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Wellhead Management Program
Engineering Study 91-36

Submitted to

Officer In Charge of Construction
Marine Corps Base
Camp Lejeune, North Carolina

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from

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Wellhead Management Program
Marine Corps Base, Camp Lejeune, North Carolina

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List of Commonly Used Acronyms

AOC - Area of Concern

DCE - Dichloroethylene

NC DEM - Department of Environmental Management, under the North Carolina Department of Environment, Health, and Natural Resources (NCDEHNR).

HPIA - Handnot Point Industrial Area

LUST - Leaking Underground Storage Tank

MCAS - Marine Corps Air Station

MCB - Marine Corps Base

MCL - Maximum Contamination Limits

NCAC - North Carolina Administrative Code

RI - Remedial Investigation

SDWA - Safe Drinking Water Act

SWTR - Surface Water Treatment Regulations as administered by the Environmental Protection Agency

TCE - Trichloroethylene

USGS - United States Geological Survey, Water Resources, Raleigh, North Carolina

UST - Underground Storage Tank

WiRO - Wilmington Regional Office of the Department of Environmental Management (DEM)

VOC - Volatile Organic Compounds

WHP - Wellhead Protection

WPA - Wellhead Protection Area

WMP - Wellhead Management Program

ZOT - Zone of Travel

WELLHEAD MANAGEMENT PLAN

1.0 Introduction

This report describes a Wellhead Management Program (WMP) prepared for Camp Lejeune Marine Corps Base and adjoining Marine Corps Air Station (MCAS) at New River. The site is located in east-central Onslow County, North Carolina. Geophex was contracted by Marine Corps Base (MCB) Camp Lejeune to complete Engineering Study No. 91-36, entitled "Wellhead Management Study, Marine Corps Base, Camp Lejeune, NC" awarded by Officer of Charge of Construction, Marine Corps Base, Camp Lejeune, NC, under A/E Contract N63470-90-D-6756.

The results of this investigation are based on: (1) a review of groundwater and surface water records maintained by the United States Geological Survey (USGS), (2) a review of water well records maintained by North Carolina Department of Environmental Management (NC DEM), Wilmington Regional Office (WiRO), (3) a review of well construction and water production records on file at the Holcomb Boulevard Water Treatment Facility at MCB, (4) interviews with related Federal, State, and local agencies including: EPA Groundwater Protection Office in Washington, DC, and Region IV office in Atlanta, GA; NC DEM Groundwater Division in Raleigh, NC, and Washington, NC; City of Jacksonville, and Onslow County Water System Managers in Jacksonville, NC. Results of the investigation provide the basis of recommendations for the establishment of a WMP at MCB.

1.1 Purpose

The purpose of the WMP is to assure an acceptable quality and quantity of groundwater resources for present and future MCB requirements by instituting a policy of protection, preservation, and enhancement. The ultimate objective of the WMP is to protect the public health, safety, and welfare of all residents within the MCB water use district.

1.2 Scope of Work

Geophex was contracted in September 1991 to conduct the WMP study. The following scope of work was incorporated as part of this engineering study:

A. Prepare a "Wellhead Management Plan" for MCB, Camp Lejeune and future acquisition areas to include the following main components:
   1. Maintenance and improvement of existing water supplies and resources;
   2. Developing new sources;
   3. Delineation of water resource protection/management areas including specific management activities;
   4. Development and maintenance of a wellhead data base to include:
      a. well number,
      b. well type,
      c. well yield,
      d. reference elevation,
      e. well construction,
         - material,
         - size,
         - depth,
         - screened elevation,
      f. location,
      g. contaminants detected,
      h. data references, and
      i. comments,
   5. Develop water balance computer program to include;
      a. estimate of water flows within the collection system,
      b. inputs: line sizes, head loss efficiencies, etc,
      c. water quality input.
   6. Evaluate and map aquifer recharge areas and wellhead protection areas, contamination sources, and new and existing supply areas; all to be put into a fully operational AutoCAD software package, which includes digitizing capabilities, graphical management, and 8-1/2" by 11" format output, compatible with hardware owned or supplied by Environmental Management Division (EMD), MCB.

B. Review groundwater recharge preservation areas and determine whether preservation areas are adequate.

C. Review wellhead protection practices to determine whether these practices threaten present or future groundwater resources.

D. Review current hydrogeologic inventory data of MCB including USGS studies, Soil Conservation Service reports, well yield data, well analytical data, Installation Restoration Program data, Underground Storage Tank Program data, and others

E. Review statutory framework for groundwater including Well Construction Act (NCGS 87-83), Water Use Act (NCGS 143-214.11), Control of Sources of Water Pollution (NCGS 143-215.1), Oil Pollution and Hazardous Substances Control Act (NCGS 143-215.75), Leaking Petroleum Underground Storage Tank Cleanup Act (NCGS 143-215.94), and others.

F. Determine level of protection criteria such as national primary and secondary drinking water standards, groundwater standards (which may be based on health advisory threshold levels, lifetime cancer risk levels, taste or odor threshold limits, or potential regulatory standards).

G. Review on-site potential contamination waste disposal practices; storm water management practices; chemical usage, storage, and handling; and military training practices to determine whether these practices are risking present or future groundwater resources.

H. Review groundwater extraction practices to determine whether these practices are risking present or future groundwater resources, and whether these practices withdraw groundwater safely and efficiently.

I. Prepare environmental documentation to support implementation of all phases of the Wellhead Management Plan.

2.0 MCB Physical Setting

The following is a brief overview of the physical setting of the study area, including the geology, groundwater hydrology, and surface hydrology as it relates to groundwater and the operation of the MCB well field.

2.1 Location

Camp Lejeune Marine Corps Base and adjoining New River Air Station occupies approximately 230 square-miles of east-central Onslow County, North Carolina (Figure 1). It is the worlds largest amphibious training base, housing more than 40,000 full-time troops. The base is divided into six major areas of development: (1) Camp Geiger, (2) Montford Point (Camp Johnson), (3) Mainside, (4) Courthouse Bay, (5) Onslow Beach, and (6) the Rifle Range. The Marine Corps Air Station (MCAS), New River is under separate command, but is considered part of this study because Camp Lejeune maintains all MCAS water production and treatment facilities.

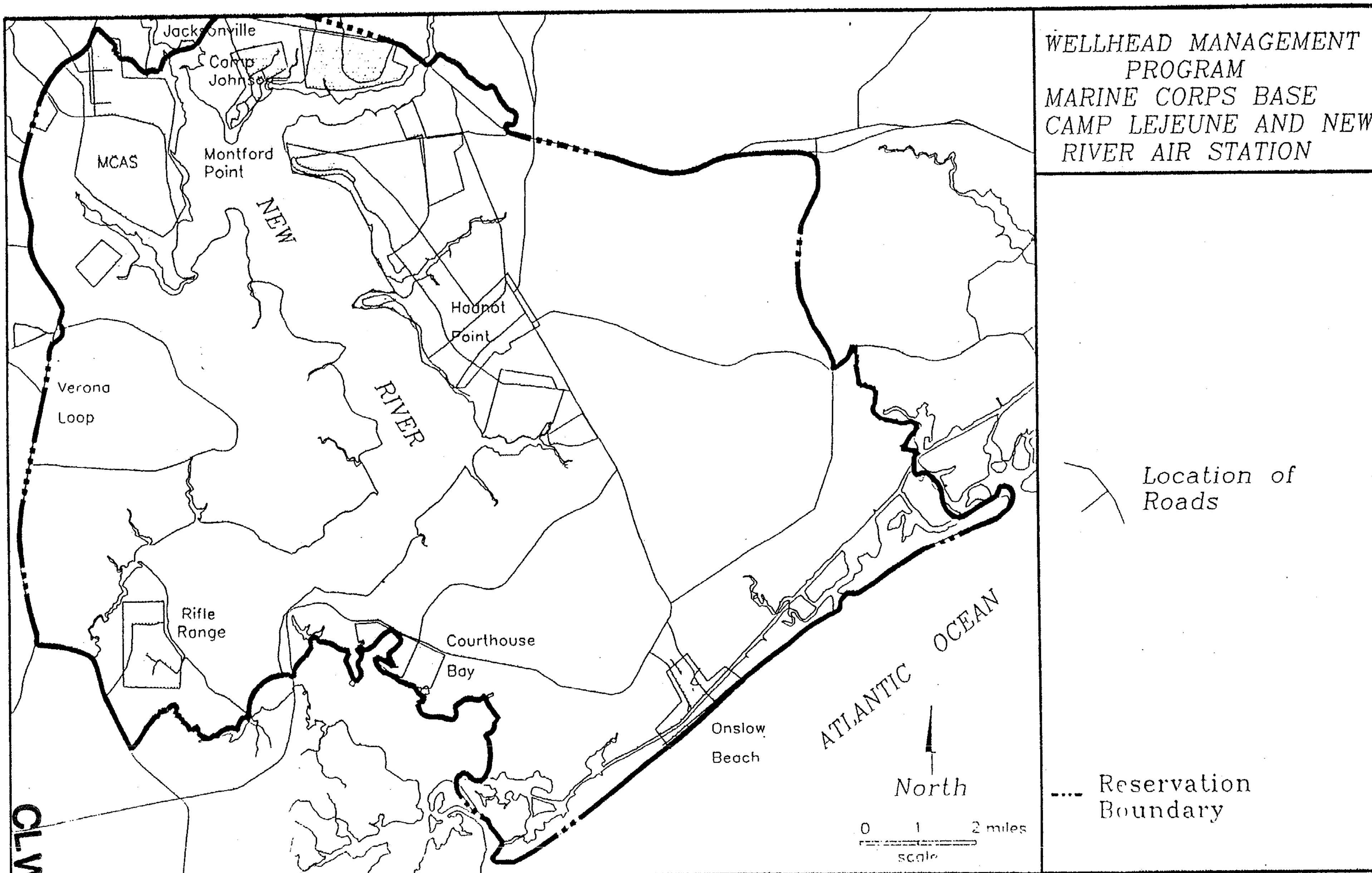

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Figure 1. MCB Location Map Showing Six Bases, and Areas of Major Development.

Additional properties, totaling more than 60 square-miles have recently been acquired as part of a major land expansion for MCB. MCB's total area now exceeds150,000 acres, occupying approximately 30 percent of Onslow County.

2.2 Surface Features

MCB has a varied surface morphology that provides a diversity of settings for troop training. The following is a brief overview of prominent surface features as they relate to surface and groundwater conditions. The reader is referred to Figure 2, for the location of the features discussed below.

MCB is located in the eastern Coastal Plain Physiographic Province of North Carolina. The northeast-southwest trending eastern margin of the base borders the Atlantic Ocean and barrier island coastline of Onslow Beach. The area is typified by low-lying, broad, flat, poorly-drained interstreams dissected by a dendritic stream system that terminates in one of two types of marginal estuarine systems: (1) back-flooded trunk microtidal estuaries that flow predominantly southeastward directly into the ocean via tidal inlets (e.g., New and White Oak Rivers) and (2) back-barrier microtidal lagoons that parallel the shoreward side of the barrier island systems (e.g., Stump Sound). Waters in the back-barrier lagoons flow through numerous natural and artificial tidal channels eventually discharging to the ocean through a series of small inlets.

The axis of the lagoon system is bisected by the dredged channel of the Atlantic Intracoastal Waterway. Movement of water from the fluvial and estuarine system eastward towards the tidal lagoons and ocean is strongly influenced by the presence of the waterway channel.

A linear northeast-southwest trending relict shoreline scarp, approximately 30 feet in elevation, parallels the modern coastline and follows the general trend of NC Route 172.

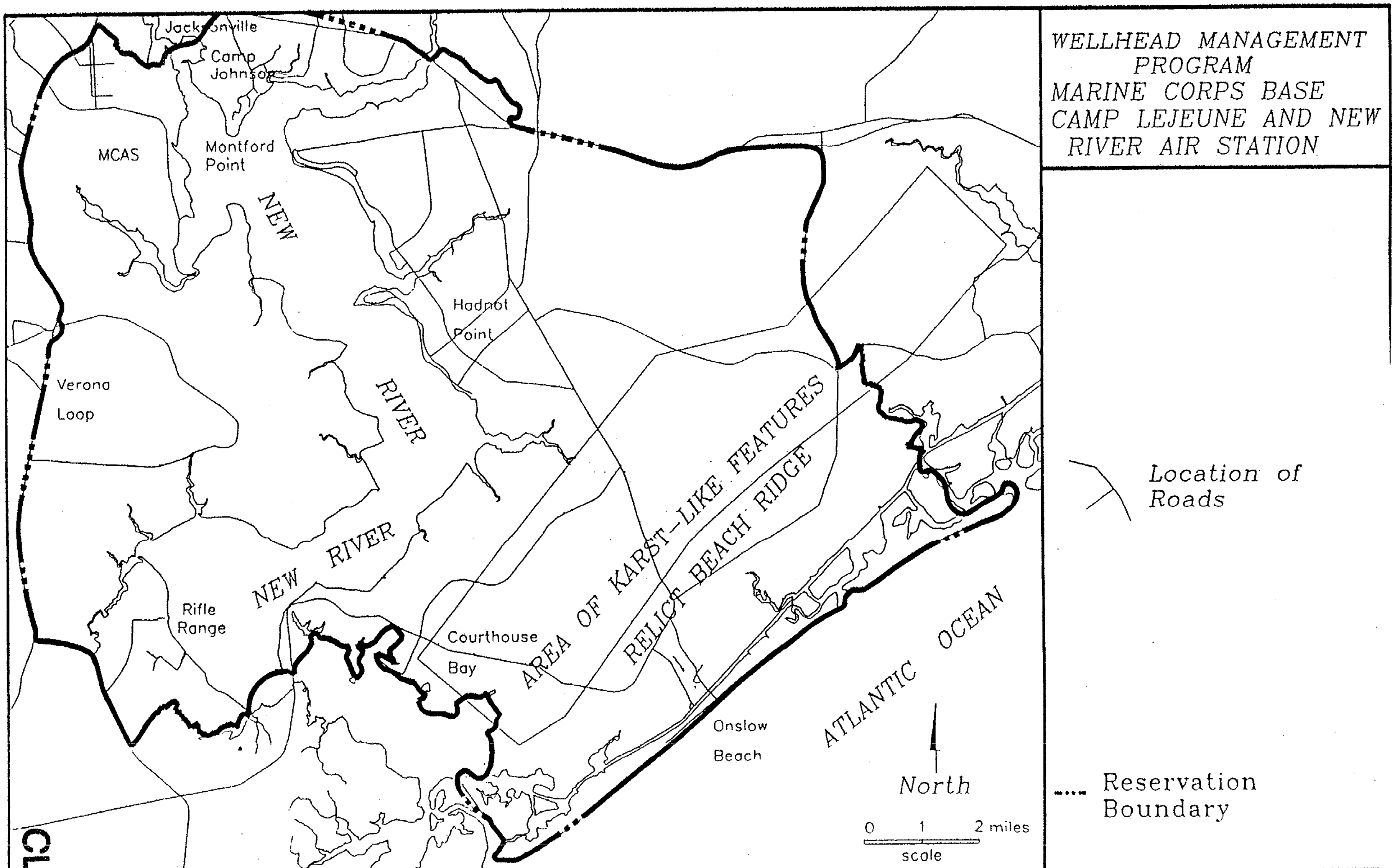

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Figure 2. Location of Prominent Land Surface Features.

The scarp separates low-lying wet swampy areas immediately landward of the modern back-barrier lagoon system from a drier upland terrace region to the west, which is interrupted by numerous internally draining lakes, ponds, and depressions. The origin of these drainage features is not clearly understood; however, they occur in an area underlain by porous limestone bedrock and thus may represent sinkholes and other features typical of karst topography. Although human activity in the area has produced additional ponds and depressions, most of the depressions are believed to be natural because they can be found on maps that predate the purchase of the land by MCB and prior to the introduction of large earth moving equipment to the area. The occurrence of karst features in the area is an important factor in considering regional groundwater protection because recharge in these areas is likely to be much higher than surrounding non-karst regions.

2.3 Surface Water Hydrology

Surface drainage in the vicinity of MCB is dominated by a dendritic stream system consisting of small, sluggish, black water streams that drain upland areas of the interstream divides. These small upland or third-order streams feed larger second-order lateral tributaries of the first-order New River and White Oak River drainage basins. The relict beach scarp discussed in Section 2.2 forms the drainage divide between surface waters flowing eastward to the Intracoastal Waterway and back-barrier lagoon and westward towards the New River. The first-, second-, and third-order drainage divides associated with the New and White Oak Rivers and the back-barrier drainage system are shown in Figure 3. The position of drainage divides are important because they determine the source of water that recharges the water table aquifer.

Waters within the third-order streams are fresh but become progressively more saline as they enter second-order tributaries and ultimately the New River Estuary and back-barrier lagoons which are brackish to marine. Salinities in the estuaries and their tributaries are controlled by fresh water discharge from fluvial sources such as the upper portion of the New River and its tributaries, and from salt water incursions induced by astronomical and wind-generated tides.

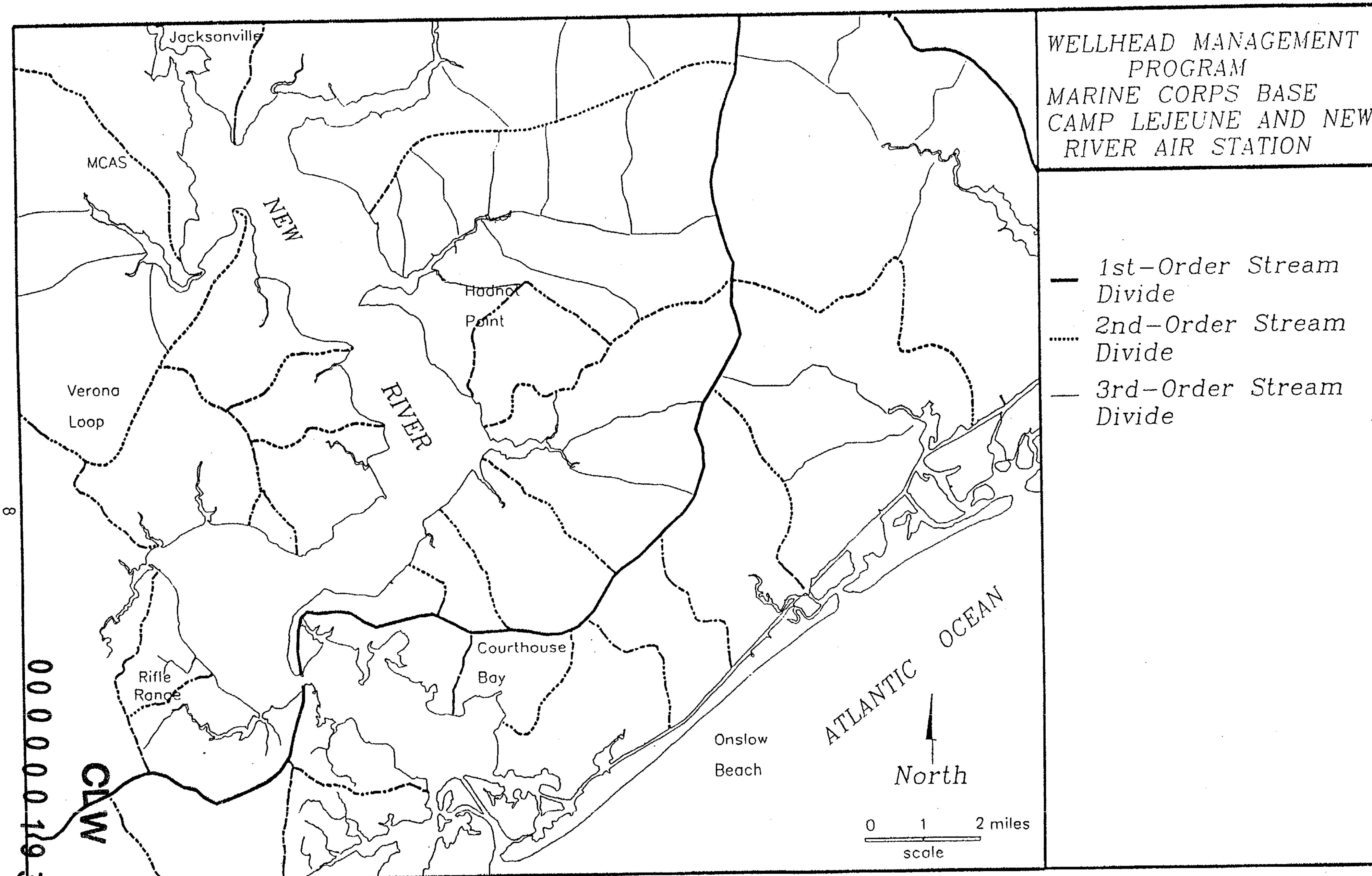

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Figure 3. Location of First-, Second-, and Third-Order Drainage Divides.

In general, westerly winds and intense precipitation events lower salinities, while southeasterly winds and the absence of precipitation produce concomitant increases. Data collected at the USGS stream gage station located at the New River US-17 Bridge in Jacksonville indicate salinities vary widely from nearly fresh to waters containing 20 parts per thousand of salt.

Surface water runoff estimates for MCB are based upon an average annual rainfall of 56 inches and an average recharge rate of 16 inches per year (Winner and Coble, 1989). By difference, the average annual runoff and transpiration is 40 inches, or approximately one-million gallons per acre. Recharge may be locally enhanced by elevated ponds, relict geologic channel structures, and improperly abandoned wells or borings. Conversely, recharge may be adversely affected by building, parking lot and road construction as these activities tend to increase run-off.

2.4 Geology

MCB is situated in the Atlantic Coastal Plain physiographic province which is underlain by a seaward-dipping wedge of marine sediments ranging from Cretaceous to Late Neogene in age. Lithologies are dominated by indurated to unindurated sandy limestones, calcareous sandstones, sandy clays, and clayey sands. These strata disconformably overlay Jurassic and older crystalline basement rocks exposed in the Piedmont to the west, and thicken eastward from a feather-edge at the fall-line 80 miles westward, to over 4,000 feet at the continental shelf edge (Hine and Riggs, 1986). Marine strata in the vicinity of MCB thicken from 800 feet in western Onslow County to more than 1400 feet at Onslow Beach.

Ward and Blackwelder (1980) identified four lithostratigraphic units in the shallow subsurface at MCB. These four units have lithostratigraphic names of formational rank and are named from stratigraphically lowest to highest: the Cretaceous Peedee Formation, the Eocene Castle Hayne Formation, the Oligocene River Bend Formation, and the Miocene Belgrade Formation. These strata are in most places overlain by a surficial veneer of undifferentiated Pleistocene sands of variable thickness.

The thickness of these surficial sands is largely related to their position relative to the relict beach scarp described in Section 2.2.

The Peedee Formation is only known from drill-hole data in the vicinity of MCB. It is composed of sands, clayey sand, and clay (Brown, 1985). The Castle Hayne Formation forms a widespread basal limestone unit of varying composition that outcrops along the upper courses of the New River, north of MCB. The Castle Hayne Formation is in turn overlain by the moldic limestone of the River Bend Formation. The River Bend Formation has not been reported cropping-out at MCB, but presumably occurs in the subsurface. The Belgrade Formation is the upper limestone unit in the area and rests unconformably on the River Bend Formation where present, or directly on the Castle Hayne Formation in areas where the River Bend is absent. The Belgrade Formation, generally a very porous, moldic limestone, is exposed along the shoreline of Stone Bay and has also been recovered in dredge spoils discharged along the nearby Intracoastal Waterway (Crowson, 1970).

2.5 Groundwater Hydrology

Harned and others (1989) defined six aquifer systems that occur beneath MCB. These units are called, from bottom to top: the Upper and Lower Cape Fear Aquifers, Black Creek Aquifer, Peedee Aquifer, Beaufort Aquifer, Castle Hayne Aquifer, and surficial (water table) aquifer (Figure 4). Fresh water is present in the surficial and Castle Hayne aquifers upto a depth of approximately 300 feet.

2.5.1 Water Table Aquifer

The surficial aquifer at MCB Camp Lejeune is composed of Quaternary and Miocene sand, silt, and clay. This aquifer ranges in thickness from 0 feet in the channels of the New River and its tributaries to 75 feet in the southeastern portion of Camp Lejeune (Harned et. al., 1989).

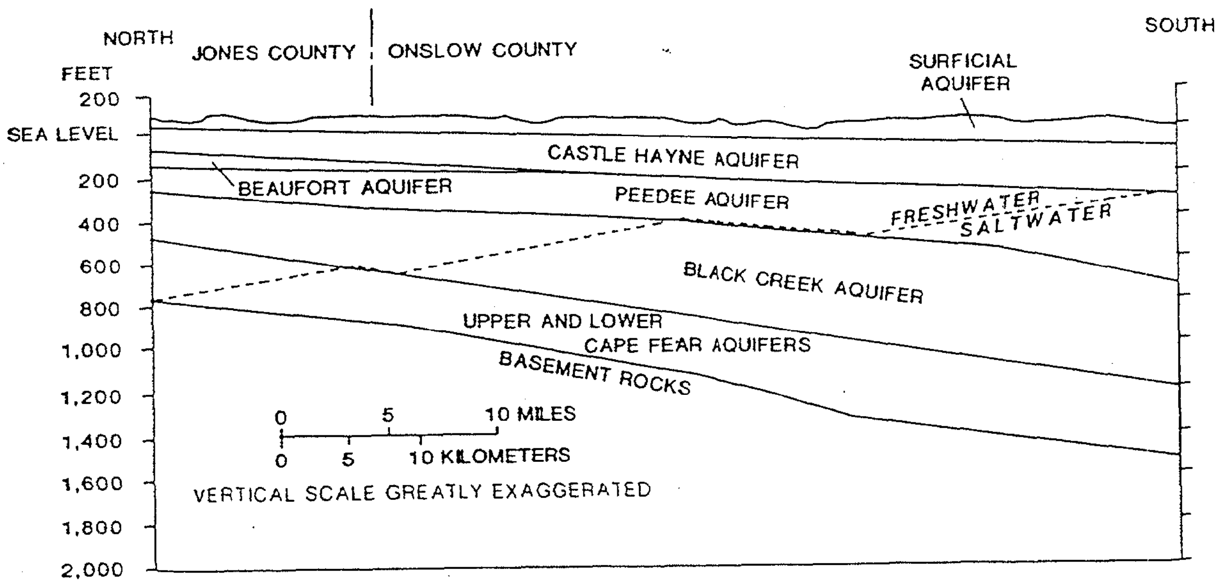

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Figure 4. Geologic Cross-Section Showing the Relationship Between Six Major Aquifer Systems.

2.5.2 Castle Hayne Aquifer

The Castle Hayne Formation forms a widespread basal limestone unit of varying composition that outcrops along the uppper courses of the New River, north of MCB. The Castle Hayne Formation is in turn overlain by the moldic limestone of the River Bend Formation. The Belgrade Formation is the upper limestone unit in the area and rests unconformably on the River Bend Formation where present, or directly on the Castle Hayne Formation in areas where River Bend Formation is absent.

The upper surface of the Castle Hayne Aquifer is semi-confined by a discontinuous clay bed that overlies the Belgrade Formation, and confined from below by the upper confining unit overlying the Beaufort and Peedee Aquifers. The Castle Hayne Aquifer is not as well confined at MCB, as it is northeast of MCB in Craven County. The Castle Hayne Aquifer thickens toward the southeast, from 175 feet in northern portion of the base to 375 feet at the coast and is approximately 340 feet thick in the Hadnot Point area.

2.6 Well Monitoring Programs

MCB personnel are charged with monitoring all phases of water production. Water level data from each well are collected on an irregular basis. However, the USGS has a cooperative program with MCB to collect aquifer data on a continuous basis. Water quality data is currently maintained at EMD and Base Utilities. Records of pumping activities are maintained by MCB Utility personnel.

2.6.1 Water Levels

formation is collected on Water levels are monitored in production wells by base personnel. Water level measurements are generally made each time the production rate of each well is adjusted (on an annual or semi-annual basis). These data are maintained in a central file at the Holcomb Boulevard Water Treatment Facility. Continuous readings of water levels in several non-pumping wells are recorded by the USGS at five MCB sites (Figure 5). This inpunch tape and is not readily available until USGS personnel pass the punched tape through a reader.

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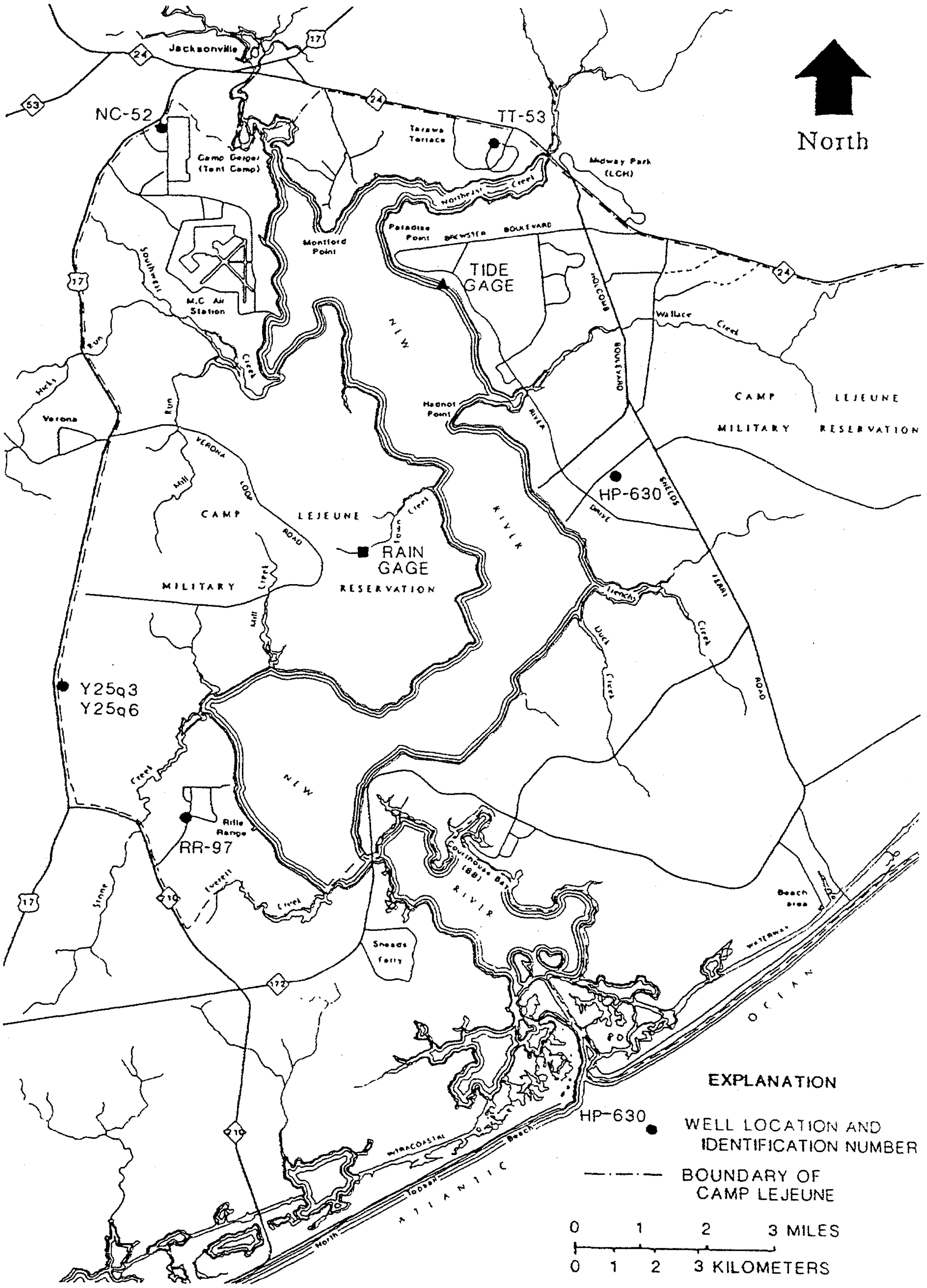

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Figure 5. Location of USGS and NC DEM monitoring stations (from Harned and others, 1989).

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2.6.2 Water Quality

MCB well monitoring program includes sampling and analyses of water from wells suspected of contamination. A planned well sampling scheme is currently being managed by EMD. This program requires a baseline analyses of all wells, and subsequent testing of wells on a variable time schedule dictated by the presence or absence of contaminants. Results of the monitoring program is being archieved in a central data base at EMD.

3.0 MCB Water Well System

The following is a review of the existing water production system at MCB. The review includes only the existing wellfields and raw water mains. It does not include the water treatment plants and drinking water distribution system. Details of the construction of each water supply well, raw water piping and valving and overall layout were provided in a folio of 48 engineer drawings entitiled "Water Distribution System, Existing Conditions", and other files containing well completion and pump test data.

3.1 Water Supply Wells

MCB has installed more than 110 groundwater production wells that are connected by more than 13 miles of water mains. Based on information obtained from MCB daily operation records, 99 of these wells are considered active (from MCB Hadnot Point Water Treatment Facility well records). Information concerning the status of each well as of November 1, 1991 is presented in Table 1. Water production wells are grouped according to the treatment plants they supply. Pertinent well information for each well is presented according to the water treatments system to which they currently contribute, including: raw water main connection status (on-line or off-line), well depth (ft.), depth to the top of the pump (ft), depth to the bottom of the water level airline (ft), drawdown (ft), original production rate of the well (gpm), most current production rate, and VOC contamination level in each well.

Wells constructed at Tarawa Terrace are no longer in use and most likely will be abandoned.

Table 1. Pumping Status for MCB Camp Lejeune Wells
Source: Holcomb Boulevard Water Treatment Plant (11-21-1991)

HADNOT POINT									
Building Number	Pump Status on/off line	Well Depth (Ft. Below TOC)	Pump Depth (Ft. Below TOC)	Air Line Depth	Static Water Level (feet)	Drawdown (feet)	Production (gpm)	Pump Dischage Pressure (psi)	Contaminant (ug/l)
HP 602	off line	160	70	70	14	58	154	22	TCE = 14
HP 603	on line	195	90	63	25	55	129	65	ND
HP 606	on line	210	80	80	20	58	267	8	ND
HP 607	on line	unknown	105	90	30	76	246	20	n/a
HP 608	off line	132	60	60	27	48	208	unknown	TCE = 13
HP 609	on line	145	70	70	15	60	199	50	ND
HP 610	on line	190	60	70	32	46	214	5	ND
HP 613	on line	150	50	50	21	38	157	32	ND
HP 616	on line	147	61	61	32	47	178	10	ND
HP 620	on line	52	32	48	24	33	224	10	ND
HP 622	on line	227	80	90	15	70	330	30	ND
HP 623	on line	197	70	115	25	45	210	20	ND
HP 628	on line	200	unknown	88	18	63	172	10	ND
HP 629	on line	230	70	100	45	90	216	20	ND
HP 632	on line	unknown	60	63	12	33	224	15	ND
HP 633	on line	205	93	72	40	58	205	8	ND
HP 634	off line	225	80	60	14	50	219	12	TCE = 2.9
HP 635	on line	215	110	63	20	53	151	12	ND
HP 636	on line	225	70	70	23	58	149	8	n/a
HP 637	off line	180	130	130	65	105	130	12	2 OF 3 ND
HP 638	on line	197	125	125	20	104	201	10	ND
HP 639	off line	182	60	63	4	56	unknown	unknown	ND
HP 640	on line	179	65	50	10	38	210	25	ND
HP 641	on line	178	70	104	26	70	351	10	ND
HP 642	on line	210	96	112	50	82	unknown	unknown	ND
HP 651	off line	199	126	125	40	109	242	52	TCE=18,900
HP 652	off line	193	126	110	6	88	216	45	TCE = 9
HP 653	off line	250	75	91	35	64	197	27	n/a
HP 654	on line	183	70	70	30	60	175	15	ND
HP 655	off line	147	80	70	20	unknown	unknown	unknown	ND
HP 660	off line	unknown	unknown	unknown	unknown	unknown	150	unknown	unknown

HADNOT POINT (CONTINUED)									
Building Number	Pump Status on/off line	Well Depth (Ft. Below TOC)	Pump Depth (Ft. Below TOC)	Air Line Depth	Static Water Level (feet)	Drawdown (feet)	Production (gpm)	Pump Dischage Pressure (psi)	Contaminant (ug/l)
HP 661	on line	135	70	70	23	60	275	38	ND
HP 662	on line	230	70	81	6	59	148	45	ND
LCH 4007	on line	150	70	70	30	64	150	25	ND
LCH 4009	on line	134	80	100	25	47	349	55	ND
HP 5186	on line	160	665	47	20	58	336	25	ND
HP 709	on line	140	86	86	24	76	239	22	n/a
HP 710	on line	140	86	86	22	51	115	12	n/a
HP 711	on line	150	85	85	19	75	235	21	n/a
HP 663	on line	180	85	85	50	73	100	45	n/a

HOLCOMB BOULEVARD									
Building Number	Pump Status on/off line	Well Depth (Ft. Below TOC)	Pump Depth (Ft. Below TOC)	Air Line Depth	Static Water Level (feet)	Drawdown (feet)	Production (gpm)	Pump Dischage Pressure (psi)	Contaminant (ug/l)
HP 643	on line	232	70	78	26	61	269	25	ND
HP 644	on line	255	90	90	30	82	230	22	ND
HP 645	off line	245	85	75	30	70	192	30	Benzene = 20
HP 646	on line	266	70	70	23	34	154	11	ND
HP 647	on line	200	70	70	32	58	302	5	ND
HP 648	on line	260	110	100	6	90	263	34	ND
HP 649	on line	279	110	100	10	90	100	52	ND
HP 650	on line	179	110	110	25	100	480	26	ND
HP 698	on line	124	86	86	23	56	216	15	n/a
HP 699	on line	124	86	86	26	47	140	10	n/a
HP 700	on line	130	86	86	38	77	192	32	n/a
HP 701	on line	100	86	86	34	70	236	15	n/a
HP 703	on line	145	86	86	26	59	293	5	n/a
HP 704	on line	124	86	86	26	64	159	5	n/a
HP 705	on line	160	86	75	40	65	214	5	n/a
HP 706	on line	185	86	85	34	67	214	5	n/a
HP 707	off line	130	86	86	24	75	50	20	n/a
HP 708	on line	176	86	86	13	55	219	10	n/a

TARAWA TERRACE									
Building Number	Pump Status on/off line	Well Depth (Ft. Below TOC)	Pump Depth (Ft. Below TOC)	Air Line Depth	Static Water Level (feet)	Drawdown (feet)	Production (gpm)	Pump Dischage Pressure (psi)	Contaminant (ug/l)
TT 23	off line	142	unknown	75	27	63	160	unknown	TCE = 37
TT 25	off line	unknown	70	70	38	60	130	32	TCE = Present
TT 26	off line	100	80	80	35	67	127	20	TCE = 3.9
TT 31	off line	94	70	70	33	61	111	23	ND
TT 52	off line	98	50	50	22	40	236	15	ND
TT 54	off line	104	63	65	32	52	119	30	ND
TT 67	off line	104	70	70	32	61	119	31	ND

RIFLE RANGE									
Building Number	Pump Status on/off line	Well Depth (Ft. Below TOC)	Pump Depth (Ft. Below TOC)	Air Line Depth	Static Water Level (feet)	Drawdown (feet)	Production (gpm)	Pump Dischage Pressure (psi)	Contaminant (ug/l)
RR 45	on line	130	80	80	55	66	192	15	ND
RR 47	on line	85	65	70	55	60	140	24	ND
RR 97	on line	200	70	70	45	59	170	38	ND
RR 229	off line	247	80	100	23	58	unknown	unknown	TCE = 3.2

COURTHOUSE BAY									
Building Number	Pump Status on/off line	Well Depth (Ft. Below TOC)	Pump Depth (Ft. Below TOC)	Air Line Depth	Static Water Level (feet)	Drawdown (feet)	Production (gpm)	Pump Dischage Pressure (psi)	Contaminant (ug/l)
BB 44	on line	62	40	42	19	30	~~125~~ 140	18	ND
BB 220	on line	150	51	51	33	46	~~119~~ 172	25	ND
BB 221	on line	200	75	75	40	590	~~230~~ 154	25	ND
BB47	on line	200	65	80	15	21	~~341~~ 294	34	ND
BB218	on line	unknown	50	77	35	52	~~192~~ 187	25	n/a

ONSLOW BEACH									
Building Number	Pump Status on/off line	Well Depth (Ft. Below TOC)	Pump Depth (Ft. Below TOC)	Air Line Depth	Static Water Level (feet)	Drawdown (feet)	Production (gpm)	Pump Dischage Pressure (psi)	Contaminant (ug/l)
BA 164	on line	unknown	45	47	17	38	~~214~~ 222	62	ND
BA 190	on line	105	80	80	13	30	~~303~~ 275	40	ND

CAMP GEIGER

Building Number	Pump Status on/off line	Well Depth (Ft. Below TOC)	Pump Depth (Ft. Below TOC)	Air Line Depth	Static Water Level (feet)	Drawdown (feet)	Production (gpm)	Pump Dischage Pressure (psi)	Contaminant (ug/l)
TC 325	off line	70	50	60	40	48	100	10	ND
TC 502	on line	184	50	50	28	27	180	16	ND
TC 504	off line	113	80	70	15	50	203	unknown	ND
TC 600	on line	170	50	50	7	39	172	30	ND
TC 604	on line	113	50	50	9	25	137	10	ND
TC 700	on line	76	50	50	10	38	125	16	ND
TC 901	off line	76	50	50	18	55	unknown	unknown	ND
TC1000	on line	153	60	60	30	55	110	34	ND
TC1001	on line	100	60	60	30	46	160	18	ND
TC 1251	on line	240	70	80	20	26	150	10	ND
TC 1253	off line	250	70	84	29	34	128	14	ND
TC 1254	on line	195	70	77	22	25	122	18	ND
TC 1255	on line	250	70	100	31	67	104	10	ND
TC 1256	on line	204	70	82	24	72	108	15	ND

MARINE CORP AIR STATION NEW RIVER

Building Number	Pump Status on/off line	Well Depth (Ft. Below TOC)	Pump Depth (Ft. Below TOC)	Air Line Depth	Static Water Level (feet)	Drawdown (feet)	Production (gpm)	Pump Dischage Pressure (psi)	Contaminant (ug/l)
AS 106	off line	179	50	50	22	30	226	15	DCE = 5
AS 131	on line	200	70	70	27	38	310	11	ND
AS 190	on line	180	60	123	unknown	60	220	14	ND
AS 191	on line	180	60	117	32	48	220	20	ND
AS 203	on line	173	77	60	15	34	220	9	ND
AS 4140	on line	unknown 193	unknown	110	30	36	110	7	ND
AS 4150	off line	unknown 193	unknown	100	20	30	128	8	TCE = Present
AS 5001	on line	193	85	85	23	50	185	10	ND
AS 5009	on line	196	75	75	15	68	111	10	ND

ND = Not Detected, TCE = Trichloroethylene, DCE = Dichloroethylene, n/a = not analysed for

Contaminant level reported is last or lowest concentration determined

The Rifle Range well system is scheduled to be disconnected from the raw water system following a scheduled link-up with the Onslow County Water System sometime in 1993. The Rifle Range wells will remain active, however, and will be redirected for irrigation purposes.

3.1.1 Hadnot Point Wells

Water wells supplying Hadnot Point Water Treatment Facility extend from Midway Park, southward, seven miles along Sneeds Ferry Road. Thirty of the 40 wells constructed are currently on line; the remaining wells have either been determined by MCB personnel to be contaminated with volatile organic compounds (VOCs) or have worn screens and produce sand.

The source of well contamination at Hadnot Point is summarized in a report by Environmental Science and Engineering, Inc. (1990) and has been attributed to long term surface spills, leaking fuel storage tanks, and uncontrolled chemical releases. The most serious contamination occurred in the vicinity of the Hadnot Point Industrial Area (HPIA) where several of the wells indicated high levels of contamination and have subsequently been secured (Wells HP-602, HP-608, HP-634, HP-637, HP-651, HP-652, and HP-653) (Environmental Science and Engineering, Inc., 1991). In addition, several wells (HP-608, HP-634, HP-637, and HP-652) have indicated levels of contamination of Trichloroethylene (TCE) only slightly above detection limits (1 to 13 ppb) (from MCB Environmental Laboratory records, 1991), and in some instances test results indicated no contamination. A summary of VOC analysis for each affected well is presented in Table 2. Because the detected contamination in these former wells has been sporadic in incidence and low in concentration, alternate contamination sources, other than the aquifer should be considered. Possible contamination sources include, leaking casings, poor outer casing sealing during well construction, and back streaming and subsequent cross-contamination from nearby contaminated wells.

Table 2. **Summary of VOC, Chloride, and Flouride Analysis for Hadnot Point and Holcomb Blvd.**
(source: Camp Lejeune EMD Laboratory)

Well Bldg. #	Sample Date / Constituent	Volatile Organic Compounds (ug/l) 30-Nov 1984	4-Dec 1984	10-Dec 1984	13-Dec 1984	16-Jan 1985	4-Feb 1985	9-Jul 1985	13 & 17 Jan-86	4,5&6 Nov-86	12-Nov 1986	17-Feb 1987	Sep 1987
601 Shut Down 12/6/84	DCE	NC	88	99	NC	8.8	74	NC	NC	NC	ND	NC	NC
	TCE		210	230		26	38				ND		
	PCE		5	4.4		ND	1.5				ND		
	Methylene Chloride		ND	10		ND	ND				ND		
	Butane						8.4						
	Pentane						2.2						
	Z-Methyl Butane						3.1						
602 Shut Down 11/30/84	DCE	630	NC	380	230/110	NC	NC	NC	NC	NC	14	NC	NC
	TCE	1600		540	340/300						2.2		
	PCE	24		ND	ND/ND						ND		
	Benzene	120		720	230/ND						SO		
	1,1-Dichloro-Ethylene	2.4		ND	ND/ND						ND		
	Toluene	5.4		ND	12/ND						ND		
	Vinyl Chloride	18		ND	ND/ND						ND		
	1,1-Dichloro-Ethane	ND		ND	ND/34						ND		
	1,2-Dichloro-Ethane	ND		ND	ND/ND						ND		
	2-Chloro Ethylvinyl Ether				ND/9.8								
603	TCE	NC	4.6	ND	NC	ND	NC	NC	ND	ND	NC	NC	
	Methylene-Chloride		ND	7		ND			ND	ND			0.16

Table 2 - Continued

Well Bldg. #	Sample Date / Chemical	Volatile Organic Compounds (ug/l) 30-Nov 1984	4-Dec 1984	10-Dec 1984	13-Dec 1984	16-Jan 1985	4-Feb 1985	9-Jul 1985	13 & 17 Jan-86	4,5&6 Nov-86	12-Nov 1986	17-Feb 1987	Sep 1987
608 Shut Down 12/6/84	DCE	NC	5.4	2.4	NC	NC	ND	NC	NC	NC	8.5	NC	NC
	TCE		110	13			9				66		
	Benzene		3.7	4			1.6				ND		
	Methylene Chloride		ND	14			ND				ND		
623	Chloro-Methane	NC	NC	NC	NC	NC	NC	ND	ND	NC	NC	NC	0.25
633	1,1,1-Trichloro-Ethane	NC	NC	NC	NC	ND	NC		3/ND	ND	NC	NC	0.18
	Chlorides							14					
634 Shut Down 12/14/84	DCE	NC	ND	2.3	NC	700	NC	NC	NC	NC	2.9	NC	NC
	TCE		ND	ND		10					ND		
	Methylene Chloride		ND	130		1300					ND		
	Vinyl Chlorides		ND	ND		6.8					ND		
636	VOC's	NC	NC	NC	NC	ND	NC		ND	NC	NC	NC	
	Acetone					88							0.15
	2-propanol					37							
	Chlorides							10					
637 Shut Down 12/14/84	Methylene Chloride	NC	ND	270	NC	ND	NC	NC	NC	NC	NC	NC	NC
642	Methylene Chloride	NC	ND	38	NC	ND	NC			ND	NC	NC	
	1,1,1-Trichloro-Ethane		ND			ND		18	3	ND			0.16

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Table 2 - Continued

Well Bldg. #	Sample Date / Constituent	Volatile Organic Compounds (ug/l) 30-Nov 1984	4-Dec 1984	10-Dec 1984	13-Dec 1984	16-Jan 1985	4-Feb 1985	9-Jul 1985	13 & 17 Jan-86	4,5&6 Nov-86	12-Nov 1986	17-Feb 1987	Sep 1987
645 Shut Down Nov-86	Benzene	NC	NC	NC	NC	NC	ND	NC	NC	20	NC	290	NC
	1,2-Dechloro-Ethane						ND			ND		4	
	Ethyl-Benzene						ND			ND		33	
	Toluene						ND			7.5		15	
	Xylenes						ND			ND		36	
	Acetone									ND		170	
	Chlorides							18					
651 Shut Down 2/4/85	DCE	NC	NC	NC	NC	3400	1580/8070	NC	NC	NC	140	NC	NC
	TCE					3200	18,900/17,600				32		
	PCE					386	400/397				45		
	1,1,Dicholo-Ethylene					187	ND/ND				7		
	Vinyl Chloride					655	ND/ND				140		
	Phathalates										P		
652	TCE	NC	NC	NC	NC	9	NC	NC	NC	NC	ND	NC	NC
653	TCE	NC	NC	NC	NC	5.5	NC	NC	NC	NC	2.6	NC	NC
	Phathalates										P		

ND = not detected, NC = not collected, P = present but not quantified, n/a = not analyzed
TCE = Trichloroethylene, DCE = Dichloroethylene, PCE = Pentachloroethane
1,200/1,100 indicates results from duplicate samples collected by different field personel
Shut Down date indicates time well was isolated from water supply.

Remedial Investigations (RI) are currently underway at the Hadnot Point Industrial Area (HPIA) site by Environmental Science and Engineering, Inc. and Baker Environmental to determine the extent of contamination and recommend a plan for remedial action.

3.1.2 Holcomb Boulevard Wells

The 18 wells supplying the Holcomb Boulevard Water treatment facility extend from Paradise Point along Holcomb Boulevard, eastward to NC Highway 24. All but two of these wells are in use. According to MCB Environmental personnel, well HP-645 was reported to contain low concentrations of benzene (20 ppb, reported by MCB Environmental Lab) that resulted from the leakage of the back-up generator's 200-gallon fuel tank located next to the well pad.

Well HP-707 has relatively low yields of approximately 50 gpm and originally was thought to be clogged by iron precipitating bacteria, according to MCB personnel. Subsequent treatment of the well on numerous occasions with chlorinated agents has resulted in no improvement in yields. The well is currently not in use because, according to Mr. Stanley Miller, "it's not worth the trouble and the power to turn it on." Because this well has historically yielded low quantities of water, even when new, the possibility of improper well construction should not be ruled out as an explanation for poor production.

3.1.3 Tarawa Terrace Wells

The Tarawa Terrace Water Treatment Facility is no longer in use along with wells belonging to the system. Two years ago, the wells supplied water to the Holcomb Water Treatment Facility; however, during an extreme period of cold, the water main carrying water across Northeast Creek broke and fell into the water. Repairs have not been made and thus these wells remain inactive.

Three wells on the Tarawa Terrace system, TT-23, TT-25 and TT-26, have reported low-level contamination by the volatile organic compound, TCE, from an uncertain origin (possibly an offsite dry cleaning business).

According to MCB Environmental personnel, the contamination levels ranged from 37 ppb in well TT-23 to trace amounts in well TT-25. The site is not listed on the 1990 Area of Interest list, prepared by Environmental Science and Engineering, Inc. (ESE, 1990), but has been reported to the North Carolina Department of Environmental Management, WiRO and is presently undergoing remediation study under the guidance of WiRO personnel.

3.1.4 Camp Geiger and Marine Corps Air Station Wells.

Originally, Camp Geiger and MCAS operated separate water treatment facilities. Presently, wells at Camp Geiger deliver water to MCAS Water Treatment Facility located on Curtis Road. Wells constructed at Camp Geiger (formerly known as the Tent Camp) are the oldest within the MCB water supply system. Some wells are of open-hole construction and remain very productive, the remaining wells are screened. Some of the screened wells have deteriorated and began producing sand (TC-504 and TC-901). These wells are noted in Table 1, and are no longer in use. Several of the wells within the MCAS system have historically produced waters containing elevated levels of salt (in excess of 200 mg/liter Chloride); of these, wells 502, AS-191, AS-131, and AS-4140 are currently in service. A review of available well construction and water quality records (located at the MCB Holcomb Boulevard Water Treatment Facility) from these wells indicates a two-part hydrology that can be to the general geology of the vicinity. Well records indicate two producing zones: an upper freshwater zone in the Castle Hayne Limestone Aquifer, and a lower saline zone. The saline aquifer may be the upper portion of the Beaufort Aquifer and is thought to be present in the vicinity of MCAS. Unfortunately, well records from many of the affected wells could not be found to verify screened intervals and aquifer characteristics.

Well AS-106 was found to contain low concentrations (5 ppb reported by MCB Environmental Lab) of dichloroethane of an unknown origin. The well was secured from the well field, but no remedial action has been taken. No other wells in the area show contamination, thus this appears to be an isolated contamination event. Because this well has not been active, it is possible that the contamination plume has been directed towards adjacent pumping wells.

Well AS-4150 was found to contain trace concentrations of TCE of an unknown origin (MCB Environmental Lab). The well is presently secured. Adjacent wells show no contamination, thus the extent of contamination appears to be isolated.

3.1.5 Onslow Beach Wells

Two wells comprise the Onslow Beach water system. No contamination has been reported in any of the wells; however, USGS personnel (Dr. Alex Cardinelle, Raleigh Water Resource Office) reported strong petroleum odors emanating from drill cuttings during the construction of USGS-3 test well near the Onslow Beach wellfield. Samples from this well were not tested, and the origin of the odor remains unknown. The verification of potential contaminants at Onslow Beach is important because a loss of either or both of the wells would severely limit the availability of potable water in the Onslow Beach area.

3.1.6 Courthouse Bay Wells

Five wells comprise the Courthouse Bay water system. The MCB Environmental Laboratory has not observed contamination in any of the wells. Despite their age (>50 years), Wells BB-44 and BB-47 continue to produce water with no reported signs of declining yields. The remaining wells are less than 20 years old.

3.1.7 Rifle Range Wells

Three of the four production wells at the Rifle Range are active. The fourth well, RR-229, contained low level TCE concentrations (3.2 ppb) and was subsequently secured from the system. A waste dump, located due west of the well, is the only known possible source of TCE.

3.1.8 Small Water Supply Systems

An unknown number of wells are presently maintained by MCB to provide water at sites not supplied by one of the five treated water systems. Of these systems, six are known to have automatic chlorinators and include VL-108 (K-321 Firing Range, Verona Loop Road), OP-2 (Lucky's Mound Firing Range, Lyman Road) SFG-1 (Sneeds Ferry Gate) and BB-97 (Courthouse Bay), D-19 and SH-14. The precise location of wells D-19 and SH-14 is not presented in this report.

3.1.9 Verona Loop Area

The Onslow County Water System provides drinking water to the Verona Loop Training Area. MCB has no plans to develop an independent water supply and treatment system in the Verona Loop area.

3.1.10 New Acquistion Area (former Camp Davis)

MCB recently completed the purchase of a major land area herein called the New Acquisition Area. The land is approximately 50 sqare miles in area and is situated west of US Highway 17 and between Verona and Holly Ridge. The land area includes the properties known as Great Sandy Run Pocosine and portions of former Camp Davis (Figure 6). Groundwater information for this region is scarce; however, limited information has been reported for former Camp Davis, located on the extreme southern end of the aquisition area at Holly Ridge. The location of each well site is shown in Figure 7. A copy of the typical well design is shown in Figure 8. A field inspection of the former Camp Davis wells revealed that at least one of the nine wells on MCB property remains intact. Well No. 8 was the only well actually inspected and was found partially covered with tree branches and leaves. The steel casing appeared to be good shape with only thin surface rust. The well casing was probed and found to be bridged-off by organic debris at a depth of 42 feet however, there was no evidence that the well had been permanently abandoned. The disposition of the remaining wells is not known as many of the well locations are overgrown with briars, brush and trees. In related work, Rivers and Associates of Greenville, NC, and the Onslow County Water Supply investigated the construction of former Camp Davis Well No. 4. Well No. 4 is located south of the MCB wells on properties currently owned by International Paper. Well No. 4 is believed to be of similar construction to those wells found on MCB property. Rivers and Associates reported the well to be constructed of 106 feet of 10 inch steel surface casing and approximately 100 feet of open hole. The open hole is constructed in a layered limestone unit. An abbreviated pump test was conducted at a pumping rate of 310 gpm, and indicated a specific yield of 50.74 gpm per foot of drawdown.

Water quality analysis from this well indicated the water was fresh with a hardness in excess of 200. No volatile organic compounds were detected in the samples.

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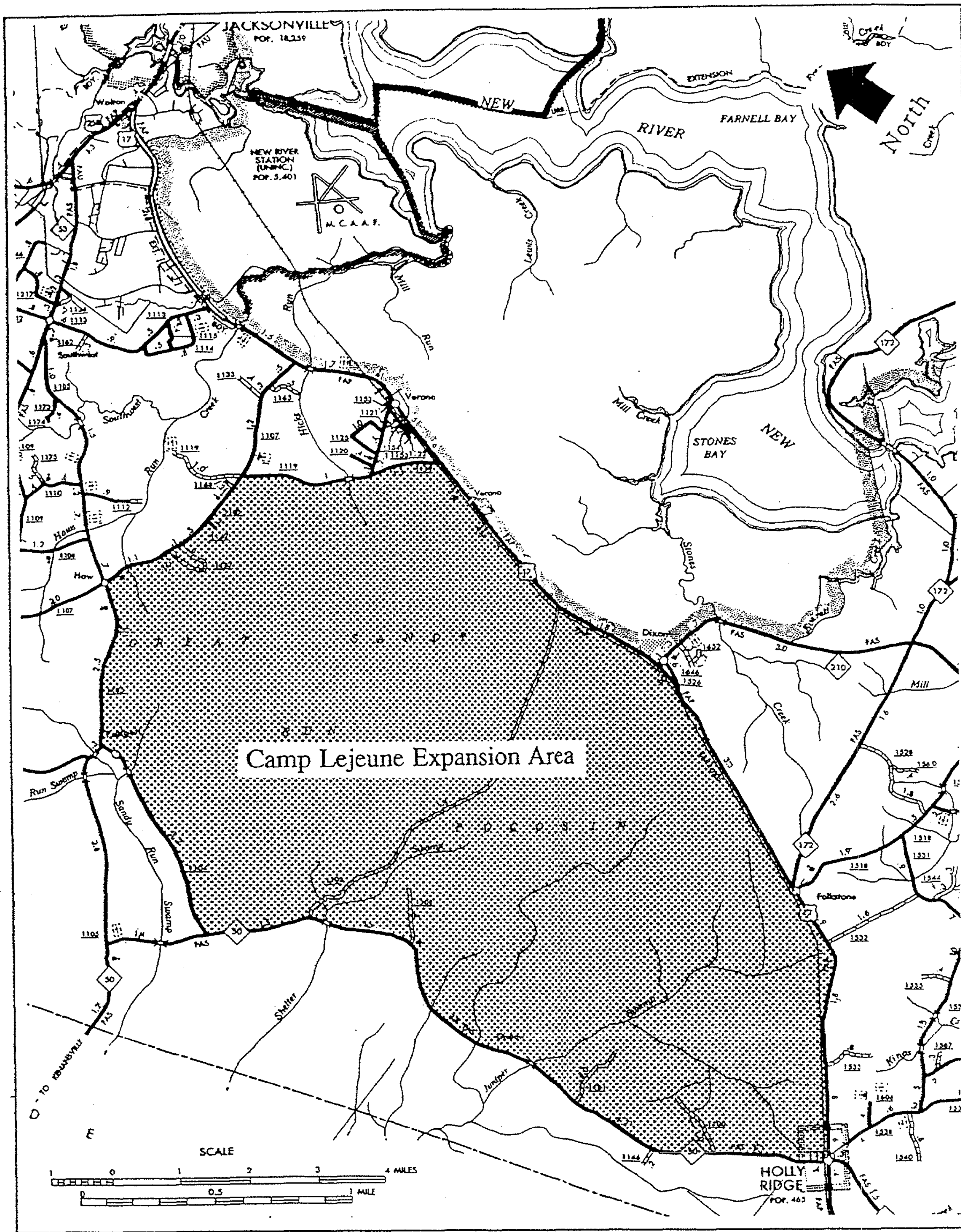

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Figure 6. Location of Newly Acquired MCB Land Area.

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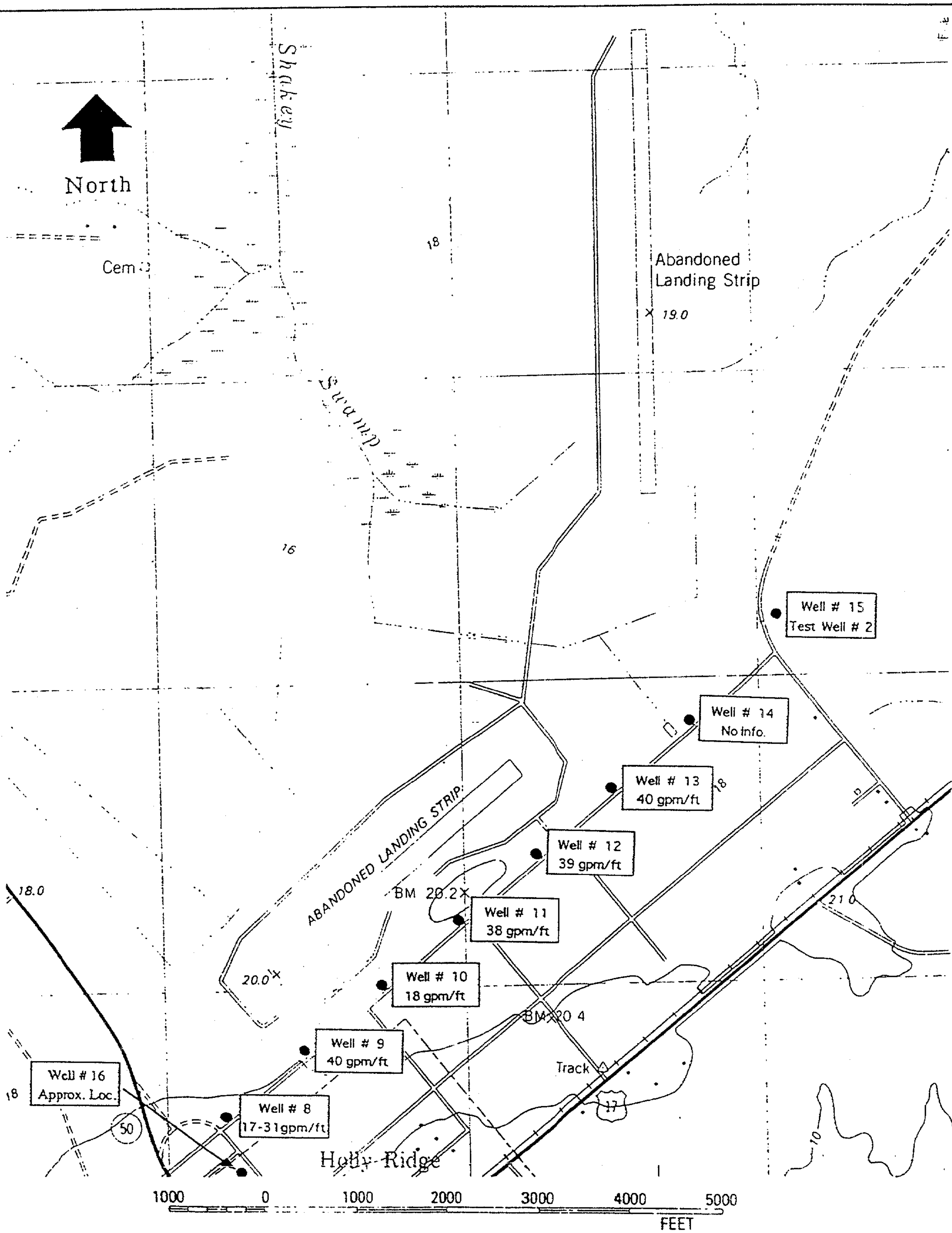

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Figure 7. Location of Abandoned Well on MCB, Formerly Camp Davis.

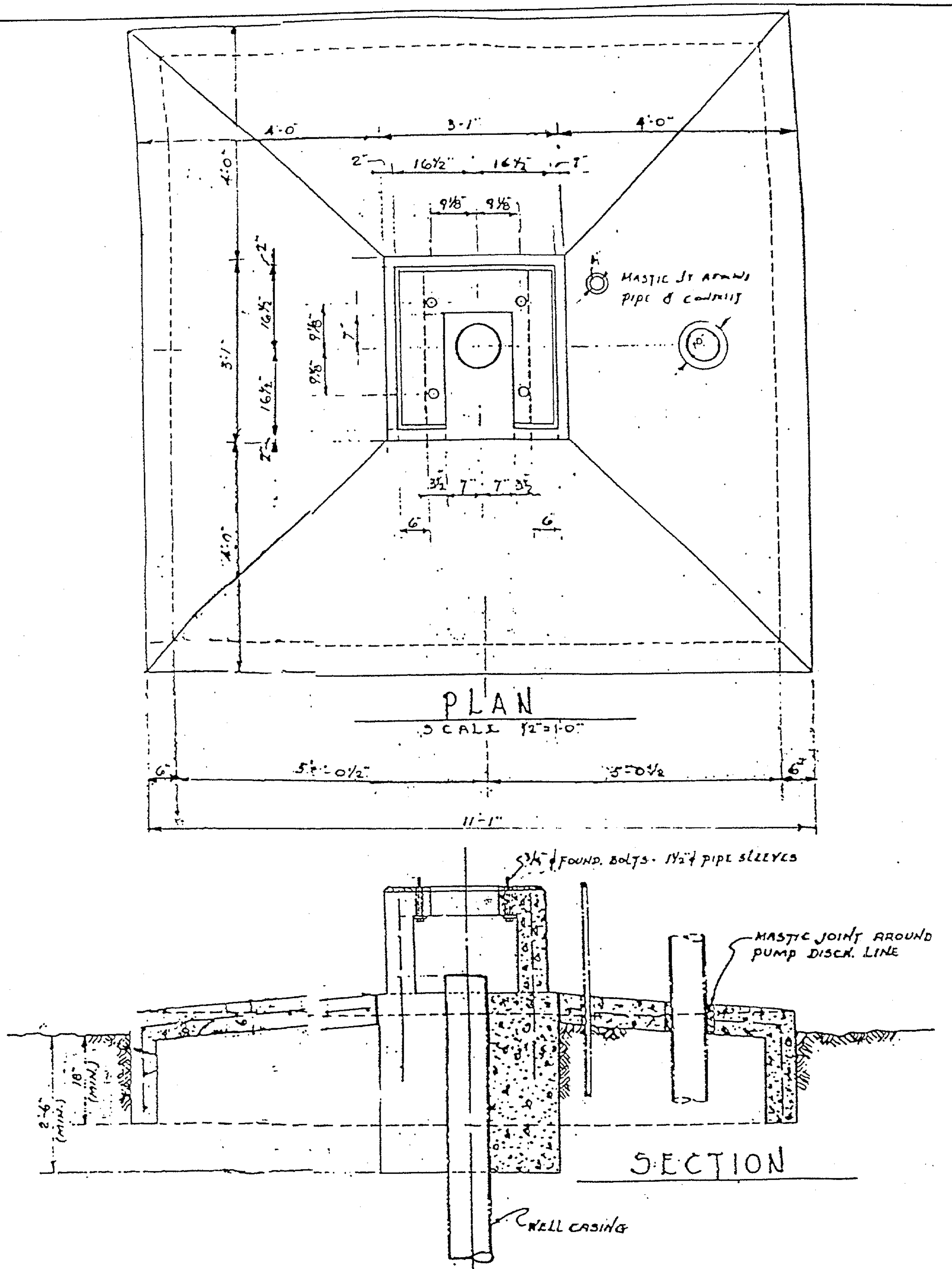

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Figure 8. Typical Well Construction for water supply wells at Former Camp Davis.

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3.2 Water Collection System

MCB well production consists of a single-well element connected to a single raw-water collection main. The single-well element typically consists of: (1) an 8- to 10-inch well averaging less than 100 feet of penetration into the Castle Hayne Aquifer and approximately 170-gpm water production, (2) a pumping unit, normally a 6-inch vertical line shaft pump, (3) a totalizer to measure flow rates, (4) a single mechanical gate valve, (5) an automatic flapper or butterfly check valve, and (6) a waste-water discharge pipe. The water collection system is constructed to comply with all public water system construction criteria including spacing from mains carrying sewer and sewer cross-overs.

An unknown length of raw-water main is constructed of asbestos/cement pipe and may provide a source of particulate asbestos to the water treatment plant. Presently, the concentration of asbestos, if any, in MCB water is unknown. In July 1991, the EPA announced new requirements for monitoring public water systems. Beginning June 30, 1992, all public water supplies must be tested for asbestos. The reader is refered to EPA Part 141-National Primary Drinking Water Regulations for details of sampling and testing intervals. The maximum contaminant level (MCL) has been established as no more than 7 million fibers (>10 microns) per liter of water.

3.3 Well Production

The MCB water collection system is composed of 73 operating wells and associated raw-water mains connecting the wells to the five active water treatment centers listed in Table 3.

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Table 3. Listing of MCB Water Production Systems

System	No. of Wells	ProductionCapacity (gpd)
Hadnot Point	35	5,900,000
Holcomb Blvd	18	5,000,000
Marine Corps Air Station	23	4,081,000
Rifle Range	4	648,000
Courthouse Bay	5	864,000
Onslow Beach	2	250,000
TOTAL CAPACITY	77	16,743,000

Non-Active Systems:

System	No. of Wells	Production Capacity (gpd)
Tarawa Terrace	7	1,152,000
Montford Point	8	622,000
TOTAL CAPACITY	14	1,774,000

3.3.1 Individual Wells

The pumping rates vary considerably for MCB wells, ranging from 50 gpm to more than 480 gpm, and average approximately 170 gpm. The pumping rate for each well is determined individually by adjusting the well drawdown to a level 10 feet above the pump intake. The pumping rate and corresponding pump discharge pressure is given for each well in Table 1.

Individual records of water production from each well are not kept; however, existing records indicate the following operational data concerning water production from wells:

- Daily hours of operation for each well are maintained at each water plant site.
- Daily water input and output records for each water treatment plant are maintained and reported monthly to the State of North Carolina.

- Flow rates for each well are measured on an infrequent basis and are largely based upon measured flow rates at a given line pressure. Therefore, line pressure fluctuations affect the output of water from each well. The line pressure at each wellhead is not routinely measured; therefore, accurate daily performance for each well is not determined.

- A random review of pumping records for individual wells indicates that pumping performance does not vary greatly over a period of several years. Where pumping rates have changed, a physical problem was usually the cause (e.g., well collapse or pump failure).

- Total water usage, and thus production, varies seasonally with the maximum water production occurring in the summer months, peaking normally in June. The minimum water consumption occurs in the winter months, with the lowest consumption occurring in November.

3.3.2 Historical Water Demand

The total water production from all MCB water treatment systems has not varied significantly over the past 10 years, with an average daily usage of 7.5 million gallons. Anticipated base expansion may increase usage if the land expansion entails an increase in troops and facilities. For the purpose of this report no net increase in water production is considered. Any increase of water demand at MCB can be met by the addition of new production wells to current well fields, establishment of new wells field areas or purchase of water from either the City of Jacksonville or the Onslow County water supply.

3.4 Well Construction

More than 160 wells have been constructed under the supervision of the NC Geological Survey, USGS, and MCB for the purpose of monitoring or producing water from the Castle Hayne Aquifer. Typical water supply wells at MCB have an average depth of 160 feet, contain approximately 40 feet of well screen, and are 8 inches in diameter. The wells have an average yield of 175 gpm against varying back-pressures. In general, well production increases from west to east, corresponding with increased aquifer thickness and transmissivity. Details on the construction of most water supply wells are presented in Appendix A. As of 1992, the average age of MCB wells is approximately 25 years. Figure 9 shows the distribution of wells by age of 83% of the existing wells. The age of the remaining 17% of wells is unknown and thus were not reported in this figure. This figure illustrates that a high percentage (>30%) of the wells are greater than 50 years in age.

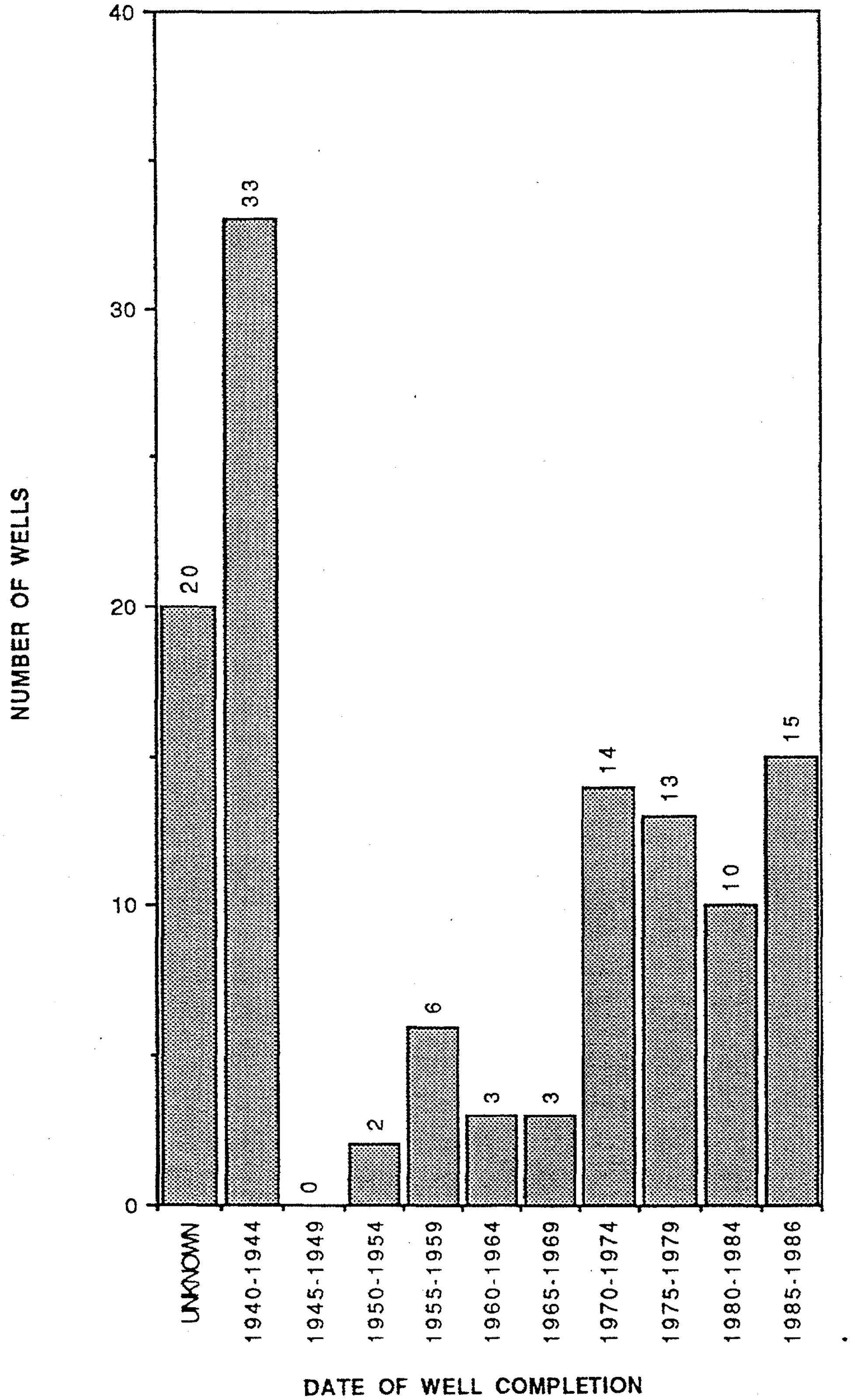

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Figure 9. Distribution of Date-of-Well Completion Versus Cummulative Percent of 83% of MCB Water Wells.

Most of MCB wells are considered to be partially penetrating or partially screened wells; they are developed in only a portion of the total aquifer thickness. USGS studies (Harned, and others, 1989) indicate most of the wells have uncharacteristically low yields given the known hydrologic properties of the Castle Hayne Aquifer. The most plausible explanation for the wells yields is poor well design. The USGS (Harned and others, 1989) calculated the specific yield of most MCB wells to be approximately one-sixth of expected values calculated from projected aquifer transmissivity. Since MCB wells average 6.3 (gal/min)/ft, (ranging from 2.2 to 12.2 (gal/min)/ft), the USGS calculation suggests a specific capacity of approximately 35 (gal/min)/ft might be achieved if the wells were fully screened and fully penetrated the aquifer.

3.4.1 General Well Construction Standards

Camp Lejeune water wells were constructed using private drilling contractors which are selected by competitive bids. The most current well specifications used in the bid selection process are presented in Appendix B. A review of the existing and proposed draft state well construction regulations [North Carolina Administrative Code (NCAC) Title 15 Chapter 2, Subchapter 2C, Section .0100)] indicate the MCB well design specifications meet or exceed all state requirements. Additional regulations concerning well placement or location of water supply wells are described in the NCAC Title 15A, Subchapter 18C, Sections .0100 through .2000.

Minimum requirements for specifications of wells supplying community water systems are established by the North Carolina Division of Environmental Health. Department of Environment, Health, and Natural Resources provides additional guidelines for design of water systems (NCAC Title 15A, Subchapter 18 C, Sections .0400 - .1000). These minimum standards provide for the construction and location of wells within the system. A copy of the regulations is included in Appendix C.

3.4.2 Water Supply Construction Standards

Figure 10 is a flow diagram from EPA's guidance manual for compliance with the filtration and disinfection requirements for public water supplies using surface water sources (EPA, 1991). The recommended method of determination of public water supplies influenced by surface waters is followed by the North Carolina Public Water Supply, Division of Environmental Health to determine if a water source is subject to the requirements of the Surface Water Treatment Regulations (source: Mr. Fred Hill, NC DEHNR, Washington Regional Office, Washington, NC). The following source evaluation protocol is followed.

1. A review of the records of the systems sources to determine whether any of the water sources are stored or come from uncovered ponds or other surface water.

2. If the source is a well, determination of whether it is clearly a groundwater source, or whether further analysis is needed to determine possible direct surface water influence.

Regulations affecting the classification of water supply systems as systems affected by surface waters have changed significantly during the past year, and merit some discussion at this time. The current definition of surface water system applies to those water systems where any of the water supply is from surface water sources. Beginning in July of 1993, the definition of surface water systems will be expanded to include those systems having any wells that are influenced in any way by surface waters. The State of North Carolina has currently adopted the following EPA criteria (EPA, 1991) to determine if any wells might be considered under the influence of surface waters.

- The well is located within 200 feet of any permanent surface stream, lake, or drainage feature.

- The uppermost screen or groundwater intake point in the well is less than 50 feet from the surface.

If either of the above conditions are met then the system may qualify to be a surface-water supplied system. All well construction records for currently active wells were reviewed in this study to determine if they might be under the direct influence of surface waters using the 1993 regulations. All MCB wells are clearly exempt except for those wells listed in Table 4.

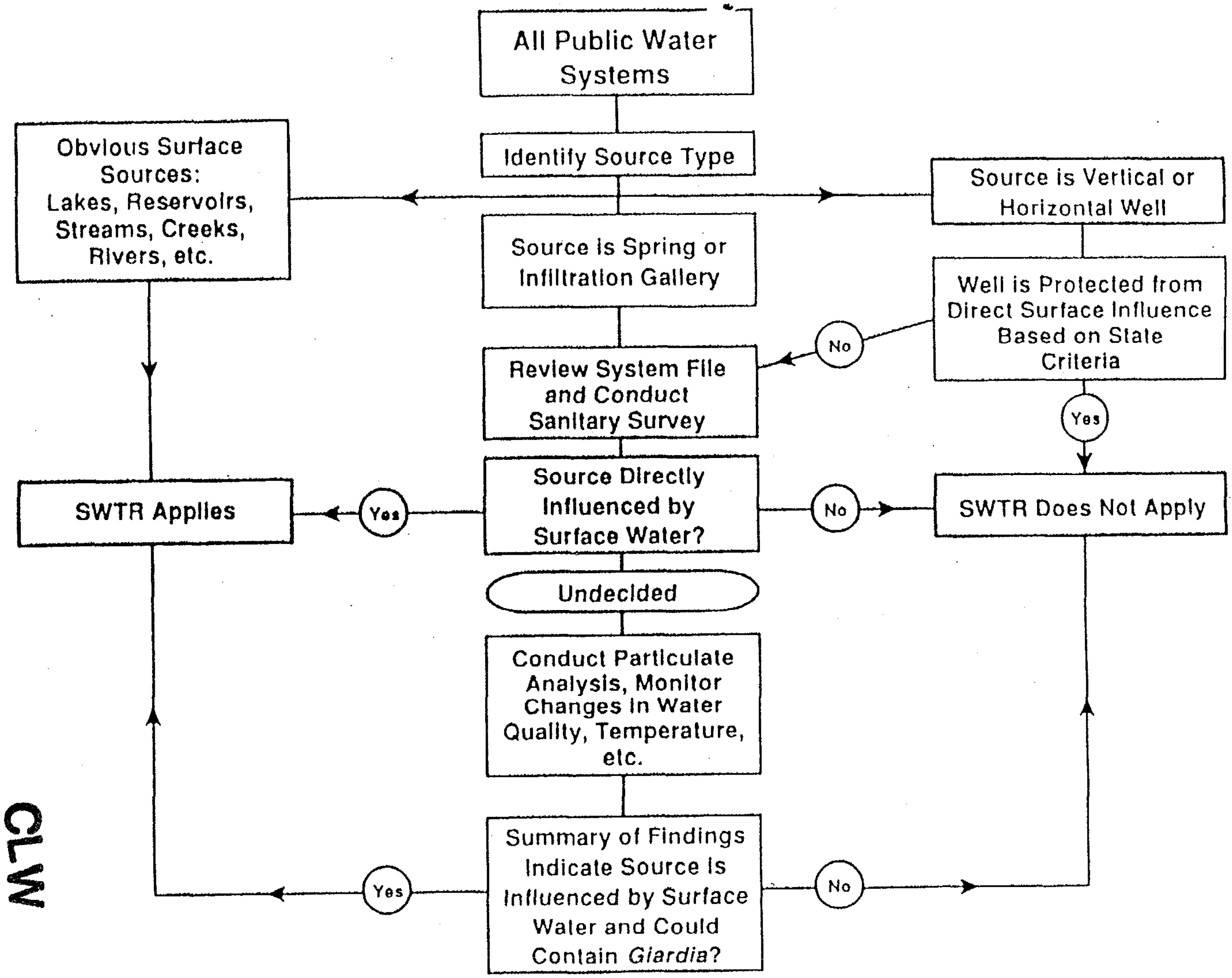

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Figure 10. EPA Flow Diagram Illustrating The Method of Determining If A Water Treatment System is Affected by SWTR.(from EPA, 1991)

Table 4. Listing of Wells Suspect of Surface Water Influence (Using EPA SWTR Criteria)

WELL NUMBER	EXPLANATION
BB-43	top ofwell screen at 30 feet.
BB-44*	top of well screen at 32 feet
BB-45	top of well screen at 45 feet
HP-601	top of well screen at 45 feet
M-168	top of well screen at 46 feet
M-628	top of well screen at 43 feet
RR-97	top of well screen at 47 feet
TC-201	top of well screen at 46 feet
TC-202	top of well screen at 35 feet
TC-600*	top of well screen at 48 feet
TC-604*	top of well screen at 45 feet
TC-700*	top of well screen at 27.5 feet
TC-901	top of well screen at 46 feet
TT-53	top of well screen at 45 feet

* Denotes wells currently in use or may be utilized for drinking water supply. Drill hole logs from all of the noted wells have been reviewed and indicate the presence of a confining unit overlying the water producing zone. The presence of a clayey unit overlying the aquifer prevents intermingling of drinking water with surface influenced waters. Thus, these wells are not considered to be under the direct influence of surface waters.

Of the wells listed in Table 4, BB-44, TC-600, TC-604, TC-700, and RR-97 are currently in service. Well RR-97, located at the Rifle Range, will be removed from the drinking water supply once Onslow County supplies the Rifle Range with water and the Rifle Range treatment facility is closed.. A review of the drill logs from the remaining wells (BB-44, TC-600, TC-604, TC-700) indicates the presence of confining units above the shallow screened intervals, thus the wells would not likely be affected by surface waters, and should not be considered as being under the influence of surface waters.

3.5 Water Quality Monitoring

Water quality analysis under the EPA Primary and Secondary Drinking Water Standards (EPA, 40 CFR Parts 141, 142 and 143, 1991) are required by MCB prior to the acceptance of new wells into the water supply system. These analyses are, for the most part, the only complete water analyses avaliable for each well.

About half of these analyses were conducted more than 30 years ago (based on a review of MCB well completion records), and thus may not accurately represent the quality of water presently being produced.

Currently, 15 water wells are out-of-service due to various levels of contamination. Past use of water from these wells has resulted in degraded water quality supplied to the water treatment plants, resulting in unacceptable levels of certain contaminants in drinking water supplied to MCB. Wells located at Hadnot Point, Holcomb Boulevard, New River Air Station, Rifle Range and Tarawa Terrace all have shown low-level contamination by various VOCs (source: MCB Environmental Lab) (Figure 11).

- Hadnot Point Wells: HP-602 HP-608, HP-634, HP-637, HP-651, HP-652, HP-653, and HP-660 (TCE present);
- Holcomb Boulevard Well: HP-645 (Benzene present);
- Tarawa Terrace Wells: TT-23, TT-25, and TT-26;
- Rifle Range Well: RR-229 (TCE present); and
- MCAS Wells: AS-106 and AS-4150 (DCE and TCE present).

Although the source of contamination for most of the above "hit" wells has not been determined, the types of contaminant can be often related to a nearby user or disposal site (Environmental Science and Engineering, Inc., 1990, 1991). Additional hits to MCB water supply wells may occur if contaminant plumes spread and find their way from contaminant sources to the Castle Hayne Aquifer via the surficial aquifer.

4.0 Regulatory Compliance (Statutory Framework)

4.1 Federal Regulations

The Safe Drinking Water Act of 1986 mandates that each State establish WHP Programs. The EPA WHP Program (EPA, 1990) established the following mininmum requirements for a wellhead protection program.

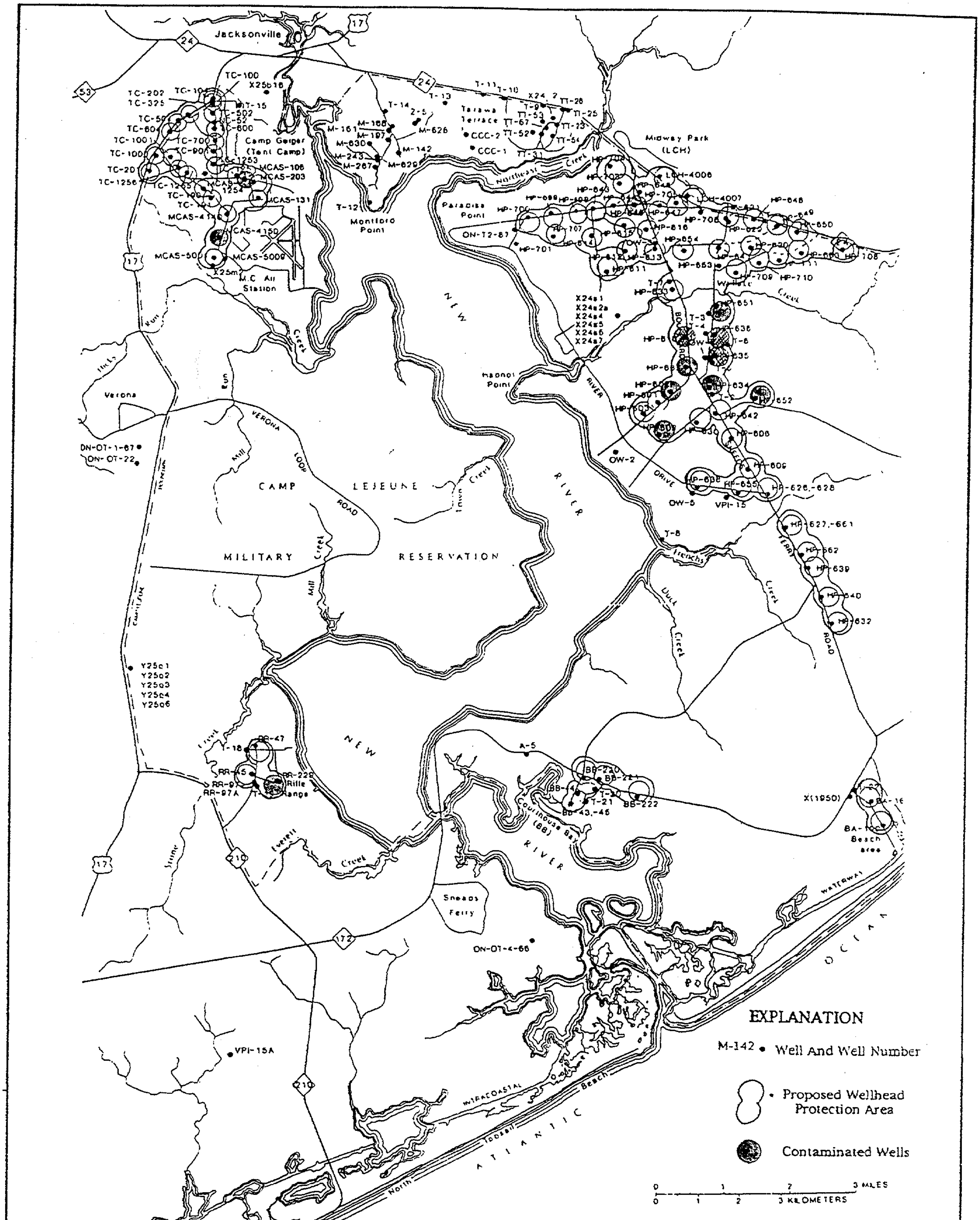

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Figure 11. Location of Wells Sited Near Potential Contamination Sources.

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- Delineate wellhead protection areas for each well or wellfield;
- Identify sources of contaminants within each wellhead protection area (WPA);
- Develop management approaches to protect the water supply with WPAs from these contaminants;
- Develop contingency plans for each drinking water supply in the event of well contamination; and
- Locate new wells properly to minimize potential contamination.

4.2 State Regulations and Compliance

North Carolina is scheduled to submit draft regulations for wellhead protection for review by EPA in June, 1992. A draft copy of the State plan was presented to MCB Environmental Management Division in November, 1991 by Geophex. Under the State plan, WHP will be administered on a county by county basis. Some NC counties have already established wellhead protection policies through land-use zoning or establishment of Areas of Environmental Concern (AEC). Managers of Onslow County and Jacksonville City water systems (personal communication, November 1991) indicated that they were in contact with local planning boards to ear mark areas for wellhead protection. Most likely, only Onslow County will enact a WHP Program because all of the city and county wells fall under the jurisdiction of the county. According to Mr. Carl Bailey of NC DEM (Raleigh), civil WPA designations can project beyond county or city jurisdiction into Military Reservations, such as MCB. The county WPAs will most likely be located north and west of Jacksonville where the Onslow County and the City of Jacksonville operate approximately 19 water supply wells in the Cretaceous Aquifers. The establishment of WPA in this region will have no impact on the operation of MCB water supply system. However, Onslow County proposes water supply development within the Castle Hayne Aquifer at Hubert and Folkstone (personal communication, Mr. Bill Harvey, Manager of Onlsow County Water). The development of wells at Hubert may affect the development of MCB wells along NC Highway 24. Presently, the exact location and size of the county wellfield is not known; thus, the immediate impact upon MCB wellfields cannot be assessed.

4.2.1 Well Construction Standards

New regulations concerning well construction are under review by NC DEM, Groundwater Division, and are expected to be effective September 1, 1992 (NC DEM Draft Well Construction Standards, Groundwater Division, Raleigh, NC). A preliminary review of the proposed North Carolina Well Construction Standards by Geophex concludes no adverse impact on existing MCB wellfields. A copy of the draft well construction standards (NCGS 15A NCAC 2C .0101-.0103, .0105, .0107-.0114, .0116, .0118-.0119, 2L .0107) are included in Appendix D.

4.2.2 Contaminant Sources and Well Location

Existing North Carolina Well Construction Standards (NCAC Title 15, Subchapter 2C, Section .0100) prohibit the construction of wells within 100 feet of any potential contaminant, including sewers and septic tanks, fuel and chemical storage.

4.3 Level of Protection Criteria for Drinking Water

The Safe Drinking Water Act of 1986, established a timetable for EPA to set maximum contamination limits (MCL) for 83 specific contaminants. At the same time MCLs are set, EPA is to establish MCL goals (MCLGs). The MCLGs are non-enforceable health goals set at levels that cause no adverse effects to humans. These primary drinking water standards are not required to be tested at each wellhead. However, individual wellhead analysis is desireable in order to identify sources of non-compliance. The primary drinking water standards are presented in Table 5.

A secondary set of drinking water standards were also established to assure suitability of drinking water. The secondary drinking water standards, presented in Table 6, deal with factors controlling taste, odor, color, and certain other non-aesthetic factors.

The primary and secondary drinking water standards are updated as needed, but generally are revised every three years.

Table 5. EPA Primary Drinking Water Standards (from EPA, 1991)

Contaminants	Health Effects	MCL[1]	Sources
Microbiological			
Total Coliforms (Coliform bacteria, fecal coliform, streptococcal, and other bacteria)	Not necessarily disease producing themselves, but can be indicators of organisms that cause assorted gastroenteric infections, dysentery, hepatitis, typhoid fever, cholera, and others: also interfere with disinfection process.	1 per 100 milliliters	human and animal fecal matter
Turbidity	Interferes with disinfection	1 to 5 NTU	erosion, runoff, and discharges
Inorganic Chemicals			
Arsenic	Dermal and nervous system toxicity effects	.05	geological, pesticide residues, industrial waste and smelter operations
Barium	Circulatory system effects	1	
Cadmium	Kidney effects	.01	geological, mining and smelting
Chromium	Liver/kidney effects	.05	
Lead	Central and peripheral nervous system damage: highly toxic to infants and pregnant women	.05[2]	leaches from lead pipes and lead-based solder pipe joints
Mercury	Central nervous system disorders: kidney effects	.002	used in manufacture of paint, paper, vinyl chloride, used in fungicides, and geological
Nitrate	Methemoglobinemia ("blue-baby syndrome")	10	fertilizer, sewage, feedlots, geological
Selenium	Gastrointestinal effects	.01	geological, mining
Silver	Skin discoloration (Argyria)	.05	geological, mining
Fluoride	Skeletal damage	4	geological, additive to drinking water, toothpaste, foods processed with fluorinated water
Organic Chemicals			
Endrin	Nervous system/kidney effects	.0002	insecticide used on cotton, small grains, orchards (cancelled)
Lindane	Nervous system/kidney effects	.004	insecticide used on seed and soil treatments, foliage application, wood protection

1 In milligrams per liter, unless otherwise noted.
2 Agency considering substantially lower number.

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Table 5 - Continued

Contaminants	Health Effects	MCL[1]	Sources
Radionuclides			
Gross alpha particle activity	Cancer	15 pCi/L	radioactive waste, uranium deposits
Gross beta particle activity	Cancer	4 mrem/yr	radioactive waste, uranium deposits
Radium 226 & 228 (total)	Bone cancer	5 pCi/L	radioactive waste, geological
Other Substances			
Sodium	Possible increase in blood pressure in susceptible individuals	None (20 mg/l reporting level)	geological, road salting

1 In milligrams per liter, unless otherwise noted.

Table 5 - Continued

Contaminants	Health Effects	MCL[1]	Sources
Methoxychlor	Nervous system/kidney effects	.1	insecticide used on fruit trees, vegetables
2.4-D	Liver/kidney effects	.1	herbicide used to control broad-leaf weeds in agriculture, used on forests, range, pastures, and aquatic environments
2.4.5-TP Silvex	Liver/kidney effects	.01	herbicide (cancelled in 1984)
Toxaphene	Cancer risk	.005	insecticide used on cotton, corn, grain
Benzene	Cancer	.005	fuel (leaking tanks), solvent commonly used in manufacture of industrial chemicals, pharmaceuticals, pesticides, paints and plastics
Carbon tetrachloride	Possible cancer	.005	common in cleaning agents, industrial wastes from manufacture of coolants
p-Dichlorobenzene	Possible cancer	.075	used in insecticides, moth balls, air deodorizers
1.2-Dichloroethane	Possible cancer	.005	used in manufacture of insecticides, gasoline
1.1-Dichloroethylene	Liver/kidney effects	.007	used in manufacture of plastics, dyes, perfumes, paints SOCs
1.1.1-Trichloroethane	Nervous system problems	.2	used in manufacture of food wrappings, synthetic fibers
Trichloroethylene (TCE)	Possible cancer	.005	waste from disposal of dry cleaning materials and manufacture of pesticides, paints, waxes and varnishes, paint stripper, metal degreaser
Vinyl Chloride	Cancer risk	.002	polyvinylchloride pipes and solvents used to join them, waste from manufacturing plastics and synthetic rubber
Total trihalomethanes (TTHM) (chloroform, bromoform, bromo-dichloromethane, dibromochloromethane	Cancer risk	.1	primarily formed when surface water containing organic matter is treated with chlorine

[1] In milligrams per liter, unless otherwise noted

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Table 6. EPA Secondary Drinking Water Standards (from EPA, 1991)

Contaminants	Suggested Levels	Contaminant Effects
pH	6.5 -8.5	Water is too corrosive
Chloride	250 mg/l	Taste and corrosion of pipes
Copper	1 mg/l	Taste and staining of porcelain
Foaming agents	0.5 mg/l	Aesthetic
Sulfate	250 mg/l	Taste and laxative effects
Total dissolved solids (hardness)	500 mg/l	Taste and possible relation blow hardness and cardiovascular disease; also an indicator or corrosivity (related to lead levels in water); can damage plumbing and limit effectiveness of soaps and detergents
Zinc	5 mg/l	Taste
Fluoride	2.0 mg/l	Dental flourishes (a brownish discoloration of the teeth)
Color	15 color units	Aesthetic
Corrosivity	non-corrosive	Aesthetic and health related (Corrosive water can leach pipe materials, such as lead, into drinking water.)
Iron	0.3 mg/l	Taste and staining of laundry
Manganese	0.05 mg/l	Taste and staining of laundry
Odor	3 threshold odor number	Aesthetic

Secondary Drinking Water Standards are unenforceable federal guidelines regarding the taste, odor, color - and certain other non-aesthetic effects - of drinking water. EPA recommends them to the States as reasonable goals, but Federal law does not require water systems to comply with them. States may, however, adopt their own enforceable regulations governing these concerns. To be safe, check your State's drinking water rules.

5.0 Wellhead Protection Program

Minimum requirements for WHP Programs were established by the EPA as a result of the 1986 Safe Drinking Water Act (SDWA). As a minimum, the SDWA requires each state's WHP to:

- Specify the roles of state and local governments and public water suppliers;
- Delineate wellhead protection areas for each well or wellfield;
- Identify sources of contaminants within each WHP area;
- Develop management approaches to protect the water supply within WHP areas from those contaminants;
- Develop contingency plans for each public water supply system in the event of well or wellfield contamination;
- Locate new wells properly to minimize potential contamination; and
- Ensure public participation in WHP program development.

Because these requirements were set up for state and local authorities, the first and last requirements would not necessarily apply to MCB. However, it is important that MCB participate at the local level when and if local WPAs are formulated.

5.1 Delineation of MCB Wellhead Protection Area

Prior to the introduction of the Wellhead Protection Programs by the EPA in 1986, the term "wellhead" was applied to the above-ground physical structure of the well, including piping and valves.

The EPA redefined the term "wellhead" to include the surface and subsurface within which contaminants are likely to move to a water-supply well or well field, and thus refers to "the surface and subsurface area surrounding a water well or well field, supplying a public water system, through which contaminants are likely to move toward and reach such water well or well field" (US EPA, 1987, p. 1-2).

The EPA recognized that the source of water for all wells ultimately comes from infiltration by surface water into the water table aquifer as it passes across the land surface and through the soil zone.
Consequently, the condition of the soil and shallow subsurface materials greatly affects the quality of water found in the water table aquifer. Surface spills of chemicals and petroleum products may eventually migrate into the groundwater system and later show up in drinking water.

The purpose of a WPA program is to delineate the area where primary infiltration occurs and, through some plan, regulate or control the release of substances within this zone. Substance control methods suggested by the EPA include: (1) land-use planning within the WPA, (2) zoning, or (3) some other method of restrainment. EPA and the State of North Carolina intended to have local governments manage wellhead protection policy through restriction of certain development activities within the WPA (NC Wellhead Protection Program, Draft Document, 1991). During the process of establishing a WPA at MCB, an inventory of existing potential contamination sources was completed by Geophex. Based on the results of this survey, several groupings of wells were found to be located within a 10-year zone of travel (ZOT) of potential contaminant sources (Figure 15).

Under the WMP, one of three following options are suggested to protect the wellhead area: (1) abandon the well, (2) move the potential contamination source to an area outside of the WPA, or (3) create a monitoring program designed to detect the potential contamination in the event of a leak.

If the monitoring alternative is selected, the frequency of monitoring should be determined by the location of the potential contamination with respect to the well (EPA, 570/9-91-008).

The protection goals proposed by Geophex for MCB are similar to the goals suggested by EPA and NC DEM, and include one or more of the following elements.

1. Provide a zone of protection around wells or well fields that affords adequate time to react to incidents of unexpected contamination. The "Time of Travel" protection strategy is based upon the time necessary to identify and cleanup contaminants before they reach a well. This goal is accomplished by delineating a protection area large enough to attenuate potential contaminants to target levels.

2. Protecting all or part of the zone of contribution from contamination by prohibiting threatening activities to take place in defined zones surrounding the wells. This is a form of zoning or land-use planning.

5.1.1 Strategy for Establishment of WPA at MCB

The EPA (EPA 1987) proposed five criteria to be used as a basis for establishing the zone of protection surrounding wells or well fields. These criteria are, in part, based upon the hydrodynamics of the aquifer system, and are described in the following sections.

- Distance

  North Carolina regulations (NCAC Title 15 Subchapter 2C Section .0100) currently employ a fixed radius concept where no public water-supply well may be constructed within 100 feet of any sewer or septic system. The EPA recommends the use of distance criteria only as a temporary measure until a better-founded basis can be established following a more complete analysis. To determine minimum required distance between a well and a sewer or septic system, a circle with an arbitrary fixed radius is drawn around each well. The radius of the circle may or may not have any relationship to pumping rates, aquifer conditions, or topographic position.

- Drawdown

  The areal extent over which drawdown occurs within an aquifer due to withdrawals from wells is commonly referred to as the zone of influence, or the cone of depression.
  In a region where regional gradient is negligible, the extent of the cone of depression coincides with the area of downward leakage and is generally circular in shape. Regional gradients tend to complicate the shape of the zone of influence by stretching the circle into an ellipse up-gradient from the well. The extent of the stretch is determined by the rate of regional groundwater flow. In this case the hydraulic potential for vertical leakage decreases rapidly away from the well. However, vertical leakage may be less than the potential if the confining unit is considered "tight." Vertical leakage into the Castle Hayne Aquifer can be accelerated by a lack of a "tight" confining unit and/or vertical geologic structures including ancient stream channels, and man-made structures such as deep ditches and poorly constructed water and monitor wells.

- Time of Travel

  The time-of-travel criterion is used to establish the time for groundwater or hypothetical contaminant to flow from a point of interest (or concern) to a well. A collection of common travel times define an isochron (contours of equal time) wherein a ZOT is established.

  ZOT provide a graphic representation of the extent of areas that would be included in a particular well or well field's zone of capture for a given time interval. Such a representation is useful in establishing the minimum acceptable distance in which a well should be located with respect to potential contaminants. The minimum acceptable distance is, in part, determined by the type of potential contaminant and the speed and effectiveness with which they can be detected, contained, and removed from the nearest WPA.

- Flow Boundaries

  Hydrogeologic mapping is utilized to establish hydrogeologic boundaries, including such natural physical boundaries such as rivers, groundwater divides, and man-induced boundaries such as those created by pumping wells. Hydrologic mapping can be useful where these boundary conditions can be clearly defined, for example, in the Piedmont and mountain regions. In the case of MCB, because the relief is low, groundwater divides are poorly defined, thus the extent of the a hydrologic cell cannot be accurately mapped.

- Assimilative Capacity

  The assimilative capacity refers to the concept that contaminants are assimilated as they pass through the saturated and/or unsaturated section of an aquifer. The extent of assimilation can be quite variable and largely depends on the mineral composition of the soils, the chemical characteristics of the aquifer, and the composition of the contaminant. Because the assimilative capacity of the water table aquifer and the Castle Hayne Aquifer is not known, it is not considered in this plan. Eliminating this factor promotes a more conservative approach to defining WPAs.

For the reasons cited below the following criterion were determined to be an inappropriate basis to found the MCB WPA Plan upon:

- The use of distance criterion would not adequately or accurately characterize the true aquifer recharge zone.
- Use of flow-boundary criterion is not used because groundwater divides in a confined and semi-confined aquifer in low relief areas such as MCB are difficult to define.
- Assimilative capacity is too poorly understood to be considered a valid option, and its exclusion only assures that the criterion employed is somewhat conservative.

- The drawdown method is not utilized because the zone of contribution surrounding a well field given a long periods of pumping can be unrealistically large and unmanageable. In addition, sufficient hydrogeologic information is not currently available to adequately describe drawdown at MCB given the complex nature of the existing well field and pumping scenarios.

Therefore, we recommend utilizing the time-of-travel criterion as the primary basis for establishing the MCB WPA. Utilization of the time of travel criterion requires the calculation of an appropriate ZOT around each well based upon know or assumed geologic and hydrologic conditions, a inventory of known contaminants or potential contaminants within the ZOT and the establishment of a routine monitoring system that is designed to detect the presense of contaminants within the ZOT.

5.1.2 Establishment of Time of Travel WHP

In an effort to standardize MCB's wellhead protection program to a format developed by the EPA, the reverse-path calculation method was employed using EPA's Wellhead Protection Area computer program, version 2.0 (Blanford and Huyokorn, 1991). This public domain software package has been installed on computer located at EMD, along with the two model simulations run by Geophex to determine the ZOTs used at MCB. Because this computer simulation is sensitive to pumping rates, aquifer transmissivity, and regional groundwater flow patterns, it is not currently possible to adequately model all MCB wells simultaneously. As an alternative, a template ZOT was generated for the different hydrogeologic conditions found: (1) in the vicinity of Holcomb Boulevard and Hadnot Point, and (2) at Camp Geiger and MCAS. Hydrogeologic input data for the Blanford and Huyokorn models were obtained from the existing USGS publication (Harned and others, 1989) and MCB well logs (Holcomb Boulevard Water Treatment Facility), and are summarized in Table 7.

The results of the Holcomb-Hadnot Point and MCAS simulations are presented in Figures 12 and 13 as steady-state, 5-, 10-, and 25-year time-related capture zones. The approximate limits and areas of each ZOT are shown in Table 8.

Table 7. Input to WHPA-MWCAP Model (Version 2.0)

Parameter Simulation Options	Holcomb Boulevard and Hadnot Point	MCAS
Units (feet and days)		
Step Length	50	50
XMIN (feet)	0	0
XMAX (feet)	10,000	10,000
YMIN (feet)	0	0
YMAX (feet)	10,000	10,000
Number of Wells	1	1
Location X (feet)	6,000	6,000
Location Y (feet)	5,000	5,000
Pumping rate (cubic ft/day)	57,754	30,802
Transmissivity	15,000	8,000
Regional slope	0.001	0.001
Orientation (degrees)	0	0
effective porosity	0.25	0.25
number of pathlines	20	20
boundary conditions	none	none
mode of calculation	Time-Related	Time-Related
Capture zone plotted	yes	yes

Zone Of Travel for Holcomb Boulevard-Hadnot Point Onslow Beach, and Rifle Range Wells

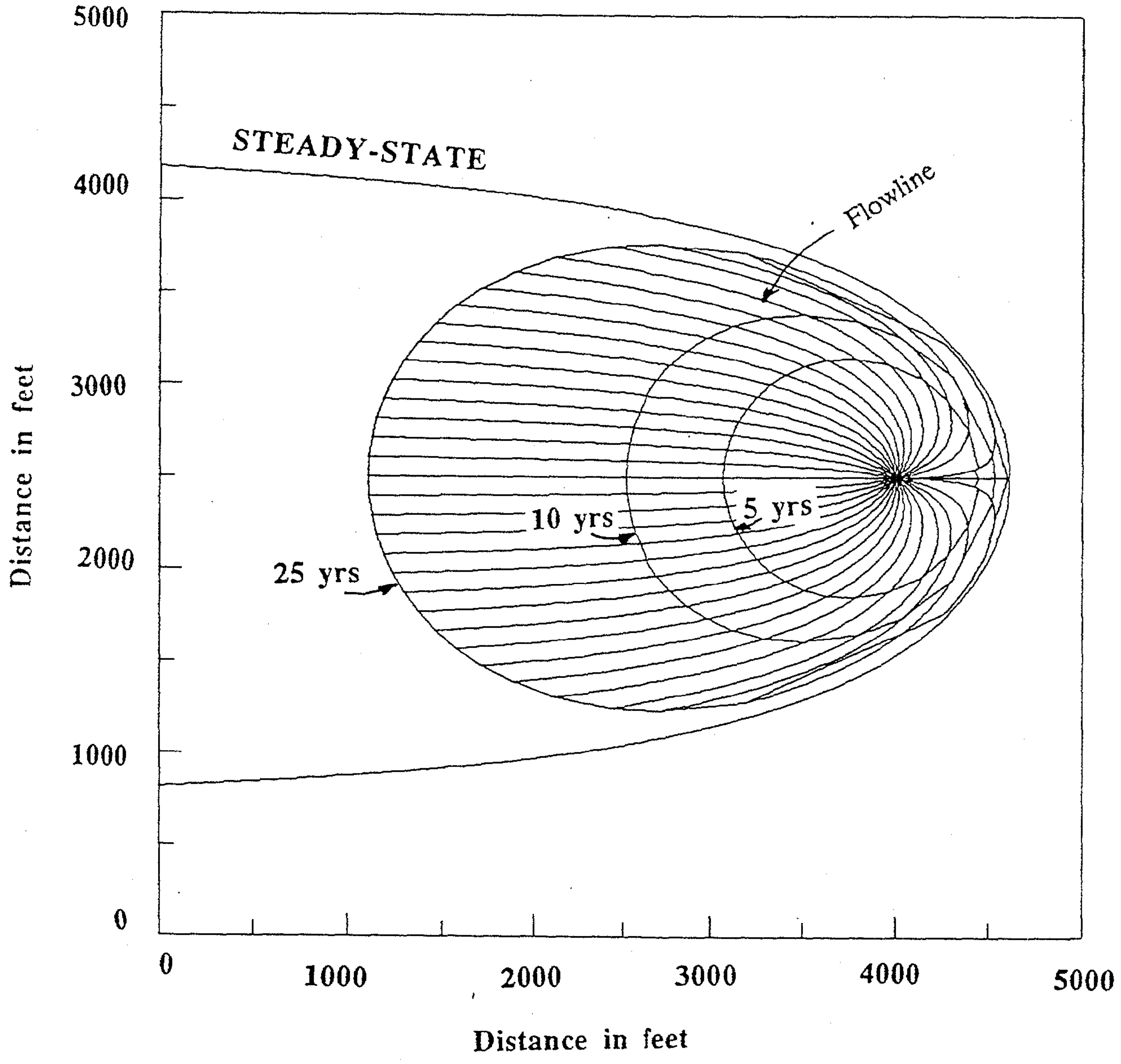

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Figure 12. Steady-State, 5-, 10-, and 25-Year, Zone of Travel (ZOT) For Typical Holcomb Boulevard-Hadnot Point, Onslow Beach, and Rifle Range Wells.

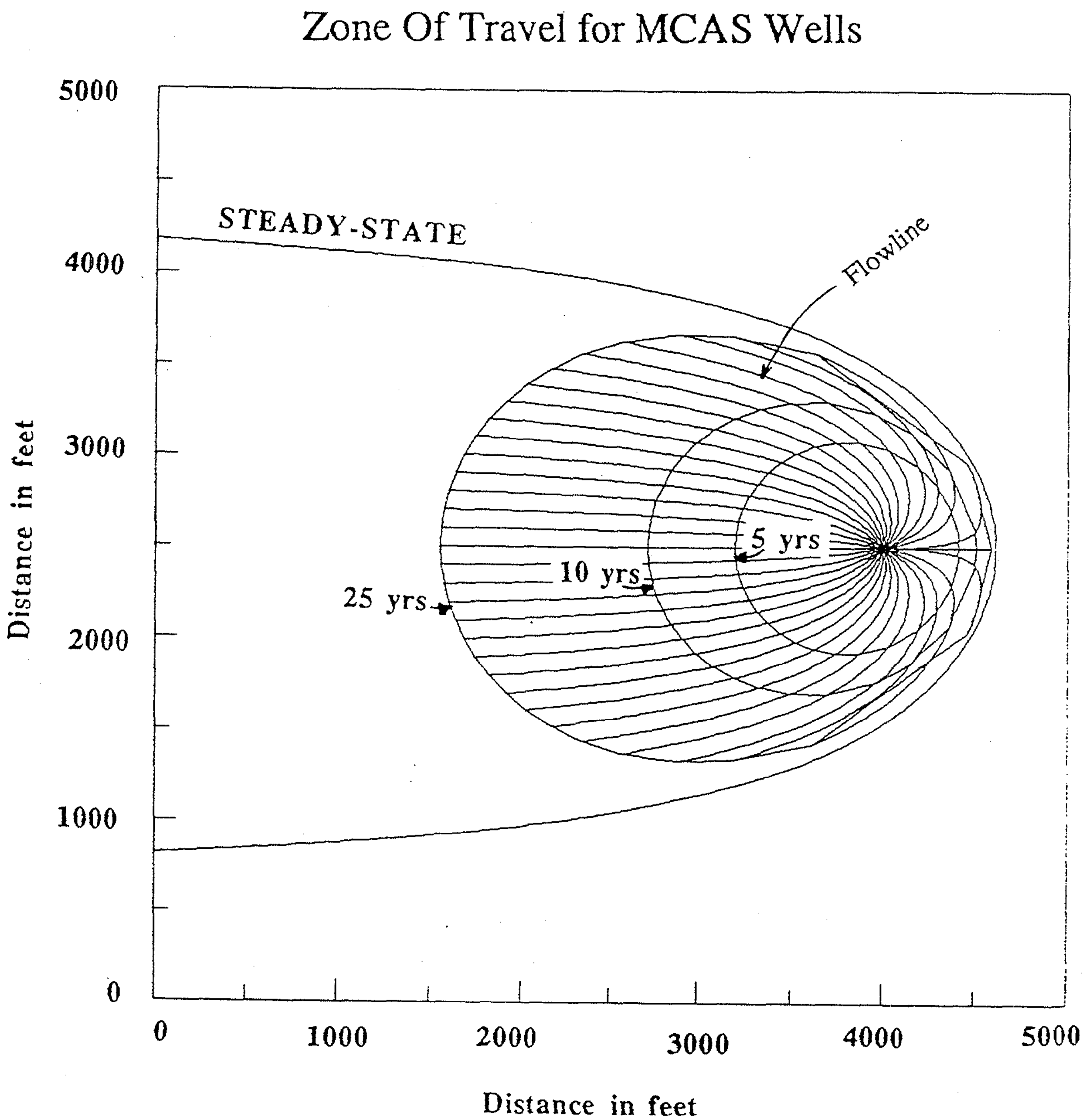

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Figure 13. Steady-State, 5-, 10-, And 25-Year, Zone of Travel (ZOT) for Typical MCAS Wells.

Table 8. Estimated Zone of Travel (ZOT) for Holcomb Boulevard-Hadnot Point and MCAS.

Location	Holcomb Boulevard -Hadnot Point	MCAS
Calculated 5 Year ZOT dimension:		
Length (feet)	1,350	1,100
Width (feet)	1,250	950
Approximate area (acres)	31	19
Calculated 10 Year ZOT dimension:		
Length (feet)	2,100	1,400
Width (feet)	1,700	1,350
Approximate area (acres)	65	34
Calculated 25 Year ZOT dimension:		
Length (feet)	3,200	2,600
Width (feet)	2,350	2,150
Approximate area (acres)	139	102

As an example, the 10-year ZOT for MCAS is elliptical in shape, approximately 1,400 x 1,350 feet in dimension and covers an area of 34 acres. In comparison, the 10-year ZOT for Holcomb-Hadnot Point is larger, measuring 2,100 x 1,700 feet and covering 65 acres. The 10-year ZOT is proposed because: (1) the 5-year ZOT does not provide adequate time for EMD to discover, conduct an RI, and then complete rehabilitative action, and (2) the 25-year ZOT consumes too much area and, at least for MCB planning purposes, is too conservative. The 10-year ZOT is proposed for MCB because it provides adequate time for discovery and clean-up of accidental contamination events, or will permit adequate time to install new wells if clean-up is not feasible.

The MCB WPA map (Figure 14) was compiled by appropriately orienting the 10-year ZOT template over each well location, and then circumscribing an inclusive boundary line around groups of wells that make up a well cluster. The composite of all ZOTs describes the 10-year WPA.

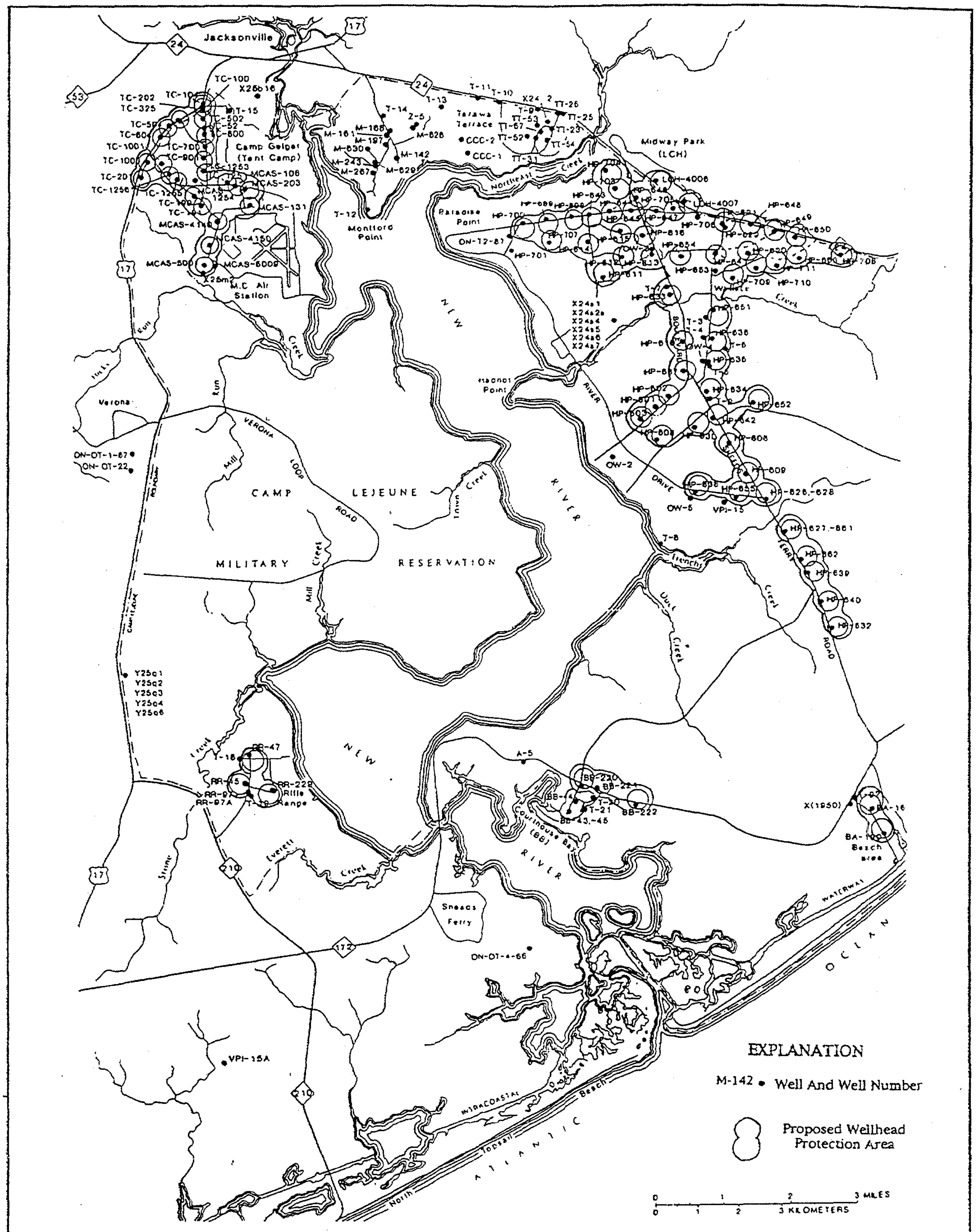

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Figure 14. Proposed Wellhead Protection Areas for all Active Wellfields at MCB.

A comparison of the 10-year WPA map and the location of potential contamination sources shows that approximately one-third of MCB wells (including MCAS) are located such that potential contamination sources fall within their 10-year WPA. Two AOCs, located at the HPIA and MCAS, contain wells that have already been contaminated (Figure 15).

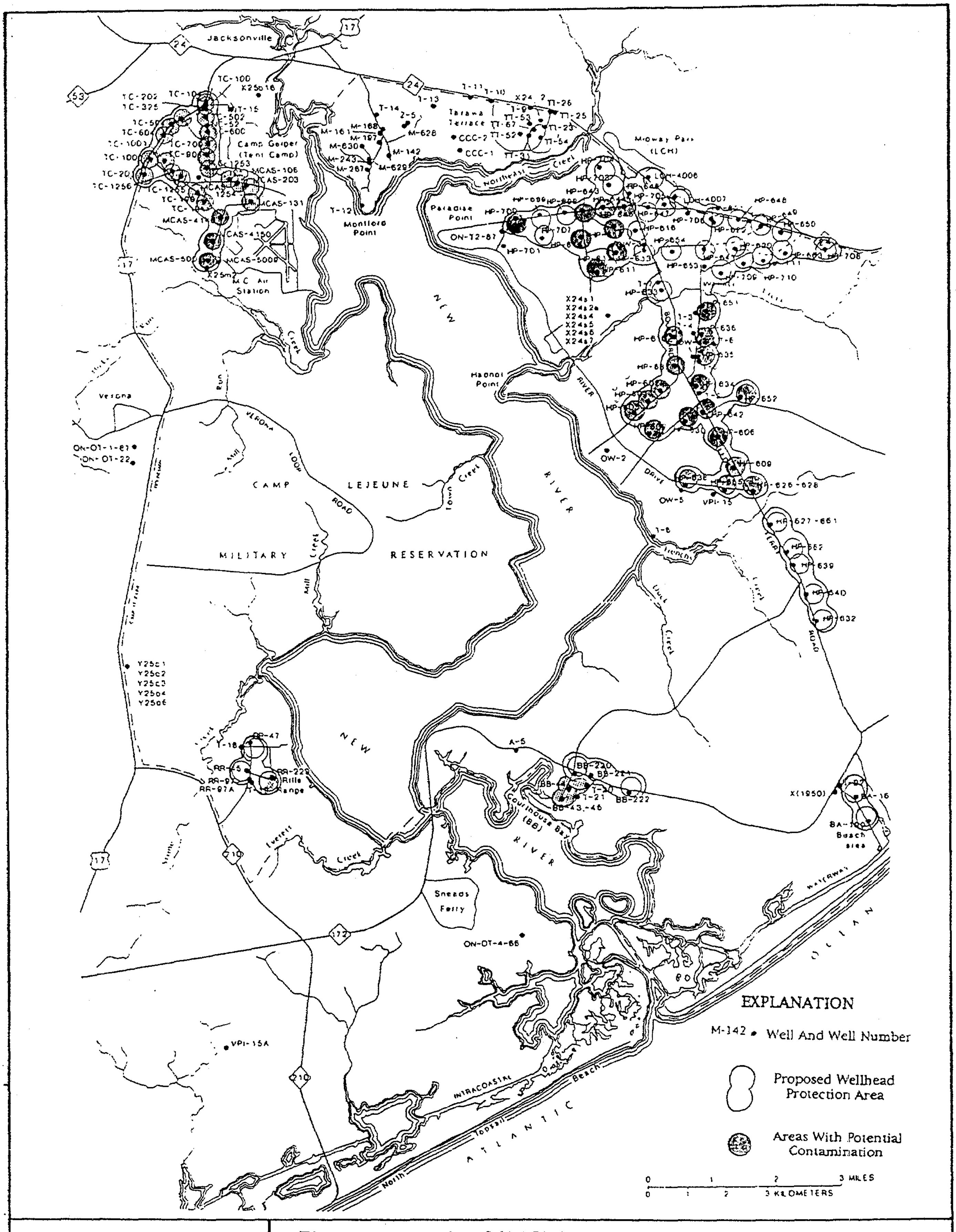
5.2 Potential On-Site Contamination Sources

Groundwater contamination is related to numerous activities at MCB and can be classified into the following categories: (1) oil pollution and hazardous substances, (2) leaking underground storage tanks, (3) waste management activities (e.g., land fills, surface impoundments, waste piles), (4) certain industrial activities (e.g., vehicle maintenance, metal fabrication, machine shops, etc.), and (5) surface water runoff from contaminated areas, including roads and parking lots.

In addition, MCB conducts various military training activities which have an unknown impact on regional groundwater quality. Related training activities include: (1) bombing and/or shelling of targets in G-10, K-2 and 1/BT-3 Impact Areas, (2) abandonment of unexploded ordnance in various training areas, and (3) logistic operations involving ammunition and/or weapons at various storage sites..

An inventory of potential on-site contamination sources supplied by MCB was reviewed. In general, these contamination sources include the following.

- Twenty-two sites where groundwater and/or soils have been contaminated and remedial investigations (RI) have or are being conducted. An inventory of these sites was prepared by Environmental Science and Engineering, Inc. (1990) for MCB and serves as a reference to all RI's considered in this study.
- Active solid waste disposal areas, including land fills and burn areas;
- Stormwater run-off;
- Chemical usage and storage;
- Underground petroleum storage, and
- Military training activities.



Geophex	Figure 15. Location Of MCB Wellfields and areas with Potential Contamination That Fall within the 10-Year Zone of Travel (ZOT).

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5.2.1 Underground Petroleum Storage

A inventory of approximately 458 underground storage tanks (USTs) was completed by Geraghty and Miller, Inc in 1989. EMD provided Geophex with a copy of the Geraghty and Miller tank locations. A shortened version of these data are presented in Appendix E. According to EMD, the Geraghty and Miller inventory of approximately 458 USTs represents only a portion of the total USTs located at MCB. Most of these USTs are associated with a building or service site provided by MCB, and are generally found within developed regions of the base. MCB currently is bringing all USTs up to compliance with current NC UST requirements for underground storge tanks (NCGS 143-215.94). An additional 1705 USTs were suspected to have existed and presumeably abandoned by removing the contents and filling with sand. Many of these USTs were associated with individual dwellings and duplexs supplied by MCB for military personnel and dependents. Because the extent of contamination, if any, associated with these USTs is not known, and the effectiveness of the tank closure to prevent groundwater and soil contamination has not been assessed these USTs should be viewed as potential sources of contamination.

5.2.2 Other Contamination Sources

The EPA prepared a list of common sources or activities related to groundwater contamination (EPA, 1990). These sources or activities are presented in Table 9. Nearly all of the potential groundwater contaminant sources listed by the EPA exist at MCB. The distribution for all these potential sources of contamination are not mapped. However, a review of base facility activities and land use clearly demonstrates most of the common sources of groundwater contamination are located on the most developed areas at MCB. On the other hand, non-developed lands contain very few, if any, of these common sources. Figure 16, shows the distribution of developed lands at MCB, which correspond to those areas with the greatest number of potential sources of contaminants. The distribution of these areas is a critical consideration in delineating WPAs.

5.3 Land Usage

The training mission of MCB has been a major factor in the determination of how land is to be best utilized. The training requirement for large, unobstucted areas with suitable staging areas for troop deployment has resulted in the establishment of two very general settings.

Table 9. EPA List of Common Sources or Activities Related to Groundwater Contamination. (Source: EPA Guide to Groundwater Supply Contingency Planning for Local and State Governments, 1990)

AGRICULTURAL

Animal burial areas
Animal feedlots
Chemical application
(e.g., pesticides, fungicides, and fertilizers)
Chemical storage areas
Irrigation
Manure spreading and pits

COMMERCIAL

Airports
Auto Repair Shops
Boat Yards
Construction Areas
Car Washes
Cemeteries
Dry Cleaning Establishments
Educational Institutions
(e.g., labs, lawns, and chemical storage areas)
Gas Stations
Golf courses (chemical application)
Jewelry and Metal Plating
Laundromats
Medical Institutions
Paint Shops
Photography Establishments/Printers
Railroad Tracks and yards/Maintenance
Research Laboratories
Road Deicing Operations
(e.g., road salt)
Road Maintenance Depots
Scrap and Junkyards
Storage Tanks
(i.e., Above-Ground, Below-Ground, and Underground)

INDUSTRIAL

Asphalt Plants
Chemical Manufacture, Warehousing, and Distribution Activities
Electrical and Electronic Products Manufacturing
Electroplaters and Metal Fabricators
Foundries
Machine and Metalworking Shops
Manufacturing and Distribution Sites for Cleaning Supplies
Mining (Surface and underground) and Mine Drainage
Petroleum Products Production, Storage, and Distribution Centers
Pipelines
(e.g., oil, gas, coal slurry)
Septage Lagoons and Sludge
Storage Tanks
(i.e., Above-Ground, Below-Ground and Underground)
Toxic and Hazardous Spills
Wells -- Operating and Abandoned
(e.g., oil, gas, water supply, injection, monitoring and exploration)
Wood Preserving Facilities

RESIDENTIAL

Furniture and Wood Strippers and Refinishers
Household Hazardous Products
Household lawn (chemical application)
Septic Systems, Cesspools, and Water Softeners
Sewer Lines
Swimming Pools
(e.g., chlorine)

WASTE MANAGEMENT

Hazardous Waste Management Units (e.g., landfills, land treatment areas, surface impoundments, waste piles, incinerators)
Municipal Incinerators
Municipal Landfills
Municipal Wastewater and Sewer Lines
Open Burning Sites
Recycling and Reduction Facilities
Stormwater Drains, Retention Basins
Transfer Stations

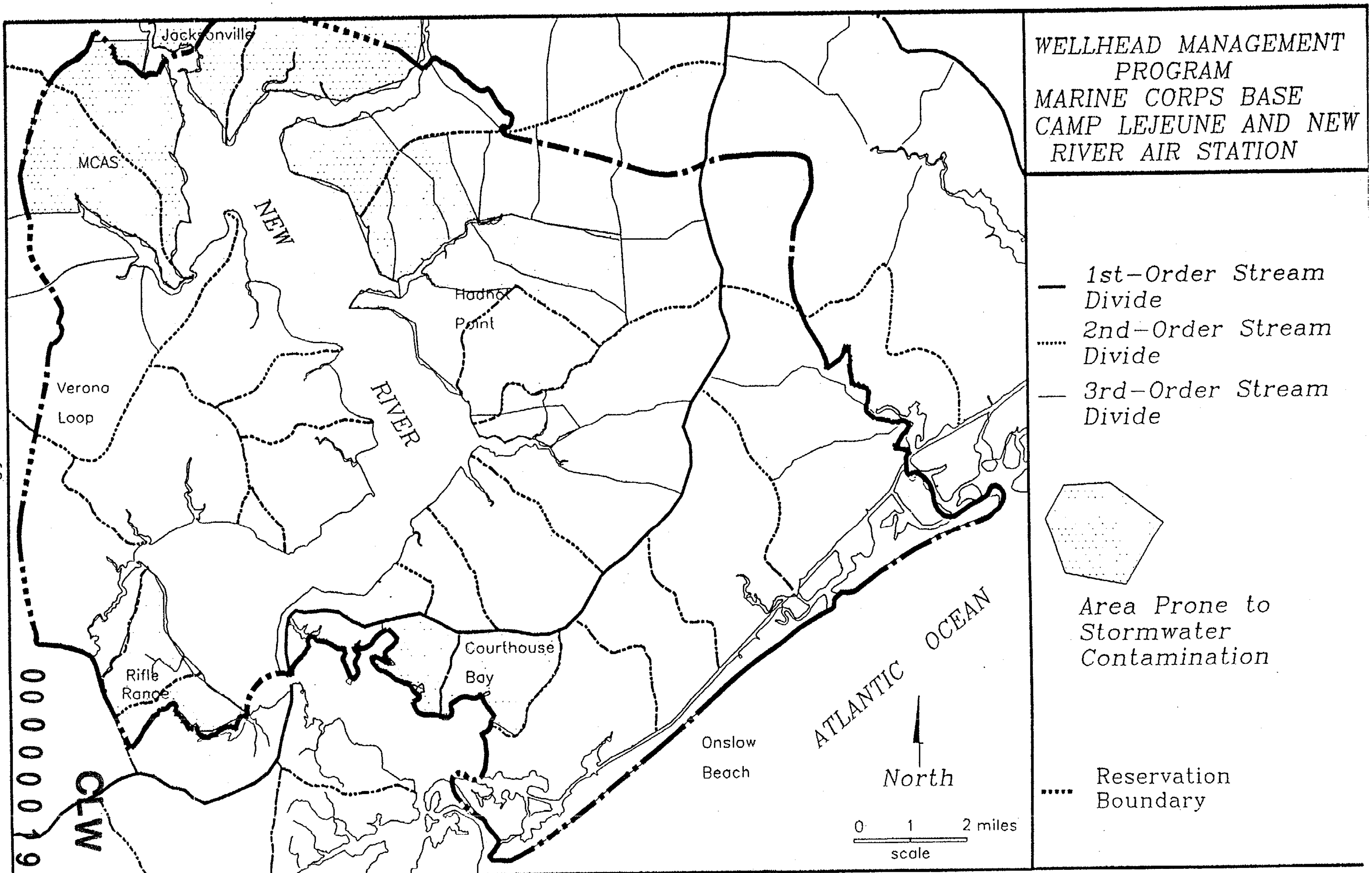

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Figure 16. Location of Developed Land Surfaces at MCB Containing Most Potential Contamination Sources.

A major portion of the base is undeveloped woodlands traversed by trails and semi-improved roads. A much smaller portion of the base is highly developed, containing services and structures to support the approximately 65,000 personnel associated with the base activities. The intense areas of development are conducive to surface and groundwater contamination. The following is a general description of the major sources of groundwater contamination identified at MCB.

5.3.1 Solid Waste Disposal

MCB maintains a single solid waste disposal site, with plans to expand the existing site by the addition of another fill layer. The site is located east of the HPIA along Sneeds Ferry Road adjacent to MCB water wells 606, 609, and 626. Water analysis from these wells indicates no VOC contamination at present, however a total chemical scan should be conducted to determine if leachate are present. An abandoned landfill was operated near the site of contaminated Well 651, west of Piney Green Road. Adjacent wells 636, 610, and 709 do not show similar contamination.

5.3.2 Storm Water Management

Storm water management is in early stages of development at MCB. Part I Group Stormwater permits were applied for in 1991 (Geophex, 1991). Chemical analyses characterizing runoff planned in Part II is not currently available, thus it was not possible to characterize the water quality between stream divides. Because water quality data was not available, a quantitative approach was not possible. First-, second- and third-order surface water drainage basins were constructed from MCB topographic maps (Figure 17). Drainage from developed regions is assumed to be contaminated, whereas drainage from undeveloped regions is assumed uncontaminated. The contaminated regions highlighted in Figure 17, show a potential adverse impact on wells in portions of the Hadnot Point and the MCAS wellfields.

5.3.3 Chemical Usage and Storage

The location of chemical usage and storage centers was not mapped in detail for this project. A review of the locations of activities involved with chemical processes provided by EMD indicates that nearly all chemical storage and user centers corresponds to previously identified developed regions of the base.

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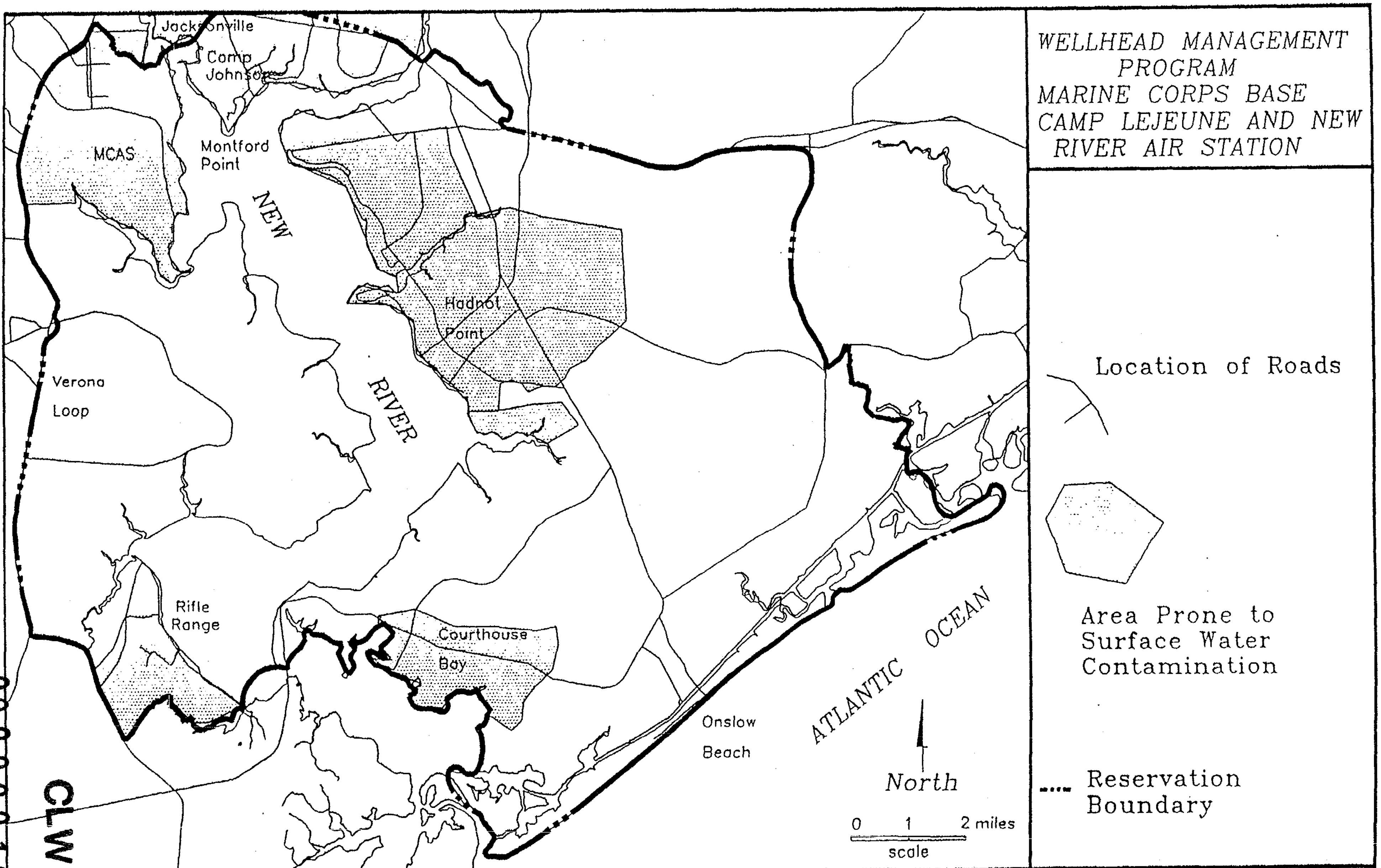

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Figure 17. Location of Drainage Basins Most Likely to Contain Contaminated Surface Water Runoff.

5.3.4 Military Training

Large portions of the MCB are designated for military training. Some regions are set aside for particular training activities that are incompatible with the development of wells; for example, G-10 Impact Area is not suitable for well development because of potential damage from artillary or rifle fire. Military training facilities, including but not limited to firing ranges, field exercise areas, tactical aircraft landing areas, and ammunition and weapon storage facilities as outlined on MCB Combat Training Charts are also considered undesireable for wellfield development (Figure 18). Border regions surrounding these properties may be suitable for well construction provided assurances are made that the wells will not be damaged by training activities.

The potential of groundwater contamination from exploded or unexploded ordnance is not well understood. A potential source of lead in the environment, and thus the groundwater, comes from the lead fill of the brass-cased bullets. Lead contamination would likely be a problem where discharged bullets are concentrated, for example at a barrier, where stray bullets are arrested. Other discharged ordinances potentially harmful to groundwater include: unexploded ordnance, incendiary devices, and residues from discharge weapons. Although no site-specific study has been conducted at Camp Lejeune, environmental evaluations of target ranges at nearby Cherry Point Marine Air Station, at Havelock, North Carolina have been conducted (Sirrine Environmental, 1990). The Cherry Point target ranges differ from Camp Lejeune's in that they received bombs dropped from planes instead of artillary shells. No impact on the water quality was detected in this study.

Because the potential for groundwater contamination is generally believed to be greater for bombs, that carry more explosive chemicals than artillary shells, and because no adverse effects have been detected with bombs, the potential for large scale groundwater contamination is presumed to be minimal.

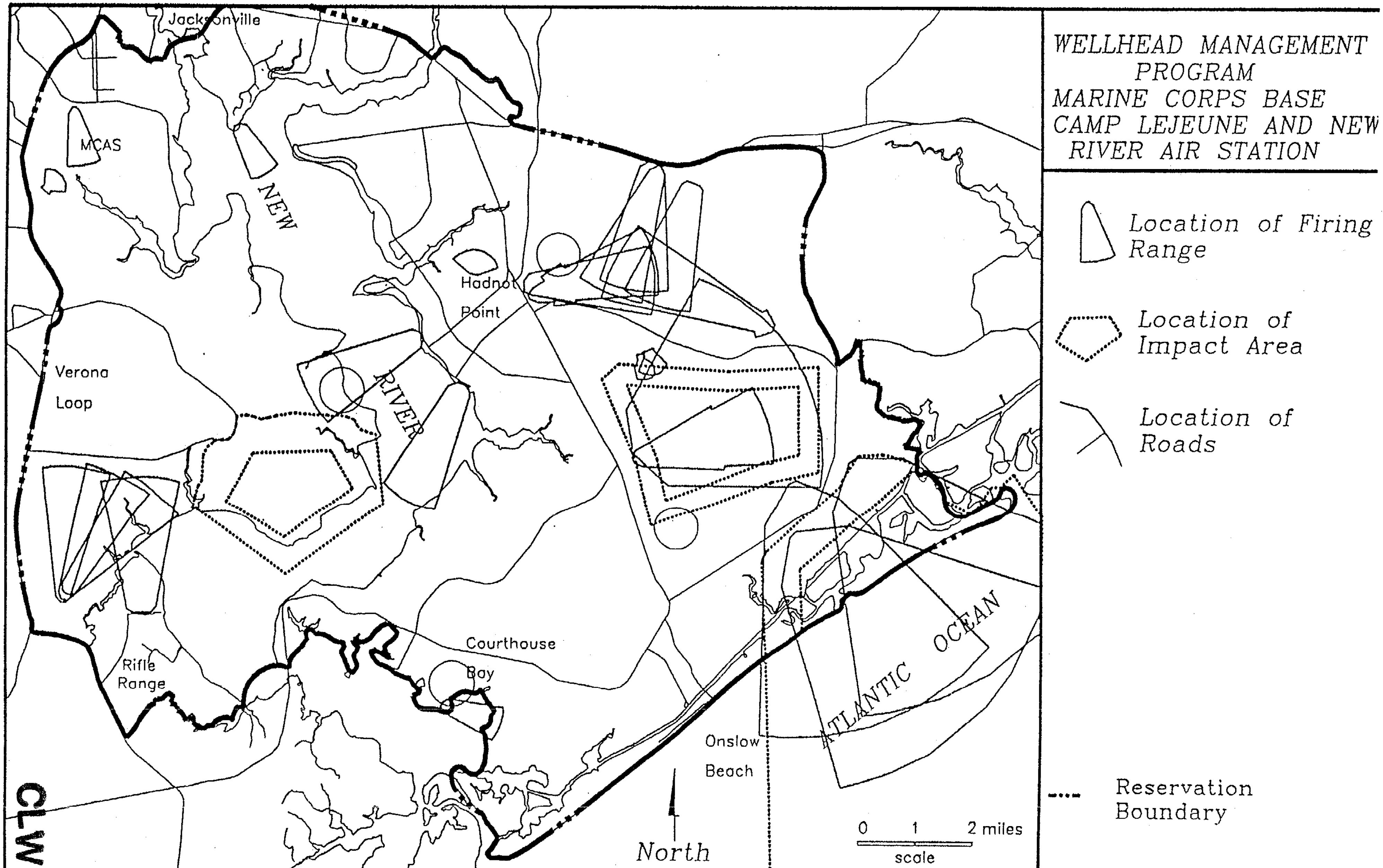

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Figure 18. Location of Military Weapons Training and Storage Sites

5.4 Groundwater Extraction Practices

Water supply systems generally adopt various pumping strategies so as to: (1) minimize maintenance, (2) routinely exercise each well, (3) reduce drawdown interference between wells, and (4) supply the correct combination of water quality and quantity to the water treatment plant. MCB regulates groundwater production by varying the number of pumping wells and the duration of pumping intervals.

The following procedure is used to set the production rate of each well (personal communication, MCB Facility Manager, Mr. Stanley Miller). The well is turned on and the drawdown level monitored until the level stabilizes. The flow from the well is adjusted upward by throttling open a gate valve located on the well discharge. As the valve is opened the withdrawal increases and the water level falls in the well. Proper flow is established when the water level falls to within 10 feet of the intake of the pump. The specific yields from wells were reviewed at varying pumping rates and found to be fairly consistent (less than 10 percent variation from low to high withdrawal rates suggesting that the aquifer is not being stressed and turbulent flow conditions are not being experienced). The consistent value can be viewed as evidence that the aquifer could yield more water if well construction can be improved.

Because the production rate of each well is held constant, increased demand for water is accomplished by turning on more wells or increasing the length of time each well is pumped. Because some of MCB wells produce less water than others, the combination of wells pumped and the demand for water determines the length of the pumping interval.

The current MCB pumping strategy for Hadnot Point, Holcomb Boulevard, Onslow Beach, and Rifle Range water treatment facilities accomplishes the four goals previously stated in Section 5.4. MCAS water production plan is different from the other MCB facilities as a result of varying production rates and degraded water quality from some wells. Four MCAS wells (TC-502, AS-131, AS-191, and AS-4140) produce water containing chloride concentrations in excess of 200 mg/l.

Elevated chloride content in these wells has been related to the inadvertant production of trihalomethanes at the water treatment plant (personal communication, Mr. Fred Hill, Regional Manager, NC Public Water Supply, Washington Regional Office). Currently, MCAS water treatment facility must pump wells in predetermined groupings, so as to maintain an overall low chloride concentration in water supplied to the treatment facility (personal communication, MCB Facility Manager, Mr. Stanley Miller).

The cause of the high chloride levels in groundwater at MCAS is not known. The USGS has suggested that high-volume pumping of wells has created conditions for saltwater intrusion from the New River (personal communication, Dr. Alex Cardinell, USGS, Raleigh, NC). They suggest a buried channel feature discovered in sub-bottom profiles near the Air Station (Cardinell, and others, 1990) has channeled saltwater from the river into selected wells at MCAS.

Analysis of surface waters from the New River at Jacksonville show varying levels of chloride content. The chloride content found in river water is sufficient to support a saltwater intrusion theory; however, historical records suggest another alternative (MCB Well Records, Holcomb Boulevard Water Treatment Facility). Well "A" drilled at Camp Geiger in 1941, and later abandoned, intersected two water bearing zones and produced water containing high-chlorides (>350 mg/l). The presence of high chloride levels in MCB wells prior to any high rates of water production indicates the saline waters are not related to high volume pumping. Instead, the presence of saline water in the first well is strong evidence that portions of the aquifer contain some connate water. During the construction of nearby well TC-325, a high-chloride aquifer was discovered at a depth of 125 to 175 feet underlying and separated by a clay unit from a low-chloride aquifer. Based upon historical records from well "A" and aquifer analysis from Well TC-325, it makes sense that high chlorides would be found in wells that intersect the deeper high-chloride aquifer. Unfortunately, existing well completion logs and water quality analysis are not sufficient to conclusively support the interpretation. However, it is important to know if two-aquifers bearing high- and low-chloride waters exists.

5.5 Aquifer Recharge Areas

The aquifer recharge areas are poorly understood in Onslow County. Regions of highest recharge can normally be delineated through a study of the regional aquifer pieziometric surface. Unfortunately these data do not exist, and thus, a detailed statement as to recharge area is not possible. However, it is generally known that groundwater recharge to the surficial aquifer in the coastal plain occurs on most land surfaces greater than five feet in elevation (Harned and others, 1990). Thus, the recharge area represents nearly the entire MCB land area.

The relative recharge rate over the region may be related to soil type and the relative vertical porosity penetrating the soil and other confining layers. Regions of relatively low and high recharge areas have been delineated from the Onslow County soil survey map (Figure 19) and serves only to point out areas where soil conditions provide relatively high degrees of protection from surface pollution sources. In this figure, areas containing clayey soils are contrasted with areas containing sandy soils. The eastern one-half of MCB is dominated by poorly drained, sandy soils. Clay soils marked by the hatched pattern (Figure 20) occur over less than 25% of the base land area. Clayey soil regions would have lower recharge rates and thus offer greater reaction time between the occurrence of a surface contamination event and possible groundwater contamination.

Recharge to the Castle Hayne Aquifer from the water table aquifer largely depends upon the thickness and permeability of the confining unit at the top of the Castle Hayne.

The detailed geology of the confining unit is not known; however, it is is suspected that the upper confining unit is quite variable in their extent and permeability over MCB. It is apparent from available information (Harned and others, 1990; and MCB Environmental Lab Records) that the confining unit is leaky. The degree of leakage is high in some regions as evidenced by the relatively short period of time needed for a surface spill to show up in a production well (e.g., Well HP-645). The ease in which the Castle Hayne Aquifer can be affected by water table conditions emphasizes the importance of maintaining high surface water quality.

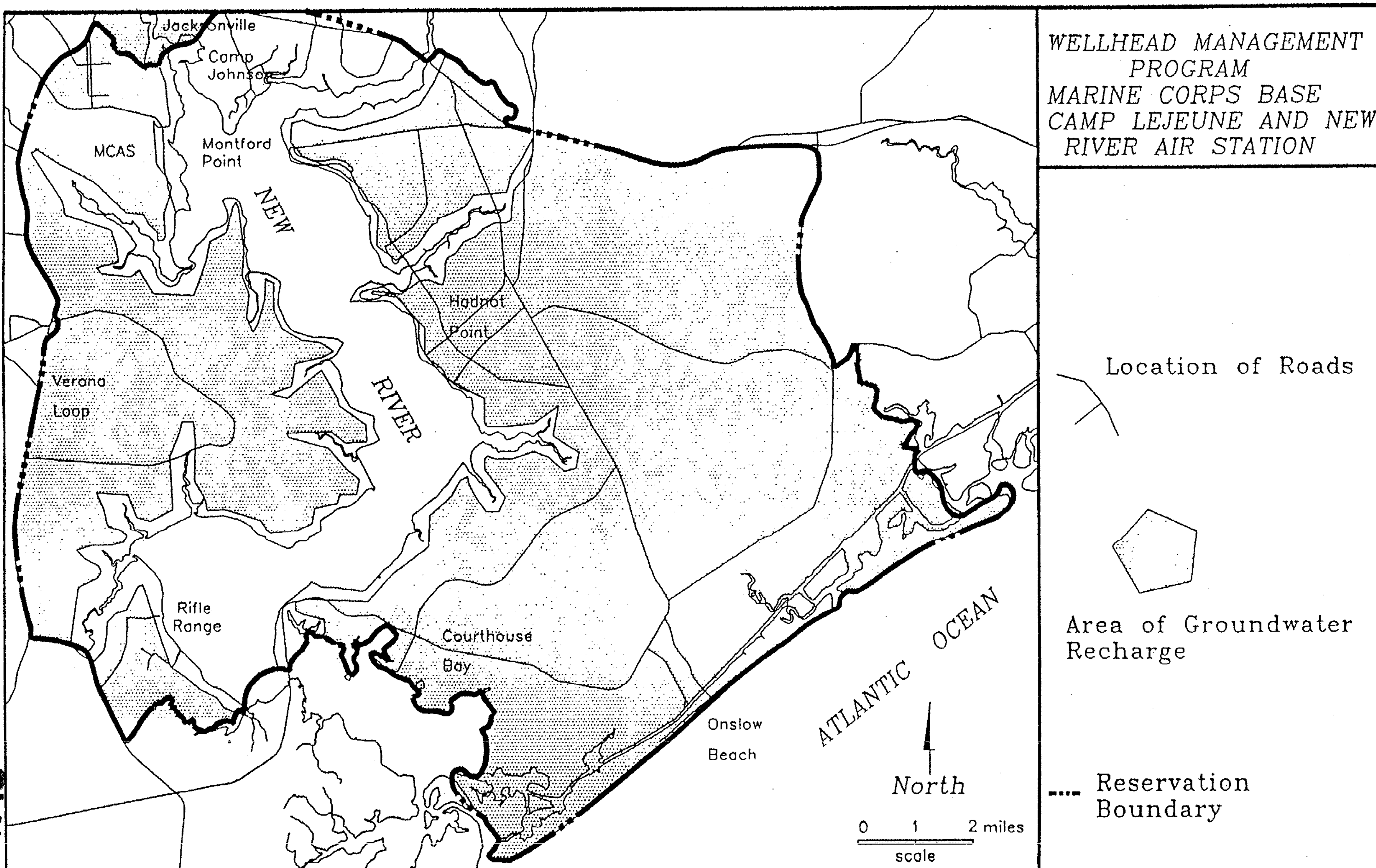

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Figure 19. Location of Groundwater Recharge Regions at MCB.

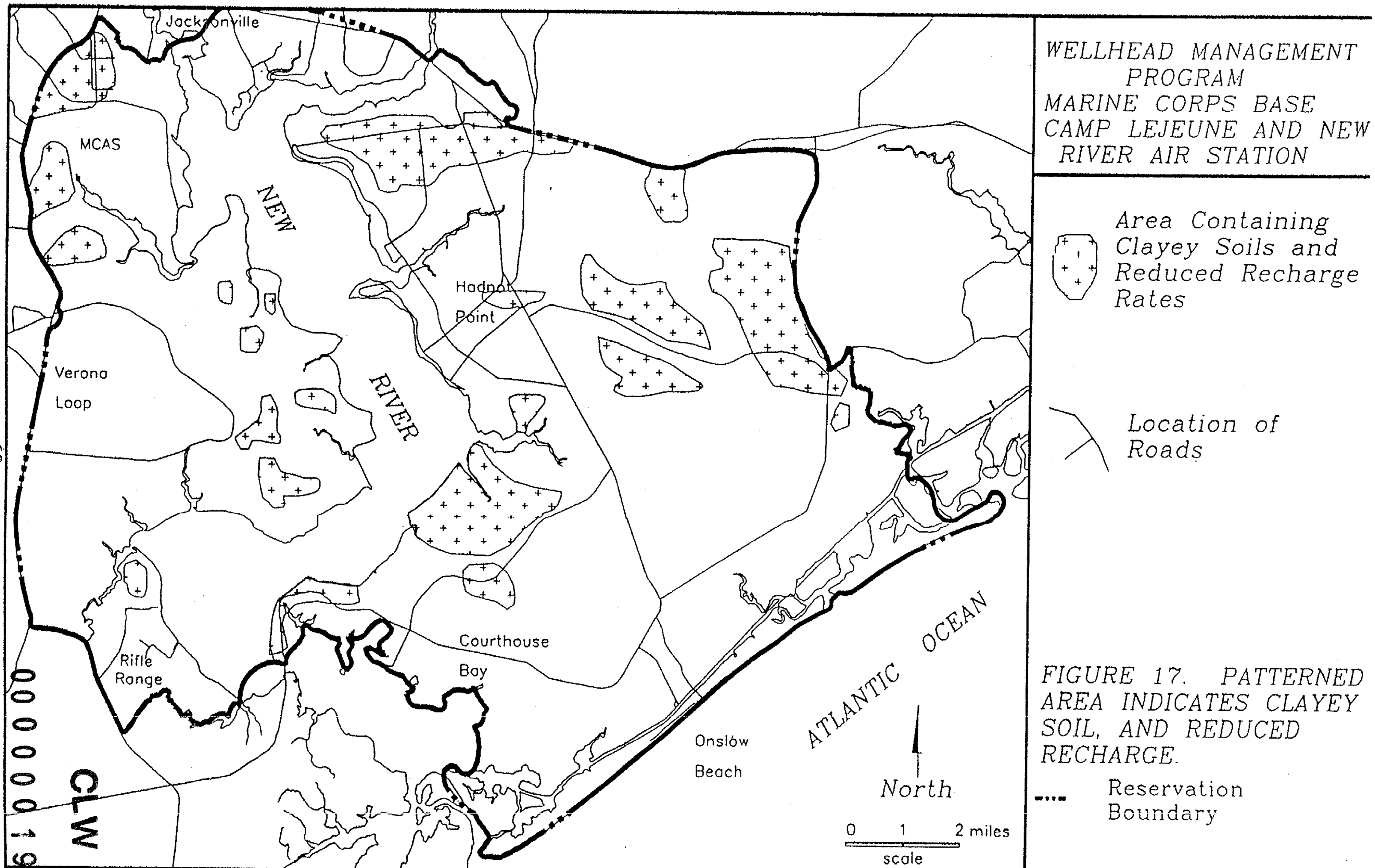

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Figure 20. Recharge potential Related to Soil Types.

Water Table Aquifer recharge for MCB is based upon an average rainfall of 56 inches (Narkunas, 1980) and an average recharge of approximately 30 percent, or an annual recharge of approximately 17 inches per year (Heath, 1991). The recharge rate far exceeds demand, thus MCB should be able to meet its own needs from within the confines of the base.

5.6 Groundwater Preservation Areas

MCB has no formally established groundwater preservation areas however, because the MCB controls more than 230 square miles of land, and because much of this land has remained undeveloped, much of these lands serve the function of groundwater preserves. The extent to which these regions have remained uncontaminated is not known. For example, G-10 Impact Area represents a large area which appears to be undeveloped; however, the potential for groundwater contamination from ordnance and residue are present. An extensive groundwater resource survey should be conducted if MCB should commit to developing a wellfield in this region. It is important that the surface areas overlying principal recharge areas remain relatively undeveloped so as to minimize contamination by accidental surface spills.

Outlines of proposed groundwater preservation areas are shown in Figure 21. These areas should be considered as potential wellfield sites, and thus, should be considered candidate sites for groundwater resource evaluation. The sites that are especially critical to WMP Program are located on Figure 22 and include the following.

- An area located approximately one mile south of MCAS along the abandoned Seaboard Coastline tracks offers an option to new well development at MCAS. This region is relatively undeveloped and should be free of surface contamination.
- A large area of land situated between NC Highway 24 and Holcomb Boulevard, in the general vicinity of the Holcomb Boulevard water treatment facility.
- A strip of land located on both sides of Sneeds Ferry Road and Courthouse Bay Road, south of the existing Hadnot Point wellfield.
- A strip of land located on both sides of NC Highway 172, between Onslow Beach and Courthouse Bay.

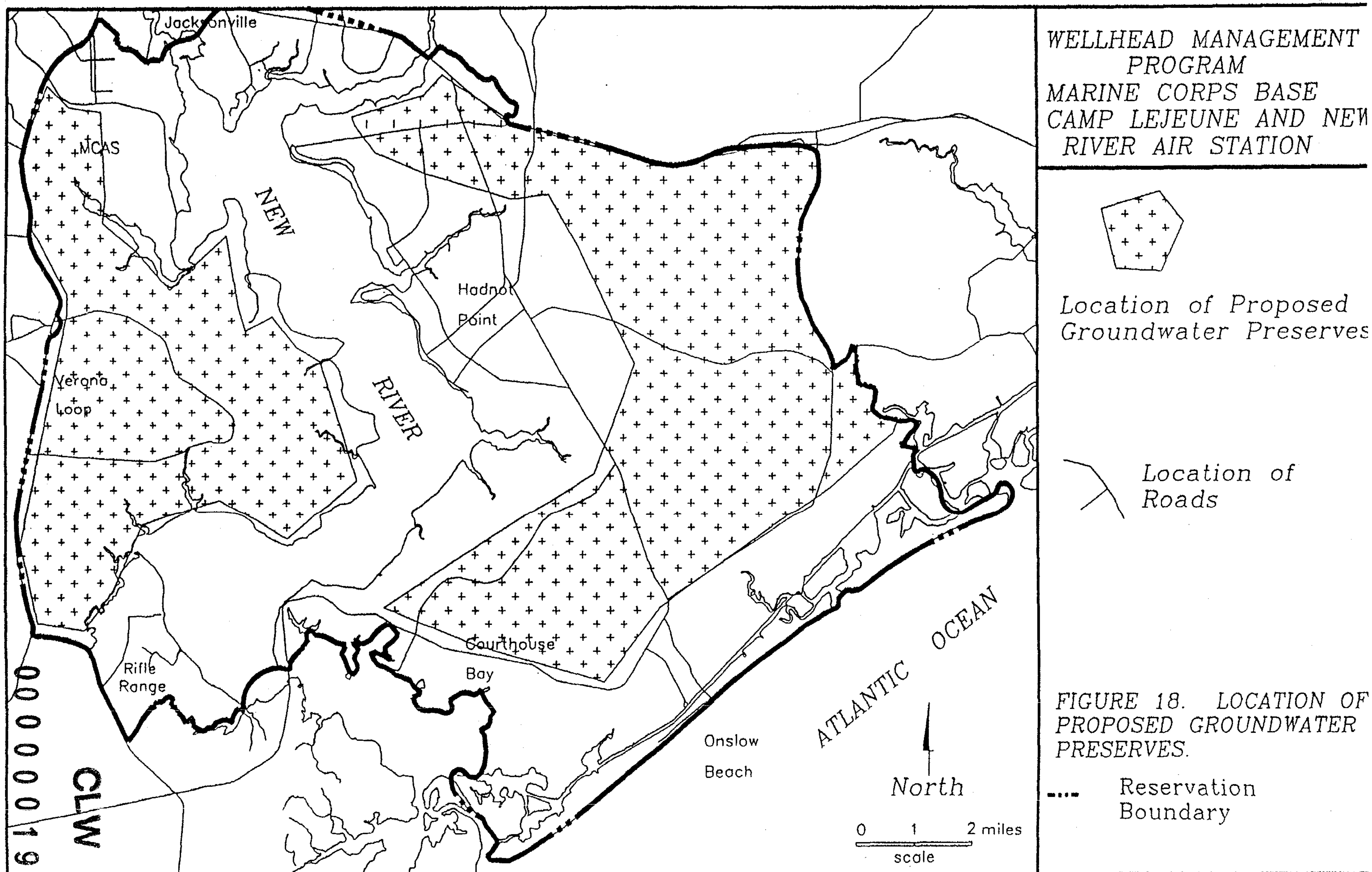

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Figure 21. Location of Proposed Groundwater Preserves.

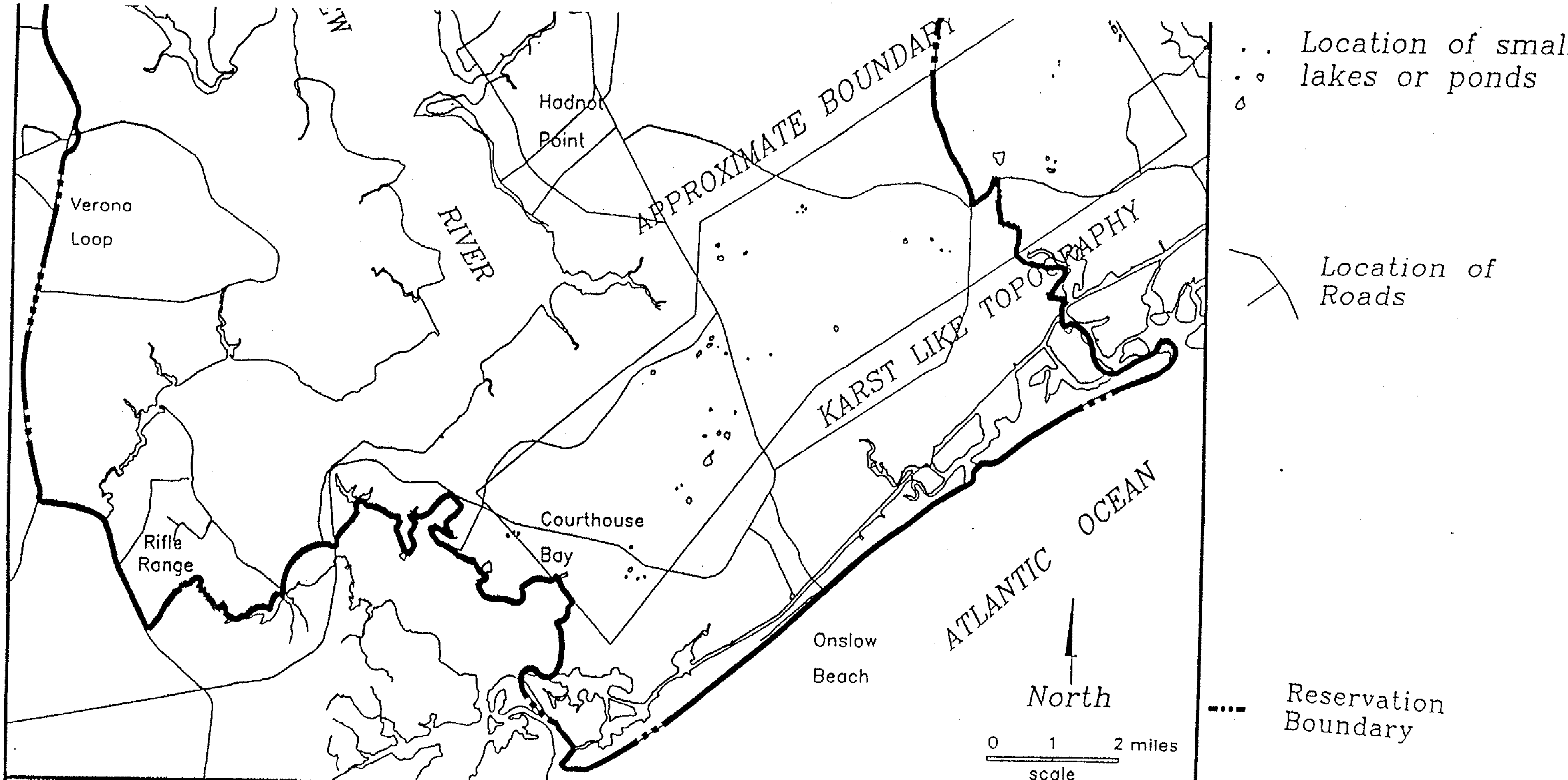

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Figure 22. Location of Potentially High-Recharge Area Associated with Karst-Like Topography.

These groundwater preservation areas represent sufficient acreage to adequately meet MCB's existing groundwater needs.

5.7 Alternate Water Supply Contingency Plan

As part of the WHP Program, a contingency plan for the location and provision of alternate drinking water supplies in the event of well or wellfield contamination is required. The alternate water supply proposed here does not include the case where the water treatment facility and distribution system is contaminated. An emergency water supply response plan should be developed by MCB in concert with other emergency response plans existing for MCB. An EPA guide to groundwater supply contingency planning for local and state governments has been provided to EMD by Geophex as a guideline for organizing this contingency plan (EPA, 440/6-90-003, 1990).

5.7.1 Short-Term, Alternate Water Sources

Options that are viable on an emergency or short-term basis may differ depending on the conditions that created the supply disruption.

Short-term alternate water supplies are designed to alleviate the immediate need for water. Short term indicates the period of time, between water loss and full restoration. It may vary from minutes to years, depending on the severity of the contamination event.
The following discussion of alternatives addresses solutions from within and outside the system.

- Management Alternatives - The MCB water collection system is designed so that any number of wells may be isolated from the remainder of the system. Proper management can control contamination by isolating contaminated wells and increasing production from non-contaminated wells. If the area of contamination is relatively small, and has affected only a few wells, then MCB's excess capacity within the system can provide sufficient alternate water. The use of water system management to provide an alternate water source should be the first course of action. Because it requires minimum effort, and relies on unused excess capacity, it is a low-cost alternative that minimizes service interruption .

- Water Conservation - In the event a substantial portion of the water supply must be isolated from the system but the entire system is not shut-down, water conservation practices must be enacted. Voluntary reduction of car washing, watering lawns, bathing, etc. will help to reduce consumption. Voluntary reduction of water consumption is attractive because it eliminates the need to supply alternative water supplies immediately.

- Interconnection of Treatment Facilities - The Holcomb Boulevard and Hadnot Point water treatment facilities are connected by a 24-inch water main which permits water sharing. This connection permits MCB to shut down water plants one at a time. Excess plant capacity exists such that a winter-time shut-down of a treatment plant is possible. A summer-time shut-down would most likely necessitate more stringent controls on water consumption. MCAS, Onslow Beach, Rifle Range, and Courthouse Bay water treatment facilities are not interconnected, thus loss of wells would pose a more serious threat to those water supplies. Outside water hook-ups to non-base water supplies, or increasing the capacity of the system would provide alternatives to the existing facilities.

- Use of Storage - In an emergency, MCB can utilize stored water. The life of stored water varies according to the season and how much is contained in tanks and lines. Because the water reserve in storage tanks can vary greatly, and may have already been contaminated, it should only be considered as a temporary supply and not a true alternative.

- Bottled Water - If an emergency situation should arise where all wells and treatment facilities have to be shut down, bottled water may offer the best alternative supply of drinking water. However, it is not feasible or economic to utilize bottled water for purposes other than food preparation and washing. The demand for bottled water is likely to be high and the availability low, thus, it is not considered a viable long-term water source.

- Tank Trucks (Water Mules) - Tank trucks offer a viable short-term alternative, but is not recommended as a long-term water source because it may be difficult to meet demand, and the cost of operating a fleet is likely to be high.

- Surface Water Supplies - Surface water alternatives do not exist at MCB. The waters of the New River are saline and would require desalination prior to use for drinking. Many tributaries of the New River have been designated as unhealthy for contact with humans.

- Interconnection With Outside Water Systems - Interconnection with another water supplier is a viable short-term alternative. MCB should consider establishing links with both the City of Jacksonville and Onslow County water systems. The establishment, and operation of water links, requires considerable planning and availability of appropriate equipment to connect alternate water supplies to the distribution system. A suggested hook-up plan may call for Tarawa Terrace I and II, and Montford Point (Camp Johnson) be linked to the City of Jacksonville; and MCAS, Rifle Range, Holcomb Boulevard and Hadnot Point linked to Onslow County water mains. The establishment of interconnection would mutually benefit the City or County in case of an emergency within their respective systems.

5.7.2 Long-Term Alternate Water Sources

Long-term alternate water sources differ for those sources previously discussed in two ways. First, the time available to evaluate and carryout alternatives is longer, allowing for a more pragmatic approach. Second, the number of alternatives is larger, and perhaps more cost effective. This underscores the importance of a viable short-term program capable of buying time to carryout a long-term program.

- Water System Management - The use of Water System Management is a realistic means to compensate for lost well production. However, if the contamination is moderate or severe, MCB will have to consider other options to be carried out in conjunction with water system management.

- Excess Capacity - The use of excess capacity to offset well loss is not a viable option for MCB. Presently, excess capacity for Hadnot Point does not exist. The other water systems have excess capacity, but many of the wells are old and may need replacing in the near future. Thus, any excess capacity that presently exists, will likely vanish in the next five to ten years.

- Surface Water Supplies - Long term development of surface water supplies would result in increased cost for water treatment. However, surface water development would yield an almost unlimited quantity of water. Development of surface water resources would require years of planning and construction before the first drop of water could be realized.
- Drilling New Wells - Construction of new wells in uncontaminated portions of the Castle Hayne Aquifer can be accomplished within a relatively short period of time, under emergency conditions. Drilling new wells into the Castle Hayne Aquifer offers MCB the most economic option to provide long-term water resources from outside the present system. New well development should not be placed near the site of contamination, and preferably away from other established wellfields.

- Alternate aquifers exist beneath MCB, including several aquifers in Cretaceous rocks beneath the Castle Hayne Aquifer. The Cretaceous aquifers contain varying concentrations of saltwater that would require desalinization as part of the water treatment plan. Despite the saline content of these aquifers, they would be less susceptible to contamination from surface spills than the Castle Hayne Aquifer.

- Aquifer Remediation - In the event of a contamination event, aquifer remediation is paramount. Contamination plumes, if left unchecked, may spread throughout the wellfield. Commonly, turning off contaminated wells accelerates the spread of the contaminants throughout the remainder of the aquifer. If the contamination is relatively small, then cleanup may offer the best long-term alternative to restoring the capacity of the water system, or in the very least, preventing large scale contamination of the aquifer.

5.7.3 Factors Affecting Future MCB Water Resources

Recharge into the Castle Hayne Aquifer is sufficient to maintain MCB water supplies provided present groundwater contamination is contained and remediated, and existing and future wellhead areas are protected. Several new factors have arisen recently that may affect existing and future water sources of MCB. The following is a brief overview of these factors.

5.7.3.1 Increased Competition for Water Resources

Increasing demand on water supplies from the City of Jacksonville and Onslow County has strained the production capacity of the Black Creek Aquifer (Narkunas, 1980). As a result both the City and County are considering obtaining water from the Castle Hayne Aquifer (personal communication, Mr. Bill Harvey, Onslow County Water System). Onslow County has the most ambitious program, which includes the completion of several exploratory wells near the communities of Hubert and Dixon.

Onslow County presently develops all of its water from Cretaceous aquifers underlying the region between Richlands and Jacksonville (Figure 23).

The County has immediate goals of developing water resources in the vicinity of Folkstone and Hubert (personal communication, Mr. Bill Harvey, Onslow County Water System). Both of these development sites will utilize treated groundwater from the Castle Hayne Aquifer. The proposed Hubert site is located near the existing Camp Lejeune water system and may impact future plans for replacement wells within the existing MCB system. The Folkstone site may be considered as a source of water for base expansion in the Fort Davis area as well as for new MCB acquisition areas. In all, Onslow County plans to expand its capacity by approximately 4.5 million gallons per day by the end of 1995. The County is seriously working towards the establishment of Wellhead Protection Areas through the mechanism of county or municipal land use zoning (personal communication, Mr. Bill Harvey, Onslow County Water System). These zoning changes could adversely impact the MCB. Enactment of the draft WHP regulations could give the County or City the power to control some of the water usage within the base property.

LEGEND

- Location Of Onslow County Wells
- ▲ Location Of Existing And Proposed City Of Jacksonville Wells
- ○ Location Of Potential Well Sites In Castle Hayne Aquifer By Onslow County

Geophex

Figure 23. Location of Onslow County and City Of Jacksonville Existing and Proposed Wellfields.

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The City of Jacksonville, and the County, currently develops groundwater from the same aquifer and vicinity. The city plans to expand its system by three wells over the next three years. Groundwater currently produced by the City does not require treatment and is of high quality. The City of Jacksonville, like the County, cannot significantly increase water production from the Cretaceous Aquifers in order to meet the increasing needs stimulated by regional growth. In the near future, the City will have to expand its groundwater production to include either the water table aquifer or the Castle Hayne Aquifer.

5.7.3.2 Contamination

Groundwater contamination remains a problem at MCB. The problem is somewhat accentuated because a great portion of MCB wells are developed in areas which are prone to contamination by existing surface contaminants, incidental spills, roadway runoff, and underground storage facilities. It is apparent that the confining unit overlying the Castle Hayne Aquifer affords very little protection from surface and surficial aquifer contamination. Therefore, the WHP program should provide for the systematic replacement of existing wells in industrially active portions of the base, with wells constructed in non-developed, protected areas. The same plan should set out to begin immediate remediation of all contaminated waters. This action would significantly reduce the possibility of new contamination events as well as reduce the spread of existing contaminants.

6.0 Conclusions and Recommendations

6.1 Proposed Wellhead Protection Areas

WPAs for all active wellfields are proposed based on a 10-year ZOT surrounding each well. Development within the WPA should be controlled so as to minimize potential contaminant sources. The contaminant sources are commonly related to activities identified by the EPA and listed in Table 9. The proposed WPAs are described below.

Proposed WPAs cover approximately 4,500 acres of land surrounding existing wellfields. Approximately 30 percent of the designated land is impacted by existing or potential groundwater contamination. These areas should be considered for one or more of the following actions:

- Removal of present or potential contaminants for the 10-year ZOT;
- Remediation of contaminated groundwater;
- Permanent abandonment of contaminated water supply wells; and
- Relocation by attrition of existing wellfields into areas that can be easily maintained with a minimum impact on the mission of MCB.

6.2 Proposed Rehabilitation Studies

Based upon the distribution of known contaminant plumes and knowledge of contaminated wells, approximately 30 percent of the existing wellfield has been or has the potential to be contaminated from surface contamination sources. Present planned, new well-development programs are not sufficient to offset the potential loss of water production from existing or potential contamination sources. Rehabilitation of groundwater resources offers a viable option to drilling new wells. Three areas, discussed below, currently impacted are recommended for rehabilitation because of the apparent high probability of success.

6.2.1 Hadnot Point Industrial Area

Six wells within HPIA have been contaminated with varying levels of TCE (MCB Environmental Lab). Four of these six wells have reported concentrations near detection levels for TCE. In addition, several of these wells indicated the presence of TCE on two of three analyses. Retesting of these marginally contaminated wells is recommended to determine if the data are statistically valid. If so, the source of contamination should be determined, and a water treatment system recommended. Remediation of the surficial and Castle Hayne Aquifer should be expedited in order to limit the spread of contamination to adjacent wells.

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6.2.2 Holcomb Boulevard

The Holcomb Boulevard well HP-645 should be retested to determine if the petroleum contamination persists. Because of the central location of the contamination with respect to adjacent wells, the potential for contamination of one or more wells exist. If petroleum contamination persists an RI program should be initiated.

Well 707 should be examined for the presence of iron precipitation around the screens using a down-hole camera. The presense of buildup over the screens would explain why production was poor. Normally treatment with chlorine solves the bacterial problems. If the screens do not appear to be covered by growth, then the well was probably constructed incorrectly, and little can be done to improve productivity, short of repacking the well.

6.2.3 Tarawa Terrace

Although the Tarawa Terrace wells are inactive, the feasiblity of re-establishing a link to Holcomb Boulevard Water Treatment Facility should be investigated as a contingent source of water in the event of a large scale contamination south of Northeast Creek. The size and distribution of the TCE contaminant plume should be further investigated to determine the potential impact on non-contaminated wells and derrive clean-up alternatives.

6.2.4 MCAS VOC Contamination

Two wells have been contaminated by low-level VOCs at MCAS. Wells AS-106 and AS-4150 should be retested to determine if the data are statiscally valid. If they remain contaminated, the source of contamination should be identified and potential impact on the wellfield assessed. Feasiblity of a water treatment system should be addressed.

6.2.5 MCAS Saltwater Contamination

Since their completion over the course of 50 years, seven water production wells have been contaminated by groundwater with elevated levels of chloride. Presently, five of these wells have chloride levels in excess of 200 mg/l. Sufficient well construction data do not exist in MCB files to determine in every case, the source of high-chloride water.

Well construction records from the responsible driller should be compared with water quality data to determine the source of saline waters. The potential cross-contamination of saline waters should be evaluated and a plan should be developed to reduce saline waters in wells and protect the low chloride aquifer form saltwater contamination.

6.2.6 Rifle Range Wells

Because the TCE content in well RR-229 was near analytical detection limits, additional testing of the water is recommended to determine if the finding is statistically valid. In addtion, adjacent wells should be sampled to determine if the contaminant has spread to other wells.

6.3 Proposed Monitoring Program

A regularly scheduled monitoring program is recommended for all existing wellfield areas. The monitoring plan should be developed in concert with other MCB water-quality monitoring programs. In addition, future well areas should be evaluated for water quality prior the construction of water supply wells. All water quality data should be maintained on the EMD mapping system so that contaminated areas can be avoided.

6.3.1 Monitoring of Existing Wells

Groundwater from all existing water supply wells should be tested for EPA Primary and Secondary Drinking Water Standards (Tables 5 and 6) (EPA, 1990). A one-time broad-based testing will generate baseline data from which subsequent changes in water quality can be compared. The baseline analysis of well-water should be conducted over a relatively short period of time (one month) during a period of relatively low rainfall and be coordinated with the routine pumping of water supply wells. Results of these analysis should be used to establish a long-term sampling and testing program that is aimed at: (1) acquiring sufficient geologic data to model drawdown and water quality over the entire wellfield region, and (2) sampling production wells at intervals sufficient to allow for timely detection of potential wellhead contamination.

The following is proposed as an initial water sampling plan to establish a baseline data set. The baseline data set should be used to design a cost-effective monitoring program.

- Sample and analyze in duplicates, all producing wells, for EPA Primary and Secondary Drinking Water Standards. This is a one-time sampling program that will establish a background data base that will describe the condition of the aquifer. Wells exceeding any of the standards should be reviewed to determine if the contaminant is the result of normal cultural activity or from natural sources.

- A sampling and analysis schedule for each well should be devised such that wells containing contaminants that marginally exceed primary or secondary drinking water standards are sampled more frequently than those wells with no contaminants. A distinction should be made between cultural and natural contaminants. Cultural contamination is likely to be much more variable than natural contaminants. For example, cultural VOC contamination requires more frequent monitoring than dissolved iron, which is usually determined by natural levels in geologic formations and do not vary substantially.

- Measure water levels and temperature for all wells. Water samples should be drawn from all wells and where suspected, analysed for contaminants.

- Locate and gather geologic and/or well completion logs for all MCB wells. Many wells have been drilled but no record exists in either EMD or Holcomb Water Treatment Plant offices. All wells should be physically inspected to determine compliance with state construction requirements. Wells not meeting state requirements should be brought into compliance or should be permanently abandoned. Wells not containing the required identification plate should have identification plates installed, and completion reports submitted to NC DEM WiRO. Existing wells, without logs or completion records, should be logged using geophysical tools to determine construction parameters and then properly identified and reported submitted to NC DEM WiRO.

6.3.2 New Monitor Wells

Existing monitor well data should be compiled in the MCB water quality data base. Monitor wells should be constructed within and around existing and proposed wellfield areas. The purpose of these monitor wells is to provide early warning of contamination that might be entering the WPA, and to help establish the baseline conditions of the aquifer before and after well development.

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6.3.3 Evaluation of New Wellfield Areas

New well construction should be located in areas where Castle Hayne Aquifer waters are uncontaminated and suitable for processing in existing MCB water treatment plants. In addition, land-use activities should be limited to exclude all potential groundwater contamination sources (see Table 9). The physical siting of the well should include a walk-over of the general area to determine the existance of unknown structures or potential contaminants. Monitor wells should be completed in advance of supply wells and analyzed for contaminants. The strategy is to determine water quality in the general vicinity of a proposed wellfield before expensive supply wells are constructed. If contamination is present, the site should be re-evaluated or a new location for the well selected.

6.3.4 Wellfield Design

After the new well sites have been selected and water quality found to be satisfactory, the wellfield layout should be designed so as to achieve the target water capacity for the least cost. The actual cost of the wellfield requires analysis of two factors: (1) capital cost - the money needed to design and install the wells, pumps, pipeline, and monitoring/control systems; and (2) operating cost - which includes maintenance and electric utility charges. Capital cost can be substantial, and is paid up-front. Thus, the real value is amortized over the life of the wells. Operating cost is paid on an as-used basis, and thus commonly is not factored in during the construction phase. Most of the operating cost of wellfields comes from electric power usage. Power usage is affected by: (1) volume of water moved - the more water pumped the more electricity used, and (2) well efficiency - defined as the ratio of the drawdown in the aquifer next to the well to the drawdown observed in the well (Figure 24). The volume of water moved is determined by the needs of the base, and thus can be regulated by turning wells on and off. Well efficiency is best maximized at the time of well construction and should be a primary consideration at well completion.

The drawdown in wells is a function of well efficiency, A properly constructed screened well may achieve efficiencies of 80 percent however, an efficiency of 50 precent to 60 percent is more normal, especially in wells that are not fully screened, as are the wells at

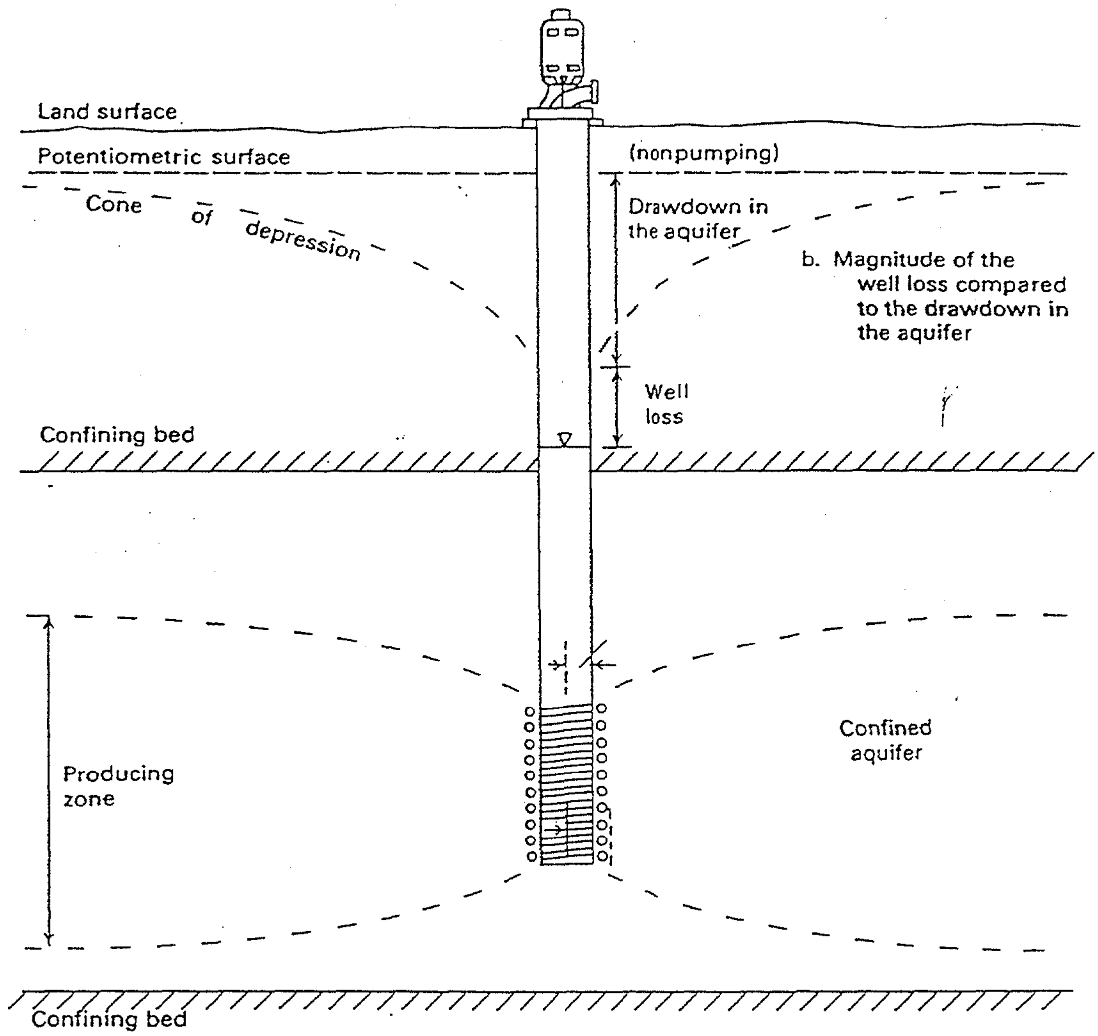

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Figure 24 Diagram showing the relationship between aquifer drawdown, drawdown in a well, and well efficiency (from Heath, 1980)

MCB. Well efficiency typically declines over the life of the well and must be considered in long-term planning. New wells should be designed to limit drawdown interference between wells.

6.4 Proposed Drilling Strategy

New water wells should be drilled to maximize water production. Enhanced water production may be achieved by: (1) completing wells throughout the entire thickness of the Castle Hayne Aquifer, (2) completing wells as open holes when possible, and (3) screening wells to achieve a well efficiency of 80 percent or better.

6.4.1 Drilling Specifications

MCB drilling specifications used for competitive bids should be changed to reflect the above needs. The approved design of water wells should be made after the construction of the pilot hole, geophysical testing, and water quality analysis. Geophysical testing should include: (1) caliper log, (2) spontaneous potential/resistance or resistivity logs, and (3) natural gamma log. The USGS and NCGS provide well logging services, and have volunteered to log MCB wells if the contractor cannot provide these services (Dr. Alex Cardinell of USGS, and Mr. Perry Nelson of NC Groundwater).

6.4.2 Wellhead Development

Enhanced production of water from wells should be investigated. The most common production enhancement techniques used in the Castle Hayne include surging of well water using compressed air or mechanical piston, and acidulation and purging of the well using corrosion inhibited hydrochloric acid.

6.5 Groundwater Areas of Concern

The two natural groundwater areas of concern identified at MCB are: (1) a suspect karst-like area that may represent a region of high recharge, and (2) a general region of elevated chloride levels found in some wells at MCAS.

6.5.1 Karst Region

Suspected karst topography was noted along a sandy relict beach ridge extending from Queens Creek to the New River. It is important to determine if the observed surface features acutally reflect near-surface solution activity. If solution is active, then local groundwater recharge is likely to be high in these areas. Regions of high recharge typically impact wellfield design and merit further investigation.

6.5.2 Saltwater Upconing Potential

The USGS proposes that saltwater infiltration causes high chloride content in wells at MCAS. Saltwater infiltration can result in a general reduction of aquifer quality, and may lead to a reclassification of groundwater by the State. The cause of high chloride conditions in MCAS wells needs to be identified, and plans to reverse the trend formulated.

6.6 Abandonment of Wells

Inactive wells should be secured against possible vandalism and sealed with a water-tight cap or seal compatible with casing and installed so that it cannot be removed easily by hand. If the well has been shutdown because of contamination, a determination as to its future utility in a remediation plan should be determined. If the well is no longer needed, it should be permanently abandoned. Well abandonment should be completed by a licensed driller, and should follow state regulations for well abandonment as stated in NCAC Title 15, Subchapter 2c, Well Construction Standards, Section .0100. MCB should complete the following tasks prior to abandonment:

- All materials should be removed from the well so as not to constrict the placement of the neat cement plug.

- Each well should be video-logged to determine integrity of well casing, well screen, screen placement, and extent to which the casing has been filled with sediment. A compilation of these data will help evaluate the effectiveness of well construction practices and the effective life of the well casing.

- If possible, the entire well screen and casing should be pulled as the abandoned w[illegible] plugged to preclude any future vertical migration of contaminants.

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Appendix A

Summary of Well Completion Logs for MCB Water Wells

EXPLANATION

"Well No." - indicates well number or MCB Building Number.

"Yr. Drilled" - indicates year in which well construction was completed.

"Total Depth" - indicates total depth of well below land surface in feet.

"Diameter" - indicates inside diameter of well casing at top of well in inches.

"Type of Finish" - indicates the well completion method used to prepare the aquifer for production:

- Gravel Pack - indicates wells are completed with stainless steel or brass screens packed with gravel material.
- Screen - indicates well is completed with stainless steel or brass screens but the packing material is not known.
- Open Hole - indicates the well is completed without screens or gravel packing.

"Screened Intervals" - indicates depth of top and bottom screens placed in the well (depths are given in feet).

"Elevation" - elevation at top of well casing.

"Water Level" - elevation of water level in well (given in feet below top of well casing). Water
levels following by a "P" indicates the well was operating at the time of measurement.

Well No.	Yr. drilled	Total depth (ft)	Diameter (in)	Type of finish	Screened intervals (ft)	Elevation (msl)	Water level (ft below surf)
A-5	1942	116	8	Gravel pack	46.5-61.5	12.71	8.3
					101-116		
BA-164	--	110	--	--	--	17*	4.5
							7.2
BA-190	1977	105	8	Screen	55-70	12*	3.6
					80-100		5.6
BB-43	1942	60	8	Gravel pack	30-60	13.1	10.4
							13.4
BB-44	1942	62	8	Gravel pack	32-62	17.8	13.4
							14.8
BB-45	1983	150	--	Screen	40-55	13*	10.1
					102-125		
BB-220	1975	150	--	Gravel pack	55-70	37*	10.2
					85-95		42P
					130-145		
BB-221	--	200	--	--	60-80	40*	33.5
					135-155		
BB-222	1985	185	10	Gravel pack	64-94	40*	55 P
					148-168		20.0
CCC-1	1941	103	10	Open hole	24	21*	
CCC-2	1942	102	8	Screen Gravel	50-60	22*	15.5
				pack	70-75		
					85-90		
HP-601	1941	195	8	Gravel pack	45.0-60.0	22*	11.3
					95-100		
					115-130		
					175-195		
HP-602	1941	160	8	Gravel pack	70-80	25*	8.7
					100-105		11.0
					120-125		
					145-150		
					155-160		
HP-603	1941	195	8	Gravel pack	70-80	24.8	51 P
					100-110		43 P
					130-140		
					160-170		
					190-195		
HP-606	1941	210	8	Gravel pack	80-90	30.4	13.7
					110-120		32 P
					140-150		
					170-180		
					220-210		

CLW 0000002016

* elevation estimated from USGS topographic map

add 607 210 ft 8" (unk)

Well No.	Yr. drilled	Total depth (ft)	Diameter (in)	Type of finish	Screened intervals (ft)	Elevation (msl)	Water level (ft below surf)
HP-608 X	1941	162	8	Gravel pack	61.5-81.5	29.7	19.4
					91.5-101.5		21.1
					121.5-131.5		
					151.5-161.5		
HP-609	1942	~~150~~ 145 ✓	8	Gravel pack	65-80	33*	9.7
					100-10		38 P
					130-150		
HP-610 X	1942	190	8	Gravel pack	60-70	20*	14.1
					90-110		16.9
					130-140		
					180-190		
HP-611 X	1942	161	8	Gravel pack	61-71	31	16.3
					91-101		21.9
					121-136		
					156-161		
HP-612 X	1942	190	8	Gravel pack	60-70	31.8	22.2
					90-95		
					115-120		
					140-145		
					155-160		
					170-175		
					185-190		
HP-613	1942	150 ✓	8	Gravel pack	60-70	24*	33 P
					90-95		13.4
					115-120		
					130-135		
					145-150		
HP-614 X	--	235	8	Gravel pack	105-120	31.4	18.2
					150-170		
					217-227		
HP-615 X	1942	158	8	Gravel pack	58-68	32	16.0
					88-89		
					108-128		
					148-158		
HP-616	1942	~~170~~ 147	8	Gravel pack	95-115	33.3	47 P°
					130-140		41 P°
					160-170		
HP-620	1944	~~54~~ 52	18	Open hole	--	35*	29 P°
							27 P°
HP-621 X	1942	77	8	Gravel pack	57-77	40.8	--

CLW

0000002017

* elevation estimated from USGS topographic map

623
622

197
227

50/300
50ft/310g

Well No.	Yr. drilled	Total depth (ft)	Diameter (in)	Type of finish	Screened intervals (ft)	Elevation (msl)	Water level (ft below surf)	
HP-626 X	--	159	8	Screen	58-63	28.3	15.0	
					82-92			
					108-123			
					144-154			
					154-159			
HP-627 X	--	163	8	Screen	65-75	30.7	--	
					92-102			
					117-122			
					133-158			
HP-628	1984	200 ✓	8	Gravel pack	60-70	26*	12.0	50ft/150gp
					85-89		56 P	
					110-120			
		230			135-145			
HP-629	1982	~~240~~	8	Gravel pack	60-70	41*	22.6	50ft/150g
					125-140		20.3	
					160-170			
					220-230			
HP-630 X	--	176	8	Gravel pack	62-67	26*	14.4	
					87-92		13.5	
					107-117			
					127-142			
		200			152-162			
HP-632	1957	~~75~~	--	--	--	34*	38 P	63ft/240g
							44 P	
HP-633	1959	205	8	Screen	55-65	23*	16.9	55/250g
					75-80		19.1	
					95-105			
					123-133			
					138-143			
					158-168			
					178-183			
					195-205			
HP-634 X	1959	225	8	Gravel pack	65-70	31*	8.6	
					73-78		12.4	
					83-88			
					93-98			
					107-117			
					124-129			
					135-140			
					153-163			
					170-175			
					195-200			
					215-225			

* elevation estimated from USGS topographic map

Well No.	*Yr. drilled*	*Total depth (ft)*	*Diameter (in)*	*Type of finish*	*Screened intervals (ft)*	*Elevation (msl)*	*Water level (ft below surf)*	
HP-635	1959	215 ✓	8	Gravel pack	65-75	17*	3.1	65/200gpm
					93-108		18.7	
					122-127			
					136-146			
					150-155			
					170-175			
					185-190			
					210-215			
HP-636 ✗	1959	~~227~~ 225	8	Gravel pack	90-100	28*	11.8	90/154gpm
					115-125			
down due to landfill					130-135			
					140-150			
					158-163			
					170-175			
					185-190			
					200-210			
					222-227			
HP-637 ✗	1971	~~172~~ 180	8	Gravel pack	90-98	31*	16.1	90/130gpm
out now					102-114		20.6	
					120-128			
					140-148			
					156-172			
HP-638 ✗	1969	196	8	Gravel pack	106-114	24*	99 P	
					126-134		20.1	
					150-158			
					162-170			
					176-184			
					188-196			
HP-639 ✗	1969	176	8	Gravel pack	62-70	23*	3.4	
					85-93		5.2	
					120-132			
					136-148			
					155-163			
					168-176			
HP-640	1969	~~176~~ 179	8	Gravel pack	64-72	30*	3.1	64ft/~~290~~ 214 gpm
					76-80		28 P	
					92-100			
					112-120			
					130-134			
					140-148			
					157-165			
					172-176			
							CLW	

0000002019

* elevation estimated from USGS topographic map

Well No.	Yr. drilled	Total depth (ft)	Diameter (in)	Type of finish	Screened intervals (ft)	Elevation (msl)	Water level (ft below surf)
HP-641	1971	178 ✓	8	Gravel pack	108-118	32*	19.5
					128-150		
					158-168		
HP-642	1971	210 ✓	8	Gravel pack	112-124	29	9.8
					136-144		
					157-163		
					174-178		
					188-196		
HP-643	1971	~~250~~ 240	10	Gravel pack	90-100	28*	16.0
					138-148		47 P
					230-240		
HP-644	1971	255 ✓	10	Gravel pack	85-100	26*	21.0
					235-250		52 P
HP-645	1971	245	10	Gravel pack	90-100	25*	15.9
					138-148		47 P
					230-240		
HP-646	1971	~~270~~ 266	10	Gravel pack	90-100	26*	23.0
					240-250		
					255-265		
HP-647	1970	200 ✓	10	Gravel pack	105-115	33*	18.4
					138-143		38 P
					175-190		
HP-648	1971	~~265~~ 260	10	Gravel pack	107-122	36*	9.4
					245-260		76 P
HP-649	1971	~~284~~ 279	10	Gravel pack	126-136	37*	13.0
					159-164		19.7
					205-210		
					232-237		
					274-279		
HP-650	1971	179 ✓	10	Gravel pack	128-133	38*	12.2
					140-150		78 P
					155-165		
					169-174		
HP-651	1971	199	10	Gravel pack	125-135	32*	16.1
					140-155		17.9
					189-194		
HP-652	1971	183 ✓	10	Gravel pack	120-130	30*	4.9
					148-158		9.0
					163-168		
					173-178		
HP-653	1978	270	--	--	--	32*	65 P
							65 P
							15.0

CLW

0000002020

* elevation estimated from USGS topographic map

Well No.	Yr. drilled	Total depth (ft)	Diameter (in)	Type of finish	Screened intervals (ft)	Elevation (msl)	Water level (ft below surf)
HP-654	1978	250	--	--	--	32*	36 P
							51 P
							15.0
HP-655	1980	145	8	--	--	26*	10.3
							12.4
HP-661	1983	140	10	Gravel pack	50-65	30*	61 P
					87-102		17.9
					125-135		
HP-662	--	100?	--	--	--	20*	71 P
HP-663	1986	180	10	Gravel pack	130-180	35*	64 P
							20.1
HP-698	1985	124	10	Gravel pack	84-124	26*	66 P
							13.2
HP-699	1985	124	10	Gravel pack	84-124	23*	57 P
							11.1
HP-700	1985	130	10	Gravel pack	100-130	20*	69 P
							15.7
HP-701	1985	110	10	Gravel pack	70-100	24*	27 P
							18.0
HP-703	1985	--	--	--	--	31*	59 P
							20.5
HP-704	1985	124	10	Gravel pack	84-114	26*	20.9
HP-705	1986	160	10	Gravel pack	120-160	34*	26.7
							24.7
HP-706	1985	176	10	Gravel pack	126-176	41*	86 P
							19
HP-707	1986	150	10?	Gravel pack?	80-140	27*	28 P
HP-708	1986	176	10	Gravel pack	126-176	41*	74 P
							9.9
HP-709	1985	140	10	Gravel pack	70-90	28*	56 P
					110-140		14.5
HP-710	1985	140	10	Gravel pack	70-90	32*	46 P
					110-140		19.6
HP-711	1985	150	10	Gravel pack	60-80	36*	44 P
					110-150		19.4
LCH-4006	--	140	8	Gravel pack	90-114	33*	19.2
					116-134		23.3
LCH-4007	--	145	8	Gravel pack	50-60	41*	25.1
					69-99		28.4
					120-130		
					140-145		

CLW

0000002021

* elevation estimated from USGS topographic map

Well No.	*Yr. drilled*	*Total depth (ft)*	*Diameter (in)*	*Type of finish*	*Screened intervals (ft)*	*Elevation (msl)*	*Water level (ft below surf)*	
M-142	1942	69	8	Open hole	--	17*	33 P	
M-161	1983	250	--	Gravel pack	--	20*	17.4	
							18.2	
M-168	1953	151	8	Screen	46-61	19*	11.4	
					76-86			
					137-142			
M-197	1971	200	8	Screen	54-64	20.6	14.1	
					76-92		9.1	
					124-129			
					136-145			
M-243	--	95	8	Gravel pack	60-65	22.5	--	
					75-90			
M-267	1981	150	8	Gravel pack	50-70	17*	13.6	
					125-145		61 P	
M-628	1942	67	8	Open hole	43-67	15*	11.5	
					(Open hole)		7.4	
M-629	1975	70	--	--	--	16*	11.4	
							33 P	
M-630	--	80	--	--	--	17*	12.2	
							42 P	
MCAS-106	1954	179	8" --	--	--	17*	15.6	unk/183 gp
							26 P	
MCAS-131	--	200 ✓	8" --	--	--	17*	15.0	unk/310 gpm
							17.3	
MCAS-203	--	173 ✓	8" --	--	--	17*	14.4	unk/220 gp
							33 P	
MCAS-4140	--	193 --	8" --	--	--	22*	20.3	unk/110 gp
							34.0	
MCAS-4150	--	193 --	8" --	--	--	21*	25 P	unk/128 gpm
MCAS-5001	--	193 ✓	8" --	--	--	21*	34 P	unk/130 gp
MCAS-5009	--	196 ✓	8" --	--	--	20*	66 P	unk/111 gp
							66 P	
NC-52	1941	70	--	Open hole	25-66	17*	4.4	
							4.1	
RR-45	1942	130	8	Gravel hole	75-80	56*	49.6	
					90-95		53.2	
					105-115			
					125-130			
RR-47	1943	85	8	Gravel pack	71-81	50*	57 P	
							49.2	
MCAS 190		180	8"					190 unk/190 gp
191		180	8"					281 unk/281 gp

CLW

000000 2022

* elevation estimated from USGS topographic map

Well No.	Yr. drilled	Total depth (ft)	Diameter (in)	Type of finish	Screened intervals (ft)	Elevation (msl)	Water level (ft below surf)	
RR-97	1977	200	8	--	45-60	56*	51 P	
					80-100		51 P	
RR-97A	--	437	8	--	365-395	56*	36.5	
					415-425			
RR-229	1983	253	10	Gravel pack	190-210	31*	21.1	
					223-233		22.9	
					247-252			
TC-100	1941	67	18	Open hole	--	19.5	6.1	
							3.9	
TC-104	1941	182	10	Open hole	107-182	18.4	14.4	
					(Open hole)			
TC-190	1978	180	--	Screen	130-140	28*	42 P	
					150-180		28 P	
TC-191	1977	180	--	Screen	130-140	27*	26.5	
					150-180		52 P	
TC-201	1941	68	8	Gravel pack	46-66	33*	20.5	
							11.3	
TC-202	1942	80	8	Screen	35-40	20.9	5.0	
					45-50			
					55-60			
					65-70			
					75-80			
TC-325	1980	--	--	--	--	21*	49.0	
TC-502	1941	184	10	Open hole	110-184	19*	24 P	110 ft/400 gpm
					(Open hole)			
TC-504	1942	113	8	Gravel pack	50-60	24*	48 P	
					75-85		48 P	
TC-600	1942	70	8	Gravel pack	48-70	19*	37 P	48 ft/104 gpm
							6.0	
TC-604	1942	113	8	Screen	45-50	26.5	4.4	45 ft/154 gpm
					60-65		37 P	
					82-87			
					97-102			
					108-113			
TC-700	1941	76	18	Open hole	27.5-76	22.1	38 P	27½ ft/125 gpm
					(Open hole)		38 P	
TC-901	1941	77	8	Screen	46-56	21.4	4.3	
					66-76		6.9	
TC-1000	1942	~~137~~ 153	8	Gravel pack	86-96	35*	38 P	86 ft/104 gpm
					116-136		38 P	
TC-1001	1942	100	8	Gravel pack	70-100	32.7	9.5	70 ft/160 gpm
TC-1251	1975	~~240~~ 155	--	Screen	120-140	20*	27 P	Unk/175 gpm
				Closed	~~160-170~~		~~27 P~~	

CLW

* elevation estimated from USGS topographic map

0000002023

Well No.	Yr. drilled	Total depth (ft)	Diameter (in)	Type of finish	Screened intervals (ft)	Elevation (msl)	Water level (ft below surf.)	
TC-1253	1975	250 ✓	--	Screen	120-135	22*	32 P	50/128gpm
					155-170		32 P	
							16.6	
TC-1254	1975	195 ✓	--	Screen	118-122	27*	32 P	unk/100gp
					145-160		32 P	
TC-1255	1975	250 ✓	--	Screen	124-132	31*	58 P	unk/50gp
					156-166		58 P	
					180-190		21.0	
TC-1256	--	204 ✓	--	Screen	124-134	31*	54 P	60ft/108gp
					154-164		54 P	
					182-192		23.0	
TT-23	--	263	--	--	--	24*	14.5	
							22.4	
TT-25	1980	200	8	Gravel pack	70-95	31*	20.8	
					155-170		28.7	
TT-26	1958	100	--	--	--	31*	20.0	
							26.6	
TT-31	-- (1973)	94	--	--	--	25*	20.5	
							25.9	
TT-52	1961	98	--	--	--	24*	19.9	
							23.2	
TT-53	1961	90	10	Gravel pack	45-49	24*	14.9	
					50-54		18.2	
					55-59			
					60-65			
					71-73			
TT-54	1961	104	--	--	--	18*	15.4	
							21.8	
TT-67	1972	98	--	--	--	26*	19.1	
							58 P	
Test Wells								
ON-OT1-67	1967	1,400	9 to 6	Open test hole	--	62*	--	
ON-OT1-66	1966	1,681	8 to 6	Open test hole	--	30*	--	
ON-OT-22	--	1,249	--	Open test hole	--	66*	--	
ON-T2-87	1987	260	5	Open test hole	--	20*	--	
OW-2	--	90	4	--	--	11*	4.0	
							5.7	
OW-3	--	75	4	--	--	23*	11.7	
							6.8	

CLW

0000002024

* elevation estimated from USGS topographic map

Well No.	Yr. drilled	Total depth	Diameter	Type of finish	Screened	Elevation	Water level
		(ft)	(in)		intervals (ft)	(msl)	(ft below surf)
OW-4	--	106	4	--	--	18*	4.3
							18.5
OW-5	--	110	4	--	90-100	26*	17.5
							17.6
T-1	1959	477	--	Open test	--	30*	--
				hole			
T-2	1959	240	--	Open test	--	29*	--
				hole			
T-3	1959	232	--	Open test	--	31*	--
				hole			
T-4	1959	262	--	Open test	--	26*	--
				hole			
T-5	1959	232	--	Open test	--	15*	--
				hole			
T-6	1959	202	--	Open test	--	34*	--
				hole			
T-7	1959	225	--	Open test	--	26*	--
				hole			
T-8	1959	500	--	Open test	--	20*	--
				hole			
T-9	1959	177	8	Gravel pack	37-42	28*	5.4
					50-60		9.6
					68-72		
					83-88		
					120-127		
					135-140		
					162-167		
					172-177		
T-10	1959	250	--	Open test	--	25*	--
				hole			
T-11	1959	202	--	Open test	--	25*	--
				hole			
T-12	1959	352	--	Open test	--	6*	--
				hole			
T-13	1959	250	--	Open test	--	19*	--
				hole			
T-14	1959	200	--	Open test	--	20*	--
				hole			
T-15	1959	477	--	Open test	--	15*	--
				hole			
T-18	1959	302	--	Open test	--	52*	--
				hole			
T-19	1959	161	--	Open test	--	55*	--
				hole			

CLW

* elevation estimated from USGS topographic map

0000002025

Well No.	*Yr. drilled*	*Total depth (ft)*	*Diameter (in)*	*Type of finish*	*Screened intervals (ft)*	*Elevation (msl)*	*Water level (ft below surf)*
T-20	1959	121	--	Open test hole	--	41*	--
T-21	1959	120	--	Open test hole	--	31*	--
T-22	1959	161	--	Open test hole	--	23*	--
X(1950)	--	33	18	Open hole	--	23*	8.5
X-24,C-2	1972	240	6	--	--	26*	18?
X-24,S-1	1987	90	4	Screen	80-90	23*	15.0
X-24,S-2(X)	1986	1,526	--	Open test hole	--	23*	--
X-24,S-2a	1987	918	8 to 4 to 2.5	Screen	908-918	23*	14.8
X-24,S-4	1987	527	8 to 4 to 2.5	Screen	517-527	23*	19.0
X-24,S-5	1987	295	4 to 2.5	Screen	285-295	23*	20.5
X-24,S-6	1987	130	6	Screen	120-130	23.47	18.2 17.0
X-24,S-7	1987	40	4	Screen	30-40	23*	17.8
X-25,b-16	1978	185	4	Open test hole	--	15*	--
X-25,M-2	1968	156	--	--	--	15*	--
Y-25,Q1	1982	80	4	Screen	58-80	67*	31.6
Y-25,Q2(X)	1982	1,355	5.5	Open Test hole	--	67*	--
Y-25,Q3	1982	240	4	Screen	150-240	66.83	34.8 33.4
Y-25,Q4	1982	550	8 to 2	Screen	525-550	?*	39.9
Y-25,Q6	1982	23	4	Screen	18-22	67*	10.4
VPI-15	1978	1,678	2.5	Cased to total depth	No openings to aquifer	30*	Casing full of water
VPI-15A	1979	1,575	4	Cased to total depth	No openings to aquifer	26*	Casing full of water
Z-5	1957	246	--	--	--	--	

* elevation estimated from USGS topographic map

Appendix B

Naval Facilities Engineering Command
Guide Specification for Water Supply Wells
Constructed at MCB

****

DEPARTMENT OF THE NAVY
NAVAL FACILITIES
ENGINEERING COMMAND
GUIDE SPECIFICATION

NFGS-02670C
30 June 1991

Superseding NFGS-02670B (03/91)

****

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ENGINEERING COMMAND	------------------------------------
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****

NFGS-02670C

ROTARY-DRILLED WATER WELL

****

Preparing Activity: PACNAVFACENGCOM

	Typed Name & Reg.	Signature	Date
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Approved by:	Erik T. Takai, P.E. Division Director	/s/	05/29/91
Approved for NAVFAC:	/s/ Carl E. Kersten, R.A.		06/30/91

****

AMSC N/A AREA FACR

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DEPARTMENT OF THE NAVY
NAVAL FACILITIES
ENGINEERING COMMAND
GUIDE SPECIFICATION

NFGS-02670C
30 June 1991

Superseding NFGS-02670B (03/91)

****

SECTION 02670

ROTARY-DRILLED WATER WELL
06/91

****

NOTE: This guide specification covers the requirements for rotary-drilled water wells (consolidated or unconsolidated) using conventional fluid rotary drilling or reverse circulation drilling.

****

****

NOTE: This revision "C" to NFGS-02670 follows a complete review of the previous version. The text is revised throughout, according to that review.

****

****

NOTE: See Note A located at rear of text.

****

PART 1 GENERAL

1.1 SUMMARY

****

NOTE: The article "Summary" is not used by the Naval Facilities Engineering Command, except in specialized cases. Delete this article when editing for project specifications.

****

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI B1.20.1	1983 Pipe Threads, General Purpose (Inch) (ANSI/ASME B1.20.1)
ANSI B40.1	1985 Gauges - Pressure Indicating Dial Type - Elastic Element (ANSI/ASME B40.1)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 53	1990 (Rev. B) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless

ASTM B 88	1989 Seamless Copper Water Tube
ASTM C 150	1989 Portland Cement
ASTM C 494	1990 Chemical Admixtures for Concrete

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C206	1988 Field Welding of Steel Water Pipe
AWWA C651	1986 (Addendum 1990) Disinfecting Water Mains
AWWA C700	1990 Cold-Water Meters-Displacement Type, Bronze Main Case, First Edition
AWWA C701	1988 Cold-Water Meters-Turbine Type for Customer Service
AWWA C702	1986 Cold-Water Meters-Compound Type

ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 570/9-75-001	Water Well Construction Practices

1.3 SUBMITTALS

****
NOTE: Where a "G" in asterisk tokens follows a submittal item, it indicates Government approval for that item. Add "G" in asterisk tokens following any added or existing submittal items deemed sufficiently critical, complex, or aesthetically significant to merit approval by the Government. Submittal items not designated with a "G" will be approved by the CQC organization.
****

Submit the following in accordance with Section 01300, "Submittals."

1.3.1 SD-04, Drawings

****
NOTE: Edit the submittal requirements based on the type of well (consolidated or unconsolidated). If the specification is written for a consolidated well, delete the well components which are not normally required in consolidated formations, such as inner casing, well screen, and gravel fill.
****

a. Rotary-drilled water well

1.3.1.1 Required Drawings

Submit drawings or catalog cuts showing rotary-drilled water well components and details of well casings, well screens, air lines, and gages. Detail drawings or catalog cuts shall be accompanied by a cross section showing the relative size, location, and spacing of the well components such as the hole size, outer casing, [inner casing,] [well screen,] [gravel filter,] air line and gage, and grout.

1.3.2 SD-08, Statements

a. Water disposal methods

b. Gravel placement equipment list

c. Gravel placement methods

1.3.3 SD-12, Field Test Reports

a. Test hole

b. Pump test

c. Water analysis

d. Plumbness and alignment test

1.3.3.1 Test Hole Reports

****

NOTE: Natural-gamma logging records the amount of natural-gamma radiation emitted by earth materials. Caliper logging records the average borehole diameter. Verify that natural-gamma logging and caliper logging are required in the geographical region of the project.

****

Upon completion of test hole, provide recommendations for permanent wells and submit data obtained [at each well site], in triplicate. Include with the recommendations the appropriate depth, details of construction, length and location of screens, screen openings, gravel size, grout, and an estimation of the quantity of water that can be obtained from each water-bearing stratum and from each completed well. Submit electric log, a drillers log drawn to scale with coarseness and fineness modulus of each strata, time penetration log (time to drill through each formation), [caliper log] [natural-gamma log], and sieve analysis to substantiate recommendations.

1.3.4 SD-13, Certificates

****

NOTE: Edit the submittal requirements based on the type of well (consolidated or unconsolidated). If the specification is written for a consolidated well, delete the well components which are not normally required in consolidated formations, such as inner casing, well screen, and gravel fill.

****

a. Casings

b. Cement

c. Air line

d. Air gage

e. Drilling mud

f. Water meter

[g. Screens]

[h. Gravel]

1.3.5 SD-16, Sample Panels

a. Test hole

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver materials in an undamaged condition. Store materials off the ground to provide protection against oxidation caused by ground contact. Replace defective or damaged materials with new materials.

1.5 GENERAL REQUIREMENTS

Provide each system complete and ready for operation. Each system, including equipment, materials, installation, and workmanship shall be in accordance with EPA 570/9-75-001, except as modified herein. In the manual referred to herein, the advisory provisions shall be considered mandatory, as though the word "shall" has been substituted for the word "should" wherever it appears. Reference to the "Project Representative" and the "Owner" shall be interpreted to mean the Contracting Officer. [Other applicable requirements are included under Section [_____], ENVIRONMENTAL PROTECTION.]

PART 2 PRODUCTS

2.1 MATERIALS

Shall conform to the respective specifications and other requirements as specified herein.

2.1.1 Casings

****

NOTE: See Note B located at rear of text.

****

****

NOTE: In unconsolidated formations where inner casings are required, the inside diameter of the outer casing shall be a minimum of 3.0 inches larger than the outside diameter of the inner casing, and the drill hole shall be slightly larger than the outside diameter of the outer casing. In consolidated formations where inner casings are not required, the drill hole shall be a minimum of 3.0 inches larger in diameter than the outside diameter of the outer casing.

****

ASTM A 53; [black steel pipe] [zinc-coated steel pipe] outer casing, [____] nominal diameter, [_____] wall thickness, [black steel pipe] [zinc-coated steel pipe] inner casing, [_____] nominal diameter, [_____]

wall thickness. Provide casings with [screwed] [or] [welded] joints.

2.1.2 Well Screens

****
NOTE: See Note C located at rear of text.
****

Type 304 or 316 stainless steel, [_____] inside diameter, [_____] type. Provide screens with adequate strength to resist external forces, both during and after installation. Length shall be [_____] [as required to provide the quantity of water specified]. Water velocity through openings shall not exceed 0.1 foot per second. Determine the well screen openings from an analysis of the sand in the water-bearing strata. Provide joints of the same material as the screen, with either threaded rings or butt-type welding rings.

2.1.3 Filter Gravel

****
NOTE: See Note D located at rear of text.
****

Provide clean, round, hard, water-worn [quartz or granite] [_____] with less than 5 percent feldspar, no fossils, carbonate, or organics, and of proper size and gradation to allow free flow of water in the well and prevent the infiltration of sand. The Contracting Officer will select gravel size, based upon the analysis of the sand in the water-bearing strata. Sterilize gravel with 20 ppm of free available chlorine for a minimum of 2 hours before using.

2.1.4 Grout

Provide neat cement grout, Type I or II portland cement conforming to ASTM C 150, and water. The mixed grout shall contain no more than 7 gallons of water per bag (1.0 cubic foot or 94 pounds) of cement.

2.1.4.1 Admixtures

ASTM C 494.

2.1.5 Air Line

ASTM B 88, Type K, copper tube, [_____] inch diameter.

2.1.6 Air Gage

ANSI B40.1.

2.1.7 Water Meter

AWWA C700 displacement type, AWWA C701 turbine type, or AWWA C702 compound type.

2.1.8 Drilling Mud

Provide a fluid composed of water and bentonite clay, readily thinned with commercial mud thinners or biodegradable polymer mud which will break down naturally. The specific gravity and the character of the mud-laden fluid shall be such that the production of the aquifers will not be impaired.

Drilling mud shall be prechlorinated with 20 ppm free available chlorine for a minimum of 2 hours.

2.1.9 Auxiliary Equipment

Provide discharge piping to dispose of pumped water during developing and testing of well. Locate the discharge piping a sufficient distance from each well to prevent flooding of the site and flow back into the well, as approved by the Contracting Officer.

PART 3 EXECUTION

3.1 TEST HOLE

****

NOTE: If the test hole is to be used as a permanent project well, it shall meet the requirements and characteristics as set forth for the permanent well. Specify minimum diameter and minimum depth of the test well. The minimum test hole diameter for logging with electric logs is 6 inches.

****

Drill a test hole at the well site before construction of the permanent well is started. Test hole shall be of sufficient size to obtain information required for the construction of the permanent well. The location, size of well, and method of drilling must be approved before work is started. Test hole shall be not less than [6] [_____] inches in diameter and not less than [_____] feet deep. Keep an accurate log and record of material drilled through and the depths at which changes in formation occur. Do not construct the permanent well until data submitted for test hole has been analyzed and approved by the Contracting Officer. Should the data obtained from any test hole indicate unfavorable conditions, exploration shall be continued at other locations approved by the Contracting Officer until a suitable well site is located. In the event additional test holes are required and approved, the contract price and time for completion will be adjusted in accordance with the contract. A test hole may be incorporated into the finished construction provided it meets the requirements for a finished well. Seal test holes not used in finished construction as recommended in Article 56 of EPA 570/9-75-001 and as approved by the Contracting Officer.

3.2 WELL CONSTRUCTION

The depth of the permanent well and number of screens provided shall be adequate to produce a guaranteed capacity of [_____] gallons per minute of clear, potable water. Methods of construction include using drilling mud for conventional fluid rotary drilling or reverse circulation drilling.

3.2.1 Drilling

****

NOTE: In unconsolidated formations where inner casings are required, the inside diameter of the outer casing shall be a minimum of 3.0 inches larger than the outside diameter of the inner casing, and the diameter of the drill hole shall be slightly larger than the outside diameter of the outer casing. In consolidated formations where inner casings are not required, the drill hole shall be a

minimum of 3.0 inches larger in diameter than the outside diameter of the outer casing.
****

Drill a hole [_____] inches in diameter to a minimum depth of [_____] feet and to additional depths as required to produce the flow capacity required.

3.2.2 Outer Casing, [Inner Casing,] and Well Screen

****
NOTE: When inner casings are not required, use first optional wording. When inner casings are required, delete first optional wording and use second optional wording.
****

Install the outer casing concentrically in the drilled hole and extend the casing down to a minimum depth of [_____] feet. [Provide welded joints in accordance with AWWA C206.] [Provide threaded joints in accordance with ANSI B1.20.1.] [Fill the void between the outer casing and the drilling hole with neat cement grout to seal the outer casing to the wall of the drilled hole.] [Install the inner casing and well screens concentrically in the outer casing and drill hole. Fill the void between the outer casing and the inner casing with neat cement grout to seal the inside wall of the outer casing to the outside wall of the inner casing.] Provide centralizers at the bottom of the casing and at other critical grouting points such as zones of unsuitable water quality. Grout casing from the bottom upward to effectively seal the annular void. Inject grout using a tremie pipe sealed to the well casing at the surface. Provide sufficient screens at the water bearing layer to be developed to secure available flow. Seal the bottom of the deepest screen with a threaded or welded plug, consisting of the same material and thickness as the screen body, or a welded plate, consisting of the same material and thickness as the screen body or casing.

3.2.3 Well Development

Set the casing[s] and allow the neat cement grout to harden a minimum of 72 hours prior to well development. Provide well development in accordance with Article 52 of EPA 570/9-75-001, except explosives will not be permitted. Furnish pumps, compressors, plungers, bailers, and other equipment required to fully develop the well for the maximum yield of water per foot of drawdown and to limit sand intrusion during the life of the well. Underream the sand strata to a diameter 16 inches greater than the outside diameter of the casing attached to the well screens. Extend the underream continuously through the entire depth of the water bearing strata. Pump the well free of sand, mud, drillings, and other foreign matter. Maximum sand concentration at the completion of well development shall be 2.0 ppm.

3.2.4 Gravel Envelope

Following completion of the underream, fill the entire annular space between the screen and the outside wall of the underreamed hole with gravel. The gravel envelope shall extend from a point equal in distance to 2.5 times the largest diameter of the underreamed hole below the lowest screen and the same distance above the highest screen. Disinfect and place the gravel with a tremie pipe in accordance with Articles 54 and 50 of EPA 570/9-75-001. Control speed of gravel placement to prevent bridging and to allow for settlement of the gravel. Gravel placement equipment and gravel placement methods shall be approved by the Contracting Officer prior to commencement of work.

3.2.5 Disinfection

Disinfect well, equipment, and material in accordance with Article 54 of EPA 570/9-75-001 and as specified herein. Portions of the well above the water level shall be maintained in a wet condition with a minimum of 50 ppm of free available chlorine for a period of not less than 30 minutes. A stock chlorine solution sufficient to produce 50 ppm of free available chlorine throughout the water in the well shall be added to the well at different water level intervals from top to bottom and then agitated to distribute the chlorine solution evenly throughout the well. The chlorine shall remain in the well for a minimum of 12 hours. After the 12-hour period, pump the well free of chlorine. Disinfect piping in accordance with AWWA C651.

3.2.6 Sanitary Seal

Provide a sanitary seal for the well to prevent contamination until the pump foundation and pump are installed on the well.

3.2.7 Abandoning Existing Wells

Abandon and seal existing wells in accordance with Article 56 of EPA 570/9-75-001 and as specified herein. Sealing shall consist of a permanent bridge neat cement seal directly above the lowest aquifer, intermediate neat cement seals between water bearing formations, and uppermost aquifer neat cement seal placed above the uppermost aquifer and the top of the well. Provide disinfected aquifer fill materials consisting of [sand and gravel between sealed layers] [as indicated].

3.3 WASTE DISPOSAL

Dispose of waste materials and soil removed from the drilled holes [by removal from the limits of Government property] [by deposition on Government property, as directed by the Contracting Officer] [as indicated].

3.4 FIELD SAMPLING AND TESTING

3.4.1 Material Samples

During drilling of test hole, take samples of materials found in each soil stratum. Preserve samples in approved containers furnished by the Contractor. In addition, take samples at 5-foot intervals below the static water level to ensure that changes in sand size are noted. Label samples to show depth below ground surface and thickness of the stratum from which the samples were obtained. Describe water-bearing strata in detail as to whether material is loose or compact, the color of material, and if gravel, whether it is water worn or angular. The presence of clay must be noted. Provide a sieve analysis for soil samples in each soil stratum.

3.4.2 Water Quality Determination

During drilling of test hole, collect, and have analyzed by a Government-approved testing laboratory, representative water samples from water-bearing strata to accurately show the quality of water from each stratum. Perform water sampling in accordance with Article 45 of the EPA 570/9-75-001. Include bacteriological and physical-chemical analysis, and further include field and routine analysis data contained in Parts I and III of DD Form 710, Physical and Chemical Analysis of Water, which accompanies this specification. In addition, analyze the water for any additional suspected minerals or contaminants which would make it unfit for human consumption, such as nitrate, fluoride, mercury, or any other contaminants.

3.4.3 Electric Log

Upon completion of test hole, furnish a complete electric log indicating spontaneous potential through the use of long and short normal resistivity logging of formations.

3.4.4 Pump Test

****

NOTE: The temporary pump capacity shall be a minimum of 160 percent of the guaranteed capacity rate.

****

Upon completion of the permanent well, provide a temporary pump, meter, air gage, and air line in the well for measuring the flow and drawdown. The temporary pump shall have a capacity of not less than [_____] gallons per minute. After determining the static water level in the well, begin pumping at a rate equal to 60 percent of the guaranteed capacity rate and check the drawdown at 15-minute intervals until drawdown stabilizes. Measure drawdown using the air line method. Continue pumping at that rate for 2 hours and check the water level at 30-minute intervals. Increase pumping rate in uniform increments of 20 percent of the guaranteed capacity rate and repeat described procedure at each increment of increased rate until the capacity of the well is determined or the 160 percent increment of the guaranteed capacity rate is reached. The capacity of the well shall be the flow obtained at a drawdown level 10 feet above the top of the uppermost screen. After determining the safe maximum yield of the well, conduct a continuous 24-hour pump test at that rate and check the drawdown at hourly intervals. Provide pipe and ditches to drain the water from the well site. Submit water disposal methods to the Contracting Officer for approval. Furnish a complete written log of the pump test, showing static water level, pumping rate, and drawdown at the specified intervals. Remove air line at completion of pump test. At the end of the 24-hour test and disinfection procedure, submit water samples to an approved testing laboratory for complete chemical and bacteriological analysis. Furnish additional samples as required by Contracting Officer.

3.4.5 Well Plumbness and Alignment Test

Upon completion of the permanent well, provide a well plumbness and alignment test using a plummet in accordance with Article 51 of the EPA 570/9-75-001. Perform the test on the entire depth of the well. The plumb or dummy shall move freely through the entire depth of the well. The well shall not vary from the vertical in excess of two-thirds of the smallest inside diameter of that part of the well being tested per 100 feet of depth. Correct defects in plumbness and alignment, and repeat test until the work is in compliance with contract requirements.

-- End of Section --

CRITERIA NOTES

NOTE A: Drawings should include the following and any other information necessary to indicate layout and general configuration of the well.

Diameter of drilled hole

Casing sizes - outside casing, inside casing

Well screen size

Minimum depth of outer casing and minimum depth of well screen

Limits of gravel envelope around inside casing and screens

Limits of neat cement grout around outer casing

Location of air line and altitude gage

Type of cap, cover, or seal required at top of well

Required well capacity in gallons per minute

NOTE B: Delete the requirements for inner casings if the specification is written for a consolidated well and it is known that inner casings are not required. Approximate well casing size should be two sizes larger than the nominal diameter of the pump. Under no circumstances should the well casing size be less than one nominal size larger than the pump bowls. Zinc coating of casing may be omitted where water is not severely corrosive or where casing size is beyond the range of economical zinc coating. Welded joints are recommended for pipe larger than 20 inches in diameter, as well as for smaller pipe where necessary, to obtain proper clearance and maintain uniform grout thickness.

NOTE C: Delete the requirements for well screens if the specification is written for a consolidated well and it is known that well screens are not required. If the specification is written for an unconsolidated well, include appropriate data for the well screen such as inside diameter and type, e.g., perforated tube, continuous or noncontinuous slot, shutter, bar, or wire wound. Well screen efficiency and strength shall be considered in screen selection. Generally, screens should have long, narrow, continuous, horizontal slots larger on the inside than on the outside for optimum efficiency. Longer screens are required where slots are noncontinuous. Screen open areas and efficiencies are more limited in perforated, slotted, shutter, and bar screens. Shutter type screens are particularly appropriate for deeper wells, where additional strength is required.

Perforated pipe base screens are appropriate in special cases where it may be necessary to drive or spud the screen into the ground.

NOTE D: Quartz and granite are common filter gravel materials, however, verify the type of filter materials locally available. Delete the requirements for gravel if the specification is written for a consolidated well and gravel is not required. The type and size of gravel depends on the formation to be developed. The gravel size should not be specified but should be recommended by the Contractor and determined by the Contracting Officer based on analysis of sand in the water-bearing strata.

NOTE E: Suggestions for improvement of this specification will be welcomed using the "Agency Response Form" located in SPECSINTACT under "System Directory" or DD Form 1426. Suggestions should be forwarded to:

Commanding Officer
Naval Construction Battalion Center
Civil Engineer Support Office
Code DSO3
Port Hueneme, CA 93043-5000

-- End --

Appendix C

North Carolina Construction Standards for Public Water Supply Wells

(Source: NCAC Title 15A Subchapter 18C Sections .0100 through .2000
Current through, January 1, 1991)

SECTION .0400 – WATER SUPPLY DESIGN CRITERIA

Rules .0401 – .0408 of Title 15A Subchapter 18C of the North Carolina Administrative Code (T15A.18C .0401 – .0408); has been transferred and recodified from Rules .1001 – .1008 Title 10 Subchapter 10D of the North Carolina Administrative Code (T10.10D .1001 – .1008), effective April 4, 1990.

.0401 MINIMUM REQUIREMENTS

The design criteria given in this Section are the minimum requirements for approval of plans and specifications of community water systems by the Division of Environmental Health, Department of Environment, Health, and Natural Resources. The Department provides additional guidelines for design of water systems in 15A NCAC 18C .0500 – .1000.

History Note: *Authority G.S. 130A–315; 130A–317; P.L. 93–523;*
Eff. January 1, 1977;
Readopted Eff. December 5, 1977;
Amended Eff. September 1, 1979.

.0402 WATER SUPPLY WELLS

(a) Well Construction. The construction of water supply wells shall conform to well construction regulations and standards of the Division of Environmental Management, N.C. Department of Environment, Health, and Natural Resources.

(b) Upper Terminal of Well. The well casing shall neither terminate below ground nor in a pit. The pump pedestal for above ground pumps of every water supply well shall project not less than six inches above the concrete floor of the well house, or the concrete slab surrounding the well. The well casing shall project at least one inch above the pump pedestal. For submersible pumps the casing shall project at least six inches above the concrete floor or slab surrounding the well head.

(c) Sanitary Seal. The upper terminal of the well casing shall be sealed watertight with the exception of a vent pipe or vent tube having a downward–directed, screened opening.

(d) Concrete Slab or Well House Floor. Every water supply well shall have a continuous bond concrete slab or well house concrete floor extending at least three feet horizontally around the outside of the well casing. Minimum thickness for the concrete slab or floor shall be four inches.

(e) Sample Tap and Waste Discharge Pipe. A water sample tap and piping arrangement for discharge of water to waste shall be provided.

(f) Yield.

(1) Wells shall be tested for yield and drawdown. A report or log of a least a 24–hour drawdown test to determine yield shall be submitted to the Division of Environmental Health for each well.
(2) Wells shall be located so that the drawdown of any well will not interfere with the required yield of another well.
(3) The combined yield of all wells of a water system shall provide in 12 hours pumping time the average daily demand as determined in subparagraph (f) (7).
(4) The capacity of the permanent pump to be installed in each well shall not exceed the yield of the well as determined by the drawdown test.
(5) A community water system using well water as its source of supply and designed to serve 50 or more residences or connections shall provide at least two wells. In lieu of a second well, another approved water supply source may be accepted.
(6) A totalizing meter shall be installed in the piping system from each well.
(7) The well or wells serving a mobile home park shall be capable of supplying an average daily demand of 250 gallons per day per connection. The well or wells serving residences shall be capable of supplying an average daily demand of 400 gallons per day per connection.

(g) Initial Disinfection of Water Supply Well. All new wells, and wells that have been repaired or reconditioned shall be cleaned of foreign substances such as soil, grease, and oil, and then shall be disinfected. A representative sample or samples of the water (free of chlorine) shall be collected and submitted to an approved laboratory for bacteriological analyses. After disinfection the water supply shall not be placed into service until bacteriological test results of representative water samples analyzed in an approved laboratory are found to be satisfactory.

(h) Initial Chemical Analyses. A representative sample of water from every new water supply well shall be collected and submitted for chemical analyses to the Division of Laboratory Services or to a laboratory approved by the Division. The results of the analysis must be satisfactory before the well is placed into service.

(i) Continuous Disinfection. Equipment designed for continuous application of chlorine or hypochlorite solution or some other approved and equally efficient disinfectant shall be provided for all well water supplies introduced on or after January 1, 1972. Equipment for determining residual chlorine concentration in the water shall be specified.

History Note: *Authority G.S. 130A-315; 130A-317; P.L. 93-523;*
Eff. January 1, 1977;
Readopted Eff. December 5, 1977;
Amended Eff. September 1, 1990; January 1, 1986; March 31, 1980; September 1, 1979.

.0403 SURFACE WATER FACILITIES

(a) Unimpounded Stream. Both the minimum daily flow of record of the stream and the estimated minimum flow calculated from rainfall and run-off shall exceed the maximum daily draft for which the water treatment plant is designed with due consideration given to requirements for future expansion of the treatment plant.

(b) Pre-settling Reservoirs. Construction of a pre-settling or pre-treatment reservoir shall be required where excessive bacterial concentrations or wide and rapid variations in turbidity and/or chemical qualities occur.

(c) Impoundments. Raw water storage capacity shall be sufficient to reasonably satisfy the designed water supply demand during periods of drought.

(d) Clearing of Land for Impoundment. The area in and around the proposed impoundment of class I and class II reservoirs shall be cleared as follows:

(1) The area from two feet above and five feet below the normal full level of the impoundment shall be cleared and grubbed of all vegetation and shall be kept cleared until the reservoir is filled, provided that the area two feet above the normal full level may be reduced if the clearing at that elevation would exceed a horizontal distance of 50 feet from the full level. Secondary growth should be removed periodically and in all cases prior to flooding. A margin of at least 50 feet around the impoundment shall be owned or controlled by the water supplier.

(2) The entire area below the five foot water depth shall be cleared and shall be kept cleared of all growth of less than six inches in diameter until the reservoir is filled. Stumps greater than six inches in diameter may be cut off at ground level.

(3) All brush, trees, and stumps shall be burned or removed from the watershed.

(e) Intakes, Pumps, Treatment Units, and Equipment. Raw water intakes, pumps, treatment units and equipment shall be designed to provide water of potable quality meeting the water quality requirements stated in Section .1500 of this Subchapter.

History Note: *Authority G.S. 130A-315; 130A-317; P.L. 93-523;*
Eff. January 1, 1977;
Readopted Eff. December 5, 1977.
Amended September 1, 1990.

.0404 WATER TREATMENT FACILITIES

(a) Mixing and Dispersion of Chemicals. Provisions shall be made for adequate mixing and dispersion of chlorine and other chemicals applied to the water. There shall be provided a minimum of 20 minutes chlorine contact time prior to pumping the water to the distribution system.

(b) Chemical Feed Machines

CLW

TITLE 15A - DEPARTMENT OF ENVIRONMENT, HEALTH, AND NATURAL RESOURCES

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Notice is hereby given in accordance with G.S. 150B-21.2 that the EHNR - Division of Environmental Management intends to amend rules cited as 15A NCAC 2C .0101 - .0103, .0105, .0107 - .0114, .0116, .0118 - .0119; 2L .0107.

The proposed effective date of this action is September 1, 1992.

The public hearings will be conducted at the following locations, dates and times:

<u>NEW BERN</u>
May 18, 1992
7:00 p.m.
Superior Court, 2nd Floor
Craven County Courthouse

<u>RALEIGH</u>
May 26, 1992
7:00 p.m.
Ground Floor Hearing Room
Archdale Building
512 N. Salisbury Street

<u>HICKORY</u>
May 28, 1992
7:00 p.m.
Auditorium
Catawba Valley Community College

Reason for Proposed Action: 15A NCAC 2C .0101 - .0103, .0105, .0107 - .0114, .0116, .0118 - .0119. *The proposed amendments to 15A NCAC 2C will amend the Well Construction Rules regarding permit requirements, variances, casing installation and grouting, and reporting; and will establish fees for well driller registration.*
15A NCAC 2L .0107. *Modify compliance boundary requirements so that permittees can maintain fixed boundary after subdivision/conveyance of property.*

Comment Procedures: All persons interested in these matters are invited to attend the public hearing. Written comments may be presented at the public hearing or submitted through May 31, 1992. Please submit comments to Mr David Hance, Division of Environmental Management, Groundwater Section, P.O. Box 29535, Raleigh, NC 27626-0535, (919) 733-3221. Please notify Mr. Hance prior to the public hearing if you desire to speak. Oral presentation lengths may be limited depending on the number of people that wish to speak at the public hearing.

IT IS VERY IMPORTANT THAT ALL INTERESTED AND POTENTIALLY AFFECTED PERSONS, GROUPS, BUSINESSES, ASSOCIATIONS, INSTITUTIONS OR AGENCIES MAKE THEIR VIEWS AND OPINIONS KNOWN TO THE DEPARTMENT THROUGH THE PUBLIC HEARING AND COMMENT PROCESS, WHETHER THEY SUPPORT OR OPPOSE ANY OR ALL PROVISIONS OF THE PROPOSED RULES.

CHAPTER 2 - ENVIRONMENTAL MANAGEMENT

SUBCHAPTER 2C - WELL CONSTRUCTION STANDARDS

SECTION .0100 - CRITERIA AND STANDARDS APPLICABLE TO WATER-SUPPLY AND CERTAIN OTHER TYPE WELLS

.0101 GENERAL PROVISIONS
(a) Authorization. The North Carolina Environmental Management Commission is required, under the provisions of Chapter 87, Article 7, Section 87, General Statutes of North Carolina (short title: North Carolina Well Construction Act) to adopt appropriate rules ~~and regulations~~ governing the location, construction, repair, and abandonment of wells, and the installation and repair of pumps and pumping equipment.
(b) <u>Purpose.</u> Consistent with the duty to safeguard the public welfare, safety, health, and to protect and beneficially develop the ground water resources of the state, it is declared to be the policy of this state to require that the location, construction, repair and abandonment of wells, and the installation of pumps and pumping equipment conform to such reasonable standards and requirements as may be necessary to protect the public welfare, safety, health, and ground water resources.

Statutory Authority G.S. 87-87.

.0102 DEFINITIONS
As used herein, unless the context otherwise requires:
(1) "Abandon" means to discontinue the use of and to seal the well according to the requirements of Rule .0113 of this Section.
(2) "Access port" means an opening in the well casing or well head installed for the primary purpose of determining the position of the water level in the well.
(3) "Agent" means any person who by mutual and legal agreement with a well owner has authority to act in his behalf in executing applications for permits. The agent may be

either general agent or a limited agent authorized to do one particular act.

(4) "ASTM" means the American Society for Testing and Materials.

(5) ~~(4)~~ "Casing" means pipe or tubing constructed of specified materials and having specified dimensions and weights, that is installed in a borehole, during or after completion of the borehole, to support the side of the hole and thereby prevent caving, to allow completion of a well, to prevent formation material from entering the well, to prevent the loss of drilling fluids into permeable formations, and to prevent entry of undesirable water.

(6) ~~(5)~~ "Commission" means the North Carolina Environmental Management Commission or its successor, unless otherwise indicated.

(7) ~~(6)~~ "Consolidated rock" means rock that is firm and coherent, solidified or cemented, such as granite, gneiss, limestone, slate or sandstone, that has not been decomposed by weathering.

(8) ~~(7)~~ "Contamination" means ~~the act of introducing into water~~ foreign materials of such nature, quality, and quantity as to cause degradation of the quality of the water.

(9) "Department" means the Department of Environment, Health, and Natural Resources.

(10) ~~(8)~~ "Designed capacity" shall mean that capacity that is equal to the rate of discharge or yield that is specified prior to construction of the well.

(11) ~~(24)~~ "Director" means the Director of the Division of Environmental Management

(12) ~~(25)~~ "Division" means the Division of Environmental Management.

(13) ~~(9)~~ "Domestic use" means water used for drinking, bathing, household purposes, livestock or gardens.

(14) "GPM" and "GPD" mean gallons per minute and gallons per day, respectively.

(15) ~~(10)~~ "Grout" shall mean and include the following:

(a) "Neat cement grout" means a mixture of not more than six gallons of clear, non-polluted water to one 94 pound bag of portland cement. ~~Up to five percent, by weight, of bentonite clay may be used to improve flow and reduce shrinkage.~~

(b) "Sand cement grout" means a mixture of not more than two parts sand and one part cement and not more than six gallons of clear, non-polluted water per 94 pound bag of portland cement

(c) "Concrete grout" means a mixture of not more than two parts gravel to one part cement and not more than six gallons of clear, non-polluted water per 94 pound bag of portland cement. One hundred percent of the gravel must pass through a one-half inch mesh screen.

(d) "Gravel cement grout, sand cement grout or rock cutting cement grout" means a mixture of not more than two parts gravel and sand or rock cuttings to one part cement and not more than six gallons of clear, non-polluted water per 94 pound bag of portland cement.

(e) "Bentonite grout" means the mixture of no less than one and one-half pounds of commercial granulated bentonite with sufficient clear, non-polluted water to produce a grout weighing no less than eleven (11) pounds per gallon of mixture. Non-organic, non-toxic substances may be added to improve particle distribution and pumpability. Bentonite grout may only be used in those instances where specifically approved in this Section.

(f) "Specialty grout" means a mixture of non-organic, non-toxic materials with characteristics of expansion, chemical-resistance, rate or heat of hydration, viscosity, density or temperature-sensitivity applicable to specific grouting requirements. Specialty grouts may not be used without prior approval by the Director.

(16) ~~(11)~~ "Liner pipe" means pipe that is installed inside a completed and cased well for the purpose of sealing off undesirable water or for repairing ruptured or punctured casing or screens.

(17) ~~(12)~~ "Monitoring well" means any well constructed for the primary ~~or incidental~~ purpose of obtaining ~~subsurface~~ samples of groundwater ~~water~~ or other liquids for examination or testing, or for the observation or measurement of groundwater levels. This definition excludes lysimeters, tensiometers, and other devices used to investigate the characteristics of the unsaturated zone.

~~(13) "Observation well" means any well constructed for the purpose of obtaining groundwater level information only.~~

(18) ~~(14)~~ "Owner" means any person who holds the fee or other property rights in the well being constructed. A well is real property and its construction on land rests ownership in the land owner in the absence of contrary agreement in writing.

(19) ~~(23)~~ "Pitless ~~adapter unit is a device~~ adapters" or "pitless units" are devices specifically manufactured to the standards specified under Rule .0107(i) ~~(4)~~ (5) of this Section for the purpose of allowing a subsurface lateral connection between a well and plumbing appurtenances.

(20) ~~(15)~~ "Public water system"

~~(a) "Public water system"~~ means a water system as defined in 15A NCAC 18C .0702 (Rules Governing Public Water Supplies) ~~for the provision, to the public, of piped water for human consumption if such system has at least 15 service connections or regularly serves an average of at least 25 individuals daily at least 60 days out of the year. Such term includes:~~

~~(i) any collection, treatment, storage, and distribution facility under control of the operator of such system and used primarily in connection with such system; and~~

~~(ii) any collection or pre-treatment storage facility not under such control which is used primarily in connection with such system.~~

~~(b) A public water system is either a "community water system" or a "non-community water system":~~

~~(i) "Community water system" means a public water system which serves at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents.~~

~~(ii) "Non-community water system" means a public water system which is not a community water system.~~

(21) ~~(16)~~ "Recovery well" means any well constructed for the purpose of removing contaminated groundwater or other liquids from the subsurface.

(22) "Settleable solids" means the volume of solid particles in a well-mixed one liter sample which will settle out of suspension in the bottom of an Imhoff Cone, after one hour.

(23) ~~(17)~~ "Site" means the land or water area where any facility, activity or situation is physically located, including adjacent or nearby land used in connection with the facility, activity or situation.

(24) ~~(18)~~ "Specific capacity" means the yield of the well expressed in gallons per minute per foot of draw-down of the water level (gpm/ft.-dd).

(25) ~~(19)~~ "Static water level" means the level at which the water stands in the well when the well is not being pumped and is expressed as the distance from a fixed reference point to the water level in the well.

(26) "Suspended solids" means the weight of those solid particles in a sample which are retained by a standard glass microfiber filter, with pore openings of one and one-half microns, when dried at a temperature of 103 to 105 degrees Fahrenheit.

(27) "Temporary well" means a monitor well, or a well that is constructed to determine aquifer characteristics, and which will be properly abandoned or converted to a permanent well within five days (120 hours) of completion of drilling of the borehole.

(28) "Turbidity" means the cloudiness in water, due to the presence of suspended particles such as clay and silt, that may create esthetic problems or analytical difficulties for contamination. Turbidity measured in Nephelometric Turbidity Units (NTU) is based on a comparison of the cloudiness in the water with that in a specially prepared standard.

(29) "Well" means any excavation that is cored, bored, drilled, jetted, dug or otherwise constructed for the purpose of locating, testing, developing, draining or recharging any groundwater reservoirs or aquifer, or that may control, divert, or otherwise cause the movement of water from or into any aquifer. Provided, however, this shall not include a well constructed by an individual on land which is owned or leased by him, appurtenant to a single-family dwelling, and intended for domestic use (including household purposes, farm livestock or gardens).

(30) ~~(20)~~ "Well capacity" shall mean the maximum quantity of water that a well will yield continuously.

(31) ~~(21)~~ "Well head" means the upper terminal of the well including adapters, ports, valves, seals, and other attachments.

(32) ~~(22)~~ "Well system" means two or more wells serving the same facility.

Statutory Authority G.S. 87-85; 87-87; 143-214.2, 143-215.3.

.0103 REGISTRATION

(a) Well Driller Registration:

(1) Every person, firm or corporation engaged in the business of drilling, boring, coring or constructing wells in any manner with the use of power machinery in the state shall register annually with the department.

(2) Registration shall be accomplished, during the period from January 1 to January 31 of each year, by completing and submitting to the department a registration application form provided by the department for this purpose.

(3) A non-refundable processing fee, in the form of a check or money order made payable to N.C. Department of Environment, Health, and Natural Resources, shall be submitted with each registration application form. Fees, for the year in which the registration will be valid, are as follows:

(A) For renewal of registration by any person, firm or corporation having registered at any time during the five calendar years prior to the date of application:

(i) fifty dollars ($50.00) for applications postmarked prior to February 1; and

(ii) sixty dollars ($60.00) for application postmarked after January 31.

(B) For registration by any person, firm or corporation that did not register at any time during the five calendar years prior to the date of application:

(i) fifty dollars ($50.00) for applications postmarked prior to February 1; or

(ii) for each succeeding calendar month after January, the fee shall be reduced by three dollars ($3.00) from that due in the proceeding month. As examples, the fee for applications postmarked February 1 through 29 would be forty-seven dollars ($47.00), while the fee for applications postmarked November 1 through 30 would be twenty dollars ($20.00).

(4) An application is incomplete until the required processing fee has been received. Incorrect or incomplete applications may be returned to the applicant.

(5) ~~(3)~~ Upon receipt of a properly completed application form, the applicant will be issued a certificate of registration.

(b) Pump Installer Registration:

(1) All persons, firms, or corporations engaged in the business of installing or repairing pumps or other equipment in wells shall register bi-annually with the department.

(2) Registration shall be accomplished, during the period from April 1 to April 30 of every odd-numbered year, by completing and submitting to the department a registration form provided by the department for this purpose.

(3) Upon receipt of a properly completed application form, the applicant will be issued a certificate of registration.

Statutory Authority G.S. 87-87; 143-21.3 (a) (10), 143-355 (e).

.0105 PERMITS

(a) It is the finding of the Commission that the entire geographical area of the state is vulnerable to groundwater pollution from improperly located, constructed, operated, altered, or abandoned non-water supply wells and water supply wells not constructed in accordance with the standards set forth in Rule .0107 of this Section. Therefore, in order to insure reasonable protection of the groundwater resources, prior permission from the Division must be obtained for the construction of the types of wells enumerated in Paragraph (b) of this Rule.

(b) No person shall locate or construct any of the following wells until a permit has been issued by the Director.

(1) any water-well or well system with a design capacity of 100,000 gallons per day (gpd) or greater;

(2) any well added to an existing system where the total design capacity of such existing well system and added well will equal or exceed 100,000 gpd;

~~(3) any test well if the design capacity of the production well or well system will be 100,000 gpd or greater;~~

(3) ~~(4)~~ any monitoring well, constructed to assess the impact of an activity not permitted by the state, when installed on property other than that on which the unpermitted activity took place;

(4) ~~(5)~~ any recovery well;

(5) ~~(6)~~ any well intended for the recovery of minerals or ores;

~~(7) any geophysical exploration well;~~

(6) ~~(8)~~ any oil or gas exploration or recovery well;

(7) ~~(9)~~ any well for recharge or injection purposes;

~~(10) any cathodic protection well;~~

(8) ~~(11)~~ any well with a design deviation from the standards specified under the rules of this Subchapter.

~~(c) Monitoring wells associated with a wastewater treatment and disposal facility for which a permit must be obtained from the department may be permitted as part of that facility, provided, however, that the permit applicant comply with all provisions of this Subchapter including construction standards and reporting requirements.~~

(c) ~~(d)~~ The ~~Commission~~ Director may delegate, through a Memorandum of Agreement, to another ~~state~~ governmental agency, the authority to permit wells that are an integral part of a facility requiring a permit from the agency. Provided, however, that the permittee comply with all provisions of this Subchapter, including construction standards and the reporting requirements as specified in Rule .0114. In the absence of such agreement, all wells specified in Paragraph (b) of this Rule require a well construction permit in addition to any other permits.

(d) ~~(e)~~ An application for a permit shall be submitted by the owner or his agent. ~~in duplicate to the department on forms furnished by the department, and shall include the following:~~ In the event that the permit applicant is not the owner of the property on which the well or well system is to be constructed, the permit application must contain written approval from the property owner and a statement that the applicant assumes total responsibility for ensuring that the well(s) will be located, constructed, maintained and abandoned in accordance with the requirements of this Subchapter.

(e) The application shall be submitted in duplicate to the Division, on forms furnished by the Division, and shall include the following:

(1) For all wells:

(A) the owner's name (facility name);

(B) the owner's mailing address (facility address);

(C) description of the well type and activity requiring a permit;

(D) facility location (map);

(E) ~~site plan showing location of all sources or potential sources of groundwater contamination and locations of proposed wells;~~ a map of the facility and general site area, to scale, showing the locations of:

(i) all property boundaries, at least one of which is referenced to a minimum of two landmarks such as identified roads, intersections, streams or lakes;

(ii) all existing wells, identified by type of use, within the property boundaries;

(iii) the proposed well or well system;

(iv) any test borings; and

(v) all sources of known or potential groundwater contamination (such as septic tank systems; pesticide, chemical or fuel storage areas; animal feedlots; landfills or other waste disposal areas) within 500 feet of the proposed well site;

(F) ~~location and description of existing wells on the same site or within the same well system;~~ the well drilling contractor's name, if known.

~~(G) location of any test borings;~~

(G) ~~(H)~~ construction diagram of the proposed ~~wells~~ well(s) including specifications describing all materials to be used, methods of construction and means for assuring the integrity and quality of the finished well(s).

(2) For water supply wells or well systems with a designed capacity of 100,000 gpd or greater the application shall include, in addition to the information required in Subparagraph (e)(1) of this Rule: ~~the application shall include:~~

(A) the number, yield and location of existing wells in the system;

(B) the design capacity of the proposed well(s);

(C) any other information that the ~~department~~ Division may reasonably deem necessary.

(3) For those monitoring wells ~~and recovery wells~~ with a design deviation from the specifications of Rule .0108 of this Section, in addition to the information required in Subparagraph (e)(1) of this Rule:

(A) a description of the subsurface conditions sufficient to evaluate the site. Data from test borings, wells pumping tests, etc., may be required as necessary;

(B) a description of the quantity, character and origin of the contamination;

(C) a justification for the necessity of the design deviation; and

(D) ~~(C)~~ any other information that the ~~department~~ Division may reasonably deem necessary.

(4) For those recovery wells with a design deviation from the specifications in Rule .0108 of this Section, in addition to the information required in Subparagraph (e)(1) and Parts (e)(3)(A), (B) and (C) of this Rule, the application shall describe the disposition of any fluids recovered if the disposal of those fluids will have an impact on any existing wells other than those installed for the express purpose of measuring the effectiveness of the recovery well(s).

(f) In the event of an emergency, monitoring wells and/or recovery wells may be constructed after verbal approval is provided by the Director or his delegate. ~~After the fact~~ After-the-fact applications shall be submitted by the driller or owner within ten days after construction begins. The application shall include construction details of the monitoring well(s) and/or recovery well(s).

(g) It shall be the responsibility of the well owner or his agent to see that a permit is secured prior to the beginning of construction of any well for which a permit is required under the rules of ~~the~~ this Subchapter.

Statutory Authority G.S. 87-87.

.0107 STANDARDS OF CONSTRUCTION: WATER-SUPPLY WELLS

(a) Location.

(1) The well shall not be located

~~(A)~~ in an area ~~not~~ generally subject to flooding. Areas which have a propensity for flooding include those with concave slope, alluvial or colluvial soils, gullies, depressions, and drainage ways;

~~(B) at a minimum horizontal distance of 50 feet from any water-tight sewage and liquid-waste collection facility (such as cast iron pipe) except in the case of wells intended for a single family dwelling where it is not feasible to obtain 50 feet separation between a well and a water-tight liquid-waste collection facility because of lot size or other fixed conditions, the horizontal separation distance shall be the maximum feasible distance, but in no case less than 25 feet; provided~~

~~the sewer line is constructed of leak-proof pipe, such as cast iron pipe, with leaded or mechanical joints;~~

~~(C)~~ ~~at a minimum horizontal distance of 100 feet from any other sewage or liquid-waste collection any disposal facility (such as a septic tank and drain fields) and any other source of existing or potential pollution or contamination, except in the case of wells intended for a single family dwelling where it is not feasible to obtain 100 feet horizontal separation between a well and a source because of lot size or other fixed conditions, the separation distance shall be maximum feasible distance, but in no case less than 50 feet.~~

(2) The minimum horizontal separation between a well, intended for a single-family residence or other non-public water system, and potential sources of groundwater contamination shall be as follows unless otherwise specified:

(A) Septic tank and drainfield .... 100 ft.
(B) Other subsurface ground absorption waste disposal system .... 100 ft.
(C) Industrial or municipal sludge-spreading or wastewater-irrigation sites .... 100 ft.
(D) Water-tight sewage or liquid-waste collection or transfer facility .... 50 ft.
(E) Other sewage and liquid-waste collection or transfer facility .... 100 ft.
(F) Cesspools and privies .... 100 ft.
(G) Animal feedlots or manure piles .... 100 ft.
(H) Fertilizer, pesticide, herbicide or other chemical storage areas .... 100 ft.
(I) Non-hazardous waste storage, treatment or disposal lagoons .... 100 ft.
(J) Sanitary landfills .... 500 ft.
(K) Other non-hazardous solid waste landfills .... 100 ft.
(L) Animal barns .... 100 ft.
(M) Building foundations .... 50 ft.
(N) Surface water bodies .... 50 ft.
(O) Chemical or petroleum fuel underground storage tanks regulated under 15A NCAC 2N:
(i) with secondary containment .... 50 ft.
(ii) without secondary containment .... 100 ft.
(P) All other sources of groundwater contamination .... 100 ft.

(3) For a well serving a single-family dwelling where lot size or other fixed conditions preclude the separation distances specified in Subparagraph (a)(2) of this Rule, the required separation distances may be reduced to the maximum possible but in no case less than the following:

(A) Septic tank and drainfield .... 50 ft.
(B) Water-tight sewage or liquid-waste collection or transfer facility .... 25 ft.
(C) Building foundations .... 25 ft.
(D) Cesspool or privies .... 50 ft.

(4) A well or well system, serving more than one single-family dwelling but with a designed capacity of less than 100,000 gpd, must meet the separation requirements specified in Subparagraph (a) (2) of this Rule;

(5) A well or well system with a designed capacity of 100,000 gpd or greater must be located a sufficient distance from known or anticipated sources of groundwater contamination so as to prevent a violation of applicable groundwater quality standards, resulting from the movement of contaminants, in response to the operation of the well or well system at the proposed rate and schedule of pumping;

(6) ~~(2)~~ Actual separation distances must conform with the more stringent of applicable federal, state and local requirements;

(7) ~~(3)~~ Wells drilled for public water supply systems regulated by the ~~Department of Human Resources~~ Division of Environmental Health shall meet the siting and all other requirements of that ~~department.~~ Division.

(b) Source of water.

(1) The source of water for any well intended for domestic use shall not be from a water bearing zone or aquifer that is known to be contaminated;

(2) In designated areas described in Rule .0117 of this Section, the source shall be greater than 35 feet;

(3) In designated areas described in Rule .0116 of this Section, the source may be less than 20 feet, but in no case less than 10 feet; and

(4) In all other areas the source shall be at least 20 feet below land surface.

(c) ~~(b)~~ Drilling Fluids and Additives. Drilling Fluids and Additives shall ~~be materials specified for use in~~ not contain organic or toxic substances and may be comprised only of:

(1) the formational material encountered during drilling; or

(2) materials manufactured specifically for the purpose of borehole conditioning or water well construction. ~~and approved by the Division.~~

(d) ~~(e)~~ Casing.

(1) If steel casing is used, then:

(A) The casing shall be new, seamless or electric-resistance welded galvanized or black steel pipe. Galvanizing shall be done in accordance with requirements of ASTM A-120.

(B) The casing, threads and couplings shall meet or exceed the specifications of ASTM A-53, A-120 or A589.

(C) The minimum wall thickness for a given diameter shall equal or exceed that specified in Table 1.

TABLE 1: MINIMUM WALL THICKNESS FOR STEEL CASING:

Nominal Diameter (in.)	Wall Thickness (in.)
For 3-1/2" or smaller pipe, schedule 40 is required	
4	0.142
5	0.156
5-1/2	0.164
6	0.185
8	0.250
10	0.279
12	0.330
14 and larger	0.375

(D) Stainless steel casing, threads, and couplings shall conform in specifications to the general requirements in ~~ANSI/~~ ASTM A-530 and also shall conform to the specific requirements in the ASTM standard that best describes the chemical makeup of the stainless steel casing that is intended for use in the construction of the well;

(E) Stainless steel casing shall have a minimum wall thickness that is equivalent to standard schedule number 10S;

(F) Steel casing shall be equipped with a drive shoe if the casing is seated in a consolidated rock formation and for any other wells if the casing is driven. The drive shoe shall be made of forged, high carbon, tempered seamless steel and shall have a beveled, hardened cutting edge. A drive shoe will not be required for wells in which the grout surrounds and extends the entire length of the casing.

(2) If Thermoplastic Casing is used, then:

(A) the casing shall be new;

(B) the casing and joints shall meet or exceed all the specifications of ASTM F-480-81, except that the outside diameters will not be restricted to those listed in F-480;

(C) the maximum depth of installation for a given SDR or Schedule number shall not exceed that listed in Table 2;

Editor's Note: This Table has been moved from Part (e)(1)(C) in this Rule. The amendments to the table are shown below. The table is shown as deleted from Part (e)(1)(C).

TABLE 2: Maximum allowable depths (in feet) of Installation of Thermoplastic Water Well Casing

Nominal Diameter (in inches)

Schedule

number-	2	2.5	3	3.5	4	5	6	8	10	12	14	16
Schedule 40-	485	635	415	315	253	180	130	85	65	65	50	50
Schedule 80-	1460	1685	1170	920	755	550	495	340	290	270	265	255

SDR Number	All Diameters (in inches)
SDR 41	20
SDR 32.5	50
SDR 27.5	~~80~~ 100
SDR 26	95
SDR 21	185
SDR 17	355
SDR 13.5	735

(D) The top of the casing shall be terminated by the drilling contractor at least twelve inches above land surface;

(E) For wells in which the casing will extend into consolidated rock, thermoplastic casing shall be equipped with a section of steel casing at least three feet in length, or other device approved by the Director, sufficient to protect the physical integrity of the thermoplastic casing during the processes of seating and grouting the casing and subsequent drilling operations.

(3) ~~In constructing any well,~~ All water-bearing zones ~~that are known to contain~~ containing polluted, saline, or other non-potable water, that are encountered or penetrated during drilling, shall be adequately cased and cemented off so that pollution of the overlying and underlying groundwater zones will not occur.

(4) Every well shall be cased ~~with~~ so that the bottom of the casing ~~extending~~ extends to a minimum depth as follows:

(A) Wells located within the area described in Rule .0117 of this ~~Subchapter~~ Section shall be cased from land surface to a depth of at least 35 feet;

(B) Wells located within the area described in Rule .0116 of this ~~Subchapter~~ Section shall be cased from land surface to a depth of at least 10 feet;

(C) Wells located in any other area shall be cased from land surface to a depth of at least 20 feet.

(5) The top of the casing shall be terminated by the drilling contractor at least 12 inches above land surface.

(6) The casing in wells constructed to obtain water from a consolidated rock formation shall be:

(A) adequate to prevent any formational material from entering the well in excess of the levels specified in Paragraph (i) of this Rule; and

(B) Firmly seated at least one foot into the rock, and

(i) sealed with grout at least one foot into the rock; or

(ii) sealed by some other method, approved by the Director, that will provide equal protection against the entrance of formation material or contaminants one foot below the top of the consolidated rock.

(7) The casing in wells constructed to obtain water from an unconsolidated rock formation (such as gravel, sand or shells) shall extend at least one foot into the top of the water-bearing formation.

(8) Upon completion of the well, the well casing shall be sufficiently free of obstacles as necessary to allow for the installation and proper operation of pumps and associated equipment.

(e) ~~(d)~~ Grouting.

(1) Casing shall be grouted to a minimum depth of twenty feet below land surface except that:

(A) In those areas designated by the Director to meet the criteria of Rule .0116 of this ~~Subchapter~~ Section, grout shall extend to a depth of two feet above the screen or, for open end wells, to the bottom of the casing, but in no case less than 10 feet.
(B) In those areas designated in Rule .0117 of this ~~Subchapter,~~ Section, grout shall extend to a minimum of 35 feet below land surface.
(C) The casing shall be grouted as necessary to seal off all aquifers or zones with water of a poorer quality than that of the producing zone(s).

~~TABLE 2: Maximum allowable depths (in feet) of Installation of Thermoplastic Water Well Casing~~

~~Nominal Diameter~~

~~Schedule number~~	~~2~~	~~2.5~~	~~3~~	~~3.5~~	~~4~~	~~5~~	~~6~~	~~8~~	~~10~~	~~12~~	~~14~~	~~16~~
~~Schedule 40~~	~~485~~	~~635~~	~~415~~	~~315~~	~~253~~	~~189~~	~~130~~	~~85~~	~~65~~	~~65~~	~~50~~	~~50~~
~~Schedule 80~~	~~1460~~	~~1685~~	~~1170~~	~~920~~	~~755~~	~~550~~	~~495~~	~~340~~	~~290~~	~~270~~	~~265~~	~~255~~

~~SDR Number~~	~~All Diameters~~
~~SDR 41~~	~~20~~
~~SDR 32.5~~	~~50~~
~~SDR 27.5~~	~~80~~
~~SDR 26~~	~~95~~
~~SDR 21~~	~~185~~
~~SDR 17~~	~~355~~
~~SDR 13.5~~	~~735~~

(2) For large diameter wells, commonly referred to as "bored" wells, cased with concrete pipe or ceramic tile, the following shall apply:
(A) The diameter of the bore hole shall be at least six inches larger than the outside diameter of the casing;
(B) The annular space around the casing shall be filled with a cement-type grout to a depth of at least 20 feet, excepting those designated areas specified in Rules .0116 and .0117 of this Section. The grout shall be placed in accordance with the requirements of this Paragraph.
(3) For any well constructed to obtain water from consolidated rock, the well casing shall be grouted, using a cement type grout, to a height of five feet above the intersection of the casing and the consolidated rock.
(4) Bentonite grout may only be used in that portion of the borehole that is below the water table throughout the year.
(5) ~~(2)~~ Grout shall be placed around the casing by one of the following methods:
(A) Pressure. ~~The annular space between the casing and the formation shall be a minimum of 1.5 inches.~~ Grout shall be pumped or forced under pressure through the bottom of the casing until it fills the annular area around the casing and overflows at the surface.
(B) Pumping. ~~The annular space between the casing and formation, shall be a minimum of 1.5 inches.~~ Grout shall be pumped into place through a hose or pipe extended to the bottom of the annular space which can be raised as the grout is applied. The grout hose or pipe should remain submerged in grout during the entire application.

(C) Other. ~~The annular space around the casing shall be a minimum of three inches. The annular space shall be completely filled with grout by any method that will insure completed filling of the space; provided the annular area does not contain water. If the annular area contains water it shall be dewatered or the grout shall be placed by either the pumping or pressures method.~~ Grout may be emplaced in the annular space, by gravity flow through a pipe, to a maximum depth of 20 feet below land surface.

(6) ~~(3)~~ If an outer casing is installed, it shall be grouted by either the pumping or pressure method.

(7) ~~(4)~~ All grout mixtures shall be prepared prior to emplacement.

(8) ~~(5)~~ The well shall be grouted within five working days after the casing is set.

(9) ~~(6)~~ No additives which will accelerate the process of hydration shall be used in grout for thermoplastic well casing.

(10) Where grouting is required by the provisions of this Section, the grout shall extend outward from the casing wall to a minimum thickness equal to either one-third of the diameter of the outside dimension of the casing or two inches, whichever is greater; excepting, however, that large diameter bored wells shall meet the requirements of Subparagraph (e)(2) of this Rule.

(f) ~~(e)~~ Well Screens.

(1) The well, if constructed to obtain water from an unconsolidated rock formation, shall be equipped with a screen that will adequately prevent the entrance of formation material into the well after the well has been developed and completed by the well contractor.

(2) The well screen be of a design to permit the optimum development of the aquifer with minimum head loss consistent with the intended use of the well. The openings shall be designed to prevent clogging and shall be free of rough edges, irregularities or other defects that may accelerate or contribute to corrosion or clogging.

(3) Multi-screen wells shall not connect aquifers or zones which have differences

~~(A)~~ in water quality which would result in contamination of any aquifer or zone.

~~(B) in water levels that would result in depletion of water from any aquifer or zone or significant change in head in any aquifer or zone.~~

(g) ~~(f)~~ Gravel- and Sand- Packed Wells.

(1) In constructing a gravel- or sand- packed well.

(A) The ~~gravel~~ packing material shall be composed of quartz, granite, or similar rock material and shall be clean, ~~rounded,~~ of uniform size, water-washed and free from clay, silt, or other deleterious material.

(B) The size of the ~~gravel~~ packing material shall be determined from a grain size analysis of the formation material and ~~should be compatible with the grain size of the aquifer.~~ shall be of a size sufficient to prohibit the entrance of formation material into the well in concentrations above those permitted by Paragraph (h) of this Rule.

(C) The ~~gravel~~ packing material shall be placed in the annular space around the screens and casing by a fluid circulation method, preferably through a conductor pipe ~~or~~ to insure accurate placement and avoid bridging.

(D) The ~~gravel~~ packing material shall be adequately disinfected

(E) For gravel -or sand- packed wells in which an outer casing, that is grouted its entire length, does not extend to the top of the producing zone, a neat cement plug of at least 10 feet in vertical thickness shall be placed in the annular area between the inner casing and formation opposite the first clay above the top screen. The remaining space shall be filled with grout or clay except the upper 20 feet, which shall be filled with grout.

(F) Centering guides must be installed within five feet of the top packing material to ensure even distribution of the packing material in the borehole.

(2) The ~~gravel pack~~ packing material shall not connect aquifers or zones which have differences

~~(A)~~ in water quality that would result in deterioration of the water quality in any aquifer or zone.

~~(B) In water levels that would result in depletion of water from any aquifer or zone or significant change in head in any aquifer or zone.~~

~~(g) Large Diameter Wells~~

~~(1) A large diameter well cased with concrete pipe and commonly referred to as a "bored" well, may be constructed.~~

~~(2) If the casing joints are not sealed, the construction shall be as follows:~~

~~(A) The bore hole shall have a minimum diameter of six inches larger than the outside diameter of the casing.~~

~~(B) The annular space around the casing shall be filled with neat cement, sand cement or concrete grout to a depth of at least 20 feet below land surface. The grout shall be placed in accordance with requirements of Rule .0107 (d)(3) of this Subchapter.~~

~~(C) The annular space around the casing below the grout shall be filled with sand or gravel.~~

~~(D) The gravel-pack material shall be composed of quartz, granite, or similar rock material and shall be clean, rounded, uniform, water-washed and free from clay, silt, or other deleterious material.~~

~~(E) The gravel shall be adequately disinfected.~~

~~(3) If the casing joints are sealed, the bore hole shall have a minimum diameter of six inches larger than the outside diameter of the casing to a depth of at least 20 feet below the land surface. The annular space around the casing shall be filled with neat or sand-cement grout to a depth of at least 20 feet below land surface.~~

~~(4) The well head shall be completed in the same manner as required for other water-supply wells.~~

(h) Well Development.

(1) All water supply wells shall be properly developed by the well driller;

(2) Development shall include removal of formation materials, mud, drilling fluids and additives ~~A total suspended solids concentrations of less than 5 milligrams per liter of formation materials is considered acceptable.~~ such that the water contains no more than:

(A) five milligrams per liter (19 milligrams per gallon) of settleable solids; or

(B) ten NTUs of turbidity as suspended solids.

(i) Well Head Completion.

(1) Access Port. Every water supply well and such other wells as may be specified by the Commission shall be equipped with a usable access port or air line. The access port shall be at least one half inch inside diameter opening so that the position of the water level can be determined at any time. Such port shall be installed and maintained in such manner as to prevent entrance of water or foreign material.

(2) Well Contractor Identification Plate.

(A) An identification plate, showing the drilling contractor and registration number and the information specified in Part (i)(2)(E) of this Rule, shall be installed on the well within ~~24~~ 72 hours after completion of the drilling.

(B) The identification plate shall be constructed of a durable weatherproof, rustproof metal, or equivalent material approved by the Director.

(C) The identification plate shall be ~~securely~~ permanently attached to the well casing or enclosure floor around the casing where it is readily visible.

(D) The identification plate shall not be removed from the well casing or enclosure floor by any person

(E) The identification ~~tag~~ plate shall be stamped with a permanent marking ~~within 30 days of completion of drilling~~ to show the:

(i) total depth of well;

(ii) casing depth (ft.) and inside diameter (in.);

(iii) screened intervals of screened wells;

(iv) ~~gravel~~ packing interval of gravel- or sand- packed wells;

(v) yield, in gallons per minute (gpm), or specific capacity in gallons per minute per foot of drawdown (gpm/ft.-dd); and

(vi) static water level and date measured;

~~(vii) drilling contractor and registration number;~~

~~(viii)~~ (vii) date well completed.

(3) Pump Installer Identification Plate.

(A) An identification plate, displaying the name and registration number of the pump installation contractor, shall be permanently attached to either the aboveground portion of the well casing, or the enclosure floor if present, within 72 hours after completion of the pump installation;

(B) The identification plate shall be constructed of a durable waterproof, rustproof metal, or equivalent material approved by the Director;

(C) The identification plate shall not be removed from the well casing or enclosure floor by any person, and

(D) The identification plate shall be stamped with a permanent marking to show the:

(i) date the pump was installed;

(ii) the depth of the pump intake; and

(iii) the horsepower rating of the pump.

(4) ~~(3)~~ Valved flow. Every artesian well that flows under natural artesian pressure shall be equipped with a valve so that the flow can be completely stopped. Well owners shall be responsible for the operation and maintenance of the valve.

(5) ~~(4)~~ Pitless ~~adapter~~ adapters or pitless units shall be allowed as a method of well head completion under the following conditions:

(A) The pitless ~~adapter unit~~ device be ~~of standard design and~~ manufactured specifically for the purpose of water well construction;
(B) ~~the unit shall meet industry standards for strength and water tightness;~~ Design, installation and performance standards shall be those specified in PAS-1 (Pitless Adapter Standard No. 1) as adopted by the Water System Council's Pitless Adapter Division;
(C) The ~~unit~~ pitless device will be compatible with the well casing;
~~(D) the unit be joined to the well casing be either a threaded coupling or welded joint;~~
(D) ~~(E)~~ The top of the ~~unit~~ pitless device shall ~~be~~ extend at least 8 inches above land surface;
(E) ~~(F)~~ The ~~unit~~ pitless device shall have an access port.

(5) All openings for piping, wiring, and vents shall enter into the well at least eight inches above land surface, except where pitless ~~adapter~~ adapters or pitless units are used, and shall be adequately sealed to preclude the entrance of contaminants into the well.

Statutory Authority G.S. 87-87; 87-88.

.0108 STANDARDS OF CONSTRUCTION: WELLS OTHER THAN WATER SUPPLY

(a) No well shall be located, constructed, operated, or repaired in any manner that may adversely impact the quality of groundwater. Any test ~~holes and borings~~ hole or boring shall be permanently abandoned by the driller in accordance with Rule .0113 of this Section within two days after drilling or two days after testing is complete, whichever is least restrictive; except in the case that a test well is being converted to a production well, in which case conversion shall be completed within 30 days.

(b) Injection wells shall conform to the standards set forth in Section .0200 of this Subchapter.

(c) Monitoring wells and recovery wells shall be located, designed, constructed, operated and abandoned with materials and by methods which are compatible with the chemical and physical properties of the contaminants involved, specific site conditions and specific subsurface conditions. Specific construction standards will be itemized in the construction permit, if such a permit is required, but the following general requirements will apply:

(1) For wells from which samples of groundwater or other liquids will be obtained for the purpose of examination or testing, or for the recovery of polluted groundwater:

(A) ~~(1)~~ The borehole shall not penetrate to a depth greater than the depth to be monitored or the depth from which contaminants are to be recovered.
(B) ~~(2)~~ The well shall not hydraulically connect separate aquifers.
(C) ~~(3)~~ The construction materials shall be compatible with the contaminants to be monitored or recovered.
(D) ~~(4)~~ The well shall be constructed in such a manner that water or contaminants from the land surface cannot migrate along the borehole annulus into ~~gravel pack~~ the packing material or well screen area.
(E) ~~(5) When a gravel pack is~~ Packing material placed around the screen ~~a seal shall be installed above the gravel.~~ shall extend to a depth at least one foot above the top of the screen. A one foot thick seal, comprised of bentonitic clay or other material approved by the Director, shall be emplaced directly above and in contact with the packing material.
(F) ~~(6)~~ Grout shall be placed in the annular space between the casing and the borehole wall from land surface to a ~~depth within two feet above the top of the well screen~~ the top of the clay seal or to the bottom of the casing for open end wells.
(G) ~~(7)~~ All wells shall be secured to reasonably insure against unauthorized access and use.
(H) ~~(8)~~ All wells shall be afforded reasonable protection against damage during construction and use.
(I) ~~(9)~~ Any wells which are flowing artesian wells shall be valved so that the flow can be regulated.
(J) The well casing shall be terminated no less than 12 inches above land surface datum unless both of the following conditions are met:
(i) site-specific conditions directly related to business activities, such as vehicle traffic, would endanger the physical integrity of the well, and
(ii) the well head is completed in such a manner so as to preclude surficial contaminants from entering the well.
(K) ~~(10)~~ Each well shall have permanently affixed an identification plate constructed of a durable material and shall contain the following information:
(i) ~~(A)~~ drilling contractor name and registration number;
(ii) ~~(B)~~ date well completed,
(iii) ~~(C)~~ total depth of well;
(iv) ~~(D)~~ a warning that the well is not ~~the~~ for water supply and that the

groundwater may contain hazardous materials; and

(v) ~~(E)~~ depth(s) to screen(s).

(L) Each well shall be developed such that the level of turbidity or settleable solids does not preclude accurate chemical analyses of any fluid samples collected.

(2) For any well which will only be used to measure groundwater levels, the following general requirements will apply:

(A) The borehole shall not penetrate to a depth greater than the depth at which fluid elevation measurements will be made;

(B) The well shall not hydraulically connect separate aquifers;

(C) The well shall be constructed in such a manner that water or contaminants from the land surface cannot migrate along the borehole channel into the packing material or well screen areas;

(D) Grout shall be placed in the annular space between the casing and the borehole from land surface to the clay seal above the packing material or to the bottom of the casing for open end wells;

(E) Unless the wells will not be left unattended, such as during a well capacity or aquifer capacity test, all wells shall be secured to reasonably insure against unauthorized access and use;

(F) All wells shall be afforded reasonable protection against damage during construction and use;

(G) Any well which is a flowing artesian well shall be valved such that flow can be regulated;

(H) The well casing shall be terminated no less than 12 inches above land surface datum unless both of the following conditions are met:

(i) site-specific conditions related to business activities, such as vehicle traffic, would endanger the physical integrity of the well, and

(ii) the well head is completed in such a manner so as to preclude surficial contaminants from entering the well.

(I) An identification plate constructed of a rustproof, durable material shall be permanently affixed to the well and shall contain the following information:

(i) drilling contractor name and registration number,

(ii) date well completed,

(iii) total depth of well,

(iv) a warning that the well is not a water supply well and that the groundwater may contain contaminants.

(d) ~~Observation Wells.~~ Wells constructed for the purpose of monitoring or testing for the presence of liquids associated with tanks regulated under 15A NCAC 2N (Criteria and Standards Applicable to Underground Storage Tanks) shall be constructed in accordance with 15A NCAC 2N .0504.

~~(1) shall be cased as specified in .0107(c) of this Subchapter unless otherwise approved by the department.~~

~~(2) shall be grouted to within two feet of the well screens or, for open end wells, to the bottom of the casing unless otherwise approved by the department.~~

(e) Wells constructed for the purpose of monitoring for the presence of vapors associated with tanks regulated under 15A NCAC 2N shall:

(1) be constructed in such a manner as to prevent the entrance of surficial contaminants or water into or alongside the well casing; and

(2) be provided with a lockable cap in order to reasonably insure against unauthorized access and use.

(f) Temporary wells and all other non-water supply wells shall be constructed in such a manner as to preclude the vertical migration of contaminants within and along the borehole channel.

(g) For sand-or gravel-packed wells, centering guides must be installed within five feet of the top of the packing material to ensure even distribution of the packing material in the borehole.

Statutory Authority G.S. 87-87; 87-88

.0109 PUMPS AND PUMPING EQUIPMENT

(a) The pumping capacity of the pump shall be consistent with the intended use and yield characteristics of the well.

(b) The pump and related equipment for the well shall be conveniently located to permit easy access and removal for repair and maintenance.

(c) The base plate of a pump placed directly over the well shall be designed to form a watertight seal with the well casing or pump foundation.

(d) In installations where the pump is not located directly over the well, the annular space between the casing and pump intake or discharge piping shall be closed with a watertight seal preferably designed specifically for this purpose.

(e) The well shall be properly vented at the well head to allow for the pressure changes within the well except when a suction lift type pump is used.

(f) A hose bibb shall be installed at the well head by the person installing the pump for obtaining water samples. In the case of offset jet pump installations the hose bibb shall be installed on the return (pressure) side of the jet pump piping.

(g) A priming tee shall be installed at the well head in conjunction with offset jet pump installations.

(h) Joints of any suction line installed underground between the well and pump shall be surrounded by ~~six inches of~~ cement, or encased in a larger pipe that is sealed at each end.
(i) The drop piping and electrical wiring used in connection with the pump shall meet all applicable underwriters specifications. ~~acceptable to the department.~~
(j) Contaminated water shall not be used for priming the pump.

Statutory Authority G.S. 87-87; 87-88.

.0110 WELL TESTS FOR YIELD
(a) Every water supply well shall be tested for capacity by a method and for a period of time acceptable to the department.
(b) The permittee may be required as a permit condition to test any well for capacity by a method stipulated in the permit.
(c) Standard methods for testing domestic well capacities include:
(1) Pump Method
(A) select a permanent measuring point, such as the top of the casing;
(B) measure and record the static water level below or above the measuring point prior to starting the pump;
(C) measure and record the discharge rate at intervals of 10 minutes or less;
(D) measure and record water levels using a steel or electric tape at intervals of 10 minutes or less;
(E) continue the test for a period of at least one hour;
(F) make measurements within an accuracy of plus or minus 0.25 of a ~~foot.~~ an inch.
(2) Bailer Method
(A) select a permanent measuring point, such as the top of the casing;
(B) measure and record the static water level below or above the measuring point prior to starting the bailing procedure;
(C) bail the water out of the well as rapidly as possible for a period of at least one hour; determine and record the bailing rate in gallons per minute at the end of the bailing period;
(D) measure and record the water level immediately after stopping bailing process.
(3) Air Rotary Drill Method
(A) measure and record the amount of water being injected into the well during drilling operations;
(B) measure and record the discharge rate in gallons per minute at intervals of one hour or less during drilling operations;
(C) after completion of the drilling, continue to blow the water out of the well for at least 30 minutes and measure and record the discharge rate in gallons per minute at intervals of 10 minutes or less during the period;
(D) measure and record the water level immediately after discharge ceases.
(4) Air Lift Method
(A) Measurements shall be made through a pipe placed in the well;
(B) The pipe shall have a minimum inside diameter of at least five-tenths of an inch and shall extend from top of the well head to a point inside the well that is below the bottom of the air line;
(C) Measure and record the static water level prior to starting the air compressor;
(D) Measure and record the discharge rate at intervals of 10 minutes or less;
(E) Measure and record the pumping level using a steel or electric tape at intervals of 10 minutes or less;
(F) Continue the test for a period of at least one hour.
(d) Public, Industrial and Irrigation Wells. Every public, industrial and irrigation well upon completion, shall be tested for capacity by the drilling contractor (except when the owner specifies another agent) by the following or equivalent method:
(1) The water level in the well to be pumped and any observation wells shall be measured and recorded prior to starting the test.
(2) The well shall be tested by a pump of sufficient size and lift capacity to satisfactorily test the yield of the well, consistent with the well diameter and purpose.
(3) The pump shall be equipped with sufficient throttling devices to reduce the discharge rate to approximately 25 percent of the maximum capacity of the pump.
(4) The test shall be conducted for a period of at least 24 hours without interruption and shall be continued for a period of at least four hours after the pumping water level stabilizes (ceases to decline). When the total water requirements for wells other than public, community or municipal supply wells are less than 100,000 gpd, the well shall be tested for a period and in a manner to satisfactorily show the capacity of the well, or that the capacity of the well is sufficient to meet the intended purpose.
(5) The pump discharge shall be set at a constant rate or rates that can be maintained throughout the testing period. If the well is tested at two or more pumping rates (a step-drawdown test), the pumping water level shall be stabilized for a period of at least four hours for each pumping rate

(6) The pump discharge rate shall be measured by an orifice meter, flowmeter, weir, or equivalent metering device. The metering device shall have an accuracy within plus or minus five percent.

(7) The discharge rate of the pump and time shall be measured and recorded at intervals of 10 minutes or less during the first two hours of the pumping period for each pumping rate. If the pumping rate is relatively constant after the first two hours of pumping, discharge measurements and recording may be made at longer time intervals but not to exceed one hour.

(8) The water level in each well and time shall be measured and recorded at intervals of five minutes or less during the first hour of pumping and at intervals of 10 minutes or less during the second hour of pumping. After the second hour of pumping, the water level in each well shall be measured at such intervals that the lowering of the pumping water level does not exceed 0.25 of ~~a foot or three inches~~ an inch between measurements.

(9) A reference point for water level measurements (preferably the top of the casing) shall be selected and recorded for the pumping well and each observation well to be measured during the test. All water level measurements shall be made from the selected reference points.

(10) All water level measurements shall be made with a steel or electric tape or equivalent measuring device.

(11) All water level measurements shall be made within an accuracy of plus or minus 0.25 of a foot ~~or three inches.~~ (three inches).

(12) After the completion of the pumping period, measurements of the water level recovery rate, in the pumped well, shall be made for a period of at least two hours in the same manner as the drawdown.

Statutory Authority G.S. 87-87; 87-88.

.0111 DISINFECTION OF WATER SUPPLY WELLS

All water supply wells shall be disinfected upon completion of construction, maintenance, repairs, pump installation and testing as follows:

(1) Chlorination.

(a) ~~(1)~~ Chlorine shall be placed in the well in sufficient quantities to produce a chlorine residual of at least 100 parts per million (ppm) in the well. A chlorine solution may be prepared by dissolving high test calcium hypochlorite (trade names include HTH, Chlor-Tabs, etc) in water. About 0.12 percent available chlorine is needed per 100 gallons of water for 100 ppm chlorine residual. As an example, a well having a diameter of six inches, has a volume of about one and five-tenths gallons per foot. If the well has 200 feet of water, the minimum amount of hypochlorite required would be 0.36 lbs. (1.5 x 200 feet = 300 gallons, 0.12 lbs. per 100 gallons, 0.12 x 3 = 0.36 lbs.)

(b) ~~(2)~~ The chlorine shall be placed in the well by one of the following or equivalent methods:

(i) ~~(a)~~ Chlorine tablets may be dropped in the top of the well and allowed to settle to the bottom.

(ii) ~~(b)~~ Chlorine solutions shall be placed in the bottom of the well by using a bailer or by pouring the solution through the drill rod, hose, or pipe placed in the bottom of the well. The solution shall be flushed out of the drill rod, hose, or pipe by using water or air.

(c) ~~(3)~~ Agitate the water in the well to insure thorough dispersion of the chlorine.

(d) ~~(4)~~ The well casing, pump column and any other equipment above the water level in the well shall be thoroughly rinsed with the chlorine solution as a part of the disinfecting process.

(e) ~~(5)~~ The chlorine solution shall stand in the well for a period of at least 24 hours.

(f) ~~(6)~~ The well shall be pumped until the system is clear of the chlorine before the system is placed in use.

~~(7) A sample of the water should be analyzed and found safe for human consumption.~~

(2) Other materials and methods of disinfection may be used upon prior approval by the Director.

Statutory Authority G.S. 87-87; 87-88.

.0112 WELL MAINTENANCE: REPAIR: GROUNDWATER RESOURCES

(a) Every well shall be maintained in a condition whereby it will conserve and protect the ~~ground water~~ groundwater resources, and whereby it will not be a source or channel of contamination or pollution to the water supply or any aquifer.

(b) All materials used in the maintenance, replacement, or repair of any well shall meet the requirements for new installation.

(c) Broken, punctured or otherwise defective or unserviceable casing, screens, fixtures, seals, or any part of the well head shall be repaired or replaced, or the well shall be properly abandoned.

(d) National Science Foundation (NSF) approved PVC pipe rated at 160 PSI may be used for liner casing. The annular space around the liner casing shall be at least five-eighths inches and shall be completely filled with neat-cement grout.

Statutory Authority G.S. 87-87; 87-88.

.0113 ABANDONMENT OF WELLS

(a) Any well which has been abandoned, either temporarily or permanently, shall be abandoned in accordance with one of the following procedures:

(1) Procedures for temporary abandonment of wells:

(A) Upon temporary removal from service or prior to being put into service, the well shall be sealed with a water-tight cap or seal compatible with casing and installed so that it cannot be removed easily by hand.

(B) The well shall be maintained whereby it is not a source or channel or contamination during temporary abandonment.

(C) Every temporarily abandoned well shall be protected with a casing.

(2) Procedures for permanent abandonment of wells:

(A) All casing and screen materials may be removed prior to initiation of abandonment procedures if such removal will not cause or contribute to contamination of the groundwaters. Any casing not grouted in accordance with Rule .0107 Paragraph (d) of this Section shall be removed or properly grouted.

(B) The entire depth of the well shall be sounded before it is sealed to ensure freedom from obstructions that may interfere with sealing operations.

(C) The well shall be thoroughly disinfected prior to sealing.

(D) In the case of gravel-packed wells in which the casing and screens have not been removed, neat-cement shall be injected into the well completely filling it from the bottom of the casing to the top.

(E) "Bored" wells shall be completely filled with cement grout, dry clay or material excavated during drilling of the well and then compacted in place.

(F) Wells, other than "bored" wells, constructed in unconsolidated formations ~~other than "bored" wells~~ shall be completely ~~dilled~~ filled with cement grout by introducing it through a pipe extending to the bottom of the well which can be raised as the well is filled.

(G) Wells constructed in consolidated rock formations or that penetrate zones of consolidated rock may be filled with cement, sand, gravel or drill cuttings opposite the zones of consolidated rock. The top of the sand, gravel or cutting fill shall be at least five feet below the top of the consolidated rock. The remainder of the well shall be filled with cement grout only.

(H) Test wells less than 20 feet in depth which do not penetrate the water table shall be abandoned in such manner as to prevent the well from being a channel allowing the vertical movement of water or a source of contamination to the groundwater supply. Test wells or borings that penetrate the water table shall be abandoned by completely filling with cement grout.

(b) Any well which acts as a source or channel of contamination shall be repaired or permanently abandoned within 30 days ~~or~~ of receipt of notice from the department.

(c) The drilling contractor shall permanently abandon any well in which the casing has not been installed or from which the casing has been removed, prior to removing his equipment from the site.

(d) The owner shall be responsible for permanent abandonment of a well except:

(1) As otherwise specified in these ~~Regulations.~~ Rules; or

(2) If well abandonment is required because the driller improperly locates, constructs, or completes the well.

Statutory Authority G.S. 87-87; 87-88.

.0114 DATA AND RECORDS REQUIRED

(a) Well Cuttings.

(1) Samples of formation cuttings shall be collected and furnished to the ~~department~~ Division from all wells when such samples are requested by the ~~department.~~ Division.

(2) Samples or representatives cuttings shall be obtained for depth intervals of 10 feet or less beginning at the land surface. Representative cuttings shall also be collected at depths of each significant change in formation.

(3) Samples of cuttings shall be placed in containers furnished by the ~~department~~ Division and such containers shall be filled, sealed and properly labeled with indelible-type markers, showing the well owner, well number if applicable, and depth interval the sample represents.

(4) Each set of samples shall be placed in a suitable container(s) showing the location, owner, well number if applicable, driller, depth interval, and date.

(5) Samples shall be retained by the driller until delivery instructions are received from the ~~department~~ Division or for a period of at least 60 days after the well

record form (GW-1), indicating said samples are available, has been received by the ~~department.~~ Division.

(6) The furnishing of samples to any person or agency other than the ~~department~~ Division shall not constitute compliance with the department's request and shall not relieve the driller of his obligation to the department.

(b) Reports.

(1) Any person completing or abandoning any well shall submit to the Division a record of the construction or abandonment. ~~on forms provided by the department.~~ For public water supply wells, a copy of each completion or abandonment record shall also be submitted to the Health Department responsible for the county in which the well is located. The record shall be on forms provided by the Division and shall include certification that construction or abandonment was completed as required by these ~~Regulations,~~ Rules, the owner's name and address, well location, diameter, depth, yield, and any other information the ~~department~~ Division may reasonably require.

(2) The certified record of completion or abandonment shall be submitted ~~to the department~~ within a period of thirty days after completion or abandonment.

(3) The furnishing of records to any person or agency other than the Division shall not constitute compliance with the reporting requirement and shall not relieve the driller of his obligation to the Department.

Statutory Authority G.S. 87-87; 87-88.

.0116 DESIGNATED AREAS: WELLS CASED TO LESS THAN 20 FEET

(a) In some areas the best or only source of potable water supply exists between ten and twenty feet below the surface of the land. In consideration of this, the Director may designate areas of the state where wells may be ~~case~~ cased to a depth less than twenty feet. To make this determination, the Director will find:

(1) that the only or best source of drinking water exists between a depth of ten and twenty feet below the surface of the land;

(2) that utilization of said source of water is in the best interest of the public.

(b) The following areas are so designated:

(1) in Currituck County on Terres Quarter Island and in an area between the sound and a line beginning at the end of SR 1130 near Currituck Sound, thence north to the end of SR 1133, thence north to the end of NC 3 at the intersection with the sound;

(2) on the Outer Banks from the northern corporate limit of Nags Head on Bodie Island, south to Ocracoke Inlet;

(3) all areas lying between the Intercoastal Waterway and the ocean from New River Inlet south to New Topsail Inlet;

(4) all areas lying between the Intercoastal Waterway and the ocean from the Cape Fear River south to the South Carolina line.

(c) In all other areas, the source of water shall be at least 20 feet below land surface, except when adequate quantities of potable water cannot be obtained below a depth of twenty feet, and at sites not within areas designated in Subparagraph (b) of this Rule the source of water may be obtained from unconsolidated rock formations at depths less than twenty feet provided that:

(1) the well driller can show to the satisfaction of the ~~department,~~ Division, that sufficient water of acceptable quality is not available to a minimum depth of fifty feet; and

(2) the proposed source of water is the maximum feasible depth above fifty feet, but in no case less than ten feet.

(3) the regional ~~or central~~ office of the department shall be notified prior to the construction of a well obtaining water from a depth between 10 and 20 feet below land surface.

Statutory Authority G.S. 87-87.

.0118 VARIANCE

(a) The Director may grant a variance from any construction standard under the rules of this Section. Any variance will be in writing, and may be granted upon oral or written application to the Director, by the person responsible for the construction of the well for which the variance is sought, if the Director finds facts to support the following conclusions:

(1) that the use of the well will not endanger human health and welfare or the groundwater;

(2) that construction in accordance with the standards was not technically feasible in such a manner as to afford a reasonable water supply at a reasonable cost.

(b) The Director may require the variance applicant to submit such information as he deems necessary to make a decision to grant or deny the variance. The Director may impose such conditions on a variance or the use of a well for which a variance is granted as he deems necessary to protect human health and welfare and the groundwater resources. The findings of fact supporting any variance under this Rule shall be in writing and made part of the variance.

(c) A variance applicant who is dissatisfied with the decision of the Director may commence a contested case by filing a petition under G.S. 150B-23 within 60 days after receipt of the decision.

Statutory Authority G.S. 87-87; 87-88; 150B-23.

.0119 DELEGATION

(a) The Director is delegated the authority to grant permission for well construction under G.S. 87-87.

(b) The Director is delegated the authority to give notices and sign orders for violations under G.S. 87-91.

(c) The Director is delegated the authority to request the Attorney General to institute civil actions under G.S. 87-95.

(d) The Director is authorized to subdelegate, to an official of the Division, the granting of a variance from any construction standard, or the approval of alternate construction methods or materials, specified under the Rules of this Section.

Statutory Authority G.S. 143-215.3(a)(1).

SUBCHAPTER 2L - GROUNDWATER CLASSIFICATION AND STANDARDS

SECTION .0100 - GENERAL CONSIDERATIONS

.0107 COMPLIANCE BOUNDARY

(a) For disposal systems permitted prior to December 30, 1983, the compliance boundary is established at a horizontal distance of 500 feet from the waste boundary or at the property boundary, whichever is closer to the source.

(b) For disposal systems permitted on or after December 30, 1983, a compliance boundary shall be established 250 feet from the waste boundary, or 50 feet within the property boundary, whichever point is closer to the source.

(c) The boundary shall be established by the Director at the time of permit issuance. Any sale or transfer of property which affects a compliance boundary shall be reported immediately to the Director. ~~and the compliance boundary re-established accordingly.~~ For disposal systems which are not governed by Paragraphs (e) or (f) of this Rule, the compliance boundary affected by the sale or transfer of property will be re-established consistent with Paragraphs (a) or (b) of this Rule, whichever is applicable.

(d) For disposal systems permitted or repermitted after January 1, 1993, no water supply wells shall be constructed or operated within the compliance boundary.

(e) For disposal systems permitted or repermitted after January 1, 1993, a permittee shall not transfer land within an established compliance boundary unless:

(1) the land transferred is serviced by a community water system as defined in 15A NCAC 18C, the source of which is located outside the compliance boundary; and

(2) the deed transferring the property:

(A) contains notice of the permit, including the permit number, a description of the type of permit, and the name, address and telephone number of the permitting agency; and

(B) contains a restrictive covenant running with the land and in favor of the permittee and the State, as a third party beneficiary, which prohibits the construction and operation of water supply wells within the compliance boundary; and

(C) contains a restrictive covenant running with the land and in favor of the permittee and the State, as a third party beneficiary, which grants the right to the permittee and the State to enter on such property within the compliance boundary for groundwater monitoring and remediation purposes.

(f) If at the time a permit is issued or reissued after January 1, 1993, the permittee is not owner of the land within the compliance boundary, it shall be a condition of the permit issued or renewed that the landowner of the land within the compliance boundary other than the permittee execute and file in the Register of Deeds in the county in which the land is located, an easement running with the land which:

(1) contains:

(A) either a notice of the permit, including the permit number, a description of the type of permit, and the name, address and telephone number of the permitting agency; or

(B) a reference to a notice of the permit with book and page number of its recordation if such notice is required to be filed by statute;

(2) prohibits the construction and operation of water supply wells within the compliance boundary; and

(3) reserves the right to the permittee and the State to enter on such property within the compliance boundary for groundwater monitoring and remediation purposes.

(g) ~~(d)~~ The boundary shall form a vertical plane extending from the water table to the maximum depth of saturation.

(h) ~~(e)~~ For ground absorption sewage treatment and disposal systems which are permitted under ~~10 NCAC 10A .1900,~~ 15A NCAC 18A .1900, the compliance boundary shall be established at the property boundary.

(i) ~~(f)~~ Penalties authorized pursuant to G.S. 143-215.6(a)(1)a. will not be assessed for violations of water quality standards within a compliance boundary unless the result of violations of permit conditions or negligence in the management of the facility.

(j) ~~(g)~~ The Director shall require:

(1) that permits for all activities governed by G.S. 143-215.1 be written to protect the quality of groundwater established by applicable standards, at the compliance boundary;
(2) that recommendations be made to ensure compliance with the applicable level of standards at the compliance boundary on all permit applications received for review from other state agencies;
(3) that necessary groundwater quality monitoring shall be conducted within the compliance boundary; and
(4) that a contravention of standards within the compliance boundary resulting from activities conducted by the permitted facility be remedied through clean-up, recovery, containment, or other response when any of the following conditions occur:
    (A) a violation of any standard in adjoining classified waters occurs or can be reasonably predicted to occur considering hydrogeologic conditions, modeling, or other available evidence;
    (B) an imminent hazard or threat to the public health or safety exists or can be predicted; or
    (C) a violation of any standard in groundwater occurring in the bedrock other than limestones found in the Coastal Plain sediments.

Statutory Authority G.S. 143-215.1 (b); 143-215.3 (a) (1); 143B-282.

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Appendix E

Location and Tank Contents of 458 Underground Storage Tanks at MCB
(Modified from Geraghty and Miller, Inc., 1990)

Building/Tank ID Number	Map Coordinates key#/coord.	Tank Capacity (gallons)	Tank Contents	distance to nearest well (ft)
0001	F7/F5X76	250	DIESEL FUEL	3000
0020-1	F7/F5X76	500	DIESEL FUEL	3000
0020-2	F7/F5X76	500	GAS/EMP	3000
0020-3	F7/F5X76	500	GAS/EMP	3000
0021-1	G8/G5X82	250	GAS/REG	4000
0024	F7/F1X73	1,000	HO/#2FO	5300
0025-1	F7/F3X76	?	UNK/SOLVENT	2000
0025-2	F7/F3X76	?	UNK/SOLVENT	2000
0025-3	F7/F3X76	?	UNK/SOLVENT	2000
0025-4	F7/F3X76	?	UNK/SOLVENT	2000
0025-5	F7/F3X76	?	UNK/SOLVENT	2000
0025-6	F7/F3X76	?	UNK/SOLVENT	2000
0025-7	F7/F3X76	?	UNK/SOLVENT	2000
0025-8	F7/F3X76	?	UNK/SOLVENT	2000
0025-9	F7/F3X76	?	UNK/SOLVENT	2000
0031/;S-715	F7/F1X72	1,000	GAS	7200
0032-1	G8/G5X82	2,000	HO/#2FO	4000
0032-2	G8/G5X82	500	GAS/REG	4000
0033	B8/B3X81	550	HO/#2FO	4000
0040-1	C7/C2X76	2,000	HO/#2FO	500
0040-2	C7/C2X76	3,000	HO/#2FO	500
0045-1	B7/B1X75	1,000	UO/EMPTY	1500
0045/;S-941-1	B7/B1X75	4,000	DIESEL FUEL	1500
0045/;S-941-2	B7/B1X75	550	GAS	1500
0207	F7/F5X75	500	HO/#2FO	3000
0331	G7/G2X76	500	HO/#2FO	3000
0333-A	G7/G2X76	500	HO/KERO	3000
0333-B	G7/G2X76	500	HO/KERO	3000
0333-C	G7/G2X76	?	HO/#2FO	3000
0340-1	G7/G2X75	500	HO/#2FO	3500
0344-1	G7/G1X76	500	HO/#2FO	2500
0599-1	G8/G3X84	550	HO/KERO	2750
0600	G6/C1X61	500	UO	7000
0728-1	F7/F1X72	550	WASTE OIL/WATER	7200
0728-2	F7/F1X72	500	HO/#2FO	7200
0738-1	F8/F2X86	1,000	HO/#2FO	1000
0738-2	F8/F2X86	275	UNK/EMP	1000
0812-1	B8/B3X81	275	HO/#2FO	420
0820-1	D7/D3X74	10,000	DF	3700

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Building/Tank ID Number	Map Coordinates key#/coord.	Tank Capacity (gallons)	Tank Contents	distance to nearest well (ft)
0820-2	D7/D3X74	10,000	GAS/SUPER UNLEADE	3700
0820-3	D7/D3X74	10,000	GAS/UNLEADED	3700
0820-4	D7/D3X74	10,000	GAS/REGULAR	3700
0901	F8/F2X86	2,000	UO/HYD	600
0903-1	F8/F2X86	550	HO/KERO	400
0907-1	F8/F4X86	550	HO/KERO	1250
0913/;S-947-1	F8/F2X86	550	UO	800
0913/;S-947-2	F8/F2X86	550	UO	800
1002-4	F8/F3X85	2,864	HO/KERO	1300
1002-5	F8/F3X85	2,644	HO/KERO	1300
1002-A	F8/F3X85	1,000	GAS	1300
1002-B	F8/F3X85	1,000	UNKNOWN	1300
1002-C	F8/F3X85	1,000	UNKNOWN	1300
1002-D	F8/F3X85	1,000	GAS	1300
1002-E	F8/F3X85	1,000	UNKNOWN	1300
1002/;S-1023	F8/F3X85	12,000	GAS	1300
1002/;S-1024	F8/F3X85	15,000	GAS	1300
1002/;S-1025	F8/F3X85	12,000	GAS	1300
1002/;S-1026	F8/F3X85	15,000	GAS	1300
1002/;S-1027	F8/F3X85	15,000	GAS	1300
1002/;S-1028	F8/F3X85	15,000	GAS	1300
1002/;S-1029	F8/F3X85	15,000	GAS	1300
1002/;S-1030	F8/F3X85	12,000	HO/KERO	1300
1002/;S-1031	F8/F3X85	15,000	GAS	1300
1002/;S-1032	F8/F3X85	12,000	HO/KERO	1300
1002/;S-1033	F8/F3X85	12,000	GAS	1300
1002/;S-1034	F8/F3X85	12,000	HO/KERO	1300
1002/;S-1035	F8/F3X85	15,000	HO/KERO	1300
1002/;S-1036	F8/F3X85	15,000	HO/KERO	1300
1100-1	F8/F2X84	1,000	GAS	500
1100-2	F8/F2X84	?	UNK/GAS/DIESEL	500
1100-3	F8/F2X84	?	UNK/GAS/DIESEL	500
1100-4	F8/F3X84	?	UNK/GAS/DIESEL	500
1101-1	F8/F3X84	560	DF	1100
1101-2	F8/F3X84	1,000	DF	1100
1101-3	F8/F3X84	500	DF	1100
1106	F8/F3X85	500	UO	2000
1205/;S-1213-1	F8/F4X85	500	UO/EMP	2000
1308	F8/F4X84	275	HO/#2FO	UNKNOWN

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Building/Tank ID Number	Map Coordinates key#/coord.	Tank Capacity (gallons)	Tank Contents	distance to nearest well (ft)
1310-1	F8/F4X84	550	UO/EMP	1900
1310-2	F8/F4X84	275	HO/#2FO	1900
1401	F8/F4X83	?	HO/#2FO	1200
1402-1	F8/F4X83	1,000	HO/#2FO	1000
1402-2	F8/F4X83	1,000	HO/#2FO	1000
1406-1	F8/F4X83	275	HO/#2FO	UNKNOWN
1406/;S-1416	F8/F4X84	600	UO	1600
1413	F8/F4X84	550	HO/#2FO	1500
1450-1	F8/F5X85	6,000	DF	3300
1450-2	F8/F5X85	6,000	DF	3300
1450-3	F8/F5X85	6,000	DF	3300
1450-4	F8/F5X85	6,000	DF	3300
1450-5	F8/F5X85	400	UO	3300
1450-6	F8/F5X85	700	UO	3300
1450-7	F8/F5X85	400	UO	3300
1501-1	F8/F4X83	1,000	HO/#2FO	1200
1502-1	F8/F4X83	550	UO/EMP	1300
1502-2	F8/F4X83	?	UNK/GAS/DF	1300
1502-3	F8/F4X83	?	UNK/GAS/DF	1300
1505	F8/F5X84	275	HO/#2FO	1100
1505/;S-1508	F8/F5X84	600	UO/EMP	1100
1601	F8/F5X83	1,500	UO/EMP	800
1604/;S-1616	F8/F5X83	600	UO	800
1607	F8/F5X83	500	UO	800
1613-1	F8/F4X82	10,000	GAS/REG	550
1613-2	F8/F4X82	10,000	GAS/REG	550
1613-3	F8/F4X82	30,000	GAS/SUNL	550
1613-4	F8/F4X82	30,000	GAS/UNL	550
1613-5	F8/F4X82	500	UO	550
1736-1	F8/F5X82	?	UO	500
1750-1	G8/G1X83	1,000	UO	1100
1750-2	G8/G1X83	1,000	UO	1100
1755/;S-1758-1	G8/G1X84	1,000	UO	1100
1765	G8/G1X82	1,000	HO/#2FO	1200
1775-1	G8/G2X84	6,000	GAS	1500
1775-2	G8/G2X84	6,000	DF	1500
1775-3	G8/G2X84	1,000	UO	1500
1775-4	G8/G2X84	1,000	UO	1500
1775-5	G8/G2X84	1,000	UO	1500

Building/Tank ID Number	Map Coordinates key#/coord.	Tank Capacity (gallons)	Tank Contents	distance to nearest well (ft)
1780-1	G8/G2X84	1,000	UO	1700
1780-2	G8/G2X84	1,000	UO	1700
1804/;S-1856-1	G8/G2X83	600	UO	1500
1804/;S-1856-2	G8/G2X83	600	UO	1500
1804/;S-1856-3	G8/G2X83	600	UO	1500
1804/;S-1856-4	G8/G2X83	600	UO	1500
1804/;S-1856-5	G8/G2X83	600	UO	1500
1804/;S-1856-6	G8/G2X83	600	UO	1500
1812	G8/G3X83	550	HO/#2FO	UNKNOWN
1815/;S-1813-1	G8/G2X83	10,000	DF	1600
1815/;S-1813-2	G8/G2X83	10,000	DF	1600
1841-1	G8/G3X84	500	UO/EMP	2400
1841-2	G8/G3X84	200	UO/EMP	2400
1841/;S-1840-1	G8/G3X84	30,000	GAS	2400
1841/;S-1840-2	G8/G3X84	30,000	DF	2400
1841/;S-1840-3	G8/G3X84	10,000	DF	2400
1841/;S-1840-4	G8/G3X84	5,000	GAS	2400
1841/;S-1840-5	G8/G3X84	6,000	DF	2400
1854-1	G8/G3X84	2,000	UO	2500
1854-2/;S1876	G8/G3X84	30,000	DF	2500
1854-3/;S1876	G8/G3X84	30,000	DF	2500
1854-4	G8/G3X84	1,000	UO	2500
1854-5/;S1875	G8/G3X84	6,000	DF	2500
1854-6/;S1875	G8/G3X84	6,000	DF	2500
1860-1	G8/G3X83	550	UO	2000
1880-1	G8/G3X83	10,000	DF	2000
1880-2	G8/G3X83	6,000	DF	2000
1880-3	G8/G3X83	1,000	UO	2000
1915	C5/C3X56	3,000	HO/#2FO	7500
1919-1	E6/E2X66	500	HO/#2FO	6600
1919-2	E6/E2X66	500	HO/#2FO	6600
1919-3	E6/E2X66	1,000	GAS (UNLEADED)	6600
1932-2	C5/C2X56	500	DF	7900
1932/;S-1920	C5/C2X56	1,000	GAS	7900
1938	D6/D2X63	250	HO/#2FO	3500
1943	E7/E2X72	7,500	HO/#2FO	7100
2615/;S-2637-1	D6/D1X63	15,000	HO/#6FO	3500
2615/;S-2637-2	D6/D1X63	15,000	HO/#6FO	3500
5400	C7/C4X75	10,000	HO/#2FO	800

Building/Tank ID Number	Map Coordinates key#/coord.	Tank Capacity (gallons)	Tank Contents	distance to nearest well (ft)
A-0002	M6/M3X65	500	UO/EMP	3700
A-0010/;SA-26	M6/M3X65	1,500	UO/EMP	4200
A-0012/;SA-30-1	M6/M3X65	500	GAS	3800
A-0012/;SA-30-2	M6/M3X65	2,000	DF	3800
A-0047-1	M6/M3X65	?	UO	4000
A-0047-2	M6/M3X65	2,000	UO	4000
A-0047-3	M6/M3X65	30,000	DF	4000
A-0047-4	M6/M3X65	5,000	GAS	4000
A-0047-5	M6/M3X65	10,000	HO/#2F0	4000
A-0047/;SA-21	M6/M3X65	30,000	DF	4000
BA-0130-1	P11/P2X113	1,000	DF	4200
BA-0130-2	P11/P2X113	1,000	GAS	4200
BA-0130-3	P11/P2X113	500	UO/EMP	4200
BA-0130/;SBA-132	P11/P2X113	500	UO/EMP	4200
BA-0138-1	N11/N3X113	550	GAS	400
BA-0138-2	N11/N3X113	550	HO/#2F0	400
BB-0004/;SBB-204	N7/N3X73	500	DF	2250
BB-0007-1	N7/N2X72	?	PROPANE	1300
BB-0009-1	N7/N2X72	10,000	HO/#6F0	1200
BB-0009-2	N7/N2X72	10,000	HO/#6F0	1200
BB-0009-3	N7/N2X72	10,000	HO/#6F0	1200
BB-0009-4	N7/N2X72	550	UO	1200
BB-0009-5	N7/N2X72	?	UO	1200
BB-0014/;SBB-1	N7/N2X72	550	DF	1500
BB-0030/;SBB-99-1	M7/M5X73	1,000	GAS	420
BB-0030/;SBB-99-2	M7/M5X73	2,000	GAS	420
BB-0046	M6/M5X65	1,000	GAS	3000
BB-0048	M7/M4X71	2,500	HO/#2F0	1100
BB-0049	M7/M4X72	2,500	HO/#2F0	800
BB-0051-1	M7/M5X73	300	UO/EMP	1000
BB-0051-2	M7/M5X73	300	UO	1000
BB-0052/;SBB-70	N7/N1X73	5,000	DF	1100
BB-0071-1	M7/M5X73	500	UO/EMP	650
BB-0071-2	M7/M5X73	500	HO/#2F0	650
BB-0071-3	M7/M5X73	500	HO/#2F0	650
BB-0071-4	M7/M5X73	500	HO/#2F0	650
BB-0071-5	M7/M5X73	500	HO/#2F0	650
BB-0071-6	M7/M5X73	500	HO/#2F0	650
BB-0101-1	N7/N2X73	2,500	DF	1300

Building/Tank ID Number	Map Coordinates key#/coord.	Tank Capacity (gallons)	Tank Contents	distance to nearest well (ft)
BB-0101-2	N7/N2X73	500	GAS	1300
BB-0177-1	N7/N1X72	6,000	GAS/SUNL	350
BB-0177-2	N7/N1X72	6,000	GAS/UNL	350
BB-0177-3	N7/N1X72	6,000	GAS/REG	350
BB-0177-4	N7/N1X72	1,000	WATER/WASTE OIL	350
BB-0177-5	N7/N1X72	600	HO/#2FO	350
BB-0190-1	N7/N1X72	550	HO/#2FO	200
BB-0190-2	N7/N1X72	550	DIESEL	200
CG-0001	B1/B4X14	500	UO	1200
FC-0040-1	G9/G3X94	6,000	GAS	275
FC-0040-2	assist94	6,000	DF	275
FC-0040-3	G9/G3X94	1,000	UO	275
FC-0045	G9/G3X94	550	UO	?
FC-0101/SFC-103	G9/G4X91	550	UO	600
FC-0102/SFC-104	G9/G4X91	1,000	UO	600
FC-0120	G8/G4X86	1,000	WASTE OIL	300
FC-0120/SFC-122-1	G8/G4X86	10,000	GAS	300
FC-0120/SFC-122-2	G8/G4X86	10,000	DF	300
FC-0190-1	G9/G4X91	500	UO	800
FC-0190-2	G9/G4X91	500	ACID/BAT	800
FC-0200-1	G9/G4X92	5,000	GAS	1400
FC-0200-2	G9/G4X92	20,000	DIESEL FUEL	1400
FC-0200-3	G9/G4X92	20,000	DIESEL FUEL	1400
FC-0200-4	G9/G4X92	20,000	DIESEL FUEL	1400
FC-0200/;SFC-204	G9/G4X92	550	UO	1400
FC-0200/;SFC-205	G9/G4X92	1,000	UO	1400
FC-0202-1	G9/G4X91	10,000	HO/#2FO	1300
FC-0230-1	G9/G5X91	2,500	DIESEL FUEL	1300
FC-0230-2	G9/G5X91	2,500	DIESEL FUEL	1300
FC-0230-3	G9/G5X91	550	UO	1300
FC-0241-1	G9/G5X92	6,000	DIESEL FUEL	1300
FC-0241-2	G9/G5X92	6,000	GAS/UNL	1300
FC-0241-3	G9/G5X92	1,000	HO/KERO	1300
FC-0251-1	G9/G5X92	2,000	UO	950
FC-0251-2	G9/G5X92	5,000	DIESEL FUEL	950
FC-0251-3	G9/G5X92	5,000	GAS	950
FC-0255-1	G9/G5X92	10,000	DIESEL FUEL	500
FC-0255-2	G9/G5X92	6,000	GAS	500
FC-0255-3	G9/G5X92	6,000	GAS	500

Building/Tank ID Number	Map Coordinates key#/coord.	Tank Capacity (gallons)	Tank Contents	distance to nearest well (ft)
FC-0260	H9/H1X92	2,000	HO/DIESEL FUEL	1600
FC-0263-1	H9/H1X92	6,000	DIESEL FUEL	900
FC-0263-2	H9/H1X92	6,000	GAS	900
FC-0263-3	H9/H1X92	6,000	DIESEL FUEL	900
FC-0263-4	H9/H1X92	6,000	GAS	900
FC-0263-5	H9/H1X92	1,000	UO	900
FC-0270-1	G9/G5X93	2,500	UO	300
FC-0270-2	G9/G5X93	2,500	UO	300
FC-0270-3	G9/G5X93	10,000	DIESEL FUEL	300
FC-0270-4	G9/G5X93	4,000	DIESEL FUEL	300
FC-0281-1	G9/G4X93	6,000	DIESEL FUEL	875
FC-0281-2	G9/G4X93	6,000	GAS	875
FC-0364	H8/H2X86	500	DIESEL FUEL	2000
FC-0739/;SGP-16	G8/G4X86	600	UO/EMP	750
G-0480	A2/A4X25	550	HO/#2F0	1800
G-0650-1	A2/A5X25	550	UO	1800
G-0650-2/;SG649	A2/A5X25	?	UO	1800
H-0001-1	F6/F2X65	1,000	#2 FUEL OIL	9000
H-0001-2	F6/F2X65	?	HO/#2F0	9000
H-0018	F6/F2X65	10,000	GAS/LEAD	9000
H-0018/;H-112	F6/F2X65	?	UO	9000
H-0019-1	F6/F2X65	15,000	HO/#6F0	9000
H-0019-2	F6/F2X65	15,000	HO/#6F0	9000
H-0019-3	F6/F2X65	15,000	HO/#6F0	9000
H-0030/;H-124	F7/F1X71	560	HO/#2F0	7000
H-0030/;H-125	F7/F1X71	560	HO/#2F0	7000
H-0120	F6/F1X65	1,000	HO/#2F0	9000
HP-0100-1	F7/F2X74	10,000	DIESEL FUEL	4200
HP-0100-2	F7/F2X74	2,000	GAS	4200
HP-0100-3	F7/F2X74	550	UO	4200
HP-0825	D7/D1X74	10,000	HO/#2F0	1400
LCH-4015-1	B8/B3X82	12,000	GAS/EMP	1200
LCH-4015-2	B8/B3X82	12,000	GAS/EMP	1200
LCH-4015-3	B8/B3X82	12,000	GAS/EMP	1200
LCH-4015-4	B8/B3X82	2,500	DF/EMP	1200
LCH-4022	B8/B3X82	2,500	HO/#2F0	1200
LCH-4025	B8/B3X82	1,000	HO/#2F0	1300
LCH-4027	B8/B2X82	?	UNKNOWN	9800
LCH-4034-1	B8/B3X82	10,000	GAS	?

Building/Tank ID Number	Map Coordinates key#/coord.	Tank Capacity (gallons)	Tank Contents	distance to nearest well (ft)
LCH-4034-2	B8/B3X82	10,000	GAS	?
LCH-4034-3	B8/B3X82	2,000	DIESEL FUEL	?
M-0090	B4/B3X46	500	UO	9800
M-0090/;SM-0195-1	B4/B3X46	5,000	DF	9800
M-0090/;SM-0195-2	B4/B3X46	5,000	DIESEL FUEL	9800
M-0101	B4/B2X46	500	UO/EMP	9700
M-0101/;SM-0191-1	B4/B2X46	550	GAS	9700
M-0101/;SM-0191-2	B4/B2X46	550	DIESEL FUEL	9700
M-0119/;SM-193	B4/B3X46	1,000	GAS	9800
M-0171-1	B4/B1X45	5,000	GAS/EMP	9700
M-0171-2	B4/B1X45	5,000	GAS/EMP	9700
M-0171-3	B4/B1X45	5,000	GAS/EMP	9700
M-0178	B4/B1X45	275	GAS/EMP	UNKNOWN
M-0214	B4/B4X44	550	HO/KERO	13200
M-0230-1/;SM-269-1	B4/B4X44	15,000	HO/DIESEL FUEL	13200
M-0230-2/;SM-269-2	B4/B4X44	15,000	HO/DIESEL FUEL	13200
M-0232	B4/B5X44	550	HO/KERO	14200
M-0233	B4/B5X44	550	HO/KERO	14200
M-0234	B4/B5X44	550	HO/KERO	14200
M-0235	B4/B5X44	550	HO/KERO	14200
M-0236	C4/C1X44	550	HO/KERO	14200
M-0255	B4/B4X44	550	HO/KERO	13200
M-0612	A5/A5X51	500	HO/KERO	7500
M-0625-1	A5/A5X52	550	UO	7500
M-0625-2	A5/A5X52	20,000	HO	7500
M-0625-3	A5/A5X22	30,000	HO	7500
NH-0100/;101	B7/B4X73	20,000	HO/#2FO	2100
NH-0100/;102	B7/B4X73	20,000	HO/#2FO	2100
NH-0100/;103	B7/B4X73	20,000	HO/#6FO	2100
NH-0100/;104	B7/B4X73	20,000	HO/#6FO	2100
NH-0118-1	B7/B4X74	10,000	GAS/UNL	2300
NH-0118-2	B7/B4X74	2,000	HO/#2FO	2300
NH-0118-3	B7/B4X74	200	UO	2300
NH-0120	C7/C1X73	1,000	HO/#2FO	2300
PT-0005	E8/E5X83	500	HO/#2FO	2500
PT-0039-1	E7/E4X76	1,000	PEST/WAT	5000
PT-0039-2	E7/E4X76	1,000	PEST/WAT	5000
RR-0014/;SRR-80	M2/M2X26	600	UO/EMP	700
RR-0015-1	M2/M2X26	500	UO	400

CLW

Building/Tank ID Number	Map Coordinates key#/coord.	Tank Capacity (gallons)	Tank Contents	distance to nearest well (ft)
RR-0015-2	M2/M2X26	1,000	DIESEL FUEL	400
RR-0015-3	M2/M2X26	10,000	HO	400
RR-0015-4	M2/M2X26	10,000	HO	400
RR-0015-5	M2/M2X26	10,000	HO	400
RR-0015/;SRR-84	M2/M2X26	10,000	GAS	400
RR-0017	M2/M2X26	?	HO/#2F0	350
RR-0020	M2/M2X31	?	HO/#2F0	600
RR-0022	M2/M2X32	?	HO/#2F0	1450
RR-0024	M2/M2X32	?	HO/#2F0	2300
RR-0072-3	M2/M2X26	5,000	GAS	1200
RR-0072-2	M2/M2X26	5,000	GAS	1200
RR-0072-1	M2/M2X26	4,000	GAS/LEAD/EMP	1200
RR-0085-1	M2/M3X26	500	HO/#2F0	475
RR-0085-2	M2/M3X26	500	GAS/EMP	475
SH-0008	J9/J2X96	750	HO/#2F0	3000
TC-0470	A2/A5X25	550	UO	2200
TC-0474	A2/A4X25	550	UO	2300
TC-0647	A3/A5X31	500	#2FO	3700
TC-0647/;STC-567	A3/A5X31	500	HO/#2F0	3700
TC-0774	B2/B1X25	600	UO/EMP	2200
TC-0865/;STC-868	B2/B2X25	550	UO	2500
TC-0912-1	B2/B2X23	6,000	GAS	130
TC-0912-2	B2/B2X23	4,000	GAS	130
TC-0912-3	B2/B2X23	6,000	GAS	130
TC-0912-4	B2/B2X23	550	HO/#2F0	130
TC-0912-5	B2/B2X23	550	UO	
TC-0942	B2/B2X24	550	UO	1350
TC-1251	B2/B4X24	1,000	DIESEL FUEL	20
TC-1255	B2/B4X21	?	DIESEL FUEL	20
TC-1500	B2/B5X24	7,500	HO/#2FO	800
TP-0447/;STP-446	E8/E5X86	12,000	UO/JP-5	800
TP-0457	E8/E5X86	2,000	HO/#2FO	750
TT-0035	B6/B2X63	600	HO/#2FO	5000
FT-0038	B6/B1X66	1,000	HO/#2FO	200
TT-0038/;STT-39-A	B6/B1X66	1,000	2# DIESEL	200
TT-0044	B6/B2X64	1,000	HO/#2FO	1900
TT-0048-1	A6/A5X63	1,000	HO/#2FO	2500
TT-0048-2	A6/A5X63	6,000	HO/#2FO	2500
TT-0049/;STT-69	A6/A4X66	1,000	GAS	100

CLW

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Building/Tank ID Number	Map Coordinates key#/coord.	Tank Capacity (gallons)	Tank Contents	distance to nearest well (ft)
TT-0060	A6/A4X66	10,000	HO	UNKNOWN
TT-2453-1	B6/B1X64	0	NA	1100
TT-2453-2	B6/B1X64	0	NA	1100
TT-2453-3	B6/B1X64	0	NA	1100
TT-2453-4	B6/B1X64	0	NA	1100
TT-2453-5	B6/B1X64	?	UO	1100
TT-2453-6	B6/B1X64	?	HO/#2FO	1100
TT-2455	B6/B1X64	1,000	HO/#2FO	1100
TT-2457	B6/B1X64	1,000	HO/#2FO	1100
TT-2459	B6/B1X64	300	HO/#2FO	1100
TT-2461	B6/B1X64	300	HO/#2FO	1100
TT-2463	B6/B1X64	300	HO/#2FO	1100
TT-2465-1	B6/B1X64	300	HO/#2FO	1100
TT-2465-2	B6/B1X64	300	HO/#2FO	1100
TT-2467	B6/B1X64	300	HO/#2FO	1100
TT-2469	B6/B1X64	300	HO/#2FO	1100
TT-2471	B6/B1X64	300	HO/#2FO	1100
TT-2473	B6/B1X64	300	HO/#2FO	1100
TT-2475	B6/B1X64	500	HO/#2FO	1100
TT-2477	B6/B1X64	?	HO/#2FO	1100
TT-2478-1	B6/B1X64	10,000	GAS	1100
TT-2478-2	B6/B1X64	10,000	GAS	1100
TT-2478-3	B6/B1X64	10,000	GAS	1100
TT-2478-4	B6/B1X64	1,000	DIESEL FUEL	1100
0061	F8/F3X81	?	HO	UNKNOWN
TC-0773	B2/B1X25	500	UO/EMP	UNKNOWN
M-0625-4	A5/A5X22	500	UO	UNKNOWN
M-0231	B4/B4X44	500	PROPANE	UNKNOWN
M-0178-2	B4/B1X45	1,000	PROPANE	UNKNOWN
1700	F8/F4X82	500	UO	UNKNOWN
H-0028	F6/F1X66	?	UNKNOWN/OIL	UNKNOWN
0712	C8/C8X82	550	HO/UNK	UNKNOWN
	Marine Corps Air Station			
AS-0109/;SAS-157	B2/B5X25	?	UO	500
AS-0110	B2/B4X25	2,000	#2FO	200
AS-0114	B2/B5X25	550	UO	250
AS-0118	B2/B5X25	1,000	UO (WASTE OIL)	300

CLW

Building/Tank ID Number	Map Coordinates key#/coord.	Tank Capacity (gallons)	Tank Contents	distance to nearest well (ft)
AS-0122	B2/B5X26	?	HO/#2FO	550
AS-0136	C2/C1X25	100,000	JP-5	1175
AS-0137	C2/C1X24	50,000	JP-5	1175
AS-0138	C2/C1X24	50,000	JP-5	1300
AS-0140	C2/C1X25	10,000	NA	1300
AS-0141	C2/C1X25	10,000	UKNOWN/EMPTY	1200
AS-0142	C2/C1X25	10,000	GAS	950
AS-0150	C2/C1X25	105,000	JP-5	1100
AS-0151	C2/C1X25	50,000	JP-5	1100
AS-0154	C2/C1X25	120,000	JP-5	1100
AS-0410-1	C2/C1X26	4,000	GAS (UNLEADED)	350
AS-0410-2	C2/C1X26	4,000	GAS	350
AS-0410-3	C2/C1X26	4,000	GAS	350
AS-0410-4	C2/C1X26	4,000	GAS	350
AS-0410-5	C2/C1X26	4,000	GAS	350
AS-0410-6	C2/C1X26	4,000	GAS/EMPTY	350
AS-0410-7	C2/C1X26	200	UO	350
AS-0427	C3/C2X32	280	DIESEL FUEL	2000
AS-0507	C3/C4X31	20,000	JP-5	2970
AS-0508-1	C3/C4X31	20,000	JP-5	2970
AS-0508-2	C3/C4X31	750	JP-5/WAT	3000
AS-0511-1	C3/C4X31	20,000	JP-5	3600
AS-0511-2	C3/C4X31	20,000	JP/5	3600
AS-0511-3	C3/C4X31	1,000	WASTE WATER & JP/5	3600
AS-0511-4	C3/C4X31	1,000	WASTE WATER & JP/5	3600
AS-0522	C2/C5X26	300	UO	2700
AS-0526	C2/C4X26	20,000	NA	UNKNOWN
AS-0527-1	C2/C4X26	20,000	NA	UNKNOWN
AS-0527-2	C2/C4X26	1,000	NA	UNKNOWN
AS-0546	C3/C4X31	590	UO	3600
AS-0547	C3/C4X31	590	UO	3600
AS-0548	C3/C4X31	590	UO	3600
AS-0549	C3/C4X31	590	UO	3600
AS-0629	B3/B3X32	500	DIESEL FUEL	3000
AS-0705	B3/B5X36	10,000	HO/#2FO	UNKNOWN
AS-0804	C3/C3X34	1,000	DIESEL FUEL	6400
AS-0820	C3/C4X34	560	HO/#2FO	6000
AS-0822	C3/C4X34	270	DIESEL FUEL	6000
AS-0843-1	C3/C4X34	270	HO/#2FO	6100

CLW

Building/Tank ID Number	Map Coordinates key#/coord.	Tank Capacity (gallons)	Tank Contents	distance to nearest well (ft)
AS-0843-2	C3/C4X34	500	DIESEL FUEL	6100
AS-0849	C3/C5X36	?	HO/#2FO	7700
AS-2800	B3/B4X35	550	HO/#2FO	7400
AS-2804	D3/D4X35	1,000	GAS	7400
AS-3000	D3/D1X32	500	DIESEL FUEL	4200
AS-3502	D3/D2X32	550	HO/#2FO	5100
AS-3504	D3/D2X32	2,000	HO/#2FO	5100
AS-3505-1	D3/D2X32	2,500	GAS	5100
AS-3505-2	D3/D2X32	2,500	DIESEL FUEL	5100
AS-3511	D3/D2X32	2,500	UNK/GAS/JP-5	UNKNOWN
AS-3512	D3/D2X32	2,500	UNK/DF/JP-5	UNKNOWN
AS-3525	D3/D2X32	550	HO/#2FO	4700
AS-3620	D2/D1X25	1,000	DIESEL FUEL	1500
AS-4135-1	C2/C4X24	1,000	DIESEL FUEL	500
AS-4135-2	C2/C4X24	1,000	GAS	500
AS-4135-3	C2/C4X24	550	UO	500
AS-4146-1	C2/C2X25	5,000	DIESEL FUEL	1500
AS-4146-2	C2/C2X25	5,000	GAS	1500
AS-4146-3	C2/C2X25	550	UO	1500
AS-4151-1	C2/C2X25	1,000	UO	750
AS-4151-2	C2/C2X25	1,000	DIESEL FUEL	750
AS-4158-1	C2/C4X23	1,000	UO	1600
AS-4158-2	C2/C4X23	550	UO	400
AS-4158-3	C2/C4X23	550	UO	400
AS-4159-1	C2/C5X23	1,000	UO	1000
AS-4159-2	C2/C5X23	550	UO	1000
AS-4165-1	C2/C4X23	3,000	DIESEL FUEL	1350
AS-4165-2	C2/C4X23	3,000	DIESEL FUEL	1350
AS-4165-3	C2/C4X23	3,000	GAS	1350
AS-0515	C2/C2X26	240	UO/SOLVENT	UNKNOWN

CLW

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