

SALEM / BEVERLY HARBORS TRIBUTARIES

1985

A. Water Quality Survey Data
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Massachusetts Department of Environmental Quality Engineering

DIVISION of WATER POLLUTION CONTROL

Thomas C. McMahon, Director



SALEM-BEVERLY HARBORS TRIBUTARIES

WATER QUALITY SURVEY

1985

MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING

DIVISION OF WATER POLLUTION CONTROL

TECHNICAL SERVICES BRANCH

WESTBOROUGH, MASSACHUSETTS

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FOREWORD

The Massachusetts Division of Water Pollution Control was established by the Massachusetts Clean Water Act, Chapter 21 of the General Laws as amended by Chapter 685 of the Acts of 1966. Included in the duties and responsibilities of the Division is the periodic examination of the water quality of various coastal waters, rivers, streams and ponds of the Commonwealth, as stated in section 27, paragraph 5 of the Acts. This section further directs the Division to publish the results of such examination together with the standards of water quality established for the various waters. The Technical Services Branch of the Division of Water Pollution Control has, among its responsibilities, the execution of this directive. This report is published under the Authority of the Acts and is among a continuing series of reports issued by the Division presenting water quality data and analyses, water quality management plans, baseline and intensive limnological studies and various special studies.

ABSTRACT

MASSACHUSETTS DIVISION OF WATER POLLUTION CONTROL. 1985. NORTH COASTAL TRIBUTARIES TO SALEM AND BEVERLY HARBORS WATER QUALITY SURVEY DATA. 35 p., 22 tables, 2 figs.

Water quality data was collected from twenty-two (22) stations and sediment data from eleven (11) stations on the rivers and tributaries flowing into the Salem and Beverly Harbors during the period of 8-11 July 1985. Water quality samples were analyzed for temperature and dissolved oxygen, five-day biochemical oxygen demand, total kjeldahl-nitrogen, ammonia-nitrogen, nitrate-nitrogen, total phosphorus, total alkalinity, pH, suspended solids, total solids, total and fecal coliform bacteria and chlorides. Water and sediment metal samples were tested for arsenic, aluminum, cadmium, chromium, copper, nickel, lead, iron, zinc, silver and mercury. Sediments were further analyzed for percent volatile, total kjeldahl-nitrogen and total phosphorus. Selected stations were analyzed for volatiles and oil and grease. Tidal data is included.

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Lawrence Experiment Station =
Wall Experiment Station

INTRODUCTION

This report is a compilation of the results of field and laboratory analyses conducted on the rivers and brooks leading into the Salem and Beverly Harbors in 1985 by the United States Environmental Protection Agency and the Technical Services Branch of the Massachusetts Division of Water Pollution Control. The main purpose of these surveys is to develop a water quality data base for waters entering the harbors.

The locations of sampling stations are shown in Figure 2. All analyses included within this report were performed on grab samples. The exact time of sampling is located with the dissolved oxygen data (Table 2). The weather was hot and sunny in the high eighties, low nineties.

In July, three one-day surveys were conducted. On July 8 and July 9, 1985, 22 grab water quality samples were collected for D.O., bacteria, chemical, nutrients and metals analysis. On July 11, 1985, 11 grab sediment samples were taken. The July 8th salt water stations were taken during an incoming tide while the July 9th samples were taken at the end of the outgoing tide. Tidal data was obtained from the 1985 Farmers Almanac.

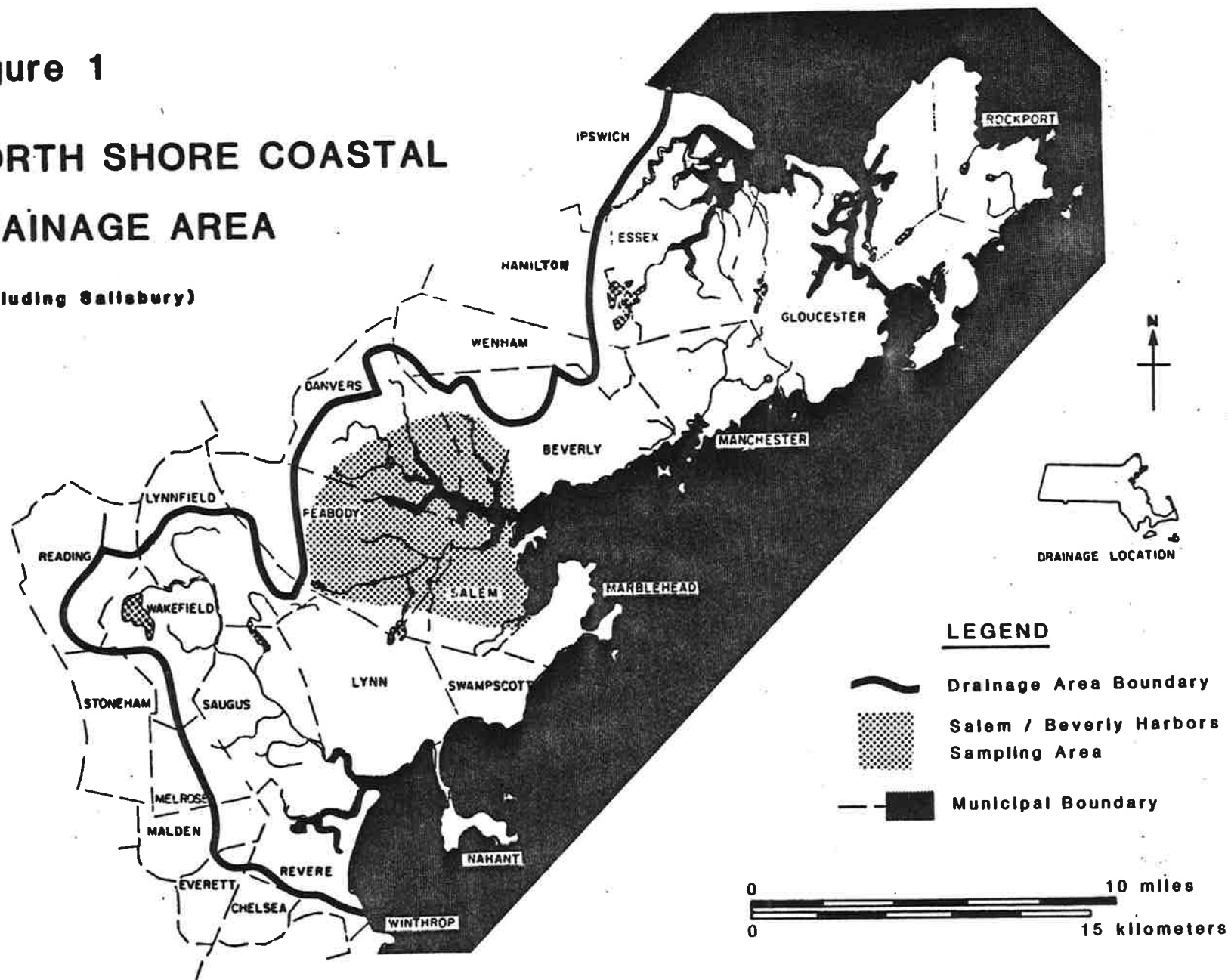
Dissolved oxygen samples were analyzed by Division personnel using the azide modification of the Winkler method. Temperature was measured in situ at the time of collection. Percent saturation values were calculated according to chloride concentrations due to tidal influence.

All chemical and bacteriological samples were transported to the Lawrence Experiment Station of the Department of Environmental Quality Engineering for analyses conducted according to the procedures set forth in the American Public Health Association's Standard Methods for the Examination of Water and Wastewater (Sixteenth edition, 1985, New York). The actual method used in the analyses of a given parameter is listed in Appendix A of this report. The data were compiled and tabulated by personnel of the Division of Water Pollution Control.

Figure 1

NORTH SHORE COASTAL DRAINAGE AREA

(Excluding Salisbury)



15 kilometers

TABLE 1
1985 SALEM-BEVERLY TRIBUTARY WATER QUALITY SURVEY
SAMPLING STATION LOCATIONS

<u>STATION NUMBER</u>	<u>RIVER</u>	<u>DESCRIPTION</u>
SB01	Forest River	Loring Ave. off Route 1A, Salem
SB02	Forest River	Route 114, beginning of harbor, Salem
SB03	South River	Discharge pipe corner of Lafayette and and Derby Street, Salem
SB04	Goldthwait Brook	Forest Ave., Peabody Industrial Park, Peabody
SB05	Goldthwait Brook	Peabody St., above Eastman Gelatin, Peabody
SB06	Goldthwait Brook	Summer St., Peabody
SB07	Proctor Brook	Endicott Street, Peabody
SB08	Strongwater Brook	Dirt road off main street below playground, Peabody
SB09	North River	Flint St., Salem
SB10	North River	Route 114, Salem
SB11	Waters River	Sylvan St., Danvers
SB12	Waters River	Route 35, Danvers
SB13	Crane Brook	Route 114, Danvers
SB14	Crane River	Mill Pond outfall, Elm St., Danvers
SB15	Crane River	Route 35, Danvers
SB16	Porter River	Junction Conant Road & Rte. 62, Danvers
SB17	Porter River	Liberty Street, Danvers
SB18	Bass River	Conant Road, Beverly
SB19	Bass River	Inlet Shoe Pond, McKay St., Beverly

TABLE 1 (CONTINUED)

SB20	Bass River	Elliot St., Shoe Pond discharge, Beverly
SB21	Danvers River	Liberty Hill Ave. bridge, Salem
SB22	Danvers River	Route 1A bridge, Salem

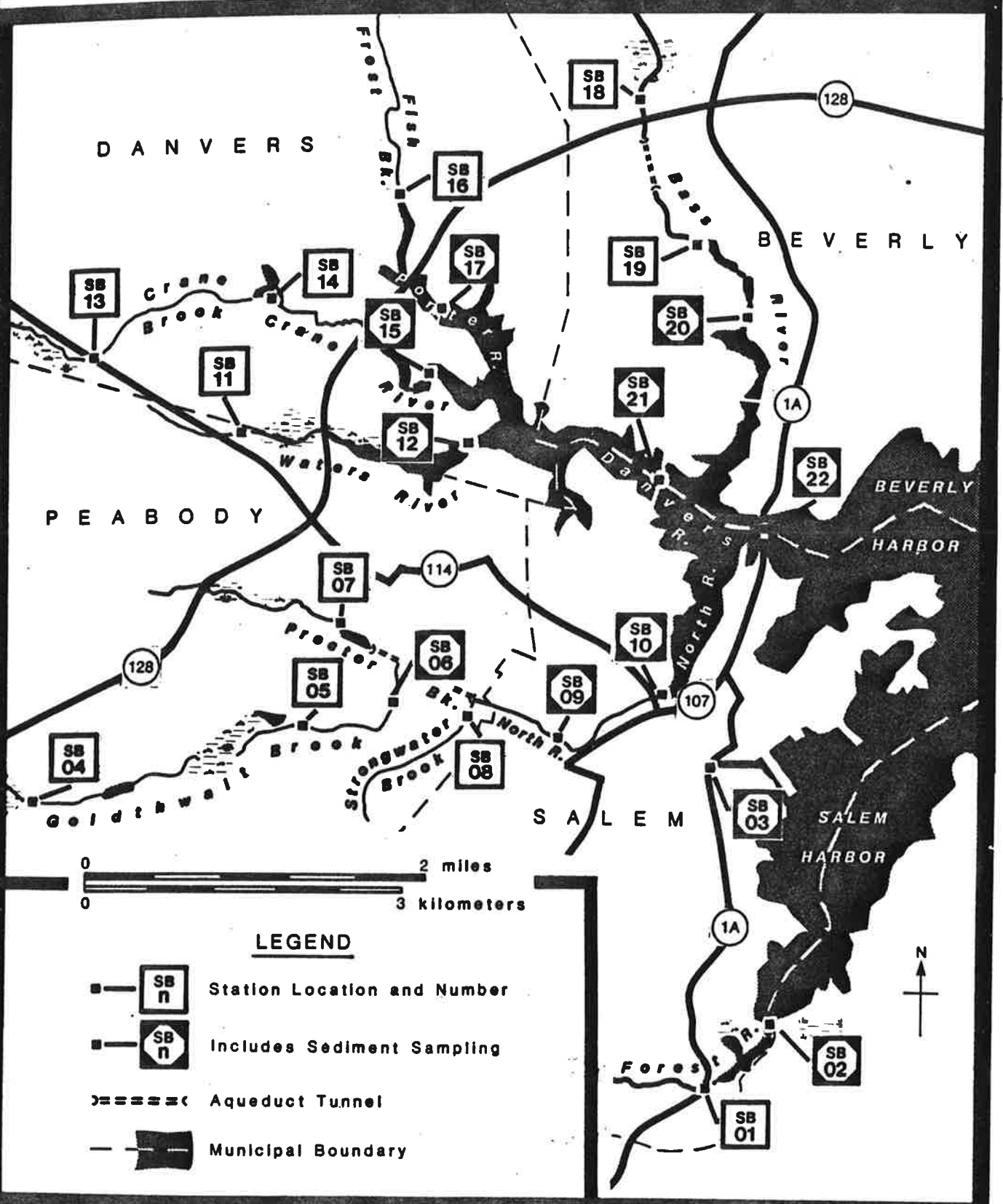


Figure 2

SALEM / BEVERLY HARBORS SAMPLING STATIONS

TABLE 2
SALEM-BEVERLY 1985 WATER QUALITY SURVEY
TIME-TEMPERATURE-DISSOLVED OXYGEN-% SATURATION DATA

<u>STATION</u>		<u>7/8/85</u>	<u>7/9/85</u>
SB01	*	1045	1036
	**	76	74
	***	7.0	6.5
	****	88	86
SB02		1055	1045
		80	73
		6.1	7.1
		89	97
SB03		1105	1055
		65	66
		4.0	5.5
		45	62
SB04		0920	0925
		68	68
		1.8	2.0
		20	22
SB05		0940	0940
		68	74
		4.3	4.8
		47	56
SB06		1000	957
		65	66
		4.8	5.0
		51	53
SB07		0950	0948
		68	67
		6.9	7.1
		75	76
SB08		1010	1005
		70	70
		5.5	5.2
		61	58
SB09		1020	1011
		74	75
		11.8	13.1
		137	153

TABLE 2 (CONTINUED)

SB10	1030	1022
	75	72
	6.9	4.9
	86	63
SB11	1245	1225
	77	67
	7.5	7.8
	90	84
SB12	1315	1130
	70	70
	8.0	6.5
SB13	1240	1230
	73	75
	6.6	6.0
	76	70
SB14	1230	1217
	81	80
	12.5	9.7
	155	119
SB15	1310	1138
	72	74
	7.9	7.3
	108	98
SB16	1220	1212
	69	70
	8.9	10.2
	98	113
SB17	1300	1142
	72	74
	7.4	7.3
	101	100
SB18	1210	1206
	72	71
	3.1	3.3
	35	37
SB19	1200	1159
	79	77
	6.6	8.7
	80	104
SB20	1150	1154
	75	76
	10.1	10.7
	128	138

TABLE 2 (CONTINUED)

SB21	1140	1120
	66	69
	7.9	8.1
	102	108
SB22	1130	1108
	65	65
	8.0	8.3
	103	107

* Time (hr.)
 ** Temperature (°F)
 *** Dissolved Oxygen (mg/l)
 **** Percent Saturation (%)

TABLE 3
SALEM-BEVERLY 1985 WATER QUALITY SURVEY
BIOCHEMICAL OXYGEN DEMAND 5-DAY (mg/l)

<u>STATION</u>	<u>7/8/85</u>	<u>7/9/85</u>
SB01	2.7	1.5
SB02	3.3	2.7
SB03	5.1	2.7
SB04	72.0	14.
SB05	5.7	32.
SB06	4.5	3.0
SB07	2.1	2.4
SB08	2.0	9.0
SB09	6.9	3.0
SB10	5.1	3.9
SB11	3.9	2.1
SB12	2.1	3.0
SB13	4.2	2.7
SB14	3.6	4.5
SB15	3.6	1.8
SB16	2.4	3.9
SB17	3.6	2.4
SB18	5.4	5.1
SB19	3.3	4.2
SB20	4.8	4.5
SB21	2.7	3.0
SB22	2.4	3.3

TABLE 4
SALEM-BEVERLY 1985 WATER QUALITY SURVEY
pH (standard units)

<u>STATION</u>	<u>7/8/85</u>	<u>7/9/85</u>
SB01	7.5	7.6
SB02	7.6	7.7
SB03	7.4	7.5
SB04	7.6	7.0
SB05	6.7	7.2
SB06	7.2	7.1
SB07	7.4	7.6
SB08	7.6	7.6
SB09	7.5	8.5
SB10	7.4	7.6
SB11	7.6	7.6
SB12	7.6	7.9
SB13	7.9	8.3
SB14	8.2	8.0
SB15	7.6	7.9
SB16	7.7	8.0
SB17	7.6	7.9
SB18	7.7	8.0
SB19	7.5	7.7
SB20	7.3	7.8
SB21	7.6	7.9
SB22	7.7	8.0

TABLE 5
SALEM-BEVERLY 1985 WATER QUALITY SURVEY
ALKALINITY (mg/l as CaCO₃)

<u>STATION</u>	<u>7/8/85</u>	<u>7/9/85</u>
SB01	104	105
SB02	108	107
SB03	107	121
SB04	60	65
SB05	25	41
SB06	92	92
SB07	67	78
SB08	72	77
SB09	75	79
SB10	98	105
SB11	72	103
SB12	101	105
SB13	166	162
SB14	80	57
SB15	100	102
SB16	55	55
SB17	103	100
SB18	84	84
SB19	44	34
SB20	59	64
SB21	102	105
SB22	101	110

TABLE 6
SALEM-BEVERLY 1985 WATER QUALITY SURVEY
HARDNESS (mg/l)

<u>STATION</u>	<u>7/8/85</u>	<u>7/9/85</u>
SB01	2,600	2,170
SB02	3,640	4,060
SB03	2,430	2,310
SB04	70	60
SB05	67	67
SB06	165	176
SB07	129	133
SB08	115	133
SB09	250	216
SB10	2,100	2,850
SB11	132	114
SB12	4,710	4,100
SB13	234	213
SB14	150	126
SB15	5,230	3,710
SB16	128	107
SB17	4,630	4,060
SB18	82	79
SB19	61	51
SB20	2,000	2,530
SB21	4,770	3,990
SB22	4,570	5,690

TABLE 7
SALEM-BEVERLY 1985 WATER QUALITY SURVEY
SUSPENDED SOLIDS (mg/l)

<u>STATION</u>	<u>7/8/85</u>	<u>7/9/85</u>
SB01	18	9.5
SB02	20	14
SB03	7.5	8.0
SB04	67	30
SB05	41	328
SB06	2.0	4.5
SB07	1.5	3.0
SB08	5.5	3.5
SB09	120	3.5
SB10	21	32.0
SB11	4.0	1.0
SB12	15	11.0
SB13	8.0	9.5
SB14	6.0	4.5
SB15	34	13
SB16	0.0	3.5
SB17	19	5.5
SB18	13	5.0
SB19	3.0	4.5
SB20	20	43
SB21	8.0	17
SB22	16	9.5

TABLE 8
SALEM-BEVERLY 1985 WATER QUALITY SURVEY
TOTAL SOLIDS (mg/l)

<u>STATION</u>	<u>7/8/85</u>	<u>7/9/85</u>
SB01	13,420	15,190
SB02	27,050	28,330
SB03	13,550	13,000
SB04	320	290
SB05	280	560
SB06	380	310
SB07	400	440
SB08	270	250
SB09	1,080	780
SB10	11,850	19,140
SB11	300	240
SB12	31,380	31,500
SB13	540	590
SB14	380	300
SB15	31,200	26,470
SB16	290	280
SB17	30,520	28,990
SB18	210	250
SB19	180	140
SB20	10,670	13,850
SB21	31,560	31,590
SB22	30,660	32,280

TABLE 9
SALEM-BEVERLY 1985 WATER QUALITY SURVEY
TOTAL KJELDAHL-NITROGEN (mg/l)

<u>STATION</u>	<u>7/8/85</u>	<u>7/9/85</u>
SB01	0.51	1.8
SB02	0.85	1.6
SB03	1.0	1.5
SB04	2.4	3.9
SB05	1.0	7.8
SB06	2.1	2.3
SB07	1.2	1.2
SB08	1.4	1.8
SB09	2.4	1.7
SB10	2.6	2.2
SB11	1.5	1.1
SB12	0.96	1.2
SB13	2.9	2.8
SB14	2.0	1.4
SB15	2.0	1.4
SB16	1.8	1.3
SB17	1.7	1.6
SB18	2.5	1.8
SB19	1.8	1.4
SB20	2.2	2.3
SB21	1.8	1.8
SB22	1.5	1.7

TABLE 10
SALEM-BEVERLY 1985 WATER QUALITY SURVEY
AMMONIA-NITROGEN (mg/l)

<u>STATION</u>	<u>7/8/85</u>	<u>7/9/85</u>
SB01	0.20	0.22
SB02	0.15	0.20
SB03	0.52	0.34
SB04	1.3	1.3
SB05	0.36	0.43
SB06	0.81	0.73
SB07	0.12	0.06
SB08	0.29	0.22
SB09	0.13	0.23
SB10	1.4	0.51
SB11	0.14	0.30
SB12	0.07	0.25
SB13	1.2	1.1
SB14	0.20	0.17
SB15	0.17	0.14
SB16	0.04	0.16
SB17	0.04	0.15
SB18	0.05	0.21
SB19	0.03	0.11
SB20	0.09	0.33
SB21	0.05	0.09
SB22	0.01	0.36

TABLE 11
SALEM-BEVERLY 1985 WATER QUALITY SURVEY
NITRATE-NITROGEN (mg/l)

<u>STATION</u>	<u>7/8/85</u>	<u>7/9/85</u>
SB01	*	*
SB02	*	*
SB03	*	*
SB04	*	*
SB05	0.3	0.4
SB06	1.2	1.2
SB07	0.5	0.7
SB08	1.1	1.1
SB09	*	*
SB10	*	*
SB11	1.0	*
SB12	*	*
SB13	0.3	0.3
SB14	0.8	0.7
SB15	*	*
SB16	0.5	0.6
SB17	*	*
SB18	*	0.1
SB19	*	*
SB20	*	*
SB21	*	*
SB22	*	*

* Sample could not be analyzed for nitrate-nitrogen due to salt interference

TABLE 12
SALEM-BEVERLY 1985 WATER QUALITY SURVEY
TOTAL PHOSPHORUS (mg/l)

<u>STATION</u>	<u>7/8/85</u>	<u>7/9/85</u>
SB01	0.12	0.11
SB02	0.19	0.14
SB03	0.12	0.11
SB04	0.68	0.24
SB05	0.40	1.5
SB06	0.23	0.16
SB07	0.08	0.09
SB08	0.11	0.19
SB09	0.65	0.10
SB10	0.30	0.24
SB11	0.06	0.05
SB12	0.16	0.10
SB13	0.08	0.06
SB14	0.06	0.05
SB15	0.09	0.08
SB16	0.08	0.10
SB17	0.10	0.12
SB18	0.10	0.08
SB19	0.05	0.02
SB20	0.10	0.09
SB21	0.08	0.08
SB22	0.05	0.09

TABLE 13
SALEM-BEVERLY 1985 WATER QUALITY SURVEY
ORTHO-PHOSPHORUS (mg/l)

<u>STATION</u>	<u>7/8/85</u>	<u>7/9/85</u>
SB01	0.05	0.06
SB02	0.10	0.10
SB03	0.06	0.07
SB04	0.34	0.17
SB05	0.37	1.2
SB06	0.18	0.09
SB07	0.04	0.03
SB08	0.09	0.10
SB09	0.47	0.08
SB10	0.25	0.20
SB11	0.05	0.03
SB12	0.04	0.06
SB13	0.04	0.04
SB14	0.03	0.03
SB15	0.04	0.06
SB16	0.05	0.06
SB17	0.04	0.06
SB18	0.07	0.05
SB19	0.02	0.02
SB20	0.06	0.06
SB21	0.03	0.03
SB22	0.03	0.04

TABLE 14
SALEM-BEVERLY 1985 WATER QUALITY SURVEY
CHLORIDE (mg/l)

<u>STATION</u>	<u>7/8/85</u>	<u>7/9/85</u>
SB01	7,600	9,000
SB02	13,400	15,000
SB03	6,800	6,600
SB04	81	78
SB05	68	80
SB06	92	94
SB07	145	174
SB08	62	64
SB09	400	340
SB10	6,000	10,000
SB11	71	80
SB12	16,000	16,800
SB13	140	130
SB14	90	80
SB15	16,600	13,500
SB16	79	82
SB17	16,200	15,000
SB18	21	21
SB19	36	40
SB20	5,000	6,800
SB21	16,800	17,000
SB22	17,200	17,000

TABLE 15
SALEM-BEVERLY 1985 WATER QUALITY SURVEY
TOTAL COLIFORM (Coliform/100 ml)

<u>STATION</u>	<u>7/8/85</u>	<u>7/9/85</u>
SB01	200	8,000
SB02	300	1,280
SB03	75,000	110,000
SB04	1,400	1,500
SB05	1,700	4,800
SB06	9,500	18,000
SB07	1,400	1,500
SB08	3,800	7,300
SB09	42,000	15,000
SB10	98,000	120,000
SB11	9,000	9,000
SB12	700	200
SB13	12,000	10,000
SB14	600	2,000
SB15	30	1,500
SB16	35,000	23,000
SB17	100	140
SB18	900	800
SB19	200	180
SB20	20,000	1,000
SB21	20	40
SB22	200	880

TABLE 16
SALEM-BEVERLY 1985 WATER QUALITY SURVEY
FECAL COLIFORM (Coliform/100 ml)

<u>STATION</u>	<u>7/8/85</u>	<u>7/9/85</u>
SB01	180	50
SB02	100	200
SB03	8,000	22,000
SB04	60	240
SB05	400	680
SB06	2,000	1,500
SB07	480	100
SB08	1,200	2,000
SB09	2,400	1,500
SB10	9,000	13,000
SB11	600	500
SB12	10	5
SB13	500	500
SB14	100	100
SB15	<5	400
SB16	5,000	3,300
SB17	20	30
SB18	380	360
SB19	10	180
SB20	1,800	200
SB21	5	<5
SB22	40	40

TABLE 17
SALEM-BEVERLY 1985 WATER QUALITY SURVEY
OIL & GREASE (mg/l)

<u>STATION</u>	<u>7/8/85</u>	<u>7/9/85</u>
SB03	0.5	0.0
SB06	—	0.4
SB09	—	2.6
SB10	—	3.6
SB15	0.0	—
SB17	0.0	—

TABLE 18
SALEM - BEVERLY 1985 WATER QUALITY SURVEY
METALS (mg/l) 7/8/85

STATION	ARSENIC	ALUMINUM	CADMIUM	CHROMIUM	COPPER	NICKEL	LEAD	IRON	ZINC	SILVER	MERCURY
SB01	<0.010	0.18	<0.02	0.02	0.02	0.06	0.15	0.65	<0.03	0.02	0.0000
SB02	<0.010	0.31	0.04	0.03	0.04	0.13	0.32	0.59	<0.03	0.04	0.0000
SB03	<0.010	0.16	0.02	<0.02	0.02	<0.05	0.13	0.55	<0.03	<0.02	0.0000
SB04	0.005	0.47	<0.02	<0.02	<0.02	<0.05	<0.04	2.9	0.05	<0.02	0.0000
SB05	0.015	0.12	<0.02	<0.02	<0.02	<0.05	<0.04	0.58	<0.02	<0.02	0.0000
SB06	0.000	0.16	<0.02	<0.02	0.02	0.05	<0.04	1.6	0.05	<0.02	0.0000
SB07	0.000	<0.10	<0.02	<0.02	<0.02	<0.05	<0.04	1.6	0.03	<0.02	0.0000
SB08	0.001	<0.10	<0.02	<0.02	<0.02	<0.05	<0.04	0.60	0.03	<0.02	0.0000
SB09	0.004	1.0	<0.02	<0.02	0.04	<0.05	<0.04	0.63	0.11	<0.02	0.0000
SB10	<0.010	0.56	<0.02	0.03	0.02	<0.05	0.19	3.7	0.05	0.02	0.0000
SB11	0.000	<0.10	<0.02	<0.02	<0.02	<0.05	<0.04	0.40	0.03	<0.02	0.0000
SB12	<0.010	0.38	<0.02	0.02	0.05	0.13	0.40	0.22	0.02	0.03	0.0000
SB13	0.003	0.12	<0.02	0.02	<0.02	<0.05	<0.04	2.2	<0.03	<0.02	0.0000
SB14	0.001	<0.10	<0.02	<0.02	<0.02	<0.05	<0.04	0.46	0.05	<0.02	0.0000
SB15	<0.010	0.31	0.04	0.03	0.05	0.13	0.39	0.24	0.03	0.03	0.0000
SB16	0.002	<0.10	<0.02	<0.02	0.02	<0.05	<0.04	0.48	<0.03	<0.02	0.0000
SB17	<0.010	0.15	0.04	0.02	0.03	0.10	0.35	0.21	<0.03	0.03	0.0000
SB18	0.002	0.10	0.02	<0.02	<0.02	<0.05	<0.04	2.3	0.04	<0.02	0.0000
SB19	0.000	<0.10	<0.02	<0.02	0.02	<0.05	<0.04	0.28	0.03	<0.02	0.0000
SB20	<0.010	0.43	<0.02	0.02	0.03	0.11	0.11	0.99	0.03	<0.02	0.0000
SB21	<0.010	0.10	0.04	0.02	0.05	0.15	0.39	0.20	0.04	0.03	0.0000
SB22	<0.010	<0.10	0.05	0.02	0.05	0.15	0.40	0.16	<0.03	0.03	0.0000

TABLE 19
SALEM - BEVERLY 1985 WATER QUALITY SURVEY
METALS (mg/l) 7/9/85

STATION	ARSENIC	ALUMINUM	CADMIUM	CHROMIUM	COPPER	NICKEL	LEAD	IRON	ZINC	SILVER	MERCURY
SB01	0.001	<0.10	<0.02	<0.02	0.04	<0.03	<0.04	0.54	<0.03	0.02	<0.0002
SB02	0.004	0.54	<0.02	<0.02	0.04	<0.03	<0.04	0.43	<0.03	0.04	<0.0002
SB03	0.003	0.50	<0.02	<0.02	0.03	<0.03	<0.04	0.55	0.03	<0.02	<0.0002
SB04	<0.010	0.13	<0.02	<0.02	0.02	<0.03	<0.04	1.8	0.03	<0.02	<0.0002
SB05	0.043	25	<0.02	<0.02	0.72	<0.03	<0.04	21	1.7	<0.02	<0.0002
SB06	<0.010	<0.10	<0.02	<0.02	0.02	<0.03	<0.04	0.66	0.04	<0.02	<0.0002
SB07	<0.010	0.13	<0.02	<0.02	<0.02	<0.03	<0.04	0.66	0.19	<0.02	<0.0002
SB08	<0.010	<0.10	<0.02	<0.02	0.02	<0.03	<0.04	0.53	0.03	<0.02	<0.0002
SB09	<0.010	<0.10	<0.02	<0.02	<0.02	<0.03	<0.04	0.57	0.03	<0.02	<0.0002
SB10	<0.010	0.19	<0.02	<0.02	0.04	<0.03	<0.04	0.68	0.03	0.02	<0.0002
SB11	<0.010	<0.10	<0.02	<0.02	<0.02	<0.03	<0.04	0.22	<0.03	<0.02	<0.0002
SB12	<0.010	0.38	<0.02	<0.02	0.04	<0.03	<0.04	0.25	<0.03	0.03	<0.0002
SB13	<0.010	0.11	<0.02	<0.02	<0.02	<0.03	<0.04	2.0	0.04	<0.02	<0.0002
SB14	<0.010	<0.10	<0.02	<0.02	0.02	<0.03	<0.04	0.43	0.03	<0.02	<0.0002
SB15	<0.010	0.50	<0.02	<0.02	0.05	<0.03	<0.04	0.23	0.03	0.03	<0.0002
SB16	<0.010	0.15	<0.02	<0.02	<0.02	<0.03	<0.04	0.55	0.20	<0.02	<0.0002
SB17	<0.010	0.36	<0.02	<0.02	0.05	<0.03	<0.04	0.23	0.04	0.03	<0.0002
SB18	<0.010	<0.10	<0.02	<0.02	<0.02	<0.03	<0.04	2.2	0.03	<0.02	<0.0002
SB19	<0.010	<0.10	<0.02	<0.02	<0.02	<0.03	<0.04	0.17	<0.03	<0.02	<0.0002
SB20	<0.010	0.68	<0.02	<0.02	0.04	<0.03	<0.04	2.3	0.07	0.03	<0.0002
SB21	<0.010	0.54	<0.02	<0.02	0.05	<0.03	<0.04	0.16	0.03	0.04	<0.0002
SB22	<0.010	0.19	<0.02	<0.02	0.06	<0.03	<0.04	0.17	<0.03	0.04	<0.0002

TABLE 20
SALEM - BEVERLY 1985 WATER QUALITY SURVEY
SEDIMENT DATA 8/11/85
(All results in mg/kg unless otherwise noted)

	<u>SB02</u>	<u>SB03</u>	<u>SB06</u>	<u>SB09</u>	<u>SB10</u>	<u>SB12</u>	<u>SB15</u>	<u>SB17</u>	<u>SB20</u>	<u>SB21</u>	<u>SB22</u>
% Vol. Solids	18.9%	6.2%	1.9%	21%	8.6%	2.6%	16%	15%	9.0%	4.6%	5.7%
TKN	47	30	12	349	113	219	536	404	187	83	99
Total-P	71	28	28	141	71	30	75	57	57	44	34
Arsenic	12	<0.50	1.2	13	10	2.0	11	17	20	5.8	6.6
Aluminum	12,500	600	3,050	11,450	7,600	3,750	13,150	550	1,000	5,950	5,950
Cadmium	3.0	<1.0	<1.0	7.0	4.5	1.5	3.0	1.5	4.0	2.0	2.0
Chromium	365	3.0	15	1,850	750	1,200	700	380	800	650	265
Copper	55	9.5	70	225	85	18	75	55	119	50	35
Nickel	22	14	22	48	20	10	32	22	30	18	15
Lead	1,850	115	490	950	455	115	270	170	420	140	85
Iron	21,500	20	4,750	19,500	10,000	3,400	6,000	6,500	17,000	9,000	12,000
Zinc	205	320	185	950	295	125	265	115	280	135	145
Silver	<1.0	<1.0	<1.0	1.0	<1.0	1.0	<1.0	<1.0	1.0	1.0	<1.0
Mercury	0.10	0.10	0.05	2.0	0.65	0.15	1.5	1.9	0.44	0.50	0.20
Oil & Grease	—	—	—	1,070	—	—	—	—	—	—	—

TABLE 21
SALEM - BEVERLY 1985 WATER QUALITY SURVEY
VOLATILE ORGANICS

<u>PARAMETER</u>	<u>SB03</u>	<u>SB06</u>
Bromdichlormethane	1.4	—
Chloroethane	—	*
Chloroform	3.7	—
1,1-Dichloroethane	2.0	4.8
1,2-Dichloroethylene	2.7	10
1,1,1-Trichloroethane	—	1.0
Trichloroethylene	<1	89
Tetrachloroethylene	—	39
Methylene chloride	2.7	—

* No standard available for quantification

TABLE 22

TIDES

<u>DATE</u>	<u>HIGH</u>	<u>LOW</u>	<u>HIGH</u>
Monday 7/8/85	4:15	10:30	16:45
Tuesday 7/9/85	5:00	11:20	17:45
Wednesday 7/10/85	6:00	12:15	18:30
Thursday 7/11/85	6:45	13:30	19:15

APPENDIX A

ANALYTICAL METHODS USED AT LAWRENCE EXPERIMENT STATION

<u>PARAMETER</u>	<u>METHOD</u>	<u>REPORTED AS</u>
BOD	5-day oxygen depletion at 20°C	mg/l BOD
Dissolved Oxygen	Azide modification of Winkler method. 0.0375 N sodium thio-sulfate titrant, 300 ml sample	mg/l D.O.
pH	Electrometric, glass indicator, silver chloride reference	Standard Logarithmic Units
Turbidity	Nephelometric. Hach Turbidi-meter. Model 2100A	Nephelometric Turbidity Units
Total Alkalinity	0.02 N sulfuric acid potentiometric titration to pH 4.5, Orion Model 701, Digital pH meter	mg/l CaCO ₃
Suspended Solids	Filtration through standard glass fiber filter paper. Residue dried at 103-105°C. Gravimetric	mg/l S.S
Total Solids	Evaporation to dryness at 103-105°C. Gravimetric	mg/l T.S.
Settleable Solids	Gravimetric settling using an Imhoff cone	ml/l Settleable Solids
Total Kjeldahl-Nitrogen	Acid digestion using Technicon BD-40 Block Digester. Colorimetric analysis (reaction of ammonia, sodium salicylate, sodium nitroprusside, and sodium hypochlorite in buffered alkaline medium) using Technicon Auto Analyzer II	mg/l TKN
Ammonia-Nitrogen	Phenate method, automated. Colorimetric analysis using Technicon Auto Analyzer II	mg/l NH ₃ -N
Nitrate-Nitrogen	Hydrazine reduction method, automated. Colorimetric analysis using Technicon Auto Analyzer II	mg/l NO ₃ -N

APPENDIX A (CONTINUED)

Total Phosphate	Acid digestion using Technicon BD-40 Block Digester. Ascorbic acid reduction colorimetric method using Technicon Auto Analyzer II	mg/l P
Total Coliform	Membrane filter technic	Total coliform/ 100 ml
Fecal Coliform	Membrane filter technic	Fecal coliform/ 100 ml
COD	Dichromate reflux	mg/l COD
Conductivity	Wheatstone Bridge type meter. Yellow Springs Instrument conductivity bridge, Model 31	umhos/cm
Color	Visual comparison of sample with known concentrations of colored solutions	Color Units
Chloride	Argentometric (titration with silver nitrate)	mg/l Cl
Silica	Colorimetric analysis (silico-molybdate reduction in acidic solution to "heteropoly blue" by aminonaphtholsulfonic acid) Technicon Auto Analyzer I	mg/l
Cadmium, Copper, Chromium, Iron, Lead, Magnesium, Manganese, Nickel, Zinc, Hardness (Ca+Mg)	Atomic Absorption Spectrophotometry. Air-acetylene flame. Perkin-Elmer Model 403	mg/l
Aluminum, ~~Tin~~	Atomic Absorption Spectrophotometry. Nitrous oxide-acetylene flame. Perkins-Elmer Model 403	mg/l
Hexavalent Chromium	Colorimetric using diphenyl-carbazide. Klett-Summerson photoelectric colorimeter	mg/l Cr ⁺⁶

APPENDIX B

THE ASSESSMENT OF WATER POLLUTION

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A workable definition of the term "water pollution" is difficult to formulate simply because pollution problems are extremely variable and site specific. The word "pollute" literally means to "render impure"; however, a more acceptable definition of pollution must take factors into account such as the chemical, physical and biological characteristics of natural water, the intended use of a receiving water, and an understanding of the nature and fate of a given pollutant after its introduction into a body of water. Regardless of how we choose to define it, water pollution involves the addition of certain characteristics to a water body which may render that water unfit for its intended utilization. Some of the more common forms of water pollution include: oxygen demanding organic wastes and sewage derivatives; man-made organic compounds such as pesticides, some industrial wastes, and inorganic toxic compounds; infectious disease producing agents; nutrients and sediments from land runoff; radioactive substances; oil and grease; and thermal discharges. In some instances, the combined effects of two or more contaminants are further enhanced by their interaction. These synergistic effects may result from a chemical reaction in the receiving water which yields a product more toxic than the reactants. For example, the discharge of an acid into a water containing a high concentration of cyanide ions would produce hydrogen cyanide, an acid that is toxic to both aquatic organisms and man. In short, whether discharged from residences, institutions, or industries, each form of pollution has a characteristic effect on the water into which it is introduced. The receiving water may become unsightly, malodorous, and/or a hazard to public health, and consequently its uses may be severely limited.

Methods used for the assessment of water quality generally fall into three main categories: chemical, physical, and biological. Chemical analyses may include the determination of pH and alkalinity in addition to the concentrations of various ions, metals, and dissolved gases such as oxygen, carbon dioxide and hydrogen sulfide. Physical parameters often measured are temperature, color, turbidity, and flow characteristics. Biological methods may be categorized as either field surveys which are an attempt to ascertain the numbers and kinds of aquatic organisms associated with various water qualities, or laboratory studies in which bioassays are conducted to determine the levels of toxicity of different chemical parameters for a given test organism.

The parameters listed above are measured in most water quality surveys conducted by the Massachusetts Division of Water Pollution Control. Although no bioassay studies are done by the Division, the Biological Section conducts macroinvertebrate surveys on selected rivers and streams throughout the Commonwealth. In addition, microscopic examinations are conducted during most surveys to determine the abundance and kinds of algae and other microorganisms present in the water. Finally, bacterial samples are obtained and analyzed during each water quality survey.

Two types of samples are collected for chemical analysis. A grab sample is an instantaneous sample collected to indicate water quality conditions at a

particular time. Composite samples are collected over a period of time at specific intervals. This method gives a better indication of the overall water quality situation during the sampling period.

Oxygen Relationships

The dissolved oxygen (D.O.) in water refers to the uncombined oxygen held in solution and thereby made available to aquatic organisms for respiration. Sources of dissolved oxygen include atmospheric aeration and the direct addition of oxygen as the byproduct of chemical reduction reactions and algal photosynthesis. Whereas respiratory processes of aquatic organisms consume oxygen throughout the day and night, photosynthetic release of oxygen is restricted to the daylight hours. As a result, productive waters exhibit a characteristic diurnal variation in dissolved oxygen concentration. The solubility of oxygen (O_2) in water is primarily a function of water temperature and the atmospheric partial pressure of oxygen. Saturation levels at standard pressure (760 mm Hg) range from 14.6 mg/l O_2 at $0^\circ C$ to 6.6 mg/l O_2 at $40^\circ C$.

Organic matter is introduced to a river or stream either as the result of natural phenomena, such as the deposition of leaves and other plant materials in autumn, or by the discharge of pollutants resulting from human related activities. Regardless of its origin, organic matter is gradually decomposed by bacteria which utilize the available dissolved oxygen in the water. Therefore, the ability of a stream segment to assimilate these organic materials, that is, its waste assimilative capacity, is dependent upon the amount of dissolved oxygen present in the water. In many instances, the assimilation of large amounts of organic wastes severely depletes the oxygen concentration in the water body rendering it unsuitable for the existence of aquatic organisms such as invertebrates and fish.

The biochemical oxygen demand (BOD) is a measure of the amount of oxygen required by bacteria to decompose a given amount of organic matter. This decomposition process occurs in two distinct steps each governed by a specific kind of bacteria. During the first step, or carbonaceous stage, carbon compounds are stabilized with a concurrent release of carbon dioxide. The second stage, nitrification, begins approximately seven days later and is the process by which nitrogenous substances are broken down to ammonia and ultimately to nitrate. The total combined oxygen demands of both stages is the ultimate BOD which may be exerted over a period of thirty days or more. Through recurrent use, the five day BOD (BOD_5) has been accepted as the standard test used in water quality analysis. While the BOD_5 of untreated sewage normally ranges from 150 to 300 mg/l, the BOD_5 of an unpolluted water rarely exceeds 2 mg/l.

Some types of organic wastes are not readily broken down by bacteria but can be decomposed by chemical processes. The chemical oxygen demand (COD) refers to the amount of oxygen required for the dichromate oxidation of a given amount of organic matter. Since some organic matter in any waste is not biodegradable, the COD is usually greater than the BOD.

Nutrients

Nutrients are substances that are essential to the growth or reproduction of organisms. In aquatic habitats algae and macrophytes rely on dissolved nitrogen and phosphorus compounds as nutrients and, as such, these substances are not harmful at low concentrations. Wastewater discharges often contain large amounts of carbon, nitrogen, and phosphorus containing compounds. Excessive nutrient loading of a water body increases plant production. As a result of this increased productivity, rapidly multiplying algal populations or "blooms" occur which may severely limit the potential use of the water. In many instances a high oxygen demand is exerted by the decomposing algae resulting from a sudden dieback.

Nitrogen compounds exist in water in a variety of forms. They may occur as cellular components, particulate matter, soluble organic substances or inorganic ions. These different forms and their interrelated chemical reactions are collectively known as the nitrogen cycle. Organic nitrogen in the form of protein, amino acid, or urea occurs in water containing organic wastes. Oxidation and reduction of these nitrogenous compounds are closely linked to the metabolic activity of many kinds of microorganisms. As described above, nitrification is tied to bacterial action, and is carried out by a fixed sequence of reactions through which ammonia, nitrite, and ultimately nitrate are produced. Therefore, the progress of decomposition of organic nitrogen can be determined by assessing the relative amounts of these compounds. Ammonia (NH_3) results from the initial decomposition of organic nitrogen and is always present in untreated sewage. It can also be formed by the reduction of nitrite. Ammonia exerts a high oxygen demand and is toxic to many aquatic organisms. Oxidation of ammonia yields nitrite (NO_2^-) which is quickly converted to nitrate (NO_3^-), the end product of the decomposition of nitrogenous matter. Nitrate is the form of nitrogen that is directly available to algae and other aquatic plants as a nutrient.

Phosphorus is present in water bodies in dissolved, colloidal, or particulate states and originates primarily from agricultural runoff and wastewaters containing detergents. It may exist as orthophosphate, polyphosphate, or in organic compounds. Although phosphorus occurs in natural waters in smaller amounts than nitrogen, it is an essential plant nutrient.

Coliform Bacteria

Fecal coliform bacteria are found in the intestinal tract of warm-blooded animals. Although not a serious health hazard by themselves, their presence in water is a good indication that sewage and associated pathogenic microorganisms may be present. Since coliforms can be detected by relatively simple test procedures they are used to indicate the extent of bacterial pollution from sewage and combined sewer overflows. Tests are usually conducted to determine the number of fecal and total coliforms present in water or wastewater. The number of total coliforms includes those of fecal origin and from non-fecal sources such as soil, grain, or decaying vegetation. In areas where urban runoff is a problem, total

coliform levels can be very high, whereas fecal coliform levels may remain minimal as long as sewage is not present in the water. Often municipal wastes are disinfected at a treatment plant to kill bacteria before they are discharged to a receiving water.

pH and Alkalinity

The pH of water is a measure of its hydrogen ion (H^+) concentration on an inverse logarithmic scale which ranges from 0 to 14. pH values of less than 7 indicate higher H^+ content and therefore acidic solutions whereas pH values above 7 denote alkaline solutions. The pH of pure water at 25°C is 7.00; however, natural waters exhibit a wide range of pH values depending upon their chemical and biological characteristics. Unpolluted river water usually has a pH between 6.5 and 8.5. In productive segments, a diurnal fluctuation in pH may occur as photosynthetic organisms take up dissolved carbon dioxide during the daylight hours. Drastic changes in pH occur when industrial effluents containing strong acids or alkali are discharged to a water body. These pH shifts are sometimes toxic to aquatic organisms. Alkalinity is defined as the capacity of water to neutralize acid. This property is attributed to the presence of several different solute species. These are primarily carbonates and bicarbonates but also hydroxides, borates, silicates, and phosphates. Alkalinity is expressed in milligrams per liter of equivalent calcium carbonate.

Solids

Suspended solids refers to the particulate matter that either floats on the surface of, or is in suspension in water or wastewater, and is removable by laboratory filtering techniques. That matter remaining in the water after filtering is referred to as dissolved solids. Suspended solids in a stream may settle out in sluggishly flowing segments causing sediments to build up on the substrate. This siltation can be particularly harmful to fish eggs and larvae by hindering their mechanisms for obtaining oxygen from the water. Suspended solids analysis provides a reliable measure of the efficiency of wastewater treatment facilities. Primary treatment should remove about 50 percent of the suspended solids from an influent while 90 percent removal should result from secondary treatment. The test for total solids measures all suspended and dissolved solids in water. They are measured by evaporating the water from a sample of known volume and weighing the residue. This residue can then be ignited in a furnace to determine the organic portion. Turbidity is a measure of the clarity of a water sample and is related to solids content. The laboratory test is based on the scattering and absorption of light by the sample and results are expressed in Nephelometric Turbidity Units (NTU).

Color

The color of natural water is primarily due to the leaching of organic debris and is empirically determined by comparing the sample with known concentrations of colored solution. It is then expressed in standard units of color. Severe color problems resulting from a pollution discharge are described qualitatively rather than numerically. Although color may

not be harmful to aquatic life, it may render the water unacceptable for drinking purposes and for some types of industrial use.

Other Parameters

Depending upon specific river conditions, a water quality survey may include additional analyses such as those for oil and grease or heavy metal content. Grease in a wastewater consists of a mixture of fats, waxes, free fatty acids, calcium and magnesium soaps, mineral oils, and certain other nonfatty substances.

Heavy metals are toxic to aquatic organisms when present in sufficient quantities. They may also have an adverse effect on sewage and industrial wastewater treatment systems. Metals that are often monitored are cadmium, chromium, copper, iron, lead, manganese, nickel, and zinc.