6/1/91-00621

Final

New HRS Deficiency Information Collection Efforts

Naval Amphibious Base Little Creek

June 1991

Reference:
Contract
N62470-89-D-4814
CTO 0002

19002-SRN

Prepared For

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command

Norfolk, Virginia

Under The

Navy CLEAN Program

Comprehensive Long-Term Environmental Action Navy

Prepared By

Baker

Baker Environmental, Inc.

Coraopolis, Pennsylvania

POPULATION ESTIMATE

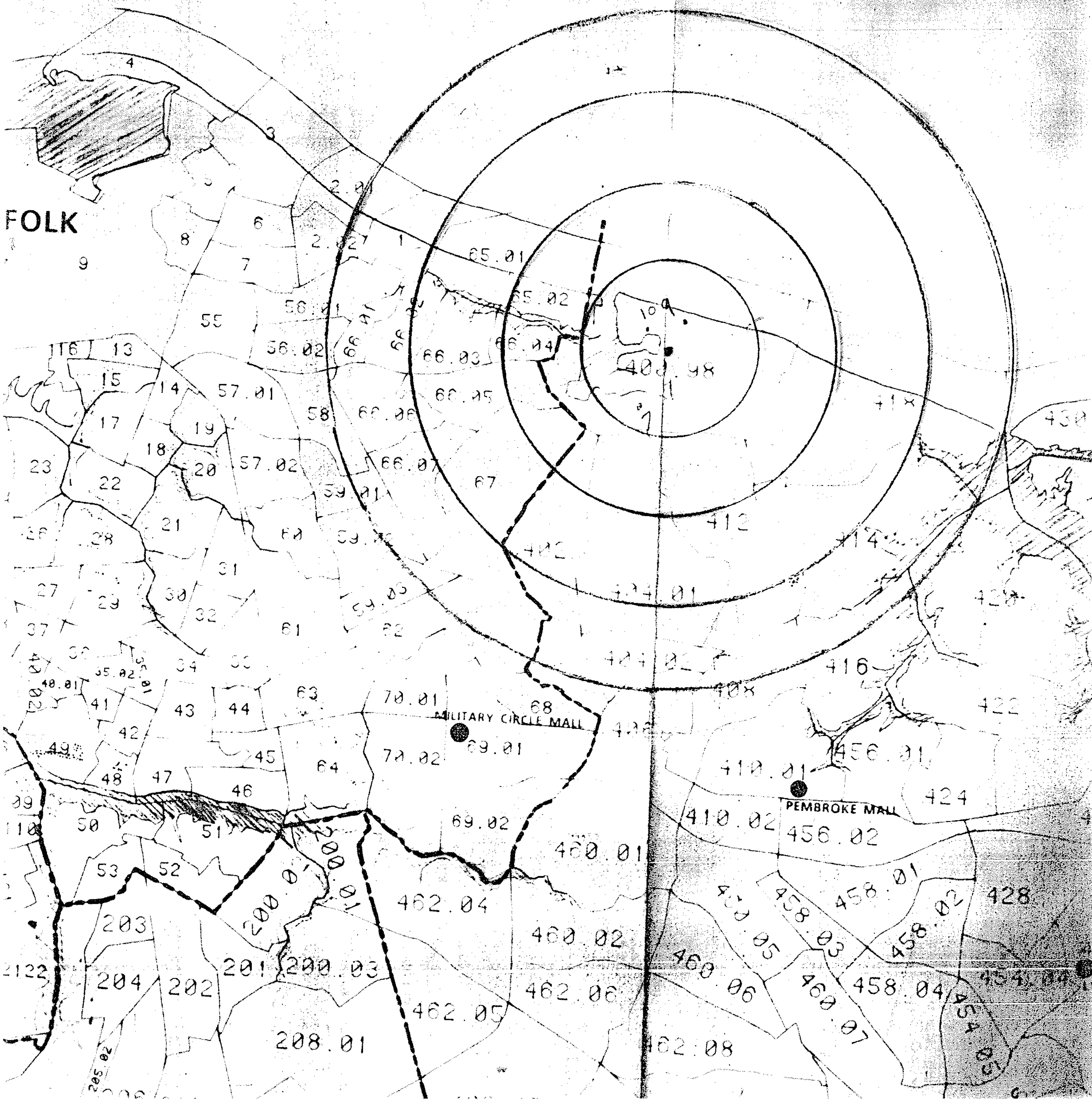
NAB LITTLE CREEK

In order to estimate the population surrounding the sites at NAB Little Creek, 1990 Census Tracts were obtained from the Hampton Roads Planning District Commission and, using circular overlays, the populations within one-, two-, three-, and four-mile radii were estimated. Because the sites are relatively close together, the population estimates for each of sites 7, 9, 10, 11, 12, and 13 are approximately the same.

Sites 7, 9, 10, 11, 12, 13

Radius	Total Population
1 mi.	2,821
2 mi.	19,412
3 mi.	44,160
4 mi.	80,172

These figures do not include the persons aboard ships in port. Each of the figures should be increased by approximately 2,500 if the Navy personnel aboard ships is included.


FOLK
MILITARY CIRCLE MALL
PEMBROKE MALL

CITY OF NORFOLK

1990 TRACT	TOTAL POP	WHITE POP	BLACK POP	AM IND ESK&ALEUT	ASIAN & PAC ISL	OTHER	HOUSING UNITS
1	2644	2170	386	15	46	27	1354
2.01	3424	2597	683	27	53	64	1811
2.02	4039	3478	428	22	79	32	1641
3	3452	2877	414	16	98	47	1895
4	3969	3622	263	19	37	28	2342
5	3606	3029	340	13	146	78	1484
6	4470	2913	1288	26	184	59	1869
7	2920	2639	156	16	95	14	1222
8	2299	1400	647	8	173	71	962
9	11866	7500	3528	72	386	380	2092
9.99	23080	15481	6216	220	480	683	0
11	1976	1385	257	12	274	48	803
12	3583	2955	481	20	70	57	1752
13	2616	1702	746	27	60	81	1243
14	1464	1084	322	9	39	10	922
15	1993	1726	185	6	42	34	946
16	1939	460	1318	15	87	59	870
17	1935	1576	330	3	21	5	1058
18	923	742	172	3	4	2	418
19	604	557	13	4	30	0	261
20	1443	1267	127	6	37	6	529
21	930	860	63	0	7	0	522
22	994	984	0	0	8	2	433
23	2275	2083	53	7	128	4	1074
24	3188	3137	12	7	26	6	1301
25	3779	1713	1963	8	87	8	1200
26	3141	2213	674	23	213	18	1272
27	3474	141	3298	11	8	16	1347
28	4432	2882	1427	10	80	33	1953
29	5354	138	5180	13	14	9	2344
30	2125	1475	595	3	44	8	904
31	2911	1559	1266	15	50	21	1169
32	2616	1082	1495	5	15	19	1102
33	2729	634	2036	13	36	10	1055
34	2248	27	2214	4	1	2	995
35.01	2582	19	2553	2	3	5	1222
35.02	1047	3	1038	0	6	0	494
36	670	547	100	0	20	3	393
37	2258	2057	117	11	57	16	1361
38	2579	2401	149	7	20	2	1250
39	273	236	26	1	7	3	187
39.99	28	12	11	0	0	5	0
40.01	1056	986	30	3	34	3	614
40.02	2911	2670	145	2	87	7	1750
41	1942	13	1918	1	7	3	745
42	1565	20	1539	0	2	4	656
43	3115	25	3081	4	5	0	1757
44	3242	12	3219	8	3	0	1107

45	551	7	532	0	6	6	246
46	2647	59	2567	9	3	9	878
46.99	3	3	0	0	0	0	0
47	2569	23	2534	4	4	4	461
48	1566	59	1506	0	0	1	471
49	2390	1283	1048	10	43	6	853
49.99	12	9	1	0	2	0	0
50	1261	8	1252	0	0	1	510
40.99	5	4	1	0	0	0	0
51	1138	81	1052	0	0	5	438
52	3982	18	3963	1	0	0	1315
53	2267	10	2251	5	0	1	900
55	2954	2306	469	14	131	34	1193
56.01	4195	3840	189	11	118	37	1668
56.02	3457	2862	450	28	77	40	1369
57.01	5707	1765	3697	37	113	95	2559
57.02	2814	351	2416	10	19	18	1082
58	5370	599	4634	18	77	42	2108
59.01	3983	948	2851	6	131	47	1525
59.02	3803	2680	841	14	220	48	1609
59.03	1630	1102	390	1	122	15	658
60	3594	2774	657	9	128	26	1479
61	7733	4996	2215	38	411	73	3058
62	3543	2517	929	11	78	8	1316
63	1	0	1	0	0	0	1
64	3561	926	2590	8	23	14	1393
65.01	4022	3014	818	46	85	59	2260
65.02	5235	3284	1718	32	112	89	2833
65.03	0	0	0	0	0	0	0
66.01	1896	1260	560	3	42	31	607
66.02	2616	2417	53	19	115	12	1012
66.03	2547	2287	107	16	118	19	976
66.04	2665	2191	331	15	104	24	1068
66.05	2830	2199	488	4	93	46	1128
66.06	4611	3178	1105	7	255	66	1883
66.07	3091	2229	505	15	331	11	1150
67	125	108	12	1	3	1	49
68	1696	1403	169	3	104	17	633
69.01	3324	1797	1305	25	178	19	1388
69.02	2675	2182	391	7	85	10	1044
70.01	1679	910	685	11	32	41	586
70.02	3772	1450	2227	10	43	42	1374
TOTAL	261229	148228	102012	1165	6815	3009	98762

NOTES:

(1) TRACTS MARKED WITH AN ASTERISK (*) ARE KNOWN TO HAVE UNDERGONE BOUNDARY CHANGES SINCE 1980. OTHER MORE SUBTLE BOUNDARY CHANGES OCCURRED AS WELL BUT ARE NOT MARKED WITH AN ASTERISK.
(2) ALTHOUGH 1990 TRACT NUMBERS ARE OFTEN SIMILAR TO 1980 NUMBERS, MANY TRACTS HAVE UNDERGONE BOUNDARY CHANGES. THEREFORE, THIS DOCUMENT SHOULD NOT BE USED FOR COMPARATIVE ANALYSES OF 1980 AND 1990 TRACT VALUES.
(3) THESE DATA ARE RAW DATA AND HAVE NOT BEEN ADJUSTED IN ANY WAY.

(4) VALUES GIVEN FOR JAMES CITY COUNTY AND WILLIAMSBURG FOR 1980 REPRESENT PRE-ANNEXATION DATA. THEY DO NOT CONTAIN AN ADJUSTMENT.

(5) THESE DATA SHOULD NOT BE PUBLISHED WITHOUT THE ABOVE CLARIFYING REMARKS.

CITY OF VIRGINIA BEACH

1990 TRACT	TOTAL POP	WHITE POP	BLACK POP	AM IND ESK&ALEUT	ASIAN & PAC ISL	OTHER	HOUSING UNITS
400.98	3814	2839	734	19	91	131	472
400.99	2522	1729	656	24	39	74	0
402	5514	2690	2633	17	108	66	1980
404.01	8120	6437	1069	27	470	117	3279
404.02	6468	3683	2489	23	165	108	2700
406	5002	3580	1192	26	158	46	2136
408	9003	6275	2258	46	313	111	3152
410.01	8603	7008	1200	28	280	87	3022
410.02	2359	2109	156	6	69	19	916
412	6133	5816	184	5	87	41	2561
414	3771	3402	238	4	125	2	1468
416	3605	3310	94	3	184	17	1317
418	10519	9360	826	37	176	120	4801
420	3476	3361	54	4	51	6	1126
422	8534	8031	295	25	132	51	3065
424	5401	4623	558	15	185	20	1885
426	2544	2252	205	15	50	22	1133
428	10260	7599	2198	31	320	112	3941
430.01	5715	5637	30	7	33	8	3199
430.02	3559	3430	71	6	48	4	1207
432	1184	647	442	7	31	57	190
434	2082	2060	5	2	11	4	1439
436	1675	1649	6	3	16	1	1010
438	3728	3661	43	5	16	3	2158
440.01	4655	4060	480	28	44	43	2695
440.02	7381	6762	487	31	62	39	4410
442.01	6322	3950	2276	17	51	28	2956
444.01	3896	3735	80	12	63	6	1358
444.02	5625	5108	362	6	131	18	2295
446	5643	5497	104	11	24	7	2088
448.04	9896	8365	1213	42	168	108	4477
448.05	3461	2753	566	16	74	52	1741
448.06	5226	3823	1269	29	56	49	2212
450.85	4395	3375	793	33	82	112	643
452	5166	4039	943	33	70	81	832
454.04	8868	6622	1726	39	367	114	2917
454.05	5097	3883	855	11	310	38	1833
454.06	4790	3654	822	33	214	67	1857
454.07	3557	2704	649	6	163	35	1089
454.08	6211	5125	784	32	178	92	2071
454.09	8592	7227	831	22	448	64	2823
454.1	2545	1967	524	18	34	2	755
454.11	14260	12397	1309	54	340	160	4806
454.12	1396	1359	10	6	21	0	1205
454.13	0	0	0	0	0	0	0
456.01	2869	2643	153	9	54	10	1136
456.02	6888	5473	1142	34	151	88	3345
458.01	4466	3627	485	15	298	41	1523
458.02	7625	6132	1125	25	275	68	2732
458.03	3052	2673	249	13	103	14	1421
458.04	9751	6705	2117	40	751	138	3540
460.01	8457	7570	622	32	206	27	3058
460.02	5545	4856	395	18	260	16	1906
460.05	6844	5911	685	30	186	32	2911
460.06	5150	4571	257	18	283	21	1636
460.07	13057	9646	2209	66	904	232	4259
460.08	8750	6491	1231	29	869	130	2775
462.04	4307	3991	147	15	148	6	1611

462.07	5147	3821	718	13	570	25	1668
462.08	7958	6536	714	23	654	31	2476
462.09	21788	15739	3589	65	2233	162	7473
462.10	12970	9282	1434	22	2140	92	3813
464	3174	2935	213	16	9	1	1238
466	966	761	198	0	7	0	371
TOTAL	393069	316408	54674	1384	17025	3581	147037

NOTES:

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6/1/91- 00621

FINAL REPORT
NEW HRS DEFICIENCY INFORMATION
COLLECTION EFFORTS
NAVAL AMPHIBIOUS BASE LITTLE CREEK

CONTRACT TASK ORDER 0002

Prepared For:

NAVAL FACILITIES ENGINEERING COMMAND
ATLANTIC DIVISION
Norfolk, Virginia

Under:

Contract N62470-89-D-4814

Prepared By:

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

JUNE 1991

TABLE OF CONTENTS

EXHIBITS

1.0 INTRODUCTION

Baker Environmental, Inc. (Baker) has been contracted by the Atlantic Division, Naval Facilities Engineering Command (LANTDIV) to obtain information on the Naval Amphibious Base Little Creek (NAB Little Creek), facility for purposes of scoring selected sites in accordance with the Revised Hazard Ranking System (December 14, 1990). This report contains the results of Baker's data collection efforts.

Specific data requirements for this facility have been identified by LANTDIV in their Scope of Work dated, March 12, 1991. The overall project assignment, which included the collection and evaluation of data and preparation of this report, is being performed by Baker under Contract Task Order (CTO) 0002.

This report is organized as follows. Section 1.0 (Introduction) identifies the purpose and administrative aspects of CTO-0002 and presents the organization of the report. Section 2.0 (Methodology) describes the scope of work and activities employed to obtain the information deficiencies. The information deficiencies identified by LANTDIV are addressed in Section 3.0 through Section 6.0. Each deficiency checklist item is identified along with the information requested immediately following. Data limitations, which are those checklist deficiency items that could not be resolved, are presented in Section 7.0. References are identified in the Reference section, which follows Section 7.0.

This report also contains three figures that identify various information requirements and complement the findings which are presented in the main body of this report. Figure 1 is a map of the facility containing information from Section 3.0. Figures 2 and 3 correspond to responses from Section 4.0.

2.0 METHODOLOGY

A project team consisting of a Project Manager, Chemical Engineer, Geologist, Civil Engineer, and Environmental Scientists were employed to obtain information to resolve data deficiencies identified by the EPA for the NAB Little Creek facility. The data deficiencies for the NAB Little Creek concern the information identified by LANTDIV in the March 12, 1991 Scope of Work.

Project files at the LANTDIV office in Norfolk, Virginia were reviewed and applicable reports were obtained by the project team. A visit to the Chesapeake Bay Program Office in Annapolis, Maryland also was made to obtain relevant information pertaining to wetlands, fisheries, sensitive environmental areas, natural resources (i.e., shellfish, etc.) and other environmental concerns. The project team subsequently reviewed all of the available information in an attempt to resolve the information needs identified by the EPA deficiency checklist. Specific items on the checklists that were identified by LANTDIV in the March 12, 1991 Scope of Work were addressed except in those cases where the checklist indicated that the information has been provided and deemed acceptable. In some cases, the checklist indicated that the information is not applicable (NA). Baker addressed these items in some cases where it was felt that providing the information may assist in the scoring of the sites. The deficiency checklist for the NAB Little Creek facility is provided in Exhibit 2-1.

The information was reviewed and evaluated for specific sites identified by LANTDIV in the Scope of Work. For the NAB Little Creek, the following sites (Table 2-1) of concern were identified for further investigation:

TABLE 2-1

NAB LITTLE CREEK
SITES FOR FURTHER INVESTIGATION

Site No.	Description
7	Amphibious Base Landfill
9	Driving Range Landfill
10	Sewage Treatment Plant Area Landfill
11	School of Music Plating Shop
12	Exchange Laundry Waste Storage Tank
13	Public Works PCP Dip Tank and Wash Rack

When the review of existing or available information was completed, the project team identified what information was still needed to respond to the deficiency checklist items. The project team then identified and contacted other potential sources of information including various Federal, State, and local agencies, public authorities, and private firms. In most cases, the agency or firm required substantial time to obtain the information and indicated that they would forward the information to Baker. Due to the condensed schedule of this project, the project team attempted to obtain information "over the phone." Telephone call reports were subsequently prepared and are included in the various exhibits to this report.

The information collected by the project team is discussed in Sections 3.0 through 6.0 of this report and illustrated on various figures and exhibits (e.g., wetlands). Figures were prepared using United States Geological Survey (USGS) quadrangle maps and topographic maps. The sites of concern are identified on each figure, along with radii depicting target distances from the sites. In some cases other maps and figures, which are more site-specific (and are of a smaller scale), are included in the exhibits.

Documentation to the responses given in Sections 3.0 through 6.0 of this report can be found in the exhibits. In most cases, the documentation consists of telephone call reports and excerpts from various technical reports. References also were used as a source of information to respond to checklist items. Statements made in this report which support the responses to the checklist item are referenced. A listing of references can be found in the Reference section.

The following sections present the findings to those checklists items identified by LANTDIV for the surface water, soil, groundwater, and air pathways that pertain to selected sites at the NAB Little Creek. The findings are based on information obtained from the LANTDIV project files and information obtained from various agencies. The checklist item number and description is given first, followed by the finding(s) generated by the project team. The checklist number corresponds to the deficiency checklist given in Exhibit 2-1.

3.0 GROUNDWATER PATHWAY

3A. Determine if ground water within a four-mile radius of each source is used for any of the following purposes and locate the wells on a four-mile radius map. The center of the radii should begin at the center of each source if the source is small or at the outer edge of the source if it is large.

There are thirty-four (34) known wells located within a four-mile radius of the sites at Naval Amphibious Base (NAB) Little Creek. These wells are shown on Figure 1, and the well uses are identified in subsequent checklist item responses. The information used to locate the wells and determine their uses consisted of a series of maps and a compilation of database information provided by the Tidewater Regional Office of the Virginia State Water Control Board (VWCB, 1991).

3A1. Private or public drinking water source

There are twenty-three (23) known public consumption and private water supply wells within a four-mile radius of the sites at NAB Little Creek. Of these, nine (9) of the wells are public consumption wells and fourteen (14) of the wells are private wells. For classification purposes, wells serving office buildings, subdevelopments, trailer courts, schools, hospitals, campgrounds, restaurants and other food services, and military installations have been considered to be public consumption wells (i.e., domestic wells), to differentiate between those wells and actual public water supply wells.

Public water within a four-mile radius of the Naval Amphibious Base Little Creek is supplied by the City of Virginia Beach Department of Public Utilities (Virginia Beach DPU) and the City of Norfolk Department of Utilities (Norfolk DU). The Norfolk DU does not have any public supply wells within the four-mile radii of the sites. Details of the Norfolk DU water distribution system are provided in Exhibit 3-1. The Virginia Beach DPU receives all of its water from the city of Norfolk and has no supply wells. Information concerning the sources of water for the Virginia Beach DPU are provided in Exhibit 3-2.

3A2. Irrigation of commercial crops (include areas)

There are three known wells that are used for irrigation of commercial crops within a four-mile radius of the sites at NAB Little Creek. These wells also are used for commercial livestock.

There is no evidence of public water, supplied by either the Norfolk DU or the Virginia Beach DPU, being used for irrigation of commercial crops within four miles of the sites (see Exhibits 3-1 and 3-2).

3A3. Commercial livestock

The three known wells used for watering commercial livestock, as identified above, also are used for irrigation of commercial crops.

There is no evidence of public water, supplied by either the Norfolk DU or the Virginia Beach DPU, being used for commercial livestock within four miles of the sites (see Exhibits 3-1 and 3-2).

3A4. Commercial aquiculture

There are no known wells used for commercial aquiculture within a four-mile radius of the sites at NAB Little Creek.

There is no evidence of public water, supplied by either the Norfolk DU or the Virginia Beach DPU, being used for commercial aquiculture within four miles of the sites (see Exhibits 3-1 and 3-2).

3A5. Industrial

There are six (6) known wells used for industrial purposes within a four-mile radius of the sites at NAB Little Creek.

There is no evidence of public water, supplied by either the Norfolk DU or the Virginia Beach DPU, being used for industrial purposes within four miles of the sites (see Exhibits 3-1 and 3-2).

3A6. Not used, but usable

There are no known wells which are usable, but not used, within a four-mile radius of the sites at NAB Little Creek.

3A7. Unusable

There are no known unusable wells within a four-mile radius of the sites at NAB Little Creek.

3A8. Water for recreational use

There are two (2) known wells used for recreational purposes within a four-mile radius of the sites at NAB Little Creek. These wells serve the YMCA Beach Club and the Lake Wright Golf Course and are shown on Figure 1.

There are no reported cases of public water from the Norfolk DU or Virginia Beach DPU being used for recreational areas within four miles of the sites (see Exhibit 3-1).

3A9. Stand-by wells used for drinking water at least once a year.

There are no known "stand-by" wells within a four-mile radius of the sites at NAB Little Creek.

The Norfolk DU has no "stand-by" wells within four miles of the sites. The Norfolk DU does have a series of four deep wells (total capacity 16 MGD) in the vicinity of the Western Lakes which can be activated if reservoir levels drop below 70 percent capacity. Three of the four wells discharge to Lake Prince, the other discharges to Lake Burnt Mills. Use of the wells is avoided when possible because the groundwater has a high phosphorous content. However, this area is outside the four-mile radii of the sites (see Exhibit 3-1).

The Virginia Beach DPU has no "stand-by" wells within four miles of the sites (see Exhibit 3-2).

3B. Outline the public water distribution system within a 4 mile radius of each source on a topographic map.

The public water distributions systems of the Norfolk DU and the Virginia Beach DPU are outlined within four miles of the sites on Figure 1. Locations and descriptions of surface water intakes and public supply wells for Norfolk DU and Virginia DPU are provided in Exhibits 3-1 and 3-2.

3C. Identify the nearest drinking water well.

The nearest drinking water well to the site is a well serving Bradford Acres subdevelopment located at 36°54'06" north latitude and 76°08'08" west longitude. The well is shown on Figure 1.

3D. Determine the population (including workers, students, and residents) drawing from each drinking water well within the following radii. The center of the radii should start at the center of each source if the source is small or at the outer edge of the source if it is large. Count the overlapping areas only once.

3D1. 0 - 1/4 mile

Site	Population
7	0
9	0
10	0
11	0
12	0
13	0

3D2. 1/4 - 1/2 mile

Site	Population
7	0
9	0
10	0
11	0
12	0
13	0

3D3. 1/2 - 1 mile

Site	Population
7	0
9	0
10	0
11	0
12	3
13	0

3D4. 1 - 2 mile

Site	Population
7	0
9	3
10	3
11	3
12	5
13	3

3D5. 2 - 3 mile

Site	Population
7	0
9	5
10	5
11	5
12	8
13	5

3D6. 3 - 4 mile

Site	Population
7	0
9	8
10	8
11	19
12	19
13	19

For wells beyond 1/2 mile from each source, all wells were considered to be domestic wells serving 2.36 residents based on information provided by Ms. Lorie Acker of the United States Environmental Protection Agency (see Exhibit 3-3). This figure was determined from a telephone call with a United States Census Bureau information specialist (see Exhibit 3-3). The above population totals are for all wells within the respective radii.

3E. Describe known or probable groundwater flow direction from each source.

This item was identified as "acceptable" on the checklist. However, the following information was available and has been provided to supplement existing information. The groundwater flow direction beneath the site is toward Little Creek Cove, ultimately discharging into Chesapeake Bay. This has been stated in REWAI, 1982, and documentation has been provided in Exhibit 3-4.

3F. Describe as precisely as possible, the geology and hydrogeology of the site area (including geological formation name, thickness, types of material, hydraulic conductivities, and depth to aquifers).

NAB Little Creek is underlain by several thousand feet of unconsolidated deposits of gravel, sand, and clay. Specific geological formations and types of materials are discussed in detail in Exhibit 3-5. The stratigraphic column of the various units, as compiled from various plates to VDMR, 1973, are as follows:

Geologic Unit

- Columbia Group
- Yorktown Formation
- Calvert Formation
- Nanjemoy Formation
- Mattaponi Formation
- "Transitional Beds"
- Patuxent Formation

Furthermore, USGS, 1987 provides a detailed discussion of the aquifers in Southeastern Virginia. Pertinent portions of the report have been included as Exhibit 3-6. Some nomenclature discrepancies have been noted between USGS, 1987 and VDMR, 1973. The discrepancies arise primarily from the fact that the USGS report presents a much more detailed description of geologic units than VDMR, 1973. Therefore, not all of the geologic units in the comparison below are identified as aquifers. However, some of these may contain both relatively minor aquifers and aquitards. An approximate correlation of geologic formations listed in VDMR, 1973 with aquifers identified in USGS, 1987 has been presented in Table 3-1.

TABLE 3-1

NAB LITTLE CREEK
GEOLOGIC FORMATION AND AQUIFER CORRELATION

Geologic Formation	Aquifer	Approximate Depth to Top of Aquifer (feet)
Columbia Group	Columbia	Surface
Yorktown Formation	Yorktown-Eastover	*Undetermined
Calvert Formation	Confining Unit	440
Nanjemoy Formation	Confining Unit	Not present beneath the site
Mattaponi Formation	Aquia/Pee Dee	695
"Transitional Beds"	Confining Unit	755
Patuxent Formation	Lower Potomac	905

* The depth and thickness of the Yorktown Formation near Little Creek NAB has not been investigated in detail, so this information has not been accurately determined.

Accurate hydraulic conductivities for the units could not be located in the published literature, largely because of the lithologic variability within each formation. However, transmissivities have been presented in Table 3-2 as a relative comparison to hydraulic conductivities. (These values were taken from Siudyla, et al., 1981 and are documented in Exhibit 3-7.):

TABLE 3-2

NAB LITTLE CREEK
TRANSMISSIVITY RANGE

Aquifer	Common Range of Transmissivities (gallons per day per foot)
Columbia	Not available
Yorktown-Eastover	1,600 to 66,000
Aquia/Pee Dee	5,000 to 10,000
Lower Potomac	15,000 to 157,000

3G. Discuss any evidence of aquitards and discontinuities between aquifers within 4 miles of the sources.

According to USGS, 1987, the hydrogeologic framework for the study area is a series of aquifers and intervening confining units, indicating that aquitards are present between aquifers under areas within four miles of the sites at NAB Little Creek. This information has been documented in Exhibit 3-6.

3H. Describe any evidence of interconnections between aquifers within 2 miles of each source.

As described above, no evidence of aquifer interconnection beneath the site has been found (see Exhibit 3-6).

3I. Estimate the annual net precipitation at the site.

This item was identified as "acceptable" on the checklist.

3J. Discuss soil or geologic conditions that might inhibit or facilitate ground water migration.

As discussed above, there are effective aquitards beneath the site which would inhibit vertical migration of contaminants. These aquitards are discussed in detail in Exhibit 3-6.

3K. Identify if any underlying aquifers are "sole source" as designated by Section 1424 (e) of the Safe Drinking Water Act.

The site is not underlain by a sole-source aquifer as designated by Section 1424(e) of the Safe Drinking Water Act, as confirmed by information received from the Environmental Protection Agency's Office of Ground Water Protection. Documentation has been provided in Exhibit 3-8.

3L. Determine if sources are located in an area of Karst topography.

The checklist response identified this item as "not applicable". It may have been intended to indicate that the site would not be located in an area of Karst topography.

3N. Determine if any areas within a 4 mile radius of each source is located in a Wellhead Protection area according to Section 1428 of the Safe Drinking Water Act.

The area, including the site and a four-mile radius of the sites at NAB Little Creek, is not located within a Wellhead Protection Program according to Section 1428 of the Safe Drinking Water Act, as Virginia does not have an established Wellhead Protection Program. This information was confirmed by Mr. Terry Wagner of the Virginia Water Control Board, and documentation has been provided in Exhibit 3-9.

4.0 SURFACE WATER PATHWAY

4A. Describe surface water bodies 0 to 15 miles downstream of the sources and provide a map of surface water bodies receiving drainage from each source.

The following surface water bodies are located on the activity: (RGH, 1984)

- Little Creek
- Little Creek Harbor (includes Desert Cove and Little Creek Cove) (above flow into the Chesapeake Bay)
- Golf Course Lakes
- Lake Bradford (inlet from drainage canals, surface outlet to Little Creek Cove) (PGA, 1986)
- Chubb Lake (inlet from drainage canals, surface outlet to Little Creek Cove) (PGA, 1986)
- Lake Whitehurst
- Lake Smith/Little Creek Reservoir (drainage to Little Creek)

The following surface water bodies are within the 15 mile target distance limit as a result of tidal influence:

- Lynnhaven River
- James River
- Elizabeth River
- Lafayette River
- Willoughby Bay
- Nansemond River

See Figure 1 for locations of these surface water bodies.

4B. Discuss the probable surface run-off pattern from each source to surface waters, including the distance to the nearest surface water body (including ponds, lakes, streams, etc.).

Surface water drainage is primarily into Little Creek Harbor and through the inlet into the Chesapeake Bay. Some drainage in the eastern portion of the NAB Little Creek is though a canal system. This system discharges into Little Creek Cove (information provided by LANTDIV) (see Exhibit 4-1).

The runoff patterns for the sites of concern are shown on Figure 2 and described below.

Site 7 (Amphibious Base Landfill) - According to the Initial Assessment Study (RGH, 1984), information is not available to confirm or discount the possibility of runoff migrating into the Lake Smith/Little Creek Reservoir. Based on current surface water elevations, is appears that the Lake Smith/Little Creek Reservoir may exert a hydraulic head which potentially causes migration toward Little Creek harbor. From the USGS Little Creek quadrangle map, it would appear that surface water runoff would flow to Little Creek Cove. The site is located about 200 feet from Little Creek Cove according to the site map in the Initial Assessment Study (RGH, 1984).

Site 9 (Driving Range Landfill) - Site 9 is presently used as a golf driving range (RGH, 1984). Based on surface elevations from the Little Creek USGS quadrangle map, surface water runoff would migrate towards the golf course lake and the Chesapeake Bay. The eastern side of the site is adjacent to the golf course lake and the northern boundary lies about 1000 feet south of the bay (USGS Little Creek quadrangle map).

Site 10 (Sewage Treatment Plant Area Landfill) - Drainage during the period of disposal was into an arm of Desert Cove which drained the areas of the base directly behind the sand dunes. This arm of the cove was filled during the major base improvements which occurred in the 1950s. According to the Initial Assessment Study, surface water runoff would migrate to Desert Cove, which is approximately 1000 feet from the site (RGH, 1984).

Site 11 (School of Music Plating Shop) - Site 11 is located close to the center of the eastern portion of the facility. Surface water runoff would appear to flow toward Little Creek Harbor, parallel to the Bay shoreline (RGH, 1984). The site is about 1500 feet from Lake Bradford and 4000 feet from Little Creek Cove.

The area where the plating shop is located is developed and the topography is flat, so it is difficult to determine runoff directions from surface elevations. According to the Initial Assessment Study, materials were reportedly disposed down the plating shop sink drain and into a sewer via existing drainage lines (RGH, 1984).

Site 12 (Exchange Laundry Waste Storage Area) - Waste was reportedly disposed into a storm drain adjacent to the the Laundry Waste Storage Area. This storm drain enters a canal about 500 feet west of the inlet (RGH, 1984). This canal drains into Lake Bradford and flows into Little Creek Cove (PGA, 1986).

Site 13 (Public Works PCP Dip Tank and Wash Rack) - Migration from Site 13 is toward the harbor (Little Creek Cove). The site is located about 2000 feet from Little Creek Cove and 300 feet from the golf course lake, according to the Initial Assessment Study (RGH, 1984).

4C. Describe the points at each source where hazardous substances begin to migrate and their probable point of entry into a surface water body and provide a map.

The point at each site where hazardous substances begin to migrate is assumed to be the low point of the site. The migratory path for each site is described as follows: (Information was obtained from the Little Creek USGS quadrangle map.)

Site 7 - Potential contaminants would appear to migrate from the north side of the site, entering the southeastern corner of Little Creek Cove.

Site 9 - Migration would appear to begin at the eastern side of the site, flowing into the west side of the golf course lake.

Site 10 - Potentially hazardous substances would appear to begin migrating from the far western point of the area, entering Desert Cove from the northeastern corner.

Site 11 - According to the Initial Assessment Study, migration of potentially hazardous substances is through the drainage channel and sewer (RGH, 1984).

Site 12 - Migration of potential contaminants is through a storm drain (RGH, 1984). The storm drain enters a canal which flows from Lake Bradford. The canal drains from the southern bank of the central part of the lake (information provided by LANTDIV).

Site 13 - Migration would appear to begin from the west side of the site towards the harbor (Little Creek) (RGH, 1984).

4D. Identify if surface water drawn from intakes within 15 miles downstream from the probable point of entry is used for any of the following purposes:

4D1. Irrigation (5-acre minimum) of commercial food crops or commercial forage crops.

According to the Virginia Beach Department of Public Utilities, public water is not being used for irrigation, commercial livestock, or as an ingredient in commercial food (see Exhibit 4-2).

4D2. Watering commercial livestock.

See response to 4D1.

4D3. Ingredient in commercial food.

See response to 4D1.

4D4. Major or designated water recreation area, excluding drinking water.

The City of Virginia Beach purchases some of its public water supply from the City of Norfolk. Norfolk uses the Little Creek Reservoir as a backup public water supply (RGH, 1984). Little Creek Reservoir is within the 15 mile target distance limit of the sites at NAB Little Creek.

Three water recreation areas use public water (see Exhibit 4-2).

- Wild Water Rapids Water Park
- Kempsville Recreation Center
- Great Neck Recreation Center

4E. Identify the following targets associated with surface water bodies 0 to 15 miles downstream of the probable point of entry:

4E1. Population (residents, workers, and students) served by intakes of drinking water.

Little Creek Reservoir is used by the City of Norfolk for public water supply. The City of Norfolk sells potable water to Virginia Beach and Chesapeake. (The actual population served by this system is not yet available, but once the information is obtained, it will be provided in the final report.)

4E2. Sensitive environments and critical habitats of a federally endangered species.

- No Critical Habitats, as defined in 50 CFR 424.02, have been identified either 15 miles downstream or upstream (tidal influence) from any of the sites (see Exhibit 4-3) (50 CFR Sections 17.95, 17.96). Grandview Natural Area is being considered for a Critical Habitat designation because of the Piping Clover (see Figure 2) (see Exhibit 4-3).

- Federally endangered and threatened sea turtles may range as far north as Virginia, but are not expected to nest in the region. These species include: the green sea turtle, hawksbill sea turtle; Kemp's ridley sea turtle; and the leatherback sea turtle (RGH, 1984) (see Exhibit 4-4). In addition, the following five species reside or breed in southwest Virginia but are not known to inhabit NAB Little Creek: Long's Bitter Cress (*Cardamine longii*) (Vascular plant - Under review); *Lilaeopsis carolinensis* (no common name) (Vascular plant - Under review); Loggerhead Sea Turtle (*Coretta coretta*) (Reptile - Threatened); Southern Bald Eagle (*Heliaeetus leucocephaius*) (Resident Bird - Threatened); and Red-Cockaded Woodpecker (*Picoides borealis*) (Resident Bird - Endangered) (RGH, 1984) (see Exhibit 4-4). Also, several federally designated threatened (T) and endangered (E) species have been identified at the city level, although their exact location could not be identified (see Exhibit 4-4) (Cline, 1990) (USDI, 1990):

  1. Bald Eagle (E) (*Haliaeetus leucocephalus*)
     (Virginia Beach and York);

2. Red-Cockaded Woodpecker (E) (*Picoides borealis*)
   (Virginia Beach and York);

3. Piping Plover (T) (*Charadrius melodus*)
   (York and Virginia Beach);

4. Northeastern Beach Tiger Beetle (T) (*Cincindela dorsalis dorsalis*)
   (York and Virginia Beach);

5. Dismal Swamp Southeastern Shrew (T) (*Sorex longirostris fisheri*)
   (Chesapeake Bay);

6. Peregrine Falcon (*Falco peregrinus anatum* (E) and *Falco peregrinus tundrius* (T))
   (Virginia Beach).

- The Virginia Department of Conservation and Recreation, Division of Natural Heritage, was contracted to conduct a rare, threatened, and endangered species study and Special Interest Areas (e.g., exemplary natural communities, animal congregation sites, etc.) study for the Little Creek Naval Amphibious Base (VaDCR, 1990). This study identified three state rare plant species and one rare animal species within 15 miles downstream, or upstream (tidal influence) of the sites. These species include: Virginia beach pinweed (*Lechea maritima var Virginica*); Bluejack oak (*Quercus incana*); Spanish moss (*Tillandsia usneoides*); and, Least tern (*Sterna antillarum*). Refer to Exhibit 4-5 for a discussion of the species, and figures showing their location. Exhibit 4-5 also contains a listing of state rare, threatened and endangered species <u>in the cities</u> within 15 miles downstream and upstream (tidal influence) of the sites.

- No national parks have been identified within 15 miles downstream or upstream (tidal influence) of the sites. (see Exhibit 4-6) (NPS, 1989a) (NPS, 1989b). However, Seashore State Park is located within 15 miles downstream of the sites (see Figure 2).

- No national monuments have been identified within 15 miles downstream or upstream (tidal influence) of the sites. (see Exhibit 4-6) (NPS, 1989a) (NPS, 1989b).

- No national seashore or lakeshore recreational areas managed by the National Park Service have been identified within 15 miles downstream or upstream (tidal influence) of the sites (see Exhibit 4-6) (NPS, 1989a) (NPS, 1989b). There may be national seashore or lakeshore recreational areas managed by other agencies, however, none have been identified.

- No federally designated scenic or wild rivers, or national river reaches designated as recreational have been identified within 15 miles downstream or upstream (tidal influence) of the sites (see Exhibit 4-7) (NPS, 1989a) (NPS, 1990) (SC, 1991).

- No state designated scenic rivers have been identified within 15 miles downstream or upstream (tidal influence) of the sites (see Exhibit 4-7) (VaDCR, 1989).

- A blue-crab (*Callinectes sapidus*) sanctuary is located in an area of the lower Chesapeake Bay, between Hampton Roads and the Chesapeake Bay Bridge-Tunnel (see Figure 2) (see Exhibit 4-8).

- Several species of fish are known to have spawning areas 15 miles downstream or upstream (tidal influence) of the sites (CBP, 1987). They include, but are not limited to: Striped Bass (*Morone saxatilis*); Blue Crab (*Callinectes sapidus*) and Bay Anchovy (*Anchoa mitchilli*). Refer to Exhibit 4-9 for maps showing habitat distribution.

- No national preserves have been identified within 15 miles downstream or upstream (tidal influence) of the sites (see Exhibit 4-6) (NPS, 1989a) (NPS, 1989b),

- Plum Tree National Wildlife Refuges has been identified within 15 miles downstream of the sites (see Figure 2) (see Exhibit 4-3) (USDI, 1986a) (SC, 1988).

- It was reported by the VA Department of Game and Inland Fisheries that Virginia does not have state wildlife refuges. Instead, they have wildlife management areas (see Exhibit 4-10). No wildlife management areas have been identified within 15 miles downstream or upstream (tidal influence) of the sites (see Exhibit 4-10) (DeLorme, 1989).

- No designated federal wilderness areas were identified within 15 miles downstream or upstream (tidal influence) of the sites (see Exhibit 4-11) (WS, 1989) (SC, 1990).

- The Seashore Natural Area within Seashore State Park has been identified within 15 miles downstream of the sites (see Figure 2) (see Exhibit 4-12) (VaDCR, 1989).

- The Virginia Department of Conservation and Recreation, Division of Natural Heritage, was contracted to conduct a rare, threatened, and endangered species study and Special Interest Areas (e.g., exemplary natural communities, animal congregation sites, etc.) study for the Little Creek Naval Amphibious Base (VaDCR, 1990). This study identified four Special Interest Areas within 15 miles downstream or upstream (tidal influence) of the sites. These areas include: Chub Lake Special Interest Area; East Dunes Special Interest Area; West Dunes Special Interest Area; and Little Creek Channel Special Interest Area. Chub Lake and East Dunes are ecological reserve areas, West Dunes is a botanical area, and Little Creek Channel is an endangered and threatened species area. Refer to Exhibit 4-5 for a discussion of the areas, and figures showing their location.

- No sensitive areas identified under the Near Coastal Waters Program have been identified within 15 miles downstream or upstream (tidal influence) of the sites (see Exhibit 4-13).

- No sensitive areas identified under the National Estuary Program have been identified within 15 miles downstream or upstream (tidal influence) of the sites (see Exhibit 4-13).

- The Coastal Zone Management Act is managed by the Council on the Environment (COE) as Virginia's Coastal Resources Management Program (VCRMP) in the Commonwealth of Virginia. The VCRMP coordinates the activities of the agencies that enforce the regulations in the coastal areas. An overview of the program is provided as Exhibit 4-13. The VCRMP does not site specific areas of concern; rather it identifies general areas of concern. These include the following:

    - Wetlands;
    - Subaqueous Lands;
    - Spawning, Nursery and Feeding Grounds;
    - Coastal Primary Sand Dunes;
    - Barrier Islands;
    - Significant Wildlife Habitat Areas;
    - Significant Public Recreation Areas; and,
    - Significant Mineral Resources Deposits.

As discussed in this report, there are wetlands, spawning, nursery and feeding grounds, and significant wildlife habitats within 15 miles downstream and upstream (tidal influence) of the sites.

4E3. Economically important resources.

The Chesapeake Bay and many of the surrounding water bodies, contain economically important resources such as finfish and shellfish. The following species are have been identified within 15 miles downstream or upstream (tidal influence) of the sites: Striped Bass (*Morone saxatilis*); Blueback Herring (*Alosa aestivalis*); Alewife (*Alosa pseudoharengus*); American Shad (*Alosa sapidissima*); Hickory Shad (*Alosa mediocris*); Bay Anchovy (*Anchoa mitchilli*); American Oyster (*Crassostrea virginica*); Softshell Clam (*Mya arenaria*); Hard Clam (*Mercenaria mercenaria*); and Blue Crab (*Callinectes sapidus*) (CBP, 1987). Refer to Exhibit 4-9 for maps showing habitat distribution.

4E4. Portions of surface water designated by a state for drinking water under section 305 (a) of the Clean Water Act and portions of surface water usable for drinking water.

According to the VA State Water Control Board, the Potable Water Supply (PWS) designation of water bodies in their Water Quality Standards fulfills the requirements of Section 305(a) of the Clean Water Act (see Exhibit 4-14). There are no water bodies designated as PWS within 15 miles downstream or upstream (tidal influence) of the sites (VA Water Quality Standards VR680-21-08.3).

4F. Determine the miles of wetlands (wetland frontage along surface water bodies 0 to 15 miles downstream from the probable point of entry.

From a review of the USGS 7.5 minute topographic maps, the Tidal Marsh Inventories prepared by the Virginia Institute of Marine Science and the National Wetlands Inventory (NWI) Maps, much of the water bodies within 15 miles downstream or upstream (tidal influence) contain wetland frontage. Because of the large number of wetland areas, only the larger wetlands (>3-5 acres) were plotted on Figure 2.

According to Table 4-24 (Appendix A to Part 300 - Hazard Ranking System), a total length of wetlands greater than 20 miles receives the maximum assigned value. As shown on Figure 2, there is undoubtedly greater than 20 miles of wetland frontage, therefore the actual mileage of wetland frontage was not determined.

4K. Estimate the size of the upgradient drainage area from each source.

The size of the upgradient drainage basins for the sites of concern at NAB were estimated using surface elevations on the USGS Little Creek quadrangle map and an electronic planimeter.

- Site 7- 25 acres
- Site 9- 18 acres
- Site 10- 21 acres

Sites 11, 12 and 13 are located in a highly developed area. The drainage area could not be determined from the USGS quadrangle map, due to the lack of elevation contours.

4L. Determine the 2-year, 24-hour rainfall for the site.

NAB Little Creek is located in Virginia Beach, Virginia. The Rainfall Frequency Atlas of the United States indicated a two-year, 24-hour rainfall for Virginia Beach of approximately 3.80 inches. According to the National Climatic Data center this is the most current information available (see Exhibit 4-15).

4M. Discuss the average annual stream-flow associated with each surface water body from 0 to 15 miles downstream of each source.

The Naval Amphibious Base, Little Creek is located along Little Creek Harbor and the Chesapeake Bay. These surface water bodies would be classified as shallow ocean zone and moderate depth ocean zone, according to the Federal Register p. 51614, Table 4-13 (see Exhibit 4-16).

Little Creek would be defined as a coastal tidal water, according to the Federal Register. It is affected by the tides from the Chesapeake Bay.

The Lakes on NAB Little Creek are defined as follows according to The Federal Register, pages 51613-51614.

Chubb Lake and Lake Bradford receive inflow from site drainage canals and drain through a drainage canal to Little Creek Cove.

Lake Smith/Little Creek Reservoir drains into Little Creek Cove on an emergency basis.

4O. Determine of sources are located in a 1 year, 10 year, 100 year, of 500 year flood plain.

Flood plain maps were obtained from the Federal Emergency Management Agency (FEMA), but do not include the Naval Facilities in Virginia Beach (see Exhibit 4-17).

Flood plains were provided in the Master Plan for NAB Little Creek (see Exhibit 4-17).

Site 7 - Portions of Site 7 are located within the 100-year flood plain.

Site 9 - Site 9 is located within the 100-year flood plain.

Site 10 - The site is located outside of the flood plain boundaries.

Site 12- The site is located outside of the 500-year flood plain.

Sites 11 and 13 - These sites are located in the 100-year flood plain.

4P. Discuss if fisheries(recreational or commercial) exist in surface water bodies 0 to 15 miles downstream of each source, and:

There are both recreational and commercial fisheries in surface-water bodies 15 miles downstream and upstream (tidal influence) of the sites (CBP, 1988). The exact location of most of these fisheries were unable to be identified.

4P1. Describe annual production (in pounds) of human food chain organisms (e.g., trout, shellfish, crabs) per acre of surface water bodies 0 to 15 miles down stream of each source.

The quantity (pounds) of shellfish and finfish landed in 1989 for Chesapeake Bay are presented on Table 1 in Exhibit 4-18. Table 1 also includes the approximate surface areas of the waterbodies (determined with a planimeter), along with pounds per acre of surface water.

4P2. Describe annual production (in pounds) of human food chain organisms(e.g., trout, shellfish, crabs) per acre of pond, lakes, bays, or oceans that receive surface water drainage from sources within 15 miles downstream of each source.

The quantity (pounds) of shellfish and finfish landed in 1989 for the Elizabeth River, Back River, Lynnhaven Bay, Lafayette River and James River (lower) are presented in Table 1 (see Exhibit 4-19). Table 1 also includes the approximate surface areas of the waterbodies (determined with a planimeter), along with pounds per acre of surface water. Refer to Exhibit 4-19 to determine the portion of the water bodies within the 15 mile area.

4Q. Identify closed fisheries 0 to 15 miles downstream from the sources.

There are several closed fisheries (shellfish condemnation areas) within 15 miles downstream and upstream (tidal influence) of the sites (see Exhibit 4-20). The notices and descriptions of these areas are provided in Exhibit 4-20.

5.0 AIR PATHWAY

5D. Determine if sensitive environments are within a 4 mile radius of each source.

- No Critical Habitats as defined in 50 CFR 424.02 were identified within a four-mile radius of the sites (see Exhibit 4-3) (50 CFR Sections 17.95, 17.96).

- Federally endangered and threatened sea turtles may range as far north as Virginia, but are not expected to nest in the region. These species include: the green sea turtle, hawksbill sea turtle; Kemp's Ridley sea turtle; and the leatherback sea turtle (RGH, 1984) (see Exhibit 4-4). In addition, the following five species reside or breed in southwest Virginia but are not known to inhabit NAB Little Creek: Long's Bitter Cress (*Cardamine longii*) (Vascular plant - Under review); *Lilaeopsis carolinensis* (no common name) (Vascular plant - Under review); Loggerhead Sea Turtle (*Coretta coretta*) (Reptile - Threatened); Southern Bald Eagle (*Heliaeetus leucocephaius*) (Resident Bird - Threatened); and Red-Cockaded Woodpecker (*Picoides borealis*) (Resident Bird - Endangered) (RGH, 1984) (see Exhibit 4-5). Also, several federally designated threatened (T) and endangered (E) species have been identified at the city level, although their exact location could not be identified (see Exhibit 4-5) (Cline, 1990) (USDI, 1990):

  1. Bald Eagle (E) (*Haliaeetus leucocephalus*)
     (Virginia Beach York);

  2. Red-Cockaded Woodpecker (E) (*Picoides borealis*)
     (Virginia Beach);

  3. Piping Plover (T) (*Charadrius melodus*)
     (Virginia Beach);

  4. Northeastern Beach Tiger Beetle (T) (*Cincindela dorsalis dorsalis*)
     (Virginia Beach);

  5. Dismal Swamp Southeastern Shrew (T) (*Sorex longirostris fisheri*)
     (Chesapeake Bay);

  6. Peregrine Falcon (*Falco peregrinus anatum* (E) and *Falco peregrinus tundrius* (T))
     (Virginia Beach).

- The Virginia Department of Conservation and Recreation, Division of Natural Heritage, was contracted to conduct a rare, threatened, and endangered species study and Special Interest Areas (e.g., exemplary natural communities, animal congregation sites, etc.) study for the Little Creek Naval Amphibious Base (VaDCR, 1990). This study identified three state rare plant species and one rare animal species within a four-mile radius of the sites. These species include: Virginia beach pinweed (*Lechea maritima var Virginica*); Bluejack oak (*Quercus incana*); Spanish moss (*Tillandsia usneoides*); and, Least tern (*Sterna antillarum*). Refer to Exhibit 4-5 for a discussion of the species, and figures showing their location. Exhibit 4-5 also includes a listing of state rare, threatened and endangered species <u>in the cities</u> within a four-mile radius of the sites.

- No national parks have been identified within a four-mile radius of the sites. (see Exhibit 4-6) (NPS, 1989a) (NPS, 1989b).

- No national monuments have been identified within a four-mile radius of the sites. (see Exhibit 4-6) (NPS, 1989a) (NPS, 1989b).

- No national seashore or lakeshore recreational areas managed by the National Park Service have been identified within a four-mile radius of the sites (see Exhibit 4-6) (NPS, 1989a) (NPS, 1989b). There may be national seashore or lakeshore recreational areas managed by other agencies, however, none have been identified.

- No federally designated scenic or wild rivers, or national river reaches designated as recreational have been identified within a four-mile radius of the sites (see Exhibit 4-7) (NPS, 1989) (NPS, 1990) (SC, 1991).

- No state designated scenic rivers have been identified within a four-mile radius of the sites (see Exhibit 4-7) (VaDCR, 1989).

- A blue-crab (*Callinectes sapidus*) sanctuary is located in an area of the lower Chesapeake Bay, between Hampton Roads and the Chesapeake Bay Bridge-Tunnel (see Figure 3) (see Exhibit 4-8).

- Several species of fish are known to have spawning areas within a four-mile radius of the sites (CBP, 1987). They include, but are not limited to: Striped Bass (*Morone saxatilis*); Blue Crab (*Callinectes sapidus*) and Bay Anchovy (*Anchoa mitchilli*). Refer to Exhibit 4-9 for maps showing habitat distribution.

- No national preserves have been identified within a four-mile radius of the sites (see Exhibit 4-6) (NPS, 1989a) (NPS, 1989b).

- No national wildlife refuges have been identified within a four-mile radius of the sites (see Exhibit 4-3) (USDI, 1986a) (SC, 1988).

- It was reported by the VA Department of Game and Inland Fisheries that Virginia does not have state wildlife refuges. Instead, they have wildlife management areas (see Exhibit 4-10). No wildlife management areas have been identified within a four-mile radius of the sites (see Exhibit 4-10) (DeLorme, 1989).

- No designated federal wilderness areas were identified within a four-mile radius of the sites (see Exhibit 4-11) (WS, 1989) (SC, 1990).

- No state designated natural area have been identified within a four-mile radius of the sites (see Exhibit 4-12).

- The Virginia Department of Conservation and Recreation, Division of Natural Heritage, was contracted to conduct a rare, threatened, and endangered species study and Special Interest Areas (e.g., exemplary natural communities, animal congregation sites, etc.) study for the Naval Amphibious Base Little Creek (VaDCR, 1990). This study identified four Special Interest Areas within a four-mile radius of the sites. These areas include: Chub Lake Special Interest Area; East Dunes Special Interest Area; West Dunes Special Interest Area; and Little Creek Channel Special Interest Area. Chub Lake and East Dunes are ecological reserve areas, West Dunes is a botanical area, and Little Creek Channel is an endangered and threatened species area. Refer to Exhibit 4-5 for a discussion of the areas, and figures showing their location.

- No sensitive areas identified under the Near Coastal Waters Program have been identified within a four-mile radius of the sites (see Exhibit 4-13).

- No sensitive areas identified under the National Estuary Program have been identified within a four-mile radius of the sites (see Exhibit 4-13).

- The Coastal Zone Management Act is managed by the Council on the Environment (COE) as Virginia's Coastal Resources Management Program (VCRMP) in the Commonwealth of Virginia. The VCRMP coordinates the activities of the agencies that enforce the regulations in the coastal areas. An overview of the program is provided as Exhibit 4-13. The VCRMP does not identify specific areas of concern; rather it identifies general areas of concern. These include the following:

    - Wetlands;
    - Subaqueous Lands;
    - Spawning, Nursery and Feeding Grounds;
    - Coastal Primary Sand Dunes;
    - Barrier Islands;
    - Significant Wildlife Habitat Areas;
    - Significant Public Recreation Areas; and,
    - Significant Mineral Resources Deposits.

As is discussed in this report, wetlands are located within a four-mile radius of the sites.

5E. Determine the total area of wetlands within a 4 mile radius of each source.

From a review of the USGS 7.5 minute topographic maps, the Tidal Marsh Inventories prepared by the Virginia Institute of Marine Science and the National Wetlands Inventory (NWI) Maps Atlas, much of the water bodies within a four-mile radius of the sites, contain wetland frontage (Silberhorn, 1987) (Barnard, 1979) (USDI, 1986b). Because of the large number of wetland areas, only the larger wetlands (>3-5 acres) were plotted on Figure 3. Refer to Exhibit 4-20, which contains the appropriate pages from the Tidal Marsh Inventories and the NWI Atlas. The total area of wetlands within a four-mile radius was estimated as greater than 500 acres from the tidal marsh inventories and NWI maps.

6.0 SOIL EXPOSURE PATHWAY

6D. Determine if any of the following areas are located near of within an area of soil contamination within 2 feet of the surface and provide the number of individuals within each area:

The only known areas that have soil contamination within 2 feet of the surface occur within the facility site boundaries. However, no data are available to confirm this.

6D4. Within boundaries of a terrestrial sensitive environments.

No terrestrial sensitive environments have been identified within a four-mile radius of the sites, therefore, they are not located or within an area of soil contamination within 2 feet of the surface (see section 5D). There are, however, some state rare plant and animal species within a four-mile radius of the site. Locations of soil contamination within two feet of the surface was not available, therefore, this section could not be completed.

7.0 DATA LIMITATIONS

The search for information has uncovered many sources of data which served to provide the required information for the HRS deficiency checklists. However, some of the requested information was not immediately available and will require additional investigation or time until the information is received by Baker. As the information is received or becomes available, it will be inserted into the final report.

The following information is not available, or has not yet been received.

- Information regarding one-year and ten-year flood plains that has been requested from the Federal Emergency Management Agency (FEMA) is not published or available.

- Population served by drinking water, checklist item 4E1.

- In regard to Figures 1, 2 and 3 (back cover), the title blocks will be included for the final report.

- Information on the location of soil contamination within two feet of the surface was not available, therefore, it could not be determined whether endangered species are located within that area.

Data reviewed after submission of this report will be forwarded for inclusion in this document.

REFERENCES

Barnard, 1979. Barnard, Thomas A. Jr., and Doumlele, Damon G. City of Virginia Beach Tidal Marsh Inventory, Volume 2. Lynnhaven River, Lake Rudee and Their Tributaries. Virginia Institute of Marine Science. Gloucester Point, Virginia. Special Report No. 217 in Applied Marine Science and Ocean Engineering. June 1979.

CBP, 1987. Chesapeake Bay Program. Habitat Requirements for Chesapeake Bay Living Resources. Living Resource Task Force of the Chesapeake Bay Implementation Committee. 1987.

CBP, 1988. Chesapeake Bay Program. Living Resources Monitoring Plan. Chesapeake Executive Council, Annapolis, Maryland. July 1988.

Cline, 1990. Cline, Keith. Bald Eagles in the Chesapeake. In cooperation with: U.S. Fish and Wildlife Service; Delaware Division of Fish and Wildlife; Maryland Forest, Park, and Wildlife Service; and Virginia Commission of Game and Inland Fisheries. 1990.

DeLorme, 1989. DeLorme Mapping Company. Virginia Atlas and Gazetteer. DeLorme Mapping Company, Freeport, Maine. 1989.

EPA, 1990. Environmental Protection Agency. Federal Register, 40 CFR Part 300, Hazardous Ranking System; Final Rule. December, 1990.

EPA, 1991. Environmental Protection Agency. Designated Sole Source Aquifers Nationally (Fact Sheet and Designated Aquifer List). United States Environmental Protection Agency, Office of Ground-Water Protection, Washington D.C. March, 1991.

NPS, 1989a. National Park Service. The National Parks: Index 1989. U.S. Department of the Interior, Washington, D.C. 1989.

NPS, 1989b. National Park Service. National Park System Map and Guide. U.S. Department of the Interior, National Park Service, Washington D.C. 1989.

NPS, 1990. National Park Service. The Wild and Scenic Rivers Act. U.S. Department of the Interior, National Park Service, Park Planning and Protection Division, Washington D.C. 1990.

PGA, 1986. Pierce Goodwin Alexander. Master Plan Naval Amphibious Base Little Creek, Norfolk, Virginia. Houston, Texas. November 1986.

REWAI, 1982. R.E. Wright Associates, Inc. Extent of Subsurface Fuel Contamination - Little Creek Naval Amphibious Base. Middletown, PA. October, 1982.

RGH, 1984. Rogers, Golden, and Halpern. Initial Assessment Study, Naval Amphibious Base, Little Creek, Norfolk, Virginia. Philadelphia, PA. December, 1984.

SC, 1988. Sierra Club. National Wildlife Refuge System. Sierra Club, Public Affairs, San Francisco, CA. June 1987 and updated November 1988.

SC, 1990. Sierra Club. National Wilderness Preservation System. Sierra Club, Public Affairs, San Francisco, CA. March 1985 and updated June 1990.

SC, 1991. Sierra Club. National Wild and Scenic Rivers System. Sierra Club, Public Affairs, San Francisco, CA. April 1988 and updated January 1991.

Silberhorn, 1987. Silberhorn, Gene M., and Preist, Walter I. III. City of Norfolk Tidal Marsh Inventory. Virginia Institute of Marine Science. Gloucester Point, Virginia. Special Report No. 281 in Applied Marine Science and Ocean Engineering. February 1987.

Siudyla, 1981. Siudyla, Eugene. Ground Water Resources of the Four Cities Area. Virginia State Water Control Board, Bureau of Water Control Management, Richmond, Virginia. November, 1981.

USDA, 1961. United States Department of Agriculture. Technical Paper Number 40, Rainfall Frequency Atlas of the United States. Engineering Division, Soil Conservation Service, Department of Agriculture, Washington, D.C. May 1961.

USDI, 1986a. U.S. Department of the Interior. National Wildlife Refuge System. U.S. Department of the Interior, Fish and Wildlife Service. 1986.

USDI, 1986b. U. S. Department of the Interior. Atlas of Natural Wetlands Inventory Maps of Chesapeake Bay - Volume 1. U. S. Department of the Interior, Fish and Wildlife Service. September 1986.

USDI, 1990. U.S. Department of the Interior, Fish and Wildlife Service. County Occurrences of Endangered and Threatened Species in Virginia. September, 1990.

USGS, 1984. United States Department of the Interior Geologic Survey. Little Creek Quadrangle, Virginia, 7.5 Minute Series (Topographic).

USGS, 1987. United States Geologic Survey. Hydrogeology and Analysis of the Ground-Water Flow System in the Coastal Plain of Southeastern Virginia. United States Geological Survey Water-Resources Investigation Report 87-4240 (in cooperation with the Virginia Water Control Board). 1987.

VaDCR, 1989. Virginia Department of Conservation and Recreation. The 1989 Virginia Outdoors Plan Executive Summary. Division of Planning and Recreation Resources. 1989.

VaDCR, 1990. Department of Conservation and Recreation. An Inventory of the Rare, Threatened & Endangered Species of the Little Creek Naval Amphibious Base. Division of Natural Heritage. September 1990.

VaDCR, 1991. Department of Conservation and Recreation. Natural Heritage Resources from Naval Weapons Station, Yorktown Vicinity. Division of Natural Heritage. 1991.

VDMR, 1973. Virginia Department of Mineral Resources. Geologic Studies, Coastal Plain of Virginia. Virginia Department of Conservation and Economic Development, Division of Mineral Resources, Charlottesville, VA. 1973.

VWCB, 1991. Virginia Water Control Board. Information sent by Ms. Virginia Newton, Virginia Beach, Virginia. 1991.

WS, 1989. The Wilderness Society. The National Wilderness Preservation System, 1964-1989, Washington, D.C. 1989.

EXHIBIT 2-1

HRS Scoring Deficiency Checklist Coversheet

Naval Amphibious Base Little Creek/USN Naval Air Base, Virginia

The source. of information EPA reviewed to complete the attached deficiency checklist include:

- United States Environmental Protection Agency. Notification of Hazardous Waste Site. June 11, 1981.
- Rogers, Golden and Halpern. Initial Assessment Study Naval Amphibious Base, Little Creek. December 1984.
- A.T. Kearney. Revised Phase II RCRA Facility Assessment Report. March 1989.
- CH2M HILL. HRS Scoring Sheets. April 4, 1988.

In cases where information was provided to EPA but is not acceptable, EPA has provided an explanation below. The number and the letter adjacent to the explanation corresponds to the number and the letter that appears on the HRS Scoring Deficiency Checklist.

1B3 - The sources are not located on a map of the facility. A scale should be included on the map.

1D - Releases of hazardous substances, pollutants, or contaminants to ground water, surface water, soil, and air are described. No sample results indicating a release are provided.

1F - The quantity of spills and the concentration of hazardous substances contained in the spill are not provided.

3G - Additional evidence is needed to support the existence of aquitards (pump tests).

3H - Additional evidence is needed to determine if the uppermost aquifer and the aquifer within 2 miles of each source are interconnected.

HRS SCORING DEFICIENCY CHECKLIST

EPA ID# VA 5170022482
Federal Facility ID# VA 5170022482
Facility Name Naval Amphibious Base

City Little Creek State VA Zip 23521

		INFORMATION IS PROVIDED? Y/N	ACCEPTABLE? Y/N*
I.	OVERVIEW/SITE HISTORY		
1A.	Reports submitted to EPA are referenced and copies of each reference are provided.	N	N
1B.	Describe site operations (manufacturing, storage, waste disposal practices, etc.) including the following:		
1B1.	History of the site and sources (any area containing or potentially containing hazardous substances).	Y	Y
1B2	A topographic map showing a 4-mile radius around each source.	N	N
1B3	A site and source location map and sketch.	Y	N
1B4	Regulatory history of the facility (i.e., RCRA facility, CERCLA, NPDES permits, etc.).	N	N
1C.	Describe any emergency or response actions that have occurred at the site. Description should include amount of materials removed, disposal location, and sample analytical results prior and subsequent to removal.	N	N
1D.	Describe any releases of hazardous substances, pollutants, or contaminants to ground water, surface water, soil, or air and provide sample analytical results.	Y	N
1E.	Give the following populations within each radii indicated below. The center of the radii should begin at the center of each source. Overlapping areas (populations) within the radii should be counted only once.	N	N
1E1.	0 - 1/4 mile		
1E2.	1/4 - 1/2 mile		
1E3.	1/2 - 1 mile		
1E4.	1 - 2 mile		
1E5.	2 - 3 mile		
1E6.	3 - 4 mile		

* Where information is provided but not acceptable, see attachment for a detailed explanation of why the information is not acceptable.

Facility Name: Naval Amphibious Base

		INFORMATION IS PROVIDED? Y/N	ACCEPTABLE? Y/N*
1F.	Describe any prior spills (e.g., quantity of the spill, concentration of hazardous substance) that occurred at the site.	Y	N
1G.	Describe site and source security (e.g., fences, patrols, gates, etc.).	N	N
2.	WASTE/SOURCE INFORMATION (see Section 2 of the HRS Final Rule - December 1990 Federal Register)		
2A.	Describe as specifically as possible the types of wastes produced at the site and the methods in which these wastes were treated, stored, or disposed.	N	N
2B.	Describe as specifically as possible the amount (volume, weight, etc.) of each waste type produced at the site.	Y	Y
2C.	Describe each source type (eg., landfill) located on the facility boundary.	Y	Y
2D.	Describe as specifically as possible the constituents (concentrations of individual constituents) of each waste type disposed in each source.	N	N
2E.	Describe as specifically as possible the amount of waste treated, stored, or disposed in each source (eg., landfills, impoundments, tanks).	Y	Y
2F.	Determine the depth at which wastes were deposited in each source.	N	N
2G.	Describe as specifically as possible the condition/integrity of each source (e.g., are landfills equipped with liners or caps).	N	N
2H.	Describe any secondary containment features/structures associated with each source (e.g., precipitation run-on and run-off systems, leachate collection systems, gas collection systems).	N	N
2I.	Describe the size, volume, capacity, and area of each source.	Y	Y
3.	GROUNDWATER PATHWAY INFORMATION (see Section 3 of the HRS Final Rule - December 1990 Federal Register)		
3A.	Determine if the ground water within a 4- mile radius of each source is used for any of the following purposes and locate the wells on a 4-mile radius map. The center of the radii should begin at the center of each source if the source is small or at the outer edge of the source if it is large.		

* Where information is provided but not acceptable, see attachment for a detailed explanation of why the information is not acceptable.

Facility Name: Naval Amphibious Base

		INFORMATION IS PROVIDED? Y/N	ACCEPTABLE? Y/N*
3A1.	private or public drinking water source	Y	Y
3A2.	irrigation of commercial crops (include acres)	N	N
3A3.	commercial livestock	N	N
3A4.	commercial aquiculture	N	N
3A5.	industrial	N	N
3A6.	not used, but usable	N	N
3A7.	unusable	N	N
3A8.	water for recreational area	N	N
3A9.	stand-by wells used for drinking water at least once a year	N	N
3B.	Outline the public water distribution system within a 4-mile radius of each source on a topographic map.	N	N
3C.	Identify the nearest drinking water well.	N	N
3D.	Determine the population (including workers, students, and residents) drawing from each drinking-water well within the following radii. The center of the radii should start at the center of each source if the source is small or at the outer edge of the source if it is large. Count overlapping areas only once.	N	N
3C1.	0 - 1/4 mile		
3C2.	1/4 - 1/2 mile		
3C3.	1/2 - 1 mile		
3C4.	1 - 2 mile		
3C5.	2 - 3 mile		
3C6.	3 - 4 mile		
3E.	Describe known or probable ground-water flow direction from each source.	Y	Y
3F.	Describe, as precisely as possible, the geology and hydrogeology of the site area (including geological formation name, thickness, types of material, hydraulic conductivities, and depth to aquifers).	N	N
3G.	Discuss any evidence of aquitards and discontinuities between aquifers within 4- miles of the sources.	Y	N
3H.	Describe any evidence of interconnections between the uppermost aquifer and aquifers within 2- miles of each source.	Y	N
3I.	Estimate annual net precipitation at the site.	Y	Y
3J.	Discuss soil or geologic conditions that might inhibit or facilitate ground-water migration.	N	N

* Where information is provided but not acceptable, see attachment for a detailed explanation of why the information is not acceptable.

		INFORMATION IS PROVIDED? Y/N	ACCEPTABLE? Y/N*
3K.	Identify if any underlying aquifers are "sole source" as designated by Section 1424(e) of the Safe Drinking Water Act.	N	N
3L.	Determine if sources are located in an area of Karst topography.	NA	NA
3M.	Provide ground-water sample analysis results from aquifers underlying the sources and from homewells (drinking wells) within 2- miles of each source.	N	N
3N.	Determine if any areas within a 4-mile radius of each source is located in a Wellhead Protection Area according to Section 1428 of the Safe Drinking Water Act.	N	N

4. SURFACE-WATER PATHWAY INFORMATION (see Section 4 of the HRS Final Rule - December 1990 Federal Register)

		PROVIDED? Y/N	ACCEPTABLE? Y/N*
4A.	Describe surface-water bodies 0 to 15 miles downstream of the sources and provide a map of surface-water bodies receiving drainage from each source.	N	N
4B.	Discuss the probable surface runoff pattern from each source to surface waters, including the distance to the nearest surface water body and provide a map.	N	N
4C.	Describe the points at each source where hazardous substances begin to migrate and their probable point of entry into a surface- water body (including ponds, lakes, streams, etc.).	N	N
4D.	Identify if surface water drawn from intakes within 15 miles downstream from the probable point of entry is used for any of the following purposes:		
4D1.	irrigation (5-acre minimum) of commercial food crops or commercial forage corps	N	N
4D2.	watering commercial livestock	N	N
4D3.	ingredient in commercial food	N	N
4D4.	major or designated water recreation area, excluding drinking water	N	N
4E.	Identify the following targets associated with surface-water bodies 0 to 15 miles downstream of the probable point of entry:		
4E1.	population (residents, workers, and students) served by intakes of drinking water	N	N
4E2.	sensitive environments (see Table 4-23, December 1990 Federal Register) and critical habitats of a federally endangered species	N	N
4E3.	economically important resources (e.g., shellfish)	N	N

* Where information is provided but not acceptable, see attachment for a detailed explanation of why the information is not acceptable.

Facility Name: Naval Amphibious Base

		INFORMATION IS PROVIDED? Y/N	ACCEPTABLE? Y/N*
4E4.	portions of the surface water designated by a state for drinking water use under Section 305(a) of the Clean Water Act and portions of surface water usable for drinking water	N	N
4F.	Determine the miles of wetlands (wetland frontage) along surface-water bodies 0 to 15 miles downstream from the probable point of entry.	N	N
4G.	Provide sample analytical results obtained from wetlands and/or sensitive environments 0 to 15 miles downstream of the sources.	N	N
4H.	Discuss any qualitative, quantitative, or circumstantial evidence of contamination of surface waters from sources.	Y	Y
4I.	Provide sample sediment and surface-water analytical results from points 0 to 15 miles downstream of each source.	N	N
4J.	Provide sample analytical results from surface-water intakes from 0 to 15 miles downstream of each source.	N	N
4K.	Estimate the size of the upgradient drainage area from each source.	N	N
4L.	Determine the 2-year, 24-hour rainfall for the site.	N	N
4M.	Discuss the average annual stream-flow associated with each surface-water body from 0 to 15 miles downstream of each source.	N	N
4N.	Determine surface soil types within the site area.	N	N
4O.	Determine if sources are located in a 1 year, 10 year, 100 year, or 500 year flood plain.	N	N
4P.	Discuss if fisheries (recreational or commercial) exist in surface- water bodies 0 to 15 miles downstream of each source, and:	N	N
4P1.	Describe annual production (in pounds) of human food chain organisms (e.g., trout, shellfish, crabs) per acre of surface-water bodies 0 to 15 miles down stream of each source.		
4P2.	Describe annual production (in pounds) of human food chain organisms (e.g., trout, shellfish, crabs) per acre of pond, lakes, bays, or oceans that receive surface-water drainage from sources within 15 miles downstream of each source.		

* Where information is provided but not acceptable, see attachment for a detailed explanation of why the information is not acceptable.

		INFORMATION IS PROVIDED? Y/N	ACCEPTABLE? Y/N*
4Q.	Identify closed fisheries 0 to 15 miles downstream from sources.	N	N
4R.	Provide tissue samples from human food chain organisms (fisheries) in surface-water bodies 0 to 15 miles downstream of sources and in ponds, lakes, bays, and streams that receive drainage from the sources.	N	N
5.	AIR PATHWAY INFORMATION (see Section 6 of the HRS Final Rule - December 1990, Federal Register)		
5A.	Describe if there has been an observed release of a hazardous substance to the atmosphere.	NA	NA
5B.	Determine the shortest distance to the closest residence or regularly occupied building or area from any on-site air emission source.	N	N
5C.	Determine if any of the following resources are located within a 1-mile radius of each source:	N	N
5C1.	commercial agriculture		
5C2.	commercial silviculture		
5C3.	recreation area		
5D.	Determine if sensitive environments are within a 4- mile radius of each source.	N	N
5E.	Determine the total area of wetlands within a 4-mile radius of each source.	N	N
6.	SOIL-EXPOSURE PATHWAY (see Section 5 of the HRS Final Rule - December 1990, Federal Register)		
6A.	Describe any areas of contamination that are within 2 feet of the ground surface and provide the total area of contamination.	Y	Y
6B.	Provide sample analytical results and depths of soil samples obtained in the contaminated area.	N	N
6C.	Describe the measures taken to limit access to areas with soil contamination within 2 feet of the surface (e.g., fences, guards, etc.).	N	N
6D.	Determine if any of the following areas are located near or within an area of soil contamination within 2 feet of the surface and provide the number of individuals within each area:		

* Where information is provided but not acceptable, see attachment for a detailed explanation of why the information is not acceptable.

Facility Name: Naval Amphibious Base

	INFORMATION IS PROVIDED? Y/N	ACCEPTABLE? Y/N*
6D1. within the property boundary of residence, schools, or day care centers or within 200 feet of the respective residence, school or day care	N	N
6D2. within a work place property boundary or within 200 feet of the work place area	N	N
6D3. within boundaries of commercial agriculture, silviculture, or livestock production (grazing) area	N	N
6D4. within boundaries of a terrestrial sensitive environments (see Table 5-5, December 1990 Federal Register)	N	N
6E. Provide number of individuals who live, work, or attend school within 0- to 1/4-mile, 1/4- to 1/2-mile, and 1/2- to 1-mile radius of soil contamination within 2 feet of the surface.	N	N

* Where information is provided but not acceptable, see attachment for a detailed explanation of why the information is not acceptable.

EXHIBIT 3-1

City of
Norfolk
Department of Utilities

April 16, 1991

Jeffrey S. Laskey
Chemical Engineer
Baker Environmental, Inc.
Airport Office Park, Building 3
420 Rouser Road
Coraopolis, Pennsylvania 15108

Re: Request for information on the Norfolk Water Distribution System for a Department of Navy study

(our file 10.7)

Dear Mr. Laskey:

The enclosed materials are provided to you in response to your letter of March 29, 1991. Some of the material related to groundwater is excerpted from the U.S. Geological Survey report Hydrogeology and Analysis of the Ground-Water Flow System in the Coastal Plan of Southeastern Virginia. You may wish to contact Mr. Gary Anderson, U.S.G.S office in Richmond, Virginia (804-771-2427) for further information on the on-going studies of groundwater in southeastern Virginia.

Also, the cities and counties within southeastern Virginia participate in regional studies through cooperation with the Hampton Roads Planning District Commission, a regional planning body. Several of the maps of the waters and watersheds of southeastern Virginia are from the Regional Stormwater Management Strategy for Southeastern Virginia, prepared by the HRPDC. You may want to contact Mr. John Carlock, Chief Physical Planner for further information.

Please let me know if we can be of further assistance.

Sincerely,

Neal S. Windley
Director

Attachments

Office of the Director
310 Cumberland Street • P.O. Box 1080 • Norfolk, Virginia 23501

Norfolk Department of Utilities response to request from Baker Environmental, Inc. (March 28, 1991) for information on the water distribution system of Norfolk.

(1) see attached description of the Norfolk Water Supply system and areas served.

(2) see attached map indicating water sources.

(3) see attached maps showing: The waters of southeastern Virginia, the watersheds of southeastern Virginia, and description of the Norfolk Water Supply System.

(4) See attached description of the wells used by Norfolk Utilities, and their specifications including depths. Also see attached excerpts from the U.S.G.S. Hydrogeology and Analysis of the Ground-Water Flow System in the Coastal Plain of Southeastern Virginia describing the confined aquifers within the coastal plain of Virginia. The report in its entirety (87-4240) is available from the U.S.G. S. office in Richmond, Virginia (Gary Anderson, 804-771-2427) and includes specifics about aquifer hydraulic conductivity, porosity, transmissivity, hydraulic gradient, confining layers, etc.

(5) see description of the Norfolk Water Supply System. Mixture of surface and groundwater is influenced by drought conditions which necessitate the use of emergency wells.

(6) The Norfolk water distribution system supports the populations of Norfolk, Virginia Beach and a portion of Chesapeake, totaling approximately 750,000 people.

(7) The water drawn from intakes is used primarily for Norfolk domestic use and to support our wholesale customers which include U.S. Navy facilities, and residents of Virginia Beach and Chesapeake. It should be noted that there are numerous private shallow wells throughout southeastern Virginia which are used for swimming/recreation, and for irrigation (crops and lawns). Further information on these privately owned shallow wells can be obtained from the State Water Control Board in Richmond and from the U.S.G.S. office in Richmond.

The portions of the Norfolk watershed are described as follows:

(1) the portion of the watershed of the city situated in the City of Norfolk know as Lake Wright, said lake being three (3) small, interconnected lakes or ponds known collectively as Lake Wright; and the waterworks property owned by the City of Norfolk, adjacent thereto, known as Moores Bridges Pumping Station;

(2) The portion of the watershed of the city of Norfolk in the City of Virginia Beach, Virginia,known as the eastern arm of Little Creek Reservoir; and within the portion of the watershed of the City of Norfolk situated in the City of Virginia Beach, Virginia, known as Van Wyck Canal, and the system of canals connecting the eastern and the western arms of Little Creek Reservoir, known as the Eastern Arm of the Little Creek Reservoir.

(3) The portion of the watershed of the city situated in part of the City of Virginia Beach, Virginia, and in part in the City of Norfolk, known as the western arm of Little Creek Reservoir, also known as Lake Whitehurst, and in the City of Norfolk, known as Denny's Canal, also known as the canal to Lake Wright, and the system of canals and lakes connecting Lake Whitehurst and Lake Wright, known as the Western Arm of the Little Creek Reservoir

(4) The portion of the watershed of the city situated in the City of Virginia Beach, Virginia, known as Lake Smith Reservoir;

(5) The portion of the watershed of the city situated in part in the City of Chesapeake, Virginia, and in part in the City of Virginia Beach, Virginia, known as Stumpy Lake Reservoir; also known as North Landing Reservoir;

(6) The portion of the watershed of the City situated in the City of Virginia Beach, Virginia,known as Lake Lawson Reservoir;

(7) The portion of the watershed of the city situated in the City of Suffolk, Virginia, known as Western Branch Reservoir;

(8) The portion of the watershed of the city situated in part of the City of Suffolk, Virginia, known as Lake Prince Reservoir;

(9) The portion of the watershed of the city situated in part in Isle of Wight County, Virginia, known as Upper Lake Prince Reservoir;

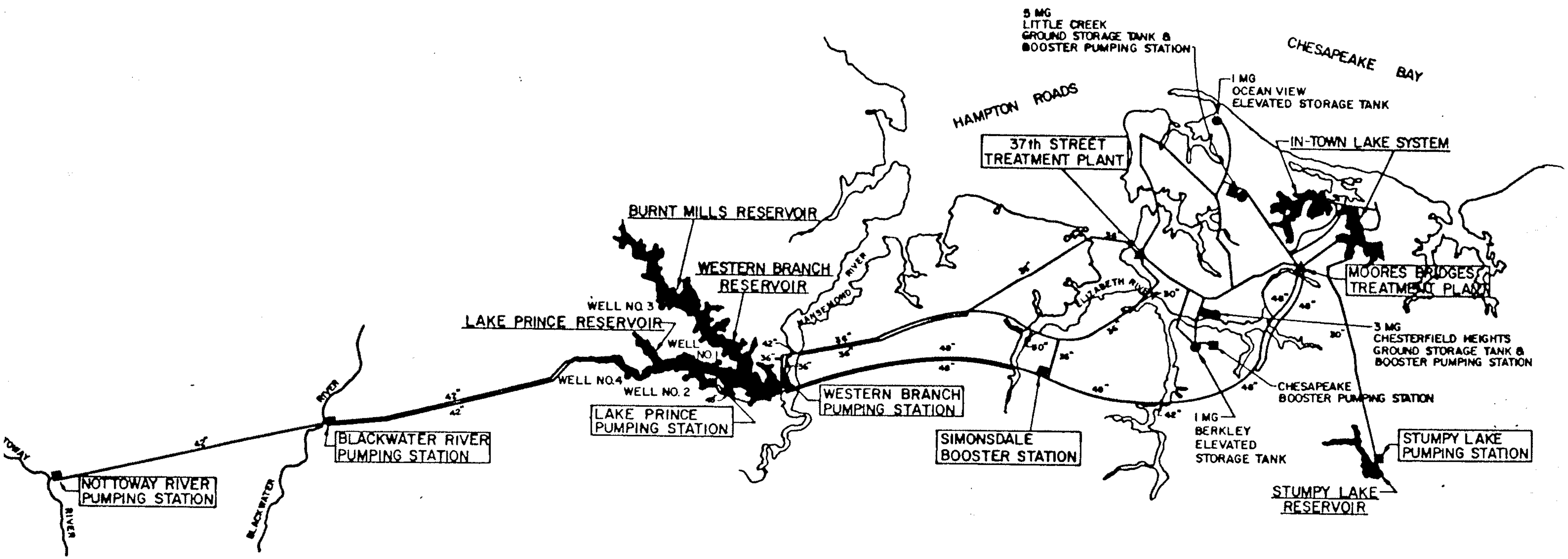
(10) The portion of the watershed of the city situated in part in the City of Suffolk, Virginia, and in part in Isle of Wight County, known as Lake Burnt Mills Reservoir;

NORFOLK WATER SUPPLY SYSTEM

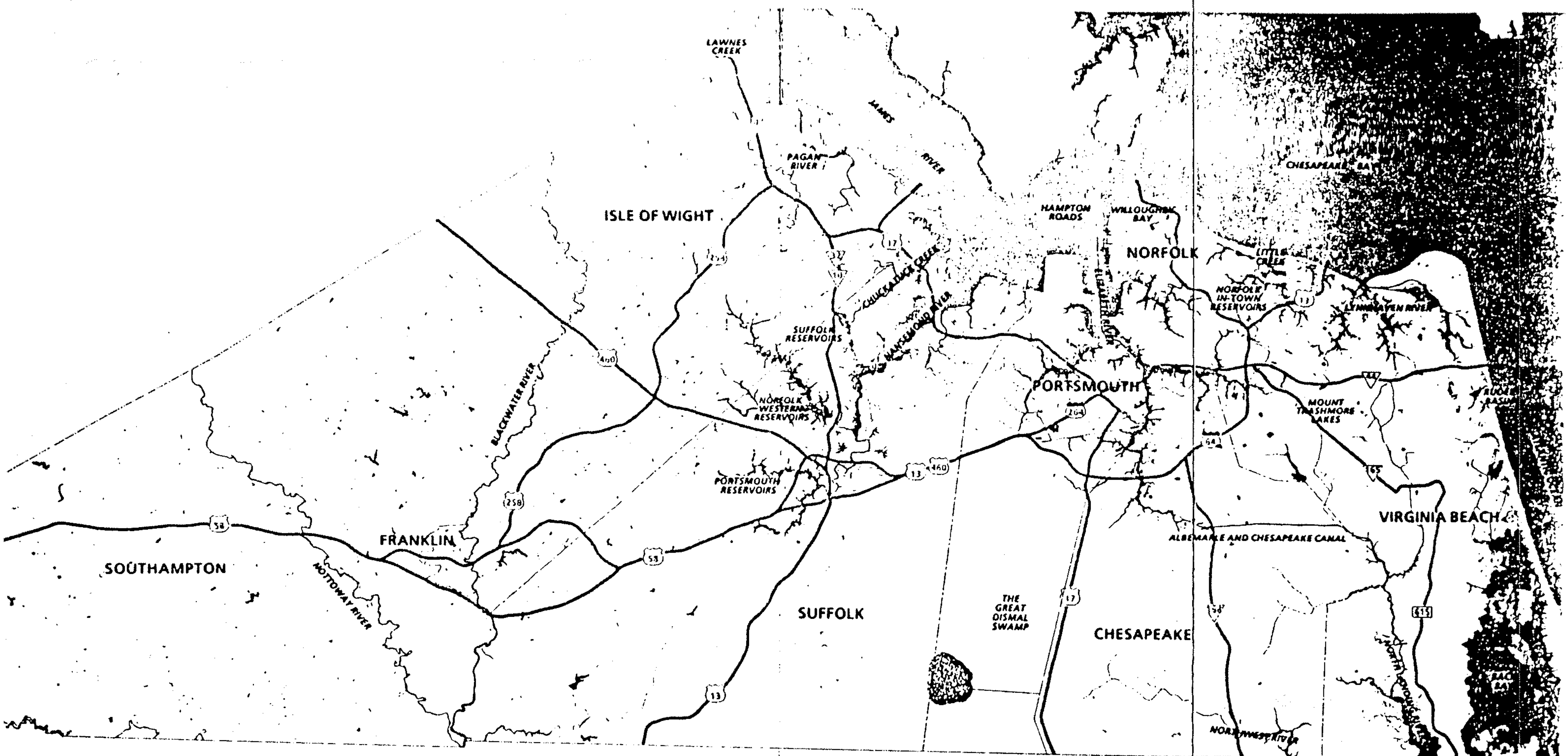
A diagram of the City of Norfolk's drinking water sources is shown in Figure 1. The cities of Chesapeake, Norfolk, and Virginia Beach are supplied with drinking water produced at Norfolk's Moores Bridges and 37th Street water treatment plants. Raw water is obtained from a combination of several sources. Lake Burnt Mills, Lake Prince, and Lake Western Branch are known collectively as the Western Lakes and serve as Norfolk's main raw water source. Water from the Blackwater and Nottoway Rivers and from four deep wells in the Western Lakes area is pumped into the Western Lakes during periods of high water demand. Lake Wright is another water source, which is used to supplement the Western Lakes source.

The 37th Street plant is the smaller of the two water treatment plants. It can process approximately 30 mgd and is served by two 36-inch line from the Western Lakes. The capacity of the Moores Bridges plant is 77 mgd, which is drawn through two 48-inch lines from the Western Lakes. Lake Wright water is generally treated independently of Western Lakes water in the number 7 and 8 basins at Moores Bridges, but it is also used to supplement the flow in basins 1-6 on occasion.

Reservoir capacities of the Western Lakes are approximately 3.4, 3.7, and 6.0 billion gallons for Lakes Burnt Mills, Prince, and Western Branch, respectively. Pump stations on the Blackwater and Nottoway Rivers (nominal capacity 48 mgd) are activated when the reservoirs drop below 97 percent capacity. Discharge from the rivers enters Lake Prince and flow from the river sources can replace the entire volume of Lake Prince in about 100 days at average, summer-pumping rates. A series of four deep wells (total capacity 16 mgd) in the vicinity of the Western Lakes can be activated if reservoir levels drop below 70 percent capacity. Three of the four wells discharge to Lake Prince, the other (Well #3) discharges to Lake Burnt Mills. Use of the wells is avoided when possible because the groundwater has a high phosphorus content. Norfolk's in-town water source, Lake Wright, has a 2-billion gallon storage capacity



NORFOLK SYSTEM WATER SUPPLY

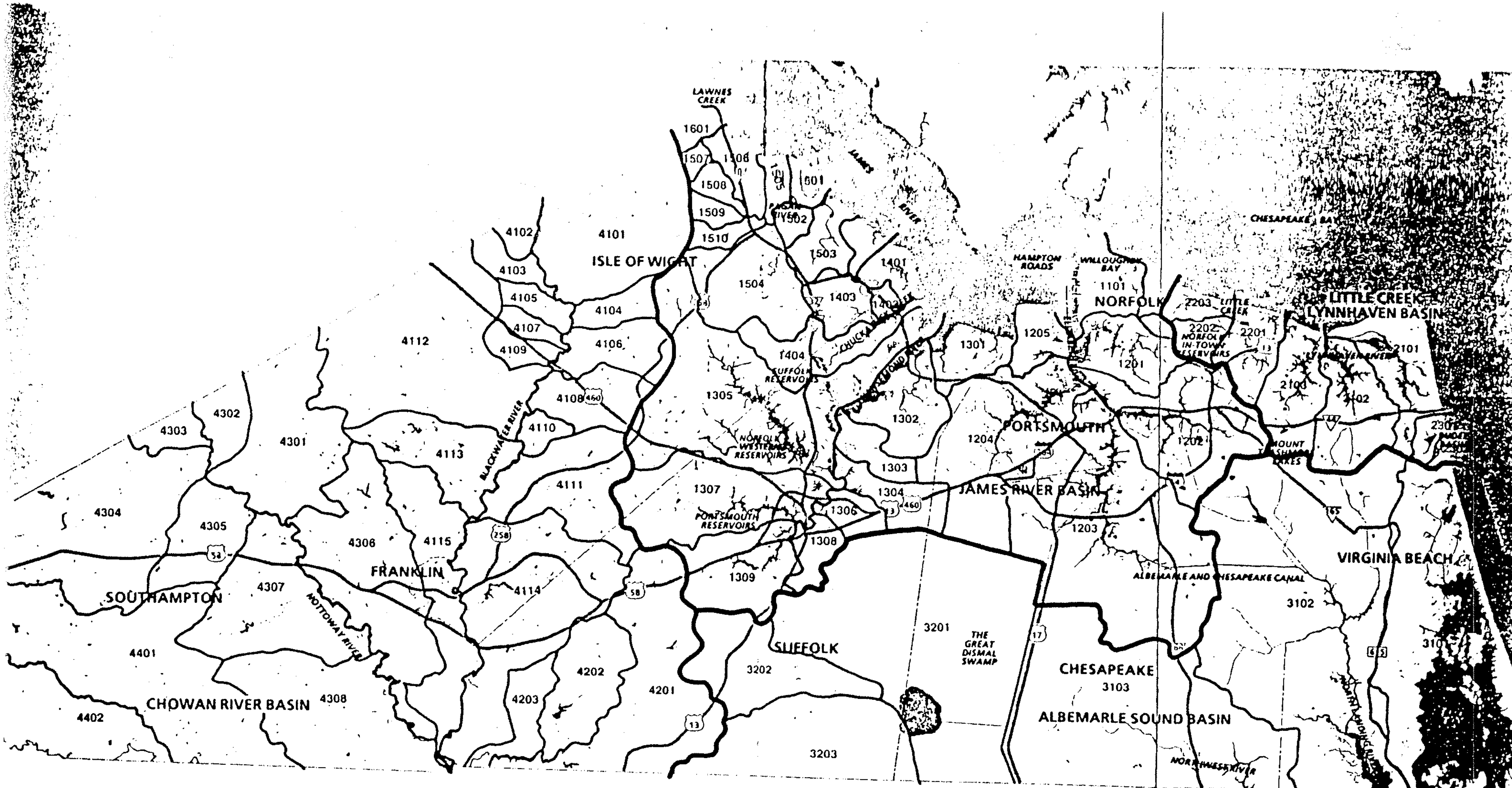


0 1 2 3 4 5 6
SCALE IN MILES
N

FIGURE I

THE WATERS OF SOUTHEASTERN VIRGINIA

PREPARED BY SOUTHEASTERN VIRGINIA PLANNING DISTRICT COMMISSION, JUNE 1988



0 1 2 3 4 5 6 SCALE IN MILES N

PREPARED BY SVPDC 1989

SOURCE: Baldwin and Gregg/Henningson, Durham and Richardson, Regional Storm Drainage Basin Study - Phase I, 1974.

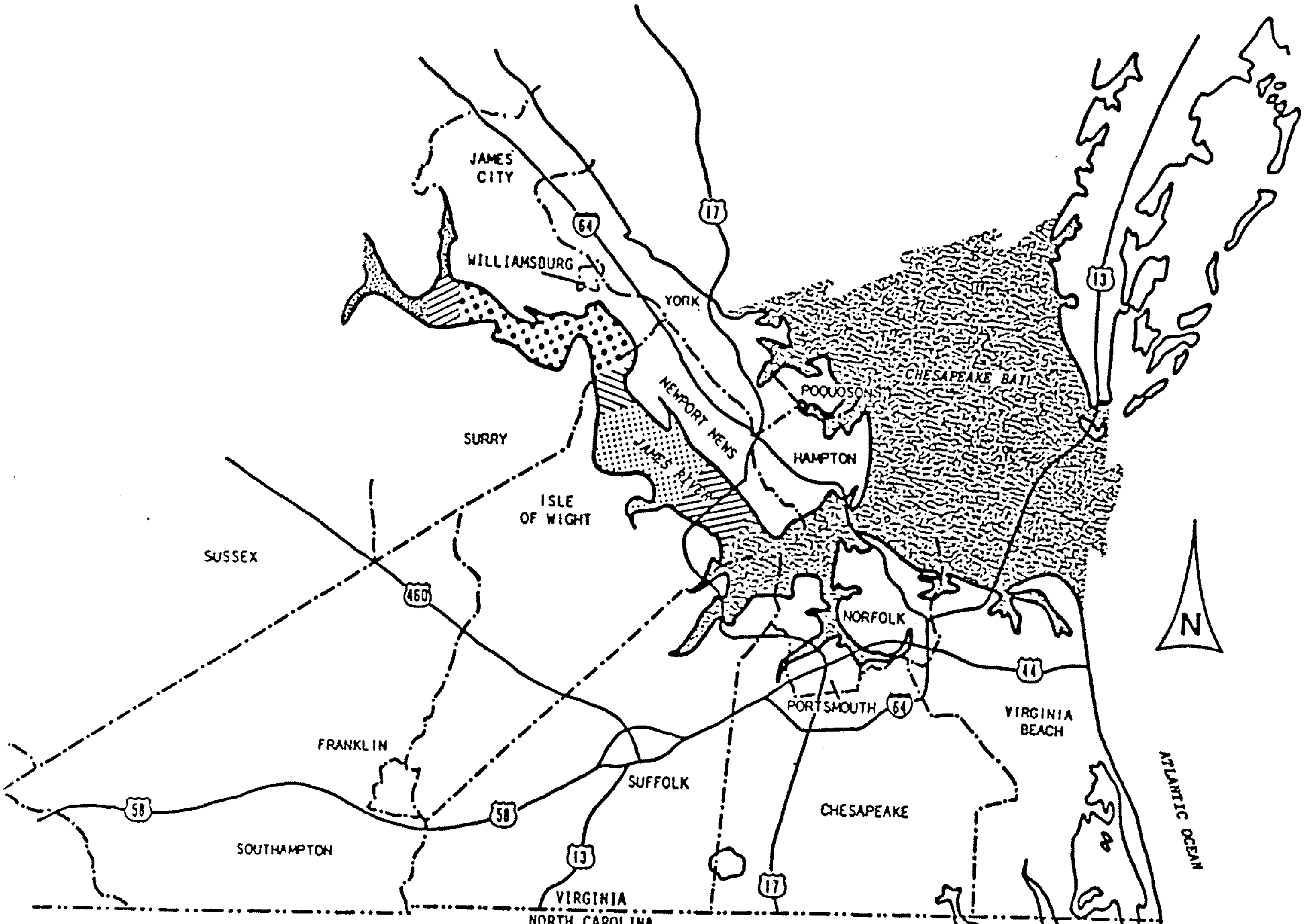
MAJOR WATERSHEDS

THIRD-ORDER DRAINAGE BASIN

0000 SVPDC DRAINAGE BASIN CODE

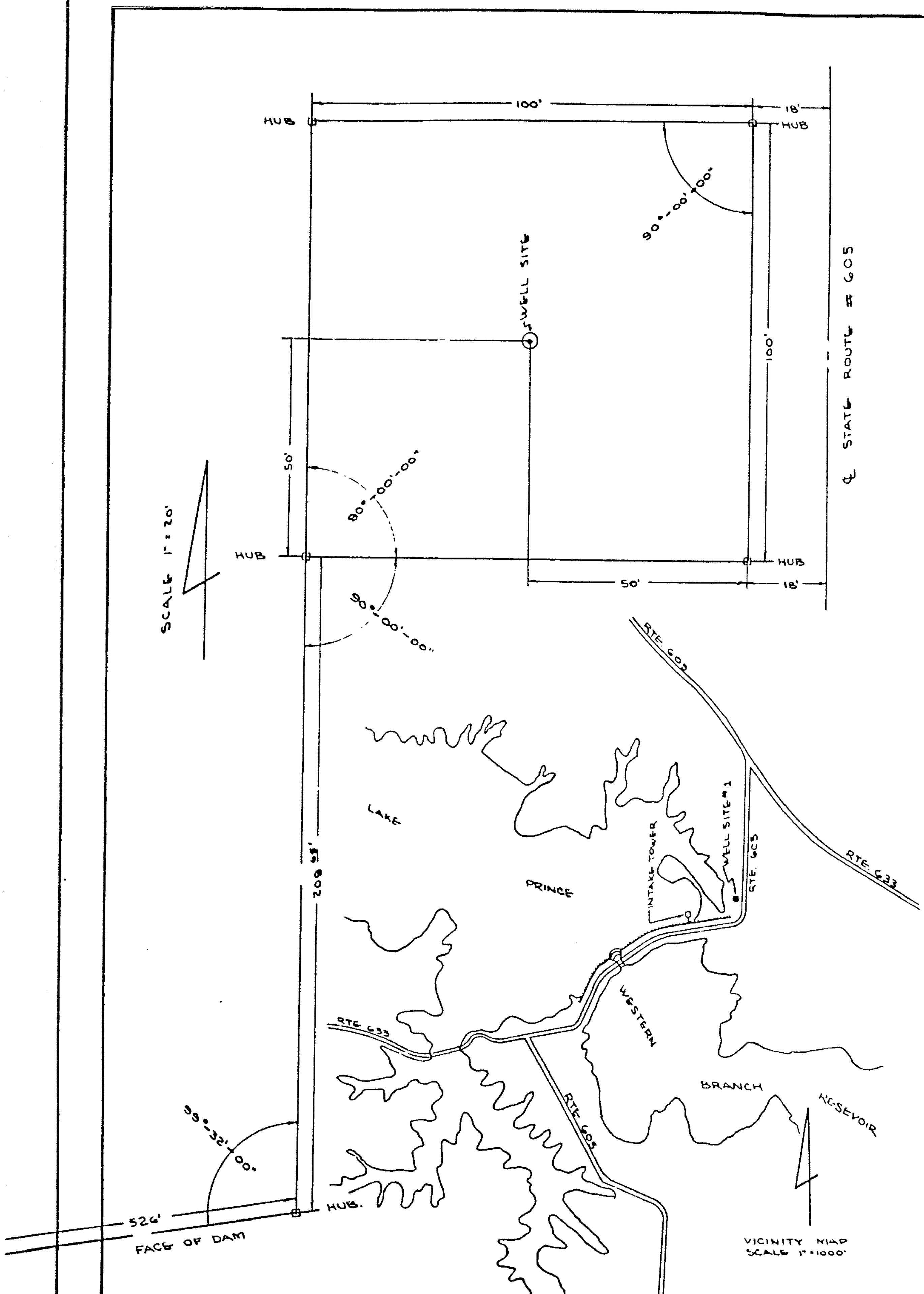
FIGURE 2
MAJOR WATERSHEDS
SOUTHEASTERN VIRGINIA

FIGURE 3:
ECOLOGICAL ZONES IN THE LOWER CHESAPEAKE BAY, HAMPTON ROADS AND THE LOWER JAMES RIVER



	SALINITY RANGES
POLYHALINE	16.5 - 30.0 ppt
MESOHALINE	3.0 - 16.5 ppt
OLIGOHALINE	0.5 - 3.0 ppt
FRESHWATER	< 0.5 ppt
TRANSITION ZONE	

PREPARED BY SVPDC 1989
SOURCE: Roberts, M.H., Jr. et al, The Chesapeake Bay: A Study of Present and Future Water Quality and its Ecological Effects, Volume II, (Gloucester Point, Virginia: VIMS).

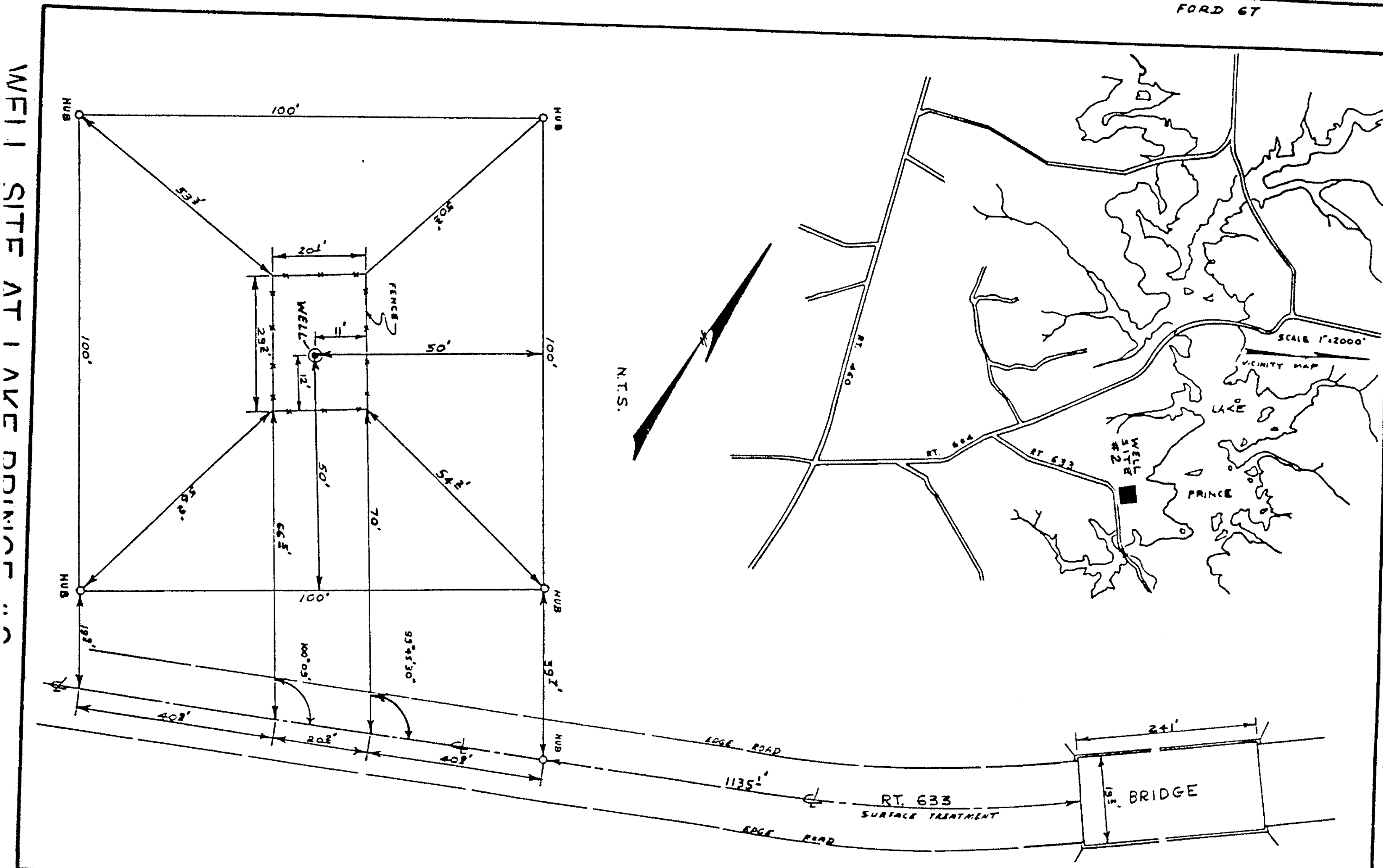


SKETCH #213 FEB 1966

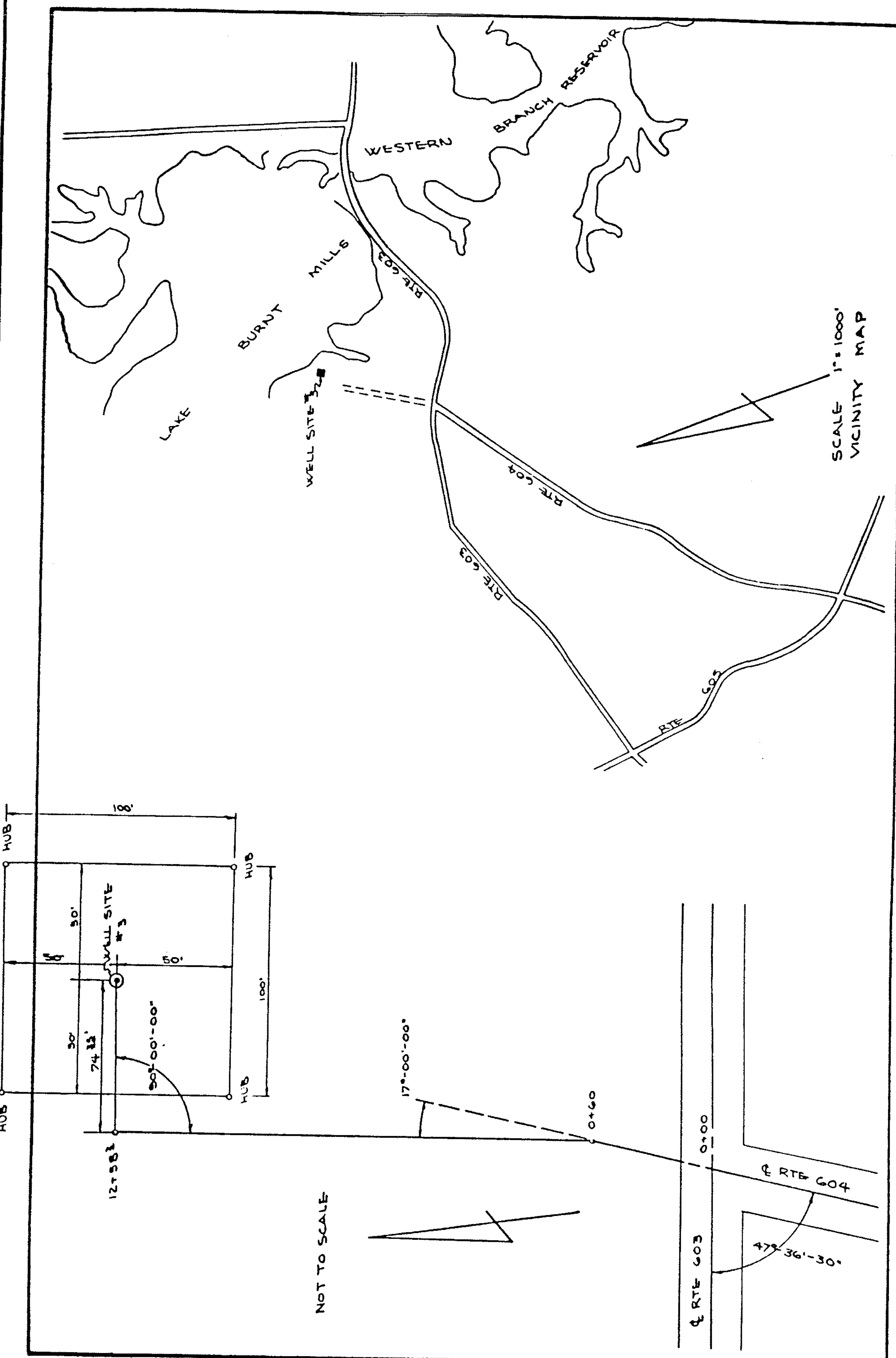
WELL SITE AT LAKE PRINCE #1

WELL SITE AT LAKE PRINCE #2

FORD 67



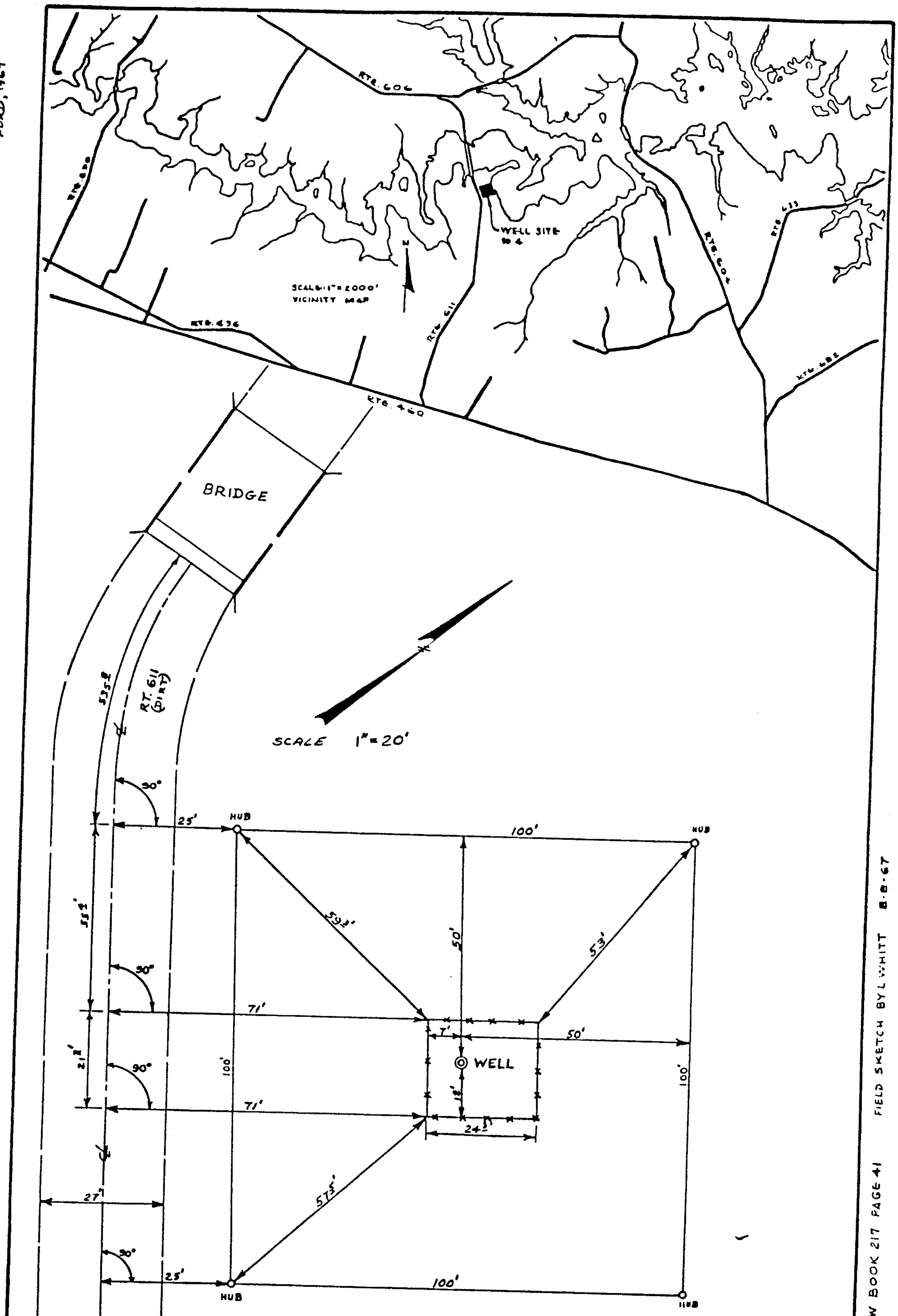
S+W BOOK 217 PG 40 FIELD SKETCH



SKETCH # 213 MARCH 1966 BROWN

WELL SITE AT LAKE BURNT MILLS # 3

FORD, 1967



S & W BOOK 217 PAGE 41 FIELD SKETCH BY L WHITT 8-8-67

7575 Log No. 162

LAYNE ATLANTIC COMPANY
NORFOLK, VA.

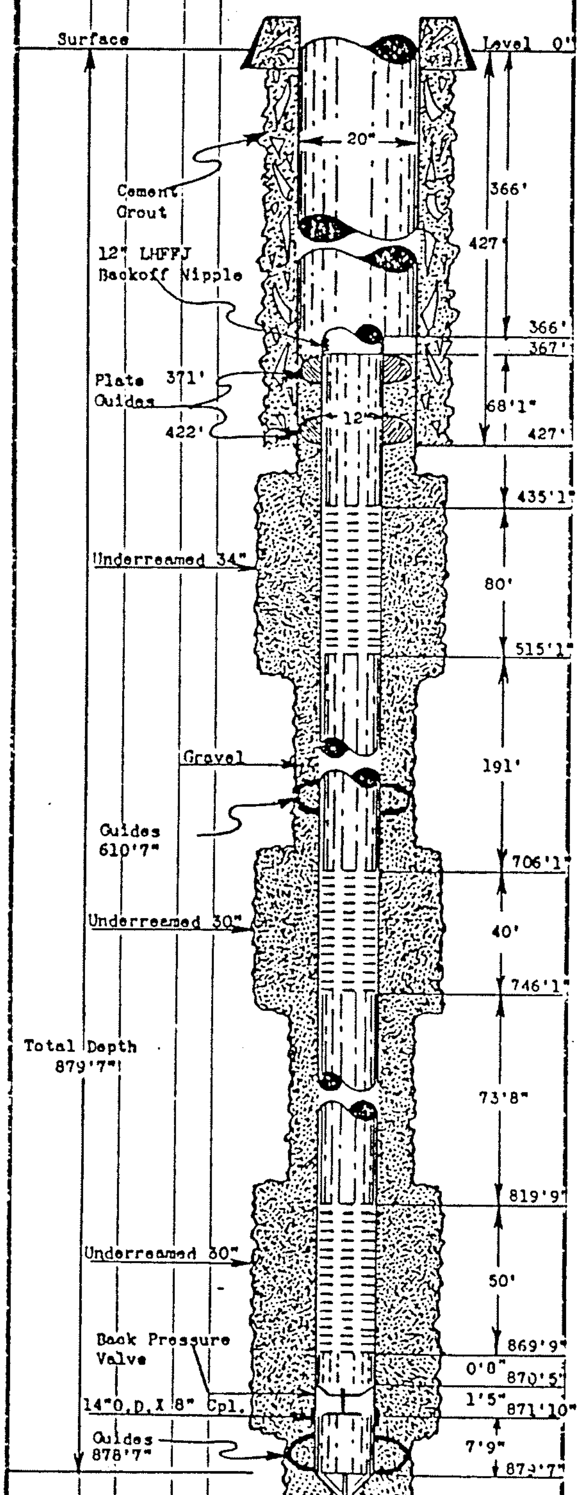
LOG OF WELL For CITY OF NORFOLK Driller: Layne & Bowler, Inc. (

Located at Lake Prince in Nansemond County, State Virginia

Date Drilling Started February 18, 19 65 Date Started February 16, 19 65

Finished Drilling March 7, 19 66 Finished July 19 66

FORMATIONS AND DEPTH OF WELL					DIMENSIONS OF CASING AND SCREEN							
TOTAL DEPTH OF ALL STRATA		DEPTH OF EACH STRATUM		FORMATION FOUND AT EACH STRATUM Elevation 40' +	TOTAL LENGTH OF ALL SCREENS and CASINGS		LENGTH OF EACH SEC. OF SCREEN OR CASING		SPECIFY SCREEN OR CASING	SIZE OF SCREEN OR CASING	GAUGE OF SCREEN	
FT.	IN.	FT.	IN.	Well No. 1	FT.	IN.	FT.	IN.		IN.		
					427		427		Casing	20		Cemented 550 Bags
					12" Casing commences at 366'							
					435	1	68	1	Casing	12		
					515	1	80		Screen	12		
					706	1	191		Casing	12		
					746	1	40		Screen	12		
					819	9	73	8	Casing	12		
					869	9	50		Screen	12		
					879	7	9	10	Casing	12 includes back pressure valve.		



Water Well Completion Report to Bob for Mr. Hodges prepared June 7, 1966.

Well No. 2 located 4800 ft. So.West of No. 1

WELL DATA:

Preliminary Test

Date Tested 3/9/ 19 66 Static Level 63'5"

Production 500 GPM Pumping Level 70'7"

D.D. 7'2" Permanent Test

Date Tested 19 Static Level

Production GPM Active St. Level

Drawdown Pumping Level

Remarks: 70 Yds. Gravel. Data submitted by Mr. Schweitzer 6/7/66. Static Level-65.43', Pumping Level-133.5' at 2,700 GPM.

PUMP DATA:

Shop No. 54520 Type Lubr. Oil

Type Head TF 1218 Size Suction 12"

Depth Setting 200(BP to MB)

Size Column 12" X 3" X 1-15/16" Length Suction 20'

Type Bowl 18" RKHC Length Air Line

No. Stages 4 Discharge- 12"

Cap'y and Head Pressure

MOTOR DATA:

Horsepower 200 Voltage 440

RPM 1200 Phase 3

Type Cycles 60

Make General Electric Frame No. 6287P20

7575 I. & B 162

LAYNE ATLANTIC COMPANY
NORFOLK, VA.

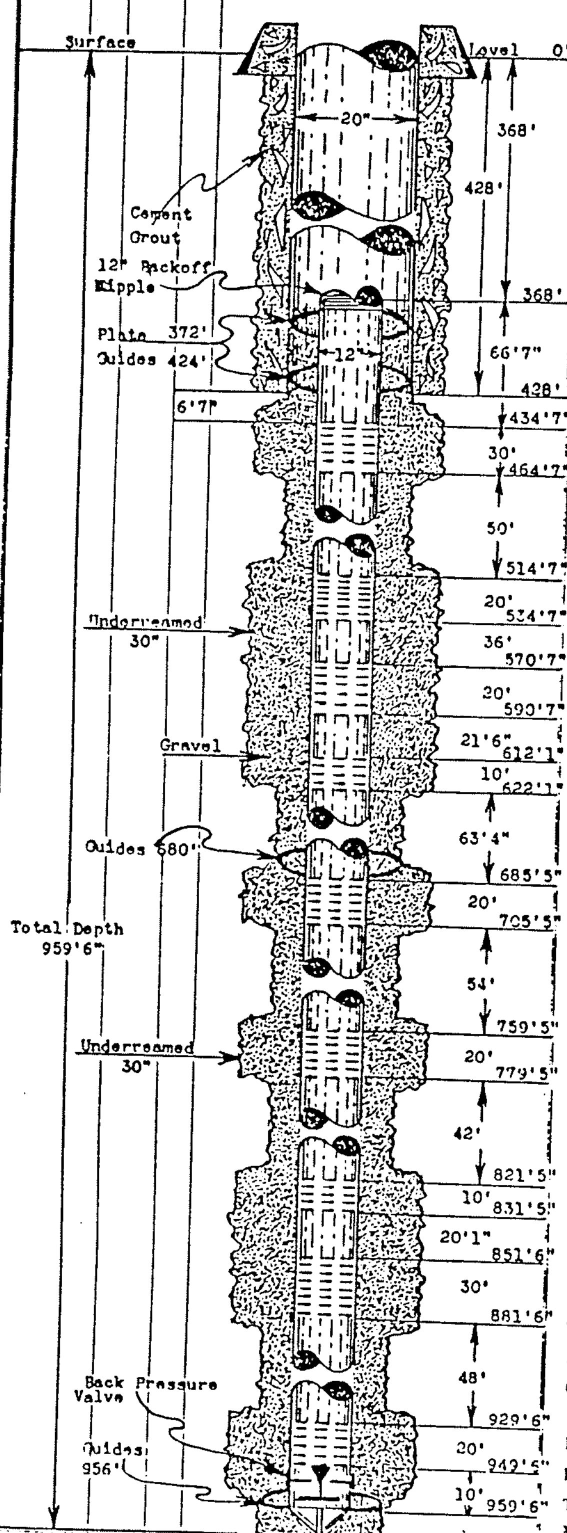
LOG OF WELL For CITY OF NORFOLK Driller: Layne & Bowler, Inc.

Located at Lake Prince in Nansemond County, State Virginia

Date Drilling Started March 13, 1966. Date Started February 16, 1966

Finished Drilling March 29, 1966 Finished July 1966

FORMATIONS AND DEPTH OF WELL					DIMENSIONS OF CASING AND SCREEN							
TOTAL DEPTH OF ALL STRATA		DEPTH OF EACH STRATUM		FORMATION FOUND AT EACH STRATUM Elevation + 60 ft	TOTAL LENGTH OF ALL SCREENS and CASINGS		LENGTH OF EACH SEC. OF SCREEN OR CASING		SPECIFY SCREEN OR CASING	SIZE OF SCREEN OR CASING	GAUGE OF SCREEN	
FT.	IN.	FT.	IN.	Well No. 2	FT.	IN.	FT.	IN.		IN.		
					428		428		Casing	20		Cemented 500 Bags
					12" Casing commences at 368'.							
					434	7	66	7	Casing	12		
					464	7	30		Screen	12		
					514	7	50		Casing	13		
					534	7	20		Screen	12		
					570	7	35		Casing	12		
					590	7	20		Screen	12		
					612	1	21	6	Casing	12		
					622	1	10		Screen	12		
					685	5	63	[illegible]	Casing	12		
					705	5	20		Screen	12		
					759	5	54		Casing	12		
					779	5	20		Screen	12		
					821	5	42		Casing	1[illegible]		
					831	5	10		Screen	12		
					851	6	20	1	Casing	12		
					881	6	30		Screen	12		
					929	6	48		Casing	12		
					949	5	20		Screen	12		
					959	6	10		Casing	12		



Water Well Completion Report to Bob for Mr. Hodges preparied June 7, 1966.

WELL DATA:

Preliminary Test

Date Tested 6/7 1966 Static Level 76.73'

Production 3000 GPM Pumping Level 140.0'

Permanent Test

Date Tested 19 Static Level

Production GPM Active St. Level

Drawdown Pumping Level

Remarks: 70 Yds. Gravel

PUMP DATA:

Shop No. 54521 Type Lubr. Oil

Type Head TF 1218 Size Suction 12"

Depth Setting 200' (BP to MB)

Size Column 12" X 3" X 1-15/16" Length Suction 20'

Type Bowl 18" RKHC Length Air Line,

No. Stages 4 Discharge- 12"

Cap'y and Head Pressure

MOTOR DATA:

Horsepower 200 Voltage 440

RPM 1200 Phase 3

Type Cycles 60

Make General Electric Frame No. 6287P20

7575

L & B
W.O. NO. 162

LAYNE ATLANTIC COMPANY
NORFOLK, VA.

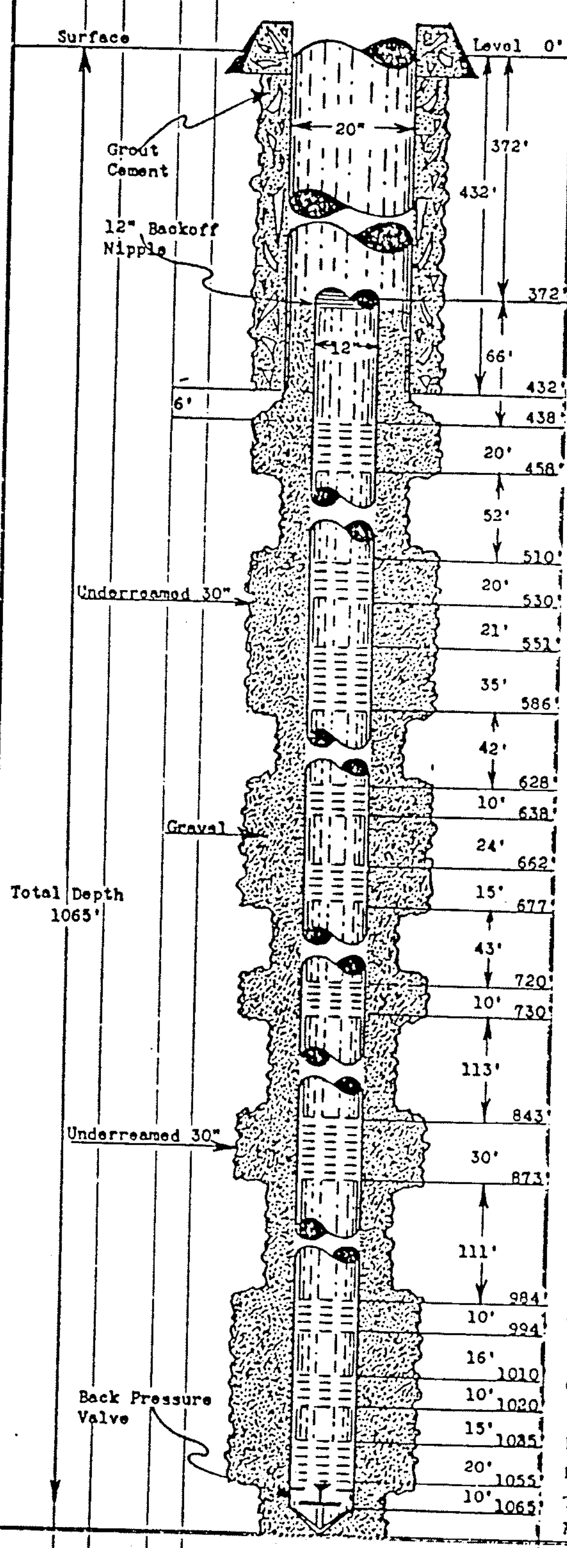
LOG OF WELL For ...... CITY OF NORFOLK .... (Driller: Layne & Bowler, Inc.)

Located at ... Lake Prince .... In ... Nansemond .... County, State Virginia

Date Drilling Started ... March 7, ... 19 66 . Date Started ..... February 16, ... 19 66

Finished Drilling ... April 5, ... 19 66 . Finished ..... July 19 66

FORMATIONS AND DEPTH OF WELL					DIMENSIONS OF CASING AND SCREEN							
TOTAL DEPTH OF ALL STRATA		DEPTH OF EACH STRATUM		FORMATION FOUND AT EACH STRATUM Elevation + 60'	TOTAL LENGTH OF ALL SCREENS and CASINGS		LENGTH OF EACH SEC. OF SCREEN OR CASING		SPECIFY SCREEN OR CASING	SIZE OF SCREEN OR CASING	GAUGE OF SCREEN	
FT.	IN.	FT.	IN.	Well No. 3	FT.	IN.	FT.	IN.		IN.		
					432		432'		Casing	20		Cemented 560 Bags
					12" casing commences at 372'							
					438		66		Casing	12		
					458		20		Screen	12		
					510		52		Casing	12		
					530		20		Screen	12		
					551		21		Casing	12		
					586		35		Screen	12		
					628		42		Casing	18		
					638		10		Screen	12		
					662		28		Casing	12		
					679		15		Screen	12		
					720		43		Casing	12		
					730		10		Screen	12		
					843		113		Casing	12		
					873		30		Screen	12		
					984		111		Casing	12		
					994		10		Screen	12		
					1010		16		Casing	12		
					1020		10		Screen	12		
					1035		15		Casing	12		
					1055		20		Screen	12		
					1065		10		Casing	12	Including back pressure valve	



Water Well Completion Report to Bob for Mr. Hodges prepared June 7, 1966.

70 Yds Gravel

WELL DATA:

Preliminary Test

Date Tested 19 Static Level

Production GPM Pumping Level

Permanent Test

Date Tested 19 Static Level

Production GPM Active St. Level

Drawdown Pumping Level

Remarks: Ran Electric Log. Static Level 85.39' during pumping of wells No. 1 & 2.

PUMP DATA:

Shop No.	54528	Type Lubr.	Oil
Type Head	TF 1218	Size Suction	12"
Depth Setting	200' (BP to MB)		
Size Column	12" X 3" X 1-15/16"	Length Suction	20'
Type Bowl	18" RKHC	Length Air Line	–
No. Stages	4	Discharge	12"
Cap'y and Head		Pressure	

MOTOR DATA:

Horsepower	200	Voltage	440
RPM	1200	Phase	3
Type		Cycles	60
Make General Electric		Frame No.	6287P20

7575

L & B
W.O. No. 162

LAYNE ATLANTIC COMPANY
NORFOLK, VA.

LOG OF WELL For CITY OF NORFOLK

Located at Lake Prince in Nansemond County, State Virginia

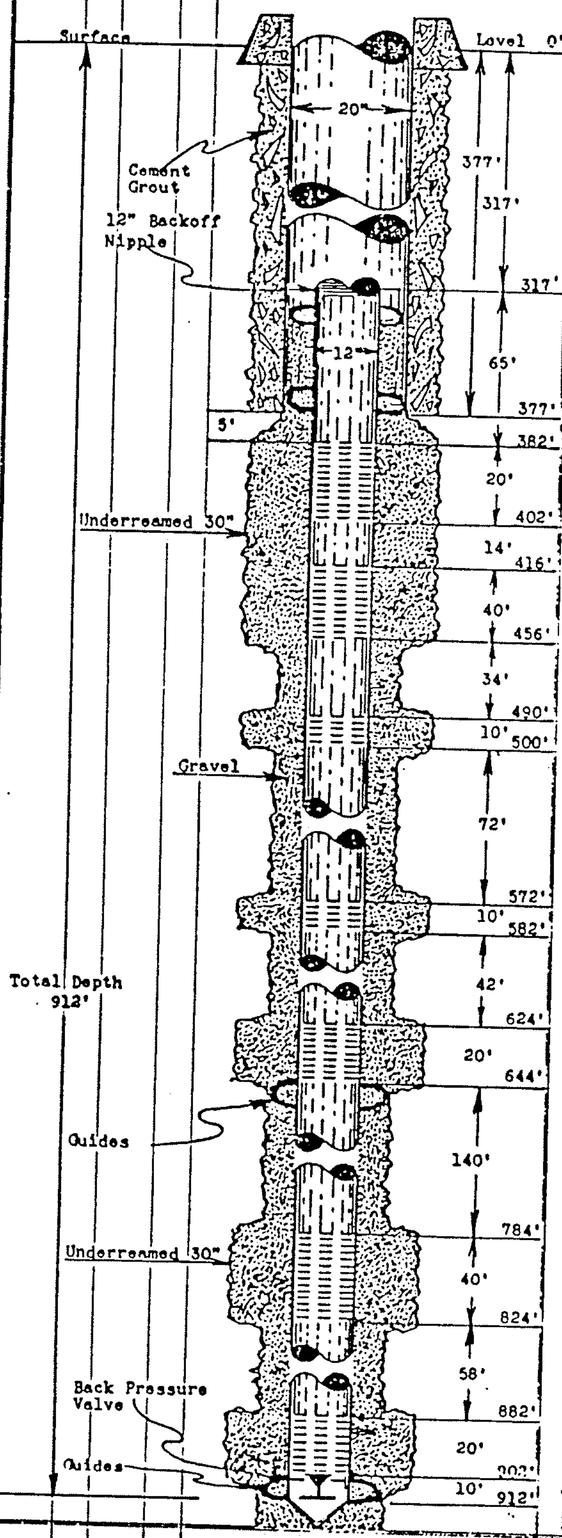
Date Drilling Started 19 Date Started February 16, 1966

Finished Drilling 19 Finished July 1966

FORMATIONS AND DEPTH OF WELL — Elevation 40' — Well No. 4

DIMENSIONS OF CASING AND SCREEN

Total Length of All Screens and Casings FT.	IN.	Length of Each Sec. of Screen or Casing FT.	IN.	Specify Screen or Casing	Size of Screen or Casing IN.	Gauge of Screen	
0		377		Casing	20		Cemented 400 Bags
12" Casing commences at 317'							
382		65		Casing	12		
402		20		Screen	12		
416		14		Casing	12		
456		40		Screen	12		
490		34		Casing	12		
500		10		Screen	12		
572		72		Casing	12		
582		10		Screen	12		
624		42		Casing	12		
644		20		Screen	12		
784		140		Casing	12		
824		40		Screen	12		
882		58		Casing	12		
902		20		Screen	12		
912		10		Casing	12	Includes back Pressure Valve	



Water Well Completion Report to Bob for Mr. Hodges prepared June 7, 1966.

70 yds. gravel.

WELL DATA:

Preliminary Test

Date Tested 19 Static Level

Production GPM Pumping Level

Permanent Test

Date Tested 6/7/ 1966 Static Level

Production 2850 GPM Active St. Level

Drawdown Pumping Level 193'

Remarks:

PUMP DATA:

Shop No. 54523 Type Lubr. Oil

Type Head TF 1218 Size Suction 12"

Depth Setting 200' (BP to MB)

Size Column 12" x 3" x 1-15/16" Length Suction 20'

Type Bowl 18" RKHC Length Air Line

No. Stages 4 Discharge- 12"

Cap'y and Head Pressure

MOTOR DATA:

Horsepower 200 Voltage 440

RPM 1200 Phase 3

Type Cycles 60

Make General Electric Frame No. 5287P20

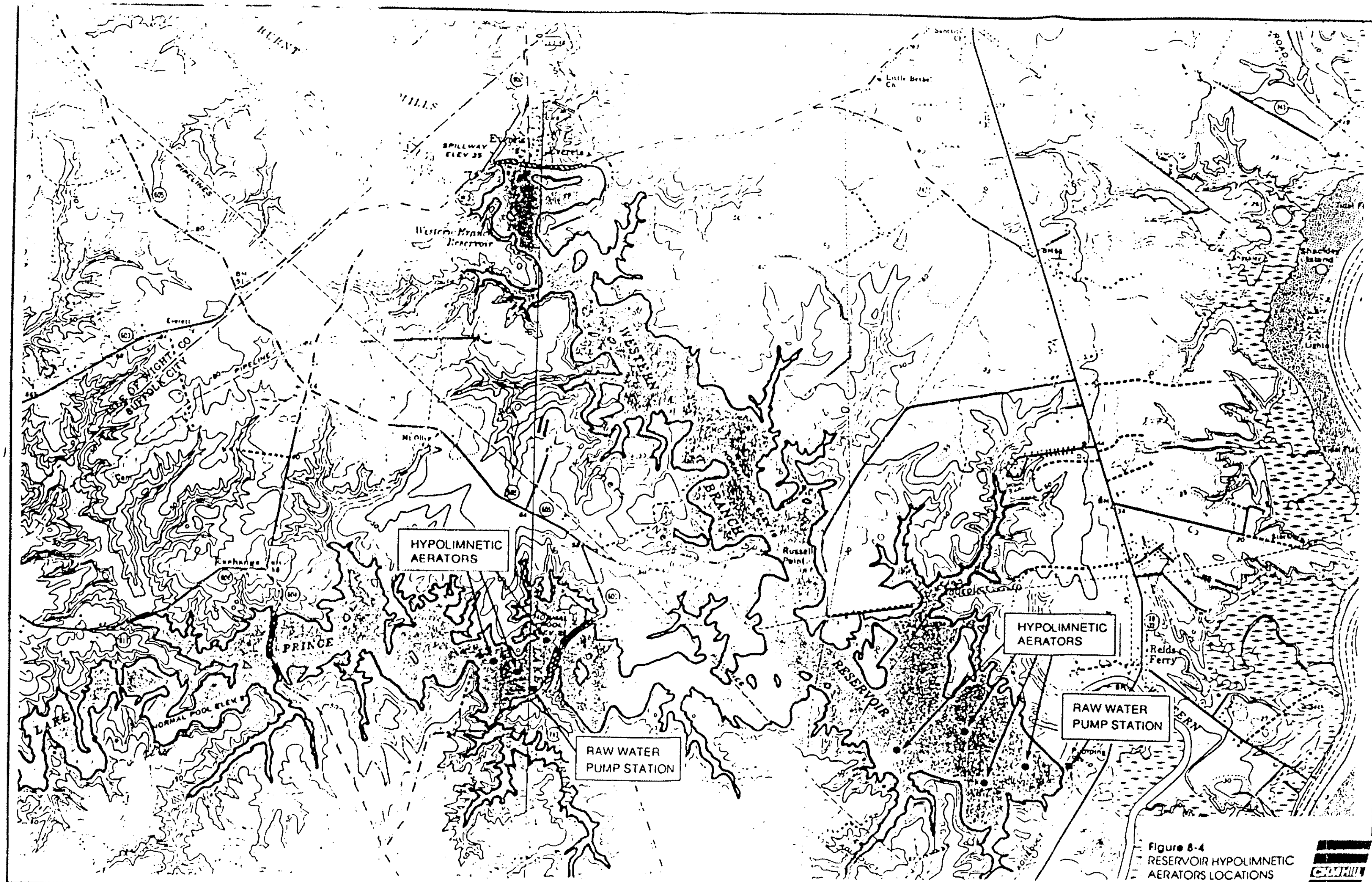


Figure 8-4
RESERVOIR HYPOLIMNETIC AERATORS LOCATIONS

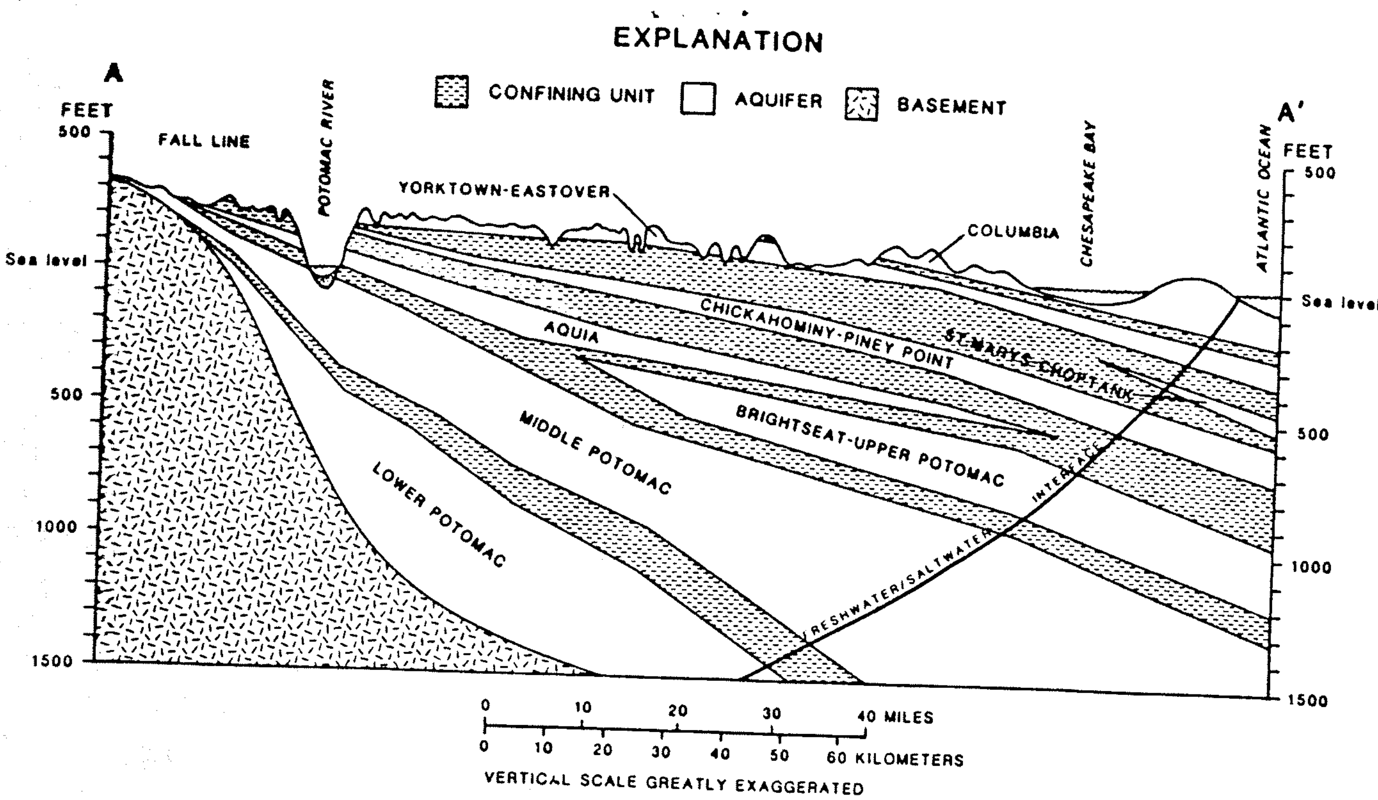


Figure 2.-- Hydrogeologic section A-A' (location of section line shown in figure 1).

CONFINED AQUIFERS

The Coastal Plain of Virginia consists of an eastward-thickening sedimentary wedge of unconsolidated, interbedded sand and clay, ranging in age from Early Cretaceous to Holocene. These sediments range in thickness from more than 6,000 feet beneath the northeastern part of the Eastern Shore Peninsula to a feather edge at the Fall Line. Eight confined aquifers, eight confining units, and an upper water-table aquifer define the hydrogeologic framework of the Coastal Plain sediments in Virginia (Meng and Harsh, 1984). The nine aquifers, from youngest to oldest, are the Columbia, Yorktown-Eastover, St. Marys-Choptank, Chickahominey-Piney Point, Aquia, Brightseat, and upper, middle, and lower Potomac. As the Columbia aquifer is unconfined throughout the Coastal Plain of Virginia, withdrawal data from the aquifer are not included in this study. The St. Marys-Choptank aquifer is not penetrated by any wells in the Virginia Coastal Plain, and therefore is not included in later discussions. This report follows the same hydrogeologic framework as described in Harsh and Laczniak (1987) which combines the Brightseat and upper Potomac aquifers. The hydrogeologic section in figure 2 shows the component aquifers in the study area with aquifer descriptions and hydrologic characteristics summarized in table 1. The following descriptions for each aquifer are summarized from Meng and Harsh (1984).

Table 1.--Description and hydrologic characteristics of the confined aquifers of the Coastal Plain of Virginia
[gal/min, gallons per minute]

Aquifer name and description	Well Yields (gal/min) Common range	Well Yields (gal/min) May Exceed	Hydrologic characteristics
Yorktown-Eastover aquifer: Sand commonly shelly; interbedded with silt, clay, shell beds, and gravel. Shallow, embayed marine in origin, deposition resulted in interfingering near-shore deposits from marine transgressions.	5-500	1,000	Multiaquifer unit. Mostly confined, unconfined updip in outcrop areas. Thickness dependent on altitude of land surface. Highest yields in eastern areas, thin to missing in western areas. Water is usually hard and of a bicarbonate type. Salty water in lower part of aquifer in eastern areas.
St. Marys-Choptank aquifer: Sand, very fine to fine, silty and clayey. Interbedded with silty clay; confined, restricted to northeastern area. Shallow, embayed marine shelf, sediments result of delta building to north.			Multiaquifer unit. Restricted to subsurface. Not utilized because of high chlorides and dissolved solids.
Chickahominy-Piney Point aquifer: Sand, moderately glauconitic, shelly; interbedded with silt, clay, and thin, indurated shell beds. Shallow, inner marine shelf in origin, deposition result of marine transgression.	10-150	350	Important aquifer in central Coastal Plain; supplies moderate to large amounts for domestic, small industrial, and water suppliers. Water is soft to hard and of a calcium-sodium-bicarbonate type and generally of good quality. Aquifer missing in western areas.
Aquia aquifer: Sand, glauconitic, shelly; [illegible]bedded with thin, indurated shell [illegible] and silty clay intervals. Shallow, inner to middle marine shelf in origin, deposition result of marine transgression.	15-210	550	Important aquifer in northern two-thirds of Coastal Plain; supplies moderate amounts for domestic, small industrial, and water suppliers. Water is usually soft and of a sodium-bicarbonate type, with high iron, sulfide, and hardness locally. Aquifer missing in eastern areas.
Brightseat-upper Potomac aquifer: Sand, very fine to medium, micaceous, lignitic, and clayey; interbedded with silty clays; confined, restricted to central and eastern areas. Shallow, estuarine and near-shore marine, sediments result of first major marine inundation of Cretaceous deltas.	20-300	1,000	Multiaquifer unit. Restricted to subsurface, and supplies second largest amount of water. Water is usually soft and of a sodium-chloride-bicarbonate type with high chlorides in eastern areas.
Middle Potomac aquifer: Sand, fine to coarse, occasional gravels; interbedded with silty clays; generally confined, unconfined in outcrop areas of northwestern Coastal Plain and major stream valleys near Fall Line. Fluvial in origin, sediments result of deltaic deposition.	20-250	1,000	Multiaquifer unit. Supplies largest amount of water. Water is usually moderately hard and of a sodium-chloride-bicarbonate type, with high chlorides in the eastern half.
Lower Potomac aquifer: Sand, medium t[illegible]ry coarse, and gravels, clayey; [illegible]ally confined, unconfined only in northwestern area of Coastal Plain. Fluvial in origin, sediments result of deltaic deposition.	100-800	1,500	Multiaquifer unit. Supplies third largest amount of water. Water is soft to very hard and of a sodium-chloride-bicarbonate type, with high chlorides in the eastern half. Thickest of all aquifers.

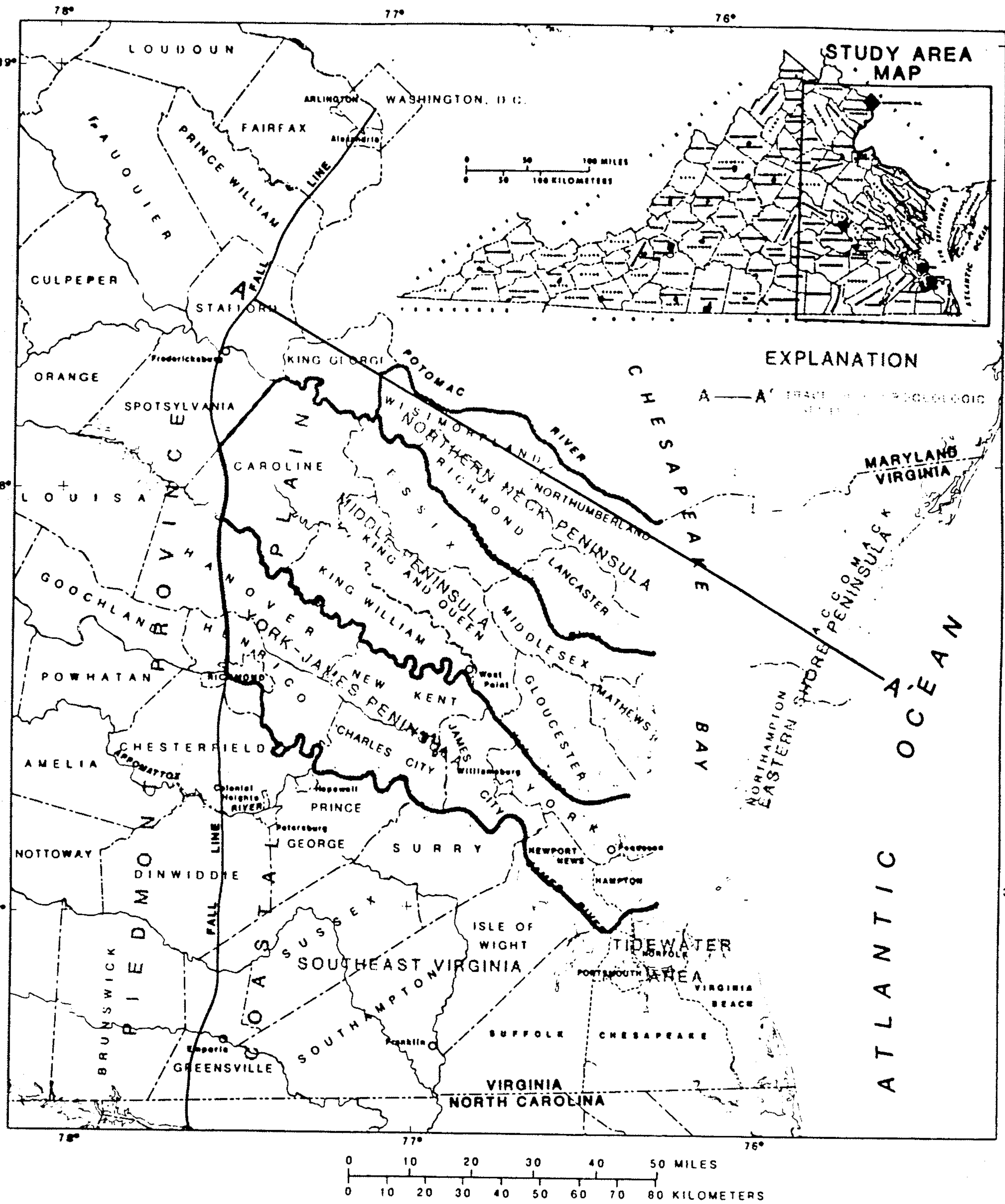


Figure 1.-- Location and extent of study area.

HYDROGEOLOGY AND ANALYSIS OF THE GROUND-WATER FLOW SYSTEM IN THE COASTAL PLAIN OF SOUTHEASTERN VIRGINIA

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 87-4240

Prepared in cooperation with the
VIRGINIA STATE WATER CONTROL BOARD

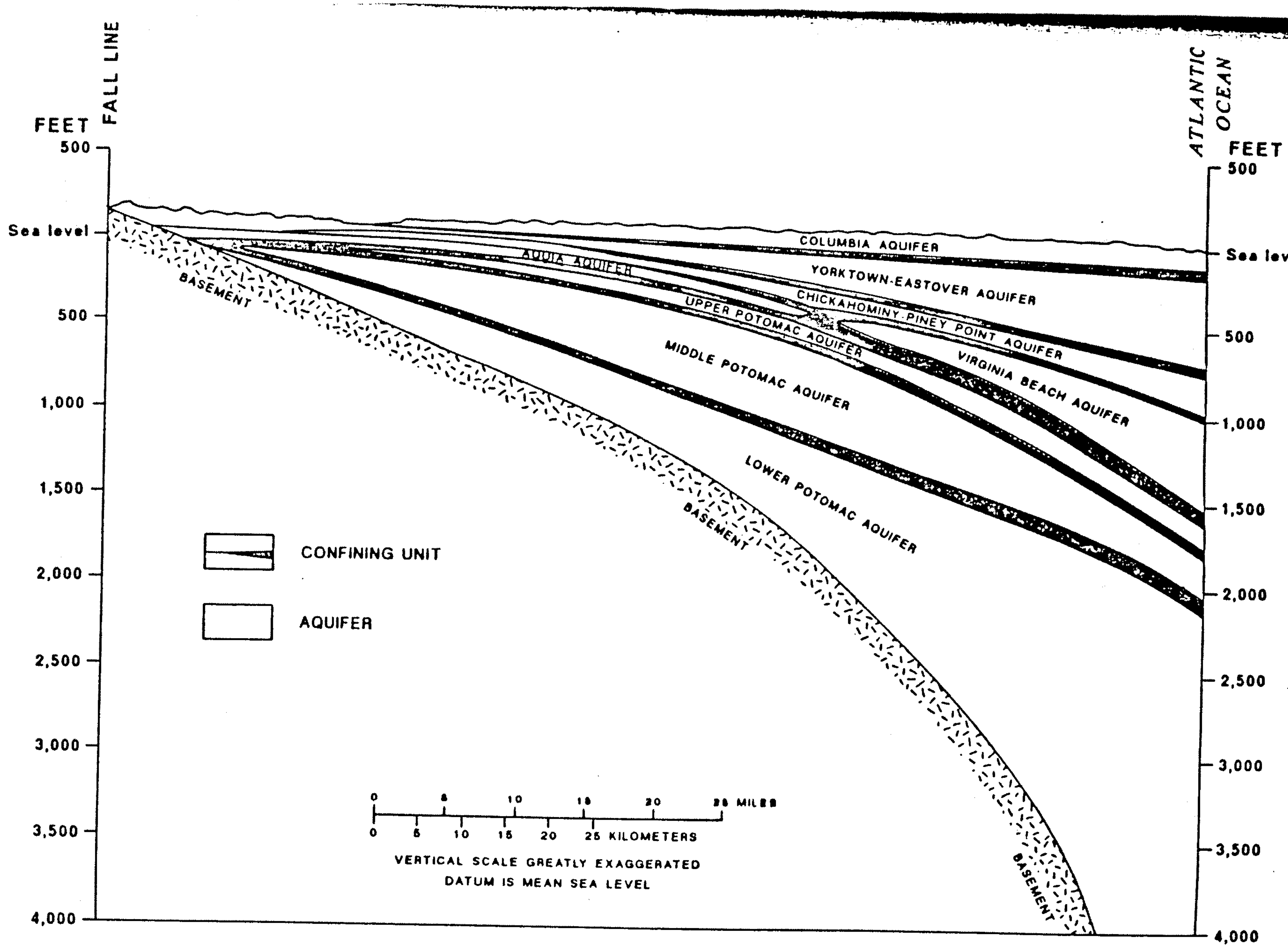


Figure 20.--General depth of aquifers, confining units, and basement from the Fall Line through southeastern Virginia.

Table 2.--Description of aquifers and well yields in model area
[Values in gallons per minute]

Aquifer name and description	Well Yield: Common range	Well Yield: May exceed	General remarks
Columbia aquifer: Sand and gravel, commonly clayey; interbedded with silt and clay. Fluvial to marine in origin; deposition resulted in terrace-type deposits from varying Pleistocene sea levels.	5-30	40	Generally unconfined, semi-confined locally. Most productive in eastern areas, very thin to missing in central and western areas. Water is very hard, calcium-bicarbonate type. Highly susceptible to pollutants from surface contamination. High concentrations of iron and nitrate in some areas. Possibility of salty water in coastal regions.
Yorktown-Eastover aquifer: Sand, commonly shelly; interbedded with silt, clay, shell beds, and gravel. Shallow, embayed marine in origin; deposition resulted in interfingering near-shore deposits from marine transgressions.	5-80	200	Multiaquifer unit. Mostly confined, unconfined updip in outcrop areas. Thickness dependent on altitude of land surface. Highest yields in eastern areas, thin to missing in western areas. Water is hard, sodium-calcium-bicarbonate type. Salty water in lower part of aquifer in eastern areas.
Chickahominy-Piney Point aquifer: Sand, moderately glauconitic, shelly; interbedded with silt, clay, and thin, indurated shell beds. Shallow, inner marine shelf in origin; deposition result of marine transgression.	10-110	200	Generally confined, except where it crops out along major stream valleys in the west. Important aquifer in central parts of Coastal Plain. Yields moderate to abundant supplies to domestic, small industrial, and municipal wells. Aquifer missing in western areas. Water is soft to hard, calcium-sodium-bicarbonate type and generally of good quality.
Aquia aquifer: Sand, glauconitic, shelly; interbedded with thin, indurated shell beds and silty clay intervals. Shallow, inner to middle marine shelf in origin; deposition result of marine transgression.	15-210	350	Generally confined, except where it crops out along major stream valleys in the west. Important aquifer in northern two-thirds of Coastal Plain. Yields moderate supplies to domestic, small industrial, and municipal wells. Aquifer missing in eastern areas. Water is soft sodium-bicarbonate type, with high iron, sulfide, and hardness locally.
Peedee aquifer: Sand, glauconitic and shelly; interbedded with dark, micaceous silt and clay. Near-shore marine in origin; deposition resulted from Late Cretaceous marine transgression.	5-40	50	Restricted to North Carolina Coastal Plain; not extensively developed. Yields small to moderate supplies to primarily domestic wells. Water is soft, sodium-bicarbonate type, with high chlorides in eastern areas.
Virginia Beach aquifer: Sand, fine- to medium-grained, glauconitic, micaceous, and lignitic; interbedded with thin clay layers and indurated zones. Shallow, inner marine shelf in origin; deposition result of marine transgression.	20-200	500	Multiaquifer unit. Restricted to southeastern Virginia and North Carolina Coastal Plain. Yields moderate to abundant supplies to domestic and industrial wells. Water is soft, sodium-bicarbonate type, with high chlorides in eastern areas and areas of high fluoride and dissolved solids.
Upper Potomac aquifer: Sand, very fine to medium, micaceous, lignitic, and clayey; interbedded with silty clay. Shallow, estuarine and marginal marine in origin; sediments result of first major marine inundation of Cretaceous deltas.	20-400	1000	Multiaquifer unit. Confined, restricted to central and eastern areas. Yields second largest supply of water in Coastal Plain. Water is soft, sodium-chloride-bicarbonate type, with high chlorides in eastern areas.
Middle Potomac aquifer: Sand, fine to coarse, occasional gravel; interbedded with silty clay. Fluvial in origin; sediments result of deltaic deposition.	20-160	700	Multiaquifer unit. Generally confined, unconfined in outcrop areas of northwestern Coastal Plain and major stream valleys near Fall Line. Yields second largest supply of water in Coastal Plain. Water is moderately hard, sodium-chloride-bicarbonate type, with high chlorides in eastern half of Coastal Plain.
Lower Potomac aquifer: Sand, medium to very coarse, and gravel, clayey. Fluvial in origin; sediments result of deltaic deposition.	100-800	1,500	Multiaquifer unit. Generally confined, unconfined in outcrop areas of northwestern area of Coastal Plain. Yields third largest supply of water in Coastal Plain. Water is soft to very hard, and of sodium-bicarbonate to sodium-chloride type, with high chlorides in eastern half of Coastal Plain.

Stratigraphy and Areal Extent of Aquifers and Confining Units

The hydrogeologic framework for the study area is a series of aquifers and intervening confining units defined on the basis of lithologic and hydrologic properties of the unconsolidated Coastal Plain sediments. One water-table and seven confined aquifers, separated by intervening confining units, were identified for the study area. One other confined aquifer (Peedee) and intervening confining unit (Peedee confining unit) located in northeastern North Carolina, as well as a confining unit (St. Marys confining unit) located north of the James River, were included in the model framework for hydrologic analysis. Table 1 summarizes relations between the hydrogeologic units and geologic formations and ages and corresponding hydrogeologic names used in previous investigations. Lower Cretaceous sediments include the lower and middle Potomac aquifers and confining units; Upper Cretaceous sediments include the upper Potomac, Virginia Beach, and Peedee aquifers and confining units; Tertiary sediments include the Aquia, Chickahominy-Piney Point, and Yorktown-Eastover aquifers, and Nanjemoy-Marlboro, Calvert, St. Marys, and Yorktown confining units; and Quaternary sediments comprise the Columbia aquifer.

A brief discussion of the nine aquifers and intervening confining units used in model analysis is presented. The reader is referred to Meng and Harsh (1984) for a more detailed description of age, lithologic characteristics, and stratigraphy of each aquifer and confining unit. This report follows the basic framework outlined by Meng and Harsh; however, the areal extent and thickness of several aquifers and confining units were revised after analyzing geophysical logs and water-level data collected during this study (A.A. Meng, U.S. Geological Survey, written commun., 1986). Figure 2 shows locations of wells used in the hydrogeologic framework analysis. Figures 3 through 10 illustrate tops of each aquifer relative to sea level and areal extent, and figures 11 through 19 illustrate thickness and areal extent of confining units. Figure 20 illustrates general depth of aquifers, confining units, and basement from the Fall Line through southeastern Virginia. Table 2 describes general hydrogeologic characteristics and well yields for individual aquifers in the model area.

The lower Potomac aquifer in the lower part of the Potomac Formation is the lowermost confined aquifer in the hydrogeologic framework and lies entirely on basement. This aquifer is thinnest along its western limit near the Fall Line and thickens seaward. Thickness in the study area ranges from near zero at the Fall Line to 882 feet at well 61C1 in the city of Norfolk. The aquifer predominantly consists of thick interbedded sequences of medium- to very coarse-grained sand, clayey sand, and clay with interbedded gravel. It is capable of supplying large quantities of water but generally lies too deep to be affordable for all but large industrial users. Elevated chloride concentrations in the east restrict its use as a potable source of water. The lower Potomac aquifer is overlain by the lower Potomac confining unit throughout its extent. The confining unit is composed of sequences of brown, gray, or dark-green carbonaceous clay, interbedded with thin, sandy clay. The clay beds are not continuous or areally extensive but, instead, are a series of interlensing clayey deposits. Because of this depositional pattern, the confining unit varies considerably in thickness, ranging from a thin edge in the western part of the study area to approximately 80 feet in the city of

Table 1.--Hydrogeologic column showing aquifers and confining units in model area

Period	Epoch	Stratigraphic formation	Hydrogeologic units: This report	Cederstrom 1945	Geraghty and Miller 1979 a & b	Siudyla and others 1981	Harsh and Laczniak 1986
Quaternary	Holocene Pleistocene	Undifferentiated sediments	Columbia aquifer	Sands of Recent deposits and the Columbia group	Water-table aquifer	Water-table aquifer	Columbia aquifer
Tertiary	Pliocene	Yorktown Formation	Yorktown confining unit	Sands and shells of the Yorktown Formation	Upper artesian aquifer system	Yorktown aquifer	Yorktown confining unit
			Yorktown-Eastover aquifer				Yorktown-Eastover aquifer
	Miocene	Eastover Formation					
		St. Marys Formation	St. Marys confining unit				St. Marys confining unit
		Choptank Formation	Not present in model area				St. Marys-Choptank aquifer
		Calvert Formation	Calvert confining unit				Calvert confining unit
	Oligocene	Old Church Formation	Chickahominy-Piney Point aquifer	Glauconitic sands of the Pamunkey coup			Chickahominy-Piney Point aquifer
	Eocene	Chickahominy Formation				Eocene-Upper Cretaceous aquifer	
		Piney Point Formation					
		Nanjemoy Formation	Nanjemoy-Marlboro confining unit				Nanjemoy-Marlboro confining unit
		Marlboro Clay					
	Paleocene	Aquia Formation	Aquia aquifer				Aquia aquifer
		Brightseat Formation	Not present in model area				Not present in Virginia
Cretaceous	Late Cretaceous	Peedee Formation (of North Carolina)	Peedee confining unit[1]			Eocene-Cretaceous aquifer	
			Peedee aquifer[1]				
		Unnamed deposits (Black Creek Formation equivalent) in Virginia	Virginia Beach confining unit	Sands of Late Cretaceous age	Lower artesian aquifer system		
			Virginia Beach aquifer				
		Potomac Formation	Upper Potomac confining unit	Sands of the Potomac Group			Upper Potomac confining unit
	Early Cretaceous		Upper Potomac aquifer				Upper Potomac aquifer
			Middle Potomac confining unit			Lower Cretaceous aquifer	Middle Potomac confining unit
			Middle Potomac aquifer				Middle Potomac aquifer
			Lower Potomac confining unit				Lower Potomac confining unit
			Lower Potomac aquifer				Lower Potomac aquifer

[1]Not present in study area but used in model simulations of ground-water flow

Virginia Beach (fig. 11). It is overlain by the middle Potomac aquifer throughout its extent.

The middle Potomac aquifer in the middle part of the Potomac Formation is the second thickest confined aquifer. It is present throughout the study area. It ranges in thickness in the study area from a thin edge along the Fall Line to approximately 500 feet in the city of Norfolk (well 61C1). The aquifer is composed of interlensing clay, silt, and fine- to coarse-grained sand, with interbedded gravel. The aquifer is capable of supplying large quantities of water and is utilized by most large industrial and municipal users throughout the western and central part of the study area. However, as with the underlying aquifer, high chloride concentrations are present in the eastern part of this aquifer, restricting its use as a potable source of water. The middle Potomac aquifer is overlain by the middle Potomac confining unit throughout its extent. As with the lower Potomac confining unit, this confining unit is highly variable in thickness throughout the study area, ranging from a featheredge in the west to 132 feet in the city of Chesapeake (well 60B3, fig. 12). It is overlain by the upper Potomac aquifer in the central and eastern part of the study area and the Aquia aquifer in the western part.

The upper Potomac aquifer in the upper part of the Potomac Formation is composed of Upper Cretaceous sediments and is the thinnest of the three Potomac aquifers. The aquifer is present in the eastern two-thirds of the study area and is confined throughout its extent. The sands thicken to the east, ranging from a thin edge at the updip limit to approximately 280 feet in the city of Virginia Beach (well 63C1). It is composed of very fine- to medium-grained, thickly-bedded sand interlayered with silty, thin clay. Gravel and coarse-grained sands are rare. The aquifer is capable of producing large quantities of generally good quality water and is a principal source of ground water for municipal and industrial use throughout the central part of the study area. Water quality degrades somewhat in the east because of increasing chloride and fluoride concentrations. The upper Potomac aquifer is overlain by the upper Potomac confining unit. The confining unit is relatively thick, attaining its maximum thickness of 192 feet in southeastern Virginia (well 61B2, fig. 13). It is overlain by the Aquia aquifer, except in the southeastern part of the study area and northeastern North Carolina where it is overlain by the Virginia Beach aquifer, and in the northeastern part of the study area where it is overlain by the Chickahominy-Piney Point aquifer.

The Virginia Beach aquifer is composed of unnamed Upper Cretaceous sediments. It is present only in southeastern Virginia and is equivalent to the Black Creek Formation in northeastern North Carolina. The aquifer is named for the city of Virginia Beach for the purpose of this report. It is confined throughout its extent. The sediments in the study area range in thickness from near zero at the updip limit to approximately 110 feet in the city of Chesapeake (well 61B2). They predominantly consist of fine- to medium-grained glauconitic sand, interbedded with thin clay layers and indurated zones. Shell material is common. The aquifer is capable of producing moderate to abundant quantities of generally good quality water for domestic and industrial use. The aquifer is overlain entirely by the Virginia Beach confining unit. This unit consists of a series of clay, silty clay, and sandy clay beds and ranges in thickness within the study area from less than 10 feet near their updip limit to 29 feet in the city of Virginia Beach (well 61A2, fig. 14). The confining unit is overlain by the Aquia aquifer, except in northeastern North Carolina where it is overlain by the Peedee aquifer, and in the northeastern part of the study area where it is overlain by the Chickahominy-Piney Point aquifer.

The Peedee aquifer in the Peedee Formation is restricted to the North Carolina Coastal Plain and is not present in the study area. However, it is described here because it is included in the model framework for hydrologic analysis. It is confined throughout its extent. The sediments range from a featheredge at their western limit to about 300 feet along the Atlantic Coast (M.D. Winner, U.S. Geological Survey, written commun., 1984), and predominantly consist of glauconitic and shelly sand, interbedded with dark, micaceous silt and clay. The aquifer is not extensively developed and primarily yields small to moderate supplies to domestic users. It is entirely overlain by the Peedee confining unit. Confining unit sediments are composed of clay, silty clay, and sandy clay and range in thickness from a thin edge at the updip limit to approximately 100 feet beneath eastern Albemarle Sound (fig. 15). The confining unit is overlain by the Aquia aquifer.

The Aquia aquifer in the Aquia Formation is the deepest Tertiary aquifer in the framework. It is present throughout the study area, except in a band along the Fall Line, in the Chesapeake Bay region, and in a band along the coast. The aquifer is confined throughout its extent, except where it crops out along major stream valleys in the west. The aquifer is thickest in the central part of the study area (approximately 65 feet at well 55F20) and thins to a featheredge along both the updip and downdip limits. The updip limit is erosional and the downdip limit is gradational where the sandy sediments change facies to clay. The sediments, deposited in shallow marine waters, are typically fine- to medium-grained glauconitic sand, interbedded with silt, clay, and thin, indurated shell beds. The aquifer is an important ground-water resource, particularly in the central part of the study area where it yields moderate supplies to domestic, small industrial, and municipal wells. The Aquia aquifer is overlain by the Nanjemoy-Marlboro confining unit. This unit is fairly uniform in thickness throughout the study area, ranging from a thin edge at its western limit to approximately 62 feet in the central part (well 57F26, fig. 16). It is overlain by the Chickahominy-Piney Point aquifer.

The Chickahominy-Piney Point aquifer in the Chickahominy and Piney Point Formations is the middle Tertiary aquifer and is present throughout the study area, except in a band along the Fall Line. It is confined throughout its extent, except where it crops out along major stream valleys in the west. The aquifer is generally wedge-shaped in cross section, ranging from near zero along its western limit to approximately 160 feet in the city of Virginia Beach (well 63C1). It is lenticular-shaped north of the James River from the updip limit to the eastern part of Williamsburg, thinning to a featheredge at its updip limit, thickening to 82 feet at well 55H6, and thinning to 30 feet in central York County (well 58F18). The aquifer then becomes wedge-shaped as it thickens eastward. The sediments, deposited in a shallow marine environment, are typically medium- to coarse-grained glauconitic sand, interbedded with silt, clay, and thin, indurated shell beds. The aquifer is an important

City of Virginia Beach

DEPARTMENT OF PUBLIC UTILITIES
(804) 427-4346
FAX (804) 426-5778

MUNICIPAL CENTER
VIRGINIA BEACH, VIRGINIA 23456-9041

April 9, 1991

Jeffrey S. Laskey
Baker Environmental, Inc.
Airport Office Park, Building 3
420 Rouser Road
Coraopolis, Pennsylvania 15108

Dear Mr. Laskey:

Re: Public Water Distribution System, Department of the Navy, Virginia Beach Area - Federal Agencies - U. S. Navy

In response to your letter of March 29, 1991, the following items numbered 1 through 7 are keyed to your list of requested information:

1. Please see attached map showing boundaries of the City of Virginia Beach's public water distribution system.

2. City of Norfolk.

3. 4. 5. We understand that you have sent Norfolk a similar inquiry. As our water supplier, they will provide the data on these items.

6. 380,000.

7. a. No
   b. No
   c. No
   d. Wild Water Rapids Water Park, 849 General Booth Boulevard, Virginia Beach VA 23451
      Kempsville Recreation Center, 800 Monmouth Lane, Virginia Beach VA 23464
      Great Neck Recreation Center, 2521 Shorehaven Drive, Virginia Beach VA 23454

Should you require additional information or assistance, please feel free to call me.

Sincerely,

for Clarence Warnstaff
Director

ac
Attachment

pc: Neal Windley, Director
Norfolk Public Utilities

Maps showing boundaries of the City of Virginia Beach's public water distribution system, mentioned in preceding letter as being attached, were not included due to size (2 sheets, approximately 4 ft. by 4 ft. each). Maps can be obtained from:

CITY OF VIRGINIA BEACH
DEPARTMENT OF PUBLIC UTILITIES
MUNICIPAL CENTER
VIRGINIA BEACH, VA 23456-9041
(804) 427-4346

EXHIBIT 3-3

CC: WGThomas/CF; WGTrimbath/JWMentz/PF; RPWattras; EPMacDonald; AM Bernhardt; JSLaskey; DPBlack (Orig.)

MICHAEL BAKER, JR., INC.

PHONE CALL REPORT

PROJECT/LOCATION: HRS Scoring - Navy Clean

S.O. No.: 19002-50-SRN

DATE: 5-9-91-10:40AM

CONTRACT NO.:

To: MR. BILL MATNEY — From: DPBlack

Repres.: U.S. Census Bureau — Repres.: Baker Environmental, Inc.

Phone No.: (301) 763-1990 — Phone No.: x6047

Subject: Average number of individuals living in a typical U.S. single-family dwelling

I called Mr. Matney (a Census Bureau information specialist) to find out the above information. I asked if it was broken out on a regional basis, and he replied that it is not. He told me that 2.36 is the current figure per household, according to the 1990 census.

PREPARED BY DPBlack TITLE Geologist PAGE 1 OF 1

OP-3

EXHIBIT 3-4

EFD-10

EXTENT OF SUBSURFACE FUEL CONTAMINATION

LITTLE CREEK NAVAL AMPHIBIOUS BASE

For

Atlantic Division
Naval Facilities Engineering Command

Contract N62470-82-B-7800

By

R. E. Wright Associates, Inc.
3240 Schoolhouse Road
Middletown, PA 17057

October, 1982

Respectfully submitted,

Robert C. Brod
Project Manager

Ned E. Wehler, PG
Vice President

AMERICAN INSTITUTE OF PROFESSIONAL GEOLOGISTS
CERTIFICATE NUMBER
4251
AIPG
NED E. WEHLER

fuel have been pumped from transfer pits, sumps, and manholes about once a month.

Fuel was observed in the new sewer soon after it was built. It is thought that seepage into the sewer line resulted from the decomposition of gaskets at pipe joints, caused by the fuel. Two or three test borings were drilled about a year after the sewer was installed in an effort to delineate the extent of subsurface fuel at the northern end of the piers. The results of these borings were inconclusive.

There has been continuing uncertainty about the extent and mobility of subsurface fuel in the pier area. Of particular cause for concern has been the possibility that relatively large amounts of fuel could become mobilized, enter the sewer line and eventually enter the treatment system at the nearby Hampton Roads Sewage Disposal Plant. This could cause serious problems with the normal operation of the plant, resulting in large costs to the Navy. It was this possibility that was largely responsible for the initiation of this study.

Subsurface Investigation

Three backhoe pits, four standpipes, and six test borings and monitoring wells were used to determine subsurface conditions in the vicinity of Piers 11 to 19. The locations of these are shown in Figure 6.

Backhoe Pits and Standpipes

Backhoe Pit BW-4 was excavated near a catch basin which holds runoff from the loading area between the piers and Tank 1551 (Figure 6). It is also located near the underground pipeline which connects Tank 1551 to the pier area. Although this location is not part of the pier area where subsurface fuel is known to occur, it is described here because of its general proximity to the piers.

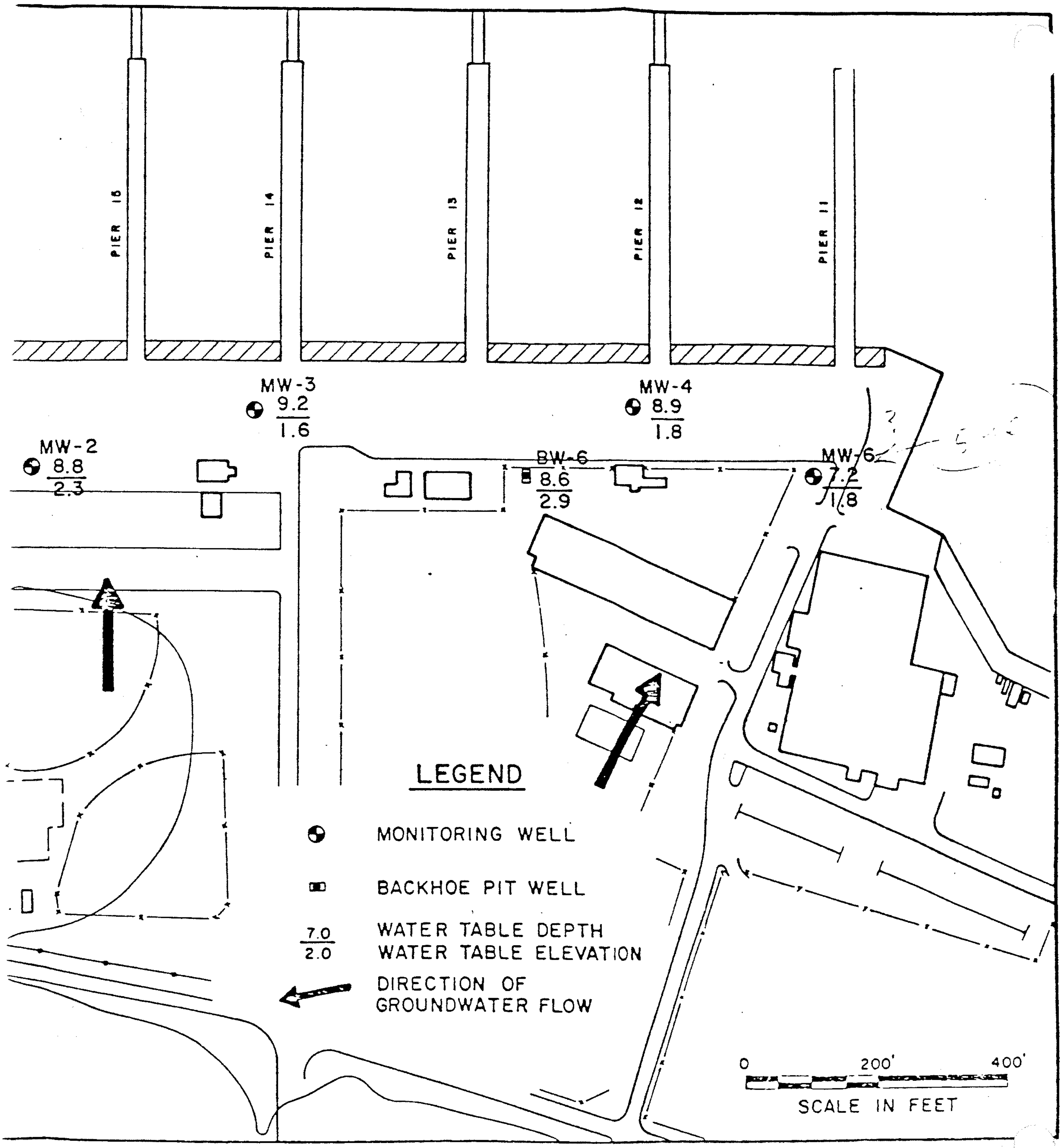
In BW-4, fill consisting of sand and pockets of silt occurred to a depth of approximately 5 feet (Appendix A). This contained a minor perched groundwater system caused by the silt pockets. Sediment from this interval seemed to have a slight fuel odor; however, a strong odor from oil in a nearby catch basin made the determination of this uncertain. The fill was underlain by naturally occurring silty sand. Groundwater in the bottom of the pit had a trace of oil sheen on its surface.

Two standpipes were installed in BW-4. As in BW-3, a deep one was placed to sample groundwater from the main groundwater system as well as the minor perched system. A shallow one was installed in order to sample the perched system only. Subsequent observations indicated that a very slight oily sheen occurred on the water surface in the deeper standpipe. A slight fuel odor was also apparent in the deeper standpipe. However, there was not a measurable thickness of free floating fuel in the deeper standpipe. No fuel was apparent in the shallow standpipe.

Therefore, it is evident that very small amounts of fuel are floating on the main water table in the vicinity of BW-4. It seems likely that it has originated from the nearby catch basin, which contains water and fuel runoff from the loading facility. A leak in the pipeline between the piers and Tank 1551 would probably have resulted in larger amounts of fuel floating on the water table.

Two backhoe pits were excavated just west of the paved parking lot that extends from Pier 11 to Pier 19. BW-5 was between Piers 17 and 18, near the pipeline that goes from the piers to

Figure 6



:ations of monitoring points
irections of groundwater flow.

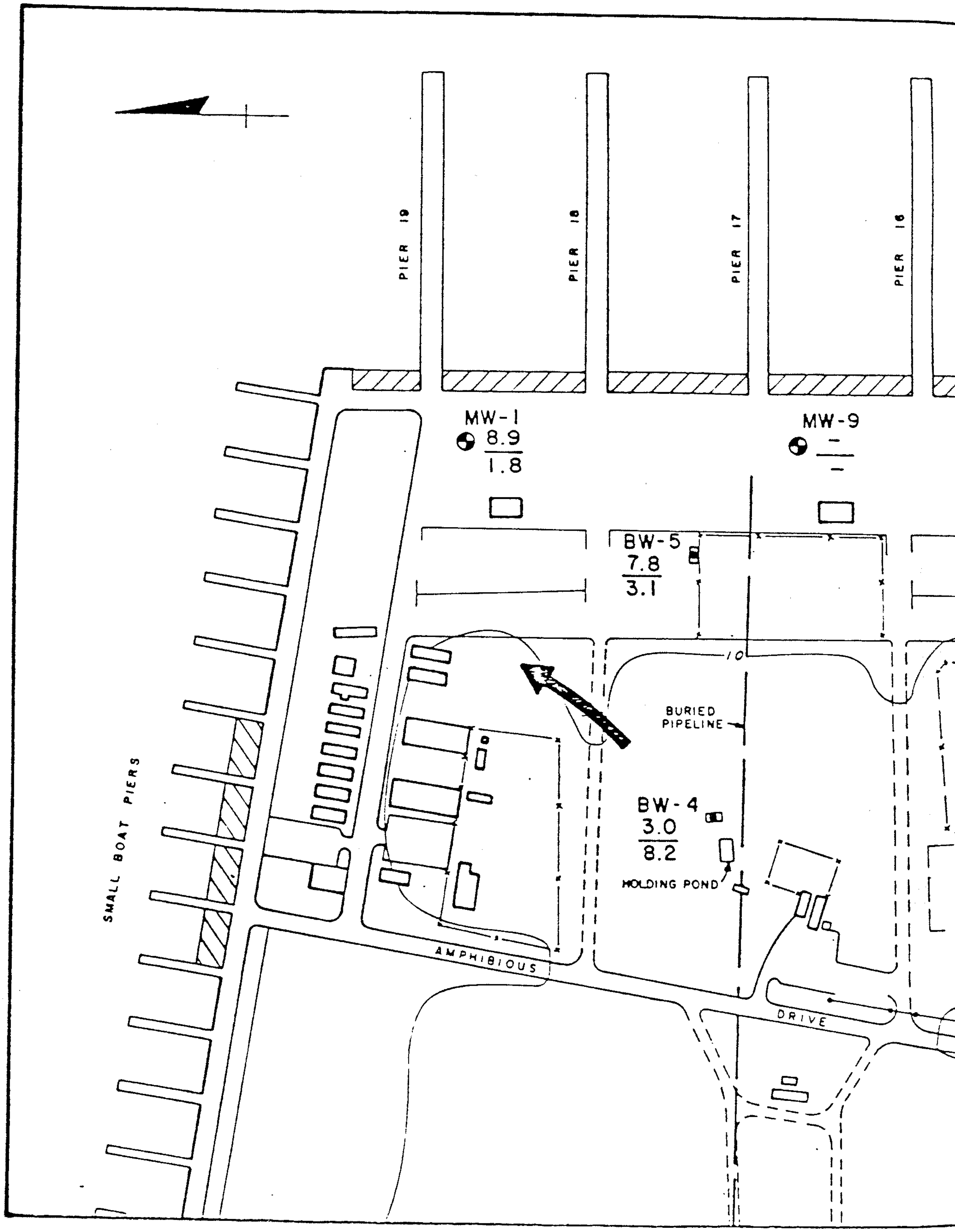


Figure 6: Pier 11-19 area, showing loc
and water-table levels. Arrows show di

Tank 1551 (Figure 6). In it, sand and silt fill extended to a depth of 7 feet, and was underlain by naturally occurring well sorted sand. A distinct fuel odor was observed in the saturated, naturally-occurring sediments below 7 feet. A standpipe installed in BW-5 had a moderately distinct fuel odor in it, but no measurable free floating fuel. Backhoe Pit BW-6 was excavated just west of the pavement opposite Pier 13 (Figure 6). In it, sand and silt fill occurred to a depth of about 6 feet, and was underlain by naturally-occurring sand. No fuel was observed in the fill; however, a distinct fuel odor was observed in saturated sediments below 7 feet. A standpipe in BW-6 had a slight fuel odor in it.

Test Borings and Monitoring Wells

In order to determine subsurface conditions beneath the pavement, six test borings and monitoring wells were installed in the pier area. Locations are shown in Figure 6. Installation procedures are described in the Methods section of this report. Geologic logs and construction details for each well are shown in Appendix B.

Monitoring Well MW-1 was installed near Pier 19. Split-spoon sampling indicated that sand fill occurred to a depth of about 7 feet, and was underlain by sand and some layers of silty sand. Slight fuel odor was observed in all sediments above the water table, and a strong fuel odor was observed in sediments at and below the water table.

Samples from below the water table would not normally be expected to contain free (undissolved) fuel. Fuel which was observed in samples from beneath the water table probably originated in groundwater at the water table, and contaminated the sampler as it passed through that interval.

Monitoring Well MW-2 was augered in the parking area between Piers 15 and 16. In it, sand fill occurred to a depth of about 5 feet, and was underlain by silty sand and layers of clay and peat. No fuel was observed in sediments down to 6 feet. A slight fuel odor was observed in sediments just above the water table and in saturated sediments at the water table.

Monitoring Well MW-3 is located in the parking area opposite Pier 14. Sand fill extended to a depth of about 6 feet and was underlain by naturally occurring fine to coarse sand with little silt. Fuel odor was observed in the upper 4 feet of sediment, and in those sediments in the zone of water-table fluctuation.

Monitoring Well MW-4 is located in the parking area opposite Pier 12. In it, sand fill extended to about 10 feet, and was underlain by layers of sand and silty sand. All sediments above the water table had strong to very strong fuel odor. An interval of 0.5 feet thickness of sand appeared at the water table and appeared to be saturated with black fuel.

Monitoring Well MW-5 was installed opposite Pier 11, and indicated that silty sand fill occurred to a depth of about 5 feet. This was underlain by relatively well sorted sand. A trace of fuel odor was observed from 3 to 5 feet and in the sediments at the water table.

Monitoring Well MW-9 is located in the parking area between Piers 16 and 17. It was installed after the monitoring wells at the Fuel Farm, when it was discovered that monitoring wells installed in the mid-1970's were plugged with sediment. Sand and silt fill occurred to a depth of about 8 feet, and these

EXHIBIT 3-5

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF CONSERVATION
AND ECONOMIC DEVELOPMENT

DIVISION OF MINERAL RESOURCES

GEOLOGIC STUDIES, COASTAL PLAIN OF VIRGINIA

BULLETIN 83 (PARTS 1 AND 2)

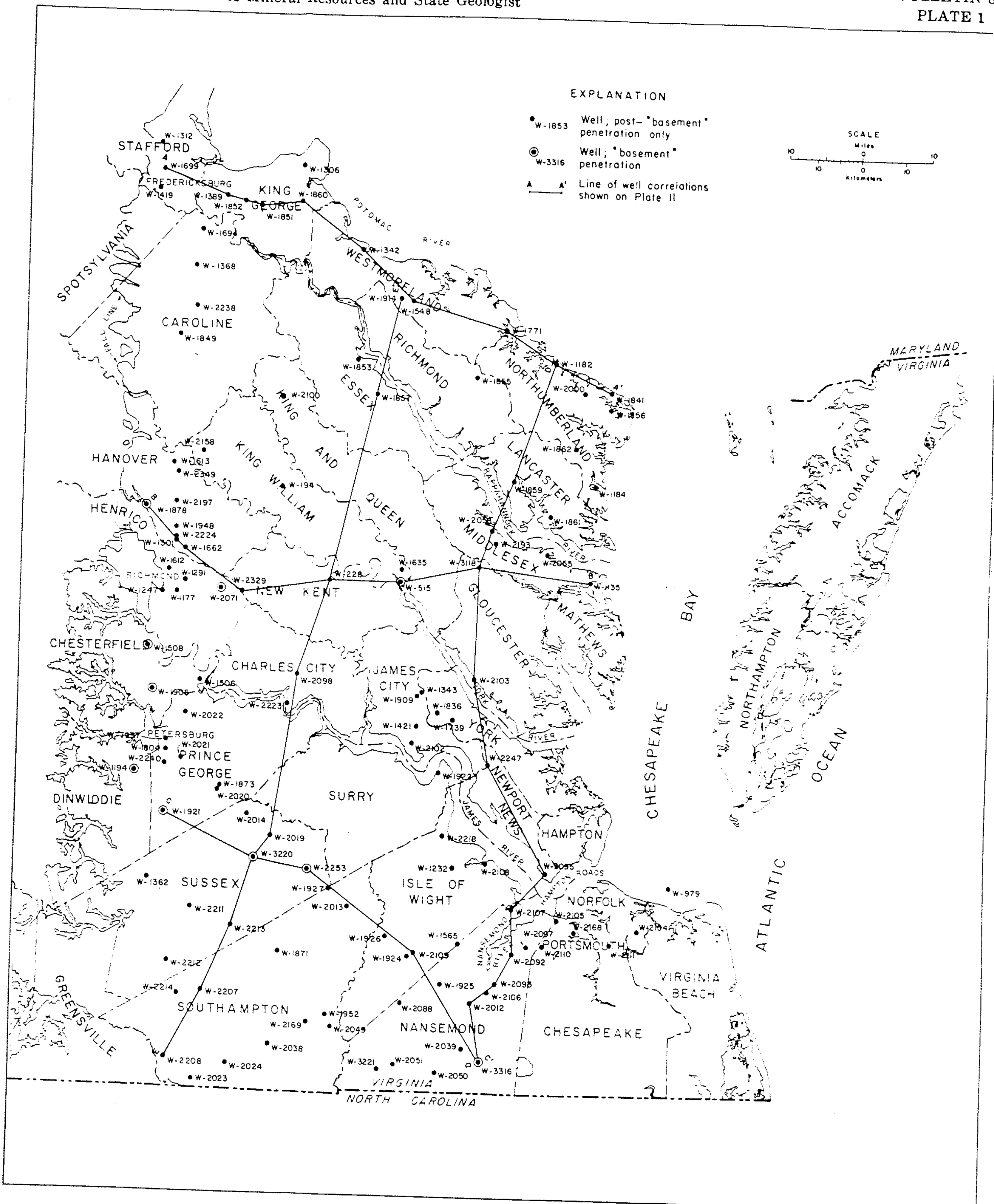
VIRGINIA DIVISION OF MINERAL RESOURCES
James L. Calver
Commissioner of Mineral Resources and State Geologist

CHARLOTTESVILLE, VIRGINIA
1973

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF MINERAL RESOURCES
James L. Calver
Commissioner of Mineral Resources and State Geologist

SP-137

BULLETIN 83
PLATE 1



CONTROL WELLS AND LINES OF WELL CORRELATIONS
COASTAL PLAIN OF VIRGINIA
1973

APPENDIX I

GEOLOGIC SUMMARIES

(Only wells used in mapping)

EXPLANATION

W-194 Numbers preceded by the letter "W" refer to those wells whose samples are on file in the Division's repository.

post-Ty, post-Tc, post-Tn, post-Tm, post-trans, and post-LK refer to the top of rocks of younger formations than the Yorktown, Calvert, Nanjemoy, Mattaponi, "transitional beds", and Patuxent respectively.

Ty Top of Yorktown Formation

Tc Top of Calvert Formation

Tn Top of Nanjemoy Formation

Tm Top of Mattaponi Formation

trans Top of "transitional beds"

LK Top of Patuxent Formation

base Top of "basement"

nd Formation top not determined

TD Total depth of well in feet

All elevations are relative to a sea level datum.

	Elevation of top (in feet)	Thickness (in feet)
W-194		
post-Ty and Ty	128	53
Tc	75	83
Tn	—8	68
Tm	—76	129
LK	—205	4 drilled
TD 337		
W-228		
Tc	5	87
Tn	—82	113
Tm	—195	75
LK	—270	67 drilled
TD 342		
W-515		
post-Ty and Ty	30	110—
Tc	nd	50+
Tn	—130	40
Tm	—170	125
LK	—295	995
base	—1290	312 drilled
TD 1632		

	Elevation of top (in feet)	Thickness (in feet)
W-979		
post-Ty	0	120—
Ty	nd	395+
Tc	—515	345
Tm	—860	125
trans	—985	135
LK	—1120	380 drilled
TD 1500		
W-1135		
post-Ty	10	75
Ty	—65	70
Tc	—135	300
Tn	—435	20
Tm	—455	170
LK	—625	157 drilled
TD 792		
W-1177		
post-Tc	162	20
Tc	142	60
Tn	82	
Tm	nd	
LK	—28	136 drilled
TD 326		
W-1182		
post-Ty	5	21
Ty	—16	21
Tc	—37	275
Tn	—312	85
Tm	—397	163
LK	—560	55 drilled
TD 620		
W-1184		
post-Ty	3	40
Ty	—37	41
Tc	—78	332
Tn	—410	47
Tm	—457	130
LK	—587	50 drilled
TD 640		
W-1194		
post-Ty	173	10
Ty	163	
Tc	nd	
base	78	80
TD 175		

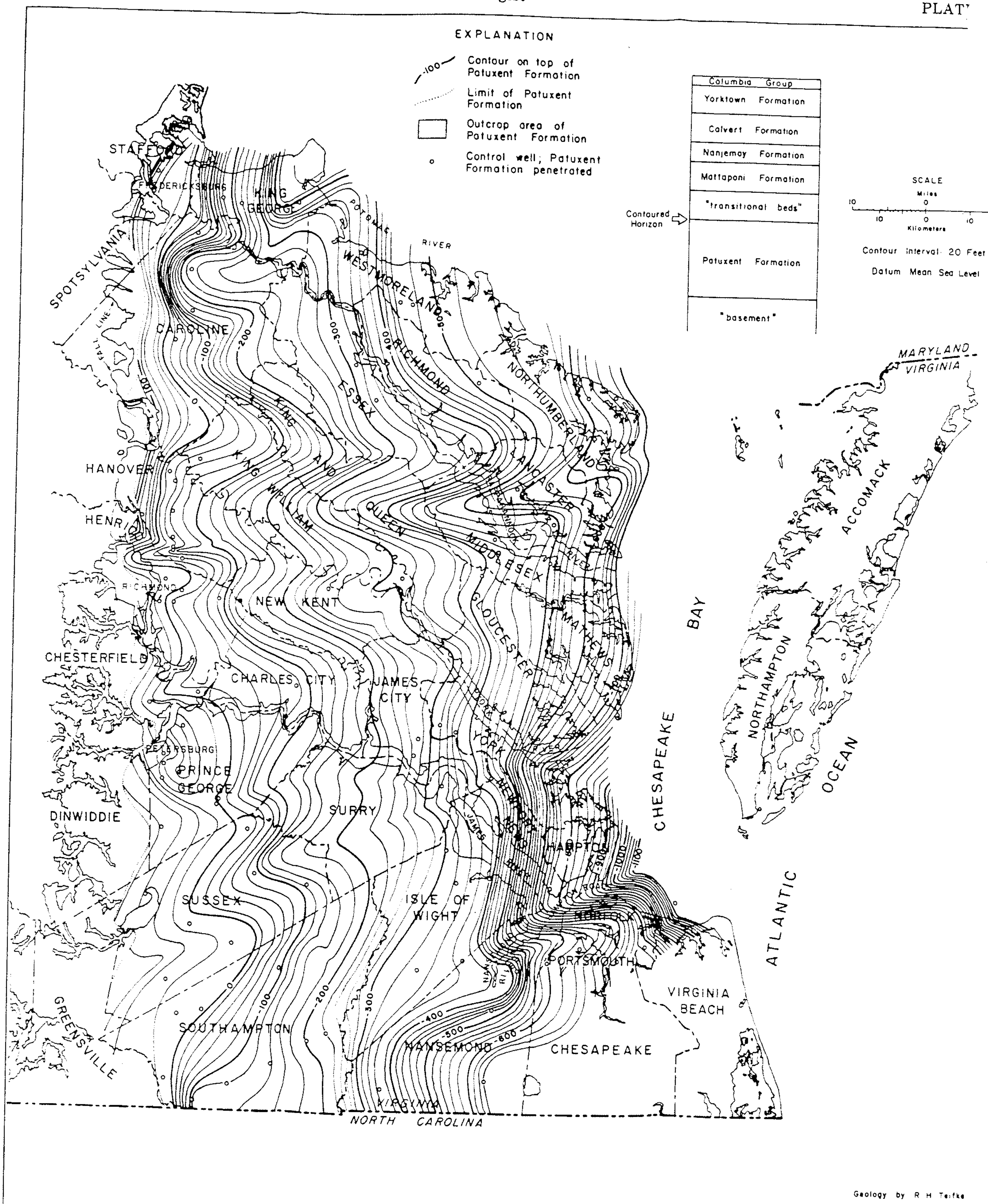
	Elevation of top (in feet)	Thickness (in feet)
Tn	−28	18 drilled
TD 186		
W-2102		
post-Ty	10	40
Ty	−30	43
Tc	−73	99
Tn	−172	68
Tm	−240	35
LK	−275	85 drilled
TD 370		
W-2103		
post-Ty	7	25
Ty	−18	172
Tc	−190	82
Tn	−272	82
Tm	−354	41
LK	−395	22 drilled
TD 424		
W-2105		
Ty	15	380
Tc	−365	55
Tm	−420	75
trans	−495	70 drilled
TD 580		
W-2106		
Ty	20	200
Tc	−180	100
Tm	−280	
trans	nd	
LK	−480	160 drilled
TD 660		
W-2107		
Ty	20	260
Tc	−240	175
Tm	−415	55
trans	−470	50 drilled
TD 540		
W-2108		
Ty	10	188
Tc	−178	82
Tm	−260	118
LK	−378	92 drilled
TD 480		

	Elevation of top (in feet)	Thickness (in feet)
W-2109		
post-Ty	82	60
Ty	22	152
Tc	−130	48
Tm	−178	50
trans	−228	105
LK	−333	45 drilled
TD 460		
W-2110		
post-Ty	7	20
Ty	−13	280
Tc	−293	80
Tm	−373	130
trans	−503	95
LK	−598	35 drilled
TD 640		
W-2111		
post-Ty	5	40
Ty	−35	320
Tc	−355	170
Tm	−525	89
trans	−614	125
LK	−739	56 drilled
TD 800		
W-2154		
post-Ty	10	100−
Ty	nd	310+
Tc	−400	210
Tm	−610	67
trans	−677	105
LK	−782	1796 drilled
TD 2588		
W-2158		
post-Tc	190	50
Tc	140	80
Tn	60	40
Tm	20	70
LK	−50	80 drilled
TD 320		
W-2168		
post-Ty	10	40
Ty	−30	290
Tc	−320	120
Tm	−440	70

	Elevation of top (in feet)	Thickness (in feet)
trans	−510	120
LK	−630	375 drilled
TD 1015		
W-2169		
post-Ty	30	10
Ty	20	60
Tm	−40	30
trans	−70	135
LK	−205	137 drilled
TD 372		
W-2193		
Ty	35	90
Tc	−55	220
Tn	−275	75
Tm	−350	75
LK	−425	194 drilled
TD 654		
W-2197		
post-Tc	185	30
Tc	155	90
Tn	65	70
Tm	−5	60
LK	−65	70 drilled
TD 320		
W-2207		
post-Ty	42	18
Ty	24	7
Tm	17	12
trans	5	2
LK	3	11 drilled
TD 50		
W-2208		
post-Tm	73	23
Tm	50	40
LK	10	3 drilled
TD 66		
W-2211		
post-Ty	80	19
Ty	61	9
Tm	52	45
LK	7	7 drilled
TD 80		

	Elevation of top (in feet)	Thickness (in feet)
W-2212		
post-Ty	129	26
Ty	103	67
Tm	36	10
LK	26	12 drilled
TD 115		
W-2213		
post-LK	35	19
LK	16	26 drilled
TD 45		
W-2214		
post-Ty	50	13
Ty	37	7
Tm	30	23
LK	7	7 drilled
TD 50		
W-2218		
post-Ty	65	10
Ty	55	160
Tc	−105	110
Tn	−215	20
Tm	−235	70
LK	−305	42 drilled
TD 412		
W-2223		
post-Tn	50	50
Tn	0	20
Tm	−20	60
LK	−80	85 drilled
TD 215		
W-2224		
post-Tc	175	50
Tc	125	80
Tn	45	60
Tm	−15	30
LK	−45	192 drilled
TD 412		
W-2238		
post-Tc	200	50
Tc	150	70
Tn	80	30
Tm	50	50
trans	0	150
LK	−150	25 drilled
TD 375		

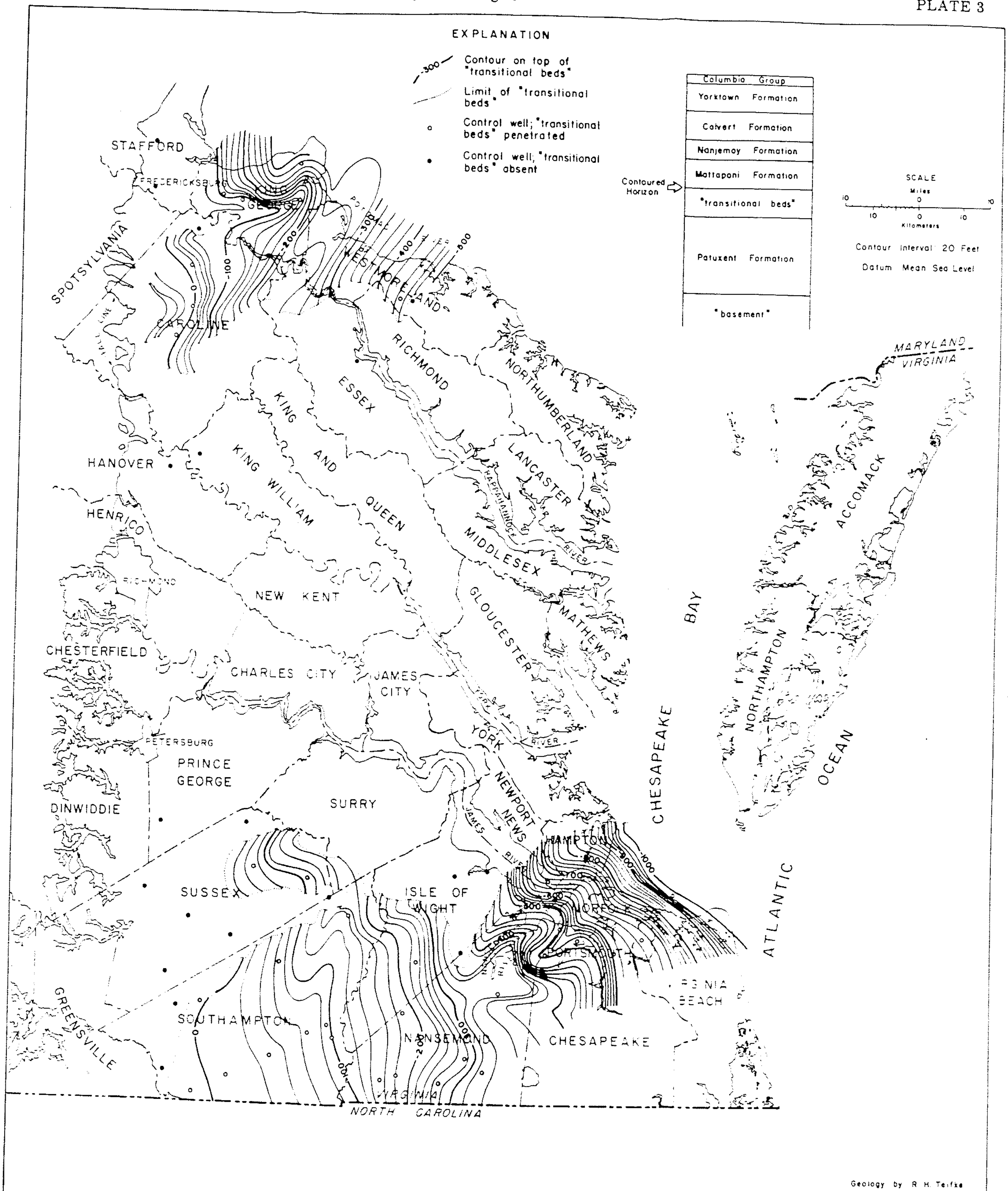
COMMONWEALTH OF VIRGINIA
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF MINERAL RESOURCES
James L. Calver
Commissioner of Mineral Resources and State Geologist



STRUCTURE-CONTOUR MAP OF THE PATUXENT FORMATION
COASTAL PLAIN OF VIRGINIA
1973

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF MINERAL RESOURCES
James L. Calver
Commissioner of Mineral Resources and State Geologist

BULLETIN 83
PLATE 3



STRUCTURE-CONTOUR MAP OF THE "TRANSITIONAL BEDS"
COASTAL PLAIN OF VIRGINIA
1973

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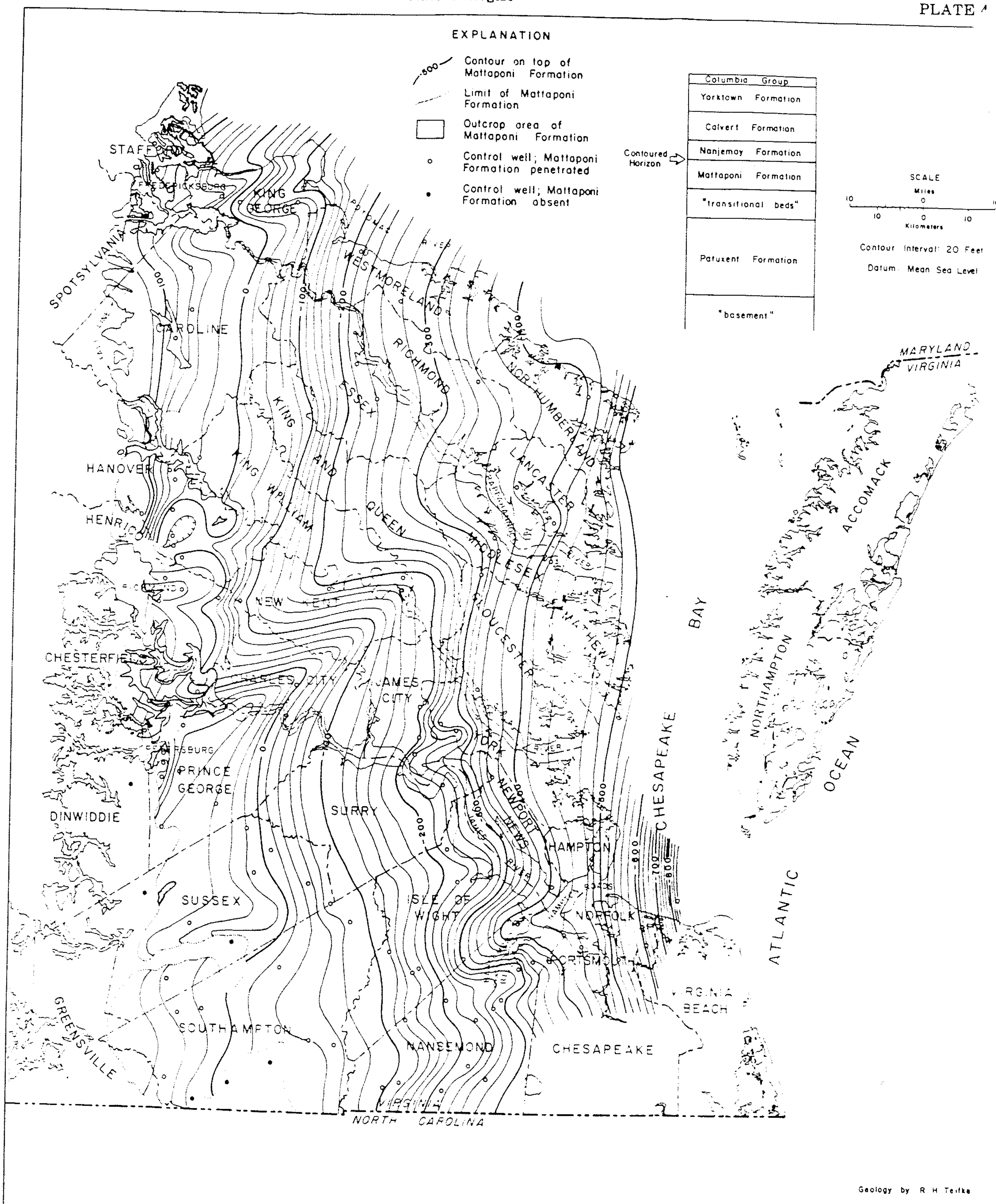
BULLETIN 83
PLATE 4



STRUCTURE-CONTOUR MAP OF THE MATTAPONI FORMATION
COASTAL PLAIN OF VIRGINIA
1973

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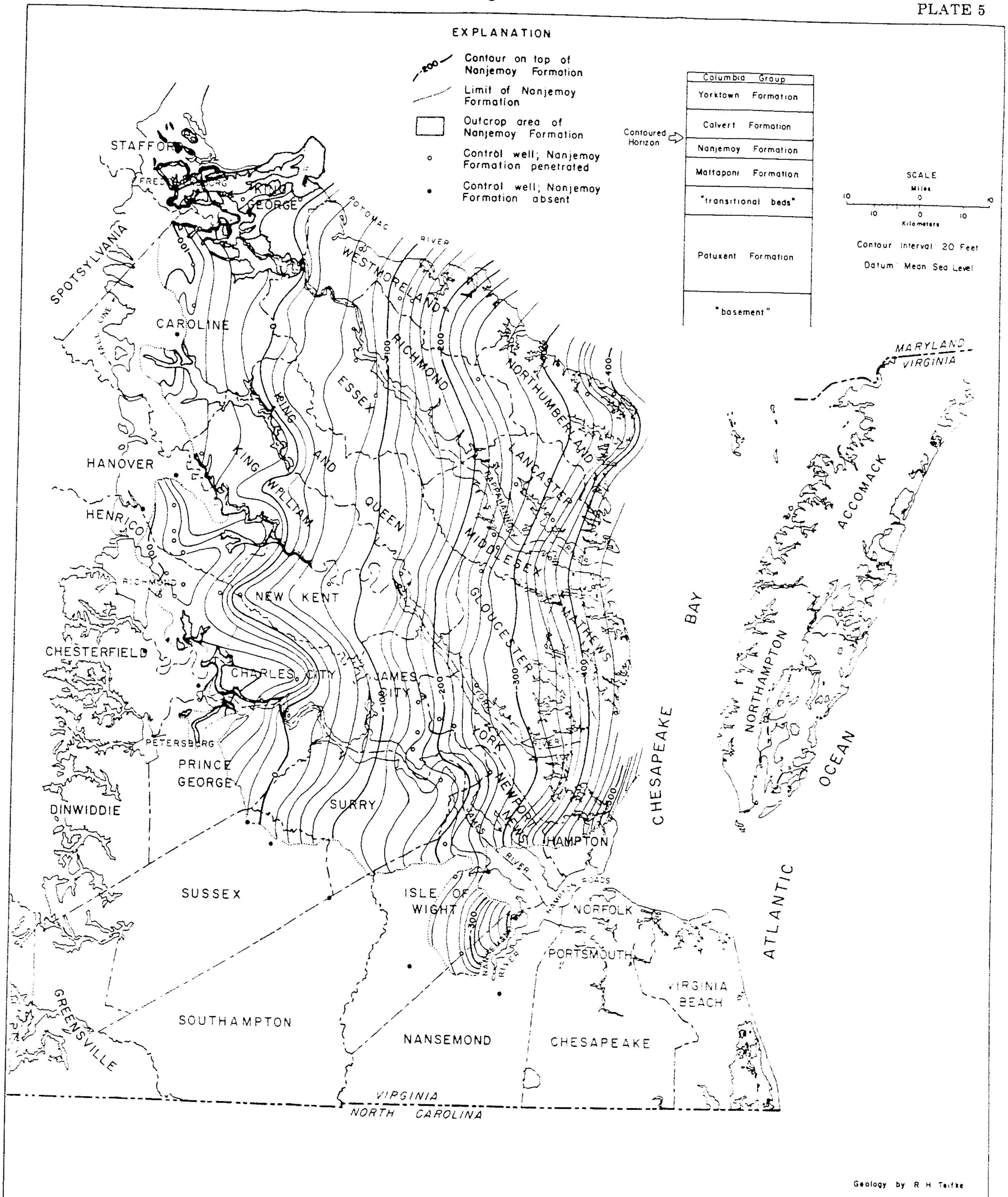
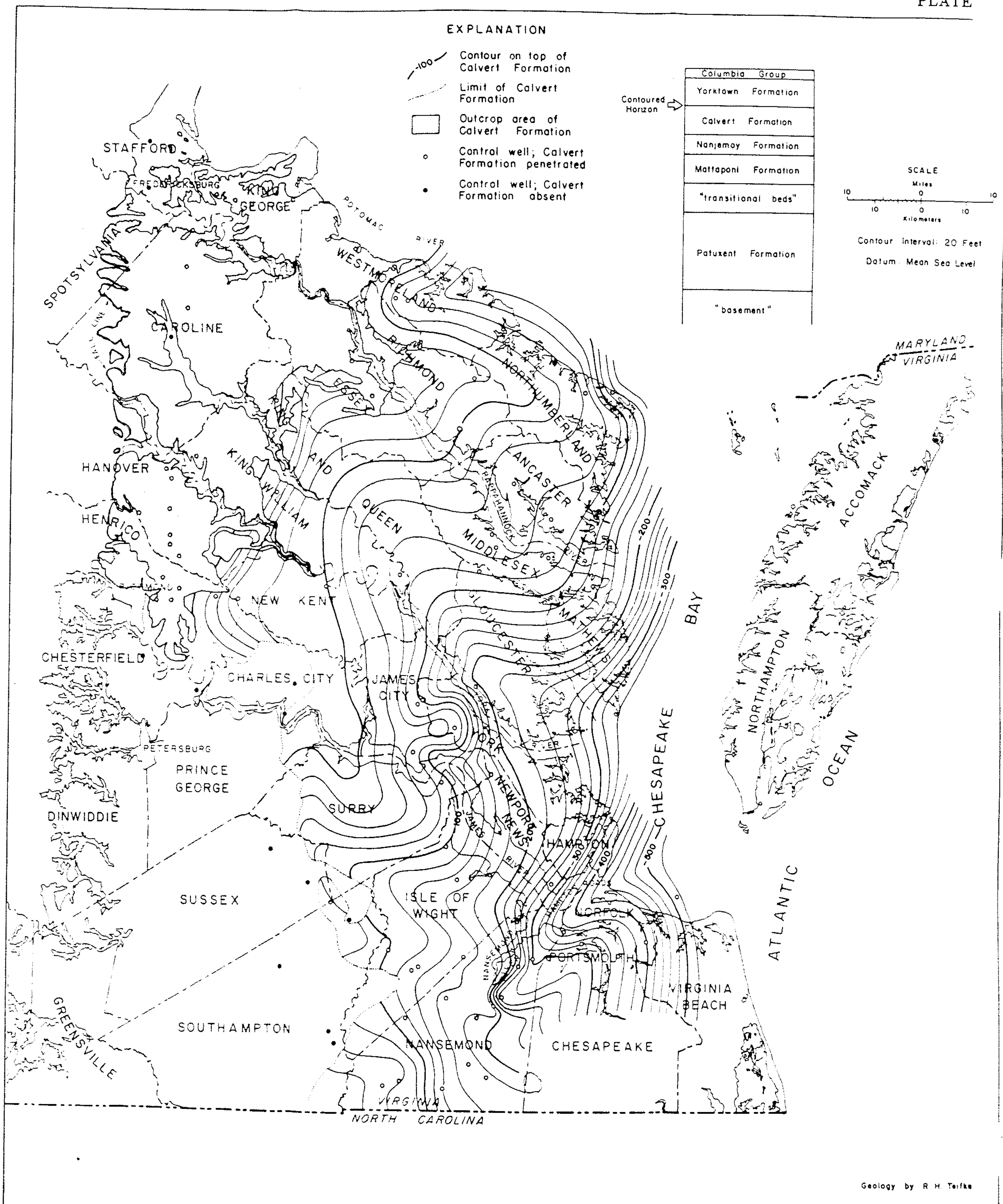
BULLETIN 83
PLATE 5



STRUCTURE-CONTOUR MAP OF THE NANJEMOY FORMATION
COASTAL PLAIN OF VIRGINIA
1973

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF MINERAL RESOURCES
James L. Calver
Commissioner of Mineral Resources and State Geologist

BULLETIN 83
PLATE



STRUCTURE-CONTOUR MAP OF THE CALVERT FORMATION
COASTAL PLAIN OF VIRGINIA
1973

EXHIBIT 3-6

HYDROGEOLOGY AND ANALYSIS OF THE GROUND-WATER FLOW SYSTEM IN THE COASTAL PLAIN OF SOUTHEASTERN VIRGINIA

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 87-4240

Prepared in cooperation with the
VIRGINIA STATE WATER CONTROL BOARD

Stratigraphy and Areal Extent of Aquifers and Confining Units

The hydrogeologic framework for the study area is a series of aquifers and intervening confining units defined on the basis of lithologic and hydrologic properties of the unconsolidated Coastal Plain sediments. One water-table and seven confined aquifers, separated by intervening confining units, were identified for the study area. One other confined aquifer (Peedee) and inter- vening confining unit (Peedee confining unit) located in northeastern North Carolina, as well as a confining unit (St. Marys confining unit) located north of the James River, were included in the model framework for hydrologic analysis. Table 1 summarizes relations between the hydrogeologic units and geologic formations and ages and corresponding hydrogeologic names used in previous investigations. Lower Cretaceous sediments include the lower and middle Potomac aquifers and confining units; Upper Cretaceous sediments include the upper Potomac, Virginia Beach, and Peedee aquifers and confining units; Tertiary sediments include the Aquia, Chickahominy-Piney Point, and Yorktown-Eastover aquifers, and Nanjemoy-Marlboro, Calvert, St. Marys, and Yorktown confining units; and Quaternary sediments comprise the Columbia aquifer.

A brief discussion of the nine aquifers and intervening confining units used in model analysis is presented. The reader is referred to Meng and Harsh (1984) for a more detailed description of age, lithologic characteristics, and stratigraphy of each aquifer and confining unit. This report follows the basic framework outlined by Meng and Harsh; however, the areal extent and thickness of several aquifers and confining units were revised after analyzing geophysical logs and water-level data collected during this study (A.A. Meng, U.S. Geological Survey, written commun., 1986). Figure 2 shows locations of wells used in the hydrogeologic framework analysis. Figures 3 through 10 illustrate tops of each aquifer relative to sea level and areal extent, and figures 11 through 19 illustrate thickness and areal extent of confining units. Figure 20 illustrates general depth of aquifers, confining units, and basement from the Fall Line through southeastern Virginia. Table 2 describes general hydrogeologic characteristics and well yields for individual aquifers in the model area.

The lower Potomac aquifer in the lower part of the Potomac Formation is the lowermost confined aquifer in the hydrogeologic framework and lies entirely on basement. This aquifer is thinnest along its western limit near the Fall Line and thickens seaward. Thickness in the study area ranges from near zero at the Fall Line to 882 feet at well 61C1 in the city of Norfolk. The aquifer predominantly consists of thick interbedded sequences of medium- to very coarse-grained sand, clayey sand, and clay with interbedded gravel. It is capable of supplying large quantities of water but generally lies too deep to be affordable for all but large industrial users. Elevated chloride concentrations in the east restrict its use as a potable source of water. The lower Potomac aquifer is overlain by the lower Potomac confining unit throughout its extent. The confining unit is composed of sequences of brown, gray, or dark-green carbonaceous clay, interbedded with thin, sandy clay. The clay beds are not continuous or areally extensive but, instead, are a series of interlensing clayey deposits. Because of this depositional pattern, the con- fining unit varies considerably in thickness, ranging from a thin edge in the western part of the study area to approximately 80 feet in the city of

Table 1.--Hydrogeologic column showing aquifers and confining units in model area

Period	Epoch	Stratigraphic formation	Hydrogeologic units: This report	Cederstrom 1945	Geraghty and Miller 1979 a & b	Sudyla and others 1981	Harsh and Laczniak 1986
Quaternary	Holocene Pleistocene	Undifferentiated sediments	Columbia aquifer	Sands of Recent deposits and the Columbia group	Water-table aquifer	Water-table aquifer	Columbia aquifer
Tertiary	Pliocene	Yorktown Formation	Yorktown confining unit	Sands and shells of the Yorktown Formation	Upper artesian aquifer system	Yorktown aquifer	Yorktown confining unit
	Miocene	Eastover Formation	Yorktown-Eastover aquifer				Yorktown-Eastover aquifer
		St. Marys Formation	St. Marys confining unit				St. Marys confining unit
		Choptank Formation	Not present in model area				St. Marys-Choptank aquifer
		Calvert Formation	Calvert confining unit				Calvert confining unit
	Oligocene	Old Church Formation	Chickahominy-Piney Point aquifer				Chickahominy-Piney Point aquifer
	Eocene	Chickahominy Formation		Glauconitic sands of the Pamunkey coup		Eocene-Upper Cretaceous aquifer	
		Piney Point Formation					
		Nanjemoy Formation	Nanjemoy-Marlboro confining unit				Nanjemoy-Marlboro confining unit
		Marlboro Clay					
	Paleocene	Aquia Formation	Aquia aquifer				Aquia aquifer
		Brightseat Formation	Not present in model area				
Cretaceous	Late Cretaceous	Peedee Formation (of North Carolina)	Peedee confining unit[1]				Not present in Virginia
			Peedee aquifer[1]			Eocene-Cretaceous aquifer	
		Unnamed deposits (Black Creek Formation equivalent) in Virginia	Virginia Beach confining unit	Sands of Late Cretaceous age	Lower artesian aquifer system		
			Virginia Beach aquifer				
		Potomac Formation	Upper Potomac confining unit	Sands of the Potomac Group			Upper Potomac confining unit
	Early Cretaceous		Upper Potomac aquifer				Upper Potomac aquifer
			Middle Potomac confining unit			Lower Cretaceous aquifer	Middle Potomac confining unit
			Middle Potomac aquifer				Middle Potomac aquifer
			Lower Potomac confining unit				Lower Potomac confining unit
			Lower Potomac aquifer				Lower Potomac aquifer

[1]Not present in study area but used in model simulations of ground-water flow

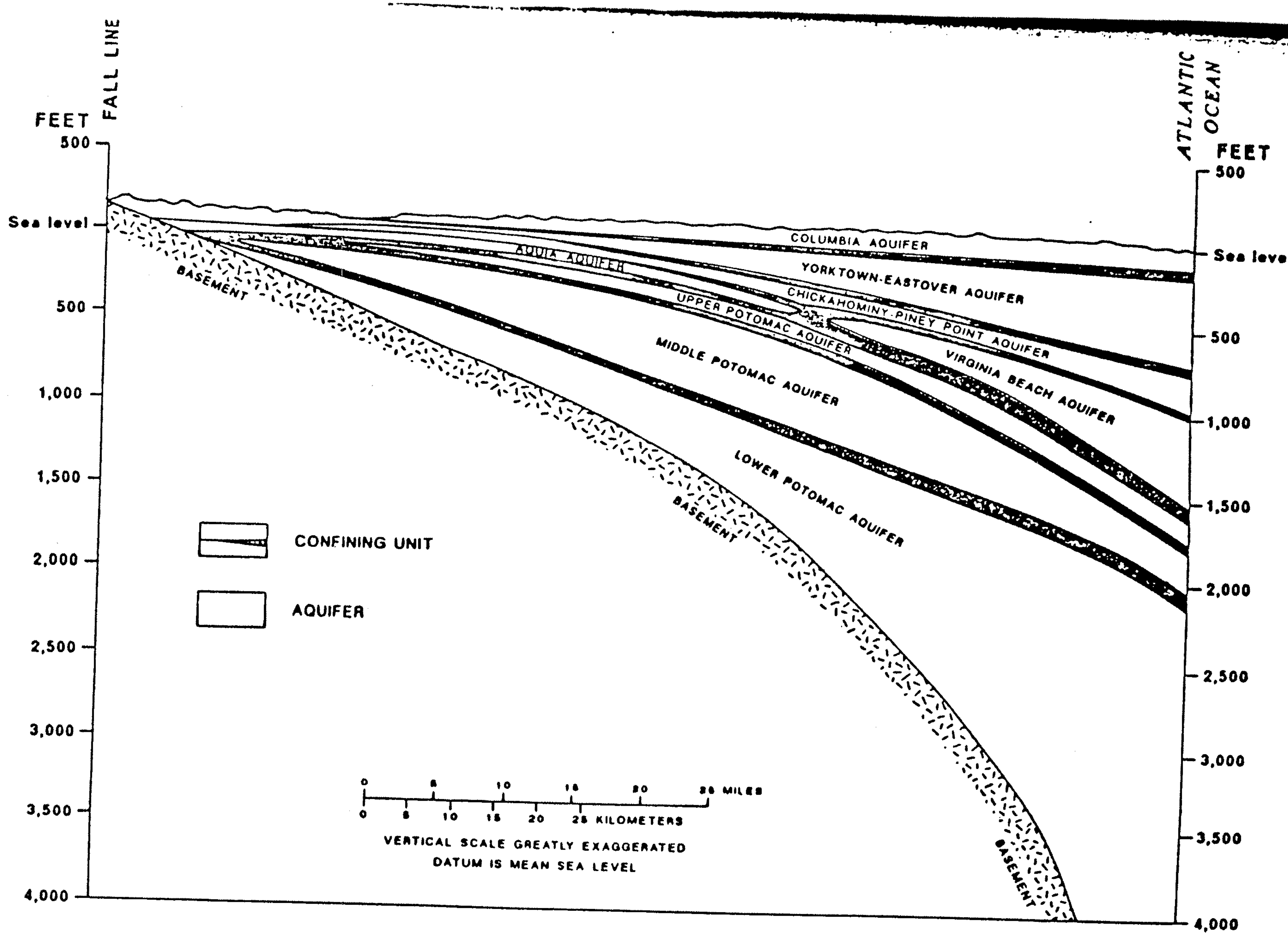


Figure 20.--General depth of aquifers, confining units, and basement from the Fall Line through southeastern Virginia.

Table 2.--Description of aquifers and well yields in model area
[Values in gallons per minute]

Aquifer name and description	Well Yield: Common range	Well Yield: May exceed	General remarks
Columbia aquifer: Sand and gravel, commonly clayey; interbedded with silt and clay. Fluvial to marine in origin; deposition resulted in terrace-type deposits from varying Pleistocene sea levels.	5-30	40	Generally unconfined, semi-confined locally. Most productive in eastern areas, very thin to missing in central and western areas. Water is very hard, calcium-bicarbonate type. Highly susceptible to pollutants from surface contamination. High concentrations of iron and nitrate in some areas. Possibility of salty water in coastal regions.
Yorktown-Eastover aquifer: Sand, commonly shelly; interbedded with silt, clay, shell beds, and gravel. Shallow, embayed marine in origin; deposition resulted in interfingering near-shore deposits from marine transgressions.	5-80	200	Multiaquifer unit. Mostly confined, unconfined updip in outcrop areas. Thickness dependent on altitude of land surface. Highest yields in eastern areas, thin to missing in western areas. Water is hard, sodium-calcium-bicarbonate type. Salty water in lower part of aquifer in eastern areas.
Chickahominy-Piney Point aquifer: Sand, moderately glauconitic, shelly; interbedded with silt, clay, and thin, indurated shell beds. Shallow, inner marine shelf in origin; deposition result of marine transgression.	10-110	200	Generally confined, except where it crops out along major stream valleys in the west. Important aquifer in central parts of Coastal Plain. Yields moderate to abundant supplies to domestic, small industrial, and municipal wells. Aquifer missing in western areas. Water is soft to hard, calcium-sodium-bicarbonate type and generally of good quality.
Aquia aquifer: Sand, glauconitic, shelly; interbedded with thin, indurated shell beds and silty clay intervals. Shallow, inner to middle marine shelf in origin; deposition result of marine transgression.	15-210	350	Generally confined, except where it crops out along major stream valleys in the west. Important aquifer in northern two-thirds of Coastal Plain. Yields moderate supplies to domestic, small industrial, and municipal wells. Aquifer missing in eastern areas. Water is soft sodium-bicarbonate type, with high iron, sulfide, and hardness locally.
Peedee aquifer: Sand, glauconitic and shelly; interbedded with dark, micaceous silt and clay. Near-shore marine in origin; deposition resulted from Late Cretaceous marine transgression.	5-40	50	Restricted to North Carolina Coastal Plain; not extensively developed. Yields small to moderate supplies to primarily domestic wells. Water is soft, sodium-bicarbonate type, with high chlorides in eastern areas.
Virginia Beach aquifer: Sand, fine- to medium-grained, glauconitic, micaceous, and lignitic; interbedded with thin clay layers and indurated zones. Shallow, inner marine shelf in origin; deposition result of marine transgression.	20-200	500	Multiaquifer unit. Restricted to southeastern Virginia and North Carolina Coastal Plain. Yields moderate to abundant supplies to domestic and industrial wells. Water is soft, sodium-bicarbonate type, with high chlorides in eastern areas and areas of high fluoride and dissolved solids.
Upper Potomac aquifer: Sand, very fine to medium, micaceous, lignitic, and clayey; interbedded with silty clay. Shallow, estuarine and marginal marine in origin; sediments result of first major marine inundation of Cretaceous deltas.	20-400	1000	Multiaquifer unit. Confined, restricted to central and eastern areas. Yields second largest supply of water in Coastal Plain. Water is soft, sodium-chloride-bicarbonate type, with high chlorides in eastern areas.
Middle Potomac aquifer: Sand, fine to coarse, occasional gravel; interbedded with silty clay. Fluvial in origin; sediments result of deltaic deposition.	20-160	700	Multiaquifer unit. Generally confined, unconfined in outcrop areas of northwestern Coastal Plain and major stream valleys near Fall Line. Yields second largest supply of water in Coasta[l] Plain. Water is moderately hard, sodium-chlori[de] -bicarbonate type, with high chlorides in easte[rn] half of Coastal Plain.
Lower Potomac aquifer: Sand, medium to very coarse, and gravel, clayey. Fluvial in origin; sediments result of deltaic deposition.	100-800	1,500	Multiaquifer unit. Generally confined, unconfined in outcrop areas of northwestern area of Coastal Plain. Yields third largest supply of water in Coastal Plain. Water is soft to very hard, and of sodium-bicarbonate to sodium-chloride type, with high chlorides in eastern half of Coastal Plain.

Virginia Beach (fig. 11). It is overlain by the middle Potomac aquifer throughout its extent.

The middle Potomac aquifer in the middle part of the Potomac Formation is the second thickest confined aquifer. It is present throughout the study area. It ranges in thickness in the study area from a thin edge along the Fall Line to approximately 500 feet in the city of Norfolk (well 61C1). The aquifer is composed of interlensing clay, silt, and fine- to coarse-grained sand, with interbedded gravel. The aquifer is capable of supplying large quantities of water and is utilized by most large industrial and municipal users throughout the western and central part of the study area. However, as with the underlying aquifer, high chloride concentrations are present in the eastern part of this aquifer, restricting its use as a potable source of water. The middle Potomac aquifer is overlain by the middle Potomac confining unit throughout its extent. As with the lower Potomac confining unit, this confining unit is highly variable in thickness throughout the study area, ranging from a featheredge in the west to 132 feet in the city of Chesapeake (well 60B3, fig. 12). It is overlain by the upper Potomac aquifer in the central and eastern part of the study area and the Aquia aquifer in the western part.

The upper Potomac aquifer in the upper part of the Potomac Formation is composed of Upper Cretaceous sediments and is the thinnest of the three Potomac aquifers. The aquifer is present in the eastern two-thirds of the study area and is confined throughout its extent. The sands thicken to the east, ranging from a thin edge at the updip limit to approximately 280 feet in the city of Virginia Beach (well 63C1). It is composed of very fine- to medium-grained, thickly-bedded sand interlayered with silty, thin clay. Gravel and coarse-grained sands are rare. The aquifer is capable of producing large quantities of generally good quality water and is a principal source of ground water for municipal and industrial use throughout the central part of the study area. Water quality degrades somewhat in the east because of increasing chloride and fluoride concentrations. The upper Potomac aquifer is overlain by the upper Potomac confining unit. The confining unit is relatively thick, attaining its maximum thickness of 192 feet in southeastern Virginia (well 61B2, fig. 13). It is overlain by the Aquia aquifer, except in the southeastern part of the study area and northeastern North Carolina where it is overlain by the Virginia Beach aquifer, and in the northeastern part of the study area where it is overlain by the Chickahominy-Piney Point aquifer.

The Virginia Beach aquifer is composed of unnamed Upper Cretaceous sediments. It is present only in southeastern Virginia and is equivalent to the Black Creek Formation in northeastern North Carolina. The aquifer is named for the city of Virginia Beach for the purpose of this report. It is confined throughout its extent. The sediments in the study area range in thickness from near zero at the updip limit to approximately 110 feet in the city of Chesapeake (well 61B2). They predominantly consist of fine- to medium-grained glauconitic sand, interbedded with thin clay layers and indurated zones. Shell material is common. The aquifer is capable of producing moderate to abundant quantities of generally good quality water for domestic and industrial use. The aquifer is overlain entirely by the Virginia Beach confining unit. This unit consists of a series of clay, silty clay, and sandy clay beds and ranges in thickness within the study area from less than 10 feet near their updip limit to 29 feet in the city of Virginia Beach (well 61A2, fig. 14). The confining unit is overlain by the Aquia aquifer, except in northeastern North Carolina where it is overlain by the Peedee aquifer, and in the northeastern part of the study area where it is overlain by the Chickahominy-Piney Point aquifer.

The Peedee aquifer in the Peedee Formation is restricted to the North Carolina Coastal Plain and is not present in the study area. However, it is described here because it is included in the model framework for hydrologic analysis. It is confined throughout its extent. The sediments range from a featheredge at their western limit to about 300 feet along the Atlantic Coast (M.D. Winner, U.S. Geological Survey, written commun., 1984), and predominantly consist of glauconitic and shelly sand, interbedded with dark, micaceous silt and clay. The aquifer is not extensively developed and primarily yields small to moderate supplies to domestic users. It is entirely overlain by the Peedee confining unit. Confining unit sediments are composed of clay, silty clay, and sandy clay and range in thickness from a thin edge at the updip limit to approximately 100 feet beneath eastern Albemarle Sound (fig. 15). The confining unit is overlain by the Aquia aquifer.

The Aquia aquifer in the Aquia Formation is the deepest Tertiary aquifer in the framework. It is present throughout the study area, except in a band along the Fall Line, in the Chesapeake Bay region, and in a band along the coast. The aquifer is confined throughout its extent, except where it crops out along major stream valleys in the west. The aquifer is thickest in the central part of the study area (approximately 65 feet at well 55F20) and thins to a featheredge along both the updip and downdip limits. The updip limit is erosional and the downdip limit is gradational where the sandy sediments change facies to clay. The sediments, deposited in shallow marine waters, are typically fine- to medium-grained glauconitic sand, interbedded with silt, clay, and thin, indurated shell beds. The aquifer is an important ground-water resource, particularly in the central part of the study area where it yields moderate supplies to domestic, small industrial, and municipal wells. The Aquia aquifer is overlain by the Nanjemoy-Marlboro confining unit. This unit is fairly uniform in thickness throughout the study area, ranging from a thin edge at its western limit to approximately 62 feet in the central part (well 57F26, fig. 16). It is overlain by the Chickahominy-Piney Point aquifer.

The Chickahominy-Piney Point aquifer in the Chickahominy and Piney Point Formations is the middle Tertiary aquifer and is present throughout the study area, except in a band along the Fall Line. It is confined throughout its extent, except where it crops out along major stream valleys in the west. The aquifer is generally wedge-shaped in cross section, ranging from near zero along its western limit to approximately 160 feet in the city of Virginia Beach (well 63C1). It is lenticular-shaped north of the James River from the updip limit to the eastern part of Williamsburg, thinning to a featheredge at its updip limit, thickening to 82 feet at well 55H6, and thinning to 30 feet in central York County (well 58F18). The aquifer then becomes wedge-shaped as it thickens eastward. The sediments, deposited in a shallow marine environment, are typically medium- to coarse-grained glauconitic sand, interbedded with silt, clay, and thin, indurated shell beds. The aquifer is an important ground-water resource in the central part of the study area and yields moderate to abundant supplies to domestic, small industrial, and municipal users. The Chickahominy-Piney Point aquifer is overlain by the Calvert confining unit in the Calvert Formation. The confining unit forms an eastward-thickening wedge of dark-green clay interbedded with sandy clay and marl. It attains a maximum thickness in the study area of 460 feet in the city of Virginia Beach (well 63C1, fig. 17). It is overlain by the Yorktown-Eastover aquifer throughout the study area. In the north-central part of the model area, it is overlain by the St. Marys confining unit.

The St. Marys confining unit in the St. Marys Formation and basal part of the overlying Eastover Formation is present only in the north-central part of the model area and consists of shelly to laminated clay interbedded with very fine-grained sand. It ranges in thickness from near zero at its southern limit to approximately 88 feet in the northern part of the model area (well 58H4, fig. 18). It is overlain by the Yorktown-Eastover aquifer.

The Yorktown-Eastover aquifer in the lower part of the Yorktown Formation and upper part of the underlying Eastover Formation is the uppermost Tertiary aquifer. It is present throughout the study area, except in the middle and upper reaches of major stream valleys where it has been removed by erosion. The aquifer is unconfined in a broad area parallel to the Fall Line in the western part of the study area, and is confined in the central and eastern parts (fig. 10). It forms an eastward-thickening wedge of shelly, very fine- to coarse-grained sand, interbedded with silt, clay, shell beds, and gravel. Thickness in the study area ranges from near zero at its western and eroded limits to approximately 280 feet in the city of Virginia Beach (well 63C1). The aquifer is an important ground-water resource in southeastern Virginia for domestic, commercial, and light industrial use. It is an important source of recharge to the underlying confined system in the western part of the study area where it is unconfined. The Yorktown-Eastover aquifer is overlain by the Yorktown confining unit in the upper part of the Yorktown Formation. This unit consists of massive, well-bedded clay and silty clay, containing shells and fine-grained sand. It ranges in thickness in the study area from a featheredge at its western limit to approximately 56 feet in the city of Virginia Beach (well 63C1, fig. 19). Along its western limit, the confining unit is highly dissected. The unit is overlain by the Columbia aquifer in the eastern part of the study area.

The Columbia aquifer is the uppermost aquifer and is unconfined throughout its extent. It is present only in the central and eastern parts of the study area. The aquifer contains the youngest sediments of the Virginia Coastal Plain, consisting of interbedded gravel, sand, silt, and clay. The sediments range in thickness from 10 to 80 feet and represent Holocene sediments and terrace-type deposits laid down during Pleistocene time when sea levels fluctuated considerably. The aquifer is an important ground-water resource for rural and domestic users. It is also a major source of recharge to the underlying aquifer system.

Hydraulic Characteristics of Aquifers

Hydraulic characteristics describe the ability of an aquifer to transmit, store, or release water. The ability to transmit water is described in terms of its transmissivity or its hydraulic conductivity[1]. Transmissivity of an aquifer is the rate at which water will flow horizontally through a vertical strip 1-foot wide extending through the full saturated thickness. It is the product of the horizontal hydraulic conductivity and saturated thickness. Hydraulic conductivity involves the water-transmitting properties of the sediment, which depend on such things as the size and arrangement of pores. Water flows more freely in coarse-grained sediment, such as gravel, than in fine-grained sediment, such as silt and clay. The ability of an aquifer to store or release water is described by its storage coefficient. Storage coefficient is the volume of water released from or taken into storage per unit of surface area of the aquifer per unit change in hydraulic head. The relative magnitude of the storage coefficient depends on whether the aquifer is confined or unconfined. In unconfined aquifers, water is released from storage primarily because of gravity drainage of sediments. Values for storage in unconfined aquifers range from 1×10^{-2} to 3×10^{-1} (Freeze and Cherry, 1979). In confined aquifers, water is released from compression of the aquifer and expansion of water. Values for confined aquifers generally range from 1×10^{-5} to 1×10^{-3} (Lohman, 1972).

Transmissivity and storage coefficient were estimated for confined aquifers within the model area and later used in model development. These estimates were derived from analyses of aquifer- and specific-capacity-test data. The aquifer tests involved collection of time-drawdown data at a pumping well and at one or more observation wells. Water-level decline was monitored in all wells throughout the pumping period. Specific-capacity tests involved one pumping well. Specific capacity is the ratio of the rate at which water is withdrawn to water-level decline in a well. Aquifer-test and specific-capacity-test data were collected from local drillers, private firms, and State and local agencies. The method of data collection and length of record and pumpage vary with each test and, therefore, data may be quite variable.

Methods developed by Theis (1935), Cooper-Jacob (1946), and Hantush (1960) were used to analyze aquifer-test data. The Theis and Cooper-Jacob methods assume that the only source of water to a pumping well is from the penetrated aquifer--no water is derived from the overlying or underlying confining units. These methods commonly are referred to as "non-leaky" solutions. The Hantush method includes vertical leakage through confining units as a source of water to a pumping well and is known as a "leaky" solution. Transmissivity values obtained by the Hantush method are lower than those computed by the non-leaky methods because of the contribution of vertical leakage. This method is considered to be the most appropriate of the three methods for analysis of aquifer-test data in Coastal Plain aquifers because confining units contribute a significant amount of water. Values for aquifer transmissivity and storage coefficient for individual aquifers in the model area that were derived from aquifer-test data are summarized by method in table 3. The values were determined as part of this study using the three methods described above where field data were obtainable. Where field data were not available, the values were obtained from State and local agencies who used one, two, or all of the above methods. No distinction is made in table 3 on the source.

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[1] Hydraulic conductivity referred to in this report is in a horizontal direction unless specifically discussed to the contrary.

Table 3.--Statistical summary of transmissivity and storage coefficient for individual aquifers in the model area derived from Hantush, Theis, and Cooper-Jacob analytical methods[a]
[ft^2/d is square feet per day; a dash indicates no value]

Aquifer		Leaky type curve (Hantush) Transmissivity (ft^2/d)	Leaky type curve (Hantush) Storage coefficient (dimensionless)	Nonleaky type curve (Theis) Transmissivity (ft^2/d)	Nonleaky type curve (Theis) Storage coefficient (dimensionless)	Nonleaky straight line (Cooper-Jacob) Transmissivity (ft^2/d)	Nonleaky straight line (Cooper-Jacob) Storage coefficient (dimensionless)
Yorktown-Eastover	Max	5,750	6.3×10^{-3}	8,820	---	8,820	1.3×10^{-2}
	Min	330	1.4×10^{-4}	210	---	30	1.0×10^{-4}
	Median	3,070	1.1×10^{-3}	2,470	---	2,160	2.5×10^{-4}
	Mean	3,020	1.7×10^{-3}	2,750	1.1×10^{-4}	1,900	2.6×10^{-3}
	Number of tests	6	6	14	1	32	10
Chickahominy-Piney Point	Max	---	---	11,300	---	16,100	---
	Min	---	---	3,710	---	130	---
	Median	---	---	5,530	---	4,790	---
	Mean	---	---	6,960	---	6,740	3.1×10^{-2}
	Number of tests	---	---	7	---	7	1
Aquia	Max	---	---	---	---	8,010	---
	Min	---	---	---	---	2,780	---
	Median	---	---	---	---	---	---
	Mean	---	---	8,680	---	---	---
	Number of tests	---	---	1	---	2	---
Upper Potomac	Max	8,750	2.4×10^{-4}	13,200	6.7×10^{-4}	15,000	---
	Min	1,850	4.1×10^{-5}	4,410	1.4×10^{-4}	2,360	---
	Median	---	---	9,350	2.6×10^{-4}	8,300	---
	Mean	---	---	9,390	3.6×10^{-4}	9,230	5.0×10^{-4}
	Number of tests	2	2	8	3	11	1
Middle Potomac	Max	---	---	38,000	9.3×10^{-3}	56,800	1.4×10^{-3}
	Min	---	---	950	1.6×10^{-6}	425	1.6×10^{-6}
	Median	---	---	4,920	---	2,540	2.2×10^{-5}
	Mean	5,960	---	9,130	---	8,870	3.2×10^{-4}
	Number of tests	1	---	10	2	15	7
Lower Potomac	Max	---	---	---	---	3,540	2.2×10^{-4}
	Min	---	---	---	---	1,370	2.0×10^{-4}
	Median	---	---	---	---	---	---
	Mean	2,630	3.5×10^{-4}	3,260	1.5×10^{-4}	---	---
	Number of tests	1	1	1	1	2	2

[a]No data available for Virginia Beach and Peedee aquifers

Table 4 summarizes well yield, specific capacity, transmissivity, and hydraulic conductivity for individual aquifers in the model area that were derived from specific-capacity tests. Specific capacity most often is used to determine the ability of a well to yield water, however, it also is used to estimate transmissivity and hydraulic conductivity. Transmissivity was derived using a solution developed by Brown (1963) and Theis (1963) where it is a function of specific capacity, time, and storage. Storage was assumed to be $1.5x10^{-1}$ for unconfined aquifers and $1.0x10^{-4}$ for confined aquifers in this solution. Hydraulic conductivity was computed by dividing transmissivity by saturated thickness. The table also gives values for specific capacity, transmissivity, and hydraulic conductivity that were adjusted for partial penetration of the well into the aquifer. These hydraulic characteristics were adjusted using a solution by Turcan (1963). Transmissivity derived from specific-capacity tests compare reasonably well with those obtained in the same areas from aquifer tests. Specific-capacity data, generally easier to obtain, may therefore be appropriate for general evaluation of aquifers in areas lacking aquifer-test data.

Occurrence and Movement of Ground Water

Following is a discussion of standard hydrological concepts as applied to the ground-water system in southeastern Virginia. These are integrated with the known hydrogeology described earlier and with water-level data from the past 100 years. This description served as the basic conceptualization necessary for model development.

Major flow boundaries are the Fall Line to the west (which separates relatively impervious, metamorphic rocks of the Piedmont physiographic province from the relatively permeable, unconsolidated sediments of the Coastal Plain physiographic province), the freshwater-saltwater interface to the east, and granitic basement. The system is part of the global hydrologic cycle (fig. 21), and depends on precipitation as its primary source of water. In southeastern Virginia about half of the precipitation returns relatively quickly to the atmosphere through evapotranspiration (water vaporization from land, surface water, and plants). The remainder either becomes overland flow or infiltrates into the ground. Infiltration first replaces soil moisture near the surface and then recharges the water-table aquifer. Ground-water movement predominantly is lateral through this aquifer. Some movement occurs vertically through confining units into deeper aquifers and laterally through these aquifers. Discharge ultimately occurs at a variety of points, including springs, streams, lakes, Chesapeake Bay, and the Atlantic Ocean.

The rate of movement within an aquifer depends on the hydraulic conductivity and hydraulic gradient. Hydraulic gradient is the change in total head (water level) per unit distance; water moves from higher to lower head. Total head involves two components: elevation and hydraulic pressure. In a water-table aquifer the water is at atmospheric pressure; therefore, the water level in a nonpumping well tapping only the water table would be the same as that of the water table. In deeper, confined aquifers the hydraulic pressure is greater than atmospheric pressure; therefore, the level in a nonpumping well tapping a confined aquifer would be some distance above the top of the aquifer.

Confining units generally have hydraulic conductivities that are much smaller than those of aquifers. As a result, most ground-water flow is

Table 4.—Statistical summary of well yield, specific capacity, transmissivity, and hydraulic conductivity for individual aquifers in the model area derived from specific-capacity tests[a]

[Gal/min is gallons per minute; gal/min/ft is gallons per minute per foot; ft²/d is square feet per day; ft/d is feet per day]

Aquifer		Well yield (gal/min)	Specific capacity (gal/min/ft) Unadjusted	Specific capacity (gal/min/ft) Adjusted[b]	Transmissivity (ft²/day) Unadjusted	Transmissivity (ft²/day) Adjusted[b]	Horizontal hydraulic conductivity (ft/d) Unadjusted	Horizontal hydraulic conductivity (ft/d) Adjusted[b]
Columbia	Max	100	16.7	35.5	3,790	8,500	92.7	170.0
	Min	3	.2	1.7	21	328	1.7	6.4
	Median	30	1.2	6.1	223	1,070	8.3	28.7
	Mean	33	3.4	8.3	760	1,730	30.0	52.1
	Number of tests	12	12	9	9	9	9	9
Yorktown-Eastover	Max	450	31.6	123.0	10,100	44,200	156.0	353.0
	Min	1	.1	.2	23	42	.1	.7
	Median	46	1.5	8.1	523	2,460	4.1	23.1
	Mean	78	3.9	18.6	1,300	6,200	11.8	50.4
	Number of tests	77	79	72	73	72	72	72
Chickahominy-Piney Point	Max	316	48.0	126.0	16,600	42,100	331.0	701.0
	Min	5	.2	.2	54	67	1.2	1.5
	Median	77	3.0	9.6	1,100	2,950	22.4	64.0
	Mean	103	7.4	15.8	2,580	5,270	57.2	103.7
	Number of tests	42	43	38	40	38	38	38
Aquia	Max	550	21.6	102.0	6,980	34,700	189.0	301.0
	Min	5	.2	.2	46	40	.7	1.8
	Median	80	2.2	5.7	640	1,670	16.6	35.1
	Mean	140	3.8	10.3	1,140	3,320	33.9	60.3
	Number of tests	30	30	30	30	30	30	30
Upper Potomac	Max	2,100	83.3	68.0	24,300	24,700	385.5	344.0
	Min	20	.6	.7	170	194	2.8	4.0
	Median	240	6.7	11.6	2,200	3,630	35.6	59.2
	Mean	403	11.1	16.5	3,560	5,380	56.7	80.3
	Number of tests	117	117	113	114	113	113	113
Middle Potomac	Max	3,000	53.1	201.0	17,500	76,300	76.7	347.0
	Min	3	.1	.2	20	60	.2	.7
	Median	120	2.7	9.3	790	3,350	6.1	22.3
	Mean	257	7.8	26.7	2,540	9,230	14.0	46.3
	Number of tests	123	133	126	126	123	123	123
Lower Potomac	Max	2,000	11.5	11.6	3,550	3,560	50.7	50.7
	Min	100	.5	.5	120	120	3.4	3.4
	Median	554	5.9	7.4	1,990	2,250	15.9	18.0
	Mean	802	5.6	6.7	1,950	2,040	20.2	21.0
	Number of tests	6	7	6	6	6	6	6
Multiple-aquifer wells	Max	3,000	55.0	---	18,900	---	---	---
	Min	5	.1	---	23	---	---	---
	Median	602	13.4	---	3,830	---	---	---
	Mean	943	19.1	---	6,230	---	---	---
	Number of tests	65	66	---	53	---	---	---

[a]No data available for Virginia Beach and Peedee aquifers

[b]Adjusted for effects of partial penetration

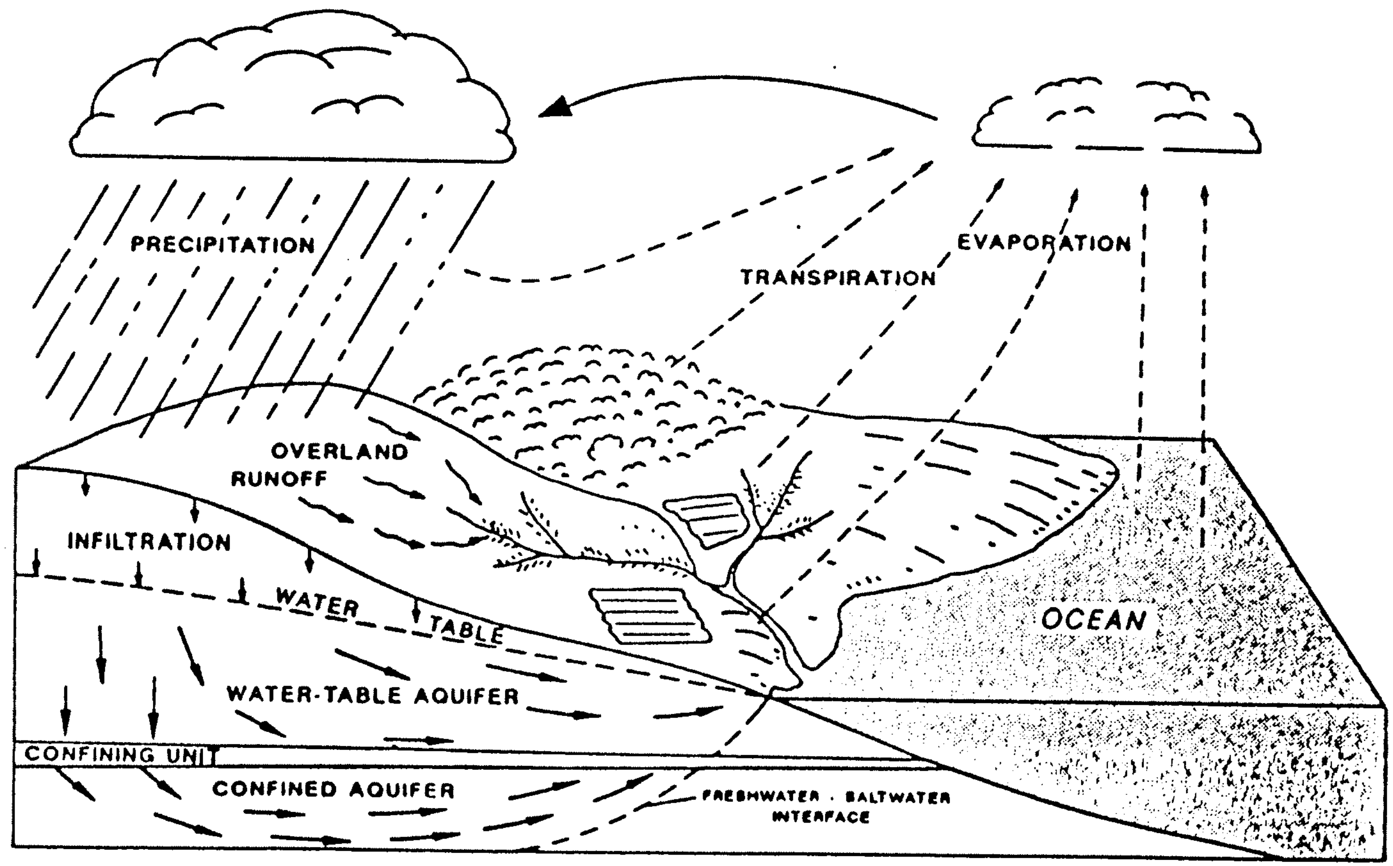


Figure 21.--Hydrologic cycle (modified from Heath, 1983).

lateral through aquifers. A small amount of vertical flow through confining units occurs, controlled by the vertical hydraulic conductivity and unit thickness. Because confining units extend over large areas, the total contribution to aquifer budgets from such vertical flow may be significant. Lateral flow through confining units is negligible.

The presence of deep river channels in southeastern Virginia, incised during the Pleistocene, significantly affects ground-water flow through aquifers and confining units. Aquifers and confining units were partially or completely eroded and replaced by material more permeable than the confining units but less permeable than the aquifers. Vertical flow through confining units in the Chesapeake Bay area and river channels is enhanced; lateral flow through aquifers in these areas is decreased. Approximate depths of the incised rivers in the Virginia Coastal Plain are presented in Harsh and Laczniak (1986) and discussed in Hack (1957).

Prior to the development of wells in southeastern Virginia, a hydraulic equilibrium existed in the multiaquifer system. Recharge to the total system balanced discharge to surface waters. The downward movement of water into the confined aquifers primarily occurred along a narrow band approximately parallel to the Fall Line and in higher elevations between major river valleys. Lateral movement within aquifers primarily was from the Fall Line eastward to Chesapeake Bay and the Atlantic Ocean and from interfluves toward major river valleys. In the east, ground water that encountered the denser saltwater was forced upward through the confining units before discharging to the Bay or Ocean (fig. 22).

The development of wells imposed new discharges on the previously stable system. Before 1920, most withdrawal was from wells that were under sufficient pressure so that water flowed to the land surface. With more drilling, water levels dropped below land surface. Pumps became necessary to maintain supplies.

In any well, pumpage is first balanced by a reduction in ground-water storage in the immediate vicinity, which results in a lower water level and a surrounding cone of depression. This in turn may affect natural flow patterns. In southeastern Virginia, the major pumpage centers (which have correspondingly large cones of depression) caused decreases or reversals in discharge to surface waters. Although the details vary depending on the specific well and its relation to discharge points, a general scenario for this kind of change is presented in figure 23 for a water-table well in the vicinity of a stream. With no pumpage, water in a fully-screened well would be the same as that of the water table, and ground water would discharge at a given rate to the stream which is at a lower level (fig. 23.2). As pumpage begins, water is removed from storage, resulting in a cone of depression (fig. 23.3). As pumpage continues, the hydraulic gradient between the ground water and the stream would be reduced and discharge to the stream would decrease; less water is removed from storage (fig. 23.4). A new equilibrium might be reached at some point (no water is removed from storage) so that discharge to the stream continues, but at a new, lower rate. However, if pumpage is high enough so that the ground-water head falls below the stream, ground-water discharge to the stream will cease completely and water will move from the stream into the ground-water system (fig. 23.5). Thus the

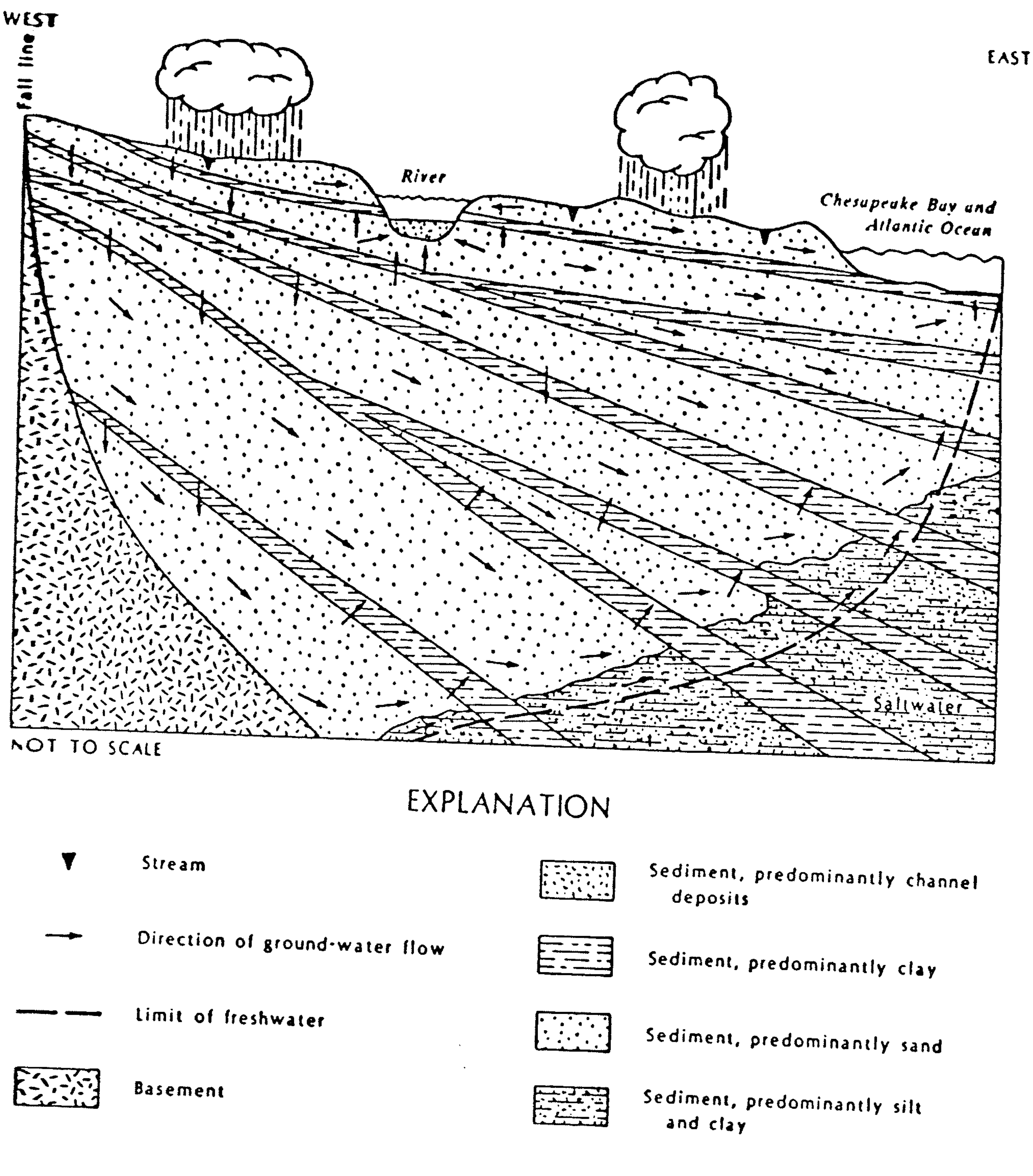


Figure 22.--Conceptualized ground-water flow in the model area for prepumping conditions.

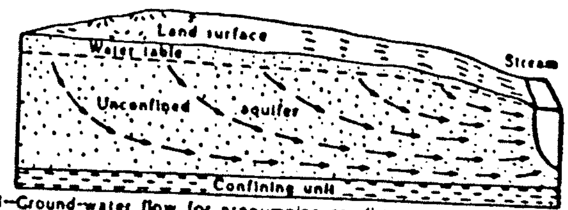


Figure 23.1—Ground-water flow for prepumping conditions; ground water discharging to stream

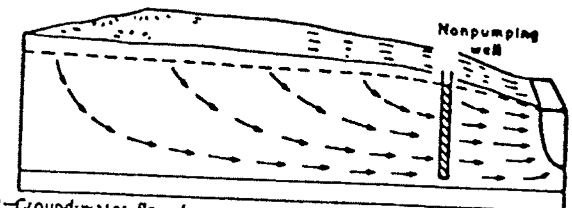


Figure 23.2—Ground-water flow for nonpumping conditions; ground water discharging to stream

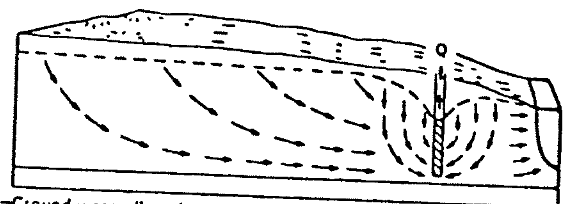


Figure 23.3—Ground-water flow for pumping conditions; reduction in storage equals pumpage

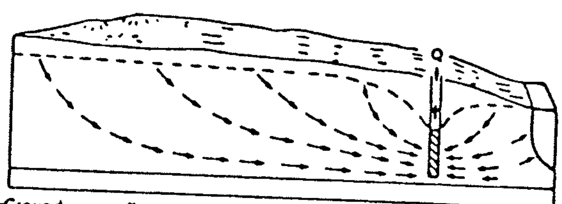


Figure 23.4—Ground-water flow as pumping continues; reduction in storage and reduction in ground-water discharge to stream equals pumpage

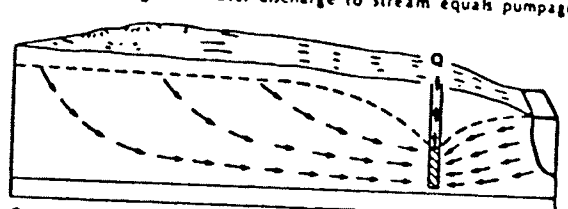


Figure 23.5—Ground-water flow as pumping continues; reduction in ground-water discharge to stream and inducement of stream water into the ground-water system equals pumpage

Figure 23.--Direction of ground-water flow for prepumping and pumping conditions and sources of water derived from a well (modified from Heath, 1983).

stream, originally a discharge point for ground water, becomes a recharge source. Any reduction in ground-water flow to a stream, of course, lowers the stream level. The lowering of the stream level may or may not be significant depending on the flow rate in the stream relative to the rate of ground-water flow to the stream. Overall, these kinds of changes involving reduction or reversal of the natural flow of ground water to surface water are present in southeastern Virginia.

Ground-Water Use

As described above, the development of wells affected the natural flow of ground water in southeastern Virginia. Ground-water use began in southeastern Virginia in the late 1800's (Sanford, 1913) and has increased steadily since that time. Withdrawals, which include naturally flowing and pumping wells and which represent an aggregate of commercial, industrial, and municipal usage, increased from less than 10 Mgal/d in 1891 to about 55 Mgal/d in 1983 (Kull and Laczniak, 1987) in the study area. Water use within the model area, which includes users outside the study area affecting ground-water flow in southeastern Virginia, was approximately 87 Mgal/d in 1983. Figure 24 shows estimated annual commercial, industrial, and municipal withdrawal for the model area from 1891 through 1983. Domestic use was not included because it was assumed to represent only a small percentage of non-returned flow.

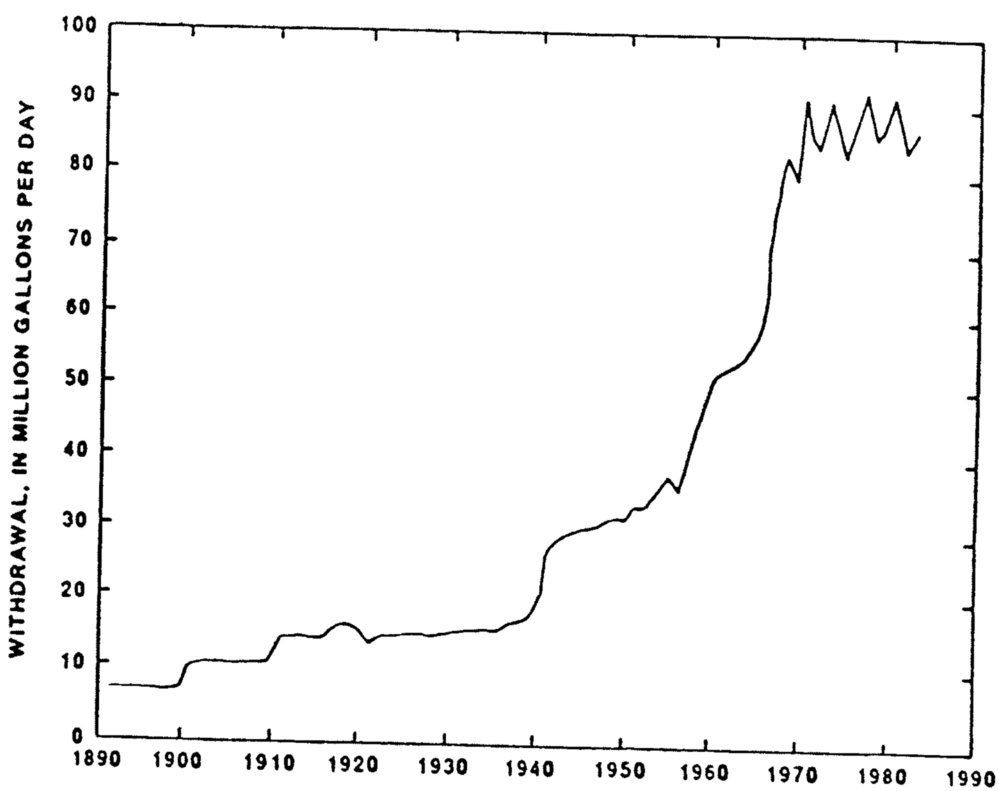


Figure 24.--Estimated annual ground-water withdrawal, 1891-1983.

EXHIBIT 3-7

GROUND WATER RESOURCES OF THE FOUR CITIES AREA, VIRGINIA

NORFOLK
VIRGINIA BEACH

PORTSMOUTH
CHESAPEAKE

By

Eugene A. Siudyla
Anne E. May
Dennis W. Hawthorne

TIDEWATER REGIONAL OFFICE

COMMONWEALTH OF VIRGINIA

STATE WATER CONTROL BOARD

BUREAU OF WATER CONTROL MANAGEMENT

Richmond, Virginia

Planning Bulletin 331

November 1981

CHAPTER III

HYDROGEOLOGY

Summary of Stratigraphy

The Four Cities area is underlain by several thousand feet of unconsolidated deposits of gravel, sand, and clay, ranging in age from Lower Cretaceous to Holocene, resting on bedrock basement of Precambrian and Triassic/Jurassic age. These deposits dip and thicken gently eastward with thickness ranging from 2000 feet in the western part of the study area to over 4000 feet in the southeastern part. Teifke (1973) divided these deposits into six geologic units (Table 2). From oldest to youngest, they are the Patuxent Formation,"transitional beds", the Mattaponi Formation, the Calvert Formation, the Yorktown Formation, and the Columbia Group. The Nanjemoy Formation of Eocene age, although found in most of the Virginia Coastal Plain, is absent in the study area. An indication of the depth and thickness of the units is given by the geologic logs of two wells in Table 3. It should be noted that the Virginia Division of Mineral Resources currently is conducting a detailed study of the stratigraphy of the Virginia Coastal Plain which will update it by 1981.

The Patuxent Formation of Early Cretaceous age overlies the "basement". The Patuxent is an alternating sequence of beds of fine gravel, coarse sand, and silty and sandy clay. Sand within the Patuxent is mainly tan, gray,or white and is characteristically felthspathic.

In Southeastern Virginia transitional beds of early Cretaceous age are found above the Patuxent Formation. The transitional beds

TABLE II - STRATIGRAPHIC AND HYDROGEOLOGIC UNITS - SOUTHEASTERN VIRGINIA

SYSTEM	SERIES	NORTH CAROLINA: STRATIGRAPHIC UNITS	NORTH CAROLINA: HYDROGEOLOGIC UNITS	VIRGINIA: STRATIGRAPHIC UNITS	VIRGINIA: HYDROGEOLOGIC UNITS	DESCRIPTION OF HYDROGEOLOGIC UNITS
QUATERNARY	RECENT PLEISTOCENE	POST-MIOCENE (UN-DIFFERENTIATED)	WATER TABLE OR QUATERNARY AQUIFER	RECENT COLUMBIA GROUP	WATER TABLE OR QUATERNARY AQUIFER	Unconsolidated sand, silt, and some gravel. Sand units yield quantities adequate for domestic and small industrial demands, used extensively for lawn watering. Unconfined aquifer.
TERTIARY	UPPER; MIOCENE MIDDLE	YORKTOWN; PUNGO RIVER	TERTIARY AQUIFER SYSTEM: SAND AQUIFER	CHESAPEAKE GROUP: YORKTOWN	YORKTOWN AQUIFER	Sand and shell beds main water-bearing units. Adequate for moderate public and industrial supplies. Artesian
				CHESAPEAKE GROUP: CALVERT	CONFINING UNITS	Silt and clay predominant, minor sand lenses.
	EOCENE	CASTLE HAYNE LIMESTONE	TERTIARY AQUIFER SYSTEM: LIMESTONE AQUIFER	NANJEMOY	NOT FOUND IN STUDY AREA	
	PALEOCENE	BEAUFORT		MATTAPONI	EOCENE-UPPER CRETACEOUS AQUIFER	Glauconitic sand and interbedded clay and silt. Infrequently used as a water supply. Yields adequate for moderate supplies. Brackish in most of area. Artesian
CRETACEOUS	UPPER	PEEDEE; BLACK CREEK	CRETACEOUS AQUIFER SYSTEM: UPPER UNIT	LOWER CRETACEOUS: TRANSITIONAL BEDS	LOWER CRETACEOUS	Interbedded gravel, sand, silt, and clay. Yields are adequate for large industrial use. Brackish in most of area. Artesian
	LOWER	UNNAMED	CRETACEOUS AQUIFER SYSTEM: LOWER UNIT	LOWER CRETACEOUS: PATUXENT		

Table 3. GEOLOGIC FORMATIONS PENETRATED BY WELLS 220-3 AND 217-6

	Elevation at top (ft-msl)	Thickness (ft)
Virginia Chemical Company Well 220-3 (N.W. Part of Study Area)		
Columbia	10	± 40
Yorktown	-30	± 290
Calvert	-320	120
Mattaponi	-440	70
"transitional beds"	-510	120
Patuxent	-630	370
Moores Bridges Well 217-6 (N. Central Part of Study Area)		
Columbia	10	± 100
Yorktown	Not determined	± 310
Calvert	-400	210
Mattaponi	-610	67
"transitional beds"	-677	105
Patuxent	-782	1,796

Adapted from Teifke, 1973

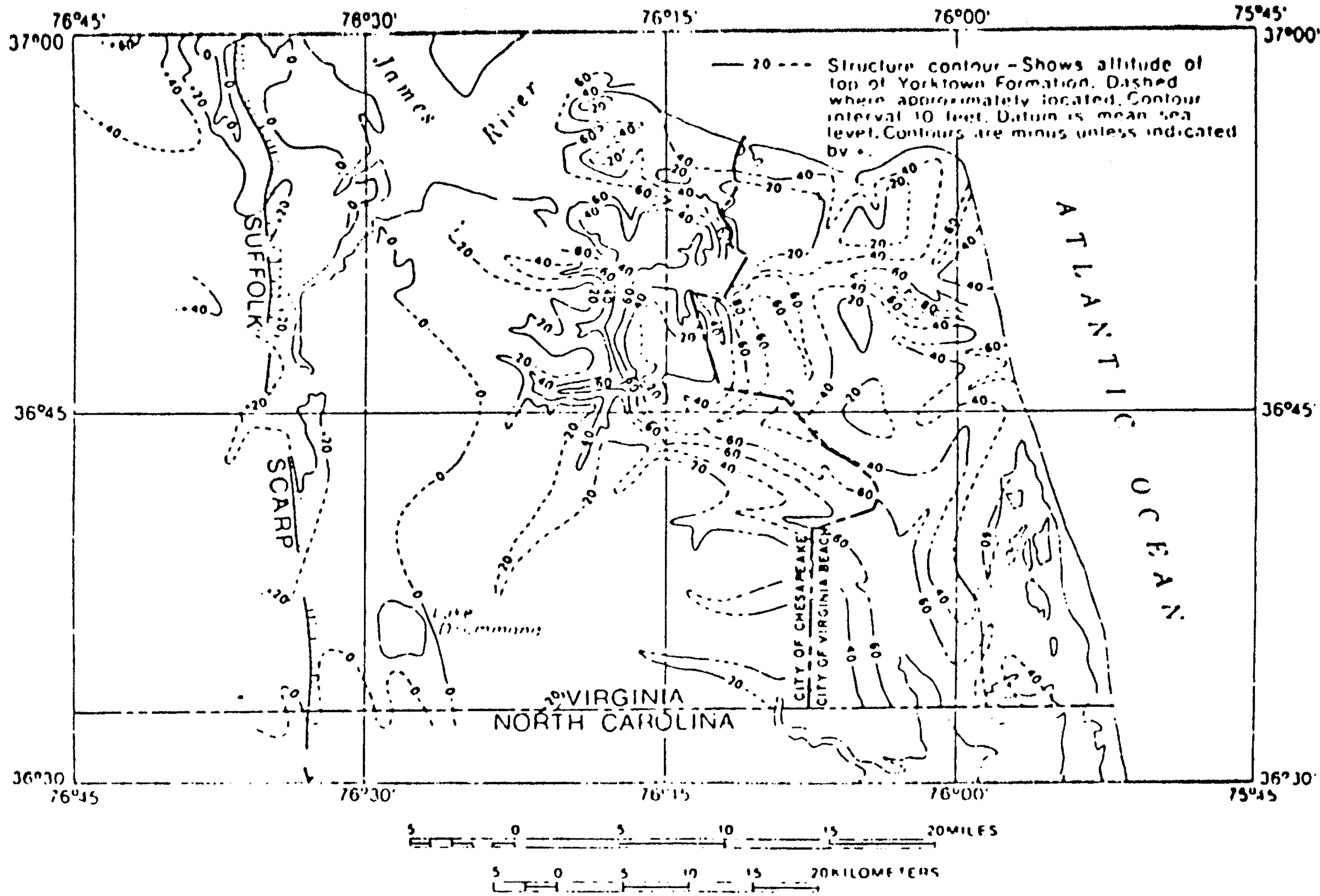
consist of sand, silt, and clay. These beds are either intermediate in composition and texture or comprise alternations of lithotypes characteristic of the Patuxent and Mattaponi Formations.

The Mattaponi Formation is of Upper Cretaceous (?), Paleocene, and Eocene age. This formation of marine origin is characterized by beds of quartz-glauconite sand, glauconitic clay, and shell. Abundant autochthonous (formed in place) glauconite is the principal lithologic criterion used to identify the formation (Teifke, 1973).

The Calvert Formation of Miocene age, which is commonly consolidated consists largely of clay and silty clay. A basal sand member consisting of medium-to-coarse sand may be present in the Calvert Formation along with some beds or lenses of phosphatic clay.

The Yorktown Formation consists of more abundant and markedly coarser sand and gravel beds and more abundant and thicker shell beds than the underlying Calvert Formation. The Yorktown is also lighter in color than the upper member of the Calvert. Plate 2 shows the topography of the top of the Yorktown Formation (Oaks and Coch, 1973).

The uppermost geologic unit, the Columbia Group, is characterized by beds of light-colored clay, sand and silt. The average thickness of the unit ranges from about 20 feet in the western part to 50 feet in the eastern part of the area. In the Four Cities area the Columbia group has been subdivided into six smaller units which, from oldest to youngest, are the Great Bridge Formation, the Norfolk Formation, the Kempsville Formation, the Londonbridge Formation, the Sand Bridge Formation and the undivided sediments (Oaks and Coch, 1973). The Division of Mineral Resources is currently updating the stratigraphy of the Columbia Group.



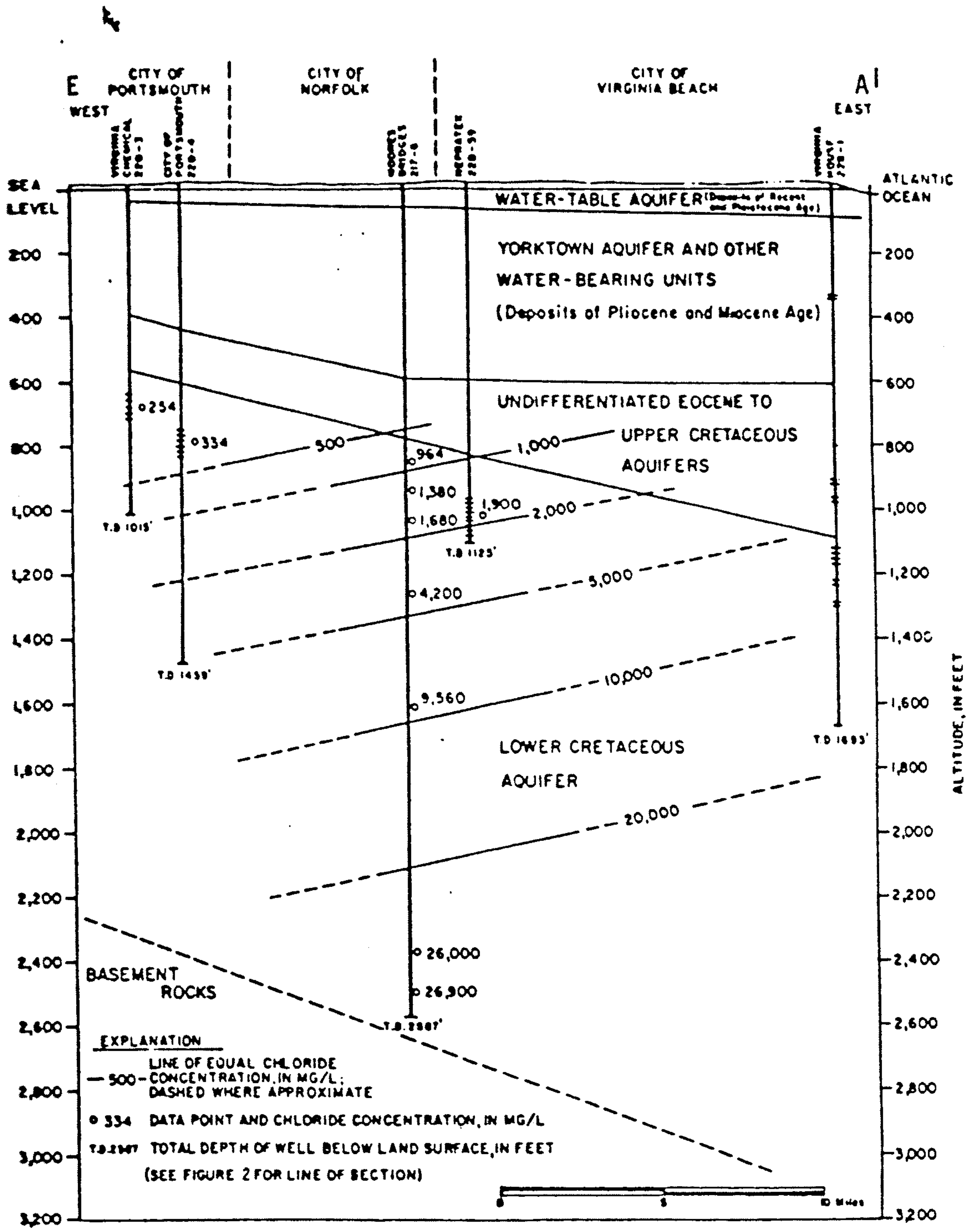
Topography of top of Yorktown Formation in the Study Area and adjoining areas. (Adapted from Oaks and Coch, 1973 and Geraghty and Miller, 1978)

Plate 2

Description of Aquifers

Four aquifers, one unconfined and three confined, underlie the study area. These aquifers and their geologic equivalents are as follows: 1) the water table aquifer (mostly the Columbia Group); 2) the Yorktown aquifer (upper part of the Yorktown Formation); 3) the Eocene-Upper Cretaceous aquifer (lower part of the Calvert and the Mattaponi Formation); 4) and the lower Cretaceous aquifer (the Potomac Group). Confining beds between and within the aquifer retard but do not prevent vertical movement of ground water. Overall, the water-bearing units comprise a leaky-aquifer system with the Lower Cretaceous aquifer exhibiting the most confinement. Cross section E-A', an east-west cross section which runs through the northern part of the study area, shows the four aquifers (Plate 3). The location of this cross section is shown in Plate 4.

Water Table Aquifer - The water table aquifer consists of beds and lenses of sand and some gravel, shell beds, silt, sandy clay, and clay. The sand and shell beds and sand and shell lenses, the major water-bearing strata, are very heterogeneous and discontinuous due to the complex marine estuarine environments in which they were deposited. Eight cross sections showing the major sand and shell beds in the water table and the Yorktown aquifer systems were developed by correlating the resistivity, gamma, and geologic logs of selected wells (Plates 4, 5, 6, 7 and 8). The geophysical and geologic logs indicate that the typical sand bodies in the water table aquifer consist of one or two beds or lenses of medium-to-coarse sand 5 to 10 feet thick. Although these cross sections are



Hydrogeologic cross-section E-A' showing vertical distribution of brackish and salty ground water in the Lower Cretaceous Aquifer. (Adapted from W. R. Lichtler and R. L. Wait, 1974 and Geraghty and Miller, 1978)

Plate 3

very generalized and so do not reflect the frequent variations between data points, they demonstrate the consistent occurence of the major sand bodies in both the water table and Yorktown aquifer system.

Recent dune sand, which was deposited by wind and wave action, occurs along the coast in a number of places. There it constitutes a part of the water table aquifer. The thickest dune sands are located at Cape Henry in the northeastern part of the study area.

Limited well yield and specific capacity data records are available for the water table aquifer (Plate 9 and Appendix B). Individual well yields range from 5 to 50 gpm and specific capacities range from about 1 to 2 gpm/ft (gallons per minute per foot of drawdown). In the 1930's and 1940's, a number of well fields consisting of batteries of small diameter wells obtained water from the water table aquifer (Cederstrom, 1945). These systems typically consisted of 10-20 wells which produced a total of between 50 and 200 gpm. Most, if not all, of these have been shut down due to increasing urbanization or substitution of city water. Cederstrom also reports that batteries of 2-inch well points about 15 feet deep yield as much as 150 gpm from dune sand at Cape Henry in northeastern Virginia Beach.

Yorktown Aquifer - Although the Yorktown Formation is 300 to 400 feet thick, the major water-bearing zones comprising the Yorktown aquifer are found in the upper 50 to 100 feet of the Yorktown Formation. The Yorktown aquifer generally is separated from the overlying water table aquifer by beds of silt, clay and sandy clay about 20 to 40 feet thick (Plates 4, 5, 6, 7, and 8). The Yorktown aquifer is separated from the underlying Eocene-Upper Cretaceous aquifer by several hundred feet of silt and clay, 350 feet thick

FOUR CITIES GROUND WATER YIELD LOCATIONS

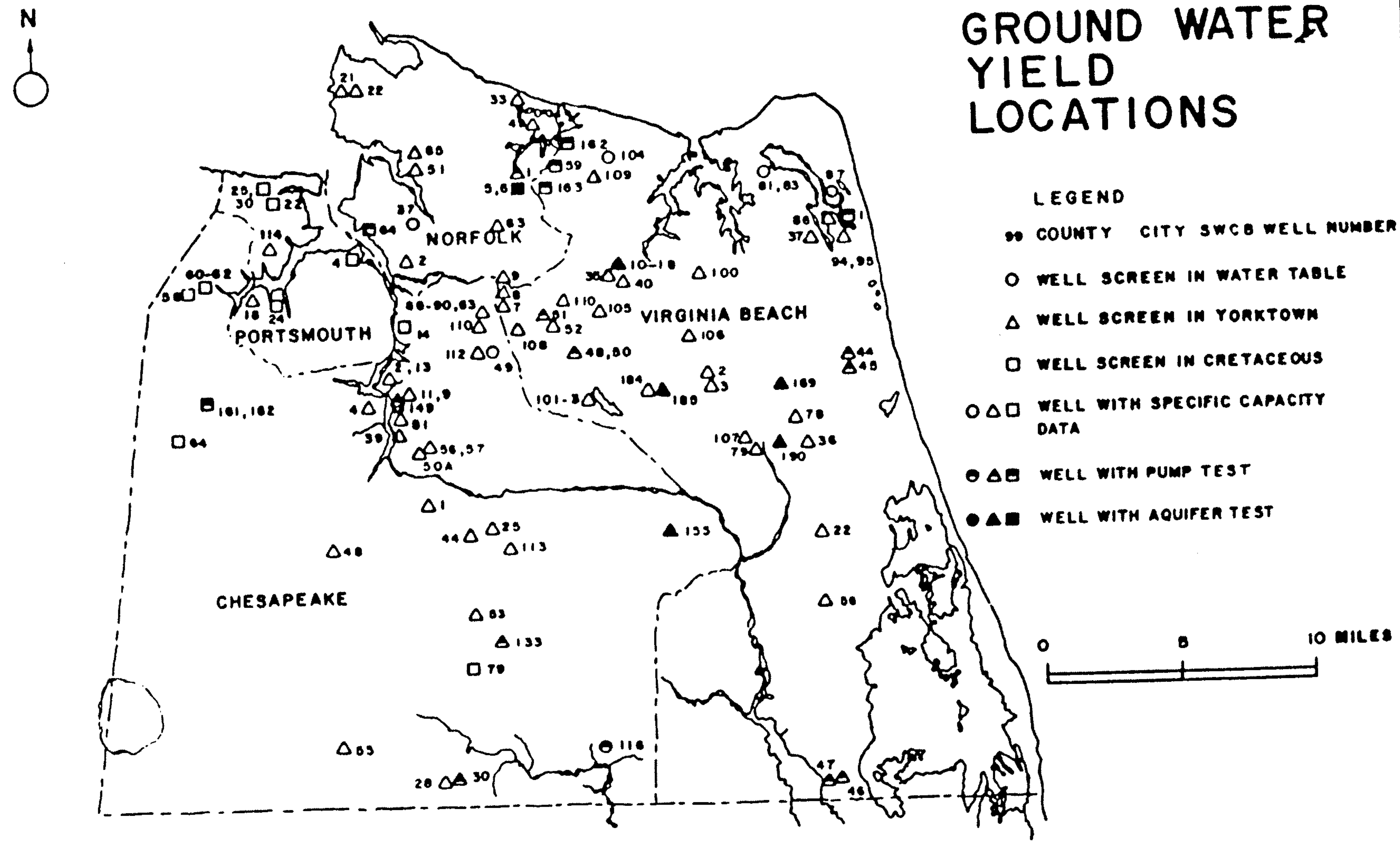


PLATE NO. 9

in the western study area to over 750 feet thick in the eastern study area.

The major water-bearing zones in the Yorktown aquifer, generally found at depths ranging from 50 to 150 feet, are composed of beds of fine-to-coarse sand, gravel, and shells generally 5 to 20 feet thick (Plates 4, 5, 6, 7 and 8). These eight cross-sections show that three major sand units, referred to as the upper, middle and lower units, comprise the Yorktown aquifer in the Four Cities area. The units are separated by silt and clay beds. Even though geophysical and geologic logs indicate that these three sand units generally are continuous throughout most of the area, the thickness, permeability, and coarseness of the units vary considerably from one data point to another. Usually one unit generally predominates in productivity from one place to another. An example can be seen by observing geophysical log correlations from well 234-136 to well 234-25 in cross section C-C' (Plate 6). The resistivity log deflection at 234-136 indicates that the upper unit predominates, whereas the deflection of the resistivity log at 234-25 indicates that the middle unit is more predominant.

Available well yield and specific capacity data for the Yorktown aquifer was limited generally to 85 larger diameter wells (6 inch or greater in diameter) used for public, commercial, or industrial supply (Plate 9 and Appendix B). Well yields for these wells range from 12 to 304 gpm with an average of about 87 gpm. Specific capacities range from 0.5 to 14.4 gpm/ft with an average of 5 gpm/ft. Area well drillers indicate that smaller diameter (1 1/4 inch to 2 inch) domestic well yields range from 5 to 50 gpm.

Eocene-Upper Cretaceous Aquifer - This aquifer is found at a depth of about 500 feet in the western part of the study area to depths of about 1000 feet in the eastern part (Plate 3). The aquifer generally consists of one or two fine-to medium-grained glauconitic sand beds 10 to 30 30 feet thick interbedded with silt and clay.

Very few wells have tapped the Eocene-Upper Cretaceous aquifer in the study area. Most deep wells go beyond the Eocene-Upper Cretaceous aquifer in order to tap the more productive Lower Cretaceous aquifer. Only six wells (all in the City of Chesapeake) are known to have tapped the Eocene-Upper Cretaceous aquifer. These wells include the abandoned Canal Bank Motel well near Cornland (234-71), the SWCB Research Station at Cornland (234-135), the City of Chesapeake test well near Saint Brides (234-146), the Oak Manor Farm well near Fentress as discussed by Cederstrom (1945), the SWCB Research Station at Fentress Naval Air Station (234-66) and the Tidewater Chemical well at Saint Brides (234-79). Only one of these wells, the Tidewater Chemical well, has well yield data; it yielded 150 gpm with a specific capacity of 2.5 gpm/ft (Plate 9 and Appendix B).

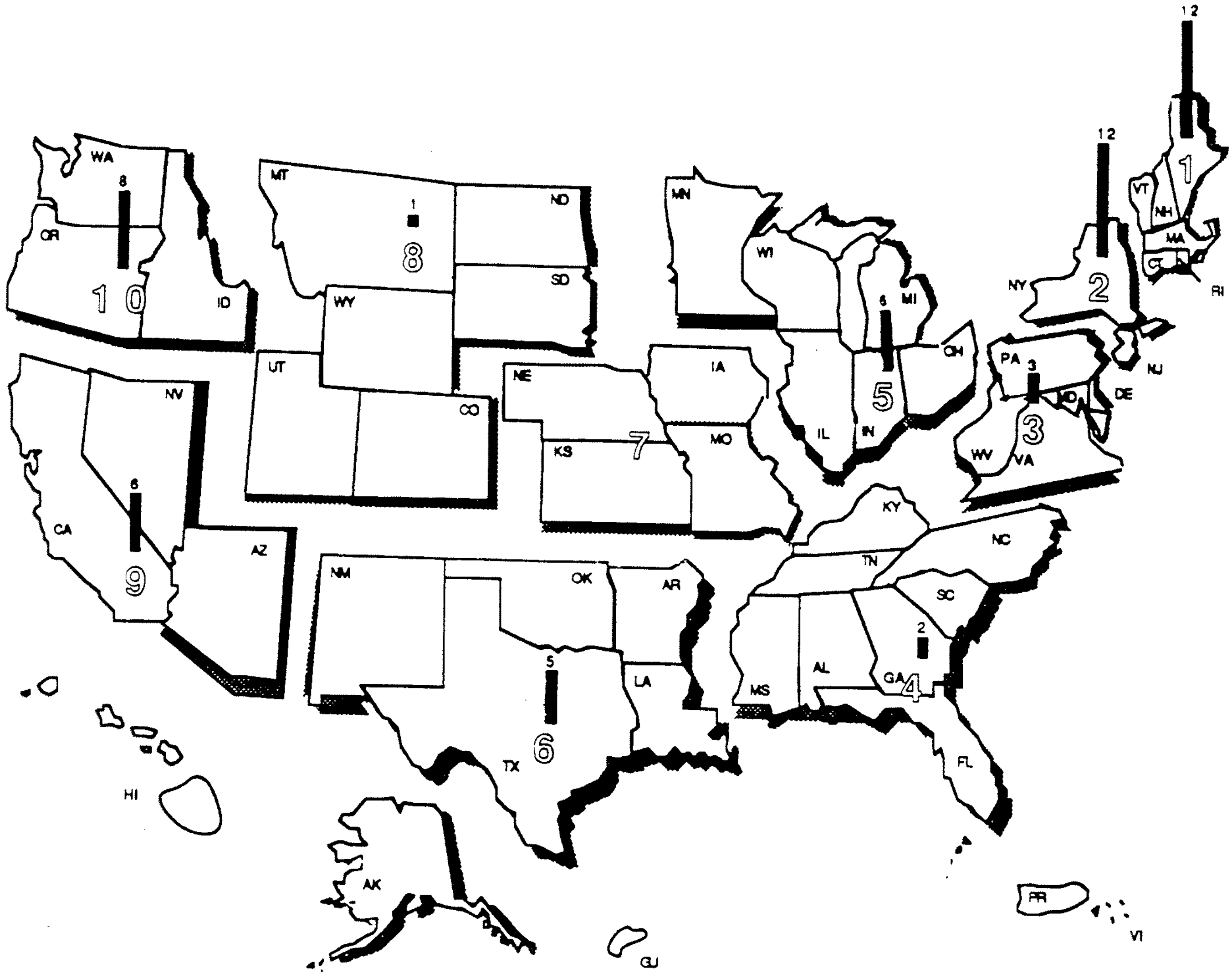
Lower Cretaceous Aquifer - The Lower Cretaceous aquifer is composed of interbedded gravel, sand, silt, and clay. Generally, it is separated from the Eocene-Upper Cretaceous aquifer by clay and silt units 50 feet or more thick. Beds of clay divide the aquifer into several permeable zones. The top of the aquifer ranges from 600 feet below land surface in the northwestern study area to about 1100 feet in the eastern part (Plate 3). The bottom of the aquifer rests on basement rocks at a depth of 2000 feet in the west, to about 4000 feet in the east.

The majority of wells drilled in the Lower Cretaceous aquifer are found in northwestern Chesapeake, in Portsmouth, and in western Norfolk where the aquifer contains fresh or slightly brackish water. Well yields for this aquifer range from 200 to 1000 gpm and specific capacities range from 2.9 to 30.8 gpm/ft (Plate 9 and Appendix B).

EXHIBIT 3-8

DESIGNATED SOLE SOURCE AQUIFERS NATIONALLY

Fact Sheet and Designated Aquifer List



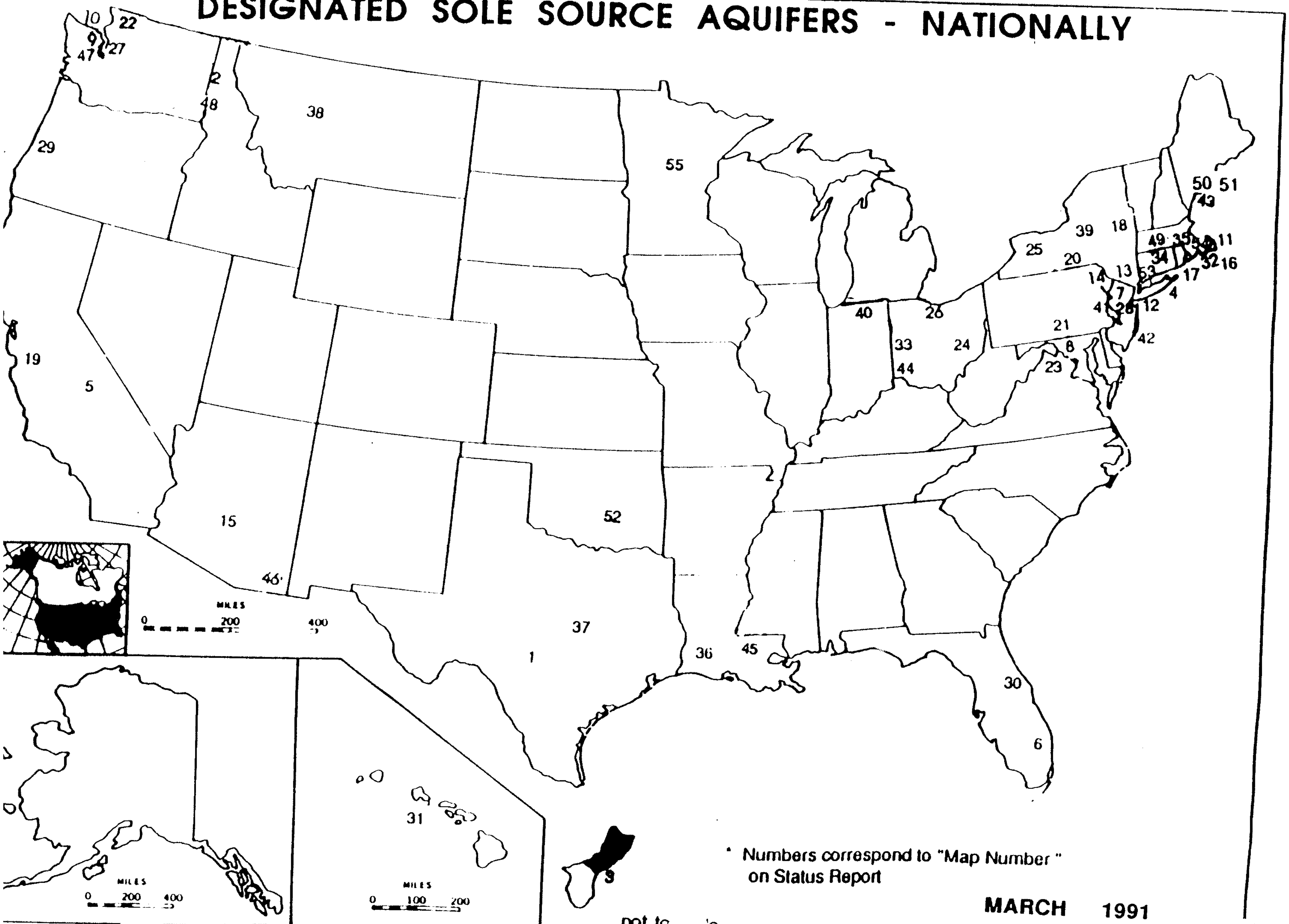
Key

8 Length of Bar indicates number of Designated Sole Source Aquifers in each EPA Region

Office of Ground-Water Protection
U.S. Environmental Protection Agency

MARCH 1991

DESIGNATED SOLE SOURCE AQUIFERS - NATIONALLY



* Numbers correspond to "Map Number"
on Status Report

MARCH 1991

(This map shows only the general relative l[ocatio]ns of designated aquifers

Sole Source Aquifer Designation Program

Background

The Sole Source Aquifer (SSA) program allows individuals and organizations to petition the Environmental Protection Agency (EPA) to designate aquifers as the "sole or principal" source of drinking water for an area. The program was established under Section 1424(e) of the Safe Drinking Water Act (SDWA) of 1974. The primary purpose of the designation is to provide EPA review of Federal financially assisted projects planned for the area to determine their potential for contaminating the aquifer "so as to create a significant hazard to public health". Based on this review, no commitment of Federal financial assistance may be made for projects "which the Administrator (of EPA) determines may contaminate such (an) aquifer," although Federal funds may be used to modify projects to ensure that they will not contaminate the aquifer.

The first aquifer to be designated was the Edwards Aquifer in the San Antonio, Texas area in 1975. The EPA proposed specific regulations for this first designated aquifer.

In 1977, EPA issued proposed regulations to implement this program. The proposed regulations contained detailed definitions, sole source designation procedures and project review criteria. Although these guidelines were not finalized, an additional twenty (20) aquifers were designated from this time until the SDWA Amendments were enacted on June 19, 1986.

The SSA program is not intended to be used to inhibit or stop development of landfills, publicly-owned treatment works (POTWs) or public facilities financed by non-Federal funds. Furthermore, the SSA program is not linked to other Federal environmental regulatory or remedial programs, except where Federal financial assistance is committed in a designated sole source aquifer area.

Recent Changes in the Program

In 1987, EPA delegated authority to approve SSA petitions to Regional Administrators. EPA also published the Sole Source Aquifer Designation Petitioner Guidance to assist SSA petitioners in preparing and submitting petitions to EPA Regional Offices.

The guidance document provides the petitioner with an outline of methods for determining the sole or principal source of drinking water and the aquifer boundaries and describes other hydrogeological and water supply data necessary for EPA Regional Offices to make a finding of sole source or principal source status.

The Safe Drinking Water Amendments of 1986 added a new Section 1427, "to establish procedures for development, implementation and assessment of demonstration programs designed to protect critical aquifer areas located within areas designated as sole or principal source aquifers under section 1424(e) of this Act." This section allows areas with either an SSA designation by June 19, 1988, or designation by June 19, 1986 and an approved Clean Water Act Section 208 plan to apply for demonstration program funds to plan, implement and evaluate innovative management approaches to protecting ground-water quality. EPA established criteria to identify critical aquifer protection areas. (See 40 CFR 149, Federal Register, February 14, 1989, pages 6836 to 6843.) No funding has been appropriated for the demonstration program for FY 87 - 91 and, as a result, no grant guidance or application forms have been developed by EPA.

Current Sole Source Aquifer Designation Status

As of March 1991, twenty-two sole source aquifer designations have been made using the 1987 petitioner guidance. In total, EPA has approved 55 SSA designations nation-wide. Also, eleven petitions are currently being evaluated for possible designation. In the past, 12 petitions have not been approved because of insufficient information or loss of petitioner interest in following up to provide needed data. A list and a map of the 55 designated Sole Source Aquifers, and a list of the eleven Sole Source Aquifer petitions undergoing designation review in the Regions are attached.

Post-Designation Review

After designation, no commitment of Federal financial assistance may be made to a project that is found through EPA review to have the potential to contaminate the aquifer so as to create a hazard to public health. The EPA has established and continues to set up arrangements with other Federal agencies to expedite this project review where sole source aquifers have been designated. In some cases, hydrogeological data for federally assisted projects is supplied under requirements of the National Environmental Policy Act (NEPA) which may be adequate for a determination regarding the potential for aquifer contamination. The Regional Offices of EPA make the determinations regarding the potential for SSA contamination for the aquifers designated in their regions. For additional details regarding the semi-annual reporting of post SSA designation reviews see, Sole Source Aquifer-Post Designation Project Review Tracking Summary for Fiscal Year 1990, available upon request.

DATE: March 1991

STATUS AS OF 03/31/91

DESIGNATED SOLE SOURCE AQUIFERS - NATIONALLY

Region	Map Number	Aquifer and/or Location	State	Petition Filed	Federal Register Notice Citation	Federal Register Notice Publication Date
VI	1.	San Antonio Area Edwards Aquifer	TX	1/03/75	40 FR 58344	12/16/75
X	2.	Spokane Valley-Rathdrum Prairie Aquifer	WA/ID	fall of '76	43 FR 5566	02/09/78
IX	3.	Northern Guam	GU	11/20/75	43 FR 17868	04/26/78
II	4.	Nassau/Suffolk Counties Long Island	NY	1/21/75	43 FR 26611	06/21/78
IX	5.	Fresno County	CA	8/09/76	44 FR 52751	09/10/79
IV	6.	Biscayne Aquifer	FL	5/08/78	44 FR 58797	10/11/79
II	7.	Buried Valley Aquifer System	NJ	1/15/79	45 FR 30537	05/08/80
III	8.	Maryland Piedmont Aquifer Montgomery, Frederick, Howard, Carroll Counties	MD	09/12/75	45 FR 57165	08/27/80
X	9.	Camano Island Aquifer	WA	4/13/81	47 FR 14779	04/06/82
X	10.	Whidbey Island Aquifer	WA	4/13/81	47 FR 14779	04/06/82
I	11.	Cape Code Aquifer	MA	3/04/81	47 FR 30282	07/13/82
II	12.	Kings/Queens Counties Brunswick Shale and	NY	6/18/79	49 FR 2950	01/24/84
II	13	Brunswick Shale and Sandtone Aquifer Ridgewood Area	NY/NJ	7/04/79	49 FR 2943	01/24/84

STATUS AS OF 03/31/91

DESIGNATED SOLE SOURCE AQUIFERS - NATIONALLY

Region	Map Number	Aquifer and/or Location	State	Petition Filed	Federal Register Notice Citation	Federal Register Notice Publication Date
II	14.	Rockaway River Basin Area	NJ	11/30/79	49 FR 2946	01/24/84
IX	15.	Upper Santa Cruz & Avra Altar Basin Aquifers	AZ	6/29/81	49 FR 2948	01/24/84
I	16.	Nantucket Island Aquifer	MA	12/02/82	49 FR 2952	01/24/84
I	17.	Block Island Aquifer	RI	2/18/83	49 FR 2952	01/24/84
II	18.	Schenectady/Niskayuna Schenectady, Saratoga and Albany Counties	NY	8/20/82	50 FR 2022	01/14/85
IX	19.	Santa Margarita Aquifer Scotts Valley, Santa Cruz County	CA	9/07/77	50 FR 2023	01/14/85
II	20.	Clinton Street-Ballpark Valley, Aquifer System, Broome and Tioga Counties	NY	2/26/81	50 FR 2025	01/14/85
III	21.	Seven Valleys Aquifer York County	PA	9/24/81	50 FR 9126	03/06/85
X	22.	Cross Valley Aquifer Snohomish, King Counties	WA	7/29/83	52 FR 18606	05/18/87
III	23.	Prospect Hill Aquifer Clark County	VA	6/27/85	52 FR 21733	06/09/87

STATUS AS OF 03/31/91

DESIGNATED SOLE SOURCE AQUIFERS - NATIONALLY

Region	Map Number	Aquifer and /or Location	State	Petition Filed	Federal Register Notice Citation	Federal Register Notice Publication Date
V	24.	Pleasant City Aquifer, Guernsey County	OH	8/27/84	52 FR 32342	08/27/87
II	25.	Cattaraugus Creek Basin Aquifer System (CCBA)	NY	2/28/85	52 FR 36100	09/25/87
V	26.	Catawba Island Bass Island Aquifer	OH	3/17/86	52 FR 37009	10/02/87
X	27.	Newberg Area Aquifer Snohomish County	WA	1/16/84	52 FR 37215	10/05/87
II	28.	Highlands Aquifer System	NY/NJ	3/14/85	52 FR 37213	10/05/87
X	29.	North Florence Dunal Aquifer Lane County	OR	6/02/85	52 FR 37519	10/07/87
IV	30.	Volusia-Floridan Aquifer Volusia, Flager, Putnam County	FL	6/18/82	52 FR 44221	11/18/87
IX	31.	Southern Oahu Basal Aquifer	HI	5/03/83	52 FR 45496	11/30/87
I	32.	Martha's Vineyard Regional Aquifer	MA	6/16/87	53 FR 3451	02/05/88
V	33.	Buried Valley Aquifer System (BVAS)	OH	11/25/87	53 FR 15876	05/04/88

STATUS AS OF 03/31/91

DESIGNATED SOLE SOURCE AQUIFERS - NATIONALLY

Region	Map Number	Aquifer and/or Location	State	Petition Filed	Federal Register Notice Citation	Federal Register Notice Publication Date
I	34.	Pawcatuck Basin Aquifer System	RI/CT	11/30/87	53 FR 17108	05/13/88
I	35.	Hunt-Annaquatucket-Pettaquamscutt Aquifer System (HAP)	RI	12/30/87	53 FR 19026	05/26/88
VI	36.	Chicot Aquifer	LA	12/05/86	53 FR 20893	06/07/88
VI	37.	Austin Area Edwards Aquifer	TX	08/29/86	53 FR 20897	06/07/88
VIII	38.	Missoula Valley Aquifer	MT	11/23/87	53 FR 20895	06/07/88
II	39.	Cortland- Homer-Preble Aquifer System	NY	9/15/87	53 FR 22045	06/13/88
V	40.	St. Joseph Aquifer System (Elkart Co)	IN	12/11/87	53 FR 23682	06/23/88
II	41.	N.J. Fifteen Basin Aquifer Systems	NJ/NY	11/18/85	53 FR 23685	06/23/88
II	42.	N.J. Coastal Plain Aquifer System	NJ	12/04/78	53 FR 23791	06/24/88
I	43.	Monhegan Island	ME	5/16/88	53 FR 24496	06/29/88

STATUS AS OF 03/31/91

DESIGNATED SOLE SOURCE AQUIFERS - NATIONALLY

Region	Map Number	Aquifer and/or Location	State	Petition Filed	Federal Register Notice Citation	Federal Register Notice Publication Date
V	44.	OKI - Miami Buried Valley Aquifer	OH	03/10/88	53 FR 25670	07/08/88
VI	45.	Southern Hills Aquifer System	LA/MS	5/19/80	53 FR 25538	07/07/88
IX	46.	Bisbee-Naco Aquifer, Cochise County	AZ	10//83	53 FR 38337	09/03/88
X	47.	Cedar Valley Aquifer King County	WA	3/3/88	53 FR 38779	10/03/88
X	48.	Lewiston Basin Aquifer	WA/ID	12/27/87	53 FR 38782	10/03/88
I	49.	Head of Neponset Aquifer Area	MA	05/10/88	53 FR 49920	12/12/88
I	50.	Vinalhaven Island Aquifer System	ME	06/03/88	54 FR 29779	07/14/89
I	51.	North Haven Island Aquifer System	ME	06/03/88	54 FR 29934	07/17/89
VI	52.	Arbuckle-Simpson Aquifer South Central Oklahoma	OK	07/29/88	54 FR 39230	09/25/89
I	53.	Pootatuck Aquifer	CT	03/09/89	55 FR 11056	03/26/90
I	54.	Plymouth-Carver Aquifer	MA	04/07/89	55 FR 32137	08/07/90
V	55.	Mille Lacs Aquifer	MN	12/87	55 FR 43407	10/29/90

PENDING SOLE SOURCE AQUIFER PETITONS - BY REGION

STATUS AS OF 03/31/91

PENDING SOLE SOURCE AQUIFER PETITIONS - BY REGION

Region	Aquifer and/or Location	State	Petitioner(s)	Petition Filed
I	Matinicus Island Aquifer	ME	State of Maine	03/90
	Islesboro Island Aquifer	ME	State of Maine	06/90
	Swan Island Aquifer	ME	State of Maine	10/90
	Long Island Aquifer (Frenchboro)	ME	State of Maine	12/90
II	NONE			
III	NONE			
IV	NONE			
V	Allen County, Silurian-Devonian Aquifer System	OH	Dumpbusters, Inc.	10/90
VI	NONE			
VII	Big Spring Ozark/St.Francis Aquifer	MO	U.S. Park Service	12/12/89
VIII	New Rockford Aquifer	ND	Orval Hovey	05/08/84
IX	San Mateo Basin Aquifer	CA	U.S. Marine Corps	06/89
X	Central Pierce County Aquifer	WA	Pierce County-Tacoma Health Department	07/01/87
	Tulalip Aquifer	WA	Seven Lakes Water Association	04/11/84
	Eastern Snake River Plain Aquifer	ID	Hagerman Valley Citizens' Alert, Inc.	10/25/82

TOTAL 11 Petitions Pending

EXHIBIT 3-9

WGThomas/CF; WDTrimbath/JWMentz/HF.
RPWattras; DPBlack (Orig.)

MICHAEL BAKER, JR., INC.

PHONE CALL REPORT

PROJECT/LOCATION: HRS SCORING - NAVY CLEAN (VIRGINIA SITES)

S.O. No.: 19002-50-SRN

DATE: 4/15/91 - 1:53 PM

CONTRACT NO.:

To: MR. TERRY WAGNER | From: DPBLACK
Repres.: VA. WATER CONTROL BOARD | Repres.: BAKER ENVIRONMENTAL, INC.
Phone No.: (804) 367-6347 | Phone No.: X6047

Subject: Wellhead Protection Areas in the State of Virginia

I called Mr. Wagner to ask him if he has a list of Wellhead Protection Areas in the state as provided for in Section 1428 of the Safe Drinking Water Act. He told me that Virginia does not have a Wellhead Protection Program, so none of our sites are located in a Wellhead Protection Area.

PREPARED BY DPBlack TITLE Geologist PAGE 1 OF 1

OP-3
9/80

EXHIBIT 4-1

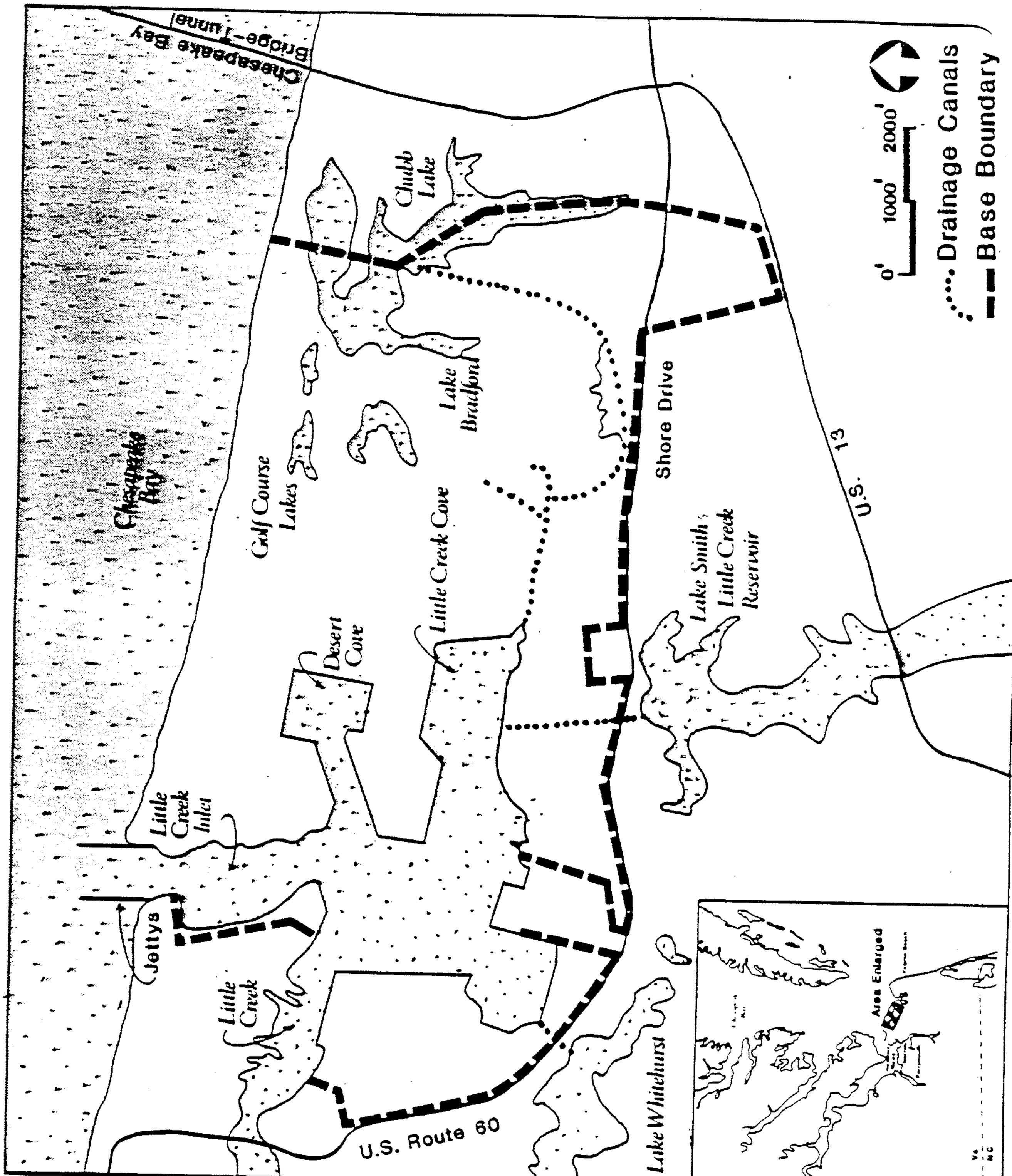


Figure 2-1
General Location Map

Rogers, Golden & Halpern

Initial Assessment Study
Naval Amphibious Base
Little Creek
Norfolk, Virginia

MASTER PLAN

NAVAL AMPHIBIOUS BASE LITTLE CREEK
NORFOLK, VIRGINIA

November 1986

Pierce Goodwin Alexander
800 Bering Drive
Post Office Box 13319
Houston, Texas 77219

Contract N62470-84-C-6925

Atlantic Division
Naval Facilities Engineering Command
Norfolk, Virginia

2.2.3 HYDROLOGY

To develop the base economically:

- Keep the existing system of major drainage canals and lakes.

NAB Little Creek

Little Creek Harbor is a tidal estuary with semi-diurnal tide range of about 2.6 feet. The spring tide range is 3.1 feet and the mean tide is 1.3 feet above mean low water (MLW). Storm-induced tide levels have been recorded ranging from 2 feet below MLW to 8.5 feet above MLW. Tidal currents in the entrance channel average 0.9 knots. In the absence of freshwater flow, tidal mixing flushes the harbor. The flushing rate is estimated to be long, on the order of weeks.

The Northwest Branch of Little Creek (see Fig. 2.1) flows into the harbor from the west through Fisherman's Cove. The City of Norfolk reservoirs, Lake Whitehurst and Lake Smith, have unlined overflow channels which discharge into the harbor from the south. During severe storm events, the bypass line from the Hampton Roads Sanitation District (HRSD) plant discharges into the southeast corner of Little Creek Cove.

Most rainfall at NAB Little Creek eventually drains to Little Creek Harbor; the only exception is rainfall on the beach which drains directly to Chesapeake Bay. Fig. 2.1 shows the major surface water areas on base. The east half of the base drains first to Chubb Lake or Lake Bradford. The interconnected lakes are drained by a canal which flows southwest, crossing under D Street and Nider Boulevard, and then turning northwest to Little Creek Cove. The wier on the canal near Nider is used to adjust the levels of the two lakes. The golf course area drains to five small lakes, which are interconnected through pipes and channels. While most of this flow is lost through infiltration or evaporation, during extreme rainfall some flow from these lakes reaches Little Creek Cove.

Water quality in Little Creek Harbor is fair. The harbor is classified as Type IIB waters by the State Water Control Board. Shellfishing is precluded by the fecal coliform levels, but swimming is permitted. Commercial fishing is not allowed by the State although sport fishing is common in the west half of the harbor. Elutriate tests of harbor sediments show that sediment levels of oil and grease are only slightly elevated in comparison to the harbor water while levels of copper, lead and other metals are significantly elevated.

The shallow groundwater zone on base extends from the ground surface to about 20 feet below mean sea level in the sediments of the Columbia formation. This water from base wells (average 15 to 20 feet deep) is used for irrigation only. While the NAB well water quality has not been measured, typical problems are high chlorides and iron content, and low PH.

The major water aquifer is the Yorktown formation, found approximately 50 to 150 feet below the surface near NAB. The formation consists of waterbearing units (sand and shell) separated by lenses of clay. The 1984 Initial Assessment Study of potential hazardous waste problems on base concluded that it was unlikely that surface contaminants had penetrated to the Yorktown formation. The Yorktown aquifer is not used for municipal supplies in the area because the quality varies radically.

Potable water supply for the base comes from the City of Norfolk system which primarily uses surface water. The City water reservoirs, Lake Whitehurst and Lake Smith, lie immediately south of the base. Subsurface flow in the City reservoirs normally would migrate toward Little Creek Harbor because the reservoir water level is above the harbor. If the reservoirs were drawn down severely, as in a drought, the subsurface flow could go towards the reservoirs.

NAB Annex

The NAB Annex lies next to the Atlantic Ocean, south of Rudee Inlet. Lake Christine is located just north of the Annex and Lovetts Marsh lies inside the NAB property (see Fig. 2.2). Rainfall on site drains to Lovetts Marsh where the water evaporates or infiltrates into the ground. A drainage ditch connects Lake Christine, Lovetts Marsh and Redwing Lake to the south at Fleet Combat Training Center (FCTC) Dam Neck. The drainage ditch is now clogged so that it probably operates only during extreme storm tides or high rainfall events. During major storms water from the marsh may flow south to Redwing Lake.

2.2.4 FLOOD PLAINS

Executive Order 11988, Flood Plain Management, requires the identification of 100-year and 500-year flood plains. Flood plain mapping on Federal property is excluded from the Federal Emergency Management Agency (FEMA) 1984 Flood Insurance Study 515531 for the City of Virginia Beach. However the storm stillwater surge elevations from this study can be used to estimate the extent of the 100-year and 500-year flood plains on base. No official flood plain maps for the base are available.

Navy policy for flood plains (NAVFACINST 11010.63B) is to accomplish land use and facility planning treating flood plains as an uninhabitable land use, to the extent possible. Projects located in flood plains require environmental documentation. Since flood plains cover most of the base, many projects at Little Creek must be located in flood plains. To develop the base effectively:

- Plan for realistic functional relationships.

- Where projects lie inside the flood plains, minimize flood damage by using the base design policy of 12 feet MSL for building floor elevation.

NAB Little Creek

The FEMA study gives 8.7 feet mean sea level (MSL) as the 100-year storm stillwater surge elevation in Chesapeake Bay along the Little Creek beach and 10.1 feet as the 500-year storm stillwater surge elevation. The ground contours which match those stillwater surge elevations define the extent of the 100-year and 500-year flood plains at NAB Little Creek (see Fig. 2.5, page 2-17). The NAB design policy raises building floor elevations well above the stillwater surge elevations.

The 100-year storm elevation with waves on Chesapeake Bay is 13 feet MSL and in Little Creek Harbor is 9 feet MSL. The barrier dunes protect the NAB developed areas from the high waves at the beachfront. The FEMA studies assume that waves that do go inland (like those at the harbor) dissipate quickly in shallow water depths.

NAB Annex

Fig. 2.6, page 2-19, shows the extent of the 100-year and 500-year flood plains. These flood plains are estimated from the 1985 FEMA stillwater surge elevations at the oceanfront adjacent to the NAB Annex: 8.7 feet for the 100-year and and 10.1 feet MSL for the 500-year storm. The 1985 FEMA maps give the 100 year storm elevation with waves as 13 feet at the oceanfront and 9 feet MSL at Lake Christine. Since flood elevations are similar, the Little Creek design policy can be extended to the NAB Annex.

EXHIBIT 4-2

Baker

Baker Environmental, Inc.
Airport Office Park, Building 3
420 Rouser Road
Coraopolis, Pennsylvania 15108

(412) 269-6000
FAX (412) 269-6097

March 29, 1991

Mr. Clarence Warnstaff
Department of Public Utilities
City of Virginia Beach
Municipal Center
Virginia Beach, VA 23456

Dear Mr. Warnstaff:

Baker Environmental, Inc. (Baker) is currently performing environmental related services under contract to the Department of the Navy in the Virginia Beach area. As part of this contract we are tasked with gathering information concerning the public water distribution system in the area.

On March 25, 1991, I spoke with Mr. Tom Leahy by telephone to discuss Baker's information requirements. At that time, he suggested that a letter outlining Baker's information needs be forwarded to you. The following is a list of the information we are required to collect. If any of this information cannot be provided by your office, the suggestion of other possible information sources would be greatly appreciated.

- The area or extent (boundaries) of the City of Virginia Beach's public water distribution system

- The source(s) of Virginia Beach's water supply (i.e., groundwater, surface water, a mixture of both, or purchased from someone)

- If water is obtained from surface water sources, determine locations of intake points

- If public water is obtained from groundwater sources, determine the location of system well(s), their specifications (e.g., depth, water level, diameter, flow rates, etc.), the aquifer(s) tapped, and specifics (e.g., hydraulic conductivity, porosity, aquifer transmissivity, hydraulic gradient, aquifer thickness, confining layers, etc.) of the aquifer(s) tapped

- If public water is obtained from a mixture of groundwater and surface water sources, determine the approximate percentage obtained from each

- Estimate the number of people served by the public water distribution system

- Identify if public water (either surface or ground) is used for:

    - Irrigation (5-acre minimum) of commercial food crops or commercial forage crops;

- Watering commercial livestock;
- Ingredient in commercial food; or,
- Major or designated water recreation area.

Baker needs to collect the above information no later than April 12,1991. I will follow up this letter with a telephone call before the end of the week to ensure that you have received the letter and so we can determine the level of effort required to collect the information (i.e., is the information readily available, how long will it take to collect, can the information be copied and mailed or should Baker supply a person to assist in the researching process, etc.).

If you have any questions upon receiving the letter, please feel free to call me at (412) 269-6000. Your assistance and efforts in performing this task are greatly appreciated.

Very truly yours,

BAKER ENVIRONMENTAL, INC.

Jeffrey S. Laskey
Chemical Engineer

City of Virginia Beach

DEPARTMENT OF PUBLIC UTILITIES
(804) 427-4346
FAX (804) 426-5778

MUNICIPAL CENTER
VIRGINIA BEACH, VIRGINIA 23456-9041

April 9, 1991

Jeffrey S. Laskey
Baker Environmental, Inc.
Airport Office Park, Building 3
420 Rouser Road
Coraopolis, Pennsylvania 15108

Dear Mr. Laskey:

Re: Public Water Distribution System, Department of the Navy, Virginia Beach Area - Federal Agencies - U. S. Navy

In response to your letter of March 29, 1991, the following items numbered 1 through 7 are keyed to your list of requested information:

1. Please see attached map showing boundaries of the City of Virginia Beach's public water distribution system.

2. City of Norfolk.

3. 4. 5. We understand that you have sent Norfolk a similar inquiry. As our water supplier, they will provide the data on these items.

6. 380,000.

7.
   a. No
   b. No
   c. No
   d. Wild Water Rapids Water Park, 849 General Booth Boulevard, Virginia Beach VA 23451
      Kempsville Recreation Center, 800 Monmouth Lane, Virginia Beach VA 23464
      Great Neck Recreation Center, 2521 Shorehaven Drive, Virginia Beach VA 23454

Should you require additional information or assistance, please feel free to call me.

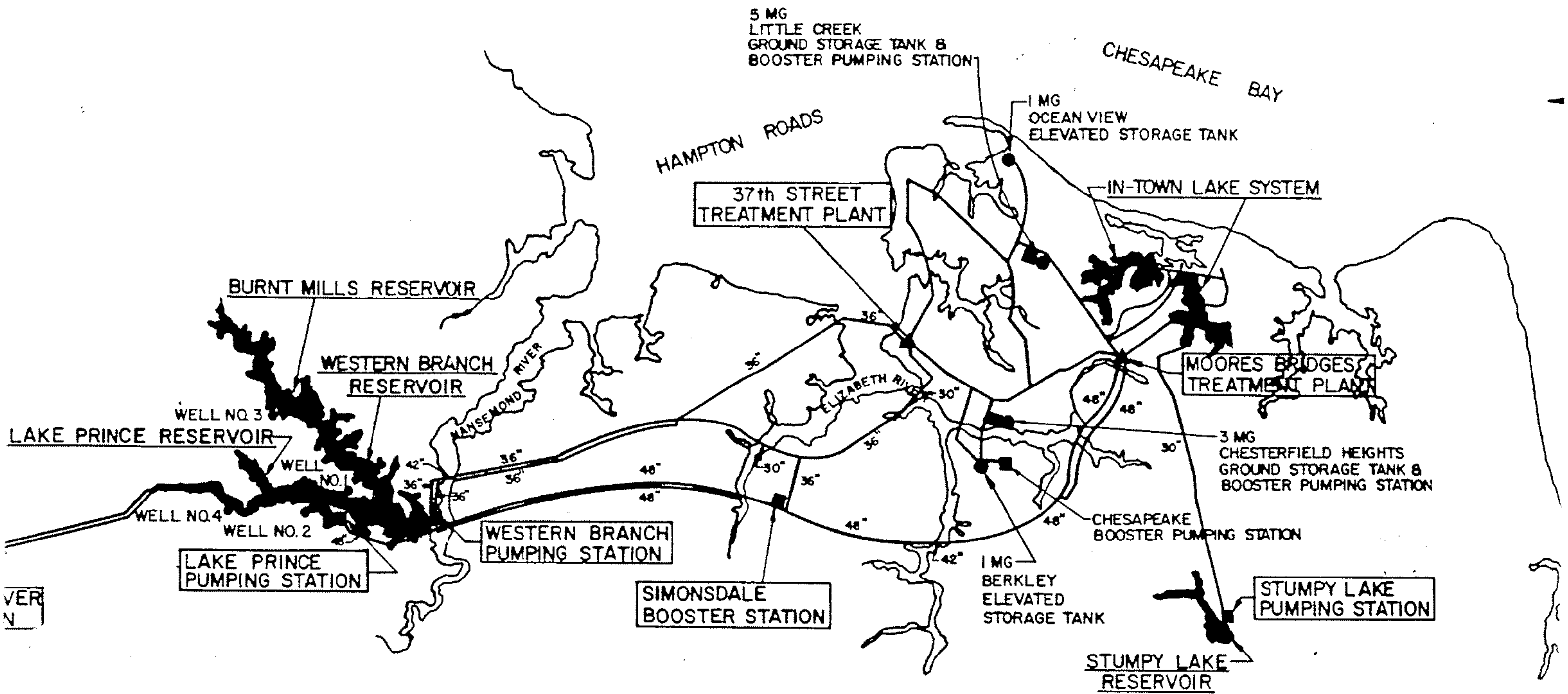
Sincerely,

Clarence Warnstaff
Director

dc

Attachment

pc: Neal Windley, Director
Norfolk Public Utilities



NORFOLK SYSTEM WATER SUPPLY

EXHIBIT 4-3

Project/Location: Navy Clean

S.O. No.: 19002-50-SRN
Date: April 8, 1991

To: Karen Mayne
Repres.: Fish and Wildlife Service
Phone No.: 804-693-6694

From: Aaron Bernhardt
Repres.: Baker Environmental, Inc.
Phone No.: 412-269-6090

Subject: Sensitive Environments

I told her we were doing a study for some U.S. Naval facilities in the Chesapeake Bay area and needed some information on sensitive environments. She told me the following:

a. There are some bald eagle nests around the sites

b. There are two state wildlife management areas
   - o Hog Island
   - o Chickahominy

c. No natural preservations; the National Park service has jurisdiction over them

d. the only endangered species information she has is down to the county level. I should talk to the state to get more specific information, especially the VA Natural Heritage Program, and the Dept. of Game and Inland Fisheries.

e. There are no federal wilderness areas in the area. Most of them are on National Forest Lands.

f. There are no Critical Habitats as defined in 50 CFR 420. Grandview Natural Area is being considered for the Piping Plover.

Project/Location: Navy Clean

S.O. No.: 19002-50-SRN
Date: May 1, 1991

To: Bridgett Costanso
Repres.: Fish & Wildlife Service (FWS)
Phone No.: 804-693-6694

From: Aaron Bernhardt
Repres.: Baker Environmental, Inc.
Phone No.: 412-269-6090

Subject: Sensitive Environments

I told her we were doing a study for some U.S. Naval facilities in the Chesapeake Bay area and needed some information on sensitive environments. Bridgett gave me the following responses:

a. There are several National Wildlife Refuges in the area. I should call each one to obtain maps showing their exact locations:
- o Back Bay (804-721-2412)
- o Great Dismal Swamp (804-968-3705)
- o Mackey Island (919-429-3100)
- o Nansemount may be managed by Dismal Swamp

b. For state designated natural areas I should call:
- o VA Department of Game and Inland Fisheries (804-683-9868)
- o VA Natural Heritage Program (804-786-7951)

c. She will send me a County list for Federally endangered species

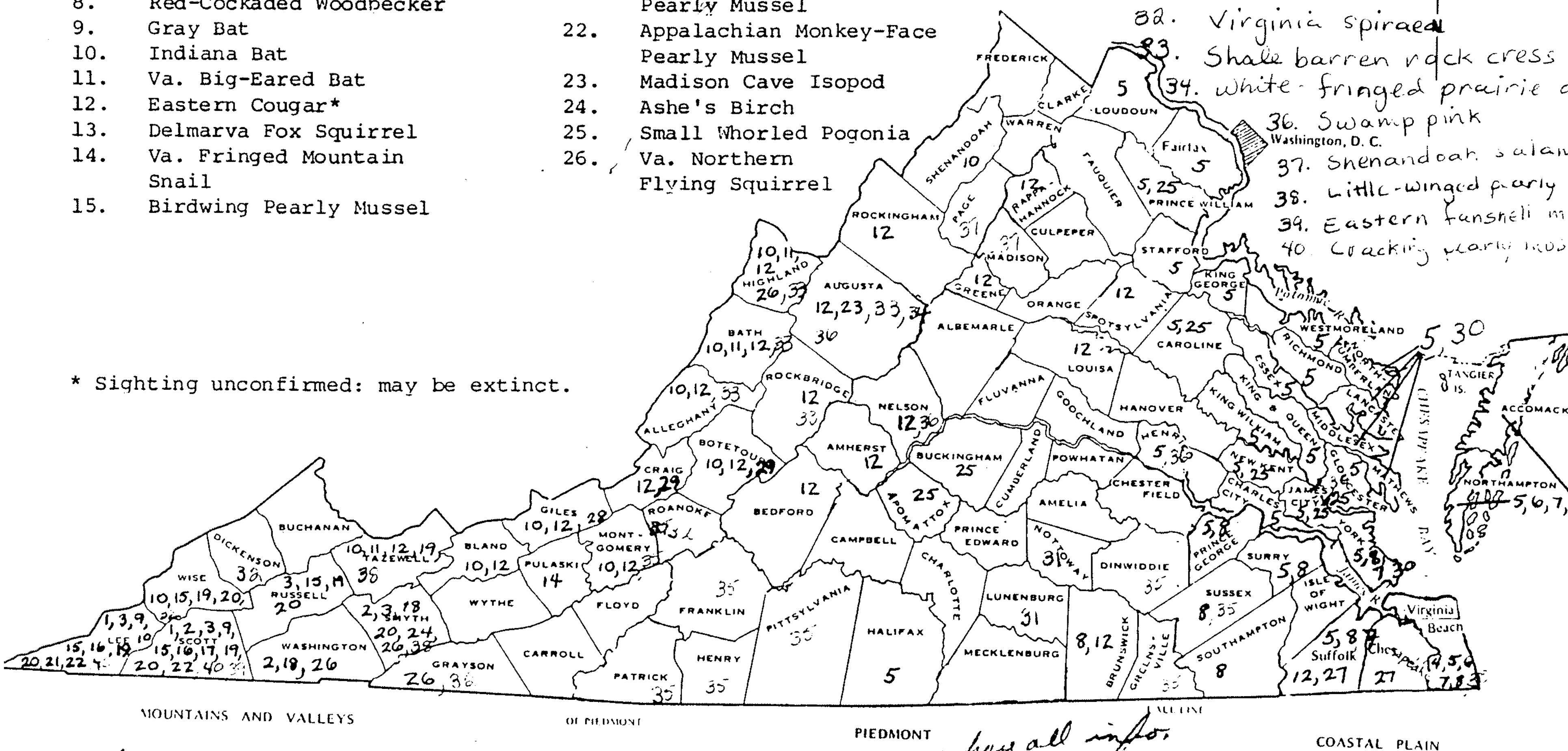
d. North Landing River and Back Bay would be Federal land Designated for the protection of natural ecosystems. They are called Focal areas. The FWS will do contaminant assessment work, wetland work. The Nature Conservancy also has purchased some land around the N. Landing River.

EXHIBIT 4-4

COUNTY OCCURRENCES OF ENDANGERED AND THREATENED SPECIES IN VIRGINIA

1. Slender Chub
2. Spotfin Chub
3. Yellowfin Madtom
4. Loggerhead Turtle
5. Bald Eagle
6. Peregrine Falcon
7. Piping Plover
8. Red-Cockaded Woodpecker
9. Gray Bat
10. Indiana Bat
11. Va. Big-Eared Bat
12. Eastern Cougar*
13. Delmarva Fox Squirrel
14. Va. Fringed Mountain Snail
15. Birdwing Pearly Mussel
16. Dromedary Pearly Mussel
17. Green Blossom Pearly Mussel
18. Tan Riffle Mussel
19. Fine-Rayed Mussel
20. Shiny Pigtoe Mussel
21. Cumberland Monkey-Face Pearly Mussel
22. Appalachian Monkey-Face Pearly Mussel
23. Madison Cave Isopod
24. Ashe's Birch
25. Small Whorled Pogonia
26. Va. Northern Flying Squirrel
27. Dismal Swamp Southeastern Shrew
28. Peters Mountain Mallow
29. James spinymussel ~~(P)~~
30. Northeastern beach tiger beetle
35. Roanoke logperch
31. Dwarf wedge mussel
32. Virginia spiraea
33. Shale barren rock cress
34. white-fringed prairie orchid
36. Swamp pink
37. Shenandoah salamander
38. Little-winged pearly mussel
39. Eastern fanshell mussel
40. Cracking pearly mussel

* Sighting unconfirmed: may be extinct.



Candidate Category I - concern for USFWS purposes, have all info.

~~SEP 1987~~

Sept. 90

(Sensitive joint vetch

Charles City

King and Queen

Westmoreland

New Kent

Essex

Chesterfield

James City)

November 1990

FEDERALLY LISTED AND PROPOSED ENDANGERED AND THREATENED SPECIES IN VIRGINIA

Common Name	Scientific Name	Status	Distribution
FISHES:			
Chub, slender	_Hybopsis cahni_	T	Powell River, Lee County; Clinch River downstream of TN line. _Critical habitat_: Powell River, main channel from the Tennessee-Virginia state line upstream through Lee County; Clinch River, TN-VA state line upstream through Scott County.
Chub, spotfin	_Hybopsis (Cyprinella) monacha_	T	North Fork Holston River, Scott and Washington Counties; Middle Fork Holston River, Washington County. _Critical habitat_: North Fork Holston River, main channel from the Virginia-Tennessee state line upstream through Scott and Washington Counties.
Logperch, Roanoke	_Percina rex_	E	Roanoke River system in Roanoke and Montgomery Counties; Pigg River system in Franklin and Pittsylvania Counties; Nottoway River system in Dinwiddie, Greenville and Sussex Counties; Smith River system in Patrick and Henry Counties.

November 1990

FEDERALLY LISTED AND PROPOSED ENDANGERED AND THREATENED SPECIES IN VIRGINIA

Common Name	Scientific Name	Status	Distribution
Madtom, yellowfin	Noturus flavipinnis	T	Copper Creek, Scott and Russell Counties; Powell River downstream of TN line. Critical habitat: Powell River, main channel from the Virginia-Tennessee state line upstream through Lee County; Copper Creek, main channel from its junction with Clinch River upstream through Scott County and upstream in Russell County to Dickensville.
Madtom, yellowfin	Noturus flavipinnis	X	Experimental populations are designated in North Fork Holston River, Smyth, Washington and Scott Counties.
Sturgeon, shortnose*	Acipenser brevirostrum	E	No recent records in VA. Potentially in Chesapeake Bay tributaries.
REPTILES AND AMPHIBIANS:			
Salamander, Shenandoah	Plethodon shenandoah	E	Shenandoah National Park, Madison and Page Counties.
Turtle, green*	Chelonia mydas	T	Oceanic; summer resident in coastal waters, including Chesapeake Bay.
Turtle, hawksbill*	Eretmochelys imbricata	E	Oceanic; summer visitor in coastal waters.
Turtle, leatherback*	Dermochelys coriacea	E	Oceanic; summer visitor in coastal waters, including Chesapeake Bay.

November 1990

FEDERALLY LISTED AND PROPOSED ENDANGERED AND THREATENED SPECIES IN VIRGINIA

Common Name	Scientific Name	Status	Distribution
Turtle, loggerhead*	Caretta caretta	T	Oceanic; summer resident in coastal waters, including Chesapeake Bay; occasionally nests in Virginia Beach, Northampton and Accomack Counties.
Turtle, Atlantic ridley*	Lepidochelys kempi	E	Oceanic; summer resident in coastal waters, including Chesapeake Bay.
BIRDS:			
Eagle, bald	Haliaeetus leucocephalus	E	Entire state - nests in eastern counties.
Falcon, American peregrine	Falco peregrinus anatum	E	Entire state - re-establishment of breeding population to coastal and mountain sites in progress.
Falcon, Arctic peregrine	Falco peregrinus tundrius	T	Entire state- migratory; concentration area along coast.
Plover, piping	Charadrius melodus	T	Accomack and Northampton Counties, Cities of Hampton, Virginia Beach, and Portsmouth.
Warbler, Bachman's	Vermivora bachmanii	E	Extremely rare - no recorded nesting.
Warbler, Kirtland's	Dendroica kirtlandii	E	Entire state - occasional migrant.
Woodpecker, red-cockaded	Picoides borealis	E	Suffolk, and Sussex Counties.

November 1990

FEDERALLY LISTED AND PROPOSED ENDANGERED AND THREATENED SPECIES IN VIRGINIA

Common Name	Scientific Name	Status	Distribution
MAMMALS:			
Bat, gray	*Myotis grisescens*	E	Lee, Scott, and Washington Counties.
Bat, Indiana	*Myotis sodalis*	E	Lee, Wise, Bland, Giles, Botetourt, Montgomery, Alleghany, Bath, Tazewell and Shenandoah Counties.
Bat, Virginia big-eared	*Plecotus townsendii virginianus*	E	Bath, Highland and Tazewell Counties
Cougar, eastern	*Felis concolor couguar*	E	Historically, entire state; continued existence unconfirmed.
Shrew, Dismal Swamp southeastern	*Sorex longirostris fisheri*	T	Cities of Chesapeake, Suffolk, and Virginia Beach.
Squirrel, Delmarva Peninsula fox	*Sciurus niger cinereus*	E	Accomack and Northampton Counties.
Squirrel, Virginia northern flying	*Glaucomys sabrinus fuscus*	E	Grayson, Highland and Smyth Counties.
Whale, blue*	*Balaenoptera musculus*	E	Oceanic.
Whale, finback*	*Balaenoptera physalus*	E	Oceanic.
Whale, humpback*	*Megaptera novaeangliae*	E	Oceanic.
Whale, right*	*Eubalaena* spp. (All species)	E	Oceanic.
Whale, sei*	*Balaenoptera borealis*	E	Oceanic.
Whale, sperm*	*Physeter catodon*	E	Oceanic.

November 1990

FEDERALLY LISTED AND PROPOSED ENDANGERED AND THREATENED SPECIES IN VIRGINIA

Common Name	Scientific Name	Status	Distribution
MOLLUSKS:			
Snail, Virginia coil	Polygyriscus virginicus	E	Pulaski County, near Radford.
Mussel, Dwarf wedge	Alasmidonta heterodon	E	Nottoway River, Nottoway and Lunenberg Counties; historically in Rappahannock and James River drainages.
Mussel, birdwing pearly	Conradilla caelata (= Lemiox rimosus)	E	Powell and Clinch Rivers, Lee, Russell, Scott and Wise Counties.
Mussel, Fanshell	Cyprogenia stegaria (= C. irrorata)	E	Clinch River, Scott County.
Mussel, dromedary pearly	Dromus dromas	E	Powell River, Lee County; Clinch River, Scott County
Mussel, green blossom	Epioblasma (=Dysnomia) torulosa gubernaculum	E	Clinch River, Scott County.
Mussel, tan riffle shell	Epioblasma walkeri (= E. Florentina walkeri)	E	Middle Fork Holston River, Smyth and Washington Counties.
Mussel, fine-rayed pigtoe	Fusconaia cuneolus	E	Clinch River, Tazewell, Russell, Scott, and Wise Counties; Powell River, Lee County.
Mussel, shiny pigtoe	Fusconaia edgariana (= F. cor)	E	Powell, Clinch and Holston Rivers, Tazewell, Russell, Scott, Wise, Lee, Washington and Smyth Counties.
Mussel, cracking pearly	Hemistena lata	E	Clinch River, Scott County; Powell River, Lee County.

November 1990

FEDERALLY LISTED AND PROPOSED ENDANGERED AND THREATENED SPECIES IN VIRGINIA

Common Name	Scientific Name	Status	Distribution
Mussel, little-winged pearly	*Pegias fabula*	E	Clinch River, Tazewell County; North and Middle Forks Holston River, Smyth County.
Mussel, Cumberland monkey-face	*Quadrula intermedia*	E	Powell River, Lee County.
Mussel, Appalachian monkey-face	*Quadrula sparsa*	E	Powell River, Lee County; Clinch River, Scott County.
Spinymussel, James	*Pleurobema collina*	E	Craig, Johns, Catawba and Patterson Creeks, Craig and Botetourt Counties; Pedlar River, Amherst County; Rocky Run, Moormans River and Mechums River, Albermarle County.
ARTHROPODS:			
Isopod, Madison Cave	*Antrolana lira*	T	Augusta County.
Amphipod, Hay's Spring	*Stygobromus hayi*	E	District of Columbia.
Beetle, American burying	*Nicrophorus americanus*	E	No recent records in Virginia; probably extirpated.
Beetle, Northeastern beach tiger	*Cicindela dorsalis dorsalis*	T	Accomack, Lancaster Middlesex, Mathews, Northampton, Northumberland, City of Hampton.

November 1990

FEDERALLY LISTED AND PROPOSED ENDANGERED AND THREATENED SPECIES IN VIRGINIA

Common Name	Scientific Name	Status	Distribution
PLANTS:			
Birch, Virginia round-leaf	*Betula uber*	E	Cressy Creek, Smyth County.
Bittercress, small anthered	*Cardamine micranthera*	E	Peters Creek and tribs, Patrick County.
Bulrush, northeastern	*Scirpus ancistrochaetus*	PE	Alleghany, Augusta, Bath and Rockingham Counties.
Mallow, Peter's mountain	*Iliamna corei*	E	Giles County.
Orchid, white-fringed prairie	*Platanthera leucophaea*	T	Augusta County.
Pink, swamp	*Helonias bullata*	T	Augusta, Henrico, and Nelson Counties.
Pogonia, small whorled	*Isotria medeoloides*	E	Appomattox, Buckingham, Caroline, Gloucester, James City, New Kent, and Prince William Counties.
Rockcress, smooth	*Arabis serotina*	E	Alleghany, Augusta, Bath, Highland, and Rockbridge Counties.
Spiraea, Virginia	*Spiraea virginiana*	T	Dickenson, Grayson, Roanoke, and Wise Counties.

*Except for sea turtle nesting habitat, principal responsibility for these species is vested with the National Marine Fisheries Service.

PE = Proposed Endangered
PT = Proposed Threatened
E = Endangered
T = Threatened
X = Experimental Population

DECEMBER, 1984

INITIAL ASSESSMENT STUDY OF NAVAL AMPHIBIOUS BASE, LITTLE CREEK NORFOLK, VIRGINIA

NEESA 13-066

NAVAL ENERGY AND ENVIRONMENTAL
SUPPORT ACTIVITY
Port Hueneme, California 93043

Creek. The following year saw the Naval Inshore Undersea Warfare Group Two, located on the east side of Little Creek Harbor since World War II, become a tenant command.

The mission of NAB Little Creek broadened in scope in 1970:

> To provide on-Base facilities and services, as required, for the administrative and logistic support of the operating forces, resident commands, organizations and other United States and allied units in order to support amphibious, counterinsurgency, unconventional warfare, restricted water and riverine warfare, special warfare, and other approved operations and training.

The early 1970s also saw the expansion and modernization of many facilities aboard the base and the beginnings of an upswing in energy cost-saving and environmental protection measures. These included investment in oil spill prevention measures. The medical department became a Branch Dispensary of the newly established Naval Regional Medical Center Portsmouth in 1971, conducting nearly a quarter million outpatient visits, processing 281,559 lab tests and 100,516 x-rays in that year.

A number of activities relocated to NAB Little Creek in 1973:

- o Commander Service Squadron Eight,
- o Atlantic Fleet Missile Weapons System Training Unit,
- o Engineering Support Department (Norfolk Detachment),
- o Fleet Composite Squadron Six, and
- o Supervisor of Shipbuilding, Conversion & Repair, Fifth Naval District.

The following year, Underwater Construction Team One relocated to NAB Little Creek and a new barracks and third service station were constructed.

In July 1975, administrative control over NAB Little Creek passed to the Commander Naval Surface Force Atlantic (COMNAVSURFLANT), a new command. Other activity changes made in the late 1970s and early 1980s included the following:

- o Underwater Demolition Team 22 was established;
- o Patrol Hydrofoil Missile Ships Logistics Command was transferred to Florida;
- o Inshore Undersea Warfare Group Two was disestablished;
- o Sea, Air and Land (SEAL) Team 2 was established;
- o Behavior Skill Training Unit (BEST) became a tenant activity; and
- o Small Arms Marksmanship Training Unit became a tenant activity.

4.2.1 Historical Sites. There are no known areas of historic or archeological interest on NAB Little Creek (Master Plan). There is a World War II lookout station on base, but it is not eligible for inclusion in the National Register (NAVFAC, 1983, Vol. II).

4.3 LEGAL ACTIONS. There have been no legal actions taken against NAB Little Creek for violation of environmental laws, according to Legal Services and its Claims Division.

4.4 BIOLOGICAL FEATURES.

4.4.1 Ecosystems. A diverse and complex group of plant associations occurs in the coastal region of Virginia. Plant distribution is primarily affected by the moisture, texture, and salinity of soils and the degree of exposure to wind, wave action, and salt spray. Generally, plants occurring just landward of the beach area are the most salt-tolerant and those found further inland are less well adapted to saline soils and salt spray. Beach communities are capable of withstanding the detrimental effects of high winds, shifting sands, high temperatures, and extremely high light intensity. Inland from the well-drained soils of the beach zone, away from the effects of salt spray, are the hydric and mesic communities that are protected from the harsh maritime environment.

The following section provides a brief description of biotic communities on NAB Little Creek, as well as Camp Pendleton (NAVFAC, 1983) and Bloodsworth Island Shore Bombardment and Bombing Range (U.S. Department of the Navy, 1982).

4.4.1.1 NAB Little Creek. Because of rather intensive development on the base, little land has been allowed to retain a natural cover of vegetation. Species composition of remaining vegetational communities generally reflects the consequences of past and ongoing habitat alterations. Training exercises, landfilling, dredging, and spoil disposal have created a cover containing a diversity of aggressive weedy invaders that have displaced many of the more sensitive native species that orginally inhabited the region.

Dune formations along the Chesapeake Bay and Little Creek Entrance Channel contain a sporadic cover of salt-tolerant plants able to withstand the drifting sands and high winds. The less stabilized dune formations are covered by herbaceous species, while the topographically higher landward dunes also contain woody shrubs. Typical herbaceous plants include broomsedge, Japanese honeysuckle, greenbrier, grapevine, and beach grass. Shrubs commonly encountered on the dunes are black cherry, scrub-live oak, and wax myrtle. Inland of the dune formations are transition forests typified by scrub-live oak, black cherry, loblolly pine, persimmon, American holly, dogwood, willow oak, sassafras, and redbay. Inland of these, coastal plant communities typical of Virginia's coastal plain have become established. Because this area also contains the most developed sections of the base, these cover types tend to be isolated tracts within urbanized areas.

Typical forest types include mixed hardwood, loblolly pine-mixed hardwood, and loblolly pine. Loblolly pine dominates the higher ground, and red maple generally replaces it in depressions. Although tidal portions of the Little Creek Inlet originally contained wetlands, these areas have since been covered by dredged spoil or used as landfill. Common reed appears to cover most areas that were formerly tidal wetlands.

Wildlife species on NAB Little Creek are limited to those that are capable of surviving in close proximity to urbanized areas. Typical species include eastern cottontail, eastern mole, house mouse, white-footed mouse, muskrat, raccoon, and eastern gray squirrel. Some of the more common overwintering birds that have been recorded in the mixed forests of the base include cedar waxwing, white-throated sparrow, Carolina wren, cardinal, and robin. The beach area is visited by a wide variety of gulls, brant, surf scoters, mallards, and royal terns. During the winter the grassy dunes are inhabited by field and seaside sparrows and mourning doves.

Approximately 275 acres of wooded land have been identified on NAB Little Creek (NAVFAC, 1967). Due to the number, size, location, and arrangement of these forested areas, they were not considered commercially operable for timber management, and a forest management plan has not been developed. A wildlife management plan was also not developed due to the limited extent of undeveloped land on the base (NAVFAC, 1968).

There are five small ponds and two large lakes on the base. These water bodies total 205 acres. In addition, approximately two miles of Chesapeake Bay bounds the base on the north, and the Little Creek Entrance Channel bounds the base on the west. Fishery Management Plans have been formulated to inventory existing fishery resources and recommend management practices to improve habitat conditions (NAVFAC, 1968; U.S. Fish & Wildlife Service, October 1977). Along the Chesapeake Bay and Little Creek Entrance Channel, striped bass, spot, bluefish, croaker, sea trout, and blue crabs are commonly encountered. The inland ponds have a history of population management problems due to periodic flooding. Twenty-one species of fish have been recorded in these freshwaters. Gizzard shad tend to dominate the catch in the lakes, while carp and bullheads are most prevalent in the ponds. Fishing is available to military personnel and guests.

4.4.1.2 Camp Pendleton. The majority of land on the Annex at Camp Pendleton has been allowed to remain in a natural cover of vegetation. Mixed forest constitutes 52 percent of the base and is the most prominent cover type. Red maple is the most common tree, while sweet gum, loblolly pine, blackgum, water oak, and willow oak are also frequently encountered within this forest. A grassy dune and remnant scrub dune community is located inland of the beach on the eastern edge of the base. The scrub dune zone has been heavily impacted by military maneuvers and the resulting barren portions are subject to severe wind erosion. A freshwater marsh totalling 22 acres is located on the southern portion of the base. This wetland, known as Lovett's Marsh, has been ditched for drainage, which has allowed upland trees and shrubs to encroach upon the marsh. Common emergent vegetation of the marsh include cattail, pickerelweed, and spike rush.

The greater diversity and acreage of natural cover types of Camp Pendleton provides habitat for larger numbers of wildlife than are found on NAB Little Creek. The freshwater wetland in particular provides food, cover, and nesting sites for a wide variety of birds. Typical mammals of this area include eastern cottontail, whitetailed deer, white-footed mouse, muskrat, raccoon, and eastern gray squirrel.

4.4.1.3 Bloodsworth Island Shore Bombardment and Bombing Range. Approximately 70 percent of the 5,358-acre island is dominated by salt-tolerant black needlerush. Around the perimeter of the island saltmarsh cordgrass is also found, while slightly higher elevations on the island tend to be dominated by groundsel-tree and marsh elder. Remnant timber stands are primarily concentrated on Fin Creek Ridge, which is located on the northern portion of the island. The remainder of the island has only small isolated hummocks with few trees still remaining. Most of the trees have been killed by salt intrusion and incendiary shelling or fire. The few individuals still alive are mostly black locust, with some red cedars and loblolly pine.

The prominence of needlerush on Bloodsworth Island limits the habitat value to furbearers and waterfowl. The island, however, provides important overwintering and stopover areas for waterfowl. Some reproduction also takes place in cordgrass/saltgrass areas in perimeter areas of the island. The heronries are perhaps the island's best known and most valuable ecological feature. The range supports the largest number of breeding pairs of great blue herons on the Lower Chesapeake Bay Islands. In addition, osprey are common throughout the island, with 31 nesting pairs recorded in 1978.

4.4.2 Endangered, Threatened, and Rare Species. Endangered and threatened biota have been designated by the Federal Government and receive protection under the Endangered Species Act of 1973 (Federal Register, January 17, 1979). The State of Virginia also officially recognizes endangered species designated by the United States. Maryland has established its own endangered list that includes species in addition to those recognized by the Federal Government (Wildlife Conservation Regulation 08.03.03). In addition to officially recognized species, there are a number of plants currently under review as potential endangered or threatened species (Federal Register, December 15, 1980 and November 28, 1983).

Recent surveys on NAB Little Creek and the two support facilities have not identified endangered or threatened species. Field studies on Bloodsworth Island conducted by the Maryland Wildlife Administration concluded that because of the absence of suitable habitat, there is no reason to believe endangered floral and faunal species inhabit the island (NAVFAC, February 1982). However, the Maryland Wildlife Administration does recognize that although the eagle does not nest on the island, it might utilize the island on a part-time basis. More recent surveys at Camp Pendleton and on portions of NAB Little Creek have also failed to reveal the presence of endangered species (Naval Facilities Engineering Command, 1983).

There are a number of species that could inhabit the region or may range over the area during migration. Sea turtles that could range as far north as Virginia, but are not expected to nest in this region, include the green sea turtle, hawksbill sea turtle, Kemp's ridley sea turtle and the leatherback sea turtle. Although the brown pelican nests south of Virginia, juveniles of this species drift north along the coast during late summer. The Arctic peregrine falcon can be found in coastal areas during migration, particularly in September and October. In addition, hacking stations have been established for the American peregrine falcon on the Eastern Shore and at Back Bay National Wildlife Refuge, and this bird may eventually be reintroduced into the region. The following five species reside or breed in southeast Virginia but are not known to inhabit NAB Little Creek or the two support facilities (NAVFAC, 1983).

Cardamine longii (Long's Bitter Cress). Under Review (Vascular Plant). This plant is known to occur on the border of salt marshes from Maine to Virginia. The disjunct populations are sensitive to pollution, draining, and habitat disturbance. Long's bitter cress, however, has not been collected from either Virginia Beach, Virginia or Dorchester County, Maryland.

Lilaeopsis carolinensis (No Common Name). Under Review (Vascular Plant). This plant is known to occur in shallow pools and ponds from the coast of southeast Virginia to South Carolina. These wetland plants are vulnerable to drainage and habitat disturbance and reach their northern limits in the Virginia Tidewater area.

Coretta coretta (Loggerhead Sea Turtle). Threatened (Reptile). The loggerhead is the most common sea turtle on the Virginia coast. The largest concentrations of these turtles off NAB Little Creek occurs during migration in the spring and fall. Although five clutches of eggs are known to have been laid near Back Bay National Wildlife Refuge from 1970 to 1980, Virginia is actually north of the turtles' nesting range and the region provides little value to loggerhead nesting success. The turtle also requires a strong surf on nesting beaches, and therefore would not be expected on NAB Little Creek's beaches. A dead loggerhead did wash up on the NAB Little Creek beach in 1980 (Virginia Institute of Marine Science, 1980).

Heliaeetus leucocephalus (Southern Bald Eagle). Threatened (Resident). Virginia provides prime habitat for the southern bald eagle. In 1978, 37 active nests were located in the state and productivity was 0.49 fledglings per active nest. Although productivity has improved greatly when compared with the low point in 1963 (0.19 fledglings per active nest), the Virginia bald eagle population is not reproducing at a level adequate to sustain the population. There are currently no bald eagles nesting in Virginia Beach. Some birds, however, do winter along area beaches or pass through the region during migration.

Picoides borealis (Red-Cockaded Woodpecker). Endangered (Resident Bird). This woodpecker is a highly specialized bird that nests only in pines afflicted with red heart fungus. Among woodpeckers, the red-cockaded has an advanced social system and is known to live in a group or clan of two to nine birds. This woodpecker has not been seen in Virginia Beach in two to three years. The last sightings were near Pungo in the southern, less developed part of the city.

4.5 PHYSICAL FEATURES.

4.5.1 Climatology. The climate of the tidewater area is characterized as oceanic, with nearby Atlantic Ocean and Chesapeake Bay providing a profound moderating effect. Winters are relatively mild and summers are cool. Average temperatures in July range from 75-87°F. Winters seldom reach the freezing mark and may near 50°F. The maximum temperature recorded over a 40-year period (1939-78) was 103°F.; the minimum, 5°F.

The average number of frost-free days per year is 245. The first killing frost occurs around November 21, and the last, around March 21. Based on the 40-year data record at Norfolk International Airport, annual precipitation averages 45 inches, with the heaviest precipitation in the summer. Snowfall averages 7.3 inches per year.

Prevailing winds from the southwest average 12.2 mph. Summer winds are "sea breezes," coming in off the ocean during the day, with land breezes returning more slowly at night. Neither northern nor tropical storms usually affect the area, but hurricanes are experienced about once every seven years (NAVFAC, 1983). Mean tidal range in Little Creek Habor is 2.6 feet, and currents average 0.9 knots (NAVFAC, 1979).

4.5.2 Topography. NAB Little Creek is located on the outer edge of the Atlantic Coastal Plain physiographic province. The Atlantic Coastal Plain is a broad, seaward-thickening wedge of sediments, with an overall surface slope toward the Atlantic Ocean. The inner portions of the coastal plain step down in elevation in a series of linear eastward-facing scarps which represent the shoreline during older, higher stands of sea level. In contrast, the outer coastal plain is characterized by low elevations and relief.

Maximum elevations on NAB Little Creek approach 40 feet above mean sea level. This occurs on the crest of the highest dunes that face Chesapeake Bay. The average elevation on the base is closer to 10 feet Mean Sea Level (MSL), and the broad, flat character of the base can be attributed to the extensive development and filling that has occurred over the years of construction. Most of the shoreline within NAB Little Creek has been improved with bulkheading and the construction of the piers and quaywall. The only remaining shoreline that is not thus bulkheaded is along the eastern side of the inlet channel (where development of a new facility for a Landing Craft Air Cushion (LCAC) base is planned) and along the eastern and southern boundaries of Little Creek Cove (where the base landfill operated until 1975).

The base was built up to its present elevations through a planned process of bulkheading, filling with dredged spoil, and importing fill as the various elements were completed. Almost all areas of the base are dry during normal tidal conditions.

EXHIBIT 4-5

AN INVENTORY OF THE RARE, THREATENED & ENDANGERED SPECIES

OF THE

LITTLE CREEK NAVAL AMPHIBIOUS BASE

VIRGINIA BEACH, VIRGINIA

DOD Contract # N62470-89-C-3841

Department of Conservation
and Recreation
Division of Natural Heritage
203 Governor St., Suite 402
Richmond, VA 23219
(804) 786-7951

Natural Heritage Technical Report # 90 - 3 1 September 1990

Birds: Breeding birds were sought during May, June, and July 1989. Birds were seen or identified by song. Breeding status was determined with criteria developed by the Virginia Society of Ornithology's Breeding Bird Atlas Project. Significant habitats for wintering or migrating birds were sought during the respective seasons.

Mammals: The presence of mammals was determined by sightings, scats, tracks, sign, and by trapping. The trapping included pitfall arrays which were located at predetermined sites ascertained to be the most probable for the occurrence of rare mammals (as well as other terrestrial vertebrates). Other habitats on the Little Creek Amphibious Base were sampled through the use of snap-trap grids. Sampling sites are indicated in Figure 2. Snap-trap grids were established in several different habitat types as well. Considering all methods, a total of 2,633 trap nights were used which included 250 trap nights with snap traps.

RESULTS

PLANTS

Summary of existing information

No previous records of rare plant species were found from Little Creek Amphibious Base. The lists of rare species recorded from Virginia Beach and Chesapeake cities were used to direct inventory. These lists, attached as Table 1, includes 74 species. It is clear from the extensive list of rare species that Virginia Beach and Chesapeake are important in their numbers of significant rare plant species.

Field investigation.

Surveys began in May 1989 and continued through the fall 1989. The rare species results are summarized in the species accounts that follow and the locations presented in Figures 3, 4, and 5. Plant status ranks were determined through Natural Heritage Methodology as described by Ludwig (1989). For a more detailed description and aids to identification of each species, refer to Gleason (1952), Godfrey and Wooten (1979,1981), and Radford, et al. (1964).

SPECIES ACCOUNTS

Lechea maritima var virginica, Virginian Beach Pinweed

Status: G5T2/S2 [Species secure over entire range, but subspecies very rare/very rare in Virginia].

Lechea maritima var virginica was recommended for special concern status at the 1989 Virginia Endangered Species Symposium. This species is a former candidate (3C) for listing as a Federally Endangered Species.

Distribution: This variety of Lechea maritima is known from Virginia and Southern Maryland. 9 coastal counties have been recorded as having populations in Virginia (Harvill, et al. 1986).

Description: Lechea maritima var. virginica is a low pinweed rarely above 4 dm tall which has woolly basal leaves and erect to strongly reclining flowering stems. Stem leaves are whorled below the flowers which bloom in early fall.

Project Findings: Lechea maritima var. virginica was first found in 1898 (a specimen in the U. S. National Museum by T. H. Kearney, Jr.). Several hundred healthy, reproductive individuals of this species were found on the foredune and secondary dunes in the open herbaceous and scrub zones between the maritime forest and the beach (Fig. 3).

Threats: No obvious threats to this species were observed at Little Creek.

Quercus incana, Blue Jack Oak

Status: G5/S2S3 [Secure over its range/Very rare to rare in Virginia].

Quercus incana was recommended for special concern status at the 1989 Virginia Endangered Species Symposium.

Distribution: Southeastern United States. 6 Coastal Plain counties in southeastern Virginia (Harvill, et al., 1986).

Description: The distinctive leaves of this oak are shaped much like those of Live Oak, Quercus virginiana, but have a distinctive pink color when emerging in Spring. Also distinctive is the leave's velvet underside.

Project Findings: Approximately sixty individuals were observed in the maritime forest community behind the open dunes (Fig. 4). The trees aged from approximately 5 to 50 years and the larger individuals were observed fruiting. The species was concentrated in the eastern portion of the forest.

Threats: A few, scattered individuals of this species were found on the golf-course side of the fence which separates the golf-course from the maritime forest. These individuals may be threatened by golf course maintenance activities or future land use changes.

Tillandsia usneoides, Spanish Moss

Status: G5/S2S3 [Common over its entire range/very rare to rare in Virginia]

Tillandsia usneoides was recommended for special concern status at the 1989 Virginia Endangered Species Symposium.

Distribution: Southeastern United States. 6 Coastal Plain counties in southeastern Virginia (Harvill, et al., 1986)

Description: This is one of Virginia's only epiphytic vascular plants, and the only of these with distinctive grey foliage gracefully dangling from the branches of trees.

Project findings: A large population of this epiphyte was found on 42 trees on portions of the eastern end of Scout Island (Fig. 5).

Threats: No immediate threats to this species were noted at Little Creek.

ANIMALS

Summary of existing information.

Fish. There were no previous records of rare fish from Little Creek Amphibious Base. The state rare swampfish, Chologaster cornuta (G5/S3), is known from the cypress ponds at Seashore State Park (C. A. Pague, unpubl. data) and may have once occurred on Little Creek Amphibious Base in undisturbed swamp forests. However, there is no supporting evidence for this hypothesis.

Amphibians. No records were found for rare amphibians on Little Creek Amphibious Base; however, early investigations in

Princess Anne County (now the City of Virginia Beach) and research in Seashore State Park indicated that several rare species were possible. Werler and McCallion (1951) reported on several species of amphibians in Virginia Beach, primarily from Seashore State Park. There is also a report of Stereochilus marginatus (Many-lined salamander) from a sandy-bottomed flowing stream near downtown Virginia Beach. However, suitable habitat does not exist at Little Creek. Siren lacertina (Greater Siren) was recorded early in this century at Lake Tecumseh (Dam Neck Lake). Rana virgatipes (Carpenter frog) is known to inhabit cypress ponds in Seashore State Park. Possible habitat occurs in wet swamps around the golf course ponds, and the wooded swale on Scout Island.

Reptiles. No rare reptiles were recorded from the study area. Werler and McCallion (1951) did not list any rare species from the vicinity of Little Creek. The Canebrake rattlesnake (Crotalus horridus atricaudatus) is known from numerous records in Virginia Beach, but primarily south of Virginia Beach Boulevard (Mitchell and Pague, in prep; D. Schwab, pers. comm.).

The Chicken turtle (Deirochelys reticularia) is known from nearby Seashore State Park. This state Endangered turtle may have occurred at Little Creek Amphibious Base since the natural state of the base bore resemblance to the habitat at Seashore State Park. Chicken turtles are known to persist in man-altered aquatic habitats farther south in their range (Gibbons, J. W., 1969; K. A. Buhlmann, pers. obs.), so we felt that the potential for their occurrence was high.

Birds: No records of rare breeding birds were found that specifically located them at Little Creek Amphibious Base. A list of rare birds known to occur in Virginia Beach and Chesapeake and with appropriate habitat occurring at Little Creek was generated from the Natural Heritage database (Table 1).

Mammals: No records for the existence of rare mammals on Little Creek Amphibious Base were found. The Dismal Swamp southeastern shrew (Sorex longirostris fisheri) is known from the City of Chesapeake and in portions of Virginia Beach and was thought to possibly occur on Little Creek Amphibious Base.

The Pungo mouse (Peromyscus leucopus easti) is a diminutive sub-species of the common white-footed mouse (P. l. leucopus). This animal has been historically described from the areas directly behind the beach dunes from Virginia Beach to False Cape (Paradiso, 1960). Sampling effort has not been extensive in the coastal zone of northern Virginia Beach; therefore, this species was thought to possibly occur in the dune habitats of Little Creek Amphibious Base.

Field investigation.

No rare fish were captured or observed in the study area. The species encountered or collected are listed in Table 3.

Eight species of amphibians were captured or heard, in the case of frogs, on Little Creek Amphibious Base (Table 3). Two of the amphibian species were salamanders and the remainder were anurans (frogs and toads). Of these, none were rare, threatened, or endangered species. Most of these species were collected in pitfall traps established in representatives of the different habitats.

Sixteen species of reptiles were observed or captured including 8 turtles, 4 snakes, and 4 lizards (Table 4). None of these species are considered rare, threatened, or endangered. The Red-eared slider (Trachemys scripta elegans) was found to inhabit the lakes. This turtle is native to the lower Mississippi valley and once was a popular turtle in the pet trade. A well-established population now exists in the open water bodies on the Base and undoubtedly resulted from released pets.

Ninety-eight species of birds were observed, many of which breed at Little Creek Amphibious Base (Table 5). While several of these species are considered rare (see Appendix A), no evidence of breeding by rare species was documented. Inventory during the winter revealed that the marshes, ponds, and lakes of Little Creek serve as a haven for waterfowl and some wading birds. Moderate waterfowl use was noted on several occasions. However, none of the sites showed evidence of serving as large congregation sites.

Mammals. During the course of our fieldwork, we captured or observed twelve species of mammals (Table 6). Four of these were captured in pitfall traps. The larger species were identified by observation, sign, and scats. None of the captured species are rare, threatened, or endangered species (however, see the notes on Peromyscus leucopus easti).

Extensive trapping in the beach dune and live oak forests produced specimens of the white-footed mouse (Peromyscus leucopus ssp). Analysis is currently underway to determine if the rare subspecies P. leucopus easti is present at Little Creek.

SPECIES ACCOUNTS

Peromyscus leucopus easti, Pungo mouse

Description: Similar to other subspecies of P. leucopus but much smaller (total length 145-162 mm) and paler with a brighter reddish wash on the flanks (Paradiso, 1960).

Status: G5T1/S1 [Species is secure over its range; subspecies is extremely rare over its range/extremely rare in Virginia].

The subspecies is listed as a candidate for listing (C2) by the U. S. Fish and Wildlife Service. It was recommended for status undetermined by the Virginia Endangered Species Symposium, 1989.

Distribution: Paradiso (1960) described the species from the area of Back Bay National Wildlife Refuge and False Cape State Park. D. Schwab (pers. comm.) reported additional captures from False Cape State Park as recently as 1988. C. O. Handley, Jr. (pers. comm.) collected material from the Duck, North Carolina barrier beach system. Paradiso predicted that the subspecies would probably be found south to Oregon Inlet, North Carolina in appropriate habitat.

Project Findings: Sixteen specimens of Peromyscus leucopus were captured during this study. The taxonomic designation of these specimens is uncertain (see the Discussion below) and currently being studied. The habitat within and just inland from the dune systems is correct for the subspecies easti. The small size of the animals collected on Little Creek Amphibious Base is also in agreement with those reported by Paradiso (1960) for easti. However, the pelage characteristics do not appear to correspond to the reported characters for easti, It is possible that this population is within an intergrade zone.

Threats: The white-footed mouse is tolerant of some disturbances and should persist in dune and backdune habitats as long as their is little loss of habitat integrity. Habitat alteration may allow the invasion other subspecies and the house mouse, Mus musculus.

Sterna antillarum (Least Tern)

Description: Sterna antillarum is the smallest tern in North America. It is characterized by a relatively short tail and white patch on the forehead. The bill is dark in juveniles; yellow in adults. Total length from bill tip to tail is 9" (23 cm). The Least Tern is a loosely colonial nester. The nest is usually a depression scraped in the sand. Most colonies are found in beaches and overwash areas, but some are found in spoil areas with sandy substrate and sparse vegetation. Egg incubation lasts approximately 22 days. Fledging occurs in 20-22 days.

Status: G4/S2 [secure throughout its range/very rare in Virginia]. This species is recommended to the Virginia Department of Game and Inland Fisheries for listing as a threatened species.

Distribution: The Least Tern ranges along the Atlantic and Gulf Coasts from Massachusetts to Texas. It is dependent on undisturbed beaches for nesting. In Virginia, the least tern occurs in scattered colonies along the barrier islands of the Eastern Shore. Least Terns also breed in Tidewater, with colonies recorded from Grand View Beach in Hampton and the U.S.Army Corps of Engineers disposal area at Craney Island. Historically, least terns also nested at Cape Henry and Sandbridge.

Project Findings: On 27 June 1990, personnel from Little Creek Amphibious Base observed nesting Least Terns on a sandy, Chesapeake Bay beach immediately east of Little Creek Channel. At this time, 40-50 adult birds were observed, at least 6 nests with 1-2 eggs were observed and 3 newly hatched chicks were seen. A revisit of the site by DNH staff on 17 July failed to observe any Least Terns, adults, nests, or young. The cause of nesting failure is unknown, but a 9 inch rainfall on 10 July may have washed the nests away. The nesting site is a beach roughly 200 x 100 m consisting of sand, sparse vegetation, and some stone debris. Virtually no shell overwash areas exist. The center area of the site contains a low mid-ridge with stone debris; the edges of the site contain more vegetation.

Threats: Currently, this beach site is used by the U.S. Navy for beach landing and training activities. Disturbance of the adult birds during the nesting season can result in egg and chick mortality due to overheating, chilling, or predation. Use of vehicles and human foot traffic in a ground-nesting bird colony has obvious impacts.

DISCUSSION

RARE PLANTS

Three rare plant species were found during the inventory of Little Creek Amphibious Base. All species formerly occurred commonly on the coastline of Virginia Beach, but are now much less common due to coastline changes, primarily habitat alteration. In northern Virginia Beach, Little Creek is one of the few strongholds for these species and consequently the finest examples remaining.

A set of interdunal swales observed at Little Creek are also significant. This wetland type has formed in the low spots between Little Creek's secondary dunes and is a notable rare-species habitat. These wetlands are similar to the interdunal swale found at Camp Pendleton during 1989 though they are not as deep and no

OTHER NATURAL HERITAGE ELEMENTS

The Division of Natural Heritage also monitors rare or exemplary natural communities, significant geological features, invertebrates, important corridors, animal congregation sites, large forested tracts of land, and several other categories. While this study was only contracted for vertebrate animals and plants, any other significant resources were noted. A rare community occurrence was present in the back dune habitats -- maritime dune forest. This natural community was once virtually continuous from the North Carolina state line to the shores of the Elizabeth River. Now, there are only a few remnants that are intact, most notably those in Back Bay National Wildlife Refuge and False Cape State Park. Large areas of this habitat occur in Seashore State Park but are threatened by the intensive use of the campground. Therefore, this community is deserving of protection.

The entire population of _Quercus incana_ is found within this community type. Therefore, protection for this community is gained by implementing the recommendations of this report for _Q. incana_.

Two other sites were notable for their potential contribution to the protection of Little Creek Amphibious Base's natural diversity. These sites are categorized as **Special Interest Areas** and described under **Protection Recommendations** below.

PROTECTION RECOMMENDATIONS

Four special interest areas are recommended to protect the habitats of rare species (Fig. 6 and Fig. 7). In addition to protecting individual species, the recommendations would provide protection for some of the best-remaining examples of dune scrub forest. This habitat was once extensive in Virginia Beach and Norfolk behind the foredunes. In the past, most of these habitats were destroyed or altered such that restoration is impractical.

The three special interest areas contain Little Creek's significant maritime communities including beach and open fore-dunes that grade back into the maritime forest communities dominated by _Quercus virginica_. The boundaries of these areas include viable portions of the maritime communities including the potentially important interdunal swales. Intact examples of these communities are becoming increasingly rare in this developing area of Virginia and therefore are of state significance.

Protecting these areas would protect all of Little Creek's known rare plant populations. Lechea maritima is found in all three areas. The two western areas, Eastern Dunes and Western Dunes contain almost the entire Quercus incana population at Little Creek. The easternmost area, Chub Lake Special Interest Area, has all of the known Tillandsia usneoides. In addition, an interdunal swale of potential significance for several rare invertebrates is on Scout Island.

If these recommendations are enacted and land-uses within each of the natural areas do not change significantly, little if any species-specific management should be required to maintain the rare plants found in the special interest areas within Little Creek. However, there is some threat, particularly in the West Dunes Special Interest Area, from off-road vehicles. Some modifications in the extent of travel of ORV's would be desirable. This would be particularly significant in the vicinity of wetlands or swales.

Chub Lake Special Interest Area
(Ecological Reserve Area)

The Chub Lake Special Interest Area encompasses two different terrestrial habitats around a lake. A maritime forest community exists immediately east of the Pistol Range and continues to the base boundary. This area contains Lechea maritima var. virginica and represents an exemplary natural community. The area including Scout Island contains an interdunal swale and a healthy population of Tillandsia usneoides. The portion of Chub Lake that is on Little Creek property is included in this natural area since concentrations of wintering waterfowl, including Black Ducks (Anas rubripes) and Canvasbacks (Aythya valisineria) were observed. The following recommendations are made which will result in the persistence of rare species in this area.

1. The area east of the Pistol Range currently receives little human use. Allowing this habitat to remain in its natural state would allow for natural community and rare species survival.

2. The Scout Island area receives recreational (camping and hiking) impacts. We note no current adverse impacts but recommend that a monitoring program be undertaken to record the persistence of the T. usneoides population. The population is small and taking by humans could eliminate it. This population is one of only a few remaining in Virginia.

3. Use of training craft on Chub Lake should be conducted when resting flocks of waterfowl are absent. Waterfowl are often present during times of severe inclement weather.

East Dunes Special Interest Area
(Ecological Reserve Area)

The East Dunes Special Interest Area incorporates the area from the Rifle Range west to the public beach access and borders the Chesapeake bay to the north and the fence along the golf course on the south. This area contains an exemplary dune and maritime forest community as well as the interdunal swales. Two of the rare plants, Tillandsia usneoides and Lechea maritima occur here. The area has received little human impact. An area which is used for beach access is excluded from the natural area in order to prevent a conflict of uses. The following recommendation is made for maintaining this natural area:

Current use of the area is compatible with the envisioned special interest areas plan. Any use of vehicles in areas other than those currently impacted will have negative impacts.

West Dunes Special Interest Area
(Botanical Area)

The West Dunes Special Interest Area includes examples of foredunes, maritime forest, and interdunal swales. The area is bounded on the east by a north-south sand road just west of the public beach and by a developed area on the west. The north side is bounded by the Chesapeake Bay and the south side by 11th Street. This area appears to be heavily used for training exercises as evidenced by "foxholes" and vehicle tracks. Two rare species of plants are found here including Quercus incana in the dune maritime forest as well as Lechea maritima var. virginica in the foredune and secondary dunes. A sizeable interdunal swale is located between the foredunes and secondary dunes. The following recommendations are made for protecting the rare plants and natural community at this site.

1. Use of vehicles needs to be restricted between the dunes, primarily those containing the maritime forest. The erosion caused by such activity eliminates the suitability of the habitat for rare plants as well as destroys the natural dune landscape.

2. The interdunal swale has been impacted by vehicles driven through it. Consideration and avoidance of this unique wetland should not create an impediment or inconvenience to present uses of this area and is critical to the restoration and protection of this community.

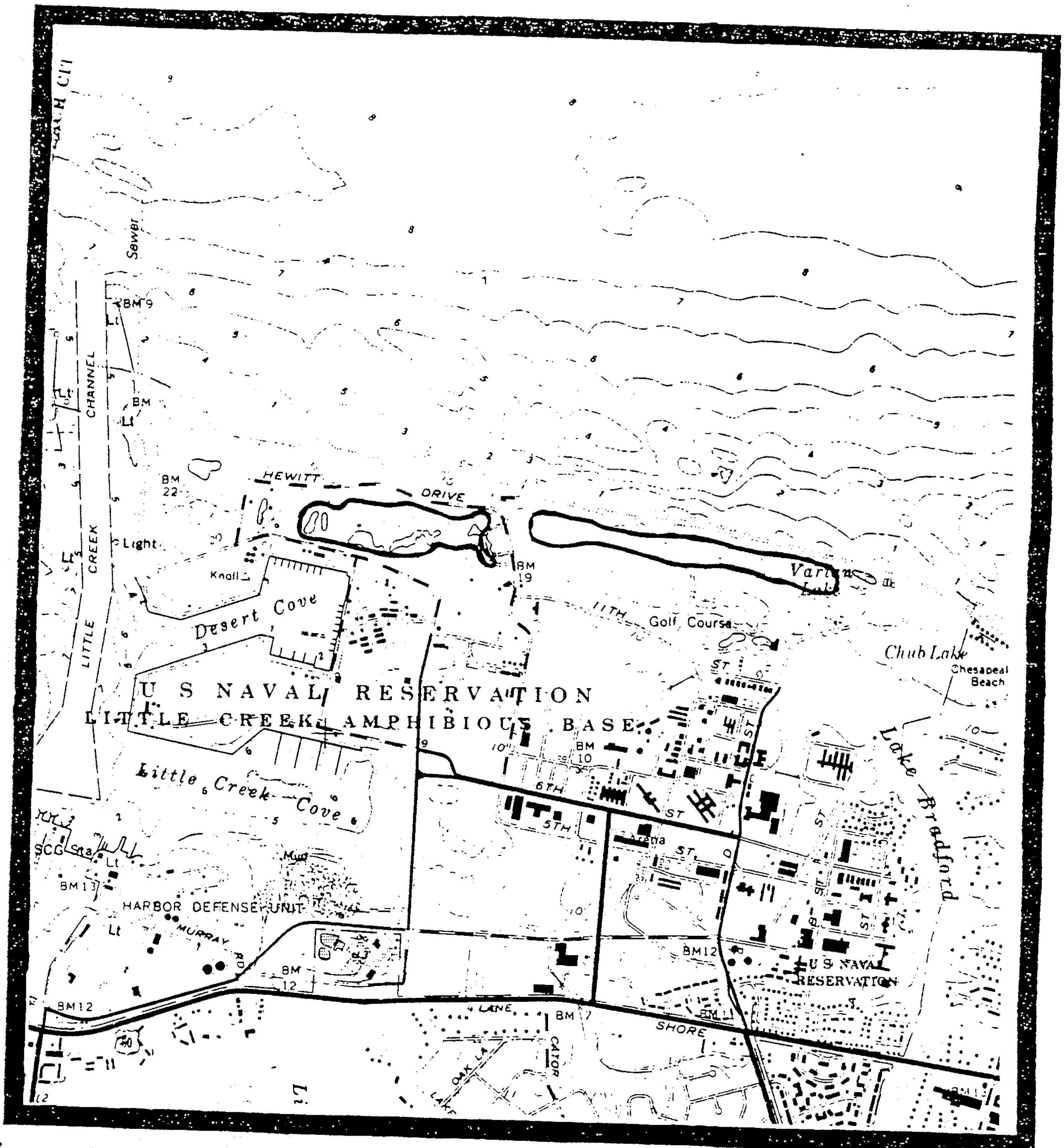


Figure 4. The locations of the rare plant Quercus incana, Bluejack oak, in the study area. The population boundaries are outlined.

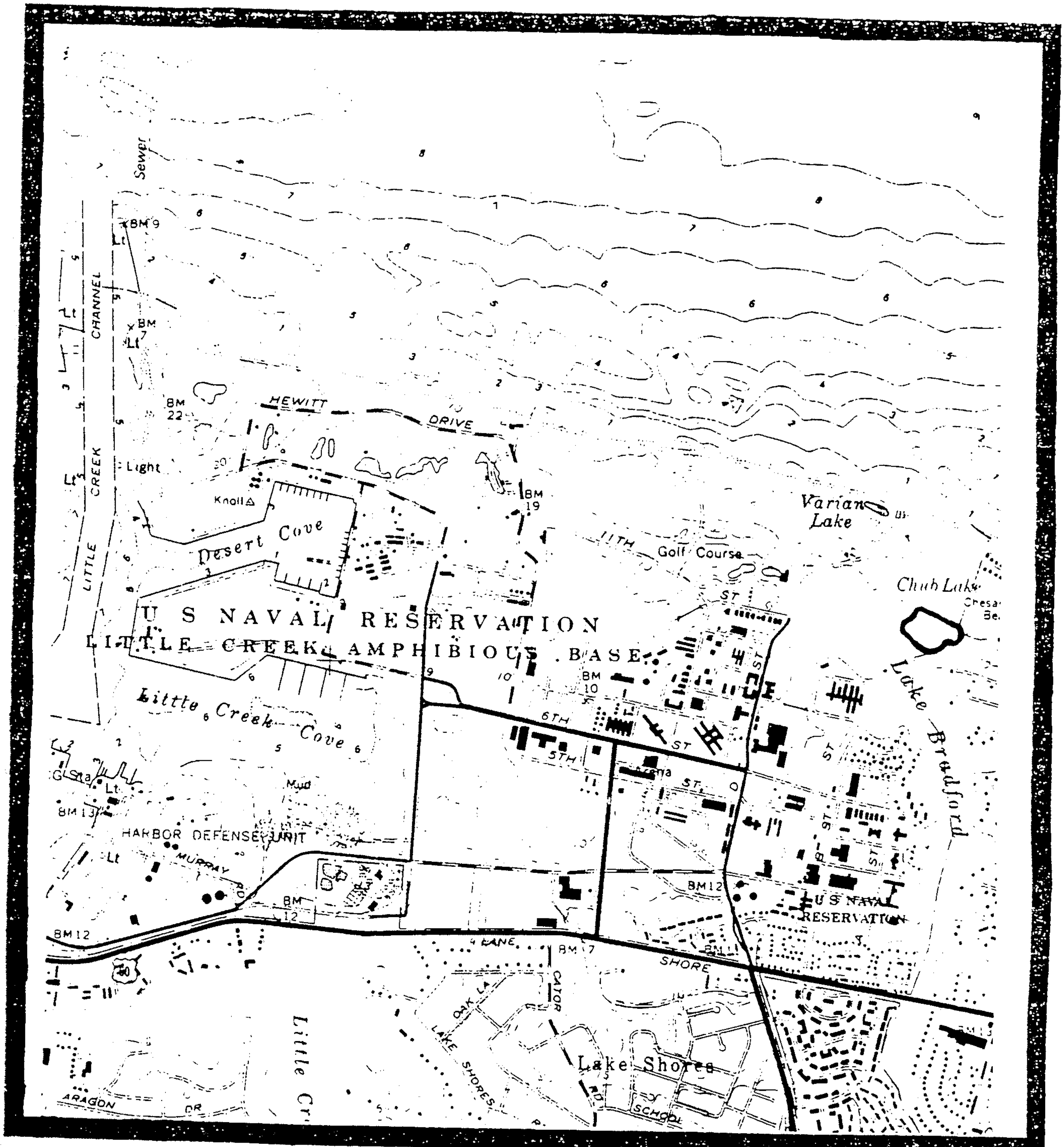


Figure 5. The locations of the rare plant Tillandsia usneoides, Spanish moss, in the study area. The population boundaries are outlined.

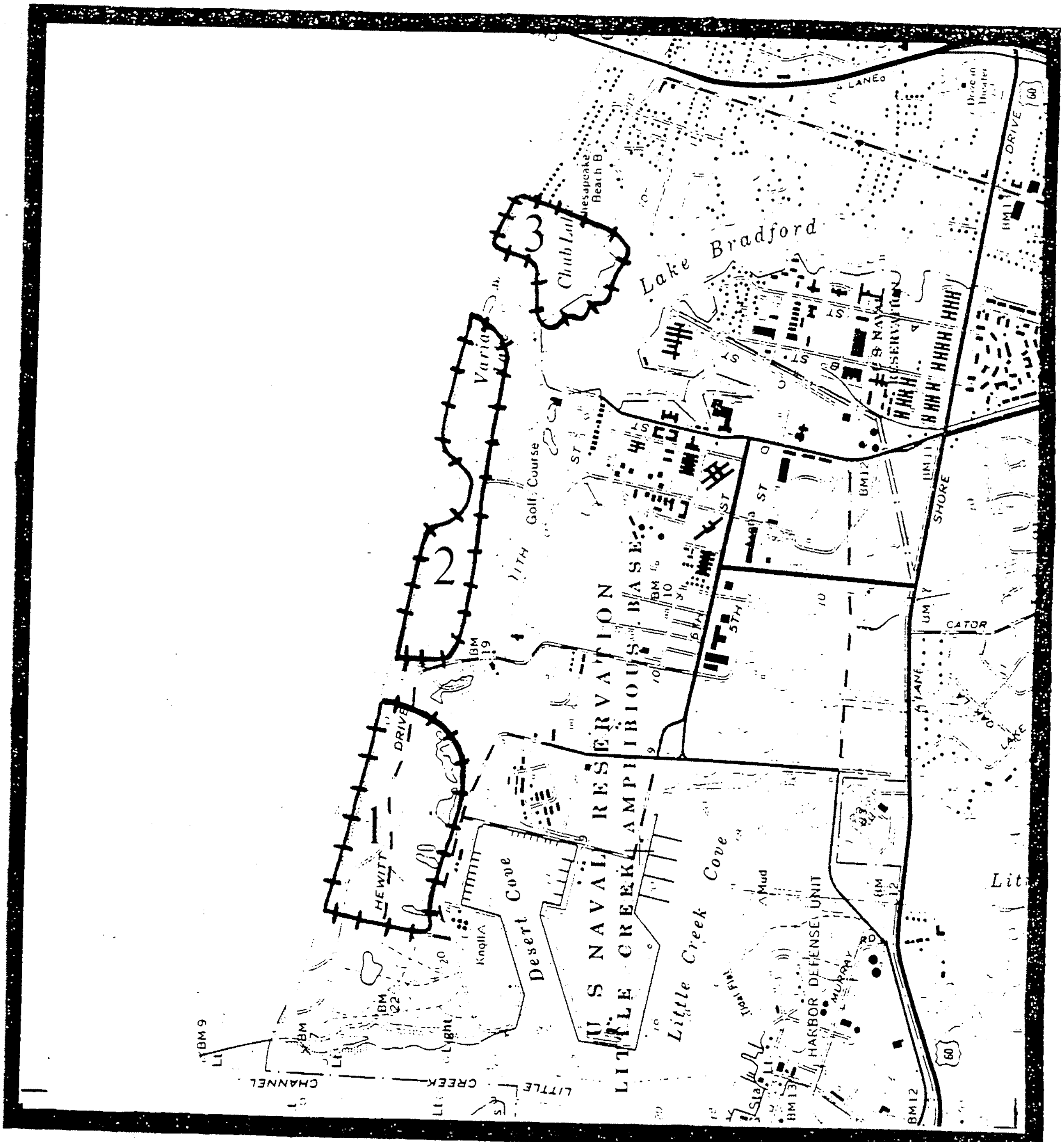


Figure 6. The recommended boundaries for 1 West Dunes, 2 East Dunes, and 3 Chub Lake special interest areas.

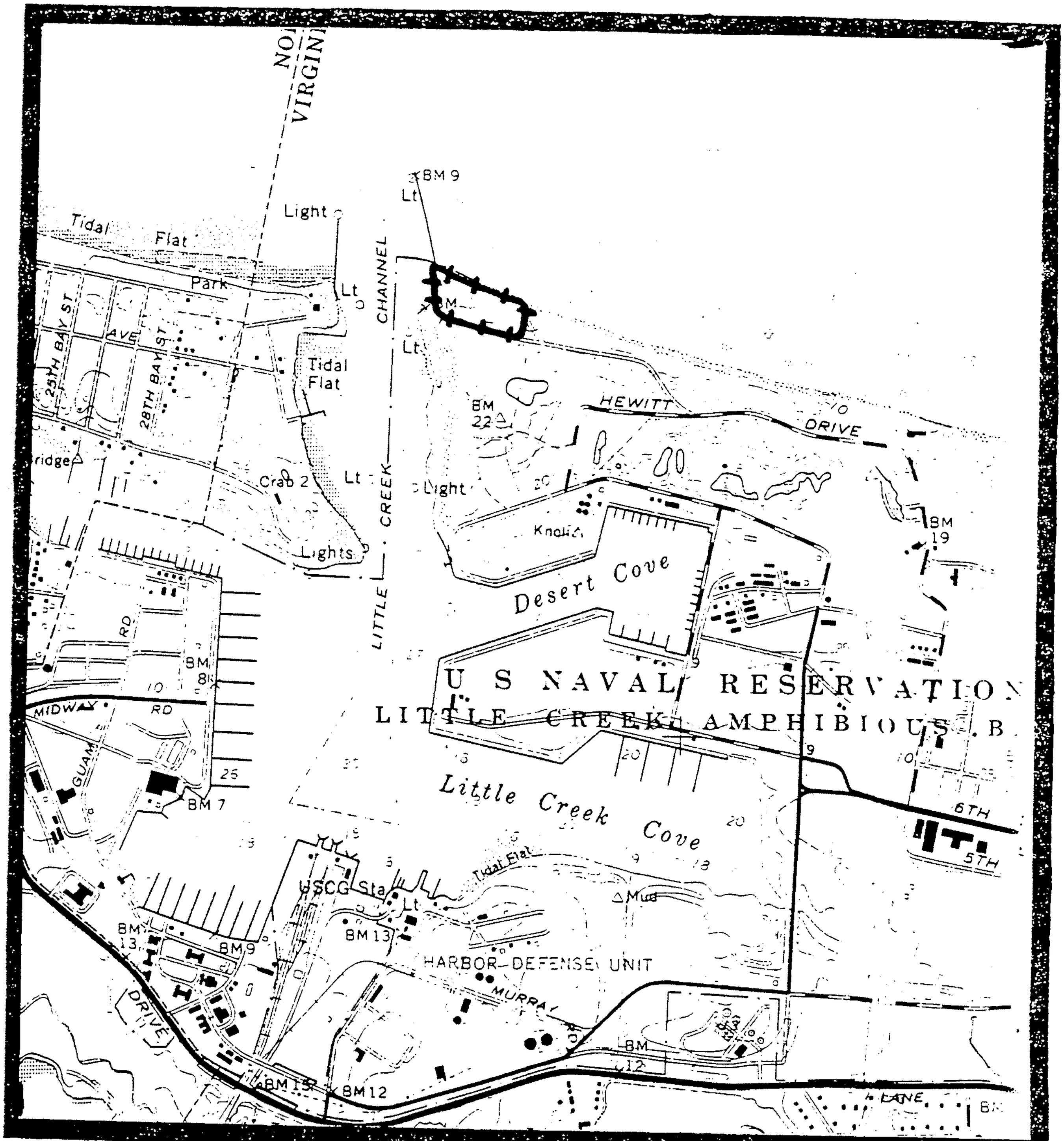


Figure 7. Location of Least Tern (<u>Sterna antillarum</u>) nesting colony on Little Creek Amphibious Base. The boundaries of the Little Creek Channel Special Interest Area are outlined.

Definition of Abbreviations used on Element Lists
of the
Virginia Natural Heritage Program
Department of Conservation and Recreation

The following ranks are used by the Virginia Natural Heritage Program to set protection priorities. The primary criterion for ranking species is the number of occurrences, i.e. the number of known distinct localities. Also of great importance is the number of individuals in existence at each locality or, if a highly mobile organism (e.g., sea turtles, many birds, and butterflies), the total number of individuals. Other considerations may include the condition of the occurrences, the number of protected occurrences, and threats. However, the emphasis remains on the number of occurrences such that ranks will be an index of known biological rarity.

S1 Extremely rare; usually 5 or fewer occurrences in the state; or may be a few remaining individuals; often especially vulnerable to extirpation.

S2 Very rare; usually between 5 and 20 occurrences; or with many individuals in fewer occurrences; often susceptible to becoming endangered.

S3 Rare to uncommon; usually between 20 and 100 occurrences; may have fewer occurrences, but with a large number of individuals in some populations; may be susceptible to large- scale disturbances.

S4 Common; usually >100 occurrences, but may be fewer with many large populations; may be restricted to only a portion of the state; usually not susceptible to immediate threats.

S5 Very common; demonstrably secure under present conditions.

SA Accidental in the state.

SH Historically known from the state, but not verified for an extended period, usually >15 years; this rank is used primarily when inventory has been attempted recently.

SN Regularly occurring migrants; transients; seasonal, nonbreeding residents. Usually no specific site can be identified with its range in the state. (Note that congregation and staging areas are monitored separately).

SU Status uncertain, often because of low search effort or cryptic nature of the element.

SX Apparently extirpated from the state.

Global ranks are similar, but refer to a species' rarity throughout its total range. Global ranks are denoted with a "G" followed by a character. Note that GA and GN are not used and GX means apparently extinct. A "Q" in a rank indicates that a taxonomic question concerning that species exists. Ranks for subspecies are denoted with a "T". The global and state ranks combined (e.g. G2/S1) give an instant grasp of a species' known rarity.

These ranks should not be interpreted as legal designations.

Federal Status

The Virginia Natural Heritage Program uses the standard abbreviations for Federal endangerment developed by the U.S. Fish and Wildlife Service, Division of Endangered Species and Habitat Conservation.

LE - Listed Endangered
LT - Listed Threatened
PE - Proposed Endangered
PT - Proposed Threatened
C1 - Candidate, category 1
C2 - Candidate, category 2
3A - Former candidate - presumed extinct
3B - Former candidate - not a valid species under current taxonomic understanding
3C - Former candidate - common or well protected
NF - no federal legal status

State Status

The Virginia Natural Heritage Program uses similar abbreviations for State endangerment.

LE - Listed Endangered
LT - Listed Threatened
C - Candidate
PE - Proposed Endangered
PT - Proposed Threatened
NS - no state legal status

The following status recommendations reflect the findings of the 1989 Virginia Endangered Species Symposium. THESE ARE NOT LEGAL DESIGNATIONS, NOR HAVE THE SPECIES YET BEEN FORMALLY PROPOSED.

RE - Recommended Endangered
RT - Recommended Threatened
RSC - Recommended Special Concern

For information on the laws pertaining to threatened or endangered species, contact:

U.S. Fish and Wildlife Service for all FEDERALLY listed species
Department of Agriculture and Consumer Services Plant Protection Bureau for STATE listed plants and insects
Department of Game and Inland Fisheries for all other STATE listed animals

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VA DEPARTMENT OF CONSERVATION & RECREATION
DIVISION OF NATURAL HERITAGE
NATURAL HERITAGE RESOURCES FROM NAVAL WEAPONS STATION,
YORKTOWN, VICINITY

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
** COUNTY: Charles City					
* GROUP: BIRDS					
HALIAEETUS LEUCOCEPHALUS	BALD EAGLE	G3	S2S3	LE	LE
PHALACROCORAX AURITUS	DOUBLE-CRESTED CORMORANT	G5	S1		
* GROUP: PLANTS					
AESCHYNOMENE VIRGINICA	SENSITIVE JOINT-VETCH	G2	S2	C2	C
BACOPA INNOMINATA	TROPICAL WATER-HYSSOP	G5	S2		
BACOPA ROTUNDIFOLIA	ROUND-LEAVED WATER-HYSSOP	G5	S1		
DROSERA BREVIFOLIA	DWARF SUNDEW	G5	S2		RSC
ELEOCHARIS VERRUCOSA	SLENDER SPIKERUSH	G3G5Q	S1		
ERIOCAULON PARKERI	PARKER'S PIPEWORT	G3	S2S3	3C	RSC
JUNCUS CAESARIENSIS	NEW JERSEY RUSH	G2	S2S3	C2	RE
MICRANTHEMUM MICRANTHEMOIDES	NUTTALL'S MICRANTHEMUM	GH	SH	C1	C
NUPHAR SAGITTIFOLIUM	YELLOW COWLILY	G3Q	S1		RSC
PEPLIS DIANDRA	WATER-PURSLANE	G5	S1		RSC
POTAMOGETON SPIRILLUS	SPIRAL PONDWEED	G5	S1		RSC
SPIRANTHES ODORATA	SWEETSCENT LADIES'-TRESSES	G5	S2		RSC
TRILLIUM PUSILLUM	LEAST TRILLIUM	G3	S2		RSC
UTRICULARIA GEMINISCAPA	HIDDEN-FRUITED BLADDERWORT	G4G5	S2		RSC
** COUNTY: Chesapeake					
* GROUP: AMPHIBIANS					
BUFO QUERCICUS	OAK TOAD	G5	SU		RSC
LIMNAOEDUS OCULARIS	LITTLE GRASS FROG	G5	S3		
RANA VIRGATIPES	CARPENTER FROG	G5	S3		RSC
STEREOCHILUS MARGINATUS	MANY-LINED SALAMANDER	G5	S3		
* GROUP: COMMUNITIES					
MID-HEIGHT HERBACEOUS	MID-HEIGHT HERBACEOUS				
PALUSTRINE WETLAND	PALUSTRINE WETLAND				
POCOSIN	POCOSIN		S1S2		
SUBMESOTROPHIC FOREST	SUBMESOTROPHIC FOREST				
* GROUP: INVERTEBRATES					
CELASTRINA EBENINA	SOOTY AZURE	G4	S3S4		
ENALLAGMA PALLIDUM	A DAMSELFLY	G4	S1		RSC
EUPHYES DUKESI	SCARCE SWAMP SKIPPER	G3G4	S2		
GOMPHAESCHNA FURCILLATA	HARLEQUIN DARNER	G5	S2		
STYGOBROMUS ARAEUS	TIDEWATER INTERSTITIAL AMPHIPOD	G?	S2	C2	

VA DEPARTMENT OF CONSERVATION & RECREATION
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NATURAL HERITAGE RESOURCES FROM NAVAL WEAPONS STATION,
YORKTOWN, VICINITY

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
* GROUP: MAMMALS					
SOREX LONGIROSTRIS FISHERI	DISMAL SWAMP SOUTHEASTERN SHREW	G5T2Q	S2	LT	LT
SYNAPTOMYS COOPERI HELALETES	DISMAL SWAMP BOG LEMMING	G5T3	S3	3C	
* GROUP: OTHER					
CHAMPION TREE					
* GROUP: PLANTS					
AGALINIS VIRGATA	PINE-BARREN GERARDIA	G3G4	S1		RSC
ASTER ELLIOTTII	ELLIOTT'S ASTER	G3G4	S1		RSC
BOLTONIA ASTEROIDES	ASTER-LIKE BOLTONIA	G5	S2		
BOLTONIA CAROLINIANA	CAROLINA BOLTONIA	G2Q	S2		
CHAMAECYPARIS THYOIDES	ATLANTIC WHITE CEDAR	G4	S2		RSC
CLADIUM JAMAICENSE	SAWGRASS	G5	S1		RSC
ERIOCAULON DECANGULARE	TEN-ANGLE PIPEWORT	G5	S1		RSC
GENTIANA AUTUMNALIS	PINE BARREN GENTIAN	G3	S1	3C	
PANICUM HEMITOMON	MAIDENCANE	G5?	S1		RSC
PSILOCARYA SCIRPOIDES	LONG-BEAKED BALDRUSH	G4	S1		RSC
SAGITTARIA ENGELMANNIANA	ENGELMANN ARROWHEAD	G5?	S1		RSC
SCIRPUS ACUTUS	HARD-STEMMED BULRUSH	G5	S2		RSC
SPIRANTHES ODORATA	SWEETSCENT LADIES'-TRESSES	G5	S2		RSC
STEWARTIA MALACODENDRON	SILKY CAMELLIA	G4	S2		RSC
TILLANDSIA USNEOIDES	SPANISH MOSS	G5	S2		RSC
TRILLIUM PUSILLUM	LEAST TRILLIUM	G3	S2		RSC
* GROUP: REPTILES					
CROTALUS HORRIDUS ATRICAUDATUS	CANEBRAKE RATTLESNAKE	G5TUQ	S1		RE
** COUNTY: Gloucester					
* GROUP: BIRDS					
HALIAEETUS LEUCOCEPHALUS	BALD EAGLE	G3	S2S3	LE	LE
* GROUP: COMMUNITIES					
BRACKISH MARSH	BRACKISH MARSH		S5		
* GROUP: PLANTS					
CHAMAECYPARIS THYOIDES	ATLANTIC WHITE CEDAR	G4	S2		RSC
CHELONE OBLIQUA	RED TURTLEHEAD	G4	S1		RSC
ELEOCHARIS TRICOSTATA	THREE-ANGLE SPIKERUSH	G3G4	S1		RSC
MALAXIS SPICATA	FLORIDA ADDER'S-MOUTH	G3G4	S2		RSC

VA DEPARTMENT OF CONSERVATION & RECREATION
DIVISION OF NATURAL HERITAGE
NATURAL HERITAGE RESOURCES FROM NAVAL WEAPONS STATION, YORKTOWN, VICINITY

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
** COUNTY: Hampton					
* GROUP: AMPHIBIANS					
AMBYSTOMA MABEEI	MABEE'S SALAMANDER	G4	S2?		RSC
* GROUP: BIRDS					
CASMERODIUS ALBUS	GREAT EGRET	G5	S2		RSC
CHARADRIUS MELODUS	PIPING PLOVER	G3	S2	LT	LT
RYNCHOPS NIGER	BLACK SKIMMER	G5	S3		
STERNA ANTILLARUM	LEAST TERN	G4	S2		RT
STERNA HIRUNDO	COMMON TERN	G5	S3		
* GROUP: INVERTEBRATES					
CICINDELA DORSALIS DORSALIS	NORTHEASTERN BEACH TIGER BEETLE	G4T2	S2	C1	RE
* GROUP: OTHER					
CHAMPION TREE					
* GROUP: PLANTS					
CAREX PEDUNCULATA	LONGSTALK SEDGE	G5	S2		
DROSERA BREVIFOLIA	DWARF SUNDEW	G5	S2		RSC
IVA IMBRICATA	SEA-COAST MARSH-ELDER	G5?	S1S2		RSC
** COUNTY: Isle of Wight					
* GROUP: AMPHIBIANS					
AMBYSTOMA MABEEI	MABEE'S SALAMANDER	G4	S2?		RSC
HYLA GRATIOSA	BARKING TREEFROG	G5	S1		RSC
SIREN INTERMEDIA	LESSER SIREN	G5	SU		
* GROUP: BIRDS					
HALIAEETUS LEUCOCEPHALUS	BALD EAGLE	G3	S2S3	LE	LE
* GROUP: COMMUNITIES					
COASTAL PLAIN SINKHOLE POND	COASTAL PLAIN SINKHOLE POND		S1		
MESOTROPHIC SEMIPERMANENTLY FLOODED PALUSTRINE FOREST	MESOTROPHIC SEMIPERMANENTLY FLOODED PALUSTRINE FOREST				
* GROUP: FISH					
ACANTHARCHUS POMOTIS	MUD SUNFISH	G5	S3		
ERIMYZON SUCETTA	LAKE CHUBSUCKER	G5	S2		
FUNDULUS LINEOLATUS	LINED TOPMINNOW	G5	S1		

VA DEPARTMENT OF CONSERVATION & RECREATION
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NATURAL HERITAGE RESOURCES FROM NAVAL WEAPONS STATION,
YORKTOWN, VICINITY

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
* GROUP: INVERTEBRATES					
ARGIA TIBIALIS	EASTERN DANCER	G5	S2		
ATLIDES HALESUS	GREAT PURPLE HAIRSTREAK	G5	S3		
ISCHNURA RAMBURII	A DAMSELFLY	G5	S2		
LESTES DISJUNCTUS AUSTRALIS	A DAMSELFLY	G5T5	S2		
MACROMIA GEORGINA	GEORGIA RIVER CRUISER	G3G5	S1		
STYGOBROMUS INDENTATUS	TIDEWATER AMPHIPOD	G?	S1	C2	
* GROUP: MAMMALS					
PEROMYSCUS GOSSYPINUS	COTTON MOUSE	G5	S3		
* GROUP: PLANTS					
ASIMINA PARVIFLORA	DWARF PAW-PAW	G5	S2		RSC
BULBOSTYLIS CILIATIFOLIA	CAPILLARY HAIRSEDGE	G5	S1S2		RSC
CAREX COLLINSII	COLLINS' SEDGE	G4	S3		RSC
CAREX DECOMPOSITA	EPIPHYTIC SEDGE	G3G4	S1	3C	
CROTALARIA ROTUNDIFOLIA	PROSTRATE RATTLE-BOX	G5	S1		
ELEOCHARIS MELANOCARPA	BLACK-FRUITED SPIKERUSH	G4	S2		RE
ERIANTHUS BREVIBARBIS	SHORT-BEARD PLUMEGRASS	G3G5	S1		RSC
EUPHORBIA AMMANNIOIDES	A SPURGE	G3G4	S2		RSC
JUNCUS ABORTIVUS	PINEBARREN RUSH	G4G5	S1		RE
JUNCUS CRASSIFOLIUS	A RUSH	G?	S2		RSC
JUSTICIA OVATA	OVATE WATER-WILLOW	G5	S1		RSC
KALMIA ANGUSTIFOLIA	SHEEP-LAUREL	G5	S2S3		RSC
LUDWIGIA BREVIPES	LONG BEACH SEEDBOX	G4G5	S2		RSC
MICRANTHEMUM UMBROSUM	SHADE MUDFLOWER	G5	S1		RSC
PANICUM HEMITOMON	MAIDENCANE	G5?	S1		RSC
PINUS PALUSTRIS	LONG-LEAF PINE	G4G5	S2		RSC
POLYGONELLA POLYGAMA	OCTOBER-FLOWER	G3G5	S1		RSC
PYXIDANTHERA BARBULATA	FLOWERING PIXIE-MOSS	G4	S1		RE
QUERCUS LAEVIS	TURKEY OAK	G5	S2		RSC
QUERCUS MARGARETTAE	SAND POST OAK	G5	S2		RSC
RHYNCHOSPORA FASCICULARIS	FASCICULATE BEAKRUSH	G5	S2		RSC
SABATIA CALYCINA	COAST ROSE-GENTIAN	G3G5	S1S2		RSC
SABATIA DIFFORMIS	TWO-FORMED PINK	G4G5	S1		RSC
SARRACENIA PURPUREA	NORTHERN PITCHER-PLANT	G5	S2		RSC
SEYMERIA CASSIOIDES	SEYMERIA	G5	S2		RSC
STIPULICIDA SETACEA	PINELAND SCALY-PINK	G4G5	S1		RSC
UTRICULARIA PURPUREA	PURPLE BLADDERWORT	G5	S2		RSC
* GROUP: REPTILES					
TANTILLA CORONATA	SOUTHEASTERN CROWNED SNAKE	G5	S2?		

VA DEPARTMENT OF CONSERVATION & RECREATION
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NATURAL HERITAGE RESOURCES FROM NAVAL WEAPONS STATION, YORKTOWN, VICINITY

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
** COUNTY: James City					
* GROUP: AMPHIBIANS					
RANA VIRGATIPES	CARPENTER FROG	G5	S3		RSC
* GROUP: BIRDS					
HALIAEETUS LEUCOCEPHALUS	BALD EAGLE	G3	S2S3	LE	LE
* GROUP: COMMUNITIES					
MID-HEIGHT HERBACEOUS	MID-HEIGHT HERBACEOUS				
PALUSTRINE WETLAND	PALUSTRINE WETLAND				
SOUTHERN MIXED HARDWOOD FOREST	SOUTHERN MIXED HARDWOOD FOREST		S3		
* GROUP: INVERTEBRATES					
ARIGOMPHUS VILLOSIPES	A POND CLUBTAIL	G5	S2		
GOMPHAESCHNA FURCILLATA	HARLEQUIN DARNER	G5	S2		
ISCHNURA PROGNATHA	A DAMSELFLY	G4	S1		RSC
LIGUMIA NASUTA	EASTERN PONDMUSSEL	G4	S3		
TACHOPTERYX THOREYI	THOREY'S GRAYBACK DAMSELFLY	G4	S1		
* GROUP: OTHER					
CHAMPION TREE					
* GROUP: PLANTS					
AESCHYNOMENE VIRGINICA	SENSITIVE JOINT-VETCH	G2	S2	C2	C
BOLTONIA ASTEROIDES	ASTER-LIKE BOLTONIA	G5	S2		
CAREX LACUSTRIS	LAKE-BANK SEDGE	G5	S1		RSC
CASSIA FASCICULATA VAR MACROSPERMA	PRAIRIE SENNA	G5T1Q	S2	C2	
CICUTA BULBIFERA	BULB-BEARING WATER-HEMLOCK	G5	S1		
ELEOCHARIS VERRUCOSA	SLENDER SPIKERUSH	G3G5Q	S1		
ERIOCAULON DECANGULARE	TEN-ANGLE PIPEWORT	G5	S1		RSC
HELENIUM BREVIFOLIUM	SHORTLEAF SNEEZEWEED	G4	S2		RSC
ISOTRIA MEDEOLOIDES	SMALL WHORLED POGONIA	G2	S2	LE	LE
JUNCUS CAESARIENSIS	NEW JERSEY RUSH	G2	S2S3	C2	RE
LISTERA AUSTRALIS	SOUTHERN TWAYBLADE	G4	S2S3		RSC
MALAXIS SPICATA	FLORIDA ADDER'S-MOUTH	G3G4	S2		RSC
NUPHAR SAGITTIFOLIUM	YELLOW COWLILY	G3Q	S1		RSC
PANICUM HIANS	GAPING PANIC GRASS	G5	S1		RSC
SPIRANTHES ODORATA	SWEETSCENT LADIES'-TRESSES	G5	S2		RSC
STEWARTIA OVATA	MOUNTAIN CAMELLIA	G4	S2		RSC
TRILLIUM PUSILLUM	LEAST TRILLIUM	G3	S2		RSC
VERBENA SCABRA	SANDPAPER VERVAIN	G5	S2		RSC
XYRIS CAROLINIANA	CAROLINA YELLOW-EYED GRASS	G4G5	S1		RSC

VA DEPARTMENT OF CONSERVATION & RECREATION
DIVISION OF NATURAL HERITAGE
NATURAL HERITAGE RESOURCES FROM NAVAL WEAPONS STATION, YORKTOWN, VICINITY

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
** COUNTY: King William King and Queen					
* GROUP: PLANTS					
ERIOCAULON PARKERI	PARKER'S PIPEWORT	G3	S2S3	3C	RSC
** COUNTY: King and Queen					
* GROUP: BIRDS					
HALIAEETUS LEUCOCEPHALUS	BALD EAGLE	G3	S2S3	LE	LE
* GROUP: COMMUNITIES					
MID-HEIGHT HERBACEOUS PALUSTRINE WETLAND	MID-HEIGHT HERBACEOUS PALUSTRINE WETLAND				
* GROUP: PLANTS					
AESCHYNOMENE VIRGINICA	SENSITIVE JOINT-VETCH	G2	S2	C2	C
BACOPA INNOMINATA	TROPICAL WATER-HYSSOP	G5	S2		
CAREX COLLINSII	COLLINS' SEDGE	G4	S3		RSC
CASSIA FASCICULATA VAR MACROSPERMA	PRAIRIE SENNA	G5T1Q	S2	C2	
ERIOCAULON PARKERI	PARKER'S PIPEWORT	G3	S2S3	3C	RSC
** COUNTY: Middlesex Gloucester					
* GROUP: PLANTS					
ERIOCAULON PARKERI	PARKER'S PIPEWORT	G3	S2S3	3C	RSC
** COUNTY: Middlesex King and Queen					
* GROUP: COMMUNITIES					
BALD CYPRESS-TUPELO SWAMP	BALD CYPRESS-TUPELO SWAMP		S4		
** COUNTY: New Kent					
* GROUP: BIRDS					
HALIAEETUS LEUCOCEPHALUS	BALD EAGLE	G3	S2S3	LE	LE
* GROUP: COMMUNITIES					
EUTROPHIC SEMIPERMANENTLY FLOODED PALUSTRINE FOREST	EUTROPHIC SEMIPERMANENTLY FLOODED PALUSTRINE FOREST				
OLIGOTROPHIC SATURATED PALUSTRINE FOREST	OLIGOTROPHIC SATURATED PALUSTRINE FLOODED FOREST				
SUBMESOTROPHIC FOREST	SUBMESOTROPHIC FOREST				

VA DEPARTMENT OF CONSERVATION & RECREATION
DIVISION OF NATURAL HERITAGE
NATURAL HERITAGE RESOURCES FROM NAVAL WEAPONS STATION, YORKTOWN, VICINITY

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
* GROUP: INVERTEBRATES					
PROBLEMA BULENTA	RARE SKIPPER	G2G3	S1	C2	
* GROUP: PLANTS					
AESCHYNOMENE VIRGINICA	SENSITIVE JOINT-VETCH	G2	S2	C2	C
BACOPA INNOMINATA	TROPICAL WATER-HYSSOP	G5	S2		
CAREX COLLINSII	COLLINS' SEDGE	G4	S3		RSC
CASSIA FASCICULATA VAR MACROSPERMA	PRAIRIE SENNA	G5T1Q	S2	C2	
ELEOCHARIS ROSTELLATA	BEAKED SPIKERUSH	G5	S1		RSC
ERIOCAULON PARKERI	PARKER'S PIPEWORT	G3	S2S3	3C	RSC
LIPARIS LOESELII	LOESEL'S TWAYBLADE	G5	S2		RSC
LYSIMACHIA RADICANS	TRAILING LOOSESTRIFE	G4G5	S1		
NUPHAR SAGITTIFOLIUM	YELLOW COWLILY	G3Q	S1		RSC
OPHIOGLOSSUM VULGATUM VAR PSEUDOPOD	ADDER'S-TONGUE	G5T5	S1		RSC
SCIRPUS ACUTUS	HARD-STEMMED BULRUSH	G5	S2		RSC
XYRIS CAROLINIANA	CAROLINA YELLOW-EYED GRASS	G4G5	S1		RSC
* GROUP: REPTILES					
REGINA RIGIDA	GLOSSY CRAYFISH SNAKE	G5	SH		
** COUNTY: Newport News					
* GROUP: BIRDS					
HALIAEETUS LEUCOCEPHALUS	BALD EAGLE	G3	S2S3	LE	LE
* GROUP: INVERTEBRATES					
CELITHEMIS FASCIATA	BANDED PENNANT	G5	S2		
* GROUP: PLANTS					
CHELONE CUTHBERTII	CUTHBERT TURTLEHEAD	G3	S2		RSC
ELEOCHARIS ROSTELLATA	BEAKED SPIKERUSH	G5	S1		RSC
** COUNTY: Norfolk					
* GROUP: BIRDS					
RYNCHOPS NIGER	BLACK SKIMMER	G5	S3		
STERNA ANTILLARUM	LEAST TERN	G4	S2		RT
STERNA HIRUNDO	COMMON TERN	G5	S3		
* GROUP: INVERTEBRATES					
ENALLAGMA DURUM	A DAMSELFLY	G5	S2		
ERYTHRODIPLAX MINUSCULA	BLUE DRAGONLET	G5	S2		
GOMPHAESCHNA ANTILOPE	TAPER-TAILED DARNER	G5	S2		

VA DEPARTMENT OF CONSERVATION & RECREATION
DIVISION OF NATURAL HERITAGE
NATURAL HERITAGE RESOURCES FROM NAVAL WEAPONS STATION,
YORKTOWN, VICINITY

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
ISCHNURA RAMBURII	A DAMSELFLY	G5	S2		
LESTES DISJUNCTUS AUSTRALIS	A DAMSELFLY	G5T5	S2		
LIBELLULA AXILENA	BAR-WINGED SKIMMER	G5	S1		
TRAMEA ONUSTA	RED-MANTLED GLIDER	G5	S1		
* GROUP: MAMMALS					
PEROMYSCUS GOSSYPINUS	COTTON MOUSE	G5	S3		
SYNAPTOMYS COOPERI HELALETES	DISMAL SWAMP BOG LEMMING	G5T3	S3	3C	
* GROUP: PLANTS					
IVA IMBRICATA	SEA-COAST MARSH-ELDER	G5?	S1S2		RSC
KALMIA ANGUSTIFOLIA	SHEEP-LAUREL	G5	S2S3		RSC
LACHNANTHES CAROLIANA	CAROLINA REDROOT	G4	S1		
LIMNOBIUM SPONGIA	AMERICAN FROG'S-BIT	G5	S2		RSC
PANICUM STRIGOSUM	ROUGH-HAIR WITCHGRASS	G5	SU		
STEWARTIA MALACODENDRON	SILKY CAMELLIA	G4	S2		RSC
* GROUP: REPTILES					
OPHISAURUS VENTRALIS	EASTERN GLASS LIZARD	G5	S1		RT
** COUNTY: Northampton					
* GROUP: BIRDS					
FALCO PEREGRINUS	PEREGRINE FALCON	G3	S1	LE	LE
HALIAEETUS LEUCOCEPHALUS	BALD EAGLE	G3	S2S3	LE	LE
* GROUP: COMMUNITIES					
DUNE GRASSLAND	DUNE GRASSLAND		S4		
DUNE SCRUB			S1		
INTERDUNE POND	INTERDUNE POND		S1		
MARITIME FOREST	MARITIME FOREST		S2S3		
SALT FLAT	SALT FLAT		S5		
* GROUP: INVERTEBRATES					
CICINDELA DORSALIS DORSALIS	NORTHEASTERN BEACH TIGER BEETLE	G4T2	S2	C1	RE
* GROUP: MAMMALS					
SYLVILAGUS FLORIDANUS HITCHENSI	SMITHS ISLAND COTTONTAIL	G5THQ	SH	C2	
* GROUP: OTHER					
BIRD NESTING COLONY					

VA DEPARTMENT OF CONSERVATION & RECREATION
DIVISION OF NATURAL HERITAGE
NATURAL HERITAGE RESOURCES FROM NAVAL WEAPONS STATION, YORKTOWN, VICINITY

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* GROUP: PLANTS					
AMARANTHUS PUMILUS	SEABEACH PIGWEED	G2	SH	C2	
ARISTIDA TUBERCULOSA	SEABEACH NEEDLEGRASS	G5	S2		
CYPERUS ENGELMANNII	ENGELMANN'S UMBRELLA-SEDGE	G4Q	S1		RSC
EUPHORBIA AMMANNIOIDES	A SPURGE	G3G4	S2		RSC
FIMBRISTYLIS CAROLINIANA	CAROLINA FIMBRY	G4	S1		RSC
GALIUM HISPIDULUM	COAST BEDSTRAW	G5	S1S2		RSC
LISTERA AUSTRALIS	SOUTHERN TWAYBLADE	G4	S2S3		RSC
PHYSALIS VISCOSA	STICKY GROUND-CHERRY	G4G5	S2		RSC
POLYGONUM GLAUCUM	SEA-BEACH KNOTWEED	G3	S2		RSC
SOLIDAGO ELLIOTTII	ELLIOTT GOLDENROD	G5	S1		RSC
SOLIDAGO TORTIFOLIA	A GOLDENROD	G3G5	S1		RSC
THELYPTERIS SIMULATA	BOG FERN	G5	S1		RSC
TILLANDSIA USNEOIDES	SPANISH MOSS	G5	S2		RSC
** COUNTY: Poquoson					
* GROUP: PLANTS					
CUSCUTA INDECORA	PRETTY DODDER	G5	S2?		
** COUNTY: Portsmouth					
* GROUP: BIRDS					
CASMERODIUS ALBUS	GREAT EGRET	G5	S2		RSC
CHARADRIUS MELODUS	PIPING PLOVER	G3	S2	LT	LT
STERNA ANTILLARUM	LEAST TERN	G4	S2		RT
STERNA HIRUNDO	COMMON TERN	G5	S3		
* GROUP: PLANTS					
BACOPA CAROLINIANA	CAROLINA WATER-HYSSOP	G4G5	S1		RSC
** COUNTY: Southampton Isle of Wight					
* GROUP: INVERTEBRATES					
LEPTODEA OCHRACEA	TIDEWATER MUCKET	G4	S3		
LIGUMIA NASUTA	EASTERN PONDMUSSEL	G4	S3		
** COUNTY: Suffolk					
* GROUP: AMPHIBIANS					
AMBYSTOMA MABEEI	MABEE'S SALAMANDER	G4	S2?		RSC
BUFO QUERCICUS	OAK TOAD	G5	SU		RSC
LIMNAOEDUS OCULARIS	LITTLE GRASS FROG	G5	S3		
SIREN INTERMEDIA	LESSER SIREN	G5	SU		
STEREOCHILUS MARGINATUS	MANY-LINED SALAMANDER	G5	S3		

VA DEPARTMENT OF CONSERVATION & RECREATION
DIVISION OF NATURAL HERITAGE
NATURAL HERITAGE RESOURCES FROM NAVAL WEAPONS STATION,
YORKTOWN, VICINITY

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
* GROUP: BIRDS					
HALIAEETUS LEUCOCEPHALUS	BALD EAGLE	G3	S2S3	LE	LE
LIMNOTHLYPIS SWAINSONII	SWAINSON'S WARBLER	G4	S2		RT
* GROUP: FISH					
ERIMYZON SUCETTA	LAKE CHUBSUCKER	G5	S2		
FUNDULUS LINEOLATUS	LINED TOPMINNOW	G5	S1		
* GROUP: INVERTEBRATES					
ARGIA TIBIALIS	EASTERN DANCER	G5	S2		
CHLOROCHROA DISMALIA	DISMAL SWAMP GREEN STINK BUG	G1	S1	C2	
ENALLAGMA DUBIUM	A DAMSELFLY	G5	S2		
EPITHECA SPINOSA	A BASKETTAIL	G3G4	S1		RT
GOMPHAESCHNA ANTILOPE	TAPER-TAILED DARNER	G5	S2		
LESTES DISJUNCTUS AUSTRALIS	A DAMSELFLY	G5T5	S2		
LESTES VIGILAX	SWAMP SPREADWING	G5	S2		
LIBELLULA AXILENA	BAR-WINGED SKIMMER	G5	S1		
MACROMIA GEORGINA	GEORGIA RIVER CRUISER	G3G5	S1		
NEHALENNIA INTEGRICOLLIS	A DAMSELFLY	G3	S1		RSC
NEONYMPHA AREOLATUS AREOLATUS	GEORGIA SATYR	G5T4	S2S4		
SOMATOCHLORA FILOSA	FINELINED EMERALD	G5	S1		
STYGOBROMUS INDENTATUS	TIDEWATER AMPHIPOD	G?	S1	C2	
SYMPETRUM AMBIGUUM	BLUE-FACED MEADOWFLY	G5	S1		
TAENIOGASTER OBLIQUA FASCIATA	A DRAGONFLY	G2?	S1		
TRAMEA ONUSTA	RED-MANTLED GLIDER	G5	S1		
ZANCLOGNATHA GYPSALIS	A NOCTUID MOTH	GU	SU		
* GROUP: MAMMALS					
PEROMYSCUS GOSSYPINUS	COTTON MOUSE	G5	S3		
PLECOTUS RAFINESQUII	EASTERN BIG-EARED BAT	G4	S1	C2	LE
SOREX LONGIROSTRIS FISHERI	DISMAL SWAMP SOUTHEASTERN SHREW	G5T2Q	S2	LT	LT
SYNAPTOMYS COOPERI HELALETES	DISMAL SWAMP BOG LEMMING	G5T3	S3	3C	
* GROUP: OTHER					
CHAMPION TREE					
* GROUP: PLANTS					
AGALINIS TENELLA	PENNELL FALSE-FOXGLOVE	G3G5Q	S1		RSC
AGALINIS VIRGATA	PINE-BARREN GERARDIA	G3G4	S1		RSC
ALETRIS AUREA	GOLDEN COLICROOT	G5	S1		RSC
ASIMINA PARVIFLORA	DWARF PAW-PAW	G5	S2		RSC
BULBOSTYLIS CILIATIFOLIA	CAPILLARY HAIRSEDGE	G5	S1S2		RSC
CALOPOGON PALLIDUS	PALE GRASS-PINK	G4G5	S1		RSC

VA DEPARTMENT OF CONSERVATION & RECREATION
DIVISION OF NATURAL HERITAGE
NATURAL HERITAGE RESOURCES FROM NAVAL WEAPONS STATION,
YORKTOWN, VICINITY

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
CAREX WALTERIANA	A SEDGE	G4	S1S2		RSC
CARPHEPHORUS TOMENTOSUS	WOLLY CHAFFHEAD	G4	S1		RSC
CHAMAECYPARIS THYOIDES	ATLANTIC WHITE CEDAR	G4	S2		RSC
CHELONE CUTHBERTII	CUTHBERT TURTLEHEAD	G3	S2		RSC
CHELONE OBLIQUA	RED TURTLEHEAD	G4	S1		RSC
CLEISTES DIVARICATA	SPREADING POGONIA	G4	S1S2		RSC
CROTALARIA ROTUNDIFOLIA	PROSTRATE RATTLE-BOX	G5	S1		
DROSERA BREVIFOLIA	DWARF SUNDEW	G5	S2		RSC
ERIOCAULON PARKERI	PARKER'S PIPEWORT	G3	S2S3	3C	RSC
GENTIANA AUTUMNALIS	PINE BARREN GENTIAN	G3	S1	3C	
HABENARIA BLEPHARIGLOTTIS	WHITE-FRINGE ORCHIS	G4G5	S2		RE
ILEX CORIACEA	BAY-GAIL HOLLY	G5	S1		RSC
JUNCUS ABORTIVUS	PINEBARREN RUSH	G4G5	S1		RE
LILIUM CATESBAEI	SOUTHERN RED LILY	G4	S1		
LISTERA AUSTRALIS	SOUTHERN TWAYBLADE	G4	S2S3		RSC
LUDWIGIA VIRGATA	SAVANNA SEEDBOX	G5	S1		RSC
LYCOPODIUM INUNDATUM	NORTHERN BOG CLUBMOSS	G5	S1		RSC
PANICUM STRIGOSUM	ROUGH-HAIR WITCHGRASS	G5	SU		
PASPALUM PRAECOX	EARLY PASPALUM	G4	S1		RSC
PINUS PALUSTRIS	LONG-LEAF PINE	G4G5	S2		RSC
PSILOCARYA SCIRPOIDES	LONG-BEAKED BALDRUSH	G4	S1		RSC
PYXIDANTHERA BARBULATA	FLOWERING PIXIE-MOSS	G4	S1		RE
QUERCUS LAEVIS	TURKEY OAK	G5	S2		RSC
RHEXIA PETIOLATA	CILIATE MEADOW-BEAUTY	G3G5	S1		RSC
RHYNCHOSPORA DEBILIS	SAVANNAH BEAKRUSH	G4?	S1		
SARRACENIA FLAVA	YELLOW PITCHER-PLANT	G4G5	S1		RE
SCLERIA MINOR	SLENDER NUTRUSH	G4G5	S2		RSC
SEYMERIA CASSIOIDES	SEYMERIA	G5	S2		RSC
SISYRINCHIUM ALBIDUM	WHITE BLUE-EYE-GRASS	G?	S1		RSC
SPHENOPHOLIS FILIFORMIS	LONG-LEAF WEDGESCALE	G3G4	S1		RSC
STYRAX AMERICANA	AMERICAN SNOWBELL	G5	S2		RSC
TRILLIUM PUSILLUM	LEAST TRILLIUM	G3	S2		RSC
VACCINIUM CRASSIFOLIUM	CREEPING BLUEBERRY	G4G5	S1		RSC
VIOLA ESCULENTA	SALID VIOLET	G4G5	S1		RSC
XYRIS CAROLINIANA	CAROLINA YELLOW-EYED GRASS	G4G5	S1		RSC
XYRIS FIMBRIATA	FRINGED YELLOW-EYED GRASS	G5	S1		RSC
ZENOBIA PULVERULENTA	DUSTY ZENOBIA	G5	S1		RSC

** COUNTY: Surry

* GROUP: AMPHIBIANS

BUFO QUERCICUS	OAK TOAD	G5	SU		RSC
HYLA GRATIOSA	BARKING TREEFROG	G5	S1		RSC
LIMNAOEDUS OCULARIS	LITTLE GRASS FROG	G5	S3		

VA DEPARTMENT OF CONSERVATION & RECREATION
DIVISION OF NATURAL HERITAGE
NATURAL HERITAGE RESOURCES FROM NAVAL WEAPONS STATION,
YORKTOWN, VICINITY

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
* GROUP: BIRDS					
HALIAEETUS LEUCOCEPHALUS	BALD EAGLE	G3	S2S3	LE	LE
* GROUP: FISH					
ENNEACANTHUS CHAETODON	BLACKBANDED SUNFISH	G5	S1		LERT
ERIMYZON SUCETTA	LAKE CHUBSUCKER	G5	S2		
FUNDULUS LINEOLATUS	LINED TOPMINNOW	G5	S1		
* GROUP: PLANTS					
CAREX DECOMPOSITA	EPIPHYTIC SEDGE	G3G4	S1	3C	
CAREX STRAMINEA	STRAW SEDGE	G5	S2		RSC
DESMODIUM OCHROLEUCUM	CREAMFLOWER TICK-TREFOIL	G5?	S1		RSC
TRIPHORA TRIANTHOPHORA	NODDING POGONIA	G4	S1		RSC
** COUNTY: Virginia Beach					
* GROUP: AMPHIBIANS					
RANA VIRGATIPES	CARPENTER FROG	G5	S3		RSC
SIREN LACERTINA	GREATER SIREN	G5	SU		
* GROUP: BIRDS					
IXOBRYCHUS EXILIS	LEAST BITTERN	G5	S2		
STERNA ANTILLARUM	LEAST TERN	G4	S2		RT
* GROUP: COMMUNITIES					
ATLANTIC WHITE CEDAR SWAMP	ATLANTIC WHITE CEDAR SWAMP		S1S2		
BRACKISH MARSH	BRACKISH MARSH		S5		
DUNE GRASSLAND	DUNE GRASSLAND		S4		
DUNE SCRUB			S1		
INTERDUNAL SWALE			S1		
MARITIME FOREST	MARITIME FOREST		S2S3		
MARITIME SHRUB SWAMP			S1S3		
POCOSIN	POCOSIN		S1S2		
SOUTHERN MIXED HARDWOOD FOREST	SOUTHERN MIXED HARDWOOD FOREST		S3		
* GROUP: FISH					
MORONE SAXATILIS	STRIPED BASS	G5	S4		
* GROUP: INVERTEBRATES					
ENALLAGMA DURUM	A DAMSELFLY	G5	S2		
EUPHYES DUKESI	SCARCE SWAMP SKIPPER	G3G4	S2		
LESTES DISJUNCTUS AUSTRALIS	A DAMSELFLY	G5T5	S2		
LIBELLULA AXILENA	BAR-WINGED SKIMMER	G5	S1		
SATYRIUM KINGI	KING'S HAIRSTREAK	G3G4	S2S3		
TRAMEA ONUSTA	RED-MANTLED GLIDER	G5	S1		

VA DEPARTMENT OF CONSERVATION & RECREATION
DIVISION OF NATURAL HERITAGE
NATURAL HERITAGE RESOURCES FROM NAVAL WEAPONS STATION,
YORKTOWN, VICINITY

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
* GROUP: MAMMALS					
SYNAPTOMYS COOPERI HELALETES	DISMAL SWAMP BOG LEMMING	G5T3	S3	3C	
* GROUP: PLANTS					
ARENARIA LANUGINOSA	A SANDWORT	G5	S1		RSC
ASTER ELLIOTTII	ELLIOTT'S ASTER	G3G4	S1		RSC
ASTER RACEMOSUS	COASTAL-PLAIN ASTER	G3?Q	S1		RSC
BOLTONIA CAROLINIANA	CAROLINA BOLTONIA	G2Q	S2		
BULBOSTYLIS CILIATIFOLIA	CAPILLARY HAIRSEDGE	G5	S1S2		RSC
CALOPOGON PALLIDUS	PALE GRASS-PINK	G4G5	S1		RSC
CAREX DECOMPOSITA	EPIPHYTIC SEDGE	G3G4	S1	3C	
CAREX RENIFORMIS	RENIFORM SEDGE	G4?	S1		RSC
CAREX WALTERIANA	A SEDGE	G4	S1S2		RSC
CASSIA FASCICULATA VAR MACROSPERMA	PRAIRIE SENNA	G5T1Q	S2	C2	
CHAMAECYPARIS THYOIDES	ATLANTIC WHITE CEDAR	G4	S2		RSC
CLADIUM JAMAICENSE	SAWGRASS	G5	S1		RSC
CLEISTES DIVARICATA	SPREADING POGONIA	G4	S1S2		RSC
CRATAEGUS AESTIVALIS	MAY HAWTHORN	G5	S1		
CUSCUTA CEPHALANTHII	BUTTON-BUSH DODDER	G5	S1?		
CUSCUTA INDECORA	PRETTY DODDER	G5	S2?		
CUSCUTA POLYGONORUM	SMARTWEED DODDER	G5	S2?		
DESMODIUM STRICTUM	PINELAND TICK-TREFOIL	G2G4	S2		RSC
DICHROMENA COLORATA	A SEDGE	G4G5	S1		RSC
ELEOCHARIS BALDWINII	BALDWIN SPIKERUSH	G4G5	S1		RSC
ERIGERON VERNUS	WHITE-TOP FLEABANE	G5	S2		RSC
EUPATORIUM RECURVANS	COASTAL-PLAIN THOROUGH-WORT	G3G4	S1		RSC
EUPHORBIA AMMANNIOIDES	A SPURGE	G3G4	S2		RSC
FIMBRISTYLIS CAROLINIANA	CAROLINA FIMBRY	G4	S1		RSC
GALIUM HISPIDULUM	COAST BEDSTRAW	G5	S1S2		RSC
GYMNOPOGON BREVIFOLIUS	BROAD-LEAVED BEARDGRASS	G5	S2		
HELIOTROPIUM CURASSAVICUM	SEASIDE HELIOTROPE	G5	S1		RSC
HETEROTHECA GOSSYPINA	COTTONY GOLDEN-ASTER	G5	S1		RSC
HYDROCOTYLE BONARIENSIS	COASTAL-PLAIN PENNY-WORT	G5	S1		RSC
HYPOXIS LONGII	LONG'S YELLOW STAR-GRASS	G4	S1	3C	
IRESINE RHIZOMATOSA	EASTERN BLOODLEAF	G5	S1S2		RSC
IVA IMBRICATA	SEA-COAST MARSH-ELDER	G5?	S1S2		RSC
JUNCUS CRASSIFOLIUS	A RUSH	G?	S2		RSC
JUNCUS ELLIOTTII	BOG RUSH	G4G5	S1S2		RSC
JUNCUS GRISCOMII	GRISCOM'S RUSH	GHQ	S1?		
JUNCUS MEGACEPHALUS	BIG-HEAD RUSH	G4G5	S2		RSC
KALMIA ANGUSTIFOLIA	SHEEP-LAUREL	G5	S2S3		RSC
LILAEOPSIS CAROLINENSIS	CAROLINA LILAEOPSIS	G3	S1S2	3C	RT
LIMNOBIUM SPONGIA	AMERICAN FROG'S-BIT	G5	S2		RSC

VA DEPARTMENT OF CONSERVATION & RECREATION
DIVISION OF NATURAL HERITAGE
NATURAL HERITAGE RESOURCES FROM NAVAL WEAPONS STATION,
YORKTOWN, VICINITY

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
LIPPIA NODIFLORA	COMMON FROG-FRUIT	G5	S1		RSC
LISTERA AUSTRALIS	SOUTHERN TWAYBLADE	G4	S2S3		RSC
LOBELIA ELONGATA	ELONGATED LOBELIA	G3G5	S1		RSC
LONICERA CANADENSIS	AMERICAN FLY-HONEYSUCKLE	G5	S2		RSC
LUDWIGIA ALATA	WINGED SEEDBOX	G3G4	S1		RSC
LUDWIGIA BREVIPES	LONG BEACH SEEDBOX	G4G5	S2		RSC
LUDWIGIA REPENS	CREEPING SEEDBOX	G5	S1		
LYCOPODIUM INUNDATUM	NORTHERN BOG CLUBMOSS	G5	S1		RSC
LYONIA LUCIDA	FETTER-BUSH	G5	S2S3		RSC
NOTHOSCORDUM BIVALVE	CROW-POISON	G4	S2		
NYMPHOIDES AQUATICA	BIG FLOATING-HEART	G5	S1		RSC
OSMANTHUS AMERICANUS	WILD OLIVE	G5	S1		RSC
PASPALUM DISTICHUM	JOINT PASPALUM	G5	S1		RSC
PHLOX PILOSA	DOWNY PHLOX	G5	S2		
PHYSALIS VISCOSA	STICKY GROUND-CHERRY	G4G5	S2		RSC
PHYSOSTEGIA LEPTOPHYLLA	SLENDER-LEAVED DRAGON-HEAD	G4G5	S2	C2	RSC
PINUS PALUSTRIS	LONG-LEAF PINE	G4G5	S2		RSC
QUERCUS HEMISPHAERICA	DARLINGTON'S OAK	G5	S2		
QUERCUS INCANA	BLUE JACK OAK	G5	S2		RSC
QUERCUS LAEVIS	TURKEY OAK	G5	S2		RSC
QUERCUS MARGARETTAE	SAND POST OAK	G5	S2		RSC
RANUNCULUS HEDERACEUS	LONG-STALKED CROWFOOT	G5	S1		
RHYNCHOSPORA DEBILIS	SAVANNAH BEAKRUSH	G4?	S1		
SCIRPUS ACUTUS	HARD-STEMMED BULRUSH	G5	S2		RSC
SCIRPUS ETUBERCULATUS	CANBY'S BULRUSH	G3G4	S1		
SOLIDAGO TORTIFOLIA	A GOLDENROD	G3G5	S1		RSC
SPARTINA PECTINATA	FRESH WATER CORDGRASS	G5	S2		RSC
SPIRANTHES ODORATA	SWEETSCENT LADIES'-TRESSES	G5	S2		RSC
STEWARTIA MALACODENDRON	SILKY CAMELLIA	G4	S2		RSC
STIPULICIDA SETACEA	PINELAND SCALY-PINK	G4G5	S1		RSC
STYRAX AMERICANA	AMERICAN SNOWBELL	G5	S2		RSC
TILLANDSIA USNEOIDES	SPANISH MOSS	G5	S2		RSC
UTRICULARIA FIBROSA	FIBROUS BLADDERWORT	G4G5	S1		RSC
VACCINIUM MACROCARPON	LARGE CRANBERRY	G4	S2		RSC
VERBENA SCABRA	SANDPAPER VERVAIN	G5	S2		RSC
XYRIS CAROLINIANA	CAROLINA YELLOW-EYED GRASS	G4G5	S1		RSC
* GROUP: REPTILES					
DEIROCHELYS RETICULARIA RETICULARIA	EASTERN CHICKEN TURTLE	G5T5	S1		LE
GRAPTEMYS GEOGRAPHICA	MAP TURTLE	G5	S3		
OPHISAURUS VENTRALIS	EASTERN GLASS LIZARD	G5	S1		RT

VA DEPARTMENT OF CONSERVATION & RECREATION
DIVISION OF NATURAL HERITAGE
NATURAL HERITAGE RESOURCES FROM NAVAL WEAPONS STATION, YORKTOWN, VICINITY

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
** COUNTY: Virginia Beach Chesapeake					
* GROUP: PLANTS					
ASTER RACEMOSUS	COASTAL-PLAIN ASTER	G3?Q	S1		RSC
** COUNTY: Williamsburg James City					
* GROUP: INVERTEBRATES					
TACHOPTERYX THOREYI	THOREY'S GRAYBACK DAMSELFLY	G4	S1		
** COUNTY: York					
* GROUP: AMPHIBIANS					
AMBYSTOMA MABEEI	MABEE'S SALAMANDER	G4	S2?		RSC
HYLA GRATIOSA	BARKING TREEFROG	G5	S1		RSC
* GROUP: BIRDS					
HALIAEETUS LEUCOCEPHALUS	BALD EAGLE	G3	S2S3	LE	LE
* GROUP: INVERTEBRATES					
CELITHEMIS FASCIATA	BANDED PENNANT	G5	S2		
* GROUP: PLANTS					
BOLTONIA CAROLINIANA	CAROLINA BOLTONIA	G2Q	S2		
CAREX LUPULIFORMIS	FALSE HOP SEDGE	G3G4Q	S1		RSC
CUSCUTA INDECORA	PRETTY DODDER	G5	S2?		
CYPERUS DIANDRUS	UMBRELLA FLATSEDGE	G5	S1		RSC
EUPHORBIA AMMANNIOIDES	A SPURGE	G3G4	S2		RSC
LIPARIS LOESELII	LOESEL'S TWAYBLADE	G5	S2		RSC
LYTHRUM ALATUM	WINGED-LOOSESTRIFE	G5	S1		RSC
MALAXIS SPICATA	FLORIDA ADDER'S-MOUTH	G3G4	S2		RSC
QUERCUS PRINOIDES	DWARF CHINQUAPIN OAK	G5	S2		RSC
QUERCUS SHUMARDII	SHUMARD'S OAK	G5	S2		RSC
STEWARTIA OVATA	MOUNTAIN CAMELLIA	G4	S2		RSC
TILLANDSIA USNEOIDES	SPANISH MOSS	G5	S2		RSC
TRIDENS STRICTUS	LONG-SPIKE FLUFF GRASS	G5	S1		RSC
UNIOLA SESSILIFLORA	LONG-LEAF SPIKEGRASS	G5	S2		
UTRICULARIA FIBROSA	FIBROUS BLADDERWORT	G4G5	S1		RSC
WISTERIA FRUTESCENS	AMERICAN WISTERIA	G5	S2		RSC
** COUNTY: York James City					
* GROUP: AMPHIBIANS					
AMBYSTOMA MABEEI	MABEE'S SALAMANDER	G4	S2?		RSC

VA DEPARTMENT OF CONSERVATION & RECREATION
DIVISION OF NATURAL HERITAGE
NATURAL HERITAGE RESOURCES FROM NAVAL WEAPONS STATION,
YORKTOWN, VICINITY

SCIENTIFIC NAME	COMMON NAME	GLOBAL RANK	STATE RANK	FEDERAL STATUS	STATE STATUS
** COUNTY: York Newport News					
* GROUP: AMPHIBIANS					
AMBYSTOMA MABEEI	MABEE'S SALAMANDER	G4	S2?		RSC
* GROUP: COMMUNITIES					
COASTAL PLAIN SINKHOLE POND	COASTAL PLAIN SINKHOLE POND		S1		
* GROUP: PLANTS					
FIMBRISTYLIS PERPUSILLA	HARPER'S FIMBRISTYLIS	G2	S1	C2	LE

EXHIBIT 4-6

Project/Location: Navy Clean

S.O. No.: 19002-50-SRN
Date: May 3, 1991

To: Roberta Damico
Repres.: National Park Service (NPS)
Phone No.: 215-597-3679

From: Aaron Bernhardt
Repres.: Baker Environmental, Inc.
Phone No.: 412-269-6090

Subject: NPS Properties

I told her we were doing a study for some U.S. Naval facilities in the Chesapeake Bay area and needed some information on NPS properties.

She said that Colonial National Historic Park was the only NPS property owned or managed in the VA Beach area.

Project/Location: Navy Clean

S.O. No.: 19002-50-SRN
Date: May 2, 1991

To: Bob Gift
Repres.: National Park Service
Phone No.: 215-597-3503

From: Aaron Bernhardt
Repres.: Baker Environmental, Inc.
Phone No.: 412-269-6090

Subject: NPS Properties

I told him we were doing a study for some U.S. Naval facilities in the Chesapeake Bay area and needed some information on NPS properties.

I asked him specifically about Natural Areas.

He replied that the NPS properties include National Natural Landmarks and National Historic Parks. They are not owned by the NPS but are designated by the NPS. I should call Pat Bently at 215-597-0011 for more information.

There are no national lakeshore recreational areas in the VA Beach area. There are no other NPS properties other than Colonial National Park, in the VA Beach area.

EXHIBIT 4-7

Project/Location: Navy Clean

S.O. No.: 19002-50-SRN
Date: May 2, 1991

To: Michael Jennings for Pat Weber
Repres.: National Park Service
Phone No.: 215-597-1582

From: Aaron Bernhardt
Repres.: Baker Environmental, Inc.
Phone No.: 412-269-6090

Subject: Scenic Rivers
I asked him about scenic rivers in the Va Beach area.

He said the James River is on the (NRI), which is for rivers that have not yet been designated by Congress for Scenic Status. He thinks it will have scenic status within one year. What portions will be designated has not been determined yet.

None of the Potomic River has been designated as Scenic, but there are many NPS properties alone the River further downstream from the ABL site.

He will send me the NRI for WV, VA and NC.

Project/Location: Navy Clean

S.O. No.: 19002-50-SRN
Date: April 25, 1991

To: Dick Livvons
Repres.: Dept of Conservation and Recreation
Phone No.: 804-786-4132

From: Aaron Bernhardt
Repres.: Baker Environmental, Inc.
Phone No.: 412-269-6090

Subject: Scenic Rivers

I told him we were doing a study for some U.S. Naval facilities in the Chesapeake Bay area and needed some information on scenic rivers.

Dick said that there are no Federally designated scenic rivers in Virginia.

He did say that there are three State Scenic Rivers in the area of Virginia Beach. They include:

- Lower James River Historic River
- Nottoway River
- North Landing River

Dick will send a report on the N. Landing River and citations from regulations for the N. Landing, Nottoway and James which will give the exact locations of the designated section.

EXHIBIT 4-8

Project/Location: Navy Clean

S.O. No.: 19002-50-SRN
Date: May 8, 1991

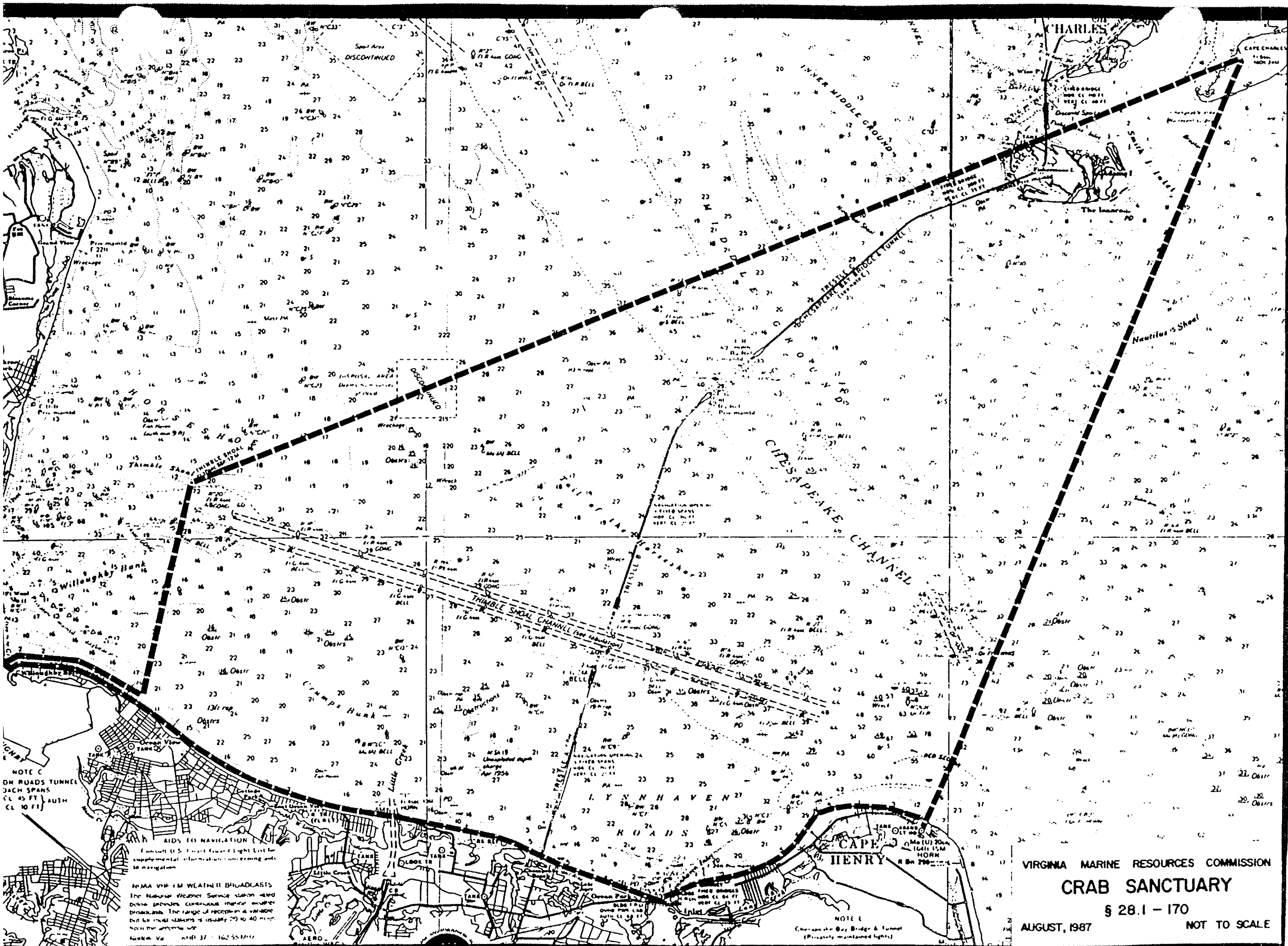
To: Joey Thompson
Repres.: MRC
Phone No.: 804-247-2200

From: Aaron Bernhardt
Repres.: Baker Environmental, Inc.
Phone No.: 412-269-6090

Subject: Marine Sanctuaries

I told her that I have received a marine sanctuary map from her office and I was just checking to verify that it was the only marine sanctuary in the VA Beach area.

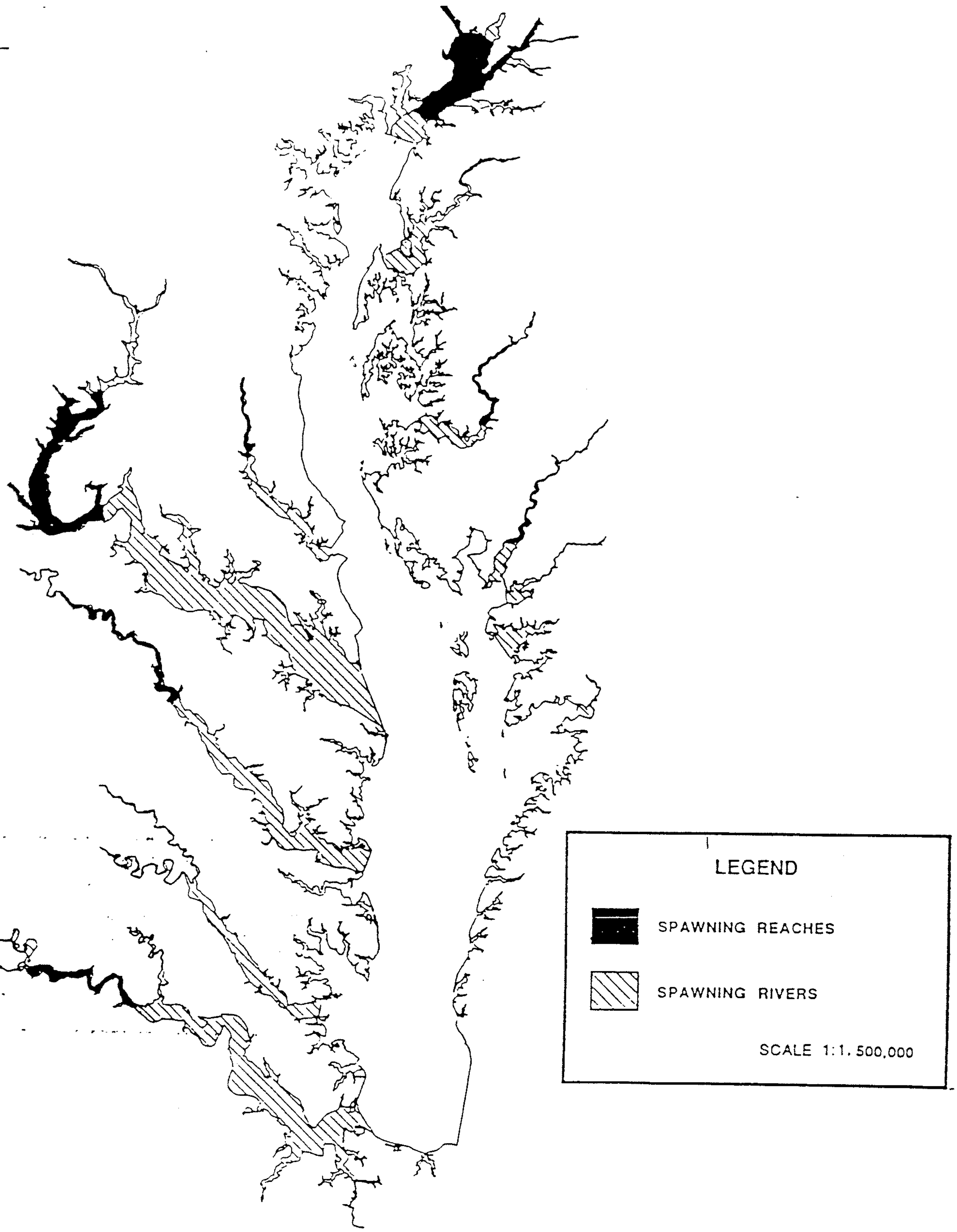
Joey said the crab sanctuary map I have is the only marine sanctuary in the area of VA Beach.



VIRGINIA MARINE RESOURCES COMMISSION
CRAB SANCTUARY
§ 28.1 – 170
AUGUST, 1987
NOT TO SCALE
CHARLES
CAPE CHARLES
INNER MIDDLE GROUND
MIDDLE GROUND
CHESAPEAKE CHANNEL
THIMBLE SHOAL CHANNEL
HORSESHOE
Thimble Shoal
Willoughby Bank
Nautilus Shoal
Smith I. Inlet
The Inner
LYNNHAVEN ROADS
CAPE HENRY
DISPOSAL AREA
DISCONTINUED
TRESTLE
AIDS TO NAVIGATION
NOAA VHF-FM WEATHER BROADCASTS
NOTE C

EXHIBIT 4-9

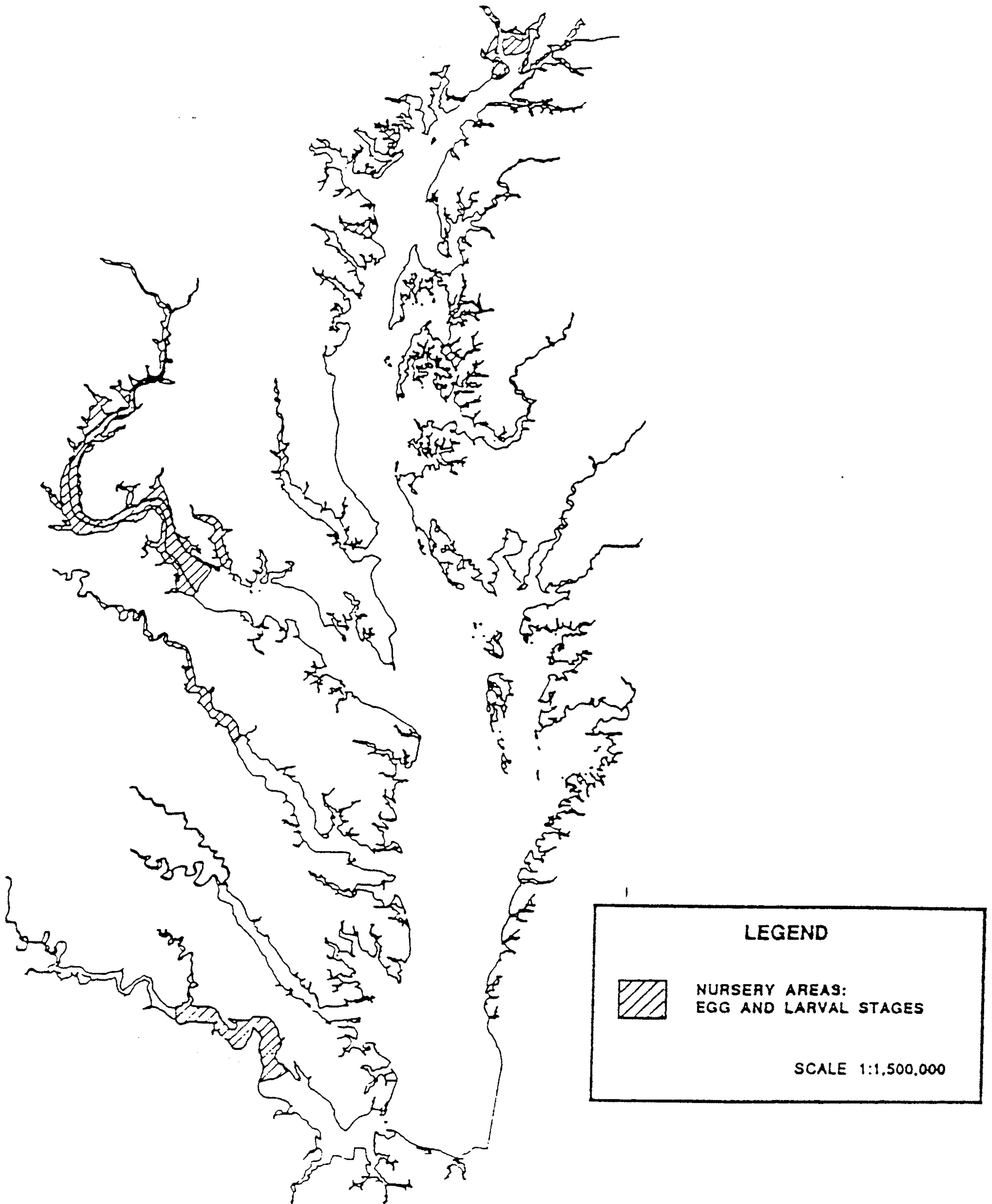
STRIPED BASS (*Morone saxatilis*): HABITAT DISTRIBUTION OF LEGISLATIVELY DEFINED SPAWNING REACHES AND RIVERS



SOURCES: Code of Maryland Regulations 08.02.05.02
Virginia Marine Resources Commission Regulation 450-01-0034

FIGURE 2

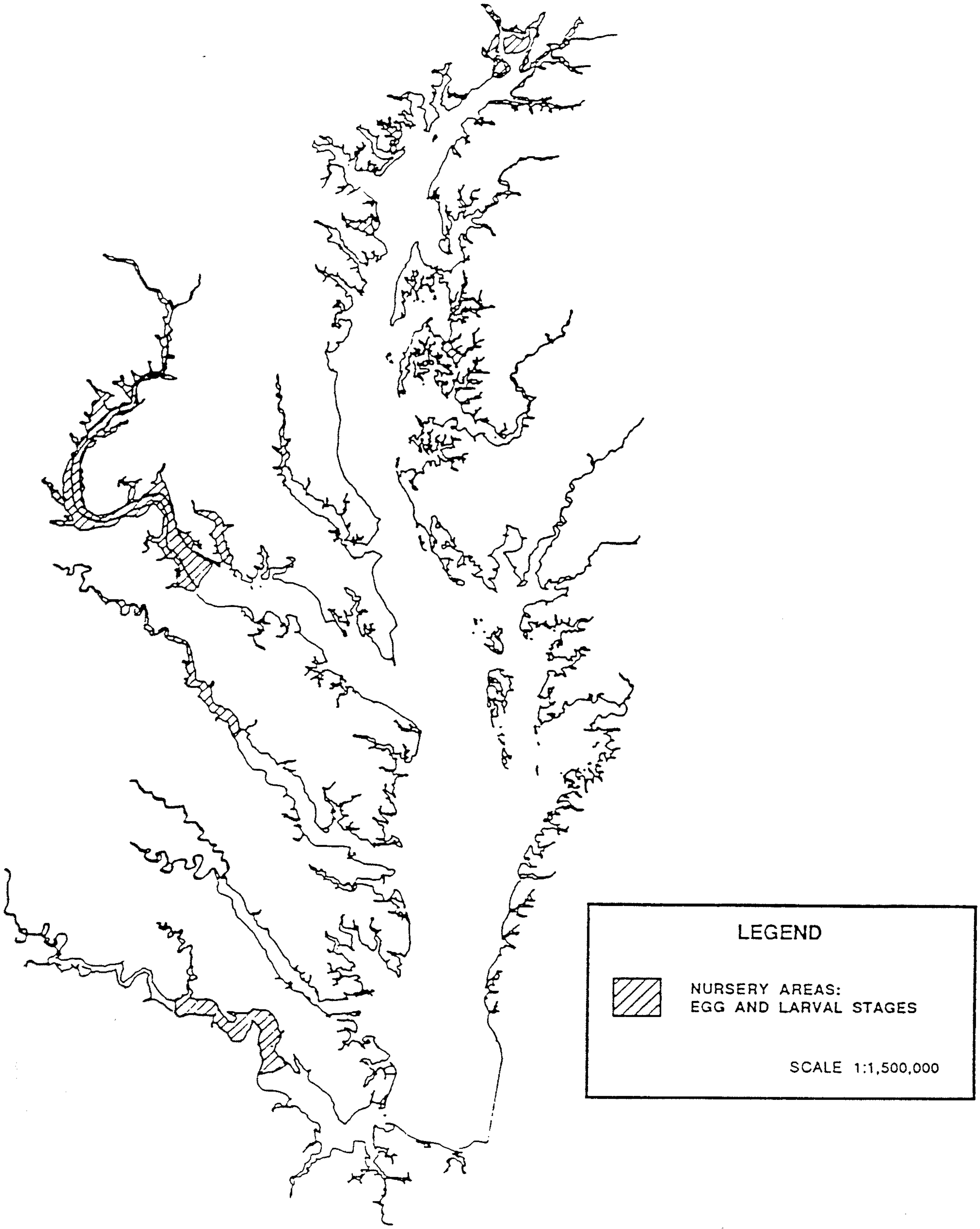
BLUEBACK HERRING (*Alosa aestivalis*): HABITAT DISTRIBUTION OF NURSERY AREAS IN CHESAPEAKE BAY



SOURCE: Corps of Engineers, 1980

FIGURE 3

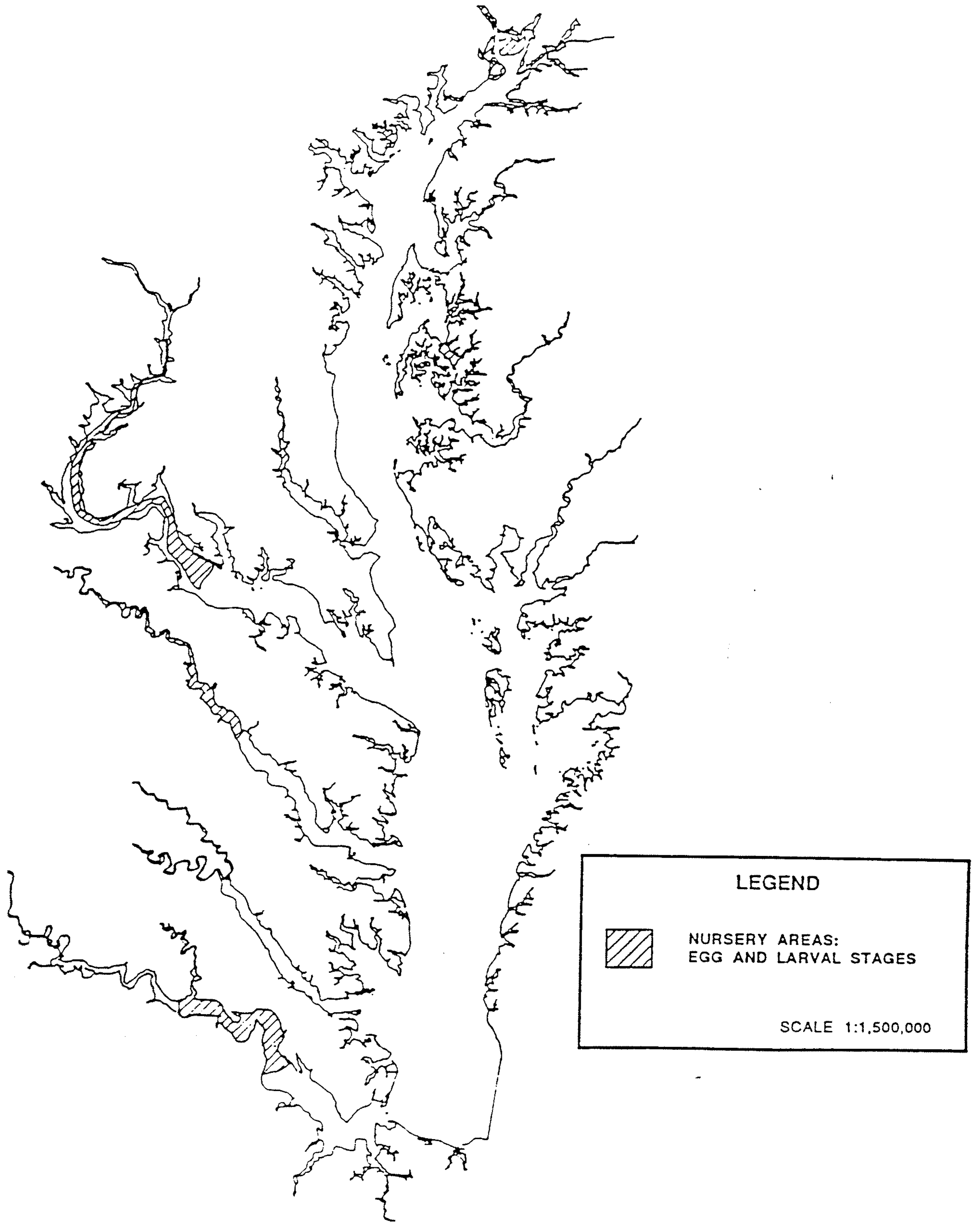
ALEWIFE (*Alosa pseudoharengus*): HABITAT DISTRIBUTION OF NURSERY AREAS IN CHESAPEAKE BAY



SOURCE: Corps of Engineers, 1980

FIGURE 4

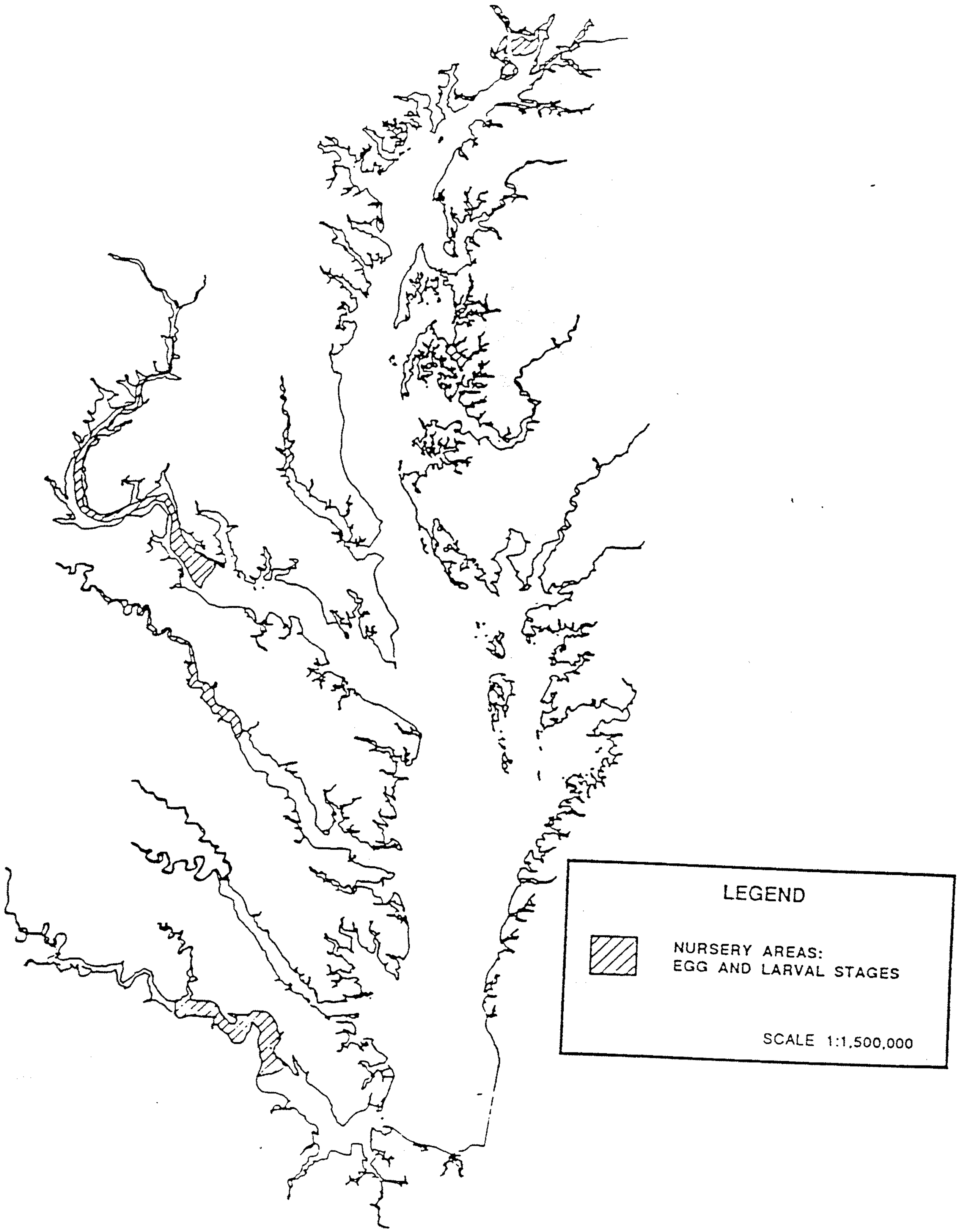
AMERICAN SHAD (*Alosa sapidissima*): HABITAT DISTRIBUTION OF NURSERY AREAS IN CHESAPEAKE BAY



SOURCE: Corps of Engineers, 1980

FIGURE 5

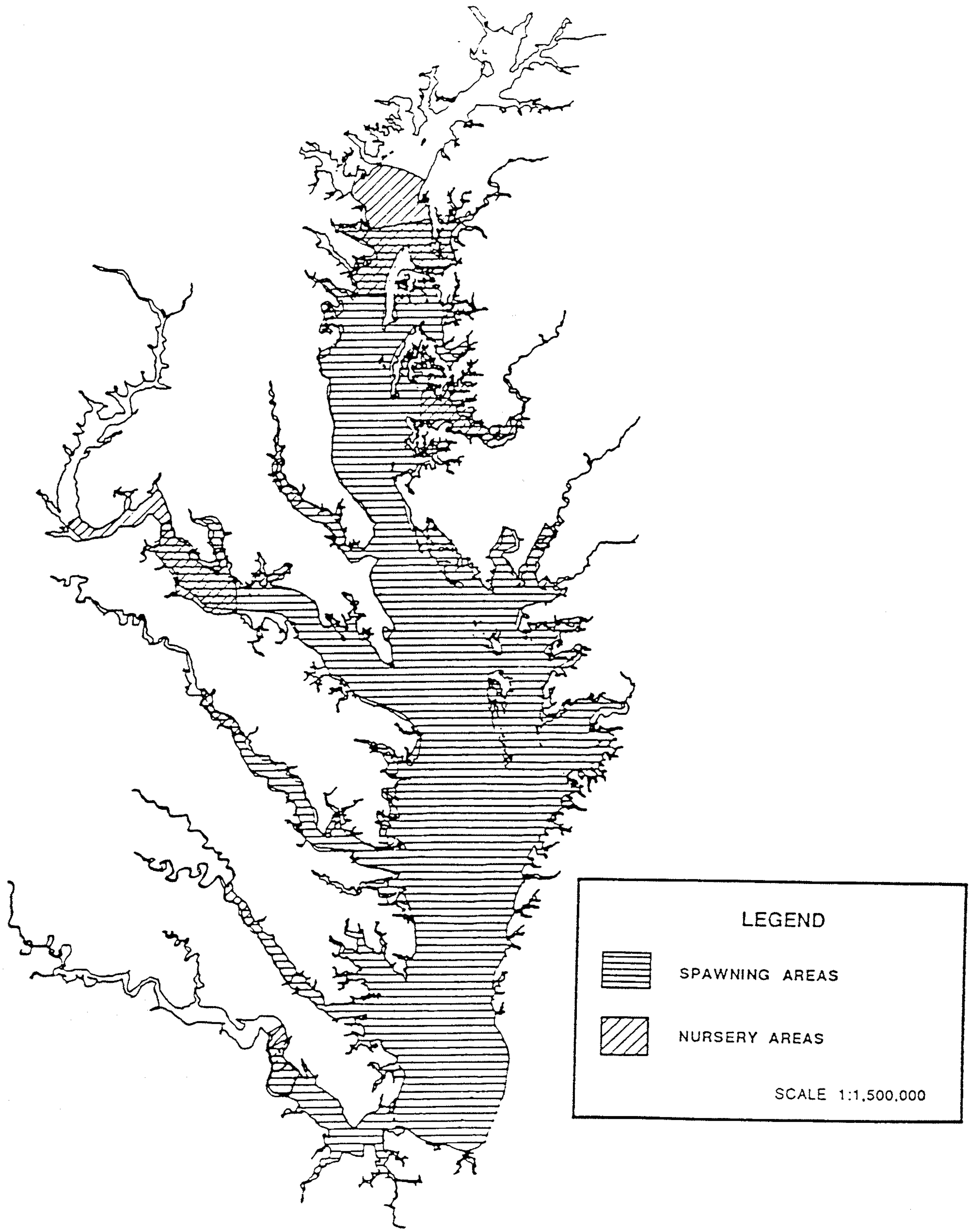
HICKORY SHAD (*Alosa mediocris*): HABITAT DISTRIBUTION OF NURSERY AREAS IN CHESAPEAKE BAY



SOURCE: Corps of Engineers, 1980

FIGURE 6

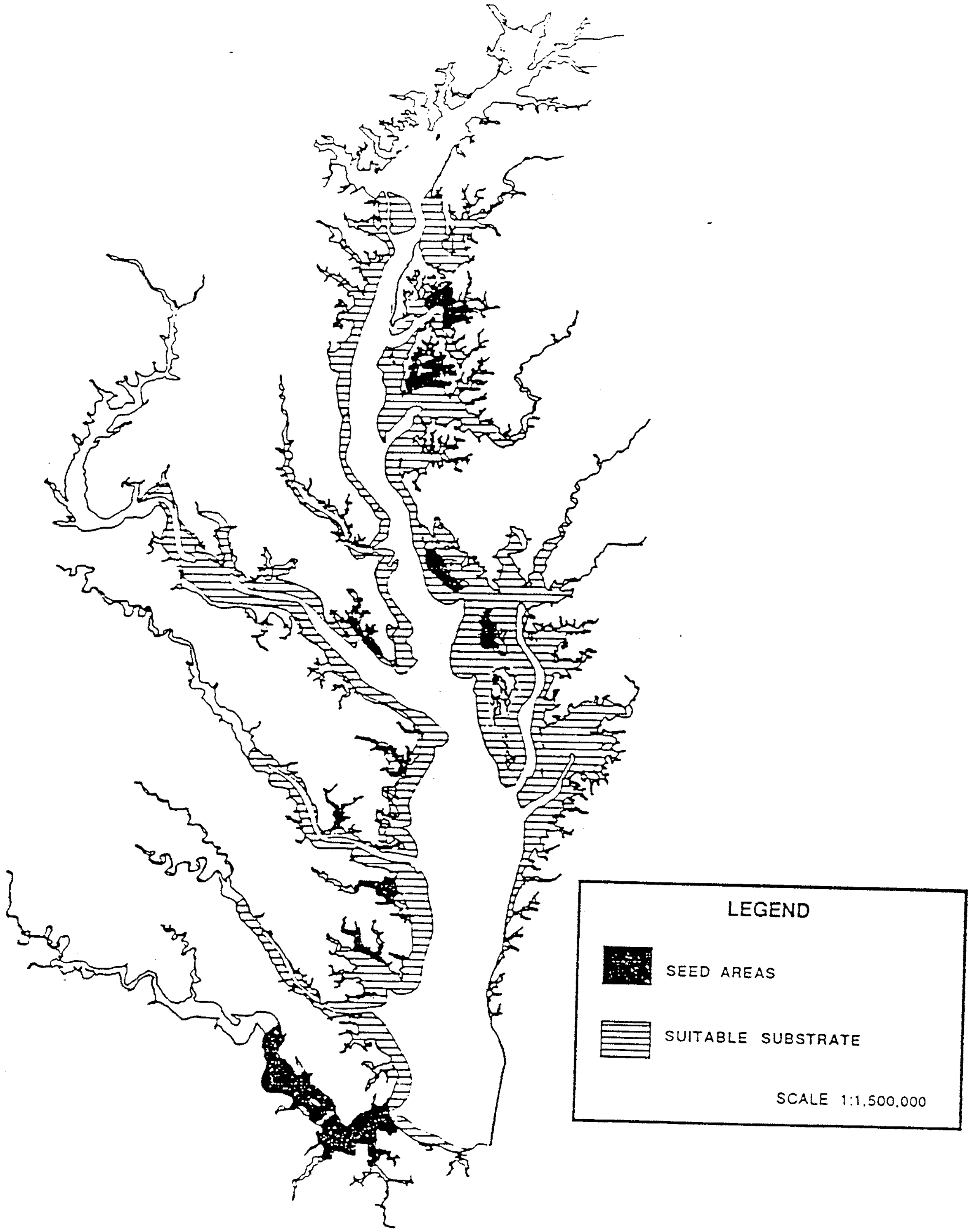
BAY ANCHOVY (*Anchoa mitchilli*): HABITAT DISTRIBUTION OF SPAWNING AND NURSERY AREAS IN CHESAPEAKE BAY



SOURCE: Corps of Engineers, 1980

FIGURE 11

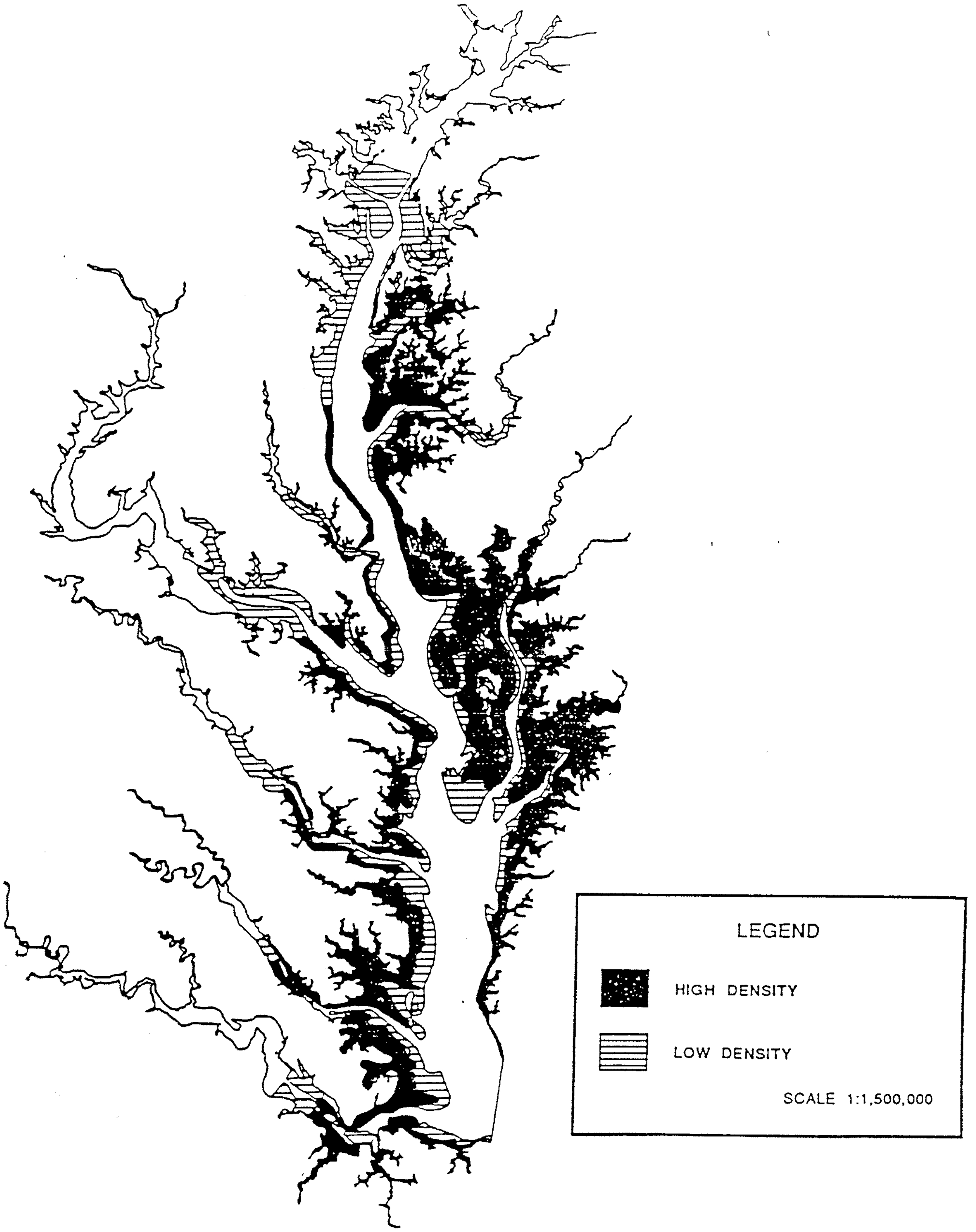
AMERICAN OYSTER (*Crassostrea virginica*): HABITAT
DISTRIBUTION OF SEED AREAS AND SUITABLE SUBSTRATE IN
CHESAPEAKE BAY



SOURCE: Corps of Engineers, 1980

FIGURE 12

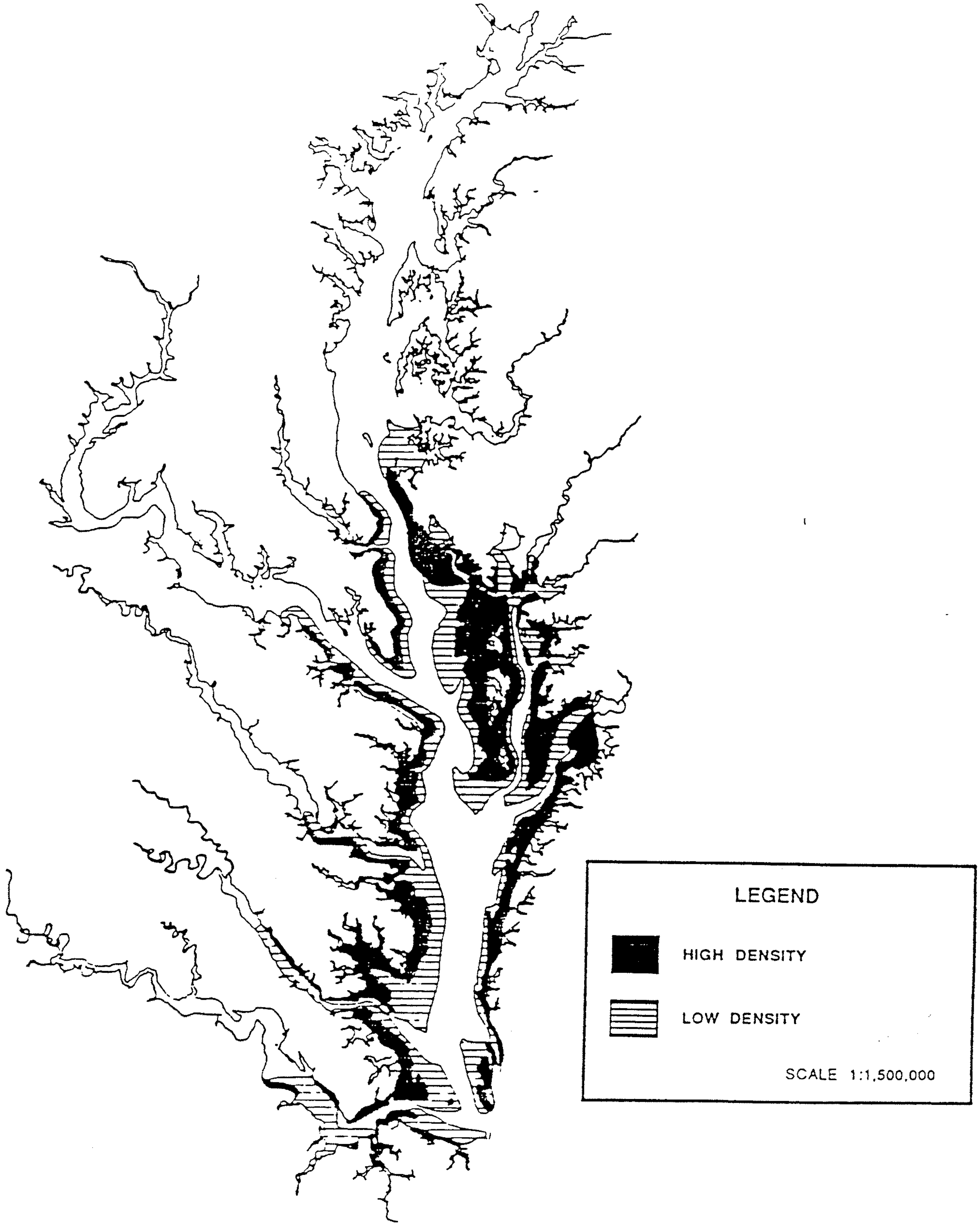
SOFTSHELL CLAM (*Mya arenaria*): HABITAT DISTRIBUTION IN CHESAPEAKE BAY



SOURCE: Corps of Engineers, 1980

FIGURE 13

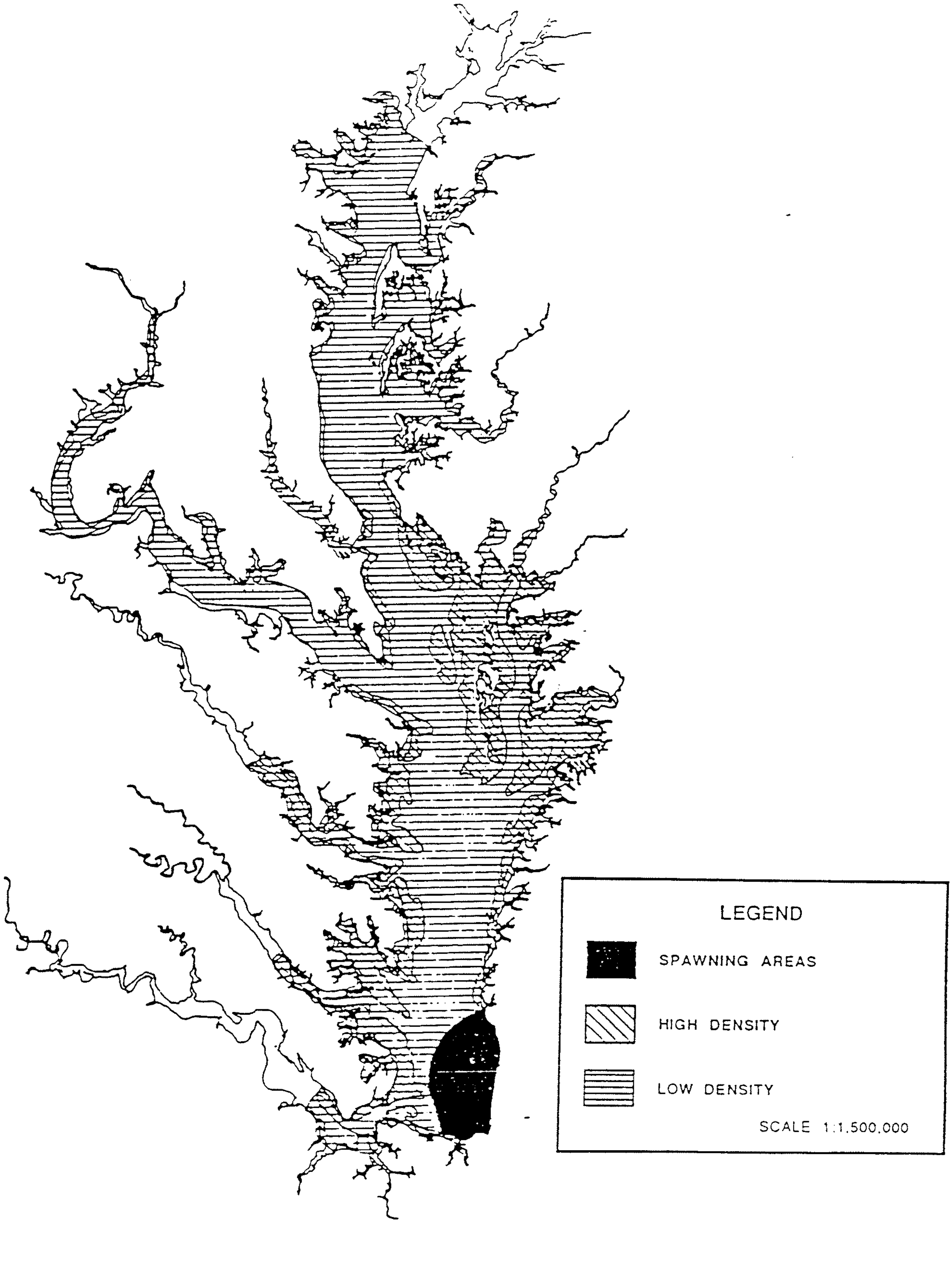
HARD CLAM (*Mercenaria mercenaria*): HABITAT DISTRIBUTION IN CHESAPEAKE BAY



SOURCE: Corps of Engineers, 1980

FIGURE 14

BLUE CRAB (*Callinectes sapidus*) : SUMMER HABITAT DISTRIBUTION OF FEMALES AND SPAWNING AREAS IN CHESAPEAKE BAY



SOURCE: Corps of Engineers, 1980

FIGURE 15

EXHIBIT 4-10

Project/Location: Navy Clean

S.O. No.: 19002-50-SRN
Date: May 1, 1991

To: Becky Wajda
Repres.: Dept of Game and Inland Fisheries

From: Aaron Bernhardt
Repres.: Baker Environmental, Inc.

Phone No.: 804-367-1000

Phone No.: 412-269-6090

Subject: Sensitive Environments

I told her we were doing a study for some U.S. Naval facilities in the Chesapeake Bay area and needed some information on sensitive environments. Becky gave me the following responses:

a. Becky said the VA does not have State Wildlife Refuges; instead they have wildlife management areas. The following areas are located in the VA Beach Area:

- o Trojen-Pocahontas (by Back Bay)
- o Ragged Island (on James River)
- o Hog Island (further up James River than Ragged Island)

b. There are several federal and state endangered species in the area including the dismal swamp shrew. We could send a letter with the general locations we are interested in.

c. The Natural Heritage Program has information on Natural Areas and the N. Landing portion purchased by the Nature Conservancy.

EXHIBIT 4-11

Project/Location: Navy Clean

S.O. No.: 19002-50-SRN
Date: April 25, 1991

To: Peter Kirby
Repres.: Wilderness Society
Phone No.: 404-355-1783

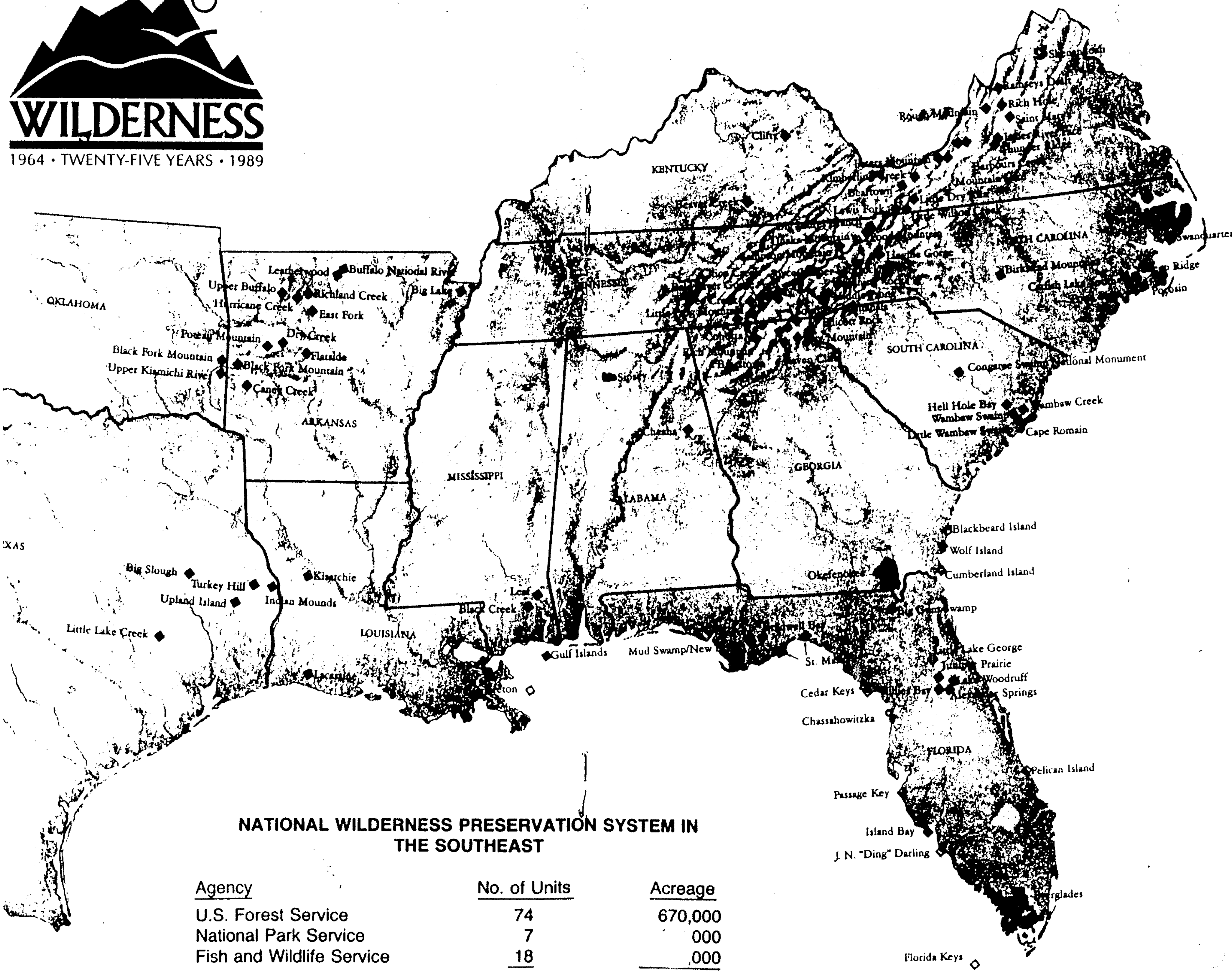
From: Aaron Bernhardt
Repres.: Baker Environmental, Inc.
Phone No.: 412-269-6090

Subject: Federal Wilderness Areas

I told him we were doing a study for some U.S. Naval facilities in the Chesapeake Bay area and needed some information on federal wilderness areas.

He said that designated federal wilderness areas only are located in National Parks and National Forests, and that there is no wilderness areas in Colonial National Park. He will send a map showing the locations of the wilderness areas.

WILDERNESS
1964 • TWENTY-FIVE YEARS • 1989



NATIONAL WILDERNESS PRESERVATION SYSTEM IN THE SOUTHEAST

Agency	No. of Units	Acreage
U.S. Forest Service	74	670,000
National Park Service	7	000
Fish and Wildlife Service	18	,000
TOTAL	[illegible]	[illegible]

EXHIBIT 4-12

Project/Location: Navy Clean

S.O. No.: 19002-50-SRN
Date: May 1, 1991

To: Ken Clark
Repres.: Va Natural Heritage Program
Phone No.: 804-786-7951

From: Aaron Bernhardt
Repres.: Baker Environmental, Inc.
Phone No.: 412-269-6090

Subject: Designated State Natural Areas

I told him we were doing a study for some U.S. Naval facilities in the Chesapeake Bay area and needed some information on designated state natural areas.

He said that there are two natural areas in the VA Beach Area:

- o North Landing Natural Area Reserve located by Pungo Ferry Road
- o There is another in Mathew County

He will send me a map showing the locations of those two areas.

The Nature Conservancy owns some private natural areas alone the N. Landing River. I should call Steve Hobbs at 804-295-6106 for more information

Ken added that the reports he sent me concerning the endangered species studies at the Navy sites were of the sensitive nature and should not be released to the public. His concern was in protecting the resources identified in the reports from vandals or collectors.

I called him back on May 8 to ask him if Seashore State Park also is a natural area. He said it is designated as a State Park Natural Area.

EXHIBIT 4-13

Project/Location: Navy Clean

S.O. No.: 19002-50-SRN
Date: May 14, 1991

To: Bill Muir
Repres.: EPA Chesapeake Bay Program
Phone No.: 215-597-2541

From: Aaron Bernhardt
Repres.: Baker Environmental Inc.
Phone No.: 412-269-6090

Subject: Near Coastals Waters Program (NCWP)

I asked him about the National Estuary Program under 302 of the CWA and he said that was not his jurisdiction. I should call Chock Spooner at 301-266-6873 who is head of the Chesapeake Bay Program (CBP).

Bill deals with the NCWP. The NCWP differs from the NEP in that it concerns waters outside the C. Bay Watershed (outside the C. Bay Bridge tunnel). The just received funding the past year so the program is just getting off the ground. They have not yet designated any areas of concern.

Project/Location: Navy Clean

S.O. No.: 19002-50-SRN
Date: May 14, 1991

To: Karen Bisland
Repres.: EPA Chesapeake Bay Program
Phone No.:301-267-0061

From: Aaron Bernhardt
Repres.: Baker Environmental, Inc.
Phone No.: 412-269-6090

Subject: National Estuary Program (NEP)

The Chesapeake Bay Program (CBP) is a pilot of the NEP but is not really connected. The CBP is more of a management type agency which manages the entire Chesapeake Bay and it's watershed. It does not designate certian areas but rather the entire Chesapeake Bay and it's watershed.

The NEP does designate certain areas as NEP Areas but there are not any in the Virginia Beach Area. They have designated 17 NEP areas in country, with the closest one in Abermarle NC.

The National Estuary Reserve program under NOAA is another program which is different than CBP and NEP.

Steve Glomb from the NEP (202-475-7114) has a map showing the 17 NEP areas.

Project/Location: Navy Clean

S.O. No.: 19002-50-SRN
Date: April 8, 1991

To: Mary Brooks
Repres.: Council on the Environment
Phone No.: 804-786-4500

From: Aaron Bernhardt
Repres.: Baker Environmental, Inc.
Phone No.: 412-269-6090

Subject: Coastal Areas

I told her we were doing a study for some U.S. Naval facilities in the Chesapeake Bay area and needed some information on coastal areas.

She said the eastern shore of VA (peninsula) is bordered with Coastal Barriers; however, she is not sure if they are actually part of the Coastal Barrier Resources System. In either case, they are greater than 15 miles away from the sites.

CHAPTER I

OVERVIEW

Virginia's Coastal Resources Management Program (VCRMP) consists of three basic elements. These are:

1) **GOALS AND POLICIES** - a set of 25 statements which set forth the goals of coastal management in Virginia and various policies embodied in statute and regulation;

2) **ACTIVITIES** - those activities and programs undertaken by state agencies, local governments and regional planning district commissions, which, directly or indirectly, affect coastal resources and thus serve, in varying degrees, to accomplish the goals of coastal resources management; and

3) **COORDINATION AND OVERSIGHT** - the executive management, policy direction, conflict resolution, and administration which directs the individual activities toward goals and policies of the VCRMP and keeps the overall programs running.

A. GOALS

The Commonwealth has established a set of twenty-five goals, which set forth a policy framework within which Virginia's network of regulatory and other programs will operate when coastal resources are involved. These goals have evolved from the Governor's Guidance Package: Areas of Emphasis for 1982-84 Biennium Budget, and from an earlier four-year coastal resources management planning program. [NOTE: These goals are intended to provide general guidance to agencies undertaking activities which affect Virginia's coastal resources. They should apply in cases where agencies are allowed discretion in the operation of programs or in individual decisions and where these goals are not inconsistent with statutory or regulatory policies. These goals are not intended to be "enforceable policies" as required in 15 CFR 923.11.]

Prevention of Environmental Pollution and Protection of Public Health

1. To maintain, protect and improve the quality of coastal waters suitable for the propagation of aquatic life and recreation involving body contact.

2. To reduce non-point pollution in tidal streams, estuaries, embayments and coastal waters caused by inappropriate land uses and inadequate land management practices.

3. To reduce the potential for damage to coastal resources from toxic and other hazardous materials through effective site selection and planning as well as improved containment and cleanup programs.

4. To prevent significant deterioration of air quality.

5. To protect the public health from contaminated seafood.

Prevention of Damage to Natural Resource Base

6. To protect ecologically significant tidal marshes from despoilation or destruction.

7. To minimize damage to the productivity and diversity of the marine environment resulting from alteration of subaqueous lands and aquatic vegetation.

8. To minimize damage to the productivity and diversity of the marine environment resulting from the disruption of finfish and shellfish population balances.

9. To reduce the adverse effects of sedimentation on productive marine systems.

10. To maintain areas of wildlife habitat and to preserve endangered species of fish and wildlife.

Protection of Public and Private Investment

11. To conserve coastal sand dune systems.

12. To reduce or prevent losses of property, tax base and public facilities caused by shorefront erosion.

13. To minimize dangers to life and property from coastal flooding and storms.

Promotion of Resources Development

14. To promote the wise use of coastal resources for the economic benefit and employment of our citizens.

15. To protect and maintain existing uses of estuarine waters for shellfish propogation and marketing.

16. To encourage provision of commercial and industrial access to coastal waters where essential to desired economic activities.

17. To coordinate State planning processes for major projects so as to facilitate consideration of alternative locations for such facilities within the context of long-term development patterns and implications.

18. To improve or maintain productive fisheries.

19. To encourage exploration and production of outer continental shelf energy reserves.

20. To provide for the extraction of mineral resources in a manner consistent with proper environmental practices.

<u>Promotion of Public Recreation Opportunities</u>

21. To provide and increase public recreational access to coastal waters and shorefront lands.

<u>Promotion of Efficient Government Operation</u>

22. To provide a shoreline permitting procedure which assures both adequate review and mitigation of probable impacts as well as timely response to applicants, administered at the local level wherever possible.

<u>Provision of Technical Assistance and Information</u>

23. To provide state and local governing officials and private citizens with technical advice necessary to make wise decisions regarding uses of and impacts on coastal resources.

24. To conduct continuing educational programs in Coastal Resources Management for local and state officials.

25. To maintain and improve base data, maps and photo-imagery supportive of decision-makers' needs.

B. ACTIVITIES

1. General

Coastal resources management is not new to Virginia. Virginians have long recognized the importance of the land and water resources which are the basis for the State's unique coastal heritage and they have taken many initiatives over the years to promote the wise use and protection of those resources. Much of the population of the state lives and works along the coastal waterways, which serve as avenues of commerce and which provide nursery grounds for Virginia's fisheries as well as recreation areas for its citizens. The Commonwealth has long regulated its fisheries and controlled encroachments into submerged public lands. The Marine Resources Commission has managed Virginia's extensive commercial fisheries since before the turn of the century. With the enactment of the Wetlands Act in 1972, the Commission's authority was expanded to include the permitting of development in vegetated wetlands. Recent amendments have further extended that authority to protect coastal primary sand dunes and non-vegetated wetlands.

In all, over 20 state agencies as well as many localities, under the authorization of numerous state laws, conduct numerous activities which contribute to the management of Virginia's coastal resources. These activities are listed in Appendix I-1. While these activities form the basis for Virginia's Coastal Resources Management Program, and all contribute to accomplishing the goals of coastal management to varying degrees, there are certain activities or sets of activities which can be identified as making key contributions in a number of areas. These are discussed below.

2. Core Regulatory Programs

The heart of Virginia's Coastal Resources Management Program is a core of eight regulatory programs through which critical land and water uses and activities are subject to the control of the state. These are listed below, by geographic area. The "enforceable policies" necessary to manage the land and water uses listed below are those contained in the state and federal statutes, and agency regulations adopted pursuant to them, which apply to the operation of these core regulatory programs. All are incorporated into Virginia's coastal management program.

State law provides for the strict control of virtually all uses and activities which involve the taking of living resources from or encroachment into the water portion of the Virginia's coastal area; for complete control of Virginia's entire tidal shoreline through strict local regulation, with state overview, of all encroachments onto tidal wetlands and coastal dunes; and for the regulation of selected significant uses and activities in upland areas along Virginia's shoreline.

a. **Fisheries Management** - Regulatory Authority Over Commercial and Recreational Fishing -- Marine Resources Commission (MRC); Commission of Game and Inland Fisheries (CGIF).

b. **Subaqueous Lands Management** - Regulatory Authority Over All Encroachments In, On, or Over State-Owned Subaqueous Lands - Marine Resources Commission (MRC).

c. **Wetlands Management** - Regulatory Authority Over All Encroachments Into Vegetated and Non-Vegetated Wetlands -- Marine Resources Commission (MRC).

d. **Dunes Management** - Regulatory Authority Over All Encroachments Into Coastal Primary Sand Dunes -- Marine Resources Commission (MRC).

e. **Nonpoint Source Pollution Control** - Regulatory Authority Over Erosion and Sedimentation From Non-Agricultural Upland Land Disturbing Activities -- Department of Conservation and Historic Resources (DCHR).

f. **Point Source Water Pollution Control** - Regulatory Authority Over Existing, Planned or Potential Discharges to State Waters -- State Water Control Board (SWCB).

g. **Shoreline Sanitation** - Regulatory Authority Over Shoreline Use of Septic or Other On-Site Domestic Waste Systems -- State Department of Health (DOH).

h. **Air Pollution Control** -- Regulatory Authority Over Emissions Affecting Air Quality. -- State Air Pollution Control Board (SAPCB)

3. Geographic Areas of Particular Concern

Virginia's Coastal Resources Management Program gives special attention to the management of special areas -- areas which contain particularly important resources or in which natural conditions pose particular threats to man and his investments. Virginia's program (Chapter V of this document) identifies eleven categories of Geographic Areas of Particular Concern (GAPC) and describes the special management treatment afforded them under law and regulation.

a. Coastal Natural Resource Areas of Particular Concern

(1) **Wetlands**

(Protected under Virginia Wetlands Act by state regulation or local regulation with Marine Resources Commission (MRC) oversight. -- See Core Regulatory Program)

(2) **Spawning, Nursery and Feeding Grounds**

- James River Oyster Seed Beds
- Public Oyster Grounds
- Blue Crab Sanctuary
- Striped Bass Spawning Sanctuaries
  Protected under special regulations of the Virginia Marine Resources Commission and selected state statutes.

(3) **Coastal Primary Sand Dunes**

Protected under Coastal Primary Sand Dune Protection Act -- see Core Regulatory Program.

(4) **Barrier Islands**

Protected under a variety of state, federal and private conservation organization ownerships.

(5) **Significant Wildlife Habitat Areas**

Ten areas protected and managed as Wildlife Management Areas by Commission of Game and Inland Fisheries.

(6) **Significant Public Recreation Areas**

Fourteen areas owned and managed by Division of State Parks and Recreation -- ongoing planning through Virginia Outdoors Plan -- acquisition may be by condemnation.

(7) **Significant Mineral Resource Deposits**

Extraction activities regulated under Minerals Other Than Coal Surface Mining Law administered by Department of Conservation and Economic Development.

b. Coastal Natural Hazard Areas of Particular Concern

(1) Highly Erodible Areas

Technical assistance to private owners through Shoreline Erosion Advisory Service under Shoreline Erosion Control Act -- financial assistance to local governments under Public Beach Conservation and Development Act.

(2) Coastal High Hazard Areas

Development in floodplains and coastal high hazard areas restricted by Uniform Statewide Building Code and through local zoning -- encouraged under Virginia Flood Damage Reduction Act.

c. Waterfront Development Areas

Availability of pass-through CZM funds to localities which ask for GAPC designation of waterfront areas and which develop special management programs for those areas.

C. COORDINATION AND OVERSIGHT

Coastal management is a mix of three different levels of responsibilities. Individual management activities, including the operation of Virginia's core regulatory programs, are conducted by a variety of individual agencies. This collection of individual activities is tied together into a comprehensive program or "network" by the overview, direction and coordination supplied by the Secretary of Natural Resources. The Council on the Environment assists the Secretary by administering the details of the program and acting as "lead agency" for purposes of program management, monitoring and reporting and grant management.

CHAPTER II

BOUNDARIES

Project/Location: Navy Clean

S.O. No.: 19002-50-SRN
Date: April 5, 1991

To: Alex Barron
Repres.: VA State Water Control Board
Phone No.: 804-367-0056

From: Aaron Bernhardt
Repres.: Baker Environmental, Inc.
Phone No.: 412-269-6090

Subject: 305(a) Water Use Designation

I told him we were doing a study for some U.S. Naval facilities in the Chesapeake Bay area and needed some information on surface waters that have been designated as drinking water.

Alex said he thinks the PWS designation in the VA water Quality Standards is the State 305(a) designation, but he will check into it and call me back.

EXHIBIT 4-15

MICHAEL BAKER, JR., INC.

PHONE CALL REPORT

PROJECT/LOCATION: Navy Clean

S.O. No.: 19002-50-SRN

DATE: April 22, 1991

CONTRACT NO.:

To: National Climatic Data Center

From:

Repres.: Al Chen

Repres.:

Phone No.: 704-CLIMATE

Phone No.:

Subject: According to Al Chen of the National Climatic Data Center, the 1961 Rainfall Frequency Atlas of the United States is current and valid for the Eastern and Central United States. He said this is the most recently published information.

PREPARED BY Eileen MacDonald TITLE AEI

PAGE 1 OF 1

federal register

Friday
December 14, 1990

Part II

Environmental Protection Agency

40 CFR Part 300
Hazard Ranking System; Final Rule

the hazardous substance with the highest toxicity/persistence factor value for the watershed to assign the toxicity/persistence factor value for the drinking water threat for the watershed. Enter this value in Table 4–1.

4.1.2.2.2 *Hazardous waste quantity.* Assign a hazardous waste quantity factor value for the watershed as specified in section 2.4.2. Enter this value in Table 4–1.

4.1.2.2.3 *Calculation of drinking water threat-waste characteristics factor category value.* Multiply the toxicity/persistence and hazardous waste quantity factor values for the watershed, subject to a maximum product of 1 x 10^8. Based on this product, assign a value from Table 2–7 (section 2.4.3.1) to the drinking water threat-waste characteristics factor category for the watershed. Enter this value in Table 4–1.

TABLE 4–12.—TOXICITY/PERSISTENCE FACTOR VALUES [a]

Persistence factor value	Toxicity factor value					
	10,000	1,000	100	10	1	0
1.0	10,000	1,000	100	10	1	0
0.4	4,000	400	40	4	0.4	0
0.07	700	70	7	0.7	0.07	0
0.0007	7	0.7	0.07	0.007	0.0007	0

[a] Do not round to nearest integer.

4.1.2.3 *Drinking water threat-targets.* Evaluate the targets factor category for each watershed based on three factors: nearest intake, population, and resources.

To evaluate the nearest intake and population factors, determine whether the target surface water intakes are subject to actual or potential contamination as specified in section 4.1.1.2. Use either an observed release based on direct observation at the intake or the exposure concentrations from samples (or comparable samples) taken at or beyond the intake to make this determination (see section 4.1.2.1.1). The exposure concentrations for a sample (that is, surface water, benthic, or sediment sample) consist of the concentrations of those hazardous substances present that are significantly above background levels and attributable at least in part to the site (that is, those hazardous substance concentrations that meet the criteria for an observed release).

When an intake is subject to actual contamination, evaluate it using Level I concentrations or Level II concentrations. If the actual contamination is based on an observed release by direct observation, use Level II concentrations for that intake. However, if the actual contamination is based on an observed release from samples, determine which level applies for the intake by comparing the exposure concentrations from samples (or comparable samples) to health-based benchmarks as specified in sections 2.5.1 and 2.5.2. Use the health-based benchmarks from Table 3–10 (section 3.3.1) in determining the level of contamination from samples. For contaminated sediments with no identified source, evaluate the actual contamination using Level II concentrations (see section 4.1.1.2).

4.1.2.3.1 *Nearest intake.* Evaluate the nearest intake factor based on the drinking water intakes along the overland/flood hazardous substance migration path for the watershed. Include standby intakes in evaluating this factor only if they are used for supply at least once a year.

Assign the nearest intake factor a value as follows and enter the value in Table 4–1:

• If one or more of these drinking water intakes is subject to Level I concentrations as specified in section 4.1.2.3, assign a factor value of 50.

• If not, but if one or more of these drinking water intakes is subject to Level II concentrations, assign a factor value of 45.

• If none of these drinking water intakes is subject to Level I or Level II concentrations, determine the nearest of these drinking water intakes, as measured from the probable point of entry (or from the point where measurement begins for contaminated sediments with no identified source). Assign a dilution weight from Table 4–13 to this intake, based on the type of surface water body in which it is located. Multiply this dilution weight by 20, round the product to the nearest integer, and assign it as the factor value.

Assign the dilution weight from Table 4–13 as follows:

TABLE 4–13.—SURFACE WATER DILUTION WEIGHTS

Type of surface water body [a]		Assigned dilution weight [b]
Descriptor	Flow characteristics	
Minimal stream	Less than 10 cfs [c]	1
Small to moderate stream	10 to 100 cfs	0.1
Moderate to large stream	Greater than 100 to 1,000 cfs	0.01
Large stream to river	Greater than 1,000 to 10,000 cfs	0.001
Large river	Greater than 10,000 to 100,000 cfs	0.0001
Very large river	Greater than 100,000 cfs	0.00001
Coastal tidal waters [d]	Flow not applicable, depth not applicable	0.0001
Shallow ocean zone [e] or Great Lake	Flow not applicable, depth less than 20 feet	0.0001
Moderate depth ocean zone [e] or Great Lake	Flow not applicable, depth 20 to 200 feet	0.00001
Deep ocean zone [e] or Great Lake	Flow not applicable, depth greater than 200 feet	0.000005
3-mile mixing zone in quiet flowing river	10 cfs or greater	0.5

[a] Treat each lake as a separate type of water body and assign a dilution weight as specified in text.
[b] Do not round to nearest integer.
[c] cfs = cubic feet per second.
[d] Embayments, harbors, sounds, estuaries, back bays, lagoons, wetlands, etc., seaward from mouths of rivers and landward from baseline of Territorial Sea.
[e] Seaward from baseline of Territorial Sea. This baseline represents the generalized U.S. coastline. It is parallel to the seaward limit of the Territorial Sea and other maritime limits such as the inner boundary of the Federal fisheries jurisdiction and the limit of States jurisdiction under the Submerged Lands Act, as amended.

• For a river (that is, surface water body types specified in Table 4–13 as minimal stream through very large river), assign a dilution weight based on the average annual flow in the river at the intake. If available, use the average annual discharge as defined in the U.S. Geological Survey Water Resources Data Annual Report. Otherwise, estimate the average annual flow.

• For a lake, assign a dilution weight as follows:

–For a lake that has surface water flow entering the lake, assign a dilution weight based on the sum of the average annual flows for the surface water bodies entering the lake up to the point of the intake.

–For a lake that has no surface water flow entering, but that does have surface water flow leaving, assign a dilution weight based on the sum of the average annual flows for the surface water bodies leaving the lake.

–For a closed lake (that is, a lake without surface water flow entering or leaving), assign a dilution weight based on the average annual ground water flow into the lake, if available, using the dilution weight for the corresponding river flow rate in Table 4–13. If not available, assign a default dilution weight of 1.

• For the ocean and the Great Lakes, assign a dilution weight based on depth.

• For coastal tidal waters, assign a dilution weight of 0.0001; do not consider depth or flow.

• For a quiet-flowing river that has average annual flow of 10 cubic feet per second (cfs) or greater and that contains the probable point of entry to surface water, apply a zone of mixing in assigning the dilution weight:

–Start the zone of mixing at the probable point of entry and extend it for 3 miles from the probable point of entry, except: if the surface water characteristics change to turbulent within this 3-mile distance, extend the zone of mixing only to the point at which the change occurs.

–Assign a dilution weight of 0.5 to any intake that lies within this zone of mixing.

–Beyond this zone of mixing, assign a dilution weight the same as for any other river (that is, assign the dilution weight based on average annual flow).

–Treat a quiet-flowing river with an average annual flow of less than 10 cfs the same as any other river (that is, assign it a dilution weight of 1).

In those cases where water flows from a surface water body with a lower assigned dilution weight (from Table 4–13) to a surface water body with a higher assigned dilution weight (that is, water flows from a surface water body with more dilution to one with less dilution), use the lower assigned dilution weight as the dilution weight for the latter surface water body.

4.1.2.3.2 *Population.* In evaluating the population factor, include only persons served by drinking water drawn from intakes that are along the overland/flood hazardous substance migration path for the watershed and that are within the target distance limit specified in section 4.1.1.2. Include residents, students, and workers who regularly use the water. Exclude transient populations such as customers and travelers passing through the area. When a standby intake is maintained on a regular basis so that water can be withdrawn, include it in evaluating the population factor.

In estimating residential population, when the estimate is based on the number of residences, multiply each residence by the average number of persons per residence for the county in which the residence is located.

In estimating the population served by an intake, if the water from the intake is blended with other water (for example, water from other surface water intakes or ground water wells), apportion the total population regularly served by the blended system to the intake based on the intake's relative contribution to the total blended system. In estimating the intake's relative contribution, assume each well or intake contributes equally and apportion the population accordingly, except: if the relative contribution of any one intake or well exceeds 40 percent based on average annual pumpage or capacity, estimate the relative contribution of the wells and intakes considering the following data, if available:

• Average annual pumpage from the ground water wells and surface water intakes in the blended system.

• Capacities of the wells and intakes in the blended system.

For systems with standby surface water intakes or standby ground water wells, apportion the total population regularly served by the blended system as described above, except:

• Exclude standby ground water wells in apportioning the population.

• When using pumpage data for a standby surface water intake, use average pumpage for the period during which the standby intake is used rather than average annual pumpage.

• For that portion of the total population that could be apportioned to a standby surface water intake, assign that portion of the population either to that standby intake or to the other surface water intake(s) and ground water well(s) that serve that population; do not assign that portion of the population both to the standby intake and to the other intake(s) and well(s) in the blended system. Use the apportioning that results in the highest population factor value. (Either include all standby intake(s) or exclude some or all of the standby intake(s) as appropriate to obtain this highest value.) Note that the specific standby intake(s) included or excluded and, thus, the specific apportioning may vary in evaluating different watersheds and in evaluating the ground water pathway.

4.1.2.3.2.1 *Level of contamination.* Evaluate the population factor based on three factors: Level I concentrations, Level II concentrations, and potential contamination. Determine which factor applies for an intake as specified in section 4.1.2.3. Evaluate intakes subject to Level I concentration as specified in section 4.1.2.3.2.2, intakes subject to Level II concentration as specified in section 4.1.2.3.2.3, and intakes subject to potential contamination as specified in section 4.1.2.3.2.4.

For the potential contamination factor, use population ranges in evaluating the factor as specified in section 4.1.2.3.2.4. For the Level I and Level II concentrations factors, use the population estimate, not population ranges, in evaluating both factors.

4.1.2.3.2.2 *Level I concentrations.* Sum the number of people served by drinking water from intakes subject to Level I concentrations. Multiply this sum by 10. Assign this product as the value for this factor. Enter this value in Table 4–1.

4.1.2.3.2.3 *Level II concentrations.* Sum the number of people served by drinking water from intakes subject to Level II concentrations. Do not include people already counted under the Level I concentrations factor. Assign this sum as the value for this factor. Enter this value in Table 4–1.

4.1.2.3.2.4 *Potential contamination.* For each applicable type of surface water body in Table 4–14, first determine the number of people served by drinking water from intakes subject to potential contamination in that type of surface water body. Do not include those people already counted under the Level I and Level II concentrations factors.

BILLING CODE 6560-50-M

MICHAEL BAKER, JR., INC.

PHONE CALL REPORT

PROJECT/LOCATION: Navy Clean

S.O. No.: 19002-50-SRN

DATE: 3-26-91

CONTRACT NO.:

To: USGS - Richmond VA

From:

Repres.: Byron Prugh

Repres.:

Phone No.: (804) 771-2427

Phone No.:

Subject: Mr. Prugh explained that not much hydrologic information was available concerning the rivers and streams in the southern Chesapeake Bay Area. No gauging stations exist on the York River since it is an estuary. Other water bodies are not gauged because of tidal influence.

In the lower Chesapeake Bay Area

- generally less than 10 feet of relief
- low flow estimates are taken 35 miles southwest of Dismal Swamp
- Soil is mostly sand
- evapotranspiration rate is very high: innercoastal divide

-

3600 West Broad Street
Room 606
Richmond, VA 23230

bbc W Trimbath / J Mentz / PF ; R Wattras / E MacDonald

PREPARED BY Eileen MacDonald TITLE AE I PAGE 1 OF 1

OP-3

EXHIBIT 4-17

NATIONAL FLOOD INSURANCE PROGRAM

FIRM

FLOOD INSURANCE RATE MAP

CITY OF
VIRGINIA BEACH,
VIRGINIA
INDEPENDENT CITY

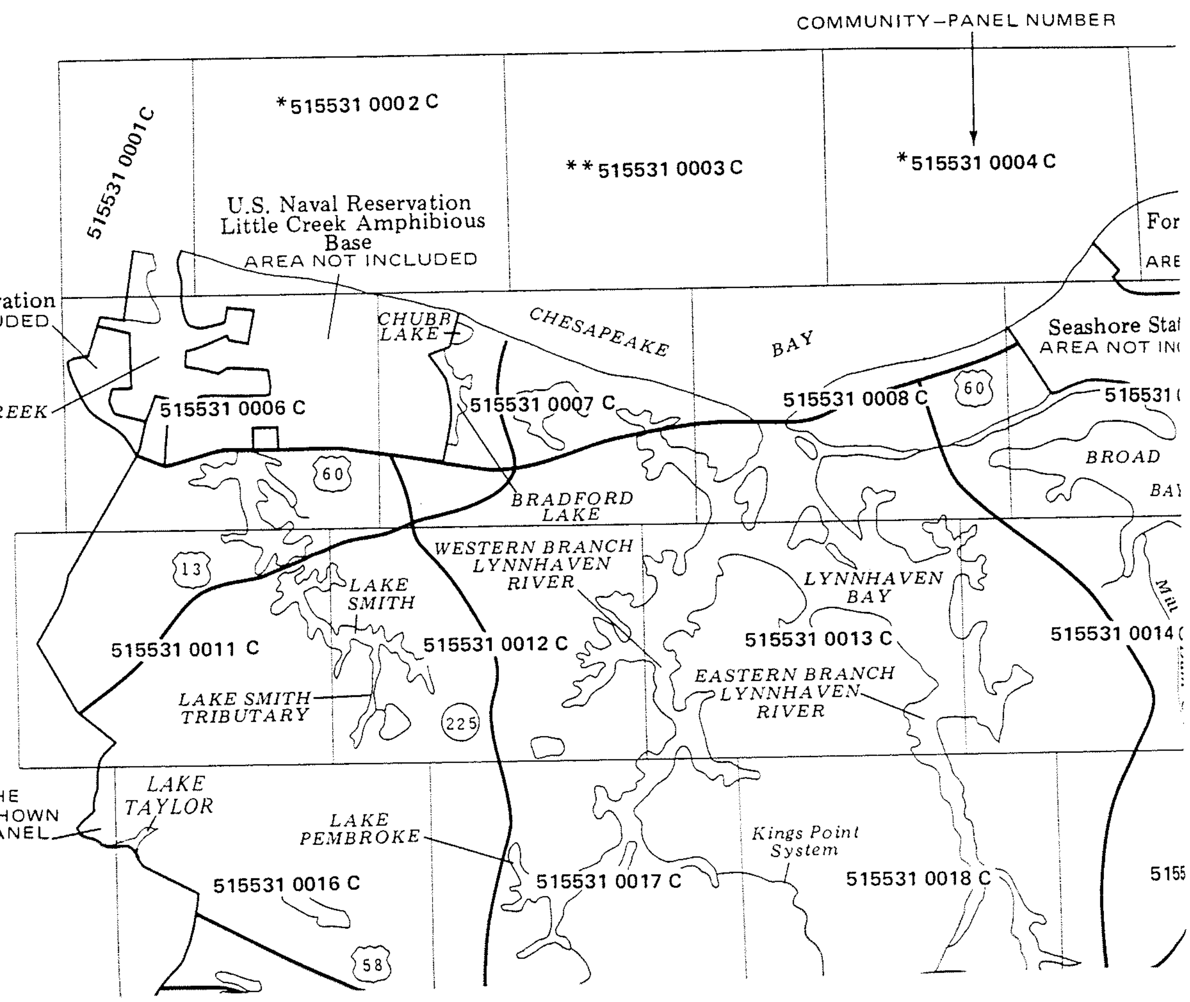
MAP INDEX

PANELS PRINTED: 1, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 60, 61, 62, 63, 66, 67, 68, 69, 70, 72, 73, 74 75, 76, 78, 79, 80, 82

COMMUNITY-PANEL NUMBERS
515531 0001-0083

MAP REVISED:
DECEMBER 5, 1990

Federal Emergency Management Agency



COMMUNITY–PANEL NUMBER
515531 0001 C
*515531 0002 C
**515531 0003 C
*515531 0004 C
U.S. Naval Reservation
Little Creek Amphibious Base
AREA NOT INCLUDED
U.S. Naval Reservation
AREA NOT INCLUDED
LITTLE CREEK
CHUBB LAKE
CHESAPEAKE
BAY
Seashore Stat
AREA NOT IN
515531 0006 C
515531 0007 C
515531 0008 C
60
BROAD
BAY
BRADFORD LAKE
WESTERN BRANCH LYNNHAVEN RIVER
LYNNHAVEN BAY
13
LAKE SMITH
515531 0011 C
515531 0012 C
515531 0013 C
515531 0014
EASTERN BRANCH LYNNHAVEN RIVER
LAKE SMITH TRIBUTARY
225
THIS AREA OF THE COMMUNITY IS SHOWN AS INSET A ON PANEL 515531 0015 C
LAKE TAYLOR
LAKE PEMBROKE
Kings Point System
515531 0016 C
515531 0017 C
515531 0018 C
58

Table 1. Annual Production of Human Food Chain Organisms per acre of Surface-Water Body 15 miles downstream or upstream (tidal influenced) from Little Creek

Water Body	Code	Pounds Landed	Size of Water Body (acres)	Pounds per Acre
Lynnhaven Bay	375	2,062	2,800	1
Elizabeth River	316	696,742	7,300	95
Lafayette River	327	0	1,500	0
Back River	301	1,569,561	4,700	334
James River (lower)	324	2,435,617	47,000	52
Chesapeake Bay (lower west)	307	23,251,890	210,000	111

Source: Virginia Marine Resources Council. "Total Landings of Shellfish and and Finfish by Water Area." 1989.

FACSIMILE TRANSMITTAL COVER SHEET

MARINE RESOURCES COMMISSION
2600 Washington Avenue
P. O. Box 756
Newport News, VA 23607

* *

DATE: 3-28-91

PLEASE DELIVER THE FOLLOWING PAGES TO:

NAME: Aaron Bernhardt

TITLE/DEPARTMENT: Baker Environmental

CONFIRMATION PHONE:

FAX # (412)-269-6097

THIS FACSIMILE DOCUMENT IS FROM:

NAME: Sonya Knur

PHONE: (804)247 - 2246

* *

NUMBER OF PAGES (including cover sheet) 3

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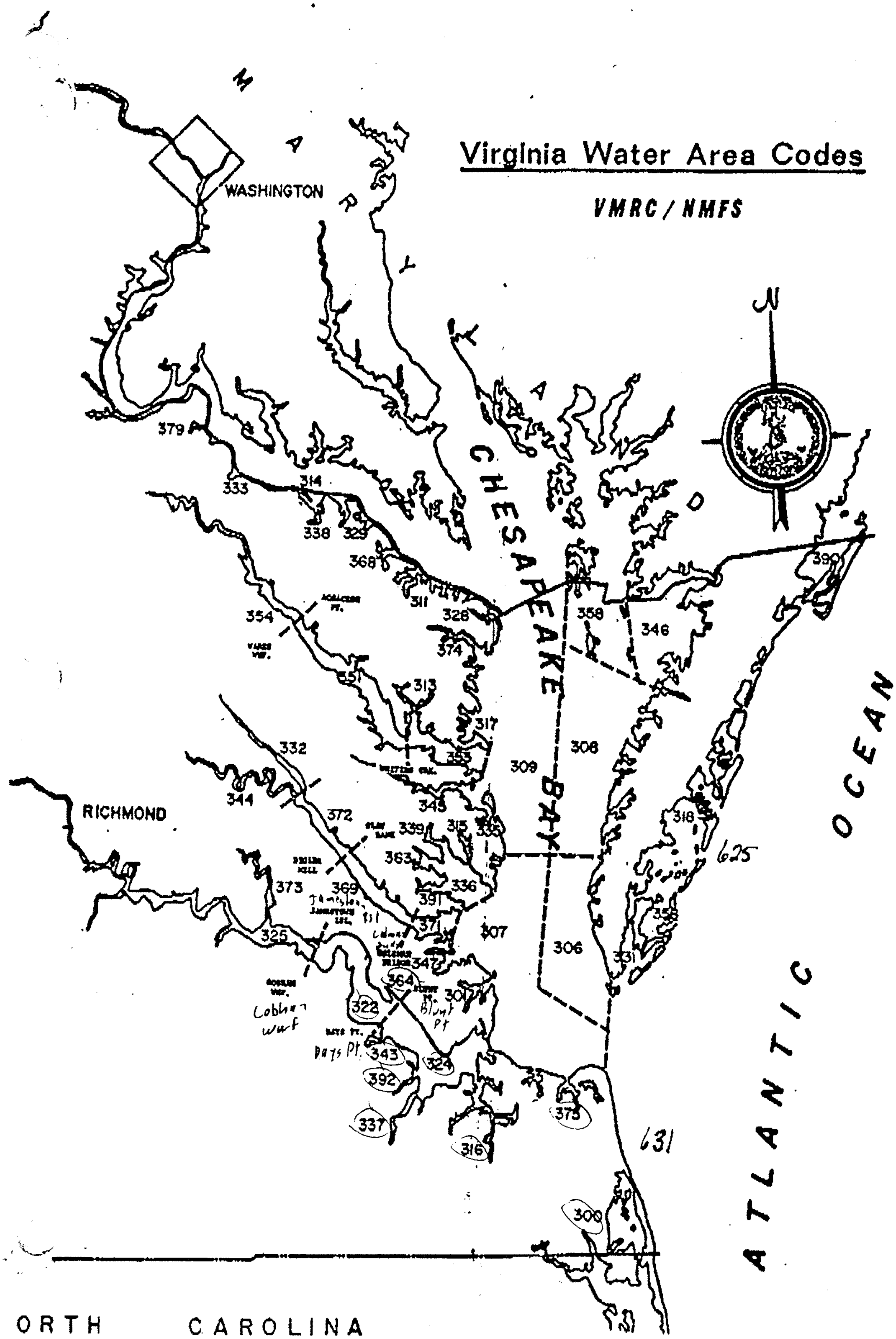
THANK YOU.

Virginia Water Area Codes

VMRC / NMFS



VIRGINIA

WATER BODY AND RIVER BASIN CODE GROUPINGS

STEM 1	SYSTEM 2	SYSTEM 3	SYSTEM 4	SYSTEM 5	SYSTEM 6	SYSTEM 7	SYSTEM 8	SYSTEM 9
LANTIC EAN	SEASIDE E. SHORE	MISC. SEASIDE CODES	CHESAPEAKE BAY	JAMES RIVER	YORK RIVER	RAPPAHANNOCK RIVER	POTOMAC RIVER	OTHER CHESAPEAKE BAY TRIBS.
'S OCEAN	302 BOGUE BAY	300 BACK BAY	305 CHES. BAY GENERAL	316 ELIZABETH RIV	332 MATTAPONI RIVER	313 CORROTOMAN RIVER	311 COAN RIVER	301 BACK RIVER
'S OCEAN	303 BRADFORD BAY	376 NORTH LANDING RIVER	306 CHES. BAY LOWER E	322 JAMES R. CENTRAL	344 PAMUNKEY RIVER	351 RAPPAHANNOCK R. CENTRAL	314 CURRIOMAN RIVER	315 EAST RIVER
	304 BURTONS BAY		307 CHES. BAY LOWER W	323 JAMES R. GENERAL	369 YORK R. CENTRAL	352 RAPPAHANNOCK R. GENERAL	329 LOWER MACHODOC CR.	328 LITTLE WICOMICO RIVER
	312 COBB BAY		308 CHES. BAY UPPER E	324 JAMES R. LOWER	370 YORK R. GENERAL	353 RAPPAHANNOCK R. LOWER	333 MATTOX CREEK	339 NORTH RIVER
	318 HOG ISLAND BAY		309 CHES. BAY UPPER W	325 JAMES R. UPPER	371 YORK R. LOWER	354 RAPPAHANNOCK R. UPPER	338 NOMINI BAY	345 PIANKATANK RIVER
	319 GARGATHY BAY		317 FLEETS BAY	327 LAFAYETTE RIVER	372 YORK R. UPPER		348 POTOMAC CREEK	347 POQUOSON RIVER
	326 KEGOTANK BAY		321 HORN HARBOR	337 NANSEMOND RIVER			355 ROSIER CREEK	360 CESAPEAKE TRIBS. GEN.
	331 MAGOTHY BAY		335 MILFORD HAVEN	343 PAGAN RIVER			368 YEOCOMICO RIVER	363 WARE RIVER
	334 METOMKIN BAY		336 MOBJACK BAY	364 WARWICK RIVER			379 UPPER MACHODOC CR.	374 GREAT WICOMICO RIVER
	341 OUTLET BAY		346 POCOMOKE SOUND	366 WILLOUGHBY BAY			380 POTOMAC R. LOWER	377 POCOMOKE RIVER
	342 OYSTER BAY		358 TANGIER SOUND	373 CHICKAHOMINY RIVER			381 POT. R. LOWER CEN	391 SEVERN RIVER
	356 SOUTH BAY		367 WINTER HARBOR	392 CHUCKATUCK CREEK			382 POT. R. UPPER CEN	
	357 SWASH BAY		375 LYNNHAVEN BAY				383 POTOMAC R. UPPER	
	359 UNCL. SEASIDE						384 POTOMAC R. GENERAL	
	365 WATTS BAY						389 POT. R. TRIBS. GEN.	
	378 UPSHUR BAY							
	390 CHINCOTEAGUE BAY							

FACSIMILE TRANSMITTAL COVER SHEET

MARINE RESOURCES COMMISSION
2600 Washington Avenue
P. O. Box 756
Newport News, VA 23607

* *

DATE: 4-8-91

PLEASE DELIVER THE FOLLOWING PAGES TO:

NAME: Aaron Bernhardt

TITLE/DEPARTMENT: Baker Environmental Inc

CONFIRMATION PHONE: (412) 269-6000

FAX # (412) 269-6097

THIS FACSIMILE DOCUMENT IS FROM:

NAME: Sonya Knur

PHONE: (804) 247-2246

* *

NUMBER OF PAGES (including cover sheet) 2

TRANSMITTING FROM FAX #: 804-247-2020

* *

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THANK YOU.

TOTAL LANDINGS OF SHELLFISH AND FINFISH BY WATER AREA
ALL LANDINGS DATA ARE PRELIMINARY
LANDINGS ARE COLLECTED ON A VOLUNTARY BASIS

1989

WATER AREA	POUNDS LANDED
300	101,247
376	0
306	6,471,054
307	23,251,890
336	1,434,742
375	2,062
316	696,742
322	1,169,332
323	0
324	2,435,617
325	123,954
327	0
337	597,509
364	1,101
366	0
373	1,219,399
392	0
369	917,952
370	0
371	2,267,002
372	113,627
301	1,569,561
315	0
339	0
347	1,163,425
363	8,000
391	0

EXHIBIT 4-19

COMMONWEALTH of VIRGINIA

C M G BUTTERY, M.D.
COMMISSIONER

Department of Health
Richmond, Virginia 23219

NOTICE AND DESCRIPTION OF SHELLFISH AREA CONDEMNATION NUMBER 17, LITTLE CREEK

EFFECTIVE 24 AUGUST 1990

Pursuant to Title 28.1, Chapter 7, §§28.1-175 through 28.1-177, §32.1-20, and §9-6.14:4.1 B16 of the Code of Virginia:

1. The "Notice and Description of Shellfish Area Condemnation Number 17, Little Creek", effective 27 April 1989, is cancelled effective 24 August 1990.

2. Condemned Shellfish Area Number 17, Little Creek, is established, effective 24 August 1990. It shall be unlawful for any person, firm, or corporation to take shellfish from area #17 for any purpose. The boundaries of the area are shown on map titled "Little Creek, Condemned Shellfish Area Number 17, 24 August 1990" which is part of this notice.

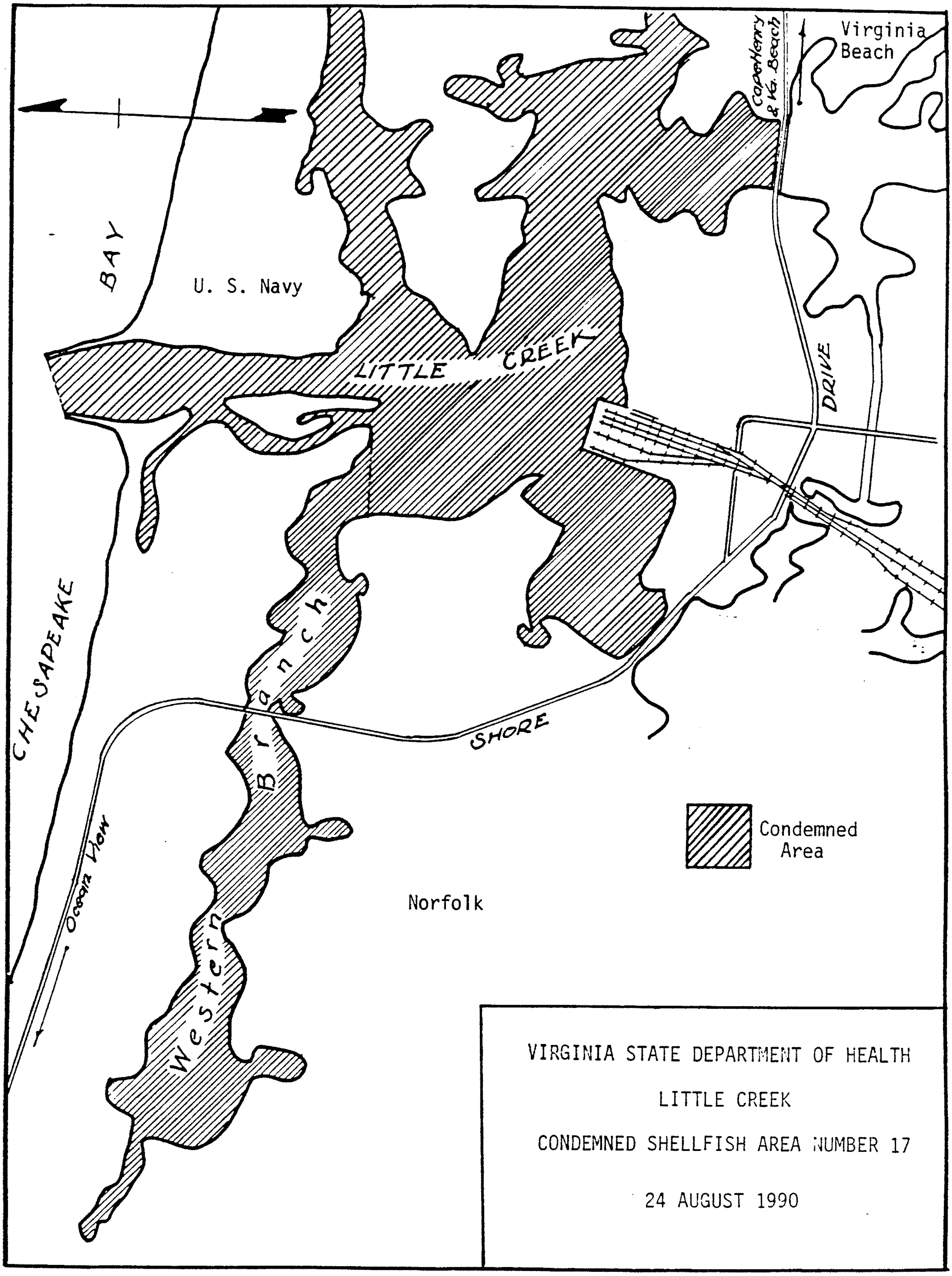
3. The Department of Health will receive, consider and respond to petitions by any interested person at any time with respect to reconsideration or revision of this order.

BOUNDARIES OF CONDEMNED AREA NUMBER 17

The condemned area shall include all of that portion of Little Creek and its tributaries lying upstream of a line drawn between the north ends of the east and west jetties.

Recommended by: ______________________________
Director, Division of Shellfish Sanitation

Ordered by: ______________________________ August 24, 1990
State Health Commissioner Date



VIRGINIA STATE DEPARTMENT OF HEALTH

LITTLE CREEK

CONDEMNED SHELLFISH AREA NUMBER 17

24 AUGUST 1990

COMMONWEALTH of VIRGINIA

C.M.G. BUTTERY, M.D.
COMMISSIONER

Department of Health
Richmond, Virginia 23219

NOTICE AND DESCRIPTION OF SHELLFISH AREA CONDEMNATION
NUMBER 25, LYNNHAVEN, BROAD AND LINKHORN BAYS AND TRIBUTARIES

EFFECTIVE 27 APRIL 1989

Pursuant to Title 28.1, Chapter 7, §§28.1-175 through 28.1-177, §32.1-20, and §9-6.14:4.1 C6 of the Code of Virginia:

1. The "Notice and Description of Shellfish Area Condemnation Number 25, Lynnhaven, Broad, and Linkhorn Bays and Tributaries", effective 26 May 1988 (emergency regulation) is cancelled effective 27 April 1989.

2. Condemned Shellfish Area Number 25, Lynnhaven, Broad and Linkhorn Bays and Tributaries, is established, effective 27 April 1989. It shall be unlawful for any person, firm, or corporation to take shellfish from area #25 for any purpose, except by permit granted by the Marine Resources Commission, as provided in Section 28.1-179 of the Code of Virginia. The boundaries of the area are shown on map titled "Lynnhaven, Broad, and Linkhorn Bays and Tributaries, Condemned Shellfish Area Number 25, 27 April 1989" which is a part of this notice.

3. The Department of Health will receive, consider and respond to petitions by any interested person at any time with respect to reconsideration or revision of this Revision.

BOUNDARIES OF CONDEMNED AREA NUMBER 25

A. The condemned area shall include all of Lynnhaven Bay, Lynnhaven River and tributaries upstream of the upstream side of the Lesner Bridge and west of the western boundary of part B, Long Creek and Canal.

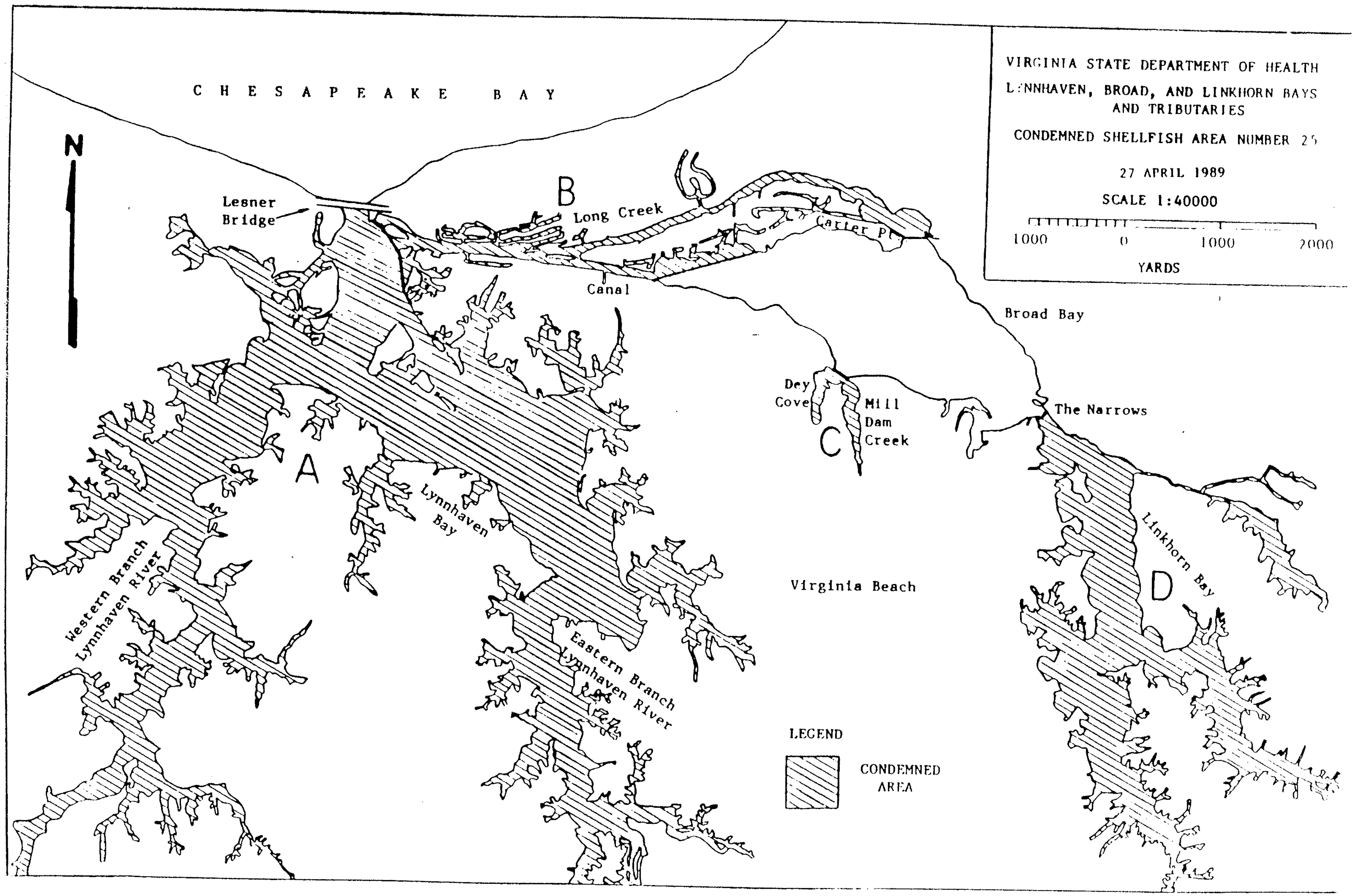
B. The condemned area shall include all of Long Creek, canal and tributaries enclosed by a line beginning at the prominent point of land south of the east end of the Lesner Bridge; thence southeasterly along the western shores of four small islands to the westernmost point of the shore; thence east and north around the shore to the south shore of Long Creek; thence easterly along the south shore to the eastern end of Long Creek Canal to the point where it enters Broad Bay; thence east northeasterly approximately 1100 yards to the southwestern point of the major shoreline projection; thence easterly along the shoreline to the easternmost projection of Carter Point; thence due east to the opposing shore; thence north and west along the north shore to the point of beginning.

C. The condemned area shall include all of Dey Cove and Mill Dam Creek and their tributaries upstream of a line across the common mouth at its narrowest point.

D. The condemned area shall include all of Linkhorn Bay and its tributaries upstream of a line across the Narrows at the most constricted point.

Recommended by: ______________________________
Director, Division of Shellfish Sanitation

Ordered by: ______________________________ 3-7-89
State Health Commissioner Date



VIRGINIA STATE DEPARTMENT OF HEALTH
LYNNHAVEN, BROAD, AND LINKHORN BAYS AND TRIBUTARIES
CONDEMNED SHELLFISH AREA NUMBER 25
27 APRIL 1989
SCALE 1:40000
1000 0 1000 2000
YARDS
CHESAPEAKE BAY
N
Lesner Bridge
B
Long Creek
Carter Pt
Canal
Broad Bay
Dey Cove
Mill Dam Creek
C
The Narrows
A
Lynnhaven Bay
Western Branch Lynnhaven River
Eastern Branch Lynnhaven River
Virginia Beach
Linkhorn Bay
D
LEGEND
CONDEMNED AREA

C.M.G. BUTTERY, M.D.
COMMISSIONER

COMMONWEALTH of VIRGINIA

Department of Health
Richmond, Virginia 23219

NOTICE AND DESCRIPTION OF SHELLFISH AREA CONDEMNATION NUMBER 60, CHESAPEAKE BAY - ADJOINING LITTLE CREEK

EFFECTIVE 27 APRIL 1989

Pursuant to Title 28.1, Chapter 7, §§28.1-175 through 28.1-177, §32.1-20, and §9-6.14:4.1 C6 of the Code of Virginia:

1. The "Notice and Description of Shellfish Area Condemnation Number 60, Chesapeake Bay - Adjoining Little Creek", effective 26 May 1988 (emergency regulation) is cancelled effective 27 April 1989.

2. Condemned Shellfish Area Number 60, Chesapeake Bay - Adjoining Little Creek, is established, effective 27 April 1989. It shall be unlawful for any person, firm, or corporation to take shellfish from area #60 for any purpose except by permit granted by the Marine Resources Commission, as provided in Title 28.1-179 of the Code of Virginia. The boundaries of the area are shown on map titled "Chesapeake Bay - Adjoining Little Creek, Condemned Shellfish Area Number 60, 27 April 1989" which is part of this notice.

3. The Department of Health will receive, consider and respond to petitions by any interested person at any time with respect to reconsideration or revision of this Revision.

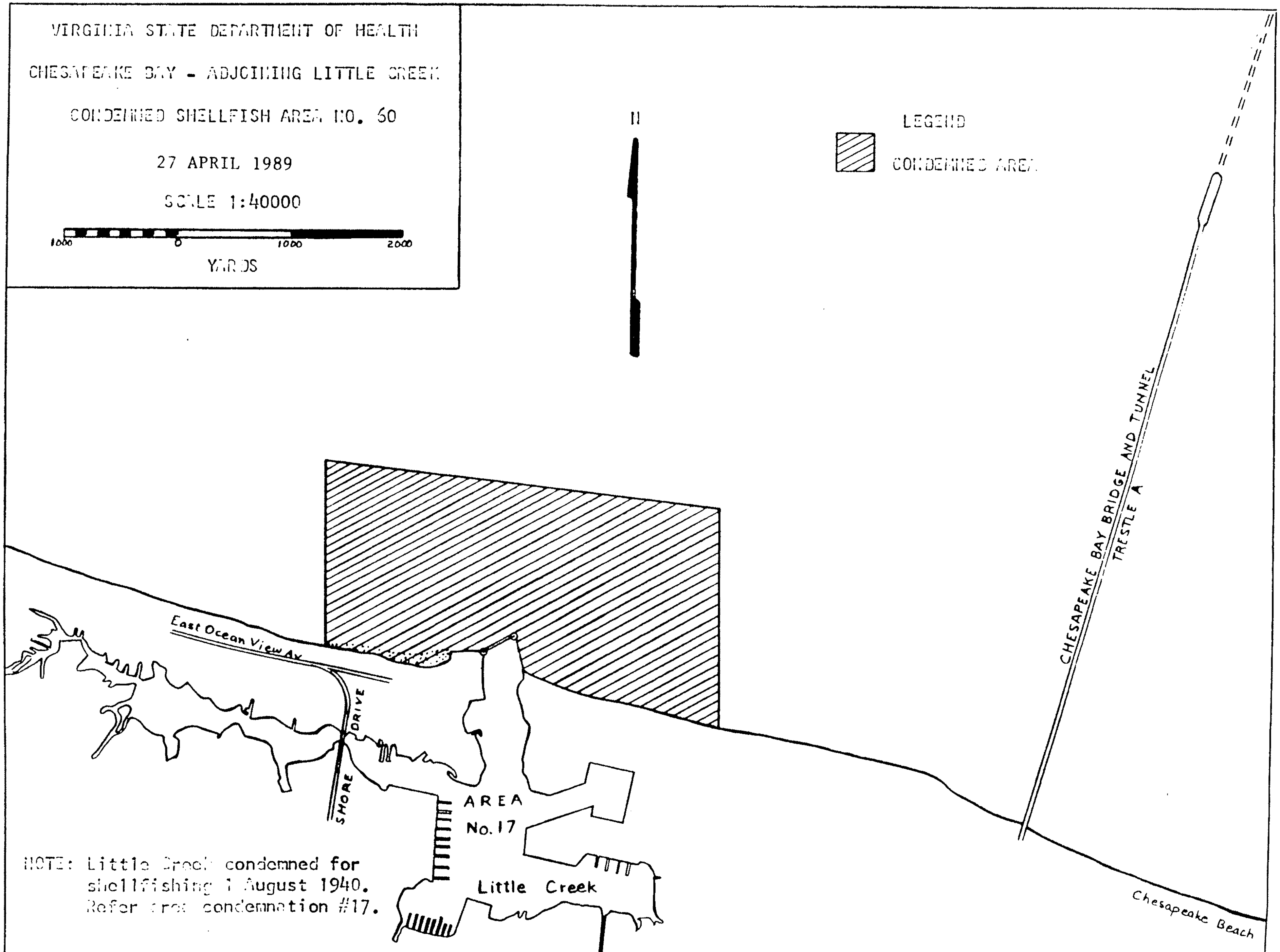
BOUNDARIES OF CONDEMNED AREA NUMBER 60

The condemned area shall include that area of Chesapeake Bay enclosed by a line beginning at a point on the beach at high water line due north of the intersection of East Ocean View Avenue and Shore Drive, thence due north to the 24 ft. contour ±1660 yards (approximately 36°56'40" 76°11'40") thence S83°30'E approximately two miles to a point on the 24 ft contour (approximately 36°56'30" 76°09'25"), thence due south to a point on the beach at high water line ±1 mile, thence along the high water line to the point of beginning crossing the mouth of Little Creek abutting Shellfish Condemned Area Number 17. This area extends approximately one mile east and one mile west of the jetty on the east side of Little Creek and offshore to the 24 ft. contour.

Recommended by: Cloyde W. Wiley
Director, Division of Shellfish Sanitation

Ordered by: [signature]
State Health Commissioner

3.7.89
Date


VIRGINIA STATE DEPARTMENT OF HEALTH
CHESAPEAKE BAY - ADJOINING LITTLE CREEK
CONDEMNED SHELLFISH AREA NO. 60
27 APRIL 1989
SCALE 1:40000
1000 0 1000 2000
YARDS
N
LEGEND
CONDEMNED AREA
CHESAPEAKE BAY BRIDGE AND TUNNEL
TRESTLE A
East Ocean View Av
SHORE DRIVE
AREA No. 17
Little Creek
Chesapeake Beach
NOTE: Little Creek condemned for shellfishing 1 August 1940. Refer area condemnation #17.

COMMONWEALTH of VIRGINIA

C.M.G. BUTTERY, M.D.
COMMISSIONER

Department of Health
Richmond, Virginia 23219

NOTICE AND DESCRIPTION OF SHELLFISH AREA CONDEMNATION NUMBER 163, SOUTH THIMBLE ISLAND, CHESAPEAKE BAY BRIDGE - TUNNEL

EFFECTIVE 27 APRIL 1989

Pursuant to Title 28.1, Chapter 7, §§28.1-175 through 28.1-177, §32.1-20, and §9-6.14:4.1 C6 of the Code of Virginia:

1. The "Notice and Description of Shellfish Area Condemnation Number 163, South Thimble Island, Chesapeake Bay Bridge - Tunnel", effective 26 May 1988 (emergency regulation) is cancelled effective 27 April 1989.

2. Condemned Shellfish Area Number 163, South Thimble Island, Chesapeake Bay Bridge - Tunnel, is established, effective 27 April 1989. It shall be unlawful for any person, firm, or corporation to take shellfish from area #163 for any purpose except by permit granted by the Marine Resources Commission, as provided in Title 28.1-179 of the Code of Virginia. The boundaries of the area are shown on map titled "South Thimble Island, Chesapeake Bay Bridge - Tunnel, Condemned Shellfish Area Number 163, 27 April 1989" which is part of this notice.

3. The Department of Health will receive, consider and respond to petitions by any interested person at any time with respect to reconsideration or revision of this Revision.

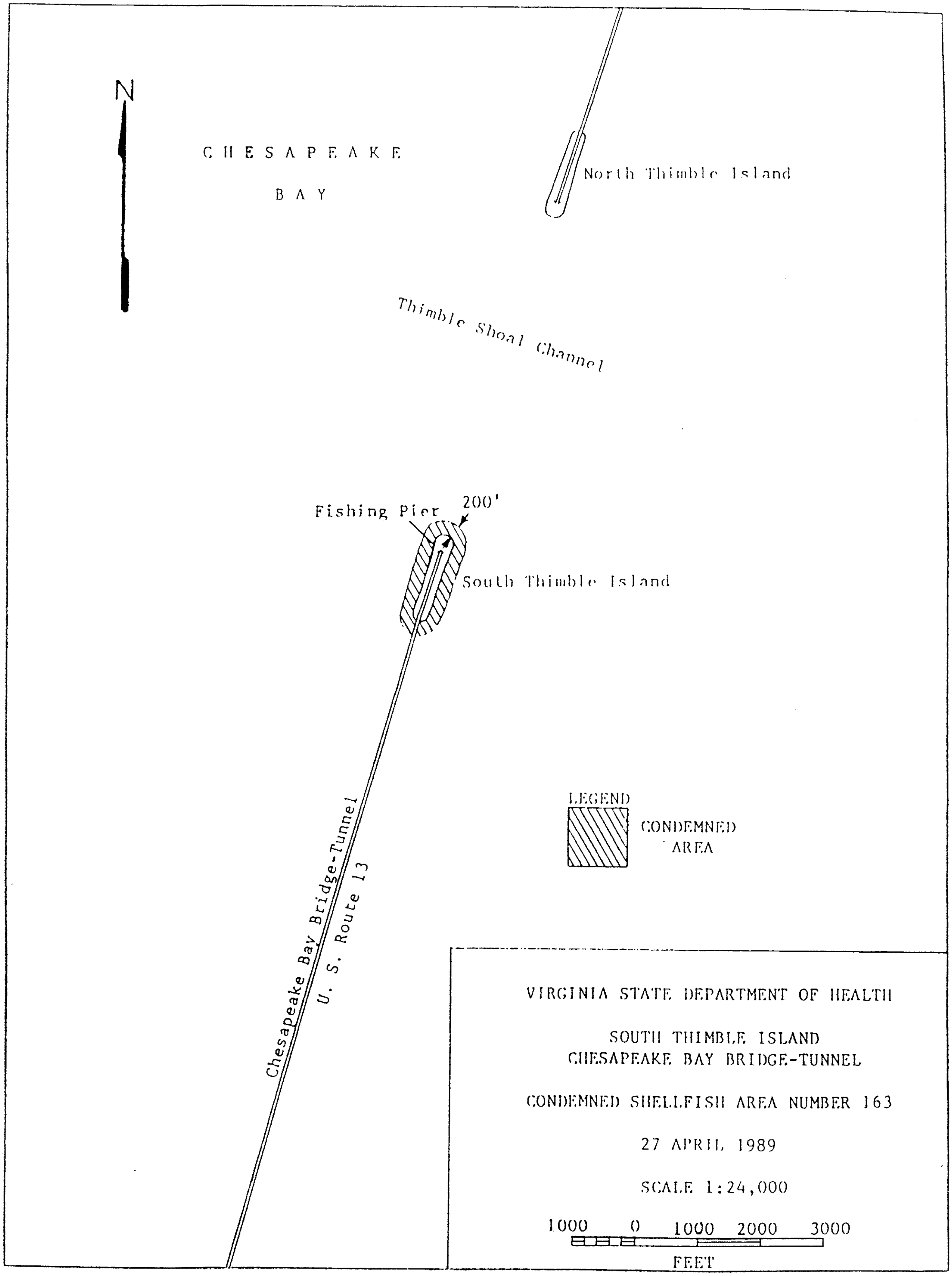
BOUNDARIES OF CONDEMNED AREA NUMBER 163

The condemned area shall include all of that portion of Chesapeake Bay enclosed by a line drawn around South Thimble Island of the Chesapeake Bay Bridge - Tunnel complex at a distance of 200 feet.

Recommended by: Cloyde W. Wiley
Director, Division of Shellfish Sanitation

Ordered by: [signature]
State Health Commissioner

3.7.89
Date


N
CHESAPEAKE
BAY
North Thimble Island
Thimble Shoal Channel
Fishing Pier
200'
South Thimble Island
Chesapeake Bay Bridge-Tunnel
U. S. Route 13
LEGEND
CONDEMNED AREA
VIRGINIA STATE DEPARTMENT OF HEALTH
SOUTH THIMBLE ISLAND
CHESAPEAKE BAY BRIDGE-TUNNEL
CONDEMNED SHELLFISH AREA NUMBER 163
27 APRIL 1989
SCALE 1:24,000
1000 0 1000 2000 3000
FEET

C.M.G. BUTTERY, M.D.
COMMISSIONER

COMMONWEALTH of VIRGINIA

Department of Health
Richmond, Virginia 23219

NOTICE AND DESCRIPTION OF SHELLFISH AREA CONDEMNATION
NUMBER 7, HAMPTON ROADS

EFFECTIVE 27 APRIL 1989

Pursuant to Title 28.1, Chapter 7, §§28.1-175 through 28.1-177, §32.1-20, and §9-6.14:4.1 C6 of the Code of Virginia:

1. The "Notice and Description of Shellfish Area Condemnation Number 7, Hampton Roads", effective 26 May 1988 (emergency regulation) is cancelled effective 27 April 1989.

2. Condemned Shellfish Area Number 7, Hampton Roads, is established, effective 27 April 1989, and shall consist of areas A and B described below. As to area A, it shall be unlawful for any person, firm, or corporation to take shellfish from this area, for any purpose, except by permit granted by the Marine Resources Commission, as provided in Section 28.1-179 of the Code of Virginia. As to area B, it shall be unlawful for any person, firm, or corporation to take shellfish from this area, for any purpose. The boundaries of the areas are shown on map titled "Hampton Roads, Condemned Shellfish Area Number 7, 27 April 1989" which is part of this notice.

3. The Department of Health will receive, consider and respond to petitions by any interested person at any time with respect to reconsideration or revision of this order.

BOUNDARIES OF CONDEMNED AREA NUMBER 7

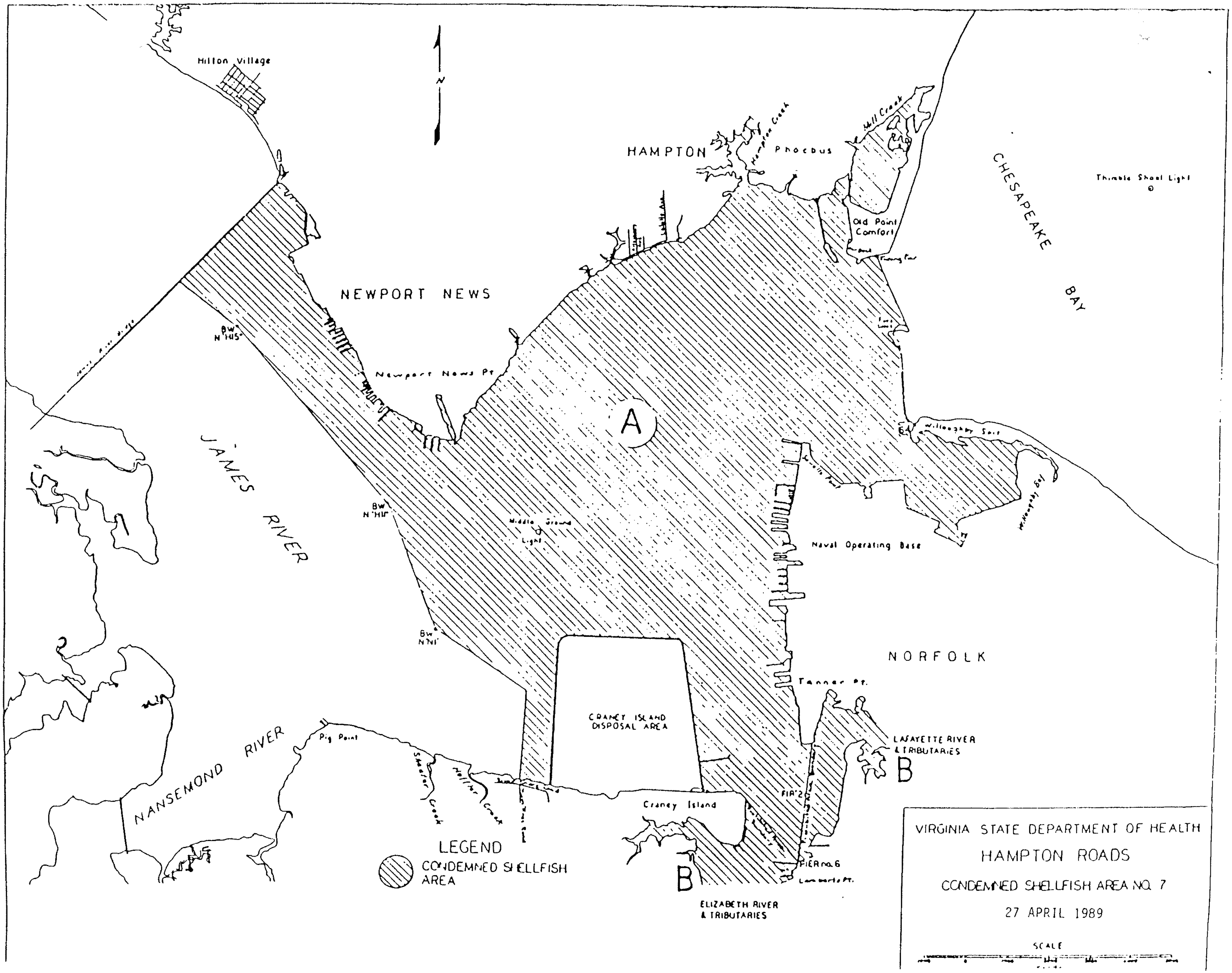
A. The condemned area shall include all of Hampton Roads bounded by a line beginning at the upstream side of the large fishing pier on the southeast side of Old Point Comfort; thence upstream to the upstream side of the southwesterly along the upstream side of the bridge for 3200 yards; thence in a southeasterly direction to navigational aid BW N"H15"; thence to navigational aid BW"N"H11"; thence to navigational aid BW"N1"; thence along a line drawn southeasterly to a point 3800 yards south of Middle Ground Light along a line drawn from Middle Ground Light to the intersection of Twin Pines Road and River Shore Road on the south shore west of Craney Island Disposal Area; thence southerly along this line to the shore; thence along the shore to the west side of Craney Island; thence clockwise around the boundaries of Craney Island Disposal Area to its intersection with the shore; thence along the shore to the northeast corner of Craney Island; thence across the Elizabeth River to pier number 6 at Lamberts Point; thence through navigational aid Fl R "2" to the southeast corner of Tanner Point; thence along the shore to the point of intersection with the eastern side of the southern end of the westbound Hampton Roads Bridge-Tunnel on Willoughby Spit; thence northerly along the eastern side of this bridge to the point of intersection with the riprapped shoreline of the Hampton Roads Bridge-Tunnel island at Fort Wool; thence easterly around this island to its easternmost point; thence north northwesterly to the intersection of the shoreline and the upstream side of the large fishing pier on the east side of Old Point Comfort at the point of beginning.

B. The condemned areas shall include all of the Elizabeth River and its tributaries and all of the Lafayette River and its tributaries lying upstream of a line drawn from the northeast corner of Craney Island to the shoreward end of pier number 6 at Lamberts Point; and thence through navigational aid Fl R "2" to the southeast corner of Tanner Point. No shellfish may be harvested from these areas for any purpose.

Recommended by: [signature]
Director, Division of Shellfish Sanitation

Ordered by: [signature]
State Health Commissioner

Date 3-7-89


N
Hilton Village
HAMPTON
Phoebus
CHESAPEAKE BAY
Thimble Shoal Light
Old Point Comfort
NEWPORT NEWS
Newport News Pt
JAMES RIVER
A
Middle Ground Light
Naval Operating Base
NORFOLK
Tanner Pt.
CRANEY ISLAND DISPOSAL AREA
LAFAYETTE RIVER & TRIBUTARIES
B
Pig Point
NANSEMOND RIVER
Craney Island
PIER no. 6
Lamberts Pt.
B
ELIZABETH RIVER & TRIBUTARIES
LEGEND
CONDEMNED SHELLFISH AREA
VIRGINIA STATE DEPARTMENT OF HEALTH
HAMPTON ROADS
CONDEMNED SHELLFISH AREA NO. 7
27 APRIL 1989
SCALE

COMMONWEALTH of VIRGINIA

C.M.G. BUTTERY, M.D.
COMMISSIONER

Department of Health
Richmond, Virginia 23219

NOTICE AND DESCRIPTION OF SHELLFISH AREA CONDEMNATION NUMBER 21, BACK RIVER

EFFECTIVE 22 AUGUST 1990

Pursuant to Title 28.1, Chapter 7, §§28.1-175 through 28.1-177, §32.1-20, and §9-6.14:4.1 B16 of the Code of Virginia:

1. The "Notice and Description of Shellfish Area Condemnation Number 21, Back River", effective 27 April 1989, is cancelled effective 22 August 1990.

2. Condemned Shellfish Area Number 21, Back River, is established, effective 22 August 1990. It shall be unlawful for any person, firm, or corporation to take shellfish from area #21 for any purpose, except by permit granted by the Marine Resources Commission, as provided in Section 28.1-179 of the Code of Virginia. The boundaries of the area are shown on map titled "Back River, Condemned Shellfish Area Number 21, 22 August 1990" which is a part of this notice.

3. The Department of health will receive, consider and respond to petitions by any interested person at any time with respect to reconsideration or revision of this order.

BOUNDARIES OF CONDEMNED AREA NUMBER 21

A. The condemned area shall include all of that portion of Watts Creek and its tributaries lying upstream of a line drawn from Marine Resources Commission survey marker "Watt" in a northwesterly direction to the southernmost tip of the prominent point of land on the opposite shore.

B. The condemned area shall include all of that portion of Topping Creek upstream of a line drawn from triangulation station "Topping" on the eastern shore at the mouth of the creek in a west by northwesterly direction to the southeasternmost point of land on the opposite shore.

C. The condemned area shall include all of that portion of Cedar Creek upstream of a line drawn from the easternmost end of Cedar Point due north to the opposite shore.

D. The condemned area shall include all of that portion of the Northwest Branch of Back River and its tributaries lying upstream of a line drawn from a point 1600 feet upstream from Marsh Point due north to the opposite shore.

E. The Condemned area shall include all of that portion of Tabbs Creek upstream of a line drawn from triangulation station "Tabb" on the eastern shore at the mouth of the creek due west to the opposing shore.

F. The condemned area shall include all of that portion of the Southwest Branch of Back River and its tributaries lying upstream of a line drawn from a point 200 feet upstream of triangulation station "Grass" due west to the opposing shore.

G. The condemned area shall include all of that portion of the Harris River and its tributaries lying upstream of a line drawn from Marine Resources Commission survey marker "Wendenberg" in a northeasterly direction to Marine Resources Commission survey marker "Johnson 1" on the opposite shore.

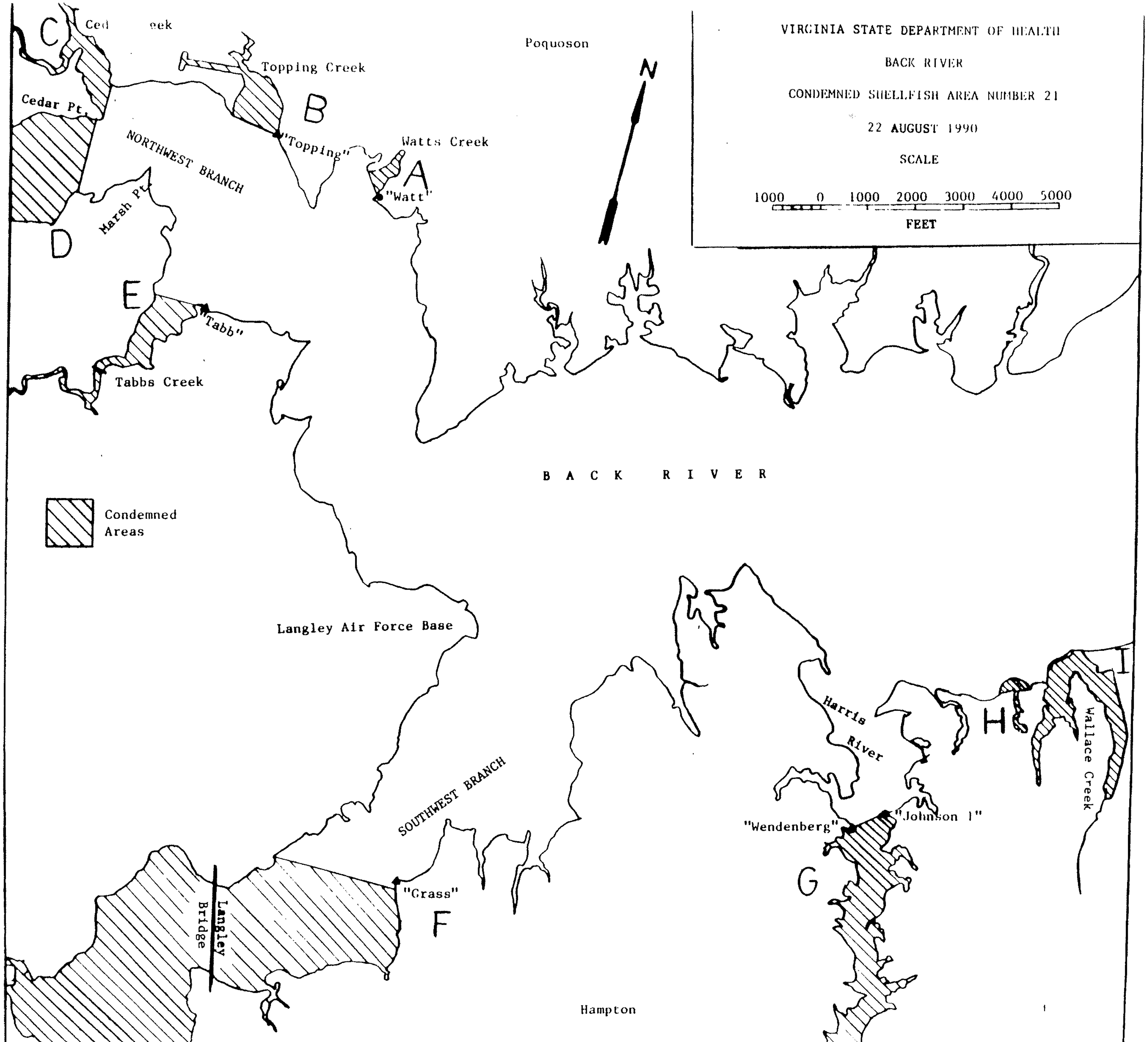
H. The condemned area shall include all of an unnamed inlet off of the south shore of Back River within 300 feet in all directions from the midpoint of a line across the mouth of the inlet.

I. The condemned area shall include all of that portion of Wallace Creek and its tributaries lying upstream of a line drawn from the northeasternmost tip of the prominent point of land on the western shore of the mouth of Wallace Creek north to the westernmost point of land of the small island north of Wallace Creek; thence along the offshore side of the island to its northeasternmost end; thence to the tip of the westernmost point of land on the downstream shore of the creek.

Recommended by: Mary P. Wright
for Director, Division of Shellfish Sanitation

Ordered by: [signature]
State Health Commissioner

August 22, 1990
Date



VIRGINIA STATE DEPARTMENT OF HEALTH
BACK RIVER
CONDEMNED SHELLFISH AREA NUMBER 21
22 AUGUST 1990
SCALE
1000 0 1000 2000 3000 4000 5000
FEET
N
Poquoson
Topping Creek
Cedar Pt.
NORTHWEST BRANCH
"Topping"
Watts Creek
"Watt"
Marsh Pt.
"Tabb"
Tabbs Creek
BACK RIVER
Condemned Areas
Langley Air Force Base
SOUTHWEST BRANCH
Harris River
Wallace Creek
"Wendenberg"
"Johnson 1"
"Grass"
Langley Bridge
Hampton
A
B
C
D
E
F
G
H
I

COMMONWEALTH of VIRGINIA

C.M.G. BUTTERY, M.D.
COMMISSIONER

Department of Health
Richmond, Virginia 23219

NOTICE AND DESCRIPTION OF SHELLFISH AREA CONDEMNATION NUMBER 158, BACK RIVER: LONG AND GRUNLAND CREEKS

EFFECTIVE 7 SEPTEMBER 1990

Pursuant to Title 28.1, Chapter 7,. §§28.1-175 through 28.1-177, §32.1-20, and §9-6.14:4.1 B16 of the Code of Virginia:

1. The "Notice and Description of Shellfish area Condemnation Number 158, Back River: Long and Grunland Creeks", effective 22 August 1990, is cancelled effective 7 September 1990.

2. Condemned Shellfish Area Number 158, Back River: Long and Grunland Creeks, is established, effective 7 September 1990. It shall be unlawful for any person, firm, or corporation to take shellfish from area #158 for any purpose, except by permit granted by the Marine Resources Commission, as provided in Section 28.1-179 of the Code of Virginia. The boundaries of the area are shown on map titled "Back River: Long and Grunland Creeks, Condemned Shellfish Area Number 158, 7 September 1990" which is a part of this notice.

3. The Department of Health will receive, consider and respond to petitions by any interested person at any time with respect to reconsideration or revision of this order.

BOUNDARIES OF CONDEMNED AREA NUMBER 158

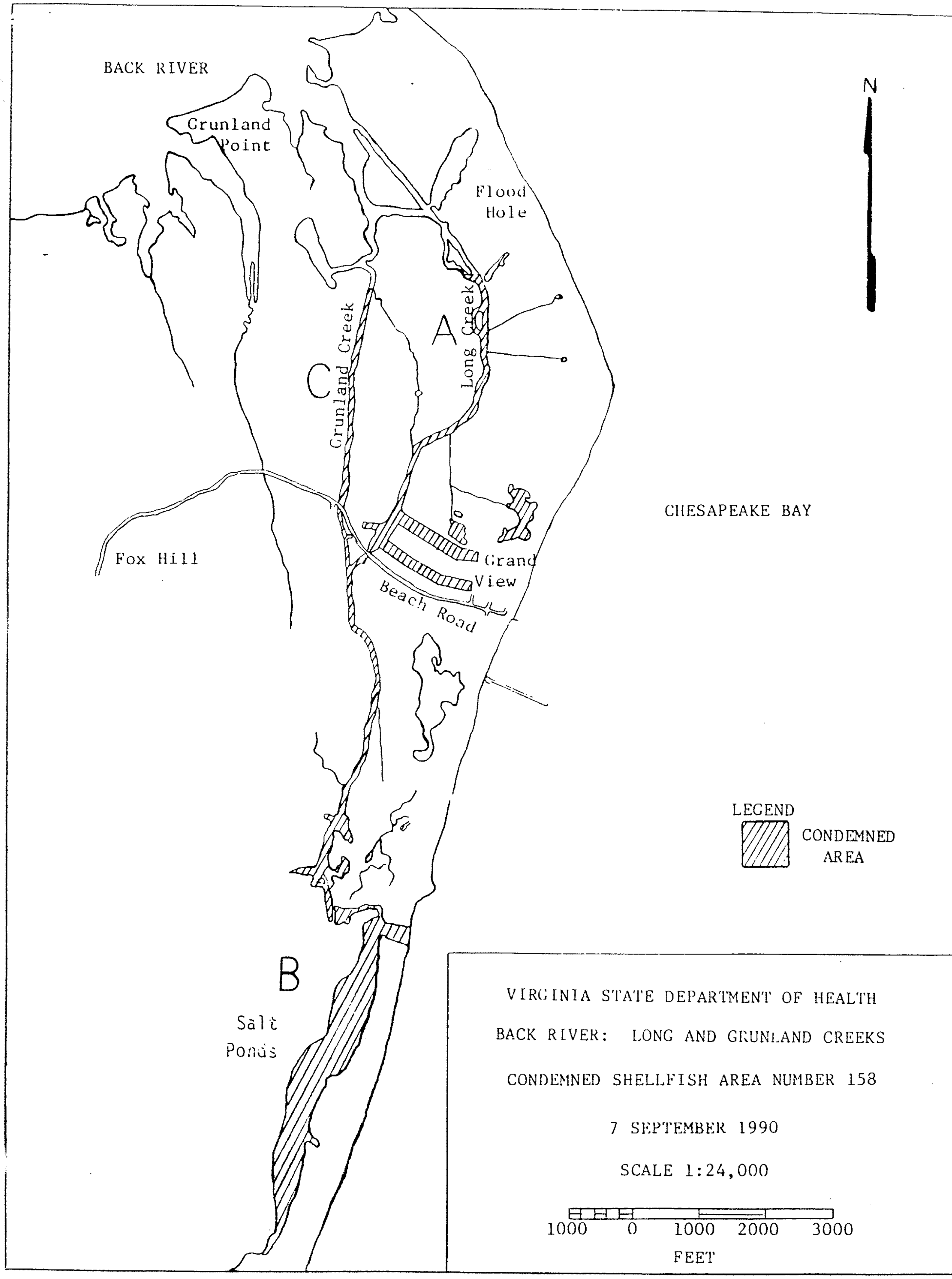
A. The condemned area shall include all of that portion of Long Creek and its tributaries lying upstream of a line drawn across Long Creek in a due east-west direction across the southernmost tip of the first small island upstream of Flood Hole.

B. The condemned area shall include all of that portion of the salt ponds (headwaters of Long Creek) and its tributaries upstream of a line drawn across the mouth at its confluence with the Chesapeake Bay.

C. The condemned area shall include all of that portion of Grunland Creek and its tributaries lying upstream of a line drawn across Grunland Creek in an east-west direction at a location 3700 feet north of Beach Road where it crosses Grunland Creek.

Recommended by: ______________________
Director, Division of Shellfish Sanitation

Ordered by: ______________________ September 7, 1990
State Health Commissioner Date



VIRGINIA STATE DEPARTMENT OF HEALTH

BACK RIVER: LONG AND GRUNLAND CREEKS

CONDEMNED SHELLFISH AREA NUMBER 158

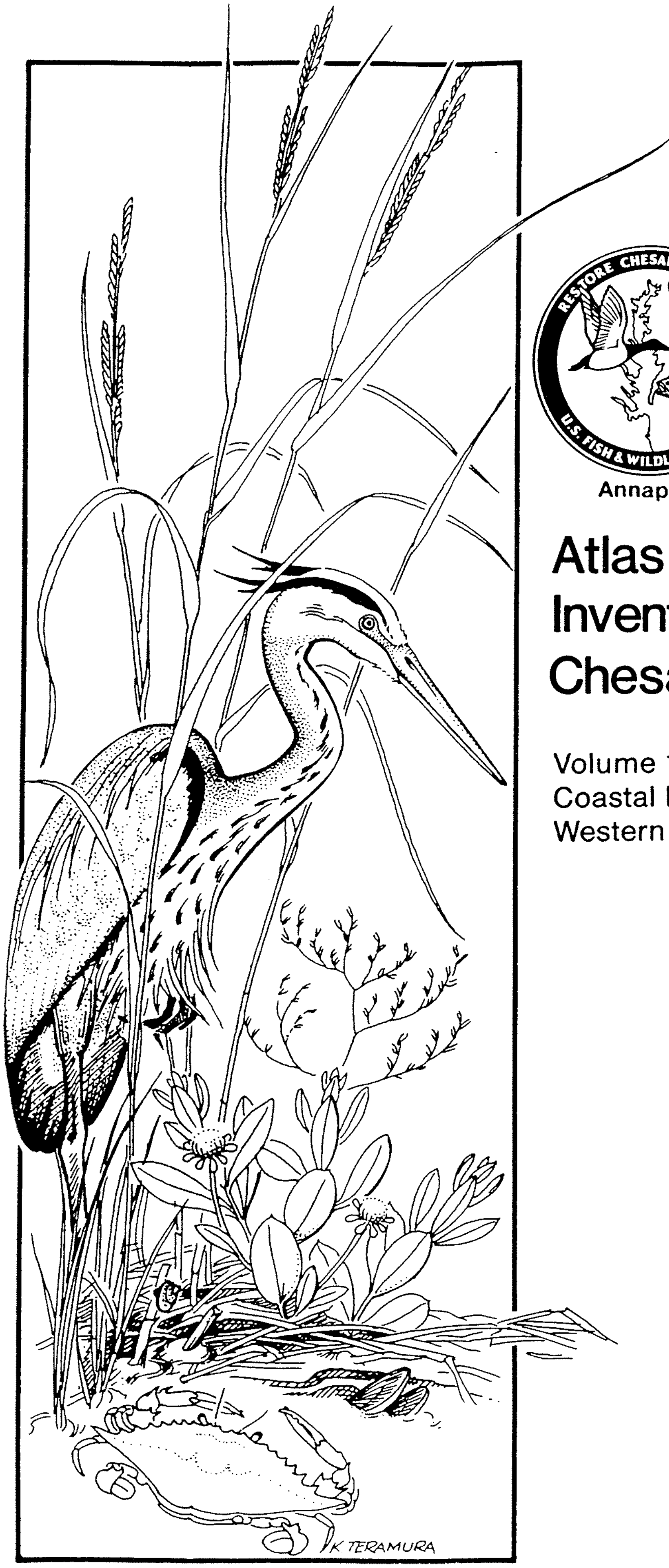
7 SEPTEMBER 1990

SCALE 1:24,000

1000 0 1000 2000 3000

FEET

EXHIBIT 4-20



Annapolis

Atlas of National Wetlands Inventory Maps of Chesapeake Bay

Volume 1
Coastal Plain Virginia
Western Shore

ATLAS OF

NATIONAL WETLANDS INVENTORY MAPS

CHESAPEAKE BAY

Volume I of IV

COASTAL PLAIN VIRGINIA--WESTERN SHORE

National Wetlands Inventory
Region 5, U. S. Fish and Wildlife Service
One Gateway Center, Suite 700
Newton Corner, Massachusetts 02158

and

Annapolis Field Office
U. S. Fish and Wildlife Service
1825 Virginia Street
Annapolis, Maryland 21401

September 1986

HOW TO USE THIS ATLAS

The Atlas contains reductions of all 1:24,000 National Wetlands Inventory maps. Maps appear in alphabetical order. Map names can be located on the index map (Figure 2). Each map shows the configuration, location and type of wetlands and deepwater habitats found within a given area.

WETLAND LEGEND

Wetland data are displayed on maps by a series of letters and numbers (alpha-numerics). Mixing of classes and subclasses are represented by a diagonal line. The more common symbols are shown below; uncommon symbols have been omitted for simplicity. For identifying these latter symbols, the reader must refer to an actual NWI map legend.

SYMBOLOGY

Systems and Subsystems:

M 1 = Marine Subtidal
M 2 = Marine Intertidal
E 1 = Estuarine Subtidal
E 2 = Estuarine Intertidal
R 1 = Riverine Tidal
R 2 = Riverine Lower Perennial
R 3 = Riverine Upper Perennial
R 4 = Riverine Intermittent
L 1 = Lacustrine Limnetic
L 2 = Lacustrine Littoral
P = Palustrine
U = Upland

Classes and Subclasses:

AB = Aquatic Bed
BB = Beach/Bar
EM1 = Emergent Wetland, Persistent
EM2 = Emergent Wetland, Nonpersistent
EM5 = Emergent Wetland, Narrow-leaved Persistent
FL = Flat
FO1 = Forested Wetland, Broad-leaved Deciduous
FO2 = Forested Wetland, Needle-leaved Deciduous
FO4 = Forested Wetland, Needle-leaved Evergreen
OW = Open Water/Unknown Bottom
SS1 = Scrub-Shrub Wetland, Broad-leaved Deciduous
SS3 = Scrub-Shrub Wetland, Broad-leaved Evergreen
SS4 = Scrub-Shrub Wetland, Needle-leaved Evergreen
UB = Unconsolidated Bottom

Water Regimes:

TIDAL		NONTIDAL	
L	Subtidal	A	Temporarily Flooded
M	Irregularly Exposed	C	Seasonally Flooded
N	Regularly Flooded	E	Seasonally Flooded-Saturated
P	Irregularly Flooded	F	Semipermanently Flooded
R	Seasonally Flooded-Tidal	H	Permanently Flooded
V	Permanently Flooded-Tidal	K	Artificially Flooded
		Z	Permanently Flooded/ Intermittently Exposed

Examples:

Alpha-numerics

E2EM5P6d	=	Estuarine (E)	SYSTEM
		Intertidal (2)	SUBSYSTEM
		Emergent Wetland (EM)	CLASS
		Narrow Leaved Persistent (5)	SUBCLASS
		Irregularly Flooded (P)	WATER REGIME
		Oligohaline (6)	WATER CHEMISTRY
		Ditched (d)	SPECIAL MODIFIER

E2FLN = Estuarine (E), Intertidal (2), Flat (FL), Regularly Flooded (N)

PFO1E = Palustrine (P), Forested Wetland (FO), Broad-leaved Deciduous (1), Seasonally Flooded-Saturated (E)

PEM/OWH = Palustrine (P), Emergent Wetland/Open Water (EM/OW), Permanently Flooded (H)

PFO/SS1A = Palustrine (P), Forested Wetland/Scrub-Shrub Wetland (FO/SS), Broad-leaved Deciduous (1), Temporarily Flooded (A)

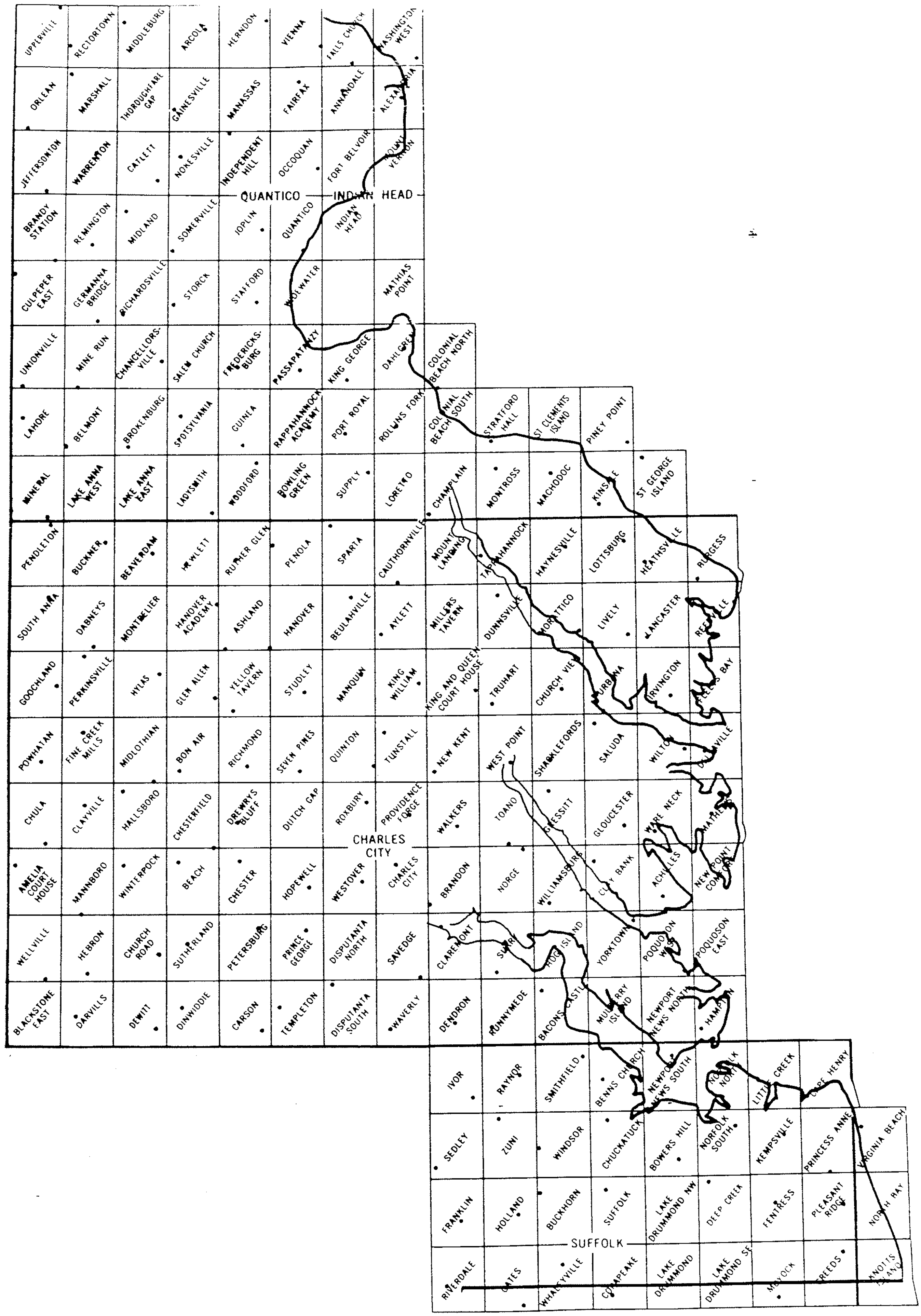
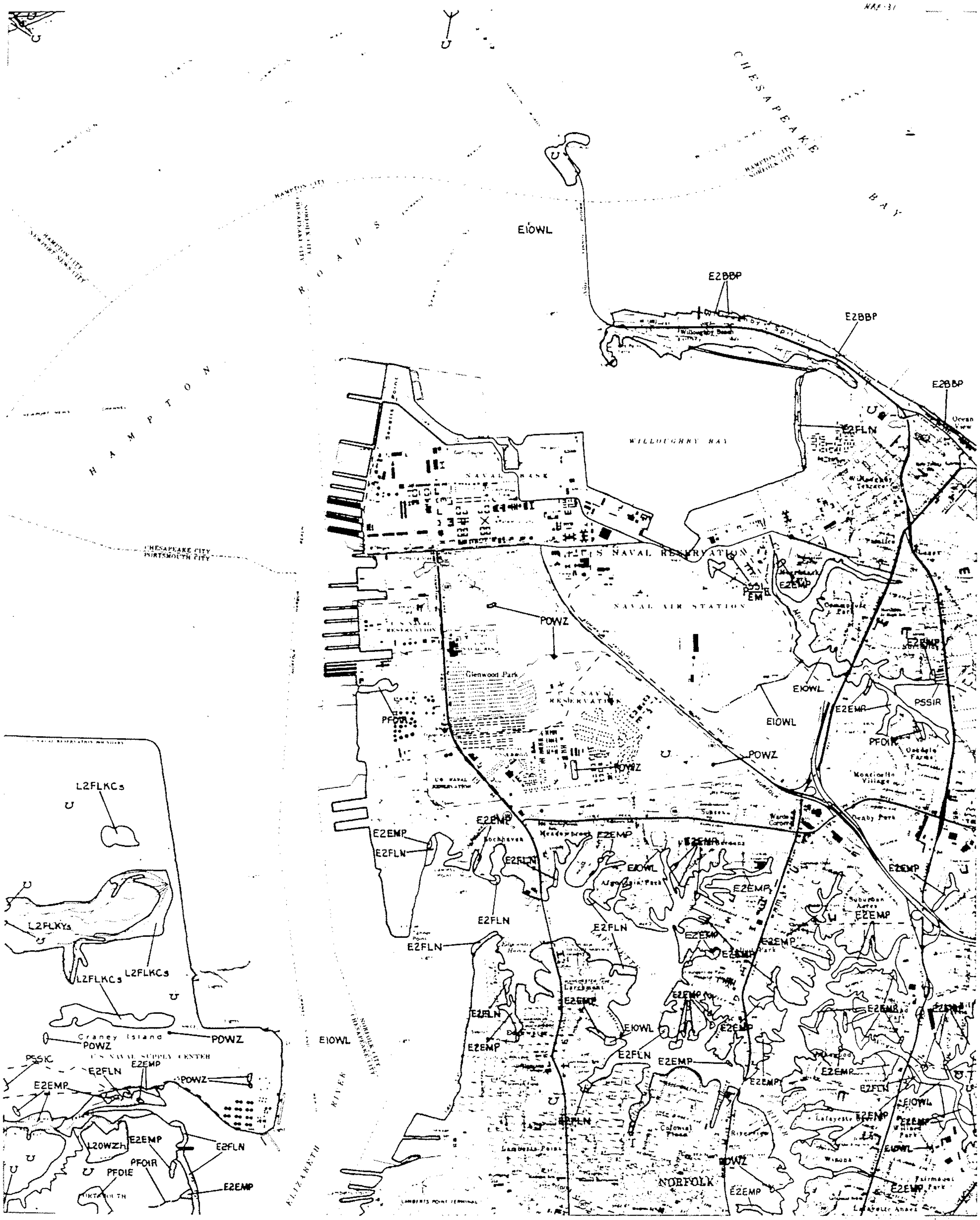


Figure 2 Map index for Virginia Coastal Plain, Western Shore

NATIONAL WETLANDS INVENTORY

UNITED STATES DEPARTMENT OF THE INTERIOR

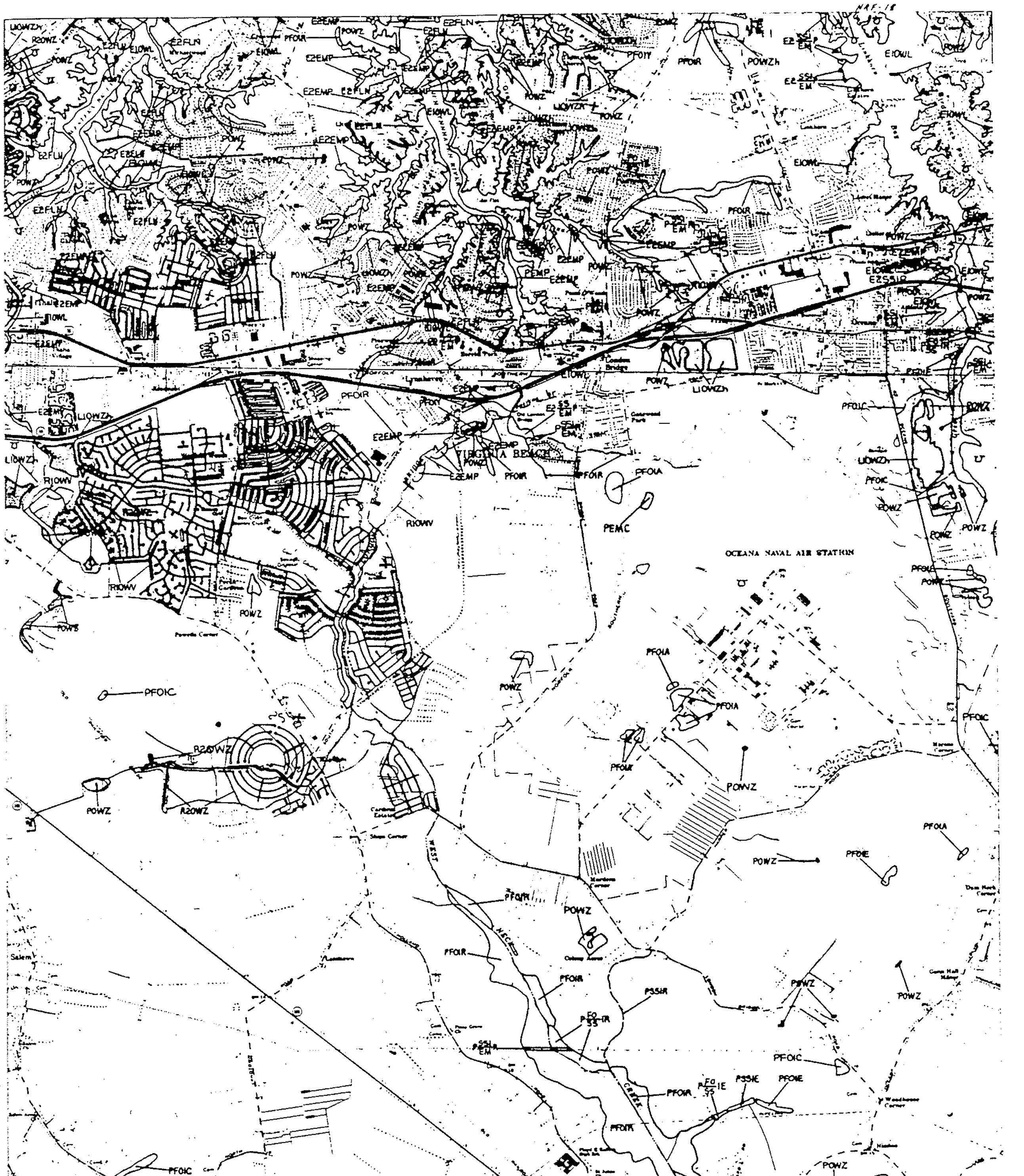


NORFOLK NE
NORFOLK

NORFOLK NORTH, VA

NATIONAL WETLANDS INVENTORY

UNITED STATES DEPARTMENT OF THE INTERIOR



NORFOLK NE
NORFOLK

PRINCESS ANNE, VA

NATIONAL WETLANDS INVENTORY
UNITED STATES DEPARTMENT OF THE INTERIOR

NATIONAL WETLANDS INVENTORY

UNITED STATES DEPARTMENT OF THE INTERIOR

NORFOLK NE
NORFOLK

KEMPSVILLE, VA

NATIONAL WETLANDS INVENTORY

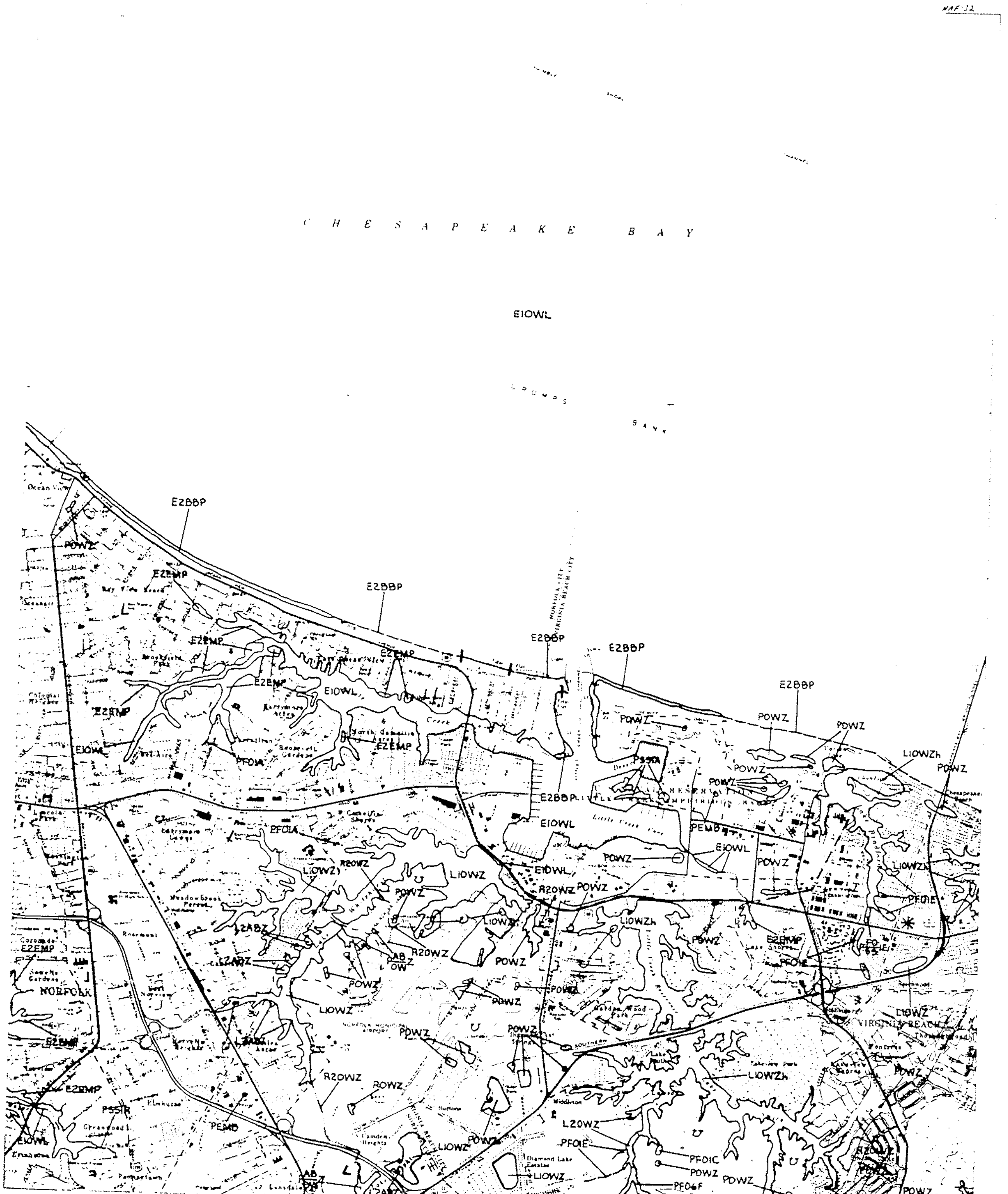
UNITED STATES DEPARTMENT OF THE INTERIOR

NORFOLK NE
NORFOLK

NORFOLK SOUTH, VA

NATIONAL WETLANDS INVENTORY

UNITED STATES DEPARTMENT OF THE INTFRIOR



NORFOLK NE
NORFOLK

LITTLE CREEK, VA

CITY OF NORFOLK
TIDAL MARSH INVENTORY

Special Report No. 281 in Applied Marine Science and Ocean Engineering

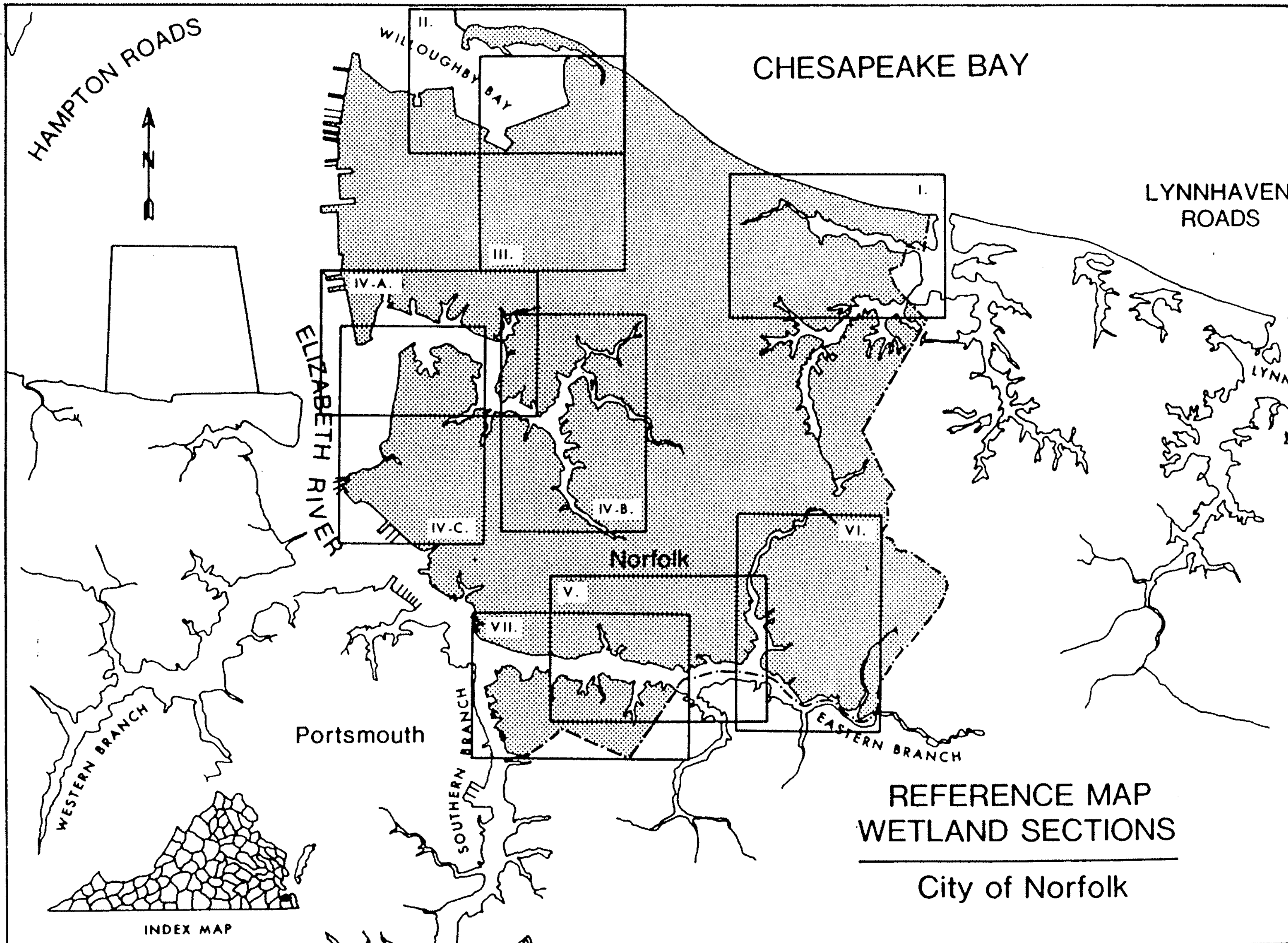
Gene M. Silberhorn and Walter I. Priest, III

Gene M. Silberhorn, Project Leader

VIRGINIA INSTITUTE OF MARINE SCIENCE
School of Marine Science
College of William and Mary
Gloucester Point, Virginia 23062

Dr. Frank O. Perkins, Dean/Director

FEBRUARY 1987


CHESAPEAKE BAY
HAMPTON ROADS
LYNNHAVEN ROADS
WILLOUGHBY BAY
ELIZABETH RIVER
Norfolk
Portsmouth
WESTERN BRANCH
SOUTHERN BRANCH
EASTERN BRANCH
I.
II.
III.
IV-A.
IV-B.
IV-C.
V.
VI.
VII.
INDEX MAP
REFERENCE MAP
WETLAND SECTIONS
City of Norfolk

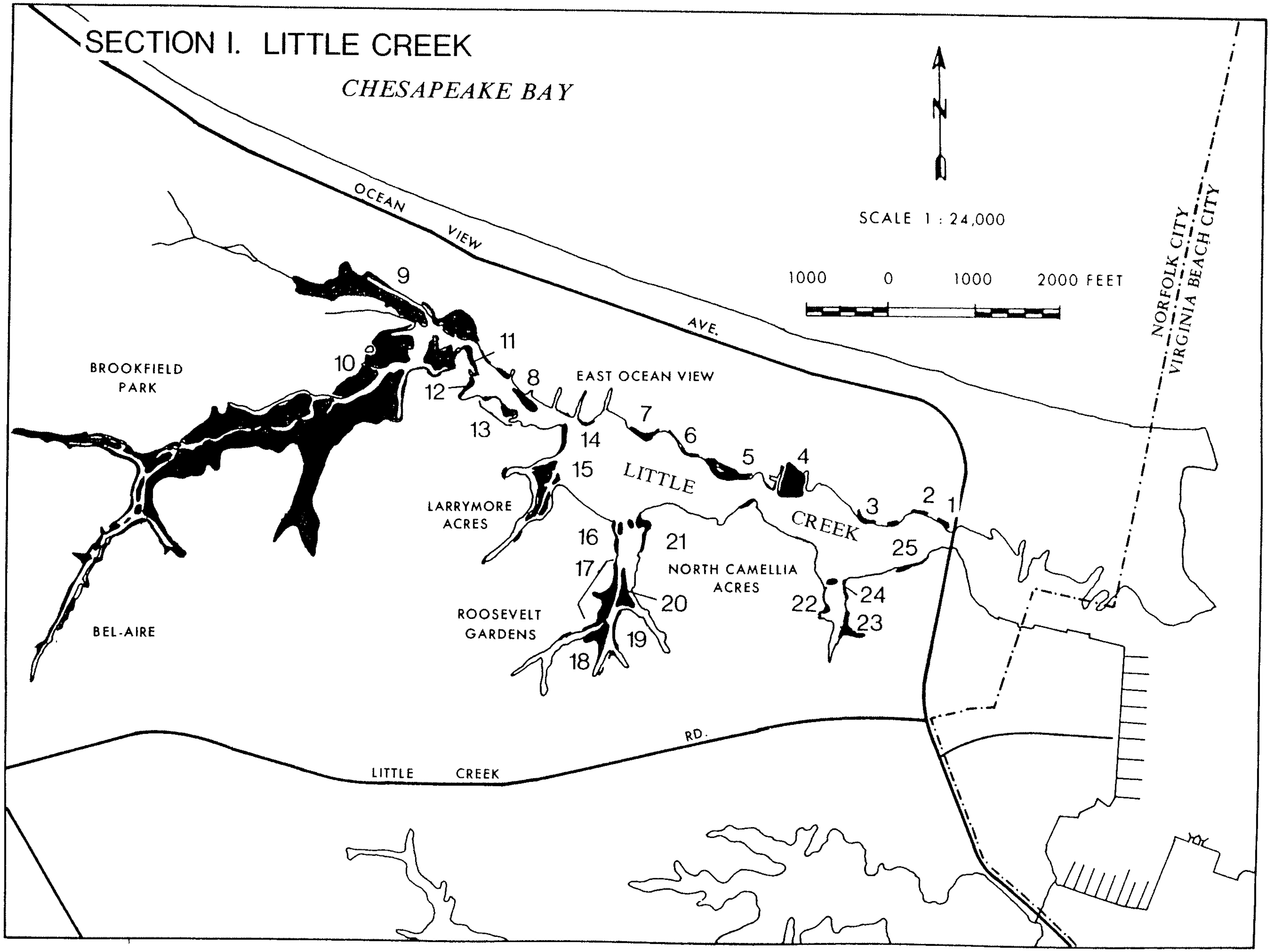
SECTION I

LITTLE CREEK

The Little Creek estuary is shared by the cities of Norfolk and Virginia Beach. Much of the Virginia Beach section of the waterway is occupied by the Little Creek Amphibious Base (U.S. Navy) and has been greatly modified for vessel mooring and related functions.

The Norfolk branch of the estuary is less developed and supports a larger marsh system (25 individual marshes totaling over 127 acres). A large portion (101.8 acres) of these marshes is intertidal saltmarsh cordgrass *(Spartina alterniflora)* wetlands. The largest single marsh (#10) is found at the upper end of the Creek with 87 acres, dominated by *Spartina alterniflora*. This is also the largest single marsh in the City of Norfolk. Most of the marshes in Little Creek, however, are much smaller, ranging in area from .25 to 13.00 acres.

As one would expect in an urban area, shoreline modifications have altered some of the marshes through bulkheading, filling and channelization.


SECTION I. LITTLE CREEK
CHESAPEAKE BAY
OCEAN VIEW AVE.
SCALE 1 : 24,000
1000 0 1000 2000 FEET
N
NORFOLK CITY
VIRGINIA BEACH CITY
BROOKFIELD PARK
EAST OCEAN VIEW
LITTLE CREEK
LARRYMORE ACRES
NORTH CAMELLIA ACRES
ROOSEVELT GARDENS
BEL-AIRE
LITTLE CREEK RD.
1
2
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Section I: Little Creek

#	Marsh Location	Acres	Sa %	Sa Acres	Jr %	Jr Acres	Md %	Md Acres	Sb %	Sb Acres	Sc %	Sc Acres	Pa %	Pa Acres	Others %	Others Acres	Observations	Marsh Type
1	East Ocean View	.25	30	.08	50	.13	5	.02	15	.04							pocket marsh	III
2	East Ocean View	.25	40	.10	20	.05	10	.03	30	.08							fringe marsh	XII
3	East Ocean View	.25	70	.18			10	.03	20	.05							fringe marsh	I
4	East Ocean View	2.00	15	.30	25	.50			60	1.20					i --	--	pocket marsh, old spoil berm	IV
5	East Ocean View	2.00	60	1.20	10	.20	15	.30	15	.30					h --	--	fringe and tidal pond	I
6	East Ocean View	.27	90	.25			5	.02	5	.02							fringe	I
7	East Ocean View	.50	50	.25			10	.05	30	.15			10	.05			fringe	I
8	East Ocean View	.70	100	.70													low island	I
9	East Ocean View	13.00	90	11.7					10	1.30							creek marsh, channelized	I
10	Brookfield Park	87.00	80	69.6	8	6.9	4	3.5	8	6.9					a -- g -- h --	-- -- --	creek marsh	I
11	Little Creek	1.00	90	.90	2	.02	3	.03	5	.05							island	I
12	Larrymore Acres	.50	75	.35			5	.03	25	.13							fringe	I
13	Larrymore Acres	3.00	80	2.40			3	.09	15	.45			2	.06			fringe	I
14	Larrymore Acres	.25	90	.22	5	.02	5	.02	--								fringe	I

Sa = Saltmarsh Cordgrass
Jr = Black Needlerush
Md = Saltgrass Meadow
Sb = Saltbushes
Sc = Big Cordgrass
Pa = Reed Grass
a = Cattails
b = Saltmarsh Fimbristylis
c = Giant Foxtail Grass
d = Marsh-fleabane
e = Marsh Mallow
f = Orach
g = Saltmarsh Aster
h = Sea Oxeye
i = Switch Grass
j = Water Dock
k = Water Hemp

Section I: Little Creek

#	Marsh Location	Acres	Sa		Jr		Md		Sb		Sc		Pa		Others		Observations	Marsh Type
			%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres		
15	Larrymore Acres	4.00	85	3.40	-		2	.08	13	.52							islands, channelized	I
16	Roosevelt Gardens	.50	70	.35	10	.05	10	.05	10	.05							fringe, island	I
17	Roosevelt Gardens	4.00	90	3.60	5	.20			5	.20							fringe	I
18	Roosevelt Gardens	2.00	90	1.80			3	.06	2	.14							fringe	I
19	North Camellia Acres	1.00	70	.70			10	.10	15	.15			5	.05			fringe	I
20	North Camellia Acres	1.00	95	.95					5	.05							low island	I
21	North Camellia Acres	.25	10	.03			80	.20	10	.03							fringe	I
22	North Camellia Acres	.25	80	.20			5	.02	5	.02							fringe	I
23	Little Creek	2.00	80	1.60					20	.40							pocket marsh	I
24	Little Creek	1.00	80	.80					20	.20							fringe	I
25	Little Creek	.25	80	.20					20	.04							fringe	I
	Total Section I	127.22		101.8		8.05		4.63		12.47				.16				

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CITY OF VIRGINIA BEACH MARSH INVENTORY

Volume 2. Lynnhaven River, Lake Rudee and Their Tributaries

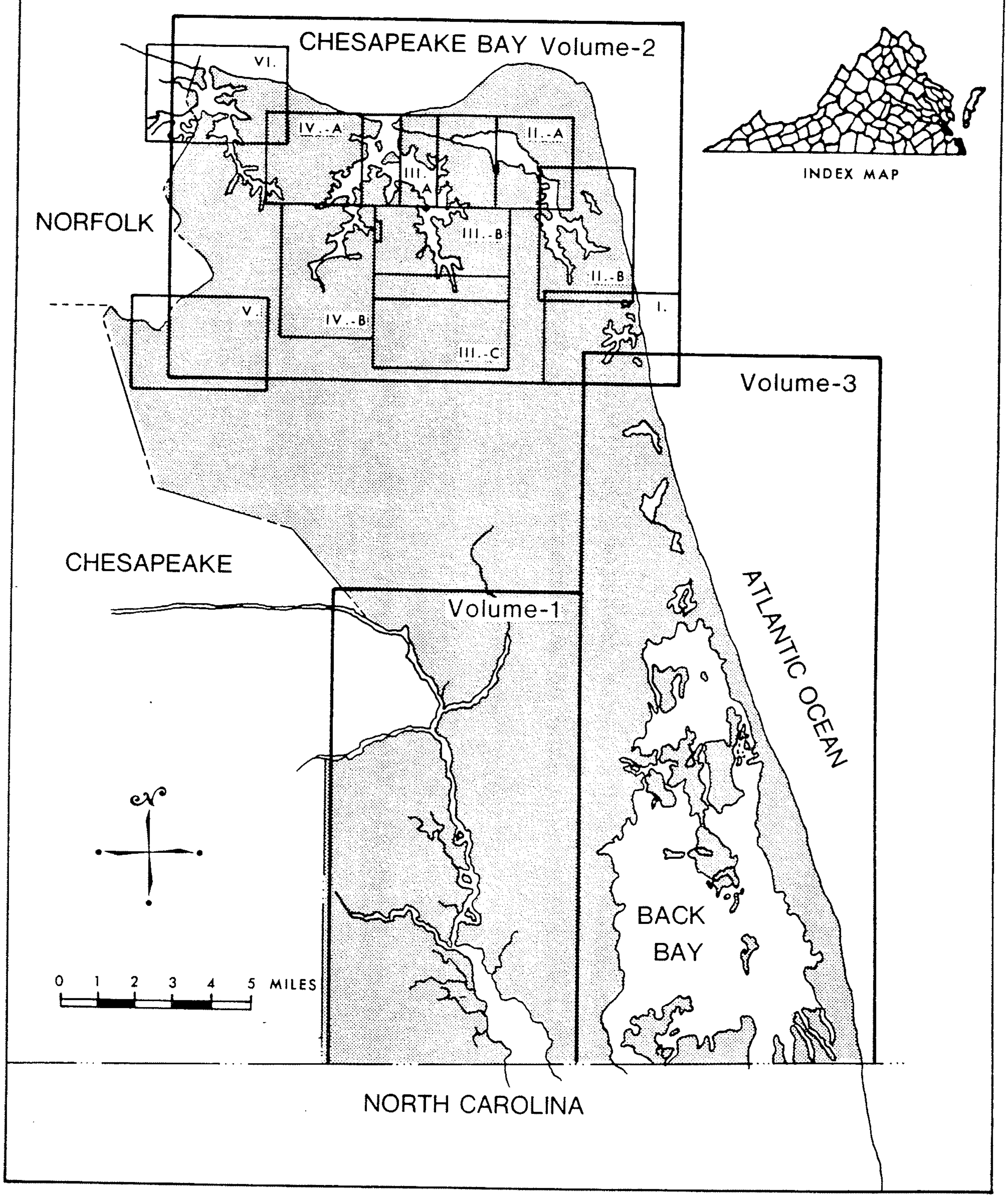
Special Report No. 217 in Applied Marine Science and Ocean Engineering

Thomas A. Barnard, Jr. and Damon G. Doumlele
G.M. Silberhorn, Project Leader

VIRGINIA INSTITUTE OF MARINE SCIENCE,
SCHOOL OF MARINE SCIENCE, COLLEGE OF
WILLIAM AND MARY
Gloucester Point, Virginia 23062
Dr. William J. Hargis, Jr., Director
JUNE 1979

REFERENCE MAP TO WETLAND SECTIONS

City of Virginia Beach

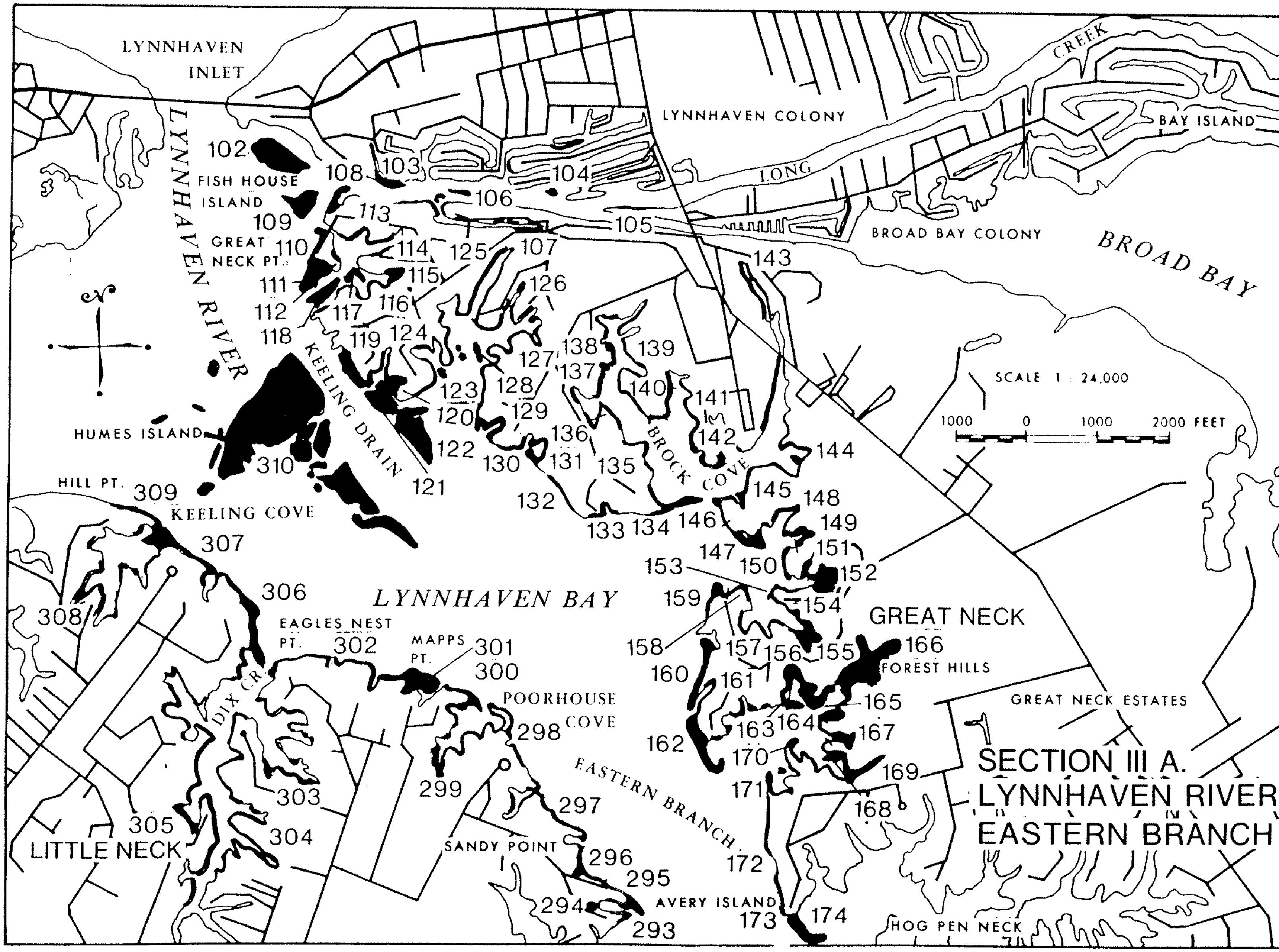


Section III

Lynnhaven River, Eastern Branch

This section contains about one half of the marshes and over one third of the total marsh acreage of this inventory. Most of the marshes along this mostly residential shoreline are small pockets and fringes composed largely of saltmarsh cordgrass. These fringes are important deterrents to erosion by boat wakes and also function as habitat, upland runoff filters and detritus producers.

The upper portion of Wolfsnare Creek (No. 219B) is unique in that it contains the only freshwater mixed (Type XI) marsh in the area described in this publication.


LYNNHAVEN INLET
LYNNHAVEN RIVER
LYNNHAVEN COLONY
LONG CREEK
BAY ISLAND
BROAD BAY COLONY
BROAD BAY
FISH HOUSE ISLAND
GREAT NECK PT.
KEELING DRAIN
HUMES ISLAND
HILL PT.
KEELING COVE
BROCK COVE
SCALE 1 : 24,000
1000 0 1000 2000 FEET
LYNNHAVEN BAY
EAGLES NEST PT.
MAPPS PT.
POORHOUSE COVE
DIX CR.
LITTLE NECK
SANDY POINT
EASTERN BRANCH
AVERY ISLAND
HOG PEN NECK
GREAT NECK
FOREST HILLS
GREAT NECK ESTATES
SECTION III A.
LYNNHAVEN RIVER
EASTERN BRANCH

SECTION III. LYNNHAVEN RIVER, EASTERN BRANCH

#	PLACE NAME	ACRES	Sa %	Sa ACRES	Jr %	Jr ACRES	Md %	Md ACRES	Sb %	Sb ACRES	Sc %	Sc ACRES	OTHER %	OTHER ACRES	OBSERVATIONS	MARSH TYPE
102	Lynnhaven Inlet	5.0	90	4.5			10	0.5	assoc					q	Low marsh island with sea oxeye also present.	I
103	Long Creek	0.5	90	0.45			10	0.05							Spit marsh. Also contains scattered saltbush.	I
104	Long Creek	0.25	100	0.25											Marsh island with some saltbush.	I
105	Long Creek	0.25	60	0.15			30	0.08					10	Sea oxeye 0.02	Fringe marsh.	I
106	Long Creek	0.25	90	0.23			10	0.02	assoc						Two marsh islands with sea oxeye and switch grass.	I
107	Long Creek	0.5	100	0.5											Fringe marsh at head of canal.	I
108	Lynnhaven Bay	0.5	50	0.25			30	0.15					20	Sea oxeye 0.1	Broad fringe and spit marsh.	I
109	Lynnhaven Bay	2.6	90	2.34	assoc.		assoc.		assoc.				10	c 0.26	Low marsh island with sea oxeye also present.	I
110	Great Neck Point	1.0	90	0.9					assoc.				10	Sea oxeye 0.1	Scattered aster, saltwort, panic grass and sea lavender.	I
111	Great Neck Point	0.5	20	0.1			70	0.35					10	Sea oxeye 0.05	Pocket marsh.	II
112	Great Neck Point	0.25	80	0.2			20	0.05							Fringe marsh.	I
113	Great Neck Point	0.5	80	0.4			20	0.1							Fringe marsh.	I
114	Great Neck Point	0.25	80	0.2			20	0.05							Fringe marsh.	I
115	Great Neck Point	0.5	100	0.5			assoc.		assoc.						Pocket marsh.	I

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f = Water Hemp
g = Switch Grass
h = Foxtail Grass
i = Arrow Arum
j = Pickerel Weed

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l = Olney Threesquare
m = Marsh Mallow
n = Saltmarsh Loosestrife
o = Smartweed

p = Wild Rice
q = Sea Lavender
r = Marsh Pink
s = Saltwort
t = Yellow Pond-lily

SECTION III. LYNNHAVEN RIVER, EASTERN BRANCH

#	PLACE NAME	ACRES	Sa %	Sa ACRES	Jr %	Jr ACRES	Md %	Md ACRES	Sb %	Sb ACRES	Sc %	Sc ACRES	OTHER %	OTHER ACRES	OBSERVATIONS	MARSH TYPE
116	Great Neck Point	0.25	100	0.25					assoc						Fringe marsh	I
117	Great Neck Point	0.5	100	0.5											Marsh island	I
118	Great Neck Point	1.0	80	0.8	assoc.		10	0.1	assoc				10	c,k,q 0.1	Old spoil on marsh island; sea oxeye also present	I
119	Keeling Drain	1.0	100	1.0			assoc		assoc						Broad fringe with sea oxeye	I
120	Keeling Drain	0.8	90	0.72	assoc				10	0.08			assoc	c	Some marsh previously filled. Sea oxeye present in marsh	I
121	Keeling Drain	2.8	100	2.8											Marsh island has some brackish marsh species present	I
122	Keeling Drain	4.9	100	4.9											Marsh island with sparsely scattered brackish water species	I
123	Lynnhaven River	0.25	100	0.25											Marsh island with old spoil in middle. Saltbush and sea oxeye	I
124	Lynnhaven River	0.25	100	0.25											2 marsh islands	I
125	Lynnhaven River	0.5	100	0.5											Fringe marsh with scattered saltbush and aster	I
126	Lynnhaven River	0.5	100	0.5											Pocket marsh	I
127	Lynnhaven River	0.25	100	0.25											Marsh fringe averages five feet wide	I
128	Lynnhaven River	0.6	90	0.54	5	0.03			5	0.03					Marsh island with scattered sea oxeye also	I
129	Lynnhaven River	1.0	80	0.8			10	0.1	10	0.1					Pocket and spit marsh with aster and sea oxeye	I

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SECTION III. LYNNHAVEN RIVER, EASTERN BRANCH

	PLACE NAME	ACRES	Sa		Jr		Md		Sb		Sc		OTHER		OBSERVATIONS	MARSH TYPE
			%	ACRES	%	ACRES	%	ACRES	%	ACRES	%	ACRES	%	ACRES		
0	Lynnhaven River	0.25	80	0.2			20	0.05							Fringe marsh averaging 8 feet wide. Saltbush & sea oxeye	I
1	Lynnhaven River	1.0	80	0.8			10	0.1	10	0.1					Cove marsh. Some needlerush	I
2	Lynnhaven River	0.25	100	0.25											Fringe marsh with some salt-bush in higher areas	I
3	Lynnhaven River	0.25	100	0.25											Fringe marsh with some salt-bush in higher areas	I
4	Brock Cove	2.0	60	1.2	10	0.2	10	0.2	10	0.2			10	Sea oxeye 0.2	Fringe and spit marsh with saltmarsh aster present	I
5	Brock Cove	0.25	90	0.23					10	0.02					Fringe marsh	I
6	Brock Cove	0.25	90	0.23	10	0.02									Fringe marsh	I
7	Brock Cove	0.25	100	0.25			assoc		assoc					c	Fringe and pocket marsh	I
8	Brock Cove	0.5	100	0.5			assoc		assoc					c,q	Pocket marsh	I
9	Brock Cove	0.5	60	0.3			10	0.05	30	0.15					Broad fringe with scattered saltmarsh aster	I
0	Brock Cove	0.5	100	0.5	assoc				assoc				assoc	c	Fringe marsh	I
1	Brock Cove	0.25	80	0.2			10	0.02	assoc				10	c,q 0.02	Fringe marsh	I
2	Brock Cove	0.5	90	0.45	10	0.05									Fringe marsh	I
3	Brock Cove	0.25	90	0.23					10	0.02					Fringe marsh	I

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SECTION III. LYNNHAVEN RIVER, EASTERN BRANCH

#	PLACE NAME	ACRES	Sa %	Sa ACRES	Jr %	Jr ACRES	Md %	Md ACRES	Sb %	Sb ACRES	Sc %	Sc ACRES	OTHER %	OTHER ACRES	OBSERVATIONS	MARSH TYPE
144	Brock Cove	1.0	90	0.9					assoc				10	k 0.1	Cove marsh	I
145	Brock Cove	0.5	90	0.45					10	0.05					Pocket marsh and fringe	I
146	Brock Cove	0.5	60	0.3	10	0.05	10	0.05	20	0.1					Fringe and spit marsh	I
147	Lynnhaven River	2.5	40	1.0	30	0.75	20	0.5	10	0.25					Spit marsh with scattered sea oxeye and water hemp	XII
148	Lynnhaven River	0.25	80	0.2	10	0.02			10	0.02					Cove marsh	I
149	Lynnhaven River	0.5	80	0.4	10	0.05			10	0.05					Cove marsh	I
150	Lynnhaven River	0.5	70	0.35	20	0.1	5	0.02	5	0.02					Broad fringe averages 10 feet wide with sea oxeye	I
151	Lynnhaven River	0.25	100	0.25											Pocket marsh with saltbush and meadow in higher parts	I
152	Lynnhaven River	2.0	90	1.8	assoc		10	0.2	assoc				assoc	d	Pocket marsh	I
153	Lynnhaven River	0.5	70	0.35	20	0.1			10	0.05					Fringe and point marsh	I
154	Lynnhaven River	0.25	70	0.18	30	0.08	assoc		assoc						Fringe and pocket marsh with sea oxeye also present	I
155	Lynnhaven River	2.4	60	1.44			30	0.72	10	0.24			assoc	d,q	Cove marsh	I
156	Lynnhaven River	0.25	80	0.2	10	0.02			10	0.02					Fringe marsh averages 10 feet wide, aster and sea oxeye present	I
157	Lynnhaven River	0.25	80	0.2	10	0.02	10	0.02							Fringe marsh with scattered aster and sea oxeye	I

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SECTION III. LYNNHAVEN RIVER, EASTERN BRANCH

#	PLACE NAME	ACRES	Sa %	Sa ACRES	Jr %	Jr ACRES	Md %	Md ACRES	Sb %	Sb ACRES	Sc %	Sc ACRES	OTHER %	OTHER ACRES	OBSERVATIONS	MARSH TYPE
158	Lynnhaven River	0.25	50	0.12	40	0.1			10	0.02					Fringe marsh averages 10 feet wide. Aster, sea oxeye	I
159	Lynnhaven River	0.5	50	0.25	20	0.1	10	0.05	10	0.05			10	Sea oxeye 0.05	Point marsh and fringe	I
160	Lynnhaven River	0.75	80	0.6					10	0.08			10	Sea oxeye 0.08	Point marsh and fringe	I
161	Lynnhaven River	0.25	40	0.1	10	0.02	30	0.08	20	0.05					Fringe marsh	XII
162	Lynnhaven River	3.0	60	1.8	20	0.6	10	0.3	10	0.3					Broad fringe and spit with old spoil in center	I
163	Lynnhaven River	0.25	100	0.25											Fringe marsh and spit with saltbush in higher areas	I
164	Lynnhaven River	0.5	100	0.5											Pocket marsh with saltbush along upland margin.	I
165	Lynnhaven River	0.75	90	0.68	10	0.08									Pocket and fringe with scattered saltbush and sea oxeye	I
166	Lynnhaven River	7.1	90	6.39	assoc				assoc				10	c,d 0.71	Extensive pocket marsh	I
167	Lynnhaven River	1.0	90	0.9	5	0.05	5	0.05							Pocket marsh with scattered saltbush and aster	I
168	Lynnhaven River	0.25	100	0.25											Marsh island	I
169	Lynnhaven River	0.5	60	0.3	10	0.05	30	0.15							Pocket and fringe with scattered saltbush	I
170	Lynnhaven River	0.25	70	0.18	30	0.08									Fringe and island with old spoil at east end	I
171	Lynnhaven River	0.5	80	0.4	20	0.1			assoc					q	Fringe and spit marsh with sea oxeye	I

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#	PLACE NAME	ACRES	Sa %	Sa ACRES	Jr %	Jr ACRES	Md %	Md ACRES	Sb %	Sb ACRES	Sc %	Sc ACRES	OTHER %	OTHER ACRES	OBSERVATIONS	MARSH TYPE
172	Lynnhaven River	0.35	50	0.18	20	0.07	20	0.07	10	0.04					Fringe marsh averages 20 feet wide. Sea oxeye	I
173	Avery Island	0.37	50	0.19			30	0.11					20	Sea oxeye 0.07	25 foot(avr.) fringe with scattered water hemp and aster	I
174	Avery Island	2.0	60	1.2	20	0.4	10	0.2	10	0.2					Spit marsh with scattered saltmarsh aster and sea oxeye	I
175	Shorehaven	0.25	90	0.23			10	0.02							Cove marsh-5 ft. wide fringe spoil behind all marsh fringe	I
176	Shorehaven	0.75	80	0.6	20	0.15									40 to 50 ft. wide fringe with Sb and Md present also	I
177	Shorehaven	0.75	60	0.45	30	0.22	assoc		assoc				10	k 0.08	Pocket marsh and fringe	I
178	Shorehaven	0.75	90	0.68	10	0.08									Pocket marsh	I
179	Shorehaven	0.25	100	0.25											Fringe marsh with Sb line	I
180	Shorehaven	0.25	100	0.25											Point marsh with scattered Jr, Sb and sea oxeye	I
181	Shorehaven	0.25	100	0.25											Pocket marsh with dredged boat slip cut in	I
182	Shorehaven	0.5	100	0.5											Pocket marsh with scattered needlerush, saltbush and meadow	I
183	Shorehaven	8.2	70	5.74	10	0.82	10	0.82	assoc				10	k,c,d,f 0.82	Channelized creek marsh	I
184	Hog Pen Neck	0.5	90	0.45	10	0.05									Channelized cove marsh	I
185	Hog Pen Neck	1.0	70	0.7	30	0.3									Cove marsh	I

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#	PLACE NAME	ACRES	Sa %	Sa ACRES	Jr %	Jr ACRES	Md %	Md ACRES	Sb %	Sb ACRES	Sc %	Sc ACRES	OTHER %	OTHER ACRES	OBSERVATIONS	MARSH TYPE
283	Eastern Branch Lynnhaven River	0.25	40	0.1	40	0.1	10	0.02	10	0.02				c	Fringe marsh averages 20 feet wide	XII
284	Eastern Branch Lynnhaven River	4.8	80	3.84	10	0.48	10	0.48	assoc					c	Cove marsh	I
285	Eastern Branch Lynnhaven River	0.25	90	0.23	10	0.02			assoc						Pocket marsh	I
286	Eastern Branch Lynnhaven River	6.6	60	3.96	20	1.32	20	1.32	assoc						Cove marsh	I
287	Sandy Point	0.25	80	0.2	10	0.02	assoc		10	0.02					Pocket marsh	I
288	Sandy Point	1.4	80	1.12	10	0.14	assoc		10	0.14					Pocket marsh	I
289	Sandy Point	0.25	80	0.2			20	0.05							Pocket marsh	I
290	Sandy Point	0.25	40	0.1	50	0.12			10	0.02					Point marsh	III
291	Sandy Point	0.5	80	0.4	10	0.05			10	0.05					Point also contains cedar and live oak trees	I
292	Sandy Point	0.25	90	0.23	10	0.02	assoc		assoc						Pocket marsh	I
293	Sandy Point	0.25	30	0.08	10	0.02	30	0.08	30	0.08				c	Point and fringe marsh with sea oxeye also present	XII
294	Sandy Point	0.25	90	0.23					10	0.02					Pocket marsh	I
295	Sandy Point	1.0	40	0.4	10	0.1	30	0.3	20	0.2				sea oxeye, k	Point marsh and islands	XII
296	Sandy Point	0.5	70	0.35	10	0.05	20	0.1	assoc					c,g,s	Pocket marsh	I

Sa = Saltmarsh Cordgrass
Jr = Black Needlerush
Md = Saltgrass Meadow
Sb = Saltbushes
Sc = Big Cordgrass

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b = Saltmarsh Fleabane
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e = Marsh Hibiscus

f = Water Hemp
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h = Foxtail Grass
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p = Wild Rice
q = Sea Lavender
r = Marsh Pink
s = Saltwort
t = Yellow Pond-lily

SECTION III. LYNNHAVEN RIVER, EASTERN BRANCH

#	PLACE NAME	ACRES	Sa %	Sa ACRES	Jr %	Jr ACRES	Md %	Md ACRES	Sb %	Sb ACRES	Sc %	Sc ACRES	OTHER %	OTHER ACRES	OBSERVATIONS	MARSH TYPE
297	Sandy Point	0.25	60	0.15	20	0.05	10	0.02	10	0.02				Sc	Point marsh and fringe	I
298	Poorhouse Cove	1.5	60	0.9	30	0.45	assoc		10	0.15				Sea oxeye	Point marsh	I
299	Poorhouse Cove	1.8	50	0.9	30	0.54	assoc		20	0.36				d,k	Cove marsh	I
300	Poorhouse Cove	1.9	70	1.33	10	0.19	10	0.19	10	0.19					Point marsh	I
301	Mapps Point	2.6	60	1.56	10	0.26	30	0.78	assoc						Point marsh	I
302	Eagles Nest Point	1.0	70	0.7	20	0.2	10	0.1	assoc						Fringe marsh	I
303	Dix Creek	0.25	100	0.25											Pocket marsh	I
304	Dix Creek	0.25	60	0.15	assoc		30	0.08	10	0.02					Fringe marsh	I
305	Dix Creek	0.25	80	0.2	assoc		20	0.05	assoc					Sea oxeye	Cove marsh	I
306	Dix Creek	2.5	50	1.25			30	0.75	10	0.25			10	Sea oxeye 0.25	Spit marsh also contains aster, sea lavender and reed grass	I
307	Keeling Cove	3.1	50	1.55	30	0.93	10	0.31	10	0.31					Point marsh and fringe	I
308	Keeling Cove	0.25	90	0.23	10	0.02									Pocket and fringe	I
309	Keeling Cove	0.25	90	0.23			assoc		10	0.02					Fringe marsh	I
310	Humes Island Marshes	38.9	90	35.01	assoc		10	3.89						c,g	Extensive marsh islands also contain sea oxeye	I

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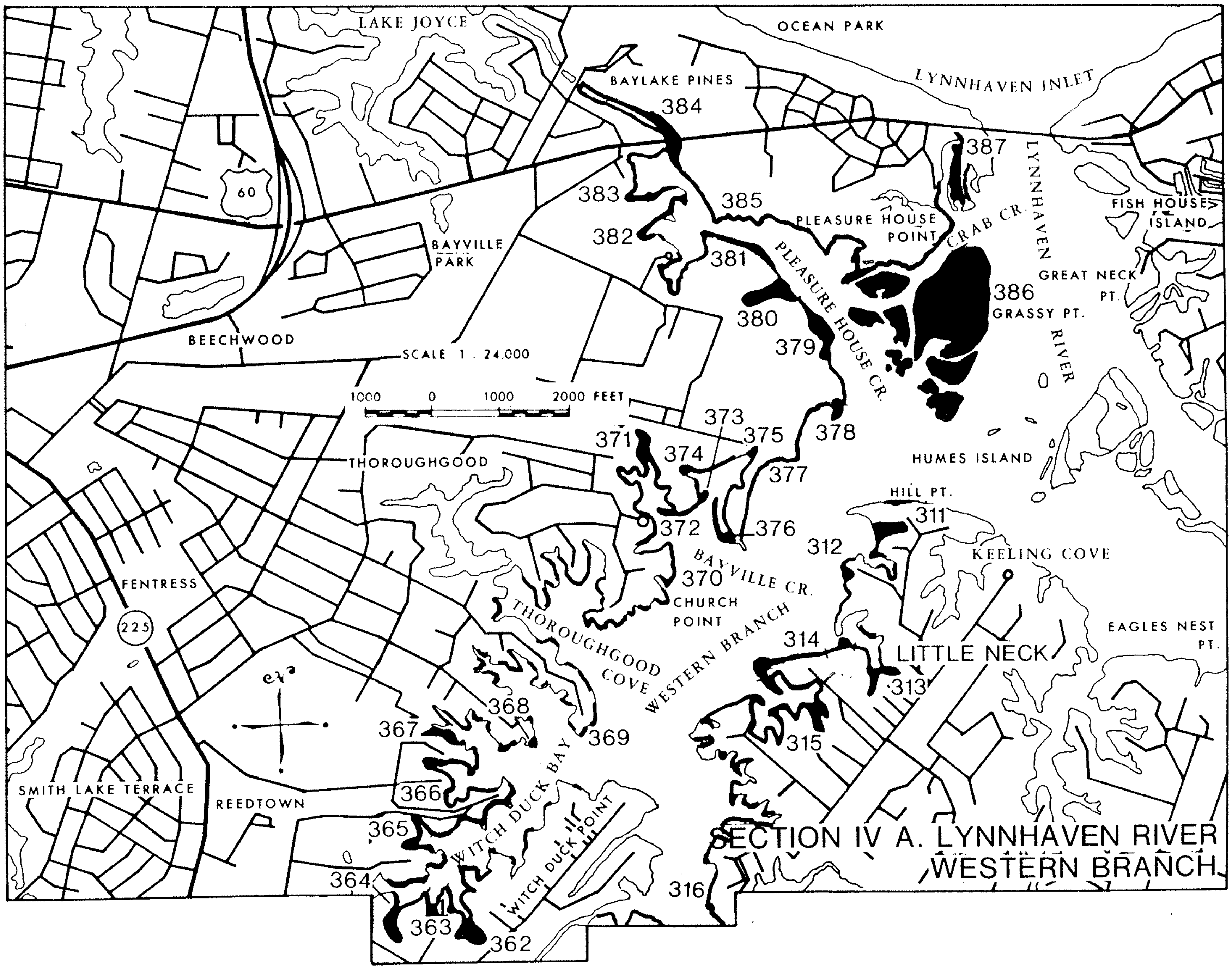
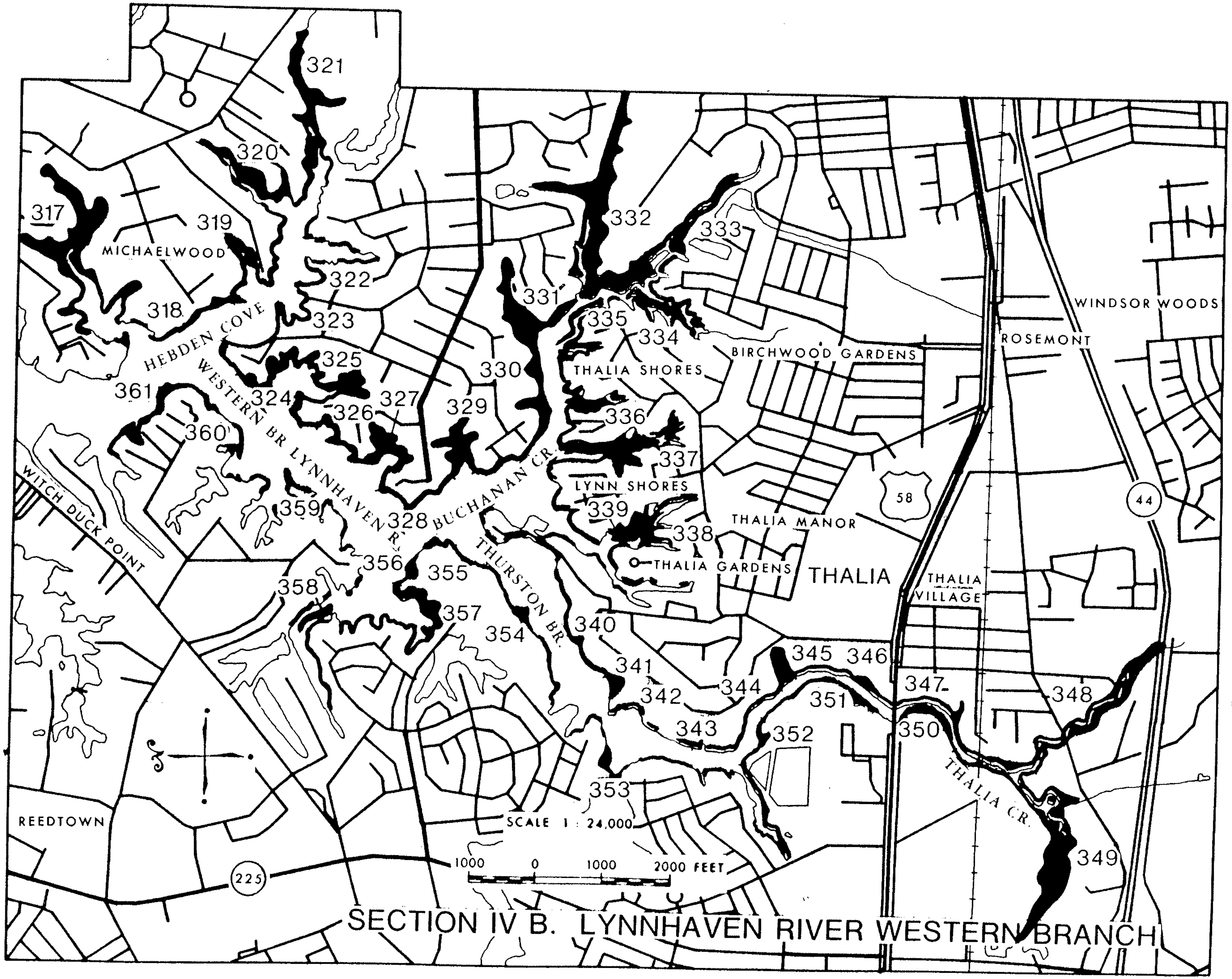
Section IV

Lynnhaven River, Western Branch

As in Section III, the marshes of this section are mostly small but numerous fringes and pockets, with creek marshes at the heads of tributaries. Saltmarsh cordgrass is more dominant than in Section III, comprising 69% of the total. The density of residential shoreline development and therefore recreational boating is relatively high here, as it is in most parts of the city. The marshes are under constant stress due to human activities which generate non-point source pollution, boat wakes, turbidity, etc. At the same time, however, the marshes are helping to alleviate these stresses in the river and thus function in the maintenance of the aquatic system's delicate ecological equilibrium.


LAKE JOYCE
OCEAN PARK
LYNNHAVEN INLET
BAYLAKE PINES
384
387
383
385
60
PLEASURE HOUSE POINT
CRAB CR.
LYNNHAVEN
FISH HOUSE ISLAND
382
381
BAYVILLE PARK
PLEASURE HOUSE CR.
GREAT NECK PT.
386
GRASSY PT.
380
RIVER
379
BEECHWOOD
SCALE 1 : 24,000
1000 0 1000 2000 FEET
373
371
375
378
374
THOROUGHGOOD
HUMES ISLAND
377
HILL PT.
311
372
376
312
KEELING COVE
BAYVILLE CR.
370
FENTRESS
CHURCH POINT
WESTERN BRANCH
225
THOROUGHGOOD COVE
314
LITTLE NECK
EAGLES NEST PT.
313
368
367
369
315
SMITH LAKE TERRACE
REEDTOWN
366
WITCH DUCK BAY
WITCH DUCK POINT
365
SECTION IV A. LYNNHAVEN RIVER
WESTERN BRANCH
364
316
363
362



SECTION IV B. LYNNHAVEN RIVER WESTERN BRANCH

SECTION IV. LYNNHAVEN RIVER, WESTERN BRANCH

#	PLACE NAME	ACRES	Sa		Jr		Md		Sb		Sc		OTHER		OBSERVATIONS	MARSH TYPE
			%	ACRES	%	ACRES	%	ACRES	%	ACRES	%	ACRES	%	ACRES		
311	Hill Point	2.4	50	1.2	30	0.72	20	0.48	assoc					k	Pocket marsh	I
312	Lynnhaven River Western Branch	0.25	100	0.25											Spit marsh and fringe	I
313	Lynnhaven River Western Branch	3.1	100	3.1											Pocket marsh	I
314	Lynnhaven River Western Branch	3.2	60	1.92	30	0.96	10	0.32							Fringe marsh	I
315	Lynnhaven River Western Branch	7.0	80	5.6	10	0.7	assoc		10	0.7				c,s	Cove and spit marshes	I
316	Lynnhaven River Western Branch	0.25	90	0.23	10	0.02			assoc						Cove marsh and fringe	I
317	Lynnhaven River Western Branch	18.0	100	18.0	assoc		assoc		assoc						Cove marsh	I
318	Hebden Cove	0.25	60	0.15	20	0.05	10	0.02	10	0.02					Spit marsh and fringe	I
319	Hebden Cove	2.7	60	1.62	10	0.27							30	k 0.81	Pocket marsh	I
320	Hebden Cove	5.5	90	4.95	assoc		10	0.55						f,k	Creek marsh	I
321	Hebden Cove	9.3	80	7.44	assoc		20	1.86						c,d,k	Creek marsh	I
322	Hebden Cove	2.5	80	2.0	20	0.5									Cove marsh	I
323	Hebden Cove	1.7	70	1.19	30	0.51									Cove marsh	I
324	Lynnhaven River Western Branch	0.25	80	0.2	20	0.05									Pocket marsh	I

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o = Smartweed

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SECTION IV. LYNNHAVEN RIVER, WESTERN BRANCH

#	PLACE NAME	ACRES	Sa %	Sa ACRES	Jr %	Jr ACRES	Md %	Md ACRES	Sb %	Sb ACRES	Sc %	Sc ACRES	OTHER %	OTHER ACRES	OBSERVATIONS	MARSH TYPE
325	Lynnhaven River Western Branch	8.0	90	7.2	10	0.8									Cove marsh with pocket	I
326	Lynnhaven River Western Branch	1.0	80	0.8	20	0.2	assoc							c	Cove marsh	I
327	Lynnhaven River Western Branch	3.8	90	3.42	10	0.38								c	Cove marsh	I
328	Lynnhaven River Western Branch	0.5	60	0.3	40	0.2			assoc						Marsh fringe averages 10 feet wide	I
329	Buchanan Creek	3.3	70	2.31	20	0.66	10	0.33							Pocket marsh	I
330	Buchanan Creek	12.2	70	8.54	10	1.22	20	2.44	assoc					c,d,f,k	Creek marsh	I
331	Buchanan Creek	0.25	90	0.23			10	0.02							Marsh island	I
332	Buchanan Creek	20.4	50	10.2			20	4.08	30	6.12	assoc			f,k	Old spoil at upper end. Saltmarsh bulrush also present	I
333	Buchanan Creek	5.4	10	0.54			20	1.08	30	1.62	10	0.54	30	k 1.62	Highly disturbed area. Upland species on old spoil	XII
334	Buchanan Creek	2.8	30	0.84	assoc		60	1.68	10	0.28	assoc			c	Marsh peninsula Saltmarsh bulrush also present	II
335	Buchanan Creek	2.0	80	1.6			20	0.4						f	Marsh island	I
336	Buchanan Creek	1.1	100	1.1											Marsh island	I
337	Buchanan Creek	1.5	100	1.5											Marsh island	I
338	Buchanan Creek	0.5	70	0.35			10	0.05	20	0.1				k	Point marsh	I

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SECTION IV. LYNNHAVEN RIVER, WESTERN BRANCH

#	PLACE NAME	ACRES	Sa %	Sa ACRES	Jr %	Jr ACRES	Md %	Md ACRES	Sb %	Sb ACRES	Sc %	Sc ACRES	OTHER %	OTHER ACRES	OBSERVATIONS	MARSH TYPE
339	Buchanan Creek	1.3	70	0.91			10	0.13	20	0.26				k	Marsh Island	I
340	Thurston Branch	0.5	70	0.35	assoc		10	0.05	10	0.05	assoc		10	d 0.05	Fringe marsh	I
341	Thurston Branch	0.25	70	0.18	10	0.02					assoc		20	k 0.05	Pocket marsh	I
342	Thurston Branch	0.25	60	0.15	10	0.02	10	0.02	10	0.02	10	0.02			Fringe marsh	I
343	Thalia Creek	0.25	60	0.15			30	0.08	10	0.02				d	Fringe marsh	I
344	Thalia Creek	0.25	60	0.15	asooc		30	0.08	10	0.02	assoc				Fringe marsh	I
345	Thalia Creek	1.4	30	0.42	assoc		40	0.56	20	0.28	10	0.14			Pocket marsh, channelized spoil on sides	XII
346	Thalia Creek	1.0	30	0.3	assoc		40	0.4	20	0.2	10	0.1		k	Fringe marsh	XII
347	Thalia Creek	3.8	20	0.76			20	0.76	20	0.76	40	1.52			Pocket & fringe	XII
348	Thalia Creek	6.7					20	1.34	30	2.01	50	3.35			Creek marsh	V
349	Thalia Creek	12.2	20	2.44			20	2.44	30	3.66	30	3.66			Creek marsh	XII
350	Thalia Creek	1.8	20	0.36			10	0.18	60	1.08	10	0.18			Broad fringe	IV
351	Thalia Creek	1.9	30	0.57			50	0.95	10	0.19	assoc		10	k,c 0.19	Fringe marsh	II
352	Thalia Creek	0.5	50	0.25	assoc		20	0.1	30	0.15	assoc				Fringe and pocket marsh	I

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SECTION IV. LYNNHAVEN RIVER, WESTERN BRANCH

	PLACE NAME	ACRES	Sa %	Sa ACRES	Jr %	Jr ACRES	Md %	Md ACRES	Sb %	Sb ACRES	Sc %	Sc ACRES	OTHER %	OTHER ACRES	OBSERVATIONS	MARSH TYPE
	Thurston Branch	0.25	60	0.15	10	0.02							30	k 0.08		I
4	Thurston Branch	2.4	60	1.44	10	0.24	10	0.24					20	d 0.48	Broad fringe also contains big cordgrass and reedgrass	I
5	Thurston Branch	0.5	80	0.4	10	0.05	assoc		10	0.05					Broad fringe	I
6	Lynnhaven River Western Branch	1.3	80	1.04	10	0.13	assoc		10	0.13					Pocket marsh and fringe	I
7	Lynnhaven River Western Branch	3.3	90	2.97					10	0.33					Cove marsh	I
8	Lynnhaven River Western Branch	0.25	100	0.25			assoc		assoc						Marsh island	I
9	Lynnhaven River Western Branch	0.25	60	0.15	assoc		30	0.08	10	0.02					Fringe marsh	I
0	Lynnhaven River Western Branch	0.25	100	0.25											Point marsh	I
1	Lynnhaven River Western Branch	0.25	30	0.08	30	0.08	10	0.02	30	0.08					Point marsh	XII
2	Witch Duck Bay	3.3	90	2.97	assoc		10	0.33	assoc					d,f	Cove marsh	I
3	Witch Duck Bay	0.25	80	0.2			10	0.02					10	d 0.02	Pocket marsh with scattered needlerush and saltbush	I
4	Witch Duck Bay	2.2	80	1.76	assoc		20	0.44	assoc					d	Pocket marsh	I
5	Witch Duck Bay	1.0	80	0.8	20	0.2	assoc							d,k	Cove marsh	I
6	Witch Duck Bay	2.0	70	1.4	10	0.2	10	0.2	10	0.2				Sea oxeye	Cove marsh	I

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SECTION IV. LYNNHAVEN RIVER, WESTERN BRANCH

#	PLACE NAME	ACRES	Sa %	Sa ACRES	Jr %	Jr ACRES	Md %	Md ACRES	Sb %	Sb ACRES	Sc %	Sc ACRES	OTHER %	OTHER ACRES	OBSERVATIONS	MARSH TYPE
367	Witch Duck Bay	0.5	100	0.5					assoc						Pocket marsh and fringe	I
368	Witch Duck Bay	0.25	50	0.12			30	0.08	20	0.05					Point marsh	I
369	Lynnhaven River Western Branch	0.25	40	0.1			40	0.1	20	0.05					Fringe marsh	XII
370	Bayville Creek	0.25	50	0.12	10	0.02	40	0.1	assoc					Sea oxeye	Point marsh and fringe	I
371	Bayville Creek	1.7	100	1.7											Pocket marsh	I
372	Bayville Creek	0.25	60	0.15	30	0.08	10	0.02	assoc					Sea oxeye	Spit marsh	I
373	Bayville Creek	1.5	90	1.35	10	0.15										I
374	Bayville Creek	0.25	100	0.25					assoc						Pocket marsh	I
375	Bayville Creek	0.25	100	0.25												I
376	Bayville Creek	2.4	80	1.92	20	0.48	assoc		assoc		assoc				Point marsh and fringe	I
377	Lynnhaven River Western Branch	1.0	60	0.6	20	0.2	10	0.1	10	0.1				c Sea oxeye	Fringe marsh. Averages 15 feet wide	I
378	Lynnhaven River Western Branch	0.8	70	0.56	30	0.24			assoc						Point marsh	I
379	Pleasure House Creek	4.6	40	1.84	40	1.84	20	0.92	assoc					d	Fringe marsh	XII
380	Pleasure House Creek	3.5	60	2.1	20	0.7	10	0.35	10	0.35				d,k	Pocket marsh also contains saltmarsh bulrush	I

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o = Smartweed

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q = Sea Lavender
r = Marsh Pink
s = Saltwort
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SECTION IV. LYNNHAVEN RIVER, WESTERN BRANCH

#	PLACE NAME	ACRES	Sa %	Sa ACRES	Jr %	Jr ACRES	Md %	Md ACRES	Sb %	Sb ACRES	Sc %	Sc ACRES	OTHER %	OTHER ACRES	OBSERVATIONS	MARSH TYPE
381	Pleasure House Creek	5.4	30	1.62	60	3.24			10	0.54					Broad fringe marsh	III
382	Pleasure House Creek	1.6	80	1.28	assoc		20	0.32	assoc					d	Cove marsh (fringing) averages 15 feet wide	I
383	Pleasure House Creek	0.75	90	0.68			10	0.08							Cove marsh (fringing) averages 12 feet wide	I
384	Pleasure House Creek	2.0	10	0.2			40	0.8	50	1.0					Fringe marsh	IV
385	Pleasure House Point	11.4	90	10.26			10	1.14							Broad fringe averages 40 feet wide, Sb.	I
386	Grassy Point Islands	51.6	90	46.44	assoc		10	5.16						q,c sea oxeye	Marsh islands	I
387	Crab Creek	4.6	70	3.22			20	0.92	assoc				10	q,c,s 0.46	Marsh in lower areas of old spoil deposits	I
	Total Section IV	263.6	69	182.89	6	15.15	12	31.82	8	20.44	4	9.51	1	3.76		

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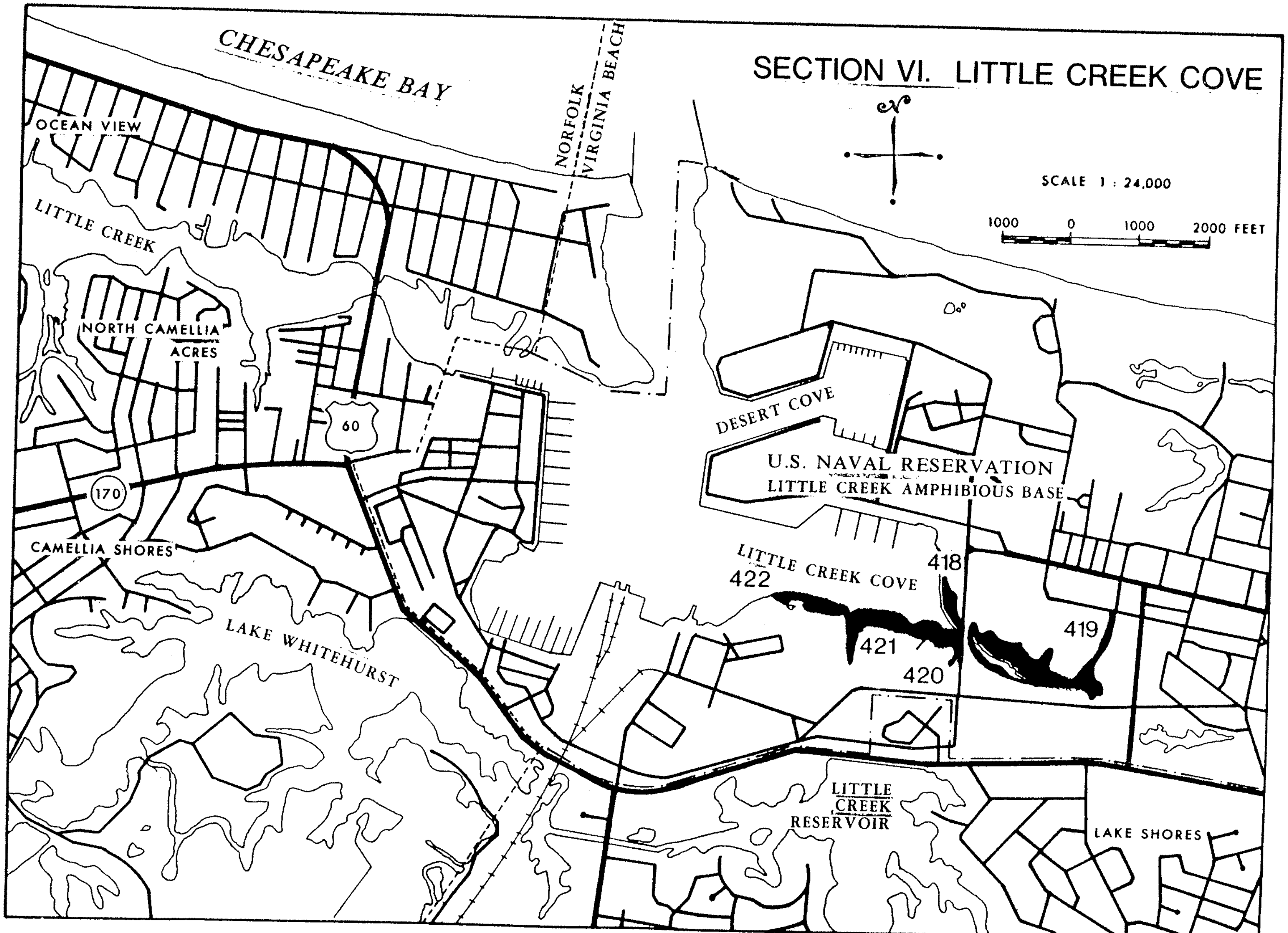
Section VI

Little Creek Cove

Little Creek Cove has been extensively bulkheaded for ship mooring by the Little Creek Amphibious Base and thus contains only five marshes. These five marshes, mostly dominated by saltmarsh cordgrass, have also been disturbed, as evidenced by the high percentage of reedgrass, Phragmites australis.

Except for the reedgrass, which may be displacing more desirable wetlands species, the marshes of Little Creek Cove are in good condition and provide valuable habitat for aquatic and semi-aquatic species.


SECTION VI. LITTLE CREEK COVE
N
SCALE 1 : 24,000
1000 0 1000 2000 FEET
CHESAPEAKE BAY
NORFOLK
VIRGINIA BEACH
OCEAN VIEW
LITTLE CREEK
NORTH CAMELLIA ACRES
60
170
CAMELLIA SHORES
LAKE WHITEHURST
DESERT COVE
U.S. NAVAL RESERVATION
LITTLE CREEK AMPHIBIOUS BASE
LITTLE CREEK COVE
418
422
419
421
420
LITTLE CREEK RESERVOIR
LAKE SHORES

SECTION VI. LITTLE CREEK COVE

#	PLACE NAME	ACRES	Sa %	Sa ACRES	Jr %	Jr ACRES	Md %	Md ACRES	Sb %	Sb ACRES	Sc %	Sc ACRES	OTHER %	OTHER ACRES	OBSERVATIONS	MARSH TYPE
418	Little Creek Cove	1.7	60	1.02			30	0.51	10	0.17				k,s	Fringe marsh	I
419	Little Creek Cove	14.7	50	7.35			10	1.47	assoc				40	q 5.88	Creek marsh, large reedgrass stands at higher elevations	I
420	Little Creek Cove	1.6	40	0.64			20	0.32	assoc				40	g,k,q 0.64	Partially diked, large amount of reedgrass	XII
421	Little Creek Cove	6.2	50	3.10			20	1.24	15	0.93			15	k,q 0.93	Fringe marsh, partially diked	I
422	Little Creek Cove	2.4	10	0.24	assoc		20	0.48	assoc				70	k,q 1.68	High marsh and ponds behind beach berm	VIII
	Total Section VI	26.6	46	12.35	assoc		15	4.02	4	1.10			34	g,k,q,s 9.13		
	Grand Total	1177.92	51	607.31	9	105.82	15	180.24	15	171.95	6	65.78	4	46.85		

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Sc = Big Cordgrass

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o = Smartweed

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s = Saltwort
t = Yellow Pond-lily

KEY

D - DOMESTIC WELL
I - INDUSTRIAL WELL
R - RECREATIONAL WELL
L - LIVESTOCK WATERING WELL
PC - PUBLIC CONSUMPTION WELL
IR - IRRIGATION WELL

LEGEND

O GROUNDWATER WELL

REVISIONS	DESIGNED DRAWN CHECKED REVIEWED S.O.	NORTH		ATLANTIC DIVISION, NAVAL FACILITIES ENGINEERING COMMAND (LANTDIV) BAKER ENVIRONMENTAL, INC. CORAOPOLIS, PENNSYLVANIA	Baker Baker Environmental, Inc.	FOUR-MILE RADII MAP GROUNDWATER PATHWAY / PUBLIC WATER DISTRIBUTION NAB LITTLE CREEK SCALE 1" = 2000' DATE JUNE 1991	FIGURE NO. 1

REVISIONS		NORTH		
	DESIGNED DRAWN CHECKED REVIEWED S.O.			

ATLANTIC DIVISION,
NAVAL FACILITIES ENGINEERING COMMAND (LANTDIV)

BAKER ENVIRONMENTAL, INC.
CORAOPOLIS, PENNSYLVANIA

Baker
Baker Environmental, Inc.

0 TO 15 MILE
SURFACE WATER MAP
NAB LITTLE CREEK

SCALE 1" = 2000'

DATE JUNE 1991

FIGURE NO.
2

REVISIONS		NORTH		
	DESIGNED DRAWN CHECKED REVIEWED S.O.	N		

ATLANTIC DIVISION,
NAVAL FACILITIES ENGINEERING COMMAND (LANTDIV)

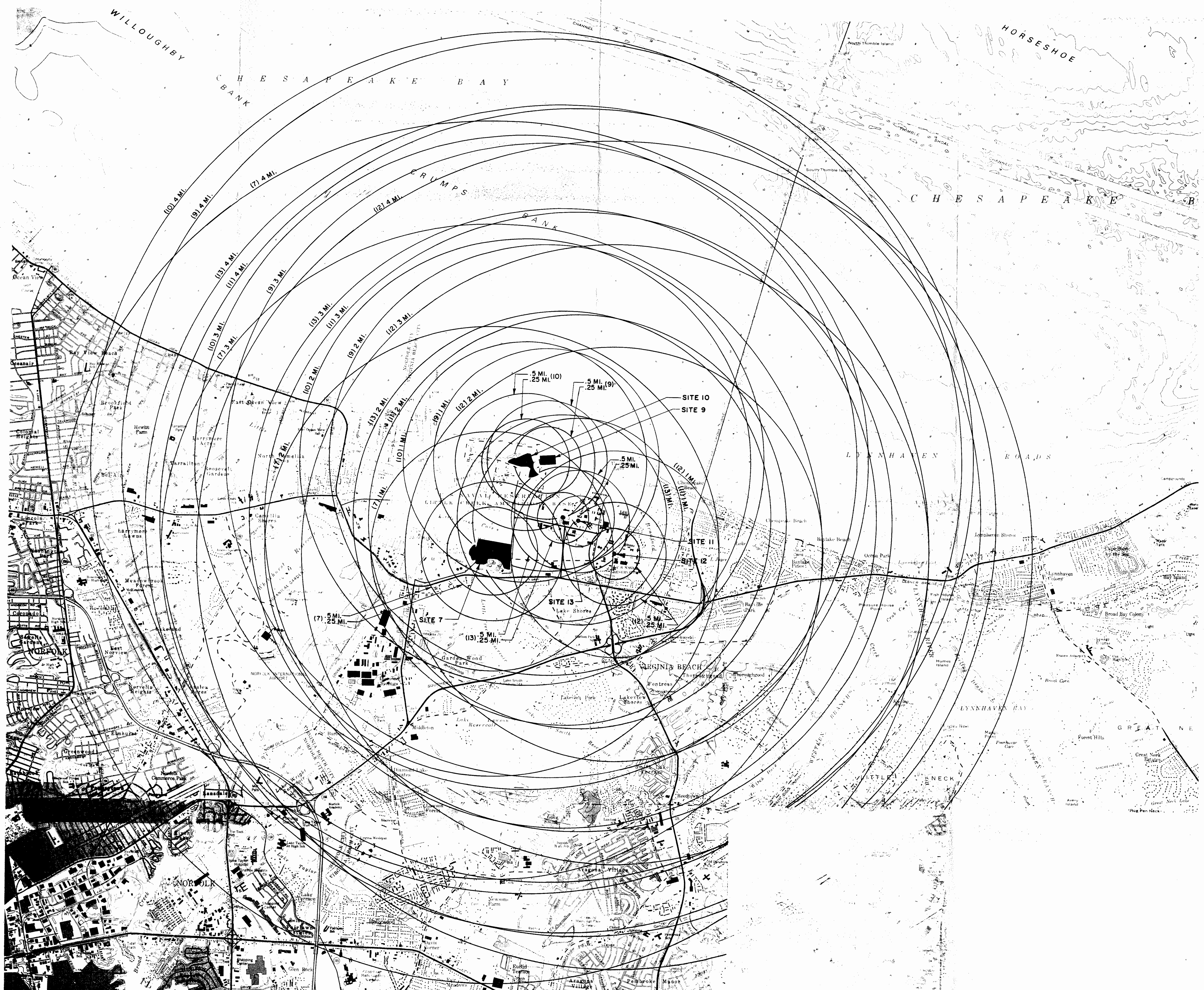
BAKER ENVIRONMENTAL, INC.
CORAOPOLIS, PENNSYLVANIA

Baker
Baker Environmental, Inc.

FOUR-MILE RADII MAP
SURFACE WATER PATHWAY
NAB LITTLE CREEK

SCALE 1" = 2000'   DATE JUNE 1991

FIGURE NO.
3



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NAVAL FACILITIES ENGINEERING COMMAND (LANTDIV)

BAKER ENVIRONMENTAL, INC.
CORAOPOLIS, PENNSYLVANIA

NAB LITTLE CREEK

SCALE

DATE

FIGURE NO.