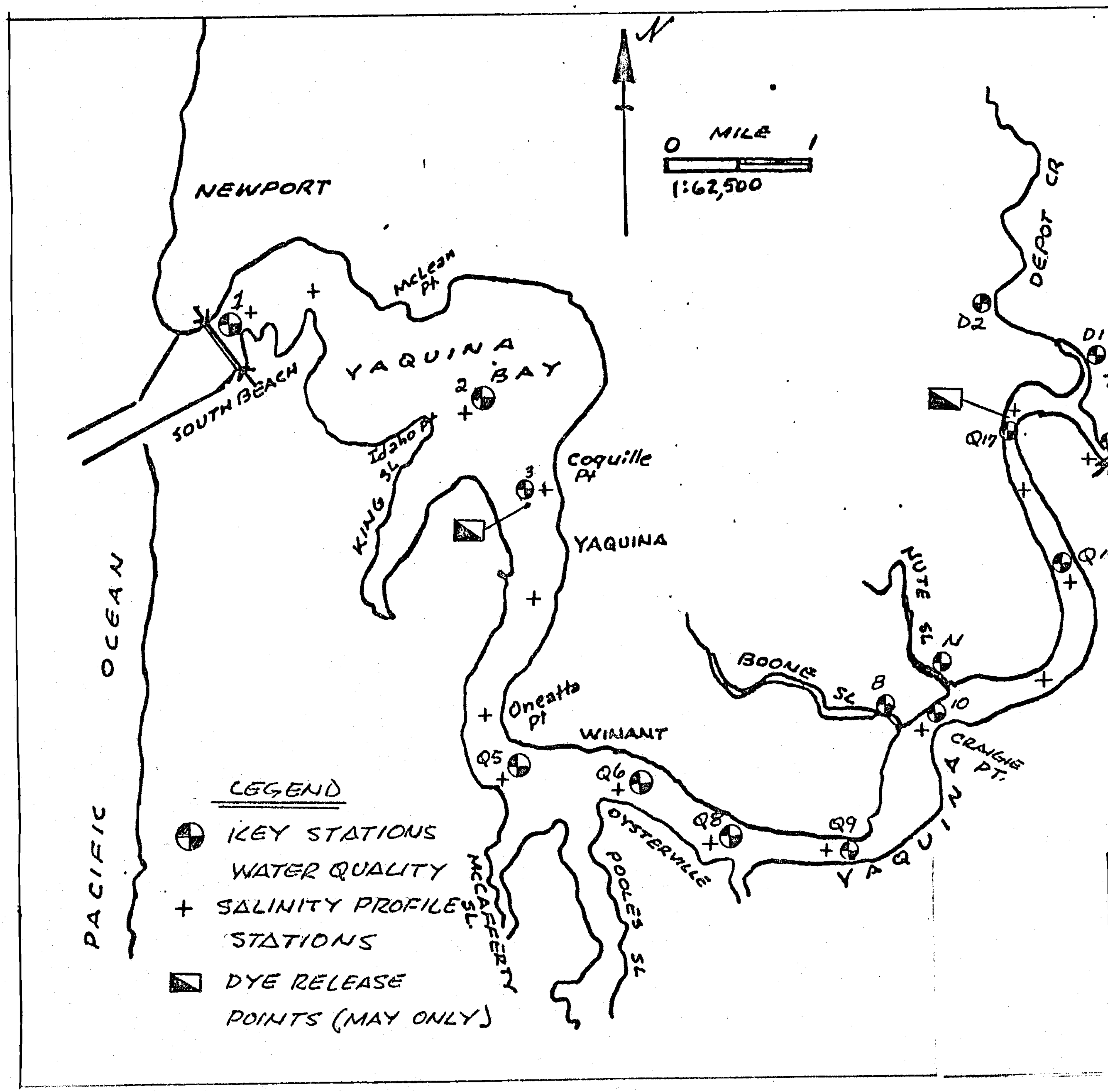
Most of the watershed was covered by boat and automobile in order to identify potential pollution sources. Numerous pipes, ditches; tributaries and channels evident from the investigation were established as sampling points. The City of Newport was not deemed to be a significant pollution factor since it had a sewage treatment plant (STP) with an ocean outfall. The Toledo STP was deemed to be a potential problem because it was a conventional secondary plant which discharged to the Yaquina River and could fail depending on circumstances. Thus, samples of raw and treated effluent were collected and examined. The major industry in Toledo, a large pulp and paper company had an ocean outfall. Other smaller industries had discharges mainly via floor and yard drains.

HYDROGRAPHY

Hydrographic studies were done in order to ascertain the time of travel and dilution of the potential sources in the Toledo area. The studies included instantaneous and continuous dye tracer methods and salinity profile measurements. The dye studies were carried out during the May period. Salinity profiles were done in both the May and November - December periods. Figure 2 shows the locations of the dye releases and salinity profile measurements. The amounts of dye and the times of release are given in Figure 3. The data from these studies produce estimates of time of travel, predictions of tidal excursion and dilution. The available dilution is derived from estimates of flow rate of the river either during ebb or flood tide.

Rhodamine B dye was used in all the studies. The amounts used were estimated from preliminary estimates of available dilution water. Two ebb tide studies were done to follow pollution from the Toledo area. One was an instantaneous release downstream from Toledo. The other was a continuous release into the effluent of the Toledo STP. Both served to determine ebb tide excursion and dilution from the Toledo area. Another dye release was made on flooding tide to demonstrate tidal excursion from the Newport area.

Figure 2 shows the sites of the salinity measurements made to determine the salinity gradients from the head of the estuary to the mouth. Also the vertical profiling was done to determine the extent of stratification. It is well known that fresh water usually stays on the surface a salt water wedge below. The vertical mixing pattern is an important factor in estimating dilution of the pollutants.



FOOD AND DRUG ADMINISTRATION
SHELLFISH SANITATION BRANCH

FIG. 2
KEY STATIONS

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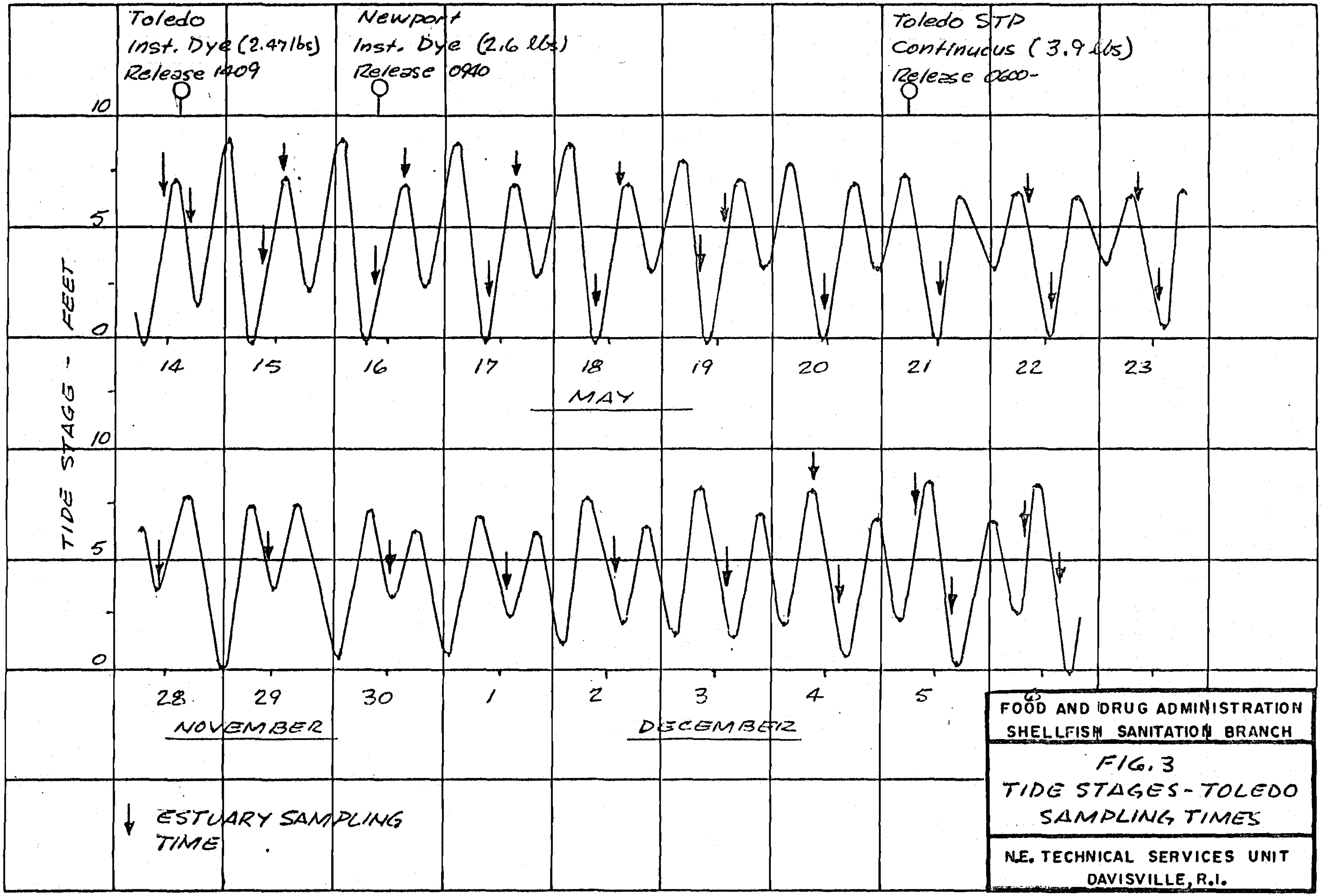

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FIG. 3
TIDE STAGES - TOLEDO
SAMPLING TIMES

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The salinity techniques also serve to complement the dye studies and provide another method to estimate tidal excursion and dilution. Salinity data were also available from the routine water quality sampling. The salinity data also supplements the use of Ketchum's analysis of flushing of the Bay given later in the report.

BACTERIOLOGICAL SAMPLING PLAN

Sampling stations in Yaquina Bay and its tributaries were established according to a number of considerations including: past history of sampling at established DEQ stations (the "Q" stations); actual pollution sources; potential pollution sources; tributary size; distance between stations along the Bay; and location of the commercial area. Figure 2 shows the key sampling sites.

During the May and November - December studies, tidal considerations determined the timing of the sampling with most samples being taken at low or ebbing tides which usually represent adverse hydrographic conditions. If pollution from Newport was a significant factor, flood tide sampling would have had to be emphasized. However, samples at high and flooding tides were also collected so that a comparison could be made between the two tides.

The duration of the study was determined by the practicality and logistics of intensive surveys. The May study was planned for ten consecutive days. The November - December study was planned for one day of preliminary tributary sampling followed by nine consecutive days of estuarine and tributary samples. These two time periods, it was felt would be sufficient to provide data over a variety of conditions, including rainfall, possible STP variations and the like. The time period should also provide sufficient data to allow certain statistical analyses to be made with confidence.

The timing of the studies; i.e. May and the November - December periods was planned for moderate and severe conditions which in general were fulfilled.

Figure 3 provides the tide levels during the two studies and the actual estuary sampling times for each day.

Sample collection and laboratory methods for the bacteriological tests followed the procedures outlined in "Recommended Procedures for the Examination of Sea Water and Shellfish," APHA, 1970 or "Standard Methods for the Examination of Water and Wastewater;" APHA, AWWA, WPCF, 13th ed., 1971. All microbiological testing involved the use of the most probable number (MPN) tube technique with 5 tubes in each dilution.

RESULTS

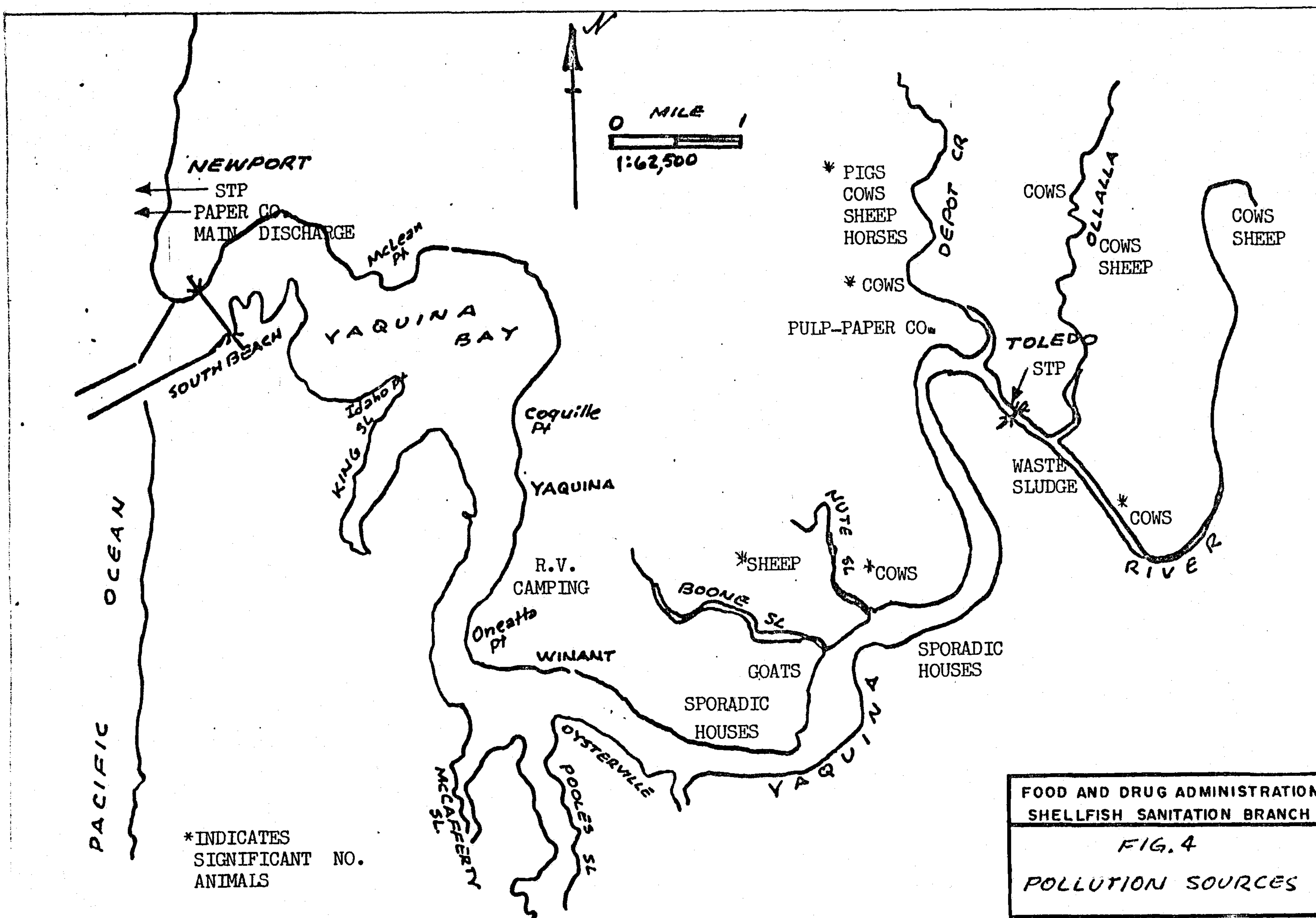
SOURCES OF POLLUTION

Figure 4 summarizes the results of the investigations into pollution sources.

The human sources include 1) the City of Toledo, i.e. the sewer system and the sewage treatment plant and 2) sporadic but numerous unsewered houses along shoreline of Yaquina Bay and its tributaries. These single houses or pockets of houses have compromised situations with respect to drain fields. Even one of the oyster houses itself offers a local problem. Observations showed flooding of the low lying areas and high water tables, as well as evidence of seepage from locations used for house drain fields.

Other nonpoint sources were evident from the observance of significant numbers of farm animals at various locations along the Bay and its tributaries. Figure 4 shows the majority of these.

Tables 2, 3, and 4 provide the fecal coliform (FC) results of sampling of the many major and minor tributaries during the May, August and November-December periods respectively. Figure 5 shows the results of some of the more significant contributors with the greater numbers of samples. These



FOOD AND DRUG ADMINISTRATION
SHELLFISH SANITATION BRANCH

FIG. 4

POLLUTION SOURCES

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TABLE 2

YAQUINA BAY

TRIBUTARY SAMPLES, MAY, 1984*

STATION	DATE	TEMP °C	SAL °/oo	TOTAL COLI MPN/100ml	FECAL COLI MPN/100ml	REMARKS
T-1	5/15	-	0	210	<3	
T-2	5/15	-	0	<3	<3	
T-3	5/15	-	0	93	93	
T-4	5/15	-	0	>2400	>2400	5/24: FC 11,000
T-5	5/15	-	0	43	43	
T-6	5/15	-	-	3.6	<3	Tidal
T-7	5/15	-	0	39	39	
T-8	5/15	-	-	43	15	Tidal
T-9	5/15	-	-	93	23	Tidal
T-10	5/15	-	-	15	9.1	Tidal
T-11	5/15	-	-	1100	460	Tidal; 5/24: FC 430
T-12	5/15	-	-	240	240	Tidal; 5/24: FC 430
T-13	5/16	-	0	460	23	
T-14	5/16	-	0	240	3	
T-15	5/16	-	-	93	7.3	Tidal
T-16	5/16	-	0	93	93	
T-17	5/16	-	0	14	<3	
T-18	5/16	-	0	>2400	>2400	5/24: FC 930
T-19	5/16	-	0	460	23	
T-20	5/16	-	0	<3	<3	
T-21	5/16	-	0	150	93	
T-22	5/16	-	0	9.1	9.1	
T-23	5/16	-	0	43	15	
T-24	5/16	-	0	240	43	
T-25	5/19	14	0	-	17	
T-26	5/19	14.5	-	-	33	Tidal
T-27	5/19	14.5	0	-	2400	5/24: FC 4600
T-28	5/19	12.5	-	-	1100	Tidal; 5/24: FC 91
T-29	5/19	12.5	0	-	<2	
T-30	5/22	12.5	2.0	93	93	
T-31	5/22	10.8	0	15	9.1	
T-33	5/22	11.5	0	75	75	
T-34	5/22	11.5	0	240	240	
T-35	5/22	11.0	0	28	21	
T-36	5/22	11.2	0	1100	240	

TABLE 2 (CONT.)

YAQUINA BAY

TRIBUTARY SAMPLES, MAY, 1984*

STATION	DATE	TEMP °C	SAL °/oo	TOTAL COLI MPN/100ml	FECAL COLI MPN/100ml	REMARKS
T-37	5/22	11.5	0	43	43	
T-38	5/22	11.5	0	460	43	
T-39	5/22	12.0	0	1100	240	
T-40	5/22	12.5	14.0	21	15	
T-41	5/22	14.5	1.0	>2400	>2400	
T-42	5/23	14.0	0	43	<3	
T-43	5/23	13.0	0	93	93	
T-44	5/23	13.5	0	20	3.6	
T-45	5/23	13.5	0	75	<3	
T-46	5/23	14.0	-	46	23	
T-70	5/23	11.8	0	1100	75	
T-71	5/23	11.2	0	240	75	
T-72	5/23	11.0	0	>2400	1100	
T-73	5/23	11.0	0	>2400	150	

*Samples and Laboratory work by Oregon D.H. and D.E.Q.

TABLE 3

YAQUINA BAY

TRIBUTARY SAMPLES - AUG. 6-8, 1984

STATION	TOTAL COLI MPN/100ml	FECAL COLI MPN/100ml	FECAL STREP MPN/100ml
T-4	>24000	2400	2100
T-4a	930	36	2400
T-4b	430	<30	2400
T-4c	3.6	<3	7.3
T-4d	>24000	>24000	2400
T-11	11000	4600	11000
T-18	>24000	>24000	4600
T-27	11000	4600	11000
T-28a	750	430	430
T-28b	210	23	3.6
T-36	4600	1500	210
T-41	160	160	93

TABLE 4
YAQUINA BAY

TRIBUTARY SAMPLES - NOV. - DEC., 1984

PRIOR TO STUDY*

STATION	DATE	TEMP °C	SAL °/oo	TC	FC	FS
T-1	11/27	9.8	0.0	1100	460	
T-2	11/27	11.2	0.0	>2400	93	
T-3	11/27	11.2	0.0	>2400	43	
T-3A	11/27	12.2	0.0	>2400	1100	
T-4	11/27	12.0	0.0	1100	75	460
T-5	11/28	10.2	0.0	>2400	23	
T-6	11/28	10.0	1.2	>2400	93	
T-7	11/27	11.7	0.0	>2400	210	
T-8	11/28	10.2	0.2	>2400	240	
T-9	11/28	10.8	0.5	>2400	<3	
T-10	11/28	9.5	1.4	460	150	
T-11	11/28	10.0	0.0	1100	93	
T-12	11/28	10.5	0.5	>2400	1100	
T-13	11/28	10.5	0.2	>2400	460	
T-15	11/28	9.2	0.5	>2400	460	
T-16	11/28	10.8	0.5	>2400	240	
T-17	11/27	10.5	0.0	1100	93	
T-18	11/27	10.5	0.0	>2400	1100	
T-19	11/28	10.5	0.0	460	23	
T-20	11/27	11.0	0.0	>2400	43	
T-21	11/27	11.0	0.0	>2400	23	
T-22	11/27	10.2	0.0	1100	460	
T-23	11/27	10.5	0.0	>2400	460	
T-24	11/28	10.5	0.0	>2400	460	
T-25	11/28	10.5	0.0	1100	3	
T-26	11/28	10.0	0.0	>2400	1100	
T-27	11/28	10.8	0.0	>2400	460	
T-28	11/28	9.5	0.0	>2400	93	
T-29	11/28	10.2	0.0	240	4	
T-30	11/28	10.0	0.0	>2400	240	
T-36	11/28	10.5	0.0	460	9	
T-40	11/28	9.5	2.2	>2400	75	
T-41	11/28	10.0	0.0	>2400	23	
T-70	11/28	10.2	0.0	>2400	43	
T-71	11/27	10.0	0.0	>2400	460	
T-72	11/27	10.0	0.0	>2400	460	
T-73	11/27	10.0	0.0	>2400	>2400	

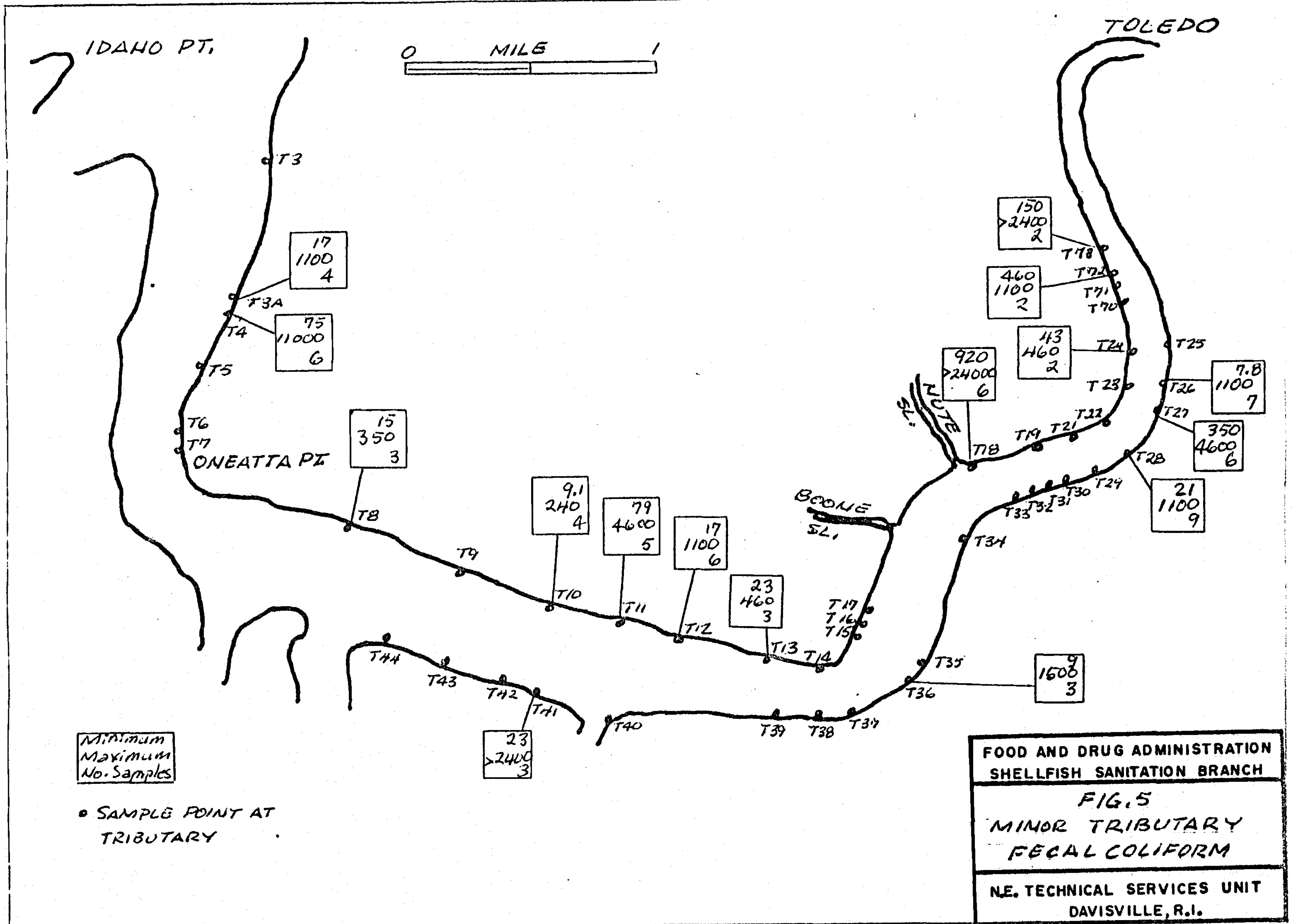
* Samples and Laboratory work by Oregon, D.H. and D.E.Q.

sampling stations include, small streams, tidal marsh discharges, ditches and the like. During the May study 51 minor tributaries were sampled. In August, 7 were sampled and in November-December, 37 were sampled.

For these minor tributary results there was no single period of time that showed the highest FC values. At some stations the higher FC values were in May, sometimes in August, or sometimes in November-December. Most of these minor tributaries were sampled because there seemed to be potential problems with either houses or animals. At the stations given in Figure 5, there is a clear correlation between the existence of houses and/or domestic animals and the high FC levels.

Toledo STP and Sewer System

The sewer system and the Toledo STP are plagued by excess infiltration. Infrequent slugs of industrial wastes from the pulp and paper company have upset the plants normal operation. During the May study an unknown quantity of organic waste was discharged to the STP. Three weeks prior to the November-December study a slug of turpentine upset the STP's operation reportedly causing chlorine residual drops. During the November-December study the large quantity of infiltration into the sewer system caused a main pumping station to overflow raw sewage when one of the pumps failed. This is covered more later.



FOOD AND DRUG ADMINISTRATION
SHELLFISH SANITATION BRANCH

FIG. 5
MINOR TRIBUTARY
FECAL COLIFORM

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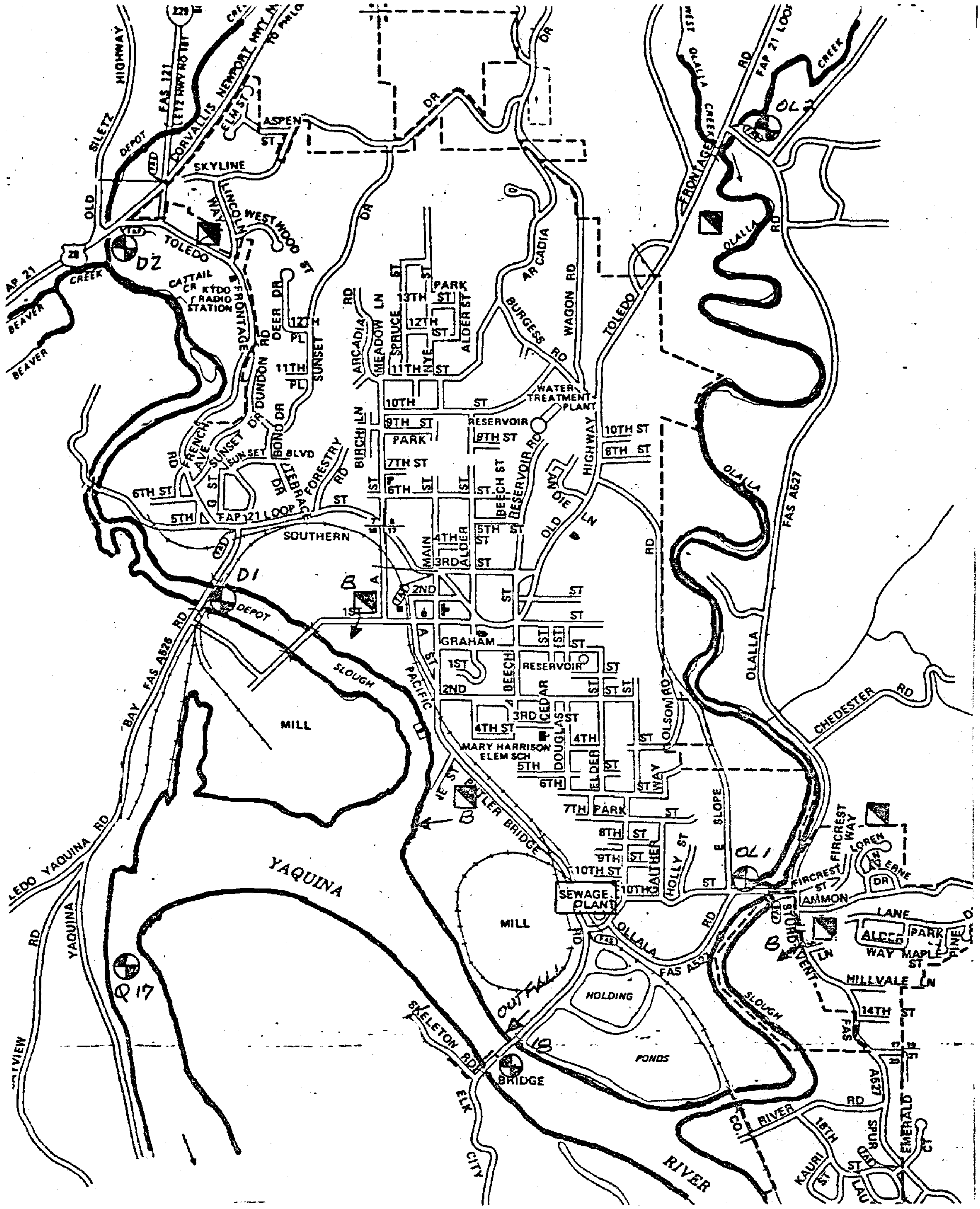
Figure 6 shows a city plan of Toledo and the locations of the pumping stations, STP and the outfalls.

The municipal STP at Toledo, is an activated sludge plant designed for 1 million gallons per day (mgd). It consists of an aerated grit chamber, comminutors, and dual activated sludge treatment units. Two secondary clarifiers serve also as chlorine contact chambers. Additional detention time of 30-40 minutes is provided in the outfall pipe. Figure 7 shows a schematic of the plant. The treatment of sewage in this plant is extremely important to the classification of Yaquina Bay, since raw sewage would definitely affect the commercial oyster area.

Infiltration: During the May study the average inflow to the plant was 1.01 mgd which although is within the design limit of the plant, reflects infiltration of up to 0.7 mgd. During the November-December study the average flow was 2.12 mgd, showing infiltration of up to 1.8 mgd. About November 23, 1984 the infiltration caused a serious bypass at a main pump station since a pump had failed. About 0.4 mgd of raw sewage overflowed to Depot Slough for about 6-7 days. (The shellfish program was not notified.) This was about 20% of the plant flow at the time.



PUMPING STATIONS (B = BYPASS)

SAMPLING STATIONS

OUTFALLS

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FIG. 6
TOLEDO SEWER SYSTEM
STP LOCATION

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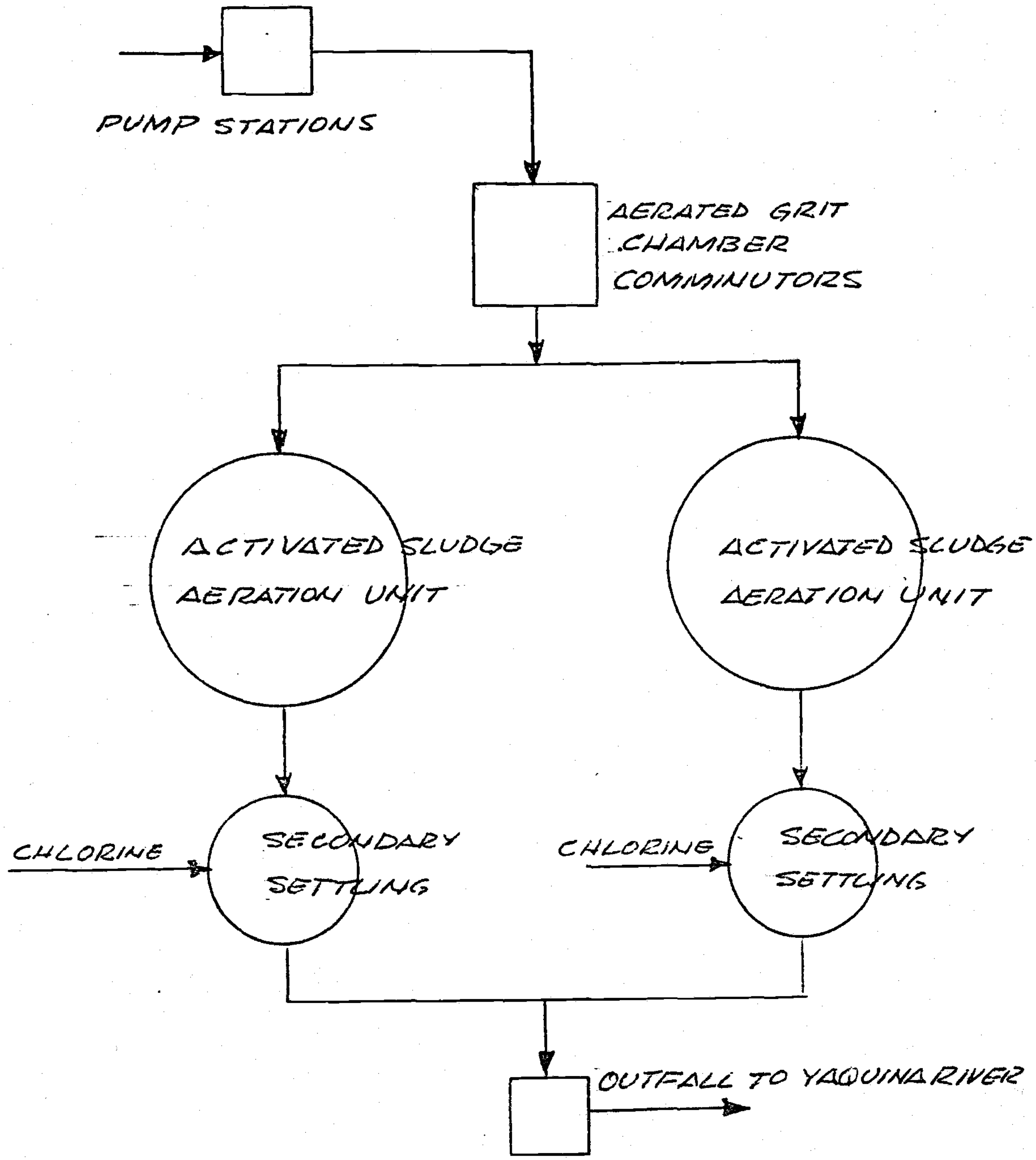

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FIG. 7
TOLEDO STP
SCHEMATIC

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The STP flows and the accompanying rain for the two study periods are given in Table 5. Figure 8a presents plots of these data for the two periods. Increases in the flow due to rain, as well as the lack of sustained drop in flow are evident. Figure 8b shows a relationship of daily rain vs. average daily plant flow. For example, 1-inch of rain nearly raises the plant flow by 1 mgd.

The largest average daily flow during the May study was 1.30 mgd and for the November-December study, 3.02 mgd. The peak instantaneous flow during the November-December study was 3.3 mgd. These high flows cause hydraulic overloads which reduce detention times in the various treatment tanks.

Results of Grab Samples: Samples of raw and chlorinated effluent were taken during both studies. The following summarizes the FC MPN/100ml results:

Study Period	Raw (in Millions)			Treated Effluent		
	Geo Mean	Min	Max	Geo Mean	Min	Max
May	1.4	.49	2.3	11	<2	330
Nov.-Dec.	.57	.13	1.6	2	<2	6.8

These data demonstrate the more dilute sewage with the greater infiltration as well as the efficiency of coliform treatment. The average chlorine residuals for the samples were 1.6 mg/l and 1.2 mg/l for the May and November-December studies respectively. There were no chlorination failures during either study.

TABLE 5

TOLEDO STP

FLOW AND RAIN DATA

DATE	MAY STUDY FLOW MGD	RAIN IN.	DATE	NOV-DEC STUDY FLOW MGD	RAIN IN.
5/1	1.79	.71	11/14	1.76	0
5/2	1.63	1.02	11/15	1.64	.14
5/3	1.61	.15	11/16	1.40	0
5/4	1.58	.14	11/17	1.44	.81
5/5	1.36	.17	11/18	1.29	.18
5/6	1.27	0	11/19	1.64	1.18
5/7	1.29	.51	11/20	1.61	.04
5/8	1.16	.15	11/21	1.39	0
5/9	1.06	.13	11/22	1.33	.68
5/10	1.23	.77	11/23	2.04	1.57
5/11	1.26	.16	11/24	1.65	.48
5/12	1.12	0	11/25	1.45	.07
5/13	1.20	.34	11/26	1.88	1.90
*5/14	1.30	.25	11/27	2.58	2.82
5/15	1.27	.07	*11/28	2.22	.41
5/16	1.00	0	11/29	3.02	1.22
5/17	.91	.03	11/30	2.96	.16
5/18	.87	0	12/1	2.34	0
5/19	.96	.44	12/2	2.06	.13
5/20	.76	.03	12/3	1.60	0
5/21	.89	.14	12/4	1.43	0
5/22	1.15	.94	12/5	1.33	0

* Study began

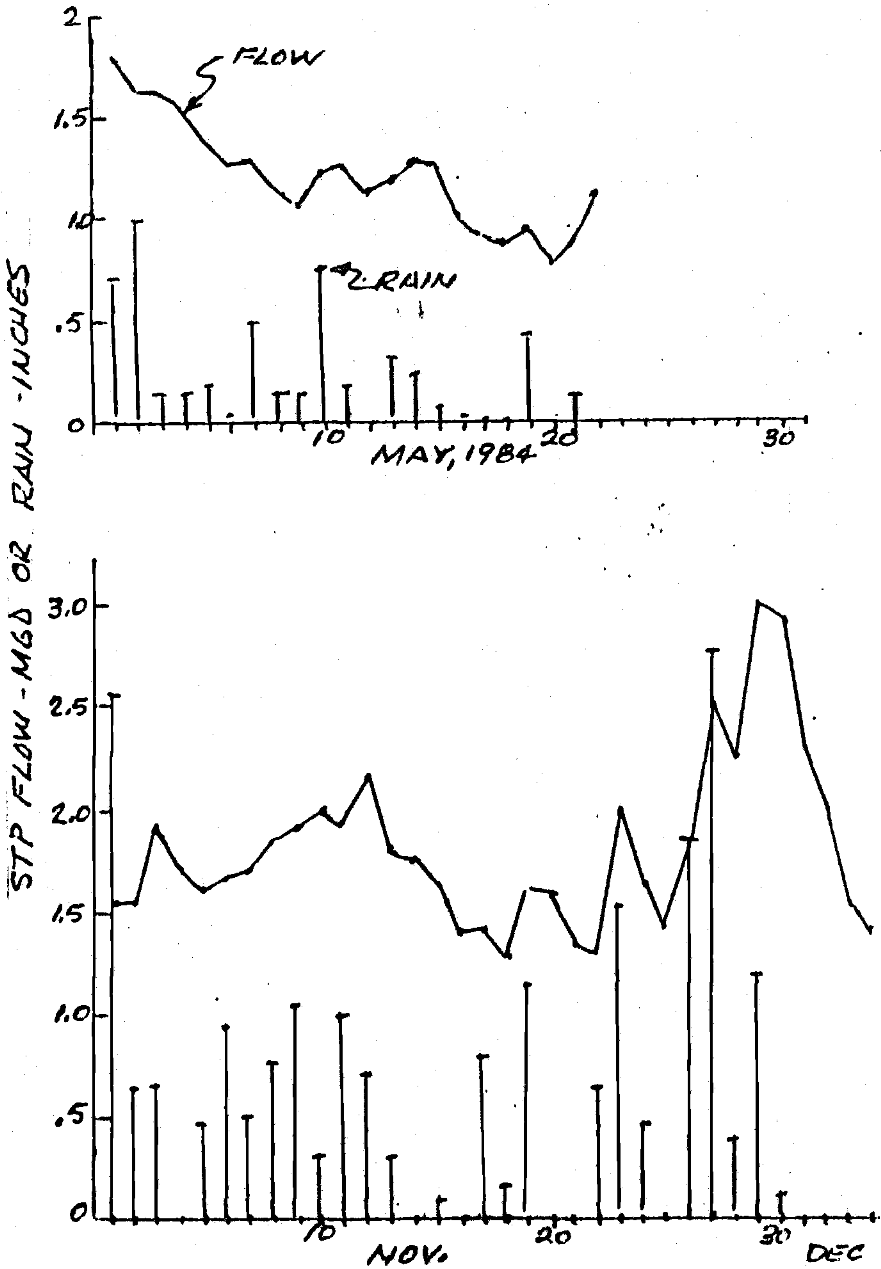

FIG. 8A

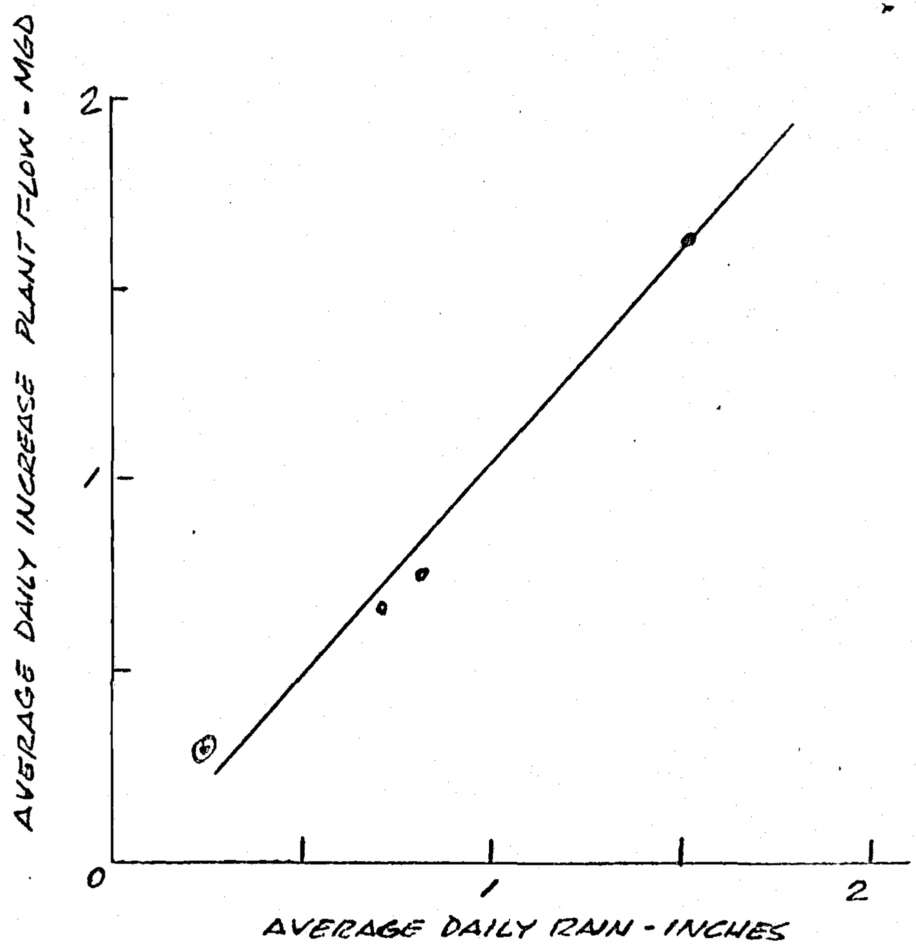

FIG. 8B

FOOD AND DRUG ADMINISTRATION
SHELLFISH SANITATION BRANCH

FIG. 8
TOLEDO STP- FLOW
AND RAINFALL

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Reliability Analysis: Table 6 presents a list of pertinent reliability factors of design, construction and operation of the Toledo sewer system and STP. Several factors are critical to the development of a management plan for a conditionally approved area. Among them are lack of: chlorine residual alarms and recording; duplicate chlorinators; holding capacity; and notification procedures.

HYDROGRAPHY

Dye Studies

The results of the instantaneous point dye release of May 14, 1984 are given in Figures 9 and 10. Figure 9 shows the progress of the dye patch from its release about 3000 feet downstream from Toledo to the edge of the commercial area. The dye patch reached the area in less than one ebb tide despite the fact that the tide range was about 5.1 feet, one of the smaller tide ranges. (Tide ranges up to 10.5 feet occurred at night during this study.) The average velocity was about 1.3 miles per hour (1.9 feet per second, fps).

Figure 10 typifies two plots for evaluating results of dye studies. The upper plot shows the reduction of the peak dye concentration in the dye patch with time as the patch dispersed while travelling down the estuary. The slope of

TABLE 6

TOLEDO STP

RELIABILITY FACTOR ANALYSIS

FACTOR (* Indicates problem for shellfish management)		
1. SEWER SYSTEM		
a. Total Containment	No	*
b. Infiltration Problems	Yes	*
c. Pumping Stations		
1) Overflows	Yes	*
2) Prone to failures	Yes	*
3) Alarms	Yes	
4) Sufficient number of auxiliary power units	No	*
2. TREATMENT PLANT		
a. Secondary	Yes	
b. Holding Ponds	No	*
c. Flood Protection	Yes	
d. Sludge disposal - remote	Yes	
e. Auxiliary Power (portable)	Yes	
f. Duplicate Units	Yes	
g. Sufficient Hydraulic Capacity	No	*
h. Alarms	Yes	
3. CHLORINATION		
a. Sufficient Residual Attainable	Yes	
b. Sufficient Contact Time	Yes	
c. Continuous Recording	No	*
d. Alarms	No	*
e. Uninterrupted Tank Change	Yes	
f. Sufficient Inventory	Yes	
g. Dual Units	No	*
4. OPERATIONS		
a. Notification of Shellfish Program	No	*
b. Routine Tasks & Maintenance	Yes	
c. Records	Yes	
d. Plant Attendance -		
1) Full Time Weekday	Yes	
2) Full Time Weekend	No	*
3) Night Time	No	*
5. MISCELLANEOUS		
a. Industrial Impact Problems	Yes	*
b. Sufficient Estuarine dispersion, dilution and time of travel	No	*

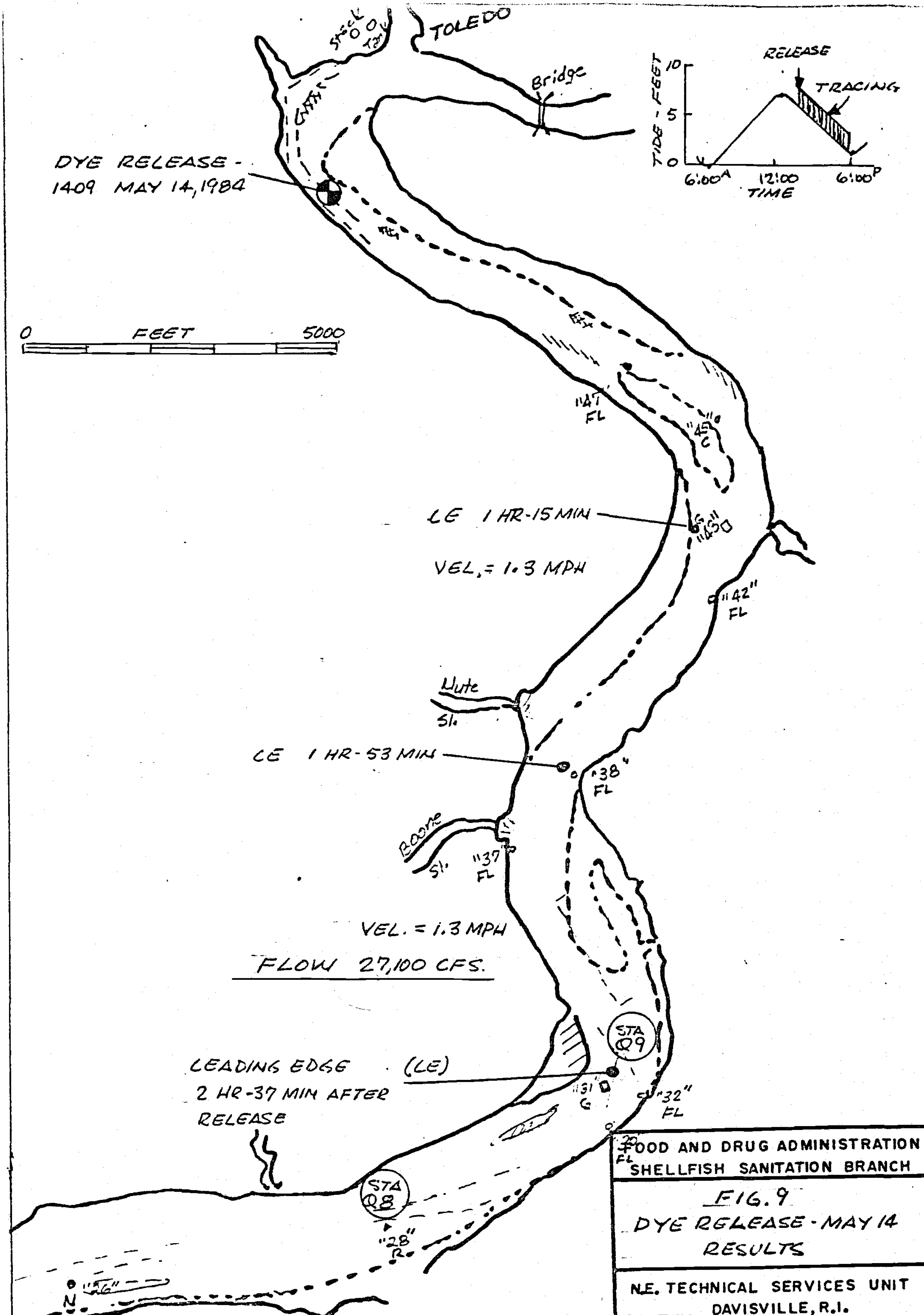

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FIG. 9
DYE RELEASE - MAY 14
RESULTS

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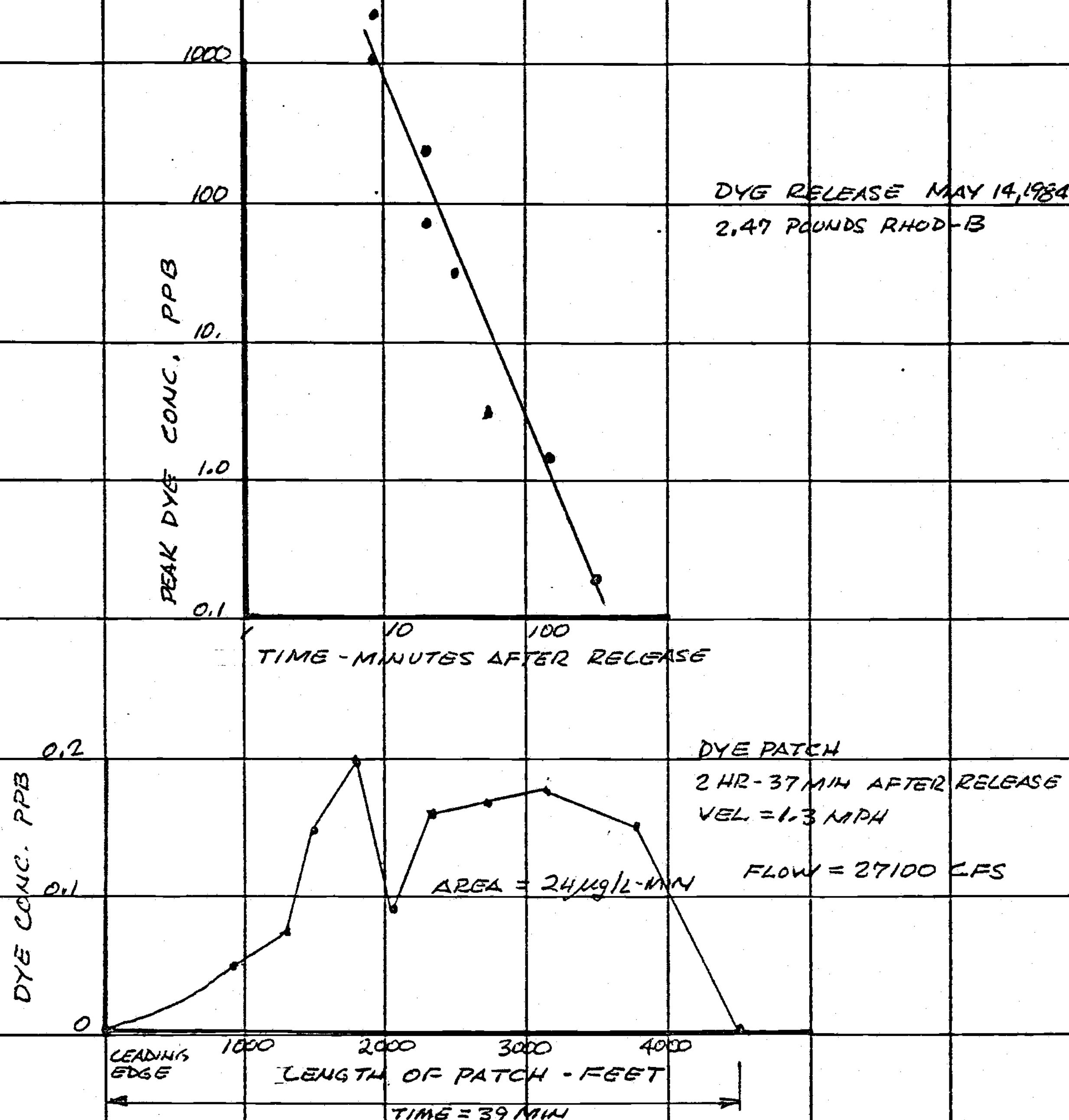

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SHELLFISH SANITATION BRANCH

FIG. 10
DYE RELEASE - MAY 14
RESULTS

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the line falls in the expected range for this type of study, indicating that there was normal longitudinal dispersion and little dye loss. Thus, calculations based on the dye concentrations would be appropos. The lower plot exemplifies one set of dye concentration measurements made on the patch about 2-hours and 37 minutes after the release. The leading edge (LE) of the dye patch at the time was at channel marker "31" or sampling station Q 9. Calculations, based on the dye concentrations, length of the patch, and amount of dye released, result in a flow rate of about 27,100 cubic feet per second (cfs). This includes both tidal and fresh water flow. In this vicinity of the Yaquina River, the cross-sectional area at high tide is between 10,000 to 20,000 square feet. With a velocity of about 1.9 fps, the flow would be in the range of 19,000 to 38,000 cfs. This approximately checks the flow derived from the dye patch properties.

The results of the continuous dye release into the Toledo STP discharge of May 21, 1984 are given in <u>Figure 11</u>. The average STP flow during the continuous release 6:00 to 9:24 am was 0.88 mgd, and the average dye concentration in the effluent was 4070 parts per billion (ppb). Dye concentrations measured anywhere in the estuary can be related directly to these values in order to calculate dilution of the sewage. Some of the dye concentrations given in <u>Figure 11</u> serve this purpose. (The leading edge values

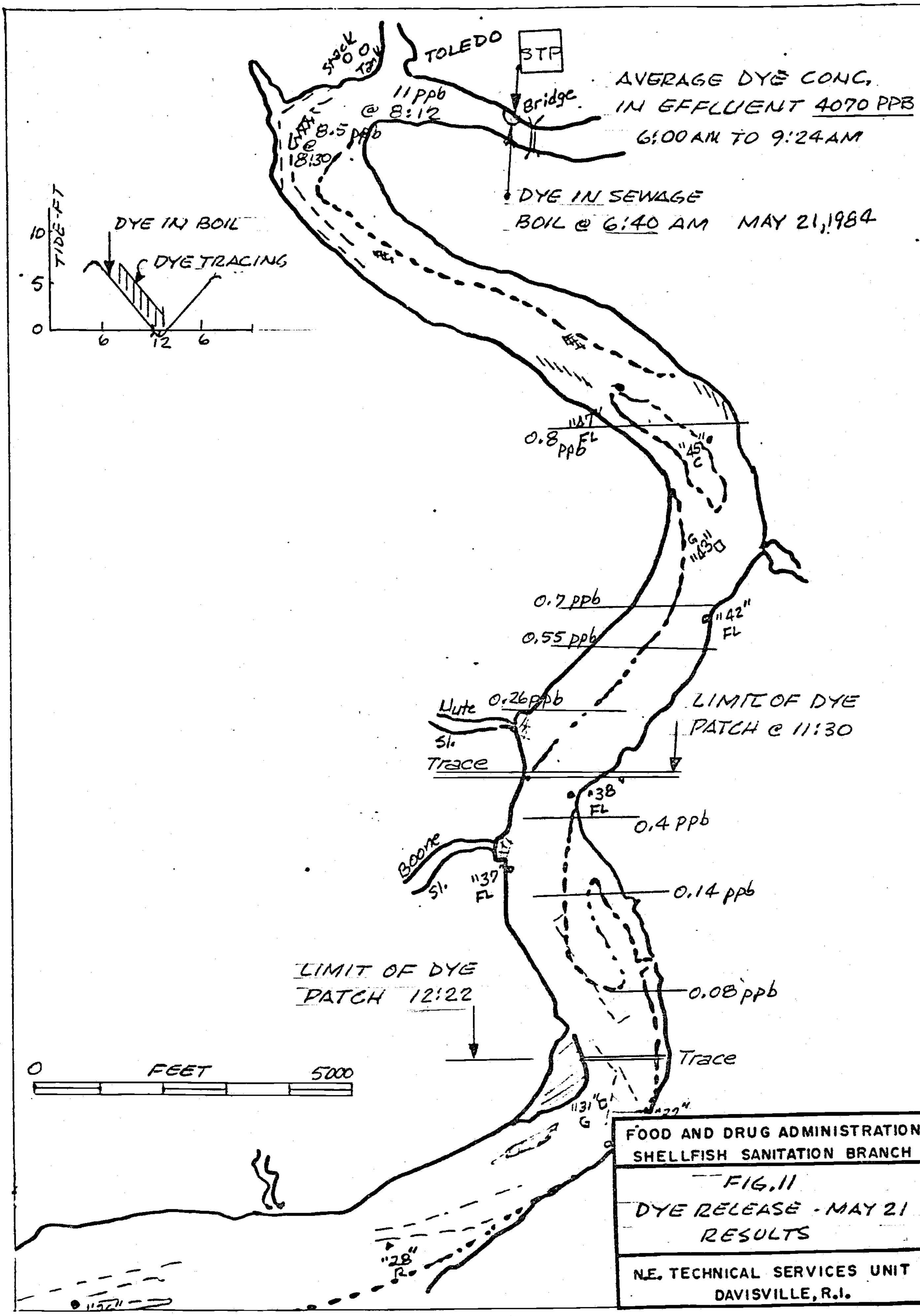

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FIG. 11
DYE RELEASE - MAY 21
RESULTS

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are not suitable.) Table 7 provides a list of times, locations, dye concentrations, dilution factors and calculated estuary flows. For this particular study, the available dilution flow for the STP discharge was 13,840 cfs- apparently about one-half of the flow found by the instantaneous release.

The results of the flood tide instantaneous line release of May 16 are shown in Figure 12. Although the full tide range was not covered, it is seen that the dye patch travelled from the Newport area to the commercial shellfish area in about 3 hours, much less than one flood tide. The average velocity was 1.2 MPH (1.76 fps). Through this reach of the estuary, the calculated flow is about 24,000 cfs. This flow rate over one tidal cycle for a 6-foot tide range closely checks the tidal prism for this reach.

Salinity Profiling

During both studies special salinity measurements were made at selected stations throughout the full reach of the estuary. Figure 2 shows the locations. The results of these measurements are summarized by identifying salinity contours (isohalines) both vertically and horizontally.

TABLE 7

RESULTS OF CONTINUOUS DYE RELEASE

May 21, 1984

TIME	LOCATION	DYE CONC. PPB	DILUTION FACTOR	CALCULATED FLOW-CFS
6:00-9:24 am	STP Effluent	4070	1:1	1.36
8:30 am	At River Bend	8.5	478:1	650
12:14 am	CAN "45"	.8	5090:1	6920
12:54 am	CAN "37"	.4	10175:1	13840

Figure 13 shows surface isohalines for low and high tide during the May study. Figure 14 contrasts the isohalines for the November - December study when the fresh water flow was much greater. Figure 15 shows the results of high and low tide vertical salinity measurements during the November - December study. The intent is to exemplify the extent of travel of the salt water wedge along the bottom during flood tide and the excursion of the fresh water on the surface during ebb tide.

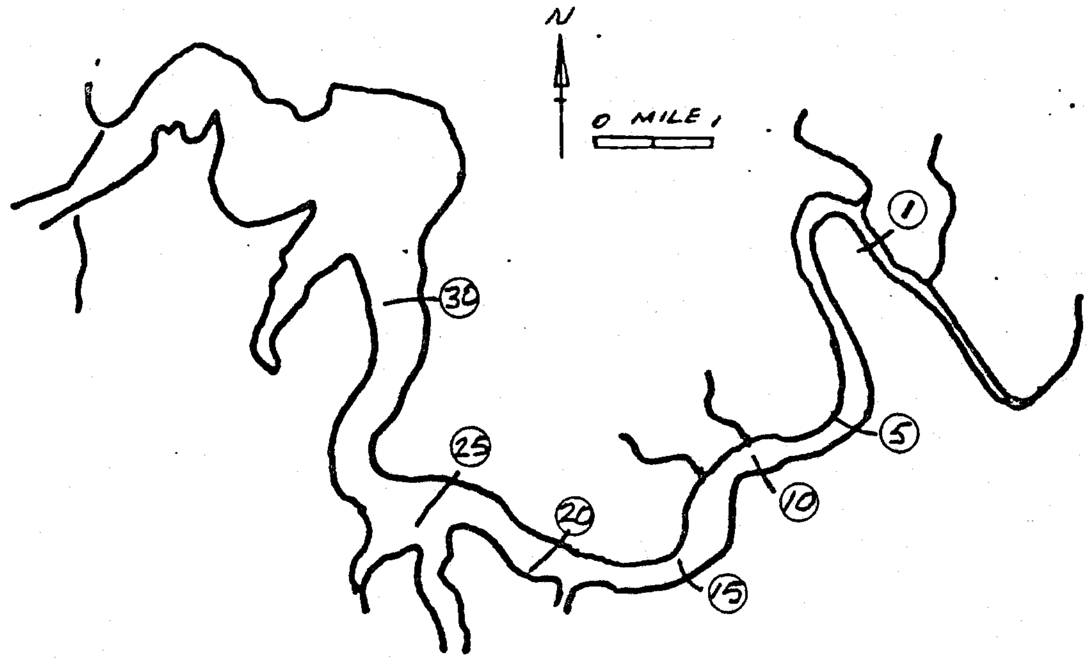
Flushing of the Bay

Further examination of the flushing features of the Bay was done using Ketchum's analysis of the tidal prism. The method is described in Appendix I.

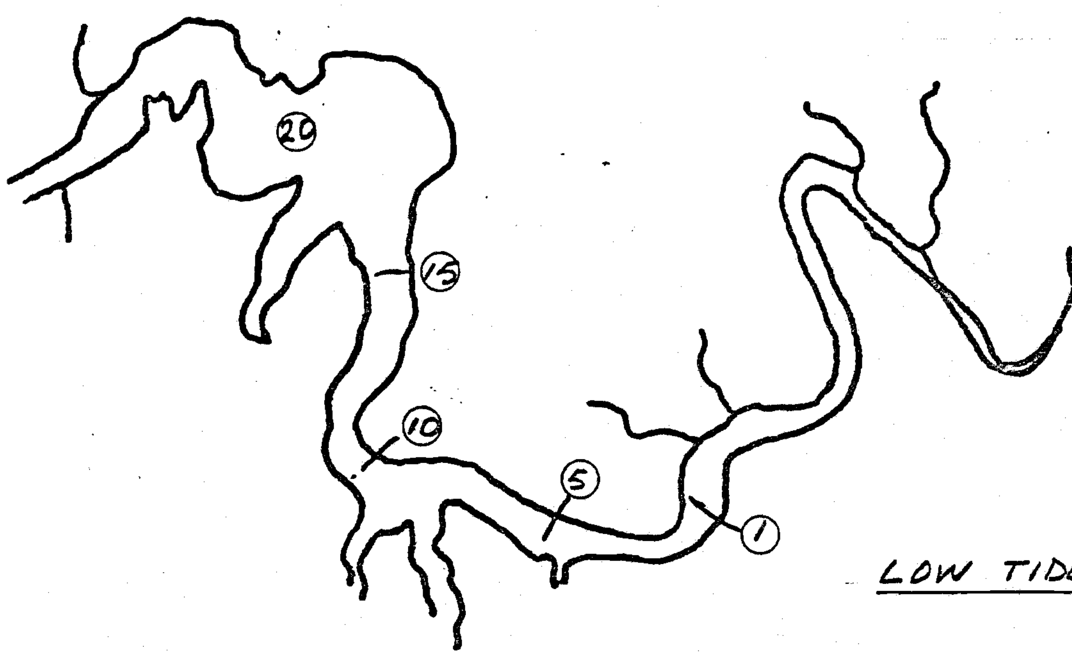
Fresh Water Inflow

Fresh water runoff has a bearing on the nonpoint pollution of Yaquina Bay. Thus, some basic knowledge of the rainfall, watershed characteristics and runoff is necessary to determine the relative impacts of the several major tributaries on the classification of the Bay.

The only active river gauging station in the watershed used by the U.S. Geological Survey is on the Yaquina River at Chitwood about 16 miles upstream from Toledo. Figure 16



HIGH TIDE MAY 15



LOW TIDE MAY 18

⑤ SALINITY - PARTS PER THOUSAND (‰)

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FIG. 13 SURFACE SALINITY ISOHALINES - MAY, 198
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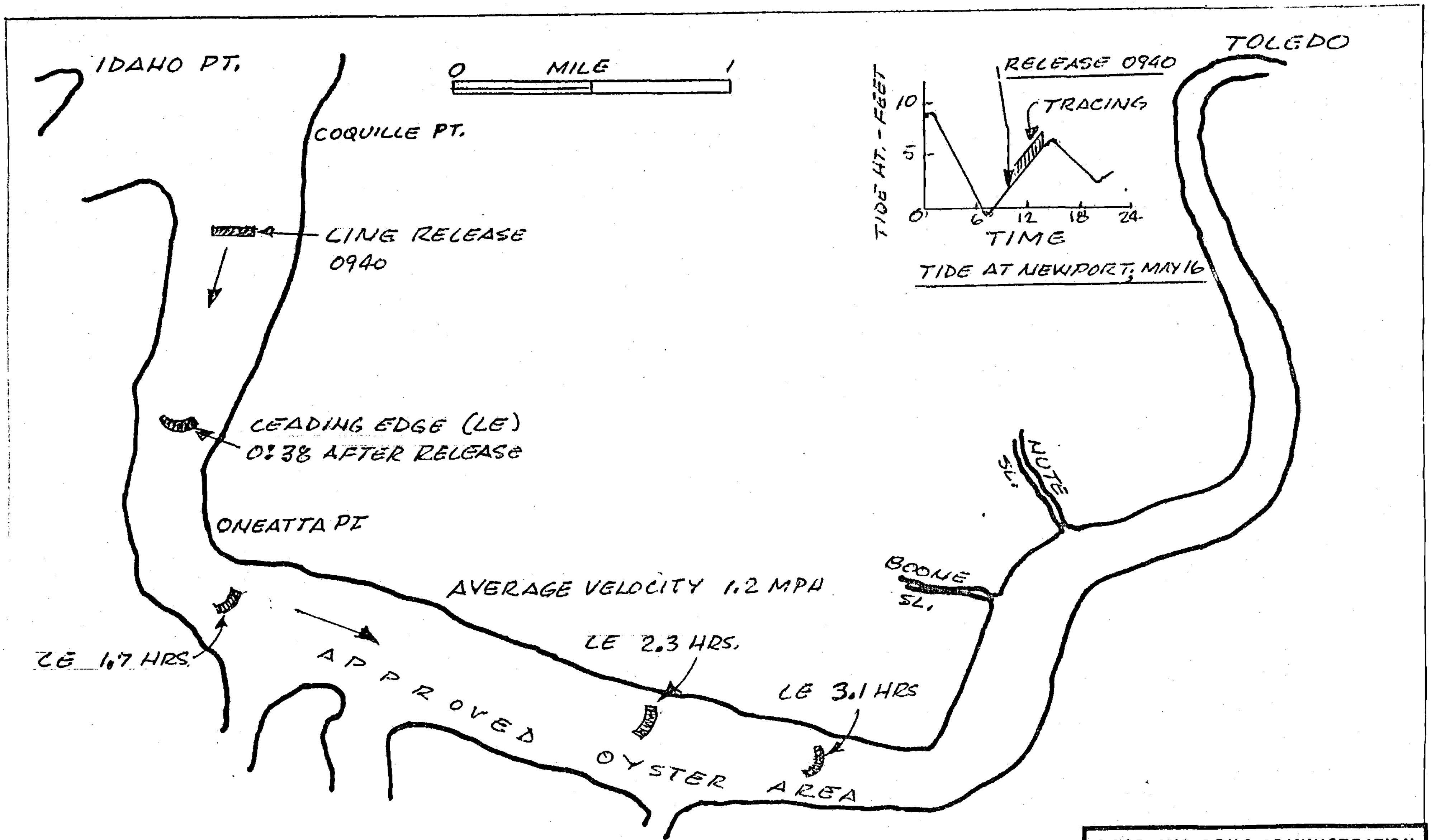

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FIG. 12
DYE RELEASE - MAY 16
RESULTS

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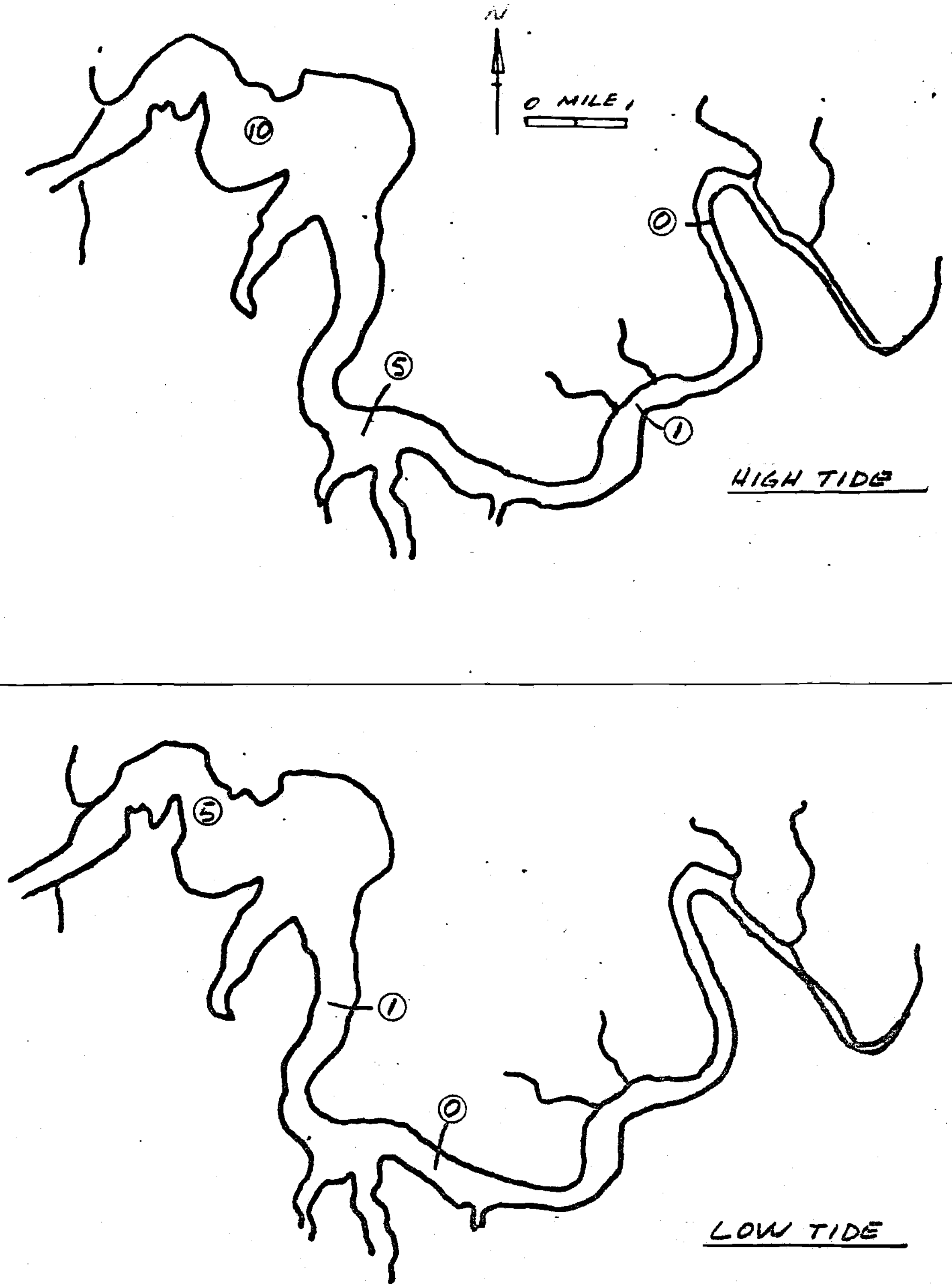

⑤ SALINITY - PARTS PER THOUSAND (‰)

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FIG. 14
SURFACE SALINITY
ISOHALINES - NOV.-DEC., 1984

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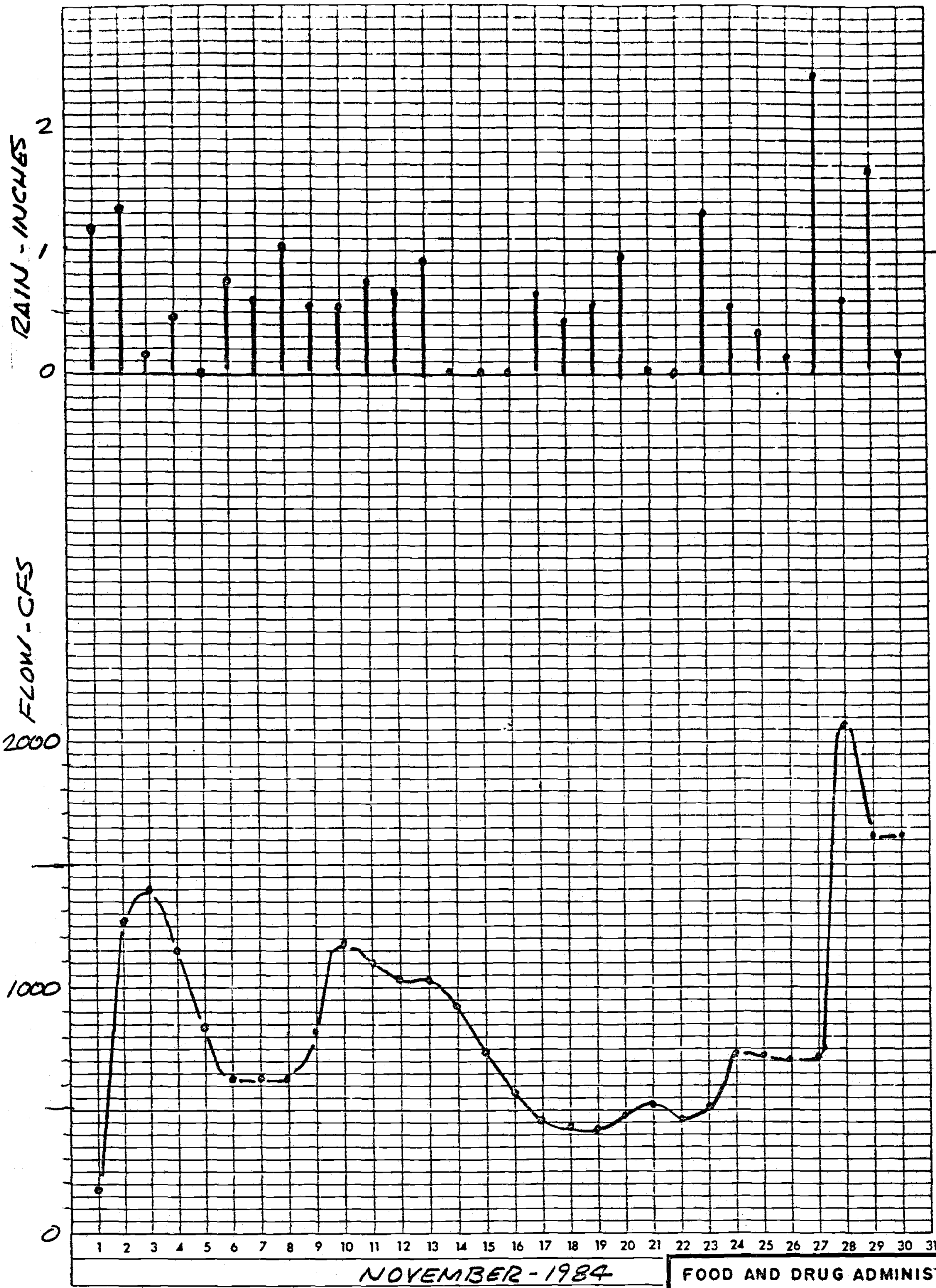

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FIG. 16
RAINFALL AND
YAQUINA R. FLOW - NOV.

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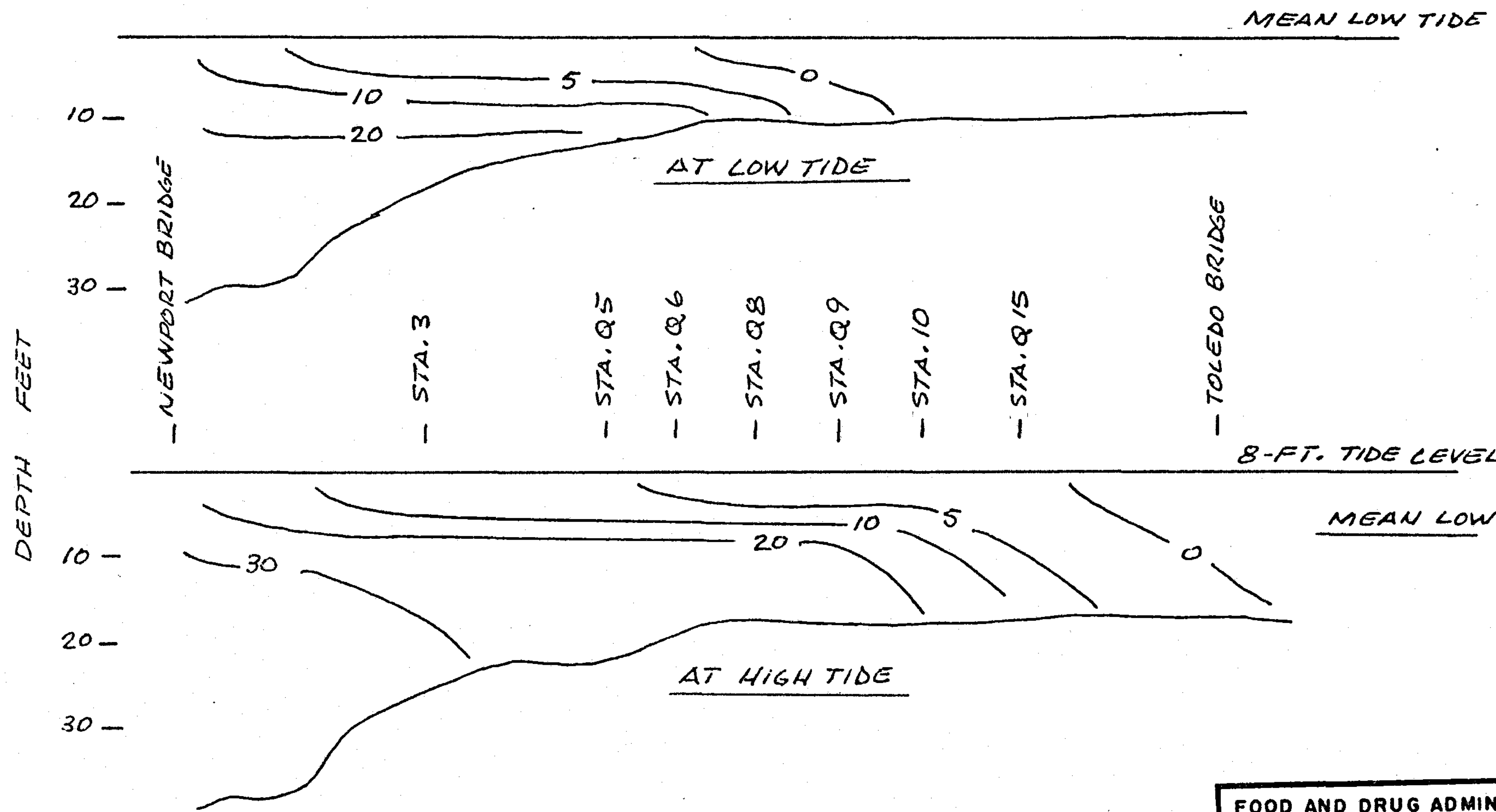

FOOD AND DRUG ADMINISTRATION
SHELLFISH SANITATION BRANCH

FIG. 15
SALINITY STRATIFICATION
NOV.-DEC., 1984

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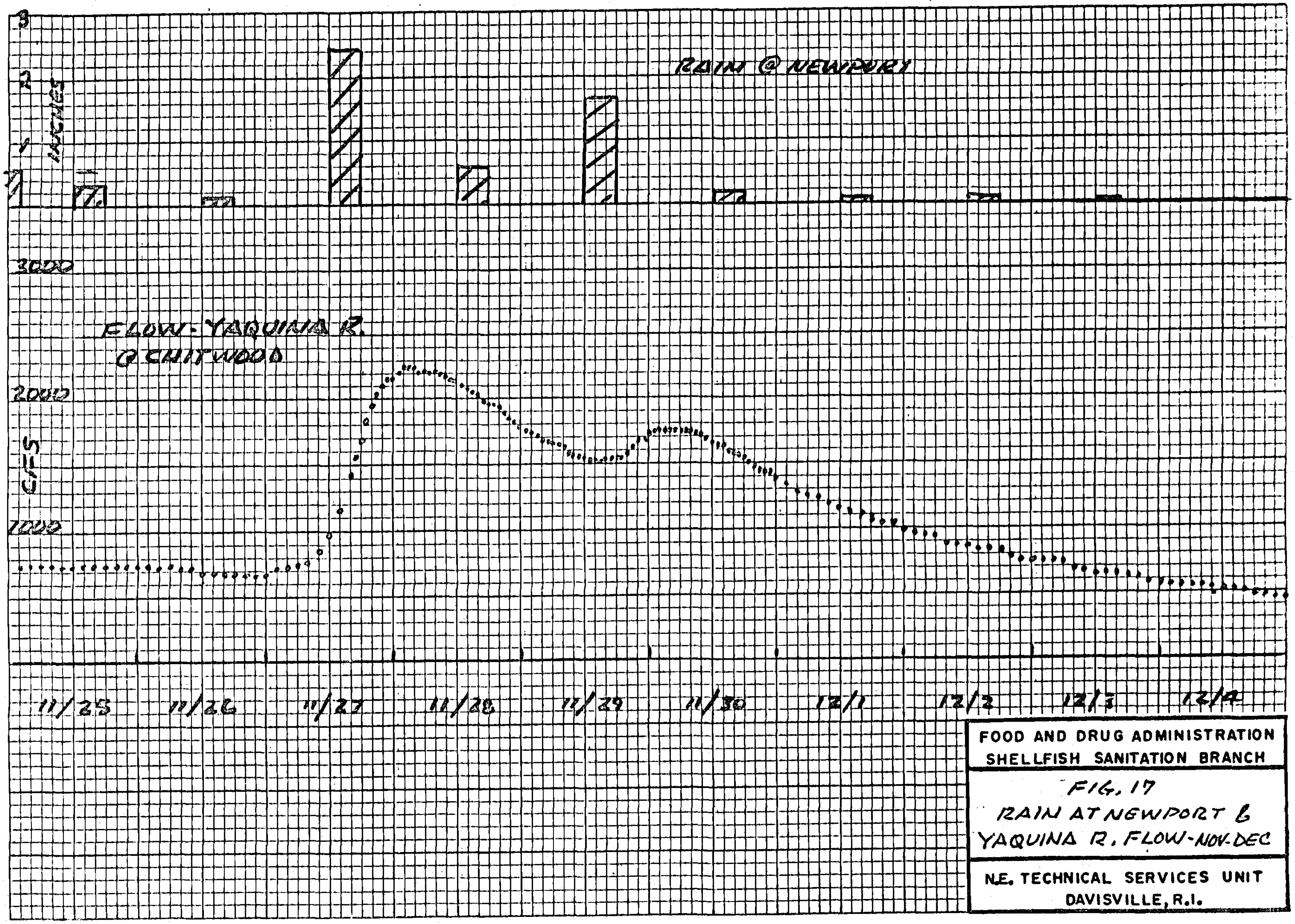

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SHELLFISH SANITATION BRANCH

FIG. 17
RAIN AT NEWPORT &
YAQUINA R. FLOW - NOV-DEC

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shows the November rainfall data for Newport and the tentative flows for the Yaquina River. The variation of river flow with rainfall is evident. (The gauge was not in service for the May study.)

Because the watershed is so hilly, the increase in flow is seen within a day after a rain. The watershed is typical of an active lumbering area - i.e. some heavily wooded, but some bare with or without reforestation. Estimates of the runoff factor "c" in the Rationall Formula Q=ciA were made from this data. The watershed area above Chitwood is 71 square miles or 45,400 acres. For November, the following accrued:

Rain (inches)	Rain in/hr	Flow Increase (cfs)	"c"
1.30	.05	300	.13
1.56	.07	600	.15
2.43	.10	1550	.34
2.54	.11	1200	.24

An average "c" is .23, which is a reasonable value for wooded areas.

<u>Figure 17</u> shows the hydrograph of the Yaquina River for the November-December study period. The effect of the 2-inch plus rain on November 27 can be seen - i.e. the river peaked to over 2200 cfs within 24-hours, and as the flow began to recede another 1-inch plus rain prevented the flow from dropping further and raised it to over 1700 cfs.

Of course there is substantially more fresh water flow into the Yaquina Bay that just that of the river at Chitwood. Estimates can be made of the total fresh water input. Because it appears that most other watersheds are somewhat similar to that of the Yaquina River, a direct proportion by watershed area can be used. Table 8 provides estimates of the total fresh water input in Yaquina Bay, as follows: 1) prior to the study; 2) the November 28 peak flow; 3) the recovery period November 29-30; and 4) the more stable period December 1-4.

As shown in Table 8, from a pre-study flow of 1630 cfs, the flow peaked to about 4655 cfs. Toward the end of the study the flow nearly attained that prior to the study.

The local major tributaries, Depot Cr., Olalla Cr. Boone Sl., and Nute Sl. have small hilly watersheds. For most rains the hydrograph can be considered quite short - i.e. several hours. Factors such as amount of antecedent rain, ground saturation, etc. are important, and pollution effects can be seen in the tributary within a few hours and within the Bay within one or two tidal cycles.

Continued heavy rain such as occurred in November, 1984 may cause a thorough flushing out of nonpoint pollution due to land wash (e.g. pastures). However, impacts of house drain field failure would continue and worsen as the ground became more saturated.

TABLE 8

RIVER FLOW ESTIMATES

STREAM	AREA SQ. MILES	FLOWS FLOW BEFORE	FLOW NOV. 28	FLOW NOV. 29-30	FLOW DEC. 1-4
BASELINE					
YAQUINA R@ CHITWOOD	71	700	2000	1600	1000
YAQUINA R INTERVAL TO TOLEDO	57	560	1600	1280	800
TOTAL YAQUINA R.		1260	3600	2880	1800
DEPOT CR	18.5	180	520	420	260
OLALLA CR	7.9	80	220	180	110
BOONE & NUTE	5.7	55	160	128	80
REMAINING WATERSHED	5.5	55	155	125	80
GRAND TOTAL		1630	4655	3733	2330

BACTERIOLOGICAL RESULTS AND DATA REDUCTION

The results of the bacteriological examinations of all fresh water, sewage, and estuarine water samples are given in raw data tables in a supplement to this report. Those tables also provide the temperature and salinity information for the water samples at the time of collection. The total number of water samples involved in the analysis of this report was 550.

Data summaries for the estuary stations, over all tides and weather conditions for both studies are given in Table 9. Table 9 lists the medians, percent of samples greater than 43 FC/100ml, the minimum and maximum values, for each study and both studies combined.

A breakdown of the results to reflect some of the tide and weather conditions was made. Table 10 shows a low tide and high tide categorization for the May study. Table 11 provides not only a low and high tide breakdown but a rain-effect categorization for the November-December study.

Table 12 itemizes the average temperature, the medians, the minimum and maximum fecal coliforms and median fecal streptococcus for the major tributaries for the two studies. The results of a sampling station on the Yaquina River several miles upstream from Toledo are also given. Table 13

TABLE 9

YAQUINA BAY, OREGON
OVERALL DATA REDUCTION
Fecal Coliform MPN/100ml

	MAY					NOV.-DEC.					OVERALL				
STATION	N	MEDIAN	% >43	MIN	MAX	N	MEDIAN	% >43	MIN	MAX	N	MEDIAN	% >43	MIN	MAX
1	13	2	0	<2	22	7	70	57	<1.8	140	20	3	20	<2	140
2	13	6.8	0	2	23	7	49	57	6.8	350	13	13	20	2	350
3 E	19	7.8	10	<2	49	11*	49	55	7.8	540	30*	12	27	<2	540
3 W	19	7.8	0	<2	23	*	-	-	-	-	*	-	-	-	-
Q 5	14	18	14	2	170	13	49	61	7.8	350	27	27	35	2	350
Q 6	19	17	21	<2	130	13	33	38	13	240	32	23	28	<2	240
Q 8	19	33	47	4.5	130	13	33	46	17	350	32	33	47	4.5	350
Q 9	13	49	85	26	240	13	49	54	11	350	26	49	69	11	350
10	13	49	54	17	240	11	33	46	11	170	24	41	54	11	240
Q 15	12	60	67	33	170	9	33	33	17	350	21	49	52	17	350
Q 17	10	49	70	23	170	8	79	62	17	350	18	60	66	17	350
18	7	33	29	17	240	7	46	55	23	130	14	33	43	17	240

N = Number of samples

* Data Station 3 NOV-DEC combined with Station 3E

TABLE 10

YAQUINA BAY STATIONS

MAY 14-23, 1984

SUMMARY OF SALINITY AND FECAL COLIFORM DATA

STATION	LOW TIDE AVG. SAL. $^{o}/oo$	LOW TIDE FECAL COLI** MEDIAN		LOW TIDE FECAL COLI** MIN	LOW TIDE FECAL COLI** MAX	HIGH TIDE AVG. SAL. $^{o}/oo$	HIGH TIDE FECAL COLI MEDIAN		HIGH TIDE FECAL COLI MIN	HIGH TIDE FECAL COLI MAX
1	23.1	2	(9)*	<2	7.8	28.9	<2	(4)	<2	22
2	17.6	11	(7)	4.5	23	25.8	6.8	(5)	2	22
3E	16.3	15	(10)	7.8	49	23.8	4.5	(8)	<2	7.8
3W	17.5	17	(10)	4.5	23	26.6	2	(7)	<2	7.8
Q5	10.2	23	(9)	11	49	16.3	8	(4)	2	13
Q6	9.3	23	(10)	13	130	17.6	6	(8)	<2	23
Q8	6.8	56	(10)	13	130	13.8	15	(8)	4.5	49
Q9	5.9	70	(9)	33	220	12.9	49	(3)	26	49
10	3.8	49	(8)	17	240	7.3	41	(4)	23	79
Q15	1.3	70	(8)	33	170	4.6	33	(3)	33	49
Q17	0.8	49	(7)	23	170	0.9	105	(2)	70	140
18	0.3	33	(7)	17	240	(All tides combined)				

* Number in ( ) is number of samples.

** MPN/100ml

TABLE 11

YAQUINA BAY STATIONS
NOVEMBER 28 - DECEMBER 6, 1984

STATION		RAIN EFFECT LOW TIDE AVG. SAL^{o}/oo	RAIN EFFECT LOW TIDE FC/100ml *	POST RAIN LOW TIDE AVG. SAL^{o}/oo	POST RAIN LOW TIDE FC/100ml	POST RAIN HIGH TIDE AVG. SAL^{o}/oo	POST RAIN HIGH TIDE FC/100ml
1	median	9.8	135(4)	18.6	13(1)	32.0	<1.8(2)
	min		70				<1.8
	max		140				<1.8
2	median	6.7	124(4)	15.4	6.8(1)	24.1	17(2)
	min		49				17
	max		350				17
3	median	4.4	79(5)	11.0	22(2)	20.1	43(4)
	min		33		11		7.8
	max		540		33		110
Q5	median	2.3	170(5)	9.8	24(4)	13.3	31(4)
	min		49		17		7.8
	max		350		49		49
Q6	median	1.9	220(5)	10.4	28(4)	12.0	23(4)
	min		46		22		13
	max		240		33		27
Q8	median	1.2	110(5)	7.7	28(4)	10.1	36(4)
	min		23		17		23
	max		350		130		79
Q9	median	.9	110(5)	7.4	33(4)	8.6	17(4)
	min		49		13		11
	max		350		79		33
10	median	.4	110(3)	4.7	22(8)		
	min		110		11		
	max		170		79		

TABLE 11 (CON'T)

YAQUINA BAY STATIONS
NOVEMBER 28 - DECEMBER 6, 1984

STATION		RAIN EFFECT AVG. SAL°/oo	LOW TIDE FC/100ml*	POST RAIN AVG. SAL°/oo	LOW TIDE FC/100ml	POST RAIN AVG. SAL°/oo	HIGH FC/100ml
Q15	median	.4	110(3)	3.8	24(6)		
	min		79		17		
	max		350		33		
Q17	median	.3	210(2)	5.6	56(6)		
	min		79		17		
	max		350		170		
18	median	.4	104(2)	1.2	33(5)		
	min		79		23		
	max		130		130		

*Number in ( ) is number of samples

TABLE 12

MAJOR TRIBUTARY DATA
SUMMARY

TRIBUTARY/STATION	MAY STUDY AVERAGE TEMP °C	MAY STUDY FECAL COLIFORM MEDIAN*	MIN	MAX	FECAL STREP MEDIAN*	NOV. - DEC. STUDY AVERAGE TEMP °C	NOV. - DEC. STUDY FECAL COLIFORM MEDIAN*	MIN	MAX	FECAL STREP MEDIAN*
DEPOT CR. D-1	12.3	330 (9)	110	920	8 (4)	8.5	79 (7)	33	130	23 (3)
DEPOT CR. D-2	12.1	104 (2)	79	130	11 (1)	8.9	75 (4)	23	79	4 (2)
OLALLA CR. OL-1	14.3	33 (9)	6.8	330	<2 (5)	8.6	79 (5)	49	920	33 (1)
OLALLA CR. OL-2	12.3	104 (6)	33	330	11 (4)	9.1	56 (4)	33	70	23 (1)
BOONE SL. B	17.0	11 (6)	2	33	<2 (4)	8.5	130 (5)	33	240	4.5 (3)
NUTE SL. N	16.0	330 (7)	33	540	33 (5)	8.7	170 (5)	33	350	27 (4)
YAQUINA R@ COUNTY PARK	13.0	23 (3)	6.8	140	2 (1)	8.1	23 (5)	17	79	-

* NUMBER OF SAMPLES IN PARENTHESIS

TABLE 13

YAQUINA BAY, OREGON
RESULTS OF SUMMER SAMPLING

STATION	AUG. 6 TC*	AUG. 6 FC*	AUG. 7 TC	AUG. 7 FC	AUG. 8** TC	AUG. 8** FC	SEPT. 19-21 FC	SEPT. 19-21 EC*
1	<3	<3	<3	<3	23	3.6		
2	<3	<3	<3	<3	<3	<3		
3E	<3	<3	<3	<3	3.6	3.6		
3W	3.6	3.6	3.6	3.6	<3	<3		
Q5	<3	<3	3.6	<3	<3	<3		
Q6	<3	<3	3.6	3.6	3	<3	7.3	7.3
							23	23
Q8	<3	<3	23	9.1	<3	<3	<3	<3
Q9	<3	<3	9.1	3.6	9.1	<3	<3	<3
10			3.6	3.6	<3	<3	<3	<3
Q15			43	9.1	15	9.1		
Q17			43	7.3	75	9.1	43	43
18			120	75	93	7.3		

* TC = Total Coliform
FC = Fecal Coliform
EC = E. Coli

** Aug. 6-8 by Oregon State
Sept 19-21 by Seafood Products Research Center, FDA.

gives the total and fecal coliform results of summer sampling by the State of Oregon and the SPRC-FDA.

IMViC Results

During both studies, a selected number of fecal coliform positive tubes from the various samples were examined for coliform speciation by IMViC testing. In May 248 isolates were examined from 213 positive FC tubes. In November-December, 213 isolates were examined from 190 tubes.

The majority of the results were categorized by study and water body: i.e. estuary; major tributary; or minor tributary. The major tributaries were Boone Slough, Nute Slough, Olalla Creek, Depot Creek and Yaquina River. The minor tributaries were all remaining discharges from sloughs, marshes, pipes, drainages, etc.

Table 14 presents a summary of these results. The two predominant IMViC codes were ++--, and --++, both also positive in EC medium (EC+) on follow up. These are *E. coli* and *Klebsiella* species. *E. coli* is associated with recent fecal contamination in the case of environmental sampling. Klebsiella is usually associated with soil and vegetation although it has been frequently found in feces.

TABLE 14

YAQUINA BAY, OREGON
IMViC - NUMBER OF ISOLATES POSITIVE

	MAY				NOV.- DEC.			
LOCATION	++-- EC+	--++ EC+	OTHERS*	TOTAL	++-- EC+	--++ EC+	OTHERS*	TOTALS
ESTUARY STA.	70	21	44	135	62	19	8	89
MAJOR TRIBS	79	9	8	96	34	8	4	46
MINOR TRIBS	15	1	0	16	37	16	5	58
TOTALS	164	31	52	247	133	43	17	193

PERCENT OF ISOLATES
(BASED ON LINE TOTALS)

ESTUARY STA.	52	16	32	100	70	21	9	100
MAJOR TRIBS	82	9	9	100	74	17	9	100
MINOR TRIBS	94	6	0	100	64	28	8	100
TOTALS	66	13	21	100	69	22	9	100

*Others Included
++-- EC-
--++ EC-
-+-- EC+
---+ EC+
-+-+ EC+ or -
++-+ EC+
-+++ EC+ or -
++++ EC+ or -
+-++ EC+

Although not found in Table 14, IMViC analyses were done on samples of sewage and oysters and the results were as follows: for oysters, 9 of 11 isolates were ++-- EC+; for raw Toledo sewage 7 of 7 isolates were ++-- EC+; and for treated Toledo sewage 1 of 2 isolates was ++-- EC+.

DISCUSSION

The purpose of this section is to interrelate the critical factors bearing on the classification of Yaquina Bay. These factors have been identified as the pollution sources located throughout the watershed, the time of travel and dilution of the pollution sources, and the bacteriological water quality.

SOURCES OF POLLUTION

Pollution sources which may impact on the bacteriological water quality have been identified. The major sources of concern include: 1) the individual nonsewered houses throughout the watershed; 2) the Toledo STP; and 3) domestic animals.

The individual nonsewered houses are located along the tributaries and tidal marshes. Some have been shown to be problematical during both study periods. Some were shown to affect water quality of the tributaries in the summer. The drain field problems of these houses are compounded during the wet season when the water table is higher. Some of these situations are significant since bacteriological levels in minor tributaries were as high as 24,000 FC/100ml. Some discharge directly into the approved commercial area with levels as high as 4600 FC/100ml.

Nonpoint pollution involves not only houses, but the domestic animals located throughout the watershed and along the banks of the Bay. These animals include cows, sheep, goats, pigs and horses. These animals graze in the low lying areas along the stream banks. The fecal material from these animals wash into the tributaries after rain and flooding. Some of the major and minor tributary sampling have reflected the effects on nonpoint pollution. Examples include high fecal coliform levels of Boone Sl. (240 FC/100ml); Nute Sl. (540 FC/100ml); T-18 (>24000 FC/100ml) with one house; and T-28 (1100 FC/100ml) with several houses.

Excessive infiltration into the sewer system of Toledo has affected the pumping stations as well as the STP. A normal sewage flow from 3000 people is about 0.3 mgd, yet, flows in excess of 3 mgd were found. The hydraulic overloads can affect the efficiency of treatment. The STP is not designed and does not have the necessary equipment to protect shellfish waters. The plant is considered to be unreliable to protected shellfish waters. Under normal operating conditions the plant may produce an acceptable effluent, but there are no assurances of continuous adequate protection because the plant lacks suitable chlorination monitoring. Fluctuations in fecal coliform levels were found in the effluent; i.e. <2 to 350 FC/100ml. The effluent reaches the commercial area in less than one ebb tide. Raw sewage from the plant could raise the FC levels in the commercial area by about 170 FC/100ml based on normal bacterial loads (0.3 mgd, 5 million FC/100ml and a dilution flow of about 13,800 cfs in the Bay). A pumping station bypass of 0.4 mgd which occurred during November was estimated to raise the fecal coliform in the Bay by at least 22 FC/100ml. This would be sufficient to close the Bay in itself.

Bacterial Population Equivalents (BPE)

Use can be made of the concept of bacterial population equivalents to further understand the relative impacts of the various sources of pollution on Yaquina Bay. The concept is described in "Observations of Fecal Coliforms in Several Recent Stream Pollution Studies"; R.K. Ballentine and F.W. Kittrell, Proc. Symposium on Fecal Coliform Bacteria in Water and Wastewater, Los Angeles. Cal., May, 1968. The BPE is derived from the flow of the stream, the bacterial concentration and a conversion factor. The formula used is:

$$BPE = Flow(cfs) x FC\text{-}MPN/100ml x (1.2x10^{-3})$$

For the Toledo STP flows and fecal coliform levels, the formula gives 2590 BPE for raw sewage in May and 1460 BPE in the raw sewage for the November-December study. The sewered population for Toledo is about 3000. The comparison is within acceptable limits.

Table 15 lists calculated BPE's for various tributaries during the three time periods of the November-December study. Because of the different flow regimes and FC levels, different total BPE's resulted. Nearly 1300 BPE's were found during the part of the study with the heavy rain and pumping station bypass. Following this, 529 BPE's were calculated for November 29-30. Toward the end of the study 117 BPE's were estimated to affect the bay. To compare these with what was found at Station Q9, BPE calculations were made using estimated flows of 18,455 cfs for November 28, 17,523 cfs for November 29-30 and 16,130 cfs for December 1-4. The results are 2,440 BPE, 700 BPE and 330 BPE for the three periods respectively. These are slightly higher but the difference can be attributed to the fact that most of the samples at Q9 were collected at low tide. Thus, some idea of the relative impacts of the various sources can be ascertained.

Under a condition of low fresh water flow and an estuary dilution flow of 13,840 cfs (6-ft tide range), 232 BPE would result in a FC of 14/100ml. The 232 BPE represents only 8% of Toledo's sewered population. Therefore a bypass of 8% of Toledo's sewage or a bacterial treatment efficiency of less than 92% would result in the program standard of 14 FC/100ml to be exceeded.

TABLE 15
YAQUINA BAY
BACTERIAL POPULATION EQUIVALENTS
NOV. - DEC., 1984

SOURCE	NOV. 28	NOV. 29-30	DEC. 1-4
Yaquina River above Toledo	560	270	71
Depot. Creek	81	40	10
Olalla Creek	92	108	6
Boone Sl.	46	16	8
NUTE Sl.	67	40	7
Toledo Pump Station	423	30	0
Remaining Watershed & Minor Tributaries	30	25	15
TOTAL	1299	529	117

HYDROGRAPHY

The results of the dye studies, salinity analysis and the tidal exchange calculations (Ketchum's analysis) have shown: 1) pollution sources travel directly to the commercial approved area; 2) short time of travel of the pollution sources to the approved area; and 3) an inadequate dilution flow.

Because the Bay is so narrow for most of its entire length there is no chance for dispersion of the pollution. Although there can be variable vertical mixing of pollutants, there generally is stratification with the fresher water containing most of the pollution staying in the upper layer where the rafted oysters are located.

Because the time of travel is less than one ebb tide there is little chance for die-off of pathogenic microorganisms. Die-off of indicator bacteria and pathogenic microorganisms can sometimes be significant in the classification of areas. However, for Yaquina Bay this factor does not work to any advantage because the water temperatures are mostly cool and the time too short for significant die-off to occur.

Furthermore, the time of travel is important in the development of a conditionally approved area with respect to delimiting the closed safety zone and the notification time.

The national program recommendation is that hydrographic travel time should be twice the notification time required to effect the closure. It cannot be ascertained at present what time is required to effect a closure after the various pollution events that might occur. However it appears that a portion of the existing commercial area may have to be included in a closed safety zone to assure that at least one full tidal cycle is made available for the notification time.

Dilution flow in the upper half of the Bay varies around 13,840 cfs depending on the tide range and fresh water inflow. However, as shown in the previous section, the flow can be considered inadequate for Toledo's raw sewage. The criticality of this available flow is exemplified by the calculation that shows that the flow is inadequate if over 8% of Toledo's raw sewage was released. The other identified pollution sources also aggravate the bacterial water quality because the dilution available is low.

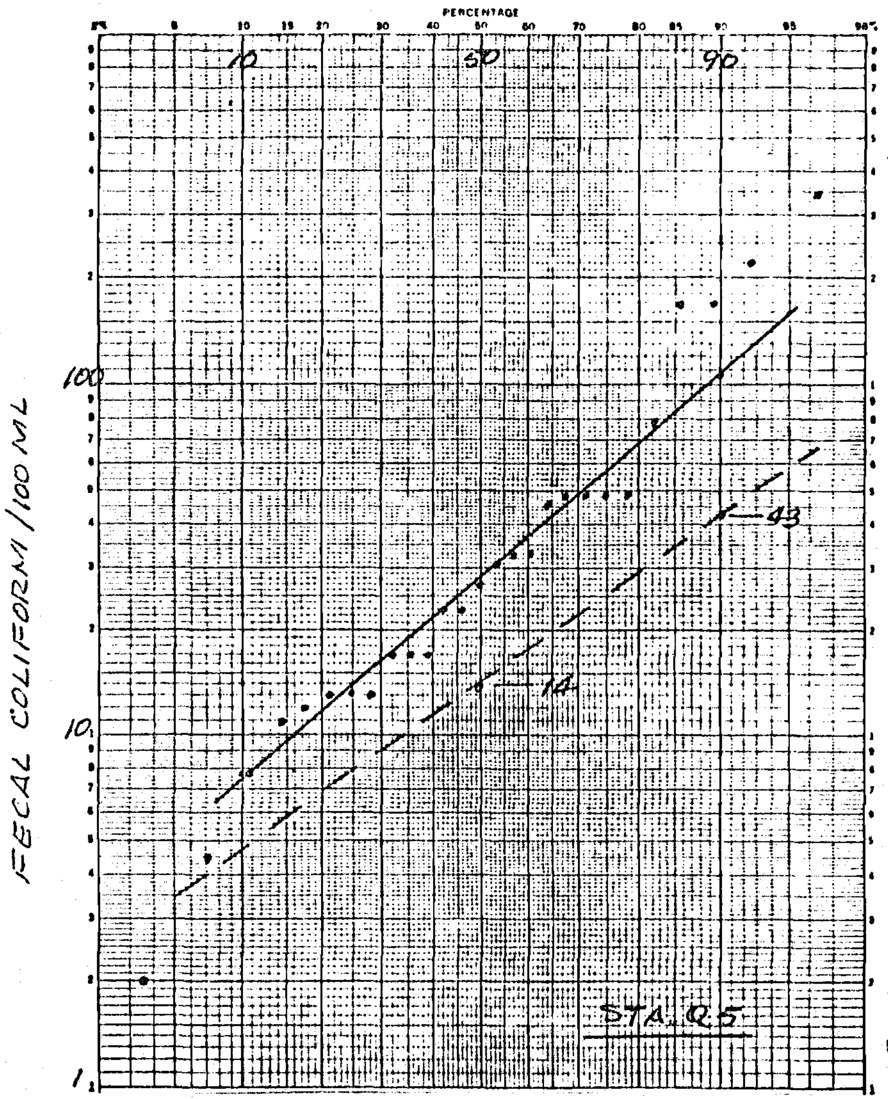
BACTERIOLOGICAL WATER QUALITY

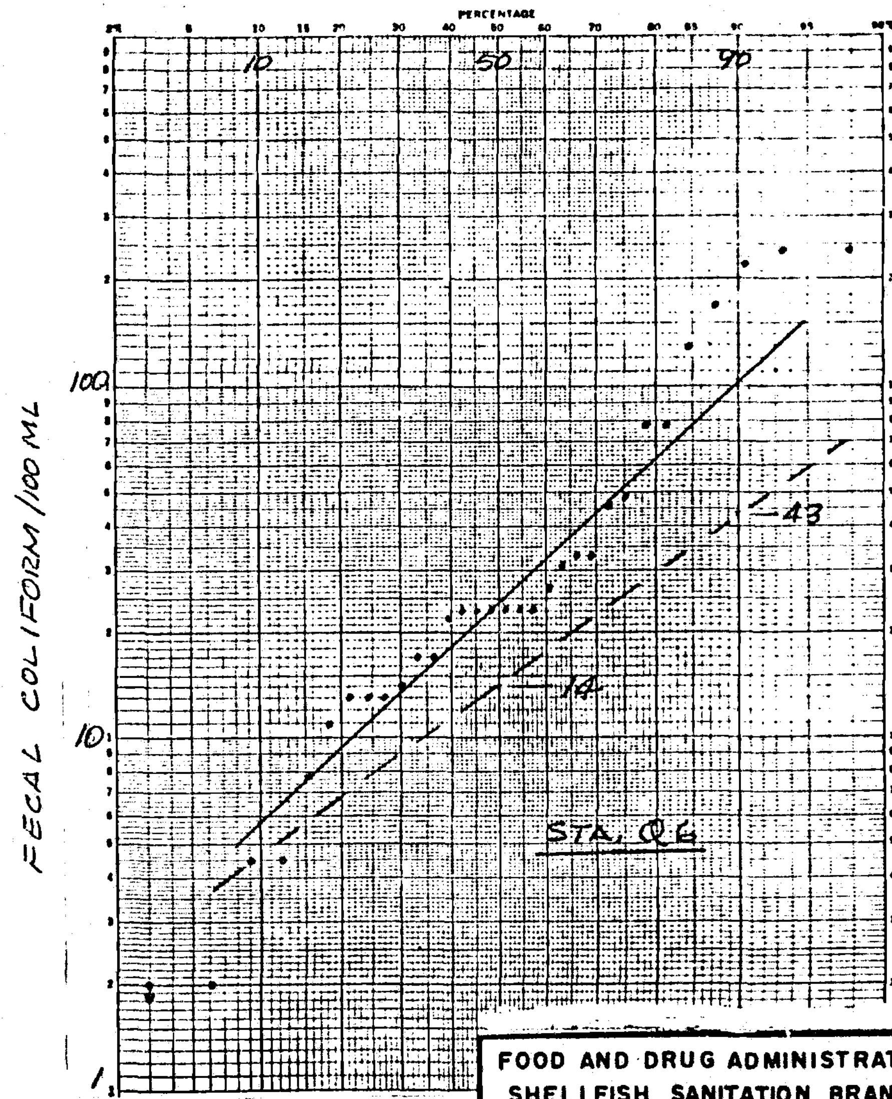
The foregoing discussion on the actual and potential pollution sources and the hydrographic factors raised sufficient issues which show that the commercial oyster area may be subject to recent microbiological pollution. The microbiological water quality was studied intensively during two periods: - May, 1984 when the Bay was presumed to be clear of any adverse rain - related effects, and November-December, 1984 when the Bay could be heavily impacted by storm conditions. Additionally, a few summer samples were taken.

The main concern is whether or not the area of Yaquina Bay covered by Stations Q5, Q6, Q8 and Q9 can meet the microbiological criteria of the National Shellfish Program.

The National Shellfish Sanitation Program (NSSP) has the following recommended water quality criteria for approved areas which can be used for direct marketing: a median value equal to or less than 14 FC/100ml, and not more than 10% of the samples should exceed 43 FC/100ml for a 5-tube MPN test. According to the program, the samples should be representative of the most adverse pollution and hydrographic conditions, since these are the conditions which might cause disease outbreaks. These adverse conditions are those which can occur frequently enough to cause concern about sanitary quality of shellfish. Unusual conditions such as might result from hurricanes are not included in this definition.

Based on 26 to 32 samples, the median values were: 27 FC/100ml for Q5, 32 FC/100ml for Q6, 32 FC/100ml for Q8 and 49 FC/100ml for Q9. Probability plots of the data for these stations are given in Figures 18 and 19. The lines of best fit were calculated for the data and the approved area





— — — SHELLFISH PROGRAM STANDARD

——— LINE OF BEST FIT

FOOD AND DRUG ADMINISTRATION
SHELLFISH SANITATION BRANCH

FIG. 18
FECAL COLIFORM-Q5, Q6
PROBABILITY PLOTS

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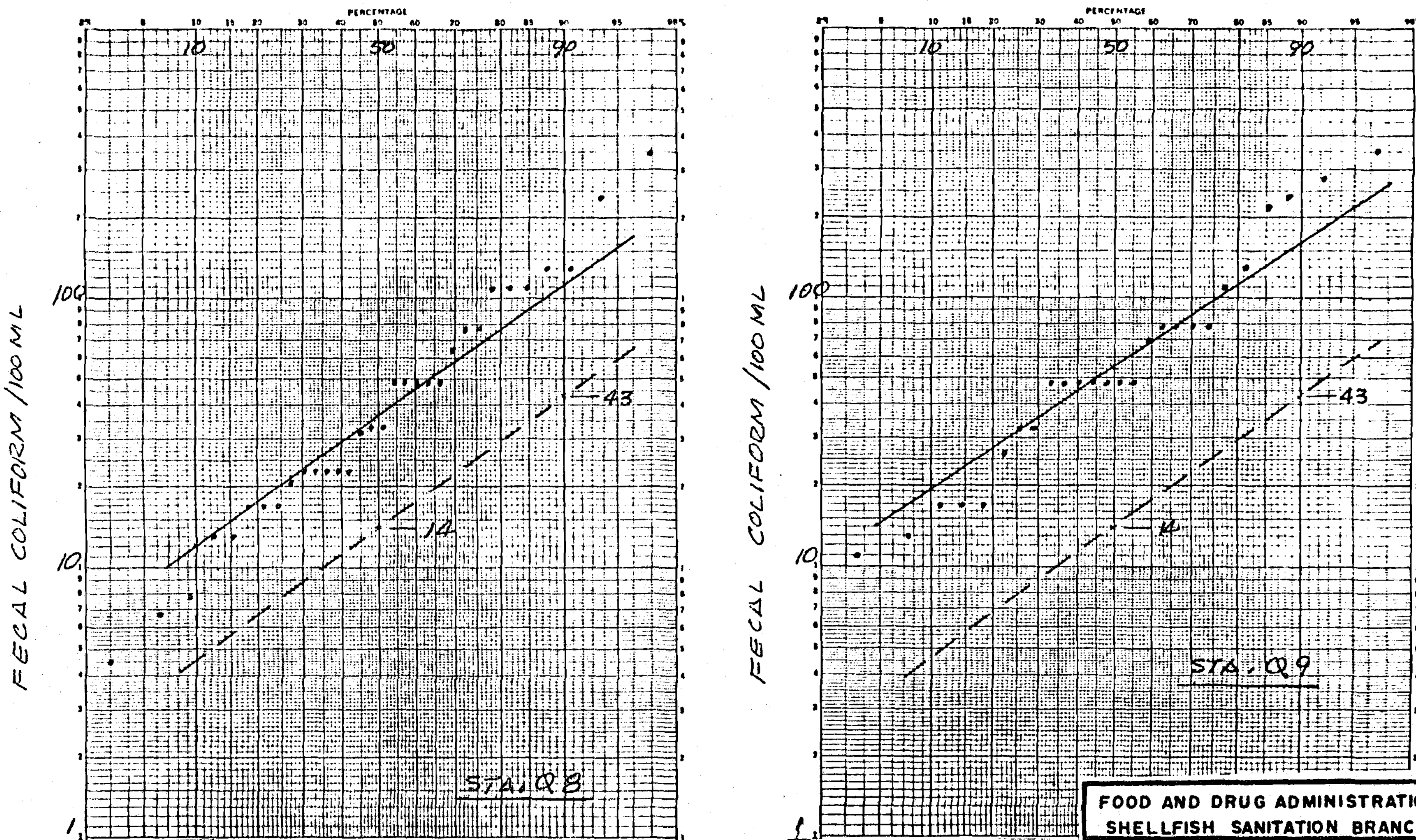

— — — SHELLFISH PROGRAM STANDARD

——— LINE OF BEST FIT

FOOD AND DRUG ADMINISTRATION
SHELLFISH SANITATION BRANCH

FIG. 19
FECAL COLIFORM - Q8, Q9
PROBABILITY PLOTS

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standard line is drawn for comparison. It is clear that overall, the data lines for all the stations are well above the program standard line. Statistical t-tests showed that there is a significant difference between all four data lines and the program standard at the .05 probability level. Statistical tests also showed that Station Q9 was significantly different than the other three stations in fecal coliform level. Overall none of the stations met the shellfish program standard for approved areas.

Since it is known that the data included in these overall medians and probability plots were from two different seasons and over differing tides, a further breakdown is in order. For the May studies, the medians were 18 FC/100ml for Q5, 17 FC/100ml for Q6, 33 FC/100ml for Q8, and 49 FC/100ml for Q9. Although Q5 and Q6 revealed some improvement, again none of the stations met the program criteria in May. The medians for the November-December study were 49 FC/100ml for Q5, 33 FC/100ml for Q6, 33 FC/100ml for Q8 and 49 FC/100ml for Q9. Again, no station met the median criterion of 14 FC/100ml for November-December.

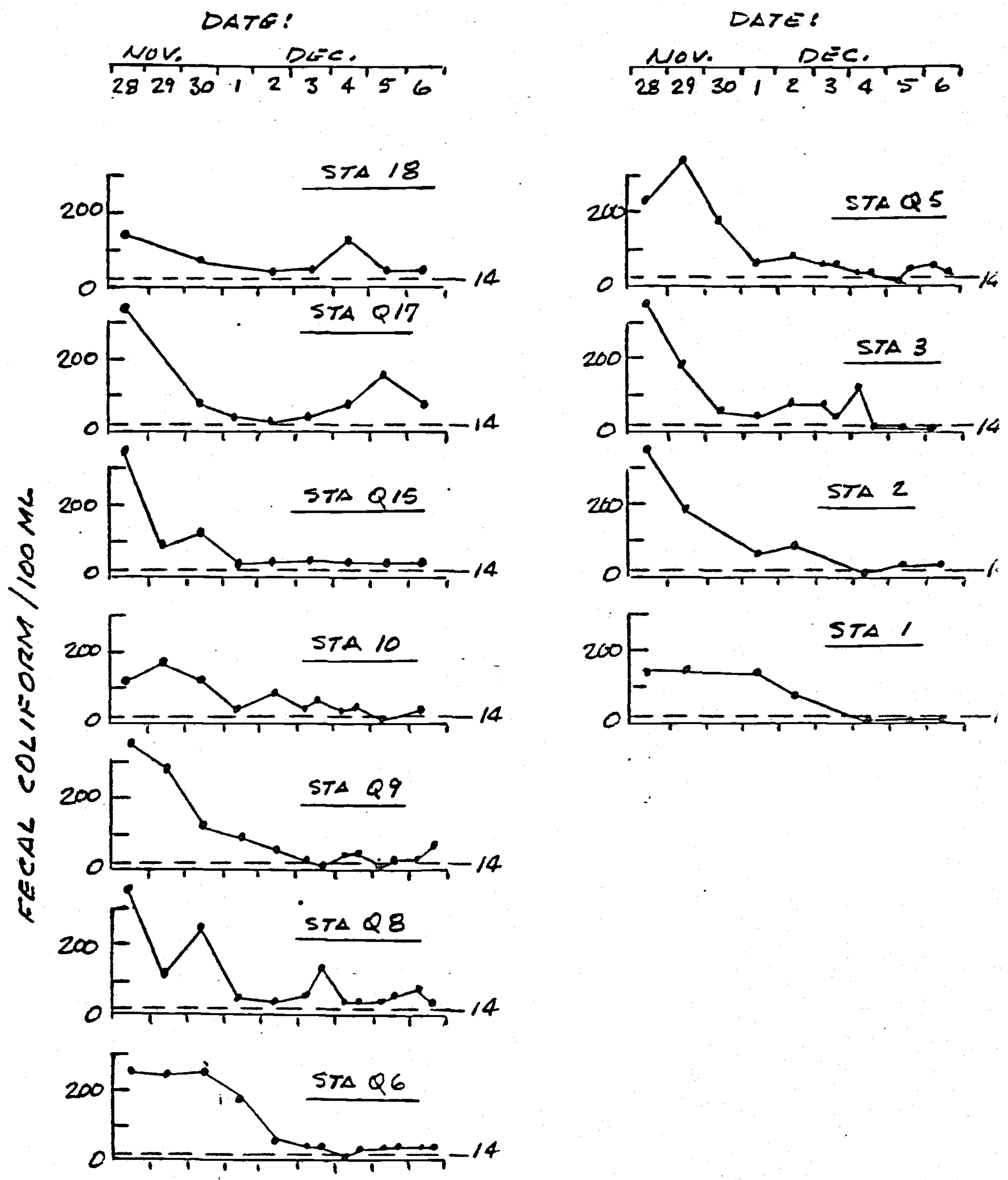
For these stations, none met the 10-percent variability criterion in either study or in the overall. Overall 23 to 49% of the samples exceeded the 43 FC/100ml. This high degree of variability is particularly important because there are too many times that the area cannot meet approved area criteria. Furthermore, maximum fecal coliform values found in the two studies are in the hundreds, well above the NSSP criteria. In May, Station Q5 had a value of 240 FC/100ml at low tide when rainfall was low. During November-December, Stations Q5, Q6, and Q9 each had maximum values of 350 FC/100ml during wet weather conditions.

Tidal influence on FC levels was significant during both studies. For example, at high tide in May, median levels were 8 FC/100ml at Q5, 6 FC/100ml at Q6, 15 FC/100ml at Q8 and 49 FC/100ml at Q9. For low tide the medians were 23, 23, 56 and 70 FC/100ml at Q5, Q6, Q8, and Q9 respectively. The classification of the area must be based on the most adverse condition even if it is for a short period of time such as around low tide because shellfish accumulate pollutants quickly. Low tide is an adverse hydrographic situation for the commercial oyster area of Yaquina Bay.

In the November-December study, <u>Table 11</u> shows that at low tide with rainfall effects, median values were 170, 220, 110, and 110 FC/100ml for Q5, Q6, Q8 and Q9 respectively. After rainfall effects had subsided somewhat and salinity levels began to rise, the median values at low tide were 24 FC/200ml at Q5, 28 FC/100ml at Q6, 28 FC/100ml at Q8 and 33 FC/100ml at Q9. At high tide the FC values at the four respective stations were 31, 23, 36 and 17 FC/100ml. Thus within a few days after heavy rainfall effects, there is some improvement in bacterial levels, but not enough to reduce FC levels to meet the national standard. Only the mouth of the bay could meet program criteria at the end of the November-December study.

Figure 20 presents a time plot of the FC results from the November-December study. The plot shows the reduction of FC levels at each station over the study period. It is clear that there are two distinct pollution periods. At the beginning of the study every estuary station showed extremely high fecal coliform levels. As the effects of the rain and pump station bypass abated the fecal coliform levels gradually dropped. The stations at the head of the bay cleared up by November 30. As the slug of pollution moved down the bay, the fecal coliform level began to drop about December 1 or 2 at the approved area. Finally the lower reaches of the bay began to clear up around December 3 or 4. This flushing of the fecal coliform from the bay follows approximately the flushing calculations given by the Ketchum's analysis - i.e. about 3 days.

The fecal coliform levels found in the May study are attributable to nonpoint human and animal sources because there was no known major municipal sewage problem. At the beginning of the May study there was heavy rain that might have caused a land wash which would raise fecal coliform levels. The fecal streptococcus levels were much lower than



FOOD AND DRUG ADMINISTRATI
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FIG. 20
F. COLIFORM RESULTS
NOV.-DEC., 1984

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fecal coliform in the major tributaries and the bay, indicating that human pollution sources were predominant. Rains on May 19 and again on May 22, both of which were close to an inch, appeared to have some local effects just below Toledo. Fecal coliform levels rose at Stations Q17 and Q15.

However, no significant increases above the already serious low tide FC levels could be seen at Station Q6. The cause of these increases appears to be increases in FC levels in Depot Cr. and Olalla Cr. the day after the rains. A sample on May 23 from the Yaquina R. a few miles above Toledo showed an elevated FC but evidently the runoff effects of the May 22 rain were not evident on the last day of sampling at Station 18 in Toledo.

The rain of May 19 appeared to have locallized effects on Boone Sl. since FC values more than doubled after this rainfall. FC values also increased in Nute Sl. but not as dramatically. These two tributaries discharge into Yaquina Bay only about one mile from the commercial shellfish area.

Of particular interest to the development of a conditionally approved area management plan is the influence of the Toledo STP. The deleterious effects of raw sewage from Toledo have been discussed. Just before the November-December study and continuing into the study, a 0.4 mgd bypass of raw sewage from Toledo occurred due to a pump station failure. Based on results of the dye studies, tidal prism calculations, and the estimated freshwater flow at the time of the bypass, it is estimated that the total dilution water available at the upstream portion of the commercial area was 15,940 cfs (or 10,300 mgd). This results in a dilution factor of 25,800:1. The Toledo raw sewage was rather weak at the time of the study with a FC level of about 570,000 FC/100ml. The likely added FC at the commercial area was 22 FC/100ml, sufficient in itself to close the area. (This bypass amounts to a BPE of about 420). This means that the majority of the FC at the commercial area was due to rainfall effects of nonpoint pollution.

IMViC Analyses - The speciation of the FC showed that the majority of isolates were *E. coli* for both studies. In May 66% of the isolates were *E. coli* and in November-December, 69% of the isolates. This testing showed definitively that fecal material was the significant source of the fecal coliform bacteria. The pattern of isolation shifted for the estuary stations and the minor tributaries from the May study to the November-December study. In May, with less runoff, the minor tributaries had a higher percentage (94%) of *E. coli* than in November-December (64%). However, the reverse was true for the estuary stations.

Fecal Streptococcus: It is also important to know if the FC derive from human or animal sources. The fecal streptococcus (FS) bacteria assists in providing some insight. The FS levels were considerably lower than the FC. If the pollution sources were strictly domestic or farm animal, the FS levels would generally be much higher than FC. For animals the FC/FS ratio is generally less than 0.7. A FC/FS ratio greater than 4.0 serves to indicate the existence of human sources. The ratios in between can be complex to interpret because of differential dieoff or mixtures of sources.

Table 16 provides FC/FS ratios for sampling stations in the commercial estuary area and some of the tributaries. Nearly every ratio is greater than 4.0. Also the ratios are higher in the May study possibly because there was less effect by domestic animals during that drier period. The major source of fecal coliform appears to be human.

In the November-December study, the higher FS levels occurred on the first few days reflecting some of the rainfall-effects of the animals. However, because of the great amounts of rain during November prior to the study, much of the domestic animal wastes may have already been washed out by runoff.

CLASSIFICATION CONSIDERATIONS

The foregoing illustrates with little doubt, that classification of Yaquina Bay as an approved area presents a hazard to the consumer. The existing commercial area does

TABLE 16

YAQUINA BAY

FECAL COLI/FECAL STREP RATIOS

STATION	MAY N	MAY RATIO	NOV. - DEC. N	NOV. - DEC. RATIO
ESTUARY				
Q 5	5	7.2	9	4.4
Q 6	8	>6.5	9	4.2
Q 8	11	>11.5	9	3.8
Q 9	-	-	10	6.4
TRIBUTARIES				
BOONE	4	>3	3	17.5
NUTE	5	5.1	4	5.0
DEPOT - D1	4	42.	3	3.4
DEPOT - D2	4	41.	-	-
OLALLA - OL1	5	>8.5	-	-
OLALLA - OL-2	4	11.9	-	-

not meet the national program criteria for an approved area. For continued harvesting the options are: (1) development of a conditionally approved management plan if feasible; and (2) purification of the shellfish.

The original intent of the survey was to develop the guidelines for a management plan. It was recognized at the outset, that conditions which might affect water quality in the commercial area are: (1) the failure of the Toledo STP or sewerage system and (2) rainfall effects on the nonpoint pollution sources - including human and animals. This study has attempted to quantify these effects.

The study has responded to the technical factors of a conditionally approved management plan comprising: 1) identification and quantification of pollution sources; and 2) hydrographic factors including time of travel, dispersion and dilution. The technical satisfactory compliance items of the NSSP involve water quality, operating procedures, closed safety zone, and critical sewage system units. Also involved are administrative procedures to be agreed on by the several parties. However, if the technical requirements cannot be attained, then the administrative aspects cannot be adequately resolved.

Technically, the commercial area of Yaquina Bay did not consistently meet the requirements of the NSSP for a conditionally approved area. As discussed above the reasons are: (1) high fecal coliform levels at low tide during both seasons studied; (2) lack of a rapid, adequate flushing of the area; (3) frequent rainfall-related pollution events in the wet season probably causing too many closures; (4) short time of travel requiring almost immediate closure; (5) numerous local pollution sources, both human and animal, which cause elevated fecal coliform levels in many minor tributaries discharging to the bay; and (6) lack of adequate reliability in the Toledo sewage treatment plant design, equipment, and attendance for protecting shellfish waters.

Because of these considerations, and the difficulties involved with establishing a conditionally approved management plan it appears that a feasible option is purification of shellfish. Relaying or basket relaying for purification probably is not appropriate because it is difficult to assure that certain portions of Yaquina Bay consistently meet the requirements of an <u>approved</u> area. Thus, controlled purification in tanks offers a suitable option. Some recommended approaches to plant construction and operation are given in Appendix II.

CONCLUSIONS

SOURCES OF POLLUTION

1. Point and nonpoint domestic sewage impacts on the microbiological water quality of the commercial shellfish area of Yaquina Bay. Human fecal material provides a majority of the fecal coliform found. The contributors are the City of Toledo and individual waste disposal systems.

2. Nonpoint animal pollution affects the microbiological water quality also.

3. The nonpoint pollution enters the Bay through many minor and the major tributaries that were found to be contaminated.

4. The sewer system of the City of Toledo (population 3000) suffers from excess infiltration. Excessive flows have in part contributed to failures of pump stations resulting in bypasses. The excessive flows hydraulically overload the sewage treatment plant. The Toledo STP does not have the necessary equipment to reliably protect shellfish waters. The local pulp and paper industry has adversely affected plant efficiency with periodic spills into the sanitary system.

5. Rainfall affects the water quality by a) causing individual disposal systems to fail, b) raises flows in the Toledo sewers, and c) causes land wash from pastures with farm animal feces. The effects on the tributaries are immediate and detrimental to water quality because the watersheds are small and hilly.

HYDROGRAPHY

1. The dilution provided by the tidal action in the Bay is inadequate for the nonpoint tributary sources. The dilution is also inadequate for the Toledo STP if more than 8% of the sewage is bypassed, or if microbiological treatment falls below 92%.

2. The pollution sources reach the commercial area with little dispersion since the Bay is narrow for nearly its entire length.

3. The time of travel from pollution sources to the commercial area is within 1/2 tidal cycle (6 hours), leaving little time for dieoff of pathogens or for notification. Individual disposal systems fail directly into the commercial area.

4. The residence time of a slug of pollution in the commercial area is about 3 days which is sufficient time

to pollute shellfish yet leaving little time for natural purification. Flushing action of the Bay for several days did not reduce fecal coliform levels sufficiently in the commercial area during the November-December study.

BACTERIOLOGICAL DATA ANALYSIS

1. None of the four sampling stations in the commercial area (Q5, Q6,Q8 or Q9) met the National Program fecal coliform standard for approved water on an overall basis. None of the stations met the standard under low tide conditions in May, 1984, (dry weather) or in November-December (wet weather). Fecal coliform criteria were exceeded by a margin large enough to state that a high risk to the shellfish consumer exists.

2. A high percentage, up to 49%, of the time the water quality exceeded the 43 FC/100ml criteria for variability when only 10% is allowed. Variable hydrographic and meteorlogical conditions resulted in variable pollution conditions requiring the separation of data to determine the most unfavorable pollution and hydrographic conditions. The variability found is not acceptable for a conditionally approved area. Maximum fecal coliforms to as high as 350 FC/100ml were found in the commercial area. These are dangerous levels.

3. Most of the fecal coliform found was E. coli an unquestioned indicator of fecal material. Thus, the fecal coliform and E. coli were indicative of recent fecal pollution.

4. Low fecal streptococcus results and high fecal coliform to fecal streptococcus ratios demonstrated a preponderance of human pollution affecting the water quality rather than animal.

CLASSIFICATION OF THE AREA

1. The approved commercial area of Yaquina Bay is improperly classified according to the requirements of the National Shellfish Sanitation Program.

2. It is not feasible to develop a management plan based on rainfall during the fall-winter wet season because heavy rainfall occurs too frequently and the effects persist too long. No good correlation has been established between rainfall and water quality.

3. The numerous nonpoint sources such as failing disposal systems for individual houses and the presence of farm animals are uncontrolled sources. This prevents a reliable operating procedure from being established.

4. An adequate closed safety zone below the pollution sources would be difficult to establish because of the closeness of the various pollution sources and the lack of sufficient dilution in the vicinity of the commercial area. Existing notification procedures for closing of the commercial shellfish area were ineffective. This feature of management would not improve unless changes were made in the alarm systems, plant attendance and the chlorination capability of the City of Toledo.

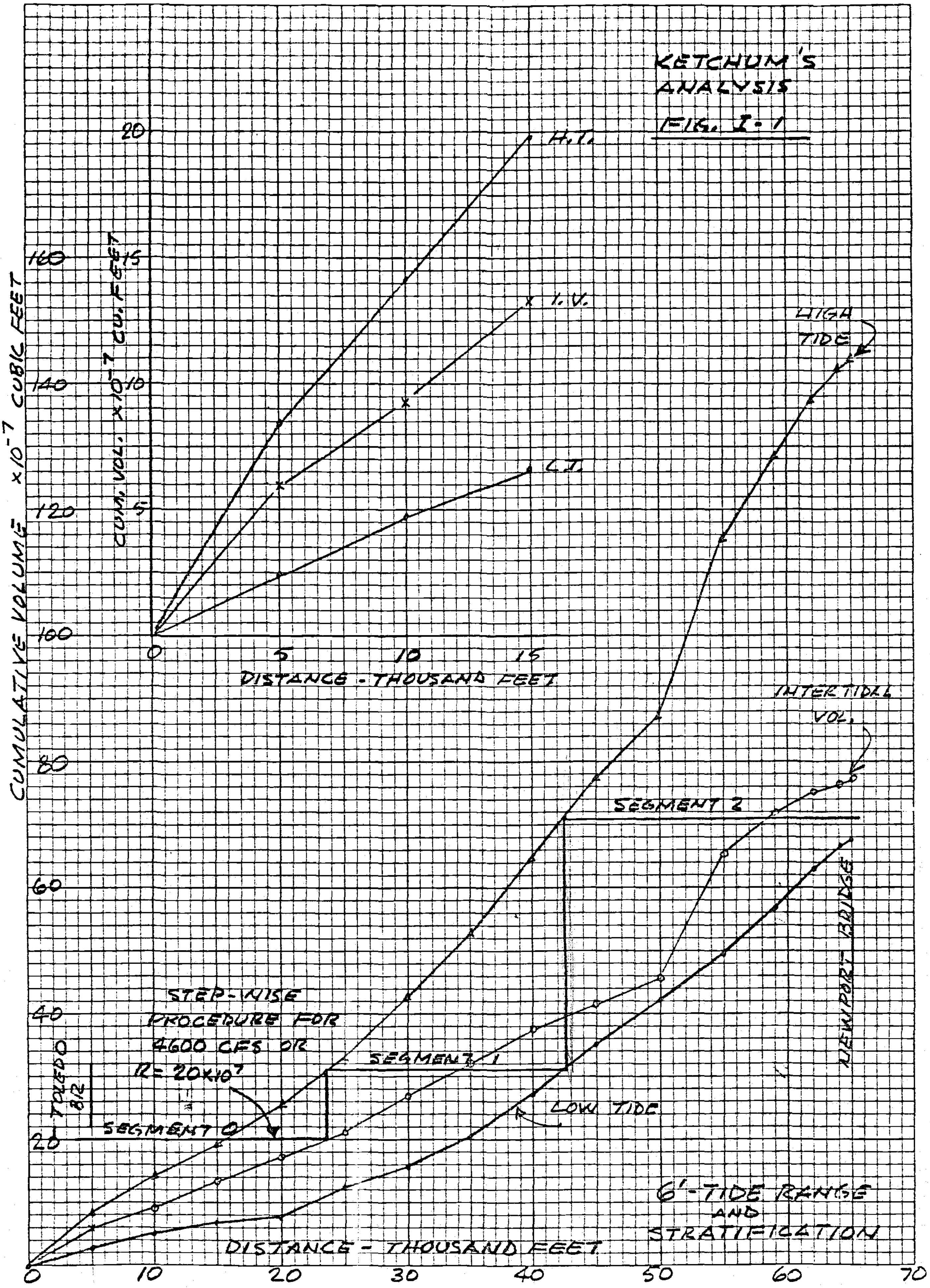
APPENDIX - I

FLUSHING RATE OF BAY

KETCHUM'S ANALYSIS

An analysis for flushing rate of the bay was made utilizing the physical dimensions of the bay, the 6-foot tide range and the freshwater flow rates encountered during November-December, 1984. The analysis was based on that described in: "The Exchanges of Fresh and Salt Water in Tidal Estuaries", Bostwick H. Ketchum, Journal of Marine Research, p. 18-38, 1951.

The method involves calculating the low tide, intertidal and high tide volumes from the head of the bay toward the mouth. This was done using cross-sectional areas (derived from measurements on Nautical Charts) at various segments throughout the bay. For purposes of this determination, the head of the bay was assumed to be 5,000 feet upstream from the Toledo Bridge. Because of the marked stratification and salt water wedge, adjustments were made at the lower reach of the bay. A graph of the cumulative volumes are given in Figure I-1.


KETCHUM'S
ANALYSIS
FIG. I-1
H.T.
I.V.
L.T.
CUM. VOL. x10^-7 CU. FEET
DISTANCE - THOUSAND FEET
CUMULATIVE VOLUME x10^-7 CUBIC FEET
HIGH TIDE
INTERTIDAL VOL.
SEGMENT 2
SEGMENT 1
SEGMENT 0
STEP-WISE PROCEDURE FOR 4600 CFS OR R = 20x10^7
TOLEDO B/2
NEWPORT BRIDGE
LOW TIDE
6'-TIDE RANGE AND STRATIFICATION
DISTANCE - THOUSAND FEET

Briefly, the analysis involves a step by step procedure which begins by assuming the first segment has an intertidal volume equal to the freshwater inflow (R) over one tidal cycle or about 12 hours. The next segment has a low tide volume equal to the high tide volume of the previous segment. This stepwise procedure is shown for one flow on Figure I-1. The various bookkeeping calculations are given in Table I-1. The results are estimates of the average flushing time (t_n) in tidal cycles for each segment and the percent of freshwater (F) in each segment. The total flushing time is calculated also, and tidal cycles are converted to days. With the percent of freshwater and the assumption that ocean water had a salinity of 32 $^o/oo$, the average salinity at each segment can be derived.

Figure I-2 plots these factors which were calculated in Table I-1. The four freshwater flows used were the total fresh water estimates for prior to and during the November-~~December study~~.

For 1,600 cfs, the zero salinity contour occurs at the bend just below Toledo. For 4,600 cfs the zero salinity occurs near Station Q5. These results are not far from those found by the field salinity measurements. During the high river flows, salinities as low as 0.9 $^o/oo$ were found at Oneatta Pt. or Station Q5.

KETHUM'S ANALYSIS WITH STRATIFICATION AND 6-FT TIDE ESTUARY: YAQUINA BAY - NOV-DEC 1956

FLOW		DIST.	CUMULATIVE VOLUME			LOCAL VOLS.			ACCUMULATION		F			
CFS	SEGMENT n	FT	ΣL.V.	ΣI.V.	ΣH.V.	I.V.	H.V.	r *	Qn	ΣQn	%	tn	Σtn	DAYS
1600	0	6500	3.0	6.9	10.0	6.9	10.0	.69	10.0	10.	100	1.45	1.45	.7
6.9×10^7 = R	1	22000	10.0	19.0	28.5	12.1	18.5	.65	10.6	20.6	57	1.54	2.99	1.5
	2	41000	28.5	38.0	67.0	19.0	38.5	.49	14.1	34.7	37	2.04	5.03	2.5
	3	64000	67.0	76.0	142	38.0	75.0	.51	13.5	48.2	18	1.96	6.99	3.5
2300	0	11000	5.8	9.9	15.0	9.9	15.0	.66	15.0	15	100	1.52	1.52	.8
R=9.9×10^7	1	29000	15.0	26.0	41.0	16.1	26	.62	16.0	31	62	1.61	3.13	1.6
	2	49000	41.0	45	86.0	19.0	45	.42	24	55	53	2.37	5.50	2.8
	3	OCEAN	86.0											
3700	0	18000	7.5	16.	23	16	23	.70	23	23	100	1.44	1.44	.7
R=16×10^7	1	36500	23	34	57	18	34	.53	30	53	88	1.89	3.33	1.7
	2	59000	57	74	128	40	71	.56	29	82	41	1.78	5.11	2.6
4600	0	23500	11	20	31	20	31	.65	31	31	100	1.55	1.55	.8
R=20×10^7	1	42500	31	39.5	71	19.5	40	.49	41	72	100	2.05	3.21	1.6
	2	NPT + BRIDGE	71	78	146	39	76	.57	39	111	51	1.95	5.16	2.6

* r = TIDAL EXCHANGE = $\frac{I.V.}{H.V.}$

$t_n = 1/r_n$ = TIDAL CYCLES

ALL VOLUMES × 10^{-7} CUBIC FEET

$F = Q_n/HV$

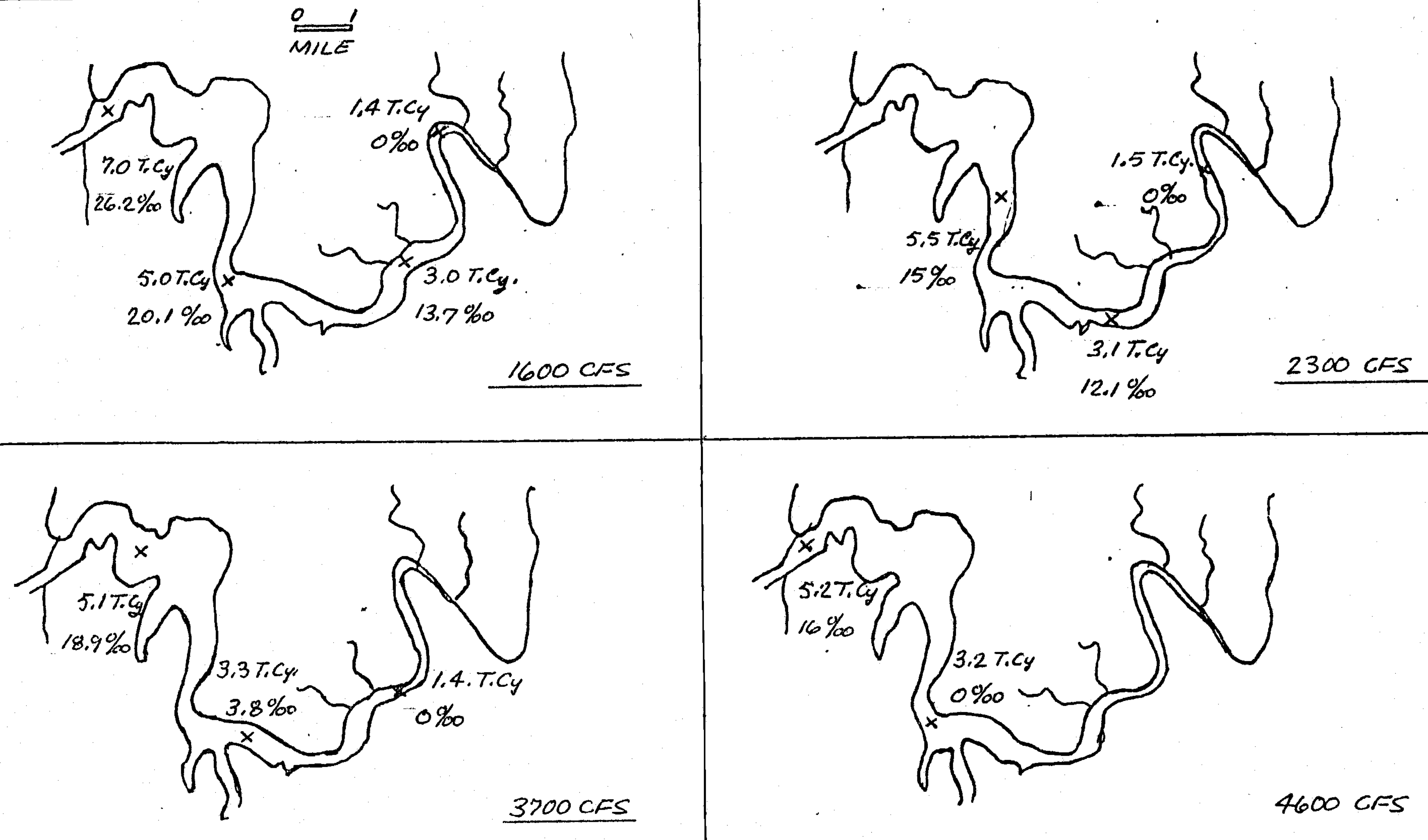
TABLE I-1

KETCHUM'S ANALYSIS

I-4

28-18

r. I.V. R Qn/(m) 1



T.Cy. = Tidal Cycles Flushing Time
‰ - Calculated Salinities
CFS = Flow of Fresh water cu. ft per sec.

FIG. I-2

RESULTS & PREDICTIONS OF KETCHUM'S ANALYSIS

At the lower river flows, 1,600 cfs, the average detention time for a particle of fresh water is about 7 tidal cycles or about 3.5 days. At the peak river flow of 4,600 cfs the average detention time is 5.2 tidal cycles or about 2.5 days.

These results will be useful for determining how long after a pollution event ends must the bay remain closed.

APPENDIX II

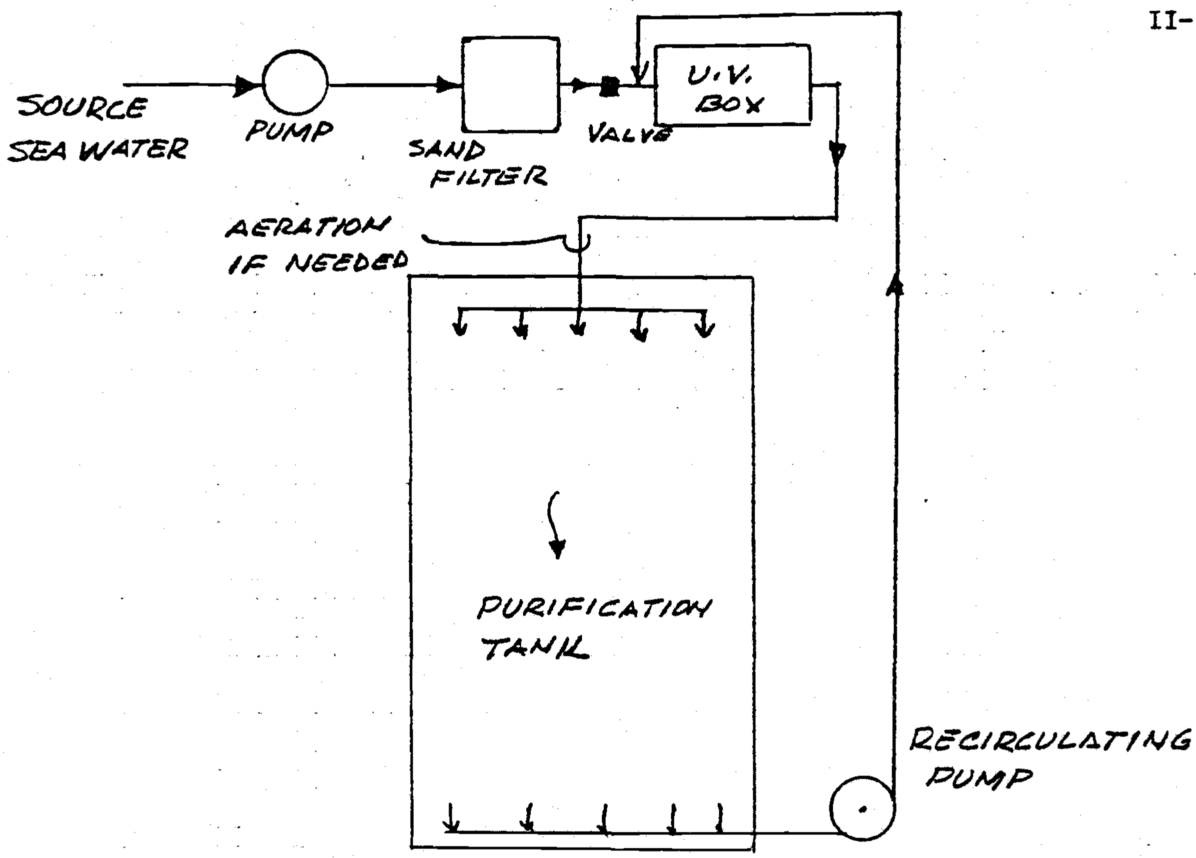
USE OF CONTROLLED PURIFICATION

This appendix provides some practical information for small controlled purification plants for oysters. More information is available in the references. In the event that any oyster dealer decides to use the process the following are recommended:

1. Construct a recirculating system as per Figure II-1. The source of sea water should be bottom water to insure higher salinity during the winter season. Provide a sand filter capable of being backwashed. Construct an ultra-violet light treatment box according to Figure II-2, for microbiological treatment or purchase a commercial unit.

2. Provide a plastic recirculating pump with motor resistant to salt water corrosion. Provide a standby pump. All piping should be plastic, easily cleaned with suitably placed cleanouts. Provide a free fall of the circulating water to maintain oxygen levels.

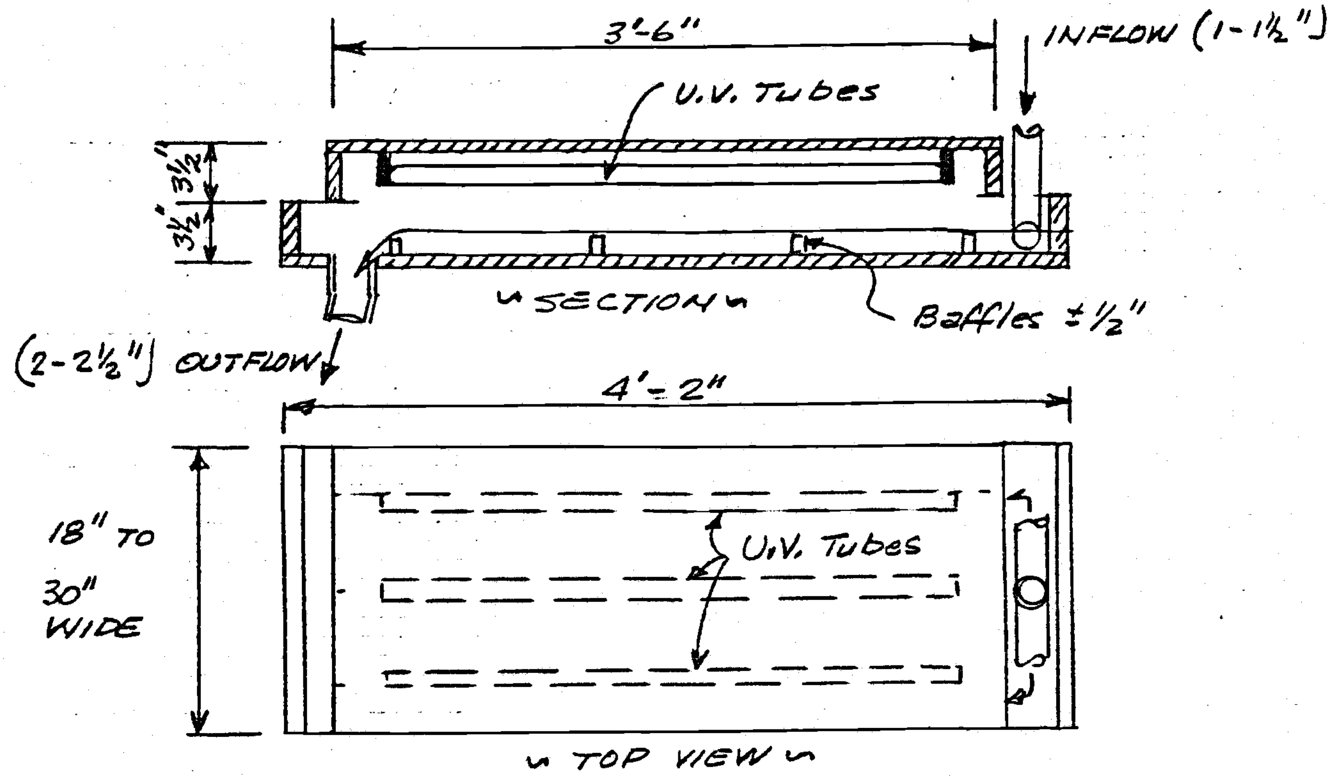
3. Provide one or more shallow tanks with the following features; a) quick filling and draining with adequate



TANK SIZE L FT	W FT	DEPTH INCHES	VOL. GALL.	APPROX. CAPACITY BUSHELS OYSTERS	NO. OF LAYERS	RECIRC. PUMP GPM
4	8	9	180	3-4	1	4
4	8	15	310	5-6	2	6
4	8	24	480	8-10	3	10
4	12	24	720	12	3	12

FIG. II-1

CONTROLLED PURIFICATION
RECIRCULATING SEAWATER
SYSTEM
AND
TANK SPECIFICATIONS



Approx. Water depth = 3/4"

Approx. U.V. Intensity = 8000-10,000 μw-sec/cm²

WIDTH	NO. U.V. TUBES	MAX. FLOW
INCHES		GPM
18	3	13
24	4	17
30	5	25

FIG. II-2

ULTRA-VIOLET LIGHT TREATMENT UNIT AND FLOW SPECIFICATIONS

slope for flushing out of sediment, etc. b) uniform flow of U.V. treated water; c) smooth light colored interior easily cleaned between each purification run.
Figure II-1 provides typical tank size and capacities for oysters.

4. Provide suitable meshed trays or baskets to hold the oysters in the tanks off the bottom. The baskets or trays shall be a maximum of 3-inches deep. Baskets or trays shall be easily cleaned.

5. The tanks should be fenced for security purposes and a roof should be installed to minimize problems from birds or rain. All electrical components should be protected from the elements and well grounded.

6. Commercially made U.V. boxes are available but the schematic drawing Figure II-2 provides view of a home-made version used in the USA and abroad for many years to treat seawater. The U.V. tubes and box require daily cleaning. U.V. tubes and electrical fixtures are readily available.

Typical operations require adherence to the requirements for the National Shellfish Sanitation Program. These operations involve: a) cleaning of all materials, tanks, etc; b) washing-culling of oysters; c) certain monitoring programs;

d) minimum of 48-hours of purification; e) record keeping; f) adequate supervision.

References

1. "Shellfish Purification - A Review of Current Technology"; Santo A. Furfari, 1976. FAO Technical Conference on Aquaculture.

2. "Proposal for Addition to Part II of the Manual - Appendix D - Controlled Purification"; 1971, 7th National Shellfish Sanitation Workshop, Proceedings pp. 333-349.

3. "Practical Considerations for Bacterial Depuration of Oysters in the Chesapeake Bay Region". B.J. Nielson, et. al. 1976. Vol. I. Virginia Institute of Marine Sciences.

Department of Health and Human Services
U.S. Public Health Service
Food and Drug Administration

Yaquina Bay, Oregon
Comprehensive Sanitary Survey
May, 1984 and November-December, 1984

SUPPLEMENT OF RAW DATA

State of Oregon Department of Health
and
Environmental Quality
and the
U.S. Food and Drug Administration

YAQUINA BAY, OREGON - MAY 1984

DATE	TIME	TEMP °C SURF	TEMP °C BOTT	SAL. °/00 SURF	SAL. °/00 BOTT	T. COLI MPN/100	F. COLI MPN/100	F.STREP MPN/100
STATION NO. 1								
5/14	1040	12.1	12.1	31.8			<2	
5/14	1644	13.2	12.5	28.5	31.0		1.8	
5/15	918	13.0	11.8	24.0	31.5		6.8	
5/16	847	13.2	12.6	21.1	26.1		4.5	
5/16	1410E	11.9	11.5	32.4	32.4		<2	
5/17	850	13.4	12.9	21.9	25.8		6.8	
5/18	852	13.4	12.9	24.1	28.5		<2	
5/19	830	13.4		25.7			2	
5/20	1100	14.0		21.5			7.8	
5/21	1256	14.2		21.1			2	
5/22	855	12.9		24.6			1.8	
5/22	1330	13.6		20.2			<2	
5/23	910	12.5		26.7			22	
STATION NO. 2								
5/14	1050E	12.8	12.2	26.3	31.2		22	
5/14	1634	13.2	12.6	26.3	29.8		6.8	
5/15	931	13.2	13.0	15.3	22.3		4.5	
5/15	Bottom						4.5	
5/16	859	13.3	13.2	14.5	17.8		13	
5/17	1408	12.5	11.7	31.5	32.4		2	
5/18	906	14.0	13.4	18.1	24.4		14	
5/19	1340	13.7		25.8			13	
5/20	1110	14.3		16.9			11	
5/21	1248	14.8		16.2			23	
5/22	905	13.8		21.5			2.0	
5/22	1323	14.0		16.3			4.5	
5/23	918	13.0		23.9			6.8	

E = Estimated Time

DATE	TIME	TEMP °C SURF	BOTT	SAL. °/00 SURF	BOTT	T. COLI MPN/100	F. COLI MPN/100	F.STREP MPN/100
STATION NO. 3E								
5/14	11:04	12.8	12.2	26.4	30.2		7.8	
5/14	1626	13.3	13.1	24.7	25.6		9.2	
5/15	945	13.3	13.0	16.0	23.9		7.8	
5/15	1406	13.5	12.0	27.2	31.7		2.0	
5/16	901	13.3	13.2	11.5	16.9		22	
5/16	1402	12.8	12.0	26.3	31.7		4.5	
5/17	902		13.8		14.9		11	
5/17	902	13.8		13.8			49	
5/17	1400	13.6	12.2	26.5	31.5		<2	
5/18	911	14.1	14.0	16.6	16.6		7.8	
5/18	1359	13.4	13.2	25.8	27.8		2	
5/19	840	14.1		19.2			13	
5/19	1335	13.9		21.1			7.8	
5/20	1114	14.1		16.3			49	33
5/21	1241	15.0		15.5			3 1	
5/22	909	13.7		17.			4.5	
5/22	1318	14.2		15.1			17	
5/23	921	13.4		20.3			7.8	
5/23	1325	15.0		14.7			13	
STATION NO. 3W								
5/14	11:11	12.8	12.4	26.2	28.8		7.8	
5/14	1629	13.2	13.2	27.9	27.9		17	
5/15	950		12.0		32.0		17	
5/15	1409	12.9		30.3			2	
5/16	910	13.3		11.7			23	
5/16	1406	13.3	12.1	30.8	31.7		<2	
5/17	908	14.0		13.7			22	
5/17	909		14.9		13.7		7.8	
5/17	1405	14.9	12.2	27.4	31.7		<2	
5/18	914	14.2	14.0	16.2	18.3		23	
5/18	1403	13.4	13.1	27.2	28.0		4	
5/19	845	14.1		19.2			17	
5/19	1338	14.2		22.4			4.5	
5/20	1116	14.2		15.9			17	
5/21	1244	15.0		15.8			4.5	
5/22	912	13.7		20.6			2.0	
5/22	1320	14.2		15.7			17	
5/23	924	13.3		23.7			2.0	
5/24	1327	15.0		16.3			7.8	

YAQUINA BAY, OREGON - May 1984

DATE	TIME	TEMP°C SURF	TEMP°C BOTT	SAL. °/00 SURF	SAL. °/00 BOTT	T. COLI MPN/100	F. COLI MPN/100	F.STREP MPN/100
STATION NO. Q5								
5/14	11:22	12.9	12.8	20.5	23.0		12	
5/14	1615	13.8	13.2	17.1	23.2		23	
5/15	1003	13.4	13.0	7.4	11.9		13	
5/15		BOTTOM					170	
5/16	925	13.1	13.1	3.6	7.4		49	1.8
5/17	921	13.8	13.8	4.8	5.6		33	
5/18	1347	14.8	13.8	19.2	23.0		2	<2
5/19	855	14.6		12.7			13	4.5
5/20	1126	14.3		11.9			27	4.5
5/21	1220E	14.9		12.7			11	<2
5/22	922	14.0		11.4			4.5	
5/22	1310	14.3		11.9			33	
5/23	931	13.5		14.2			13	
5/23	1317	14.7		10.0			23	
STATION NO. Q6								
5/14	11:28	13.2	13.2	14.6	16.5		23	
5/14	1611	13.8	13.1	14.4	23.3		13	
5/15	1012	13.1		9.1			31	
5/15	1009		13.0		10.1		49	
5/15	1355	13.5	13.1	23.9	25.6		4.5	
5/16	929	13.1	13.1	2.2	4.7		79	4.5
5/16	1350	13.9	13.5	22.2	23.7		2	<2
5/17	925	13.6	13.7	3.3	4.5		79	7.8
5/17	1345	14.7	14.2	20.5	21.1		11	<2
5/18	925	14.4	14.4	7.5	7.8		130	
5/18	1343	15.1	14.4	17.0	18.4		7.8	
5/19	858	14.6		12.7			14	<2
5/19	1330E	14.4		16.0			4.5	<2
5/20	1128	14.6		10.6			17	4
5/21	1212	14.9		12.0			13	2
5/22	925	14.0		10.9			17	
5/22	1308	14.2		11.3			23	
5/23	934	14.0		15.4			<2	
5/23	1314	14.7		9.6			23	

YAQUINA BAY, OREGON - May 1984

DATE	TIME	TEMP °C SURF	TEMP °C BOTT	SAL °/oo SURF	SAL °/oo BOTT	T. COLI MPN/100	F. COLI MPN/100	F.STREP MPN/100
STATION NO. Q8								
5/14	1136	13.2	13.2	14.6	17.3		33	
5/14	1604	13.7	13.2	10.3	19.4		79	
5/15	1016	12.9	12.9	4.0	5.2		130	
5/15	1349	13.9	13.5	19.3	21.2		7.8	
5/16	938	13.0	12.7	1.2	2.0		49	4.5
5/16	1340	14.0		16.9			6.8	<2
5/16	1338		13.7		20.0		23	<2
5/17	935	13.2	13.2	1.6	1.6		110	11
5/17	1330	15.2	14.8	13.5	14.6		4.5	<2
5/18	933	14.2	14.2	4.0	4.0		110	11
5/18	1338	14.4	14.6	13.8	14.7		49	<2
5/19	903	14.6		10.0			21	<2
5/19	1320	14.6		12.5			13	<2
5/20	1133	14.3		8.5			64	1.8
5/21	1205	14.8		9.8			17	4.5
5/22	931	14.3		9.3			17	
5/22	1305	14.3		9.5			13	
5/23	940	13.5		10.9			49	
5/23	1310	14.5		9.0			49	
STATION NO. Q9								
5/14	1140	13.2	13.1	12.3	13.6		26	
5/14	1558	13.7	13.6	7.4	10.9		33	
5/15	1025	12.9	12.8	2.4	3.0		220	
5/15	1342	13.9	13.5	13.6	16.8		49	
5/16	1333	13.9	13.9	12.8	14.2		49	
5/17	948	13.1	12.9	.8	.9		130	
5/18	940		14.1		5.3		240	
5/18	940	13.8		1.5			79	–
5/19	910	14.8		8.1			49	
5/20	1139	14.3		6.0			49	
5/21	1200	14.8		8.3			70	
5/22	1300	14.3		8.1			49	
5/23	1306	14.5		8.6			79	

DATE	TIME	TEMP°C SURF	TEMP°C BOTT	SAL °/00 SURF	SAL °/00 BOTT	T.COLI MPN/100	F. COLI MPN/100	F.STREP MPN/100
STATION NO. 10								
5/14	1145	13.0	13.0	8.3	8.9		49	
5/14	1553	13.2	13.3	4.3	8.9		70	
5/15	1335	14.2	13.8	10.1	11.1		23	
5/16	1325	14.1		8.1			33	
5/16	1325		14.0		8.7		31	
5/17	955	12.4	12.4	.4	.4		49	
5/18	942	13.2	13.2	.6	.6		240	
5/18	1329	15.4	14.6	2.6	4.7		79	
5/19	915	14.6		4.7			79	
5/20	1145	14.0		2.1			23	
5/21	1155	14.7		5.5			49	
5/22	1255	14.2		6.6			33	
5/23	1302	14.3		6.1			17	
STATION NO. Q15								
5/14	1150	12.8	12.8	5.0	5.5		33	
5/14	1548	13.2	13.2	3.3	4.8		70	
5/15	1328	14.3	13.8	6.5	7.9		49	
5/16	1316	13.9	13.9	2.3	3.8		33	
5/17	1000	12.1	12.2	.2	.3		79	
5/18	1002		13.0		.4		130	
5/18	1002	13.2		.4			33	
5/19	920E	14.2		2.1			70	
5/20	1149	13.5		1.2			170	
5/21	1147	14.3		3.1			49	
5/22	1250	13.9		3.5			33	
5/23	1259	14.4		4.8			170	

DATE	TIME	TEMP °C SURF	BOTT	SAL °/00 SURF	BOTT	T.COLI MPN/100	F. COLI MPN/100	F.STREP MPN/100
STATION NO. Q17								
5/14	1201	12.5	12.3	1.1	1.4		140	
5/14	1536	12.6	12.6	.7	.7		49	
5/16	1307	13.2	13.2	.7	.9		70	
5/18	1014	12.5	12.5	.2	.2		23	
5/19	925		13.4		.4		33	
5/19	925	13.5		.5			49	
5/20	1159	12.9		.2			170	
5/21	1139	13.7		.0			49	
5/22	1245	13.2		1.8			33	
5/23	1251	13.3		2.3			130	
STATION NO. 18								
5/14	1530	12.4	12.4	.4	.4		240	
5/16	1300	12.9	12.9	.4	.4		70	
5/19	940	13.2		.1			33	
5/20	1204	12.5		.0			22	
5/21	1135	13.3		.0			17	
5/22	1240	12.7		.0			17	
5/23	1245	13.2		1.0			33	

DATE	TIME	TEMP°C SURF	TEMP°C BOTT	SAL. °/00 SURF	SAL. °/00 BOTT	T. COLI MPN/100	F. COLI MPN/100	F.STREP MPN/100
STATION NO. B	BOONE SL							
5/15	1225	15.5		0.0			14	
5/16	1555	17					4	<2
5/18	1030	17		.75			2	<2
5/19	924	17		0			7.8	1.8
5/20	1208	17.5		0			33	2.0
5/21	1212	18.5		0			21	
STATION NO. N	NUTE SL							
5/15	1210	14.5		0.5			490	
5/17	1515	16.5		7.0			33	2.0
5/18	1015	17		0			170	49
5/19	937	17		0			110	33
5/20	1150	16		0			490	33
5/21	1225	16		0			540	46
5/23	1429	15		0			330	

DATE	TIME	TEMP°C SURF	TEMP°C BOTT	SAL. °/00 SURF	SAL. °/00 BOTT	T. COLI MPN/100	F. COLI MPN/100	F.STREP MPN/100
STATION NO. D1								
5/15	945	12.0		0.0			330	
5/16	1540	14.0					240	9.3
5/17	1459	14.0		.3			920	7.8
5/18	1105	11.5		0			110	2
5/19	1136	12.5		0			180	
5/20	1118	11.5		0			490	49
5/21	1234	12		0			130	
5/22	1328	12		0			330	
5/23	1415	11.5		0			490	
STATION NO. D2								
5/15	1003	11.0		0.0			79	
5/17	1420	13.3		0.2			130	11
5/18*	1120	11.5		0.0			70	<2
5/19 *	1147	12		0			170	2
5/20 *	1130	11.5		0			130	4.5
5/21 *	1315	13		0			49	

* Little Beaver Creek

DATE	TIME	TEMP °C SURF	TEMP °C BOTT	SAL °/00 SURF	SAL °/00 BOTT	T. COLI MPN/100	F. COLI MPN/100	F.STREP MPN/100
STATION NO. OL1								
5/15	1027	12.5		0.0			79	
5/16	1525	16.0		0.0			17	<2
5/17	1435	17.5		0.0			6.8	<2
5/18	1210	15		0			33	<2
5/19	1053	14.5		0			17	<2
5/20	1049	13.5		0			33	1.8
5/21	1250	13.5		0			49	
5/22	1408	13.5		0			23	
5/23	1340	13.0		0			330	
STATION NO. OL2								
5/15	1042	11.0		0.0			79	
5/17	1443	14.0		0.0			33	3.6
5/18	1225	13		0			79	49
5/19	1108	12.5		0			170	13
5/20	1104	12		0			330	7.8
5/21	1301	11.5		0			130	

DATE	TIME	TEMP °C SURF	TEMP °C BOTT	SAL °/00 SURF	SAL °/00 BOTT	T. COLIF MPN/100	F. COLI MPN/100	F.STREP MPN/100
STATION NO.TOLEDO INFLUENT								
5/14	1140						49×10^{4}	
5/17	1435						23×10^{5}	
5/22	1352						23×10^{5}	
STATION NO. TOLEDO EFFLUENT					CL_2			
5/14	1145				1.5		22	
5/15	1545				.15		330	
5/17	1435				2.5		2	
5/18	1245E				1.2		130	
5/19	958				2.3		<2	
5/20	945				1.5		<2	
5/21	1048				2.5		2	
5/22	1358				1.3		330	
5/23	1315				1.5		1.8	

DATE	TIME	TEMP °C SURF	TEMP °C BOTT	SAL °/00 SURF	SAL °/00 BOTT	T. COLI MPN/100	F. COLI MPN/100	F.STREP MPN/100
STATION NO. YAQUINA R C. MILL CR								
5/18	1245	14		0			23	
5/19	1020	13		0			27	2
H_2O VALVE NO "5"								
5/18	1320	16		0			4.5	<2
5/19								
TRIB T-25	1200	14					17	
TRIB T-26	1212	14.5					33	
TRIB T-27	1221	14.5					2400	
TRIB T-28	1230	12.5					1000	
TRIB T-29	1240	12.5					<2	
STATION NO. 19								
5/19	1006						540	
STATION NO. 20								
5/19	1000						170	
YAQUINA R. COUNTY PARK								
5/19	1028	13		0			6.8	2.0
5/20	1030	13		0			23	
5/23	1356	12		0			140	
YAQUINA HATCHERY								
5/20		17.5					700	2.0
DRAIN DITCH ST 1								
5/22	1338						54000	

YAQUINA BAY, OREGON

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DATE	TIME	TEMP °C	SAL °/oo	TC MPN/100	FC MPN/100	FS MPN/100
STATION NO.1						
11/28	1115	8.8	16.4	240	130	17
11/29	0958	8.3	10.4	-	140	-
12/1	1255	8.6	6.5	-	140	-
12/2	1412	8.1	5.9	-	70	-
12/4	1520	8.6	18.6	-	13	-
12/5	0733	10.1	32.8	-	<1.8	-
12/6	0717	9.9	31.1	-	<1.8	-
STATION NO. 2						
11/28	1120	8.3	7.2	-	350	-
11/29	1009	8.6	6.7	540	170	-
12/1	1302	8.7	4.0	-	49	-
12/2	1422	8.2	9.0	350	79	4.5
12/4	1512	8.2	15.4	-	6.8	-
12/5	0741	8.0	23.7	-	17	-
12/6	0724	7.8	24.5	-	17	-
STATION NO. 3						
11/28	1124	8.1	3.6	-	540	-
11/29	1010	8.5	4.0	-	170	-
11/30	1137	8.7	3.6	-	49	-
12/1	1305	8.7	3.7	79	33	13
12/2	1425	8.1	6.9	-	79	-
12/3	0944	7.2	12.2	-	79	-
12/3	1448	7.4	7.7	-	33	-
12/4	0926	7.6	22.2	-	110	-
12/4	1510	8.1	14.3	-	11	-
12/5	0745	8.5	25.4	-	7.8	-
12/6	0728	7.6	20.8	-	7.8	-
STATION NO. Q5						
11/28	1132	8.2	1.9	1600	220	79
11/29	1021	8.6	0.9	1600	350	130
11/30	1130	8.6	1.5	350	170	130
12/1	1316	8.6	2.1	540	49	11
12/2	1232	8.0	5.2	79	79	4.5
12/3	0950E*	6.7	5.7	170	49	23
12/3	1439	7.3	5.1	130	49	4.5
12/4	0934	7.7	16.9	-	17	<1.8
12/4	1503	8.0	10.8	-	17	-
12/5	0759	7.0	16.1	33	7.8	4.5
12/5	1535E*	-	-	-	31	-
12/6	0739	6.6	14.6	-	46	-
12/6	1536	7.5	13.4	-	17	-

* ESTIMATED

YAQUINA BAY, OREGON (Cont'd)

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DATE	TIME	TEMP °C	SAL °/oo	TC MPN/100	FC MPN/100	FS MPN/100
STATION NO. Q6						
11/28	1134	8.3	1.9	240	240	49
11/29	1029	8.6	0.8	540	220	130
11/30	1150	8.6	1.5	540	240	49
12/1	1320	8.6	1.2	220	170	11
12/2	1435	8.0	4.3	95	46	4.5
12/3	0958	6.5	4.8	220	23	4.5
12/3	1436	7.3	5.4	-	22	<1.8
12/4	0941	7.2	13.0	33	13	11
12/4	1500E	8.0	10.8	-	23	-
12/5	0812	7.4	17.2	-	23	4.5
12/5	1539	7.5	12.4	-	33	-
12/6	0748	6.5	13.0	-	27	-
12/6	1540	7.5	13.0	-	33	-
STATION NO. Q8						
11/28	1138	8.6	0.6	1600	350	240
11/29	1035	8.6	0.4	920	110	70
11/30	1158	8.7	0.9	350	240	33
12/1	1323	8.6	0.7	280	32	13
12/2	1439	7.8	3.2	33	23	4.5
12/3	1005E	6.7	4.4	170	49	23
12/3	1433	7.1	3.4	350	130	2
12/4	0944	6.7	9.4	-	23	4.5
12/4	1458	8.0	8.9	-	23	-
12/5	0826	6.5	13.6	-	23	2.0
12/5	1543	7.4	9.0	-	33	-
12/6	0754	6.5	13.0	-	79	-
12/6	1545	7.2	9.4	-	17	-
STATION NO. Q9						
11/28	1141	8.8	0.5	350	350	49
11/29	1105	8.6	0.4	920	280	23
11/30	1201	8.7	0.5	140	110	23
12/1	1328	8.6	0.7	170	79	4.5
12/2	1442	7.7	2.2	79	49	23
12/3	1040E	6.7	4.2	220	17	13
12/3	1429	7.1	3.4	540	13	2.0
12/4	0948	6.8	8.3	33	33	<1.8
12/4	1454	7.9	9.0	-	49	-
12/5	0832	7.0	12.4	-	11	7.8
12/5	1548	7.4	8.6	-	17	-
12/6	0800	6.3	9.3	-	17	-
12/6	1550	7.0	8.4	-	79	7.8

YAQUINA BAY, OREGON (Cont'd)

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DATE	TIME	TEMP °C	SAL °/oo	TC MPN/100	FC MPN/100	FS MPN/100
STATION NO. 10						
11/28	1145	8.8	0.4	220	110	-
11/29	1050	8.7	0.3	-	170	-
11/30	1206	8.7	0.5	-	110	-
12/1	1320	8.6	0.6	130	17	13
12/2	1447	7.5	0.7	220	79	13
12/3	1015	6.3	1.3	>1600	22	4.5
1213	1422	6.9	1.3	-	49	-
12/4	0952	7.0	9.1	-	23	-
12/4	1450	7.8	5.9	-	33	-
12/5	0842	6.6	11.0	-	11	-
12/6	0805	6.1	7.4	-	17	-
STATION NO. Q15						
11/28	1148	8.8	0.4	540	350	-
11/29	1055	8.6	0.3	-	79	-
11/30	1210	8.8	0.5	-	110	-
12/1	1334	8.6	0.6	-	17	-
12/2	1450	7.5	0.6	130	23	7.8
12/3	1025E	6.4	0.3	-	33	-
12/4	0958	6.7	6.3	-	26	-
12/5	0845	6.5	9.0	-	22	-
12/6	0810	6.0	6.5	-	33	-
STATION NO. Q17						
11/28	1200	8.8	0.2	540	350	-
11/30	1216	9.0	0.5	170	79	-
12/1	1340	8.6	0.5	-	33	-
12/2	1457	7.5	0.6	110	17	7.8
12/3	1030E	6.5	0.0	-	33	-
12/4	0959	6.9	1.9	-	79	-
12/5	0858	6.3	3.7	-	170	-
12/6	0820	5.7	2.7	-	79	-
YAQUINA R. @ MILLER CR						
12/1	1347	8.4	0.5	-	27	-
YAQUINA R. @ BOAT RAMP - COUNTY PARK						
12/2	1100	8.0	0	170	23	-
12/3	1430	8.5	0	130	17	-
12/4	1410	8.5	0	-	13	-
12/5	1510	8.0	0	-	49	-
12/6	1510	7.5	0	-	79	-

YAQUINA BAY, OREGON (Cont'd)

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DATE	TIME	TEMP °C	SAL °/oo	TC MPN/100	FC MPN/100	FS MPN/100
STATION NO. 18						
11/28	1202	8.8	0.3	130	130	-
11/30	1221	9.1	0.5	-	79	-
12/2	1501	7.5	0.6	180	33	13
12/3	1030	6.5	0.0	280	46	13
12/4	1008	6.9	1.9	-	130	-
12/5	0910	6.3	2.2	-	26	-
12/6	0824	5.6	1.3	-	23	-
TOLEDO STP - RAW						
11/28	1134	12	-	240,000	130,000	7900
11/29	1000	-	-	-	>1600	-
11/30	1345	-	-	-	1,600,000	-
12/1	1150	-	-	-	920,000	-
12/2	1525	-	-	-	540,000	-
TOLEDO STP - EFFLUENT			CL_2			
11/28	1130	11	1.0	<1.8	<1.8	-
11/29	1000	9.1	-	-	6.8	-
11/30	1345	12.5	0.5	-	<1.8	-
12/2	1525	-	1.5	13	<1.8	-
12/3	1346	-	-	21	2.0	<1.8
12/4	1435	12	1.5	-	2.0	-
12/5	1530	11.5	1.5	-	4.5	-
STAT 17A TOKYO SLOUGH						
12/4	1440	7.3	1.8	-	49	-
GEORGIA PACIFIC EFFULENT						
12/5	1044	-	-	7900	220	79
OLALLA CR. OL-1						
11/28	1206	9.0	-	-	350	
11/29	1222	9.0	0.8	920	920	33
11/30	1200	10.0	1.0	-	79	-
12/2	1130	7.5	0	540	49	-
12/5	1520	7.5	0	-	49	-

YAQUINA BAY, OREGON (Cont'd)

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DATE	TIME	TEMP °C	SAL °/00	TC MPN/100	FC MPN/100	FS MPN/100
OLALLA CR. OL-2						
11/28	1235	9.0	0.0	920	49	-
11/29	1238	9.0	-	-	70	-
11/30	1210	10.0	0.5	280	33	23
12/2	1135	8.5	-	-	64	-
DEPOT CR D-1						
11/28	1355	8.5	0.0	280	130	33
11/29	1144	9.0	1.2	-	79	-
11/30	1140	10.0	1.0	920	79	23
12/1	1130	9.5	0.0	130	33	11
12/2	1015	7.5	0.0	-	33	-
12/5	1450	7.5	0.0	-	79	-
12/6	1450	7.5	0.0	-	33	-
DEPOT CR D-2						
11/29	1201	9.0	-	-	79	-
11/30	1215	10.5	1.4	130	79	4
12/1	1230	8.5	-	220	70	4.5
12/2	1145	7.5	-	-	23	-
LITTLE BEAVER CR						
11/28	1408	9.0	-	920	79	-
MOUTH DEPOT SL.						
12/3	1411	6.6	0.0	-	33	-
12/4	1438	7.0	1.3	-	46	-
12/5	0911	6.2	0.8	-	29	-
12/6	0828	5.4	1.0	-	49	-
BOONE SLOUGH - B						
11/28	1434	8.5	0.0	1600	240	-
11/29	1047	9.0	1.0	920	79	11
11/30	1110	9.0	0.6	-	130	-
12/1	1100	8.5	0.0	920	130	4.5
12/3	1450	7.5	-	350	33	2.0
NUTE SLOUGH - N						
11/28	1438	9.0	0.0	1600	350	-
11/29	1114	9.0	1.0	350	350	70
11/30	1120	8.5	1.0	>1600	170	33
12/1	1112	8.5	0.0	920	110	22
12/3	1445	8.5	0.0	920	33	2

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MISCELLANEOUS TRIBUTARY AND MARSH DRAIN SAMPLES

STATION	DATE	TIME	TEMP °C	SAL °/oo	TC MPN/100	FC MPN/100	FS MPN/100	REMARKS
T-3A	11/29	0932	-	-	-	220	-	
T-3A	11/29	1005	-	-	-	17	-	
T-3A	11/30	1021	10.5	-	-	33	-	
T-4	11/29	1002	10.5	-	540	170	23	
T-4	11/30	1021	10.0	-	-	130	-	
T-6	11/30	-	9.5	3.0	-	49	-	Parker Sl
T-8	11/30	1035	9.5	2.0	-	350	-	
T-9	11/30	-	10.5	1.0	-	14	-	
T-10	11/29	1104	9.0	1.8	920	240	49	Johnson Sl
T-10	11/30	1100	9.0	3.0	-	170	-	
T-11	11/29	1024	10.5	-	-	79	-	
T-12	11/29	-	10.0	-	920	350	14	
T-12	12/1	1040	9.5	1.6	540	350	23	
T-12	12/6	1100	10.5	4.0	-	17	-	
T-13	12/1	1050	10.0	-	240	49	13	
T-18	11/29	1124	10.0	-	-	920	-	
T-18	12/1	1118	10.5	-	-	1300	-	
T-26	11/28	1330	10.8	0.0	>1600	920	23	
T-26	11/29	1337	9.5	0.6	-	110	-	
T-26	12/2	1110	7.5	0.0	170	23	2	
T-26	12/4	1420	9.5	2.0	-	7.8	-	
T-27	12/4	1430	10.0	-	-	350	-	
T-28	11/28	1325	9.5	0.0	540	240	49	
T-28	11/29	1344	9.5	0.6	-	49	-	
T-28	12/2	1115	8.0	0.0	350	21	4.5	
T-28	12/4	1425	9.0	0.0	-	22	-	

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STATION	DATE	TIME	TEMP °C	SAL °/oo	TC MPN/100	FC MPN/100	FS MPN/100	REMARKS
				DRAIN PIPES IN TOLEDO				
Pipe 1	11/29	1140	8.2	0	-	>1600	-	street drain
Pipe 1	11/30	1400	11.5	-	-	540	-	street drain
Pipe 1	12/1	1140	11.0	-	-	79	-	street drain
Pipe 1	12/2	1040	8.5	-	1100	170	13	street drain
Pipe 2	11/30	1400	13.5	-	-	64	-	street drain
Pipe 3	11/30	1400	11.5	-	-	350	-	street drain
C.B.	12/3	1500	-	-	-	2	-	C. Basin drai
Drain Pipe	11/29	1215	8.0	-	-	<1.8	-	Dredge Spoil Area
Tide Gate	11/30	1150	10.5	0.5	-	920	-	Dredge Spoil Area
Tide Gate	12/2	1030	-	-	1300	33	49	Dredge Spoil Ar

YAQUINA BAY, OREGON (Cont'd)

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OYSTERS

DATE	TIME	TC MPN/100	FC MPN/100	FS MPN/100	
OREGON OYSTER CO.		(SAMPLES FROM BASKET HOLDING)			
11/28	1510	1300	130	45	
11/29	1018	-	330	230	
11/30	-	-	230	33	
12/2	-	-	130	23	
12/3	1052	2400	110	45	
12/4	1520	-	45	-	
12/5	1420	-	78	-	
12/6	1110	-	330	-	
FOWLER OYSTER CO. (SAMPLES FROM WET STORAGE TANK)					
11/29	-	-	45	700	(water 9.5°C; 1°/oo
12/3	1035	340	45	<1.8	(water 10.°C; 23°/oo
12/4	-	-	20	-	(water 9.0°C; 16°/oo)
12/6	1045	-	<18	-	