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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

Contract No. N62470-90-D-6756

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

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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.

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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

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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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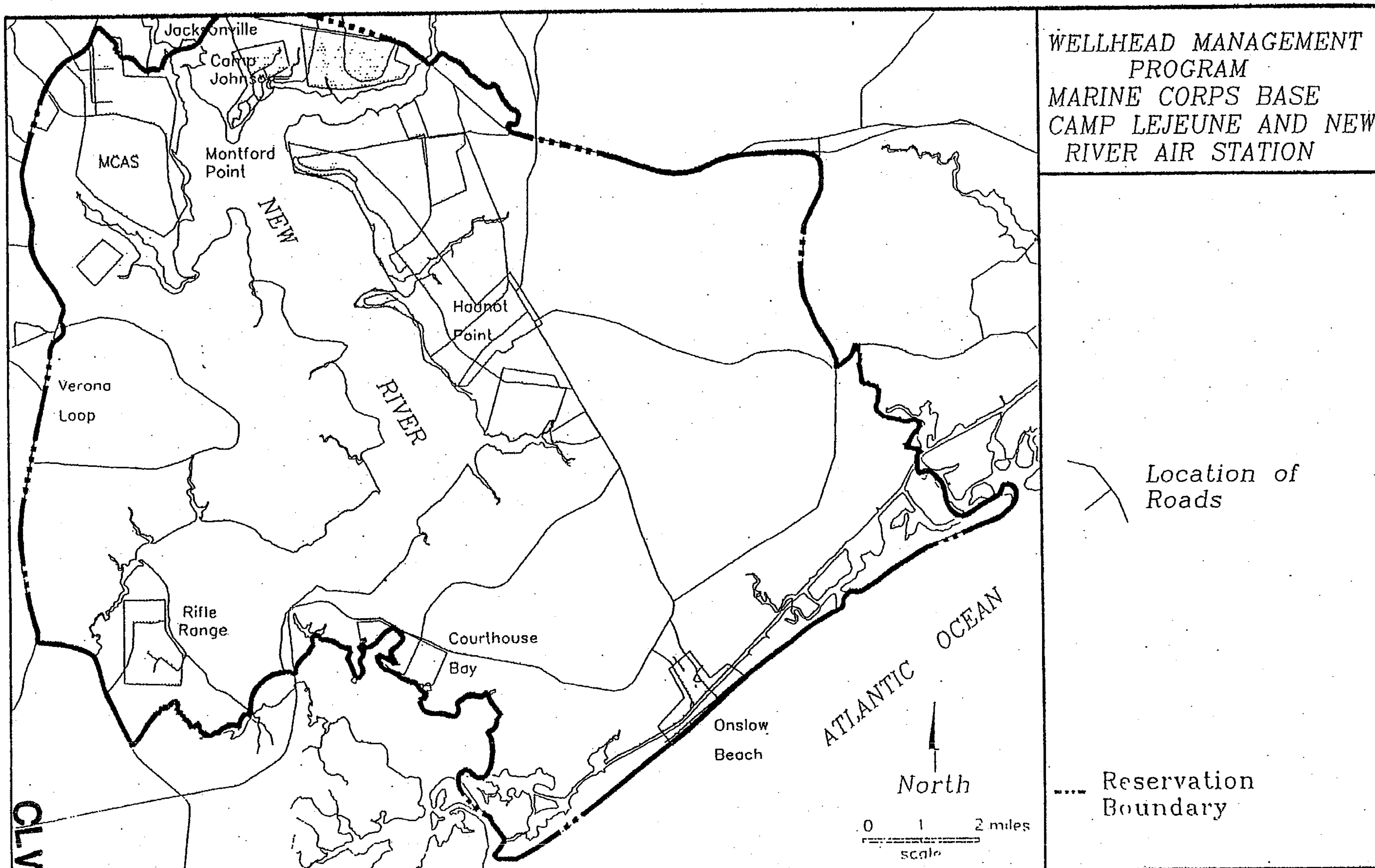

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Figure 1. MCB Location Map Showing Six Bases, and Areas of Major Development.

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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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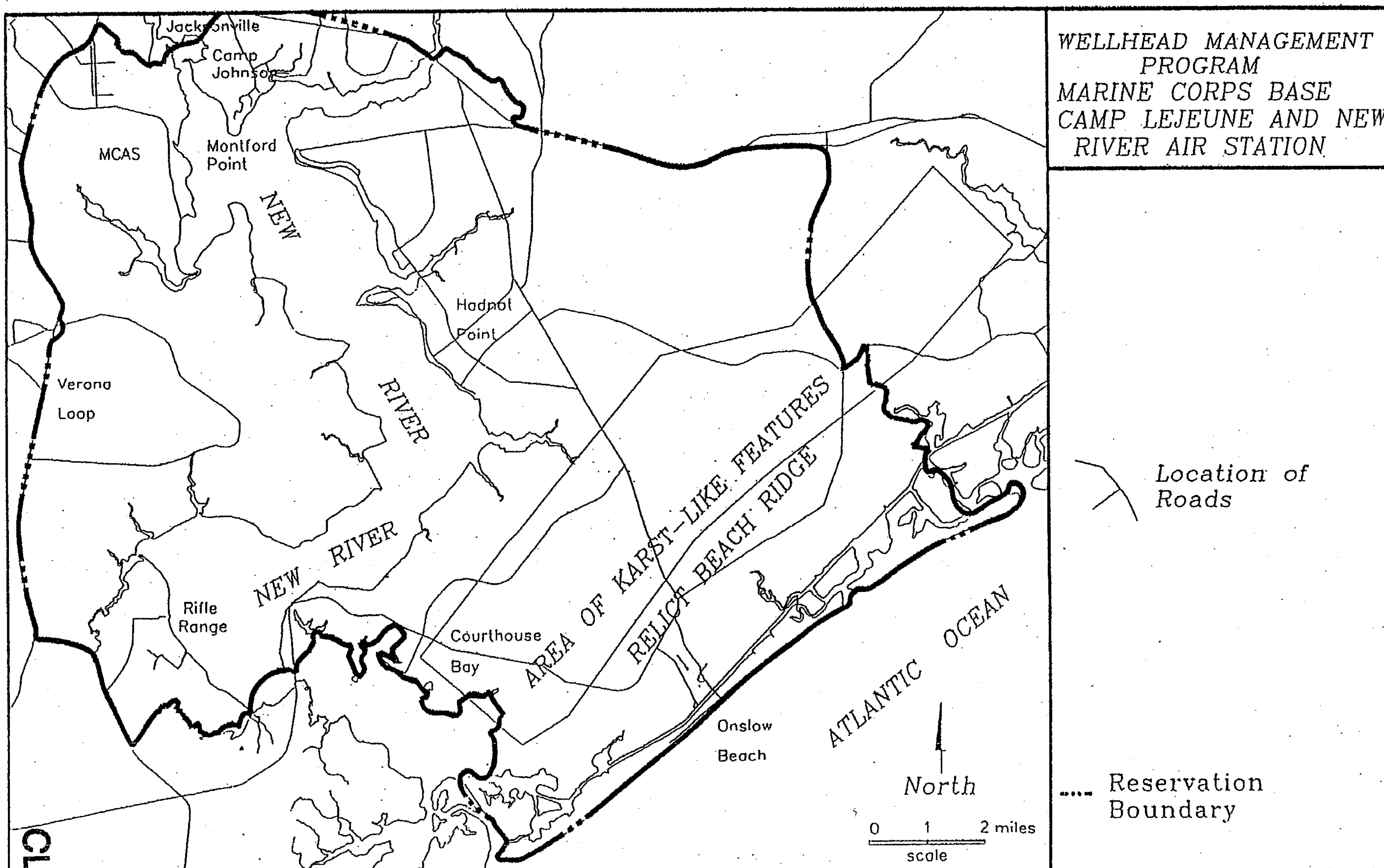

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Figure 2. Location of Prominent Land Surface Features.

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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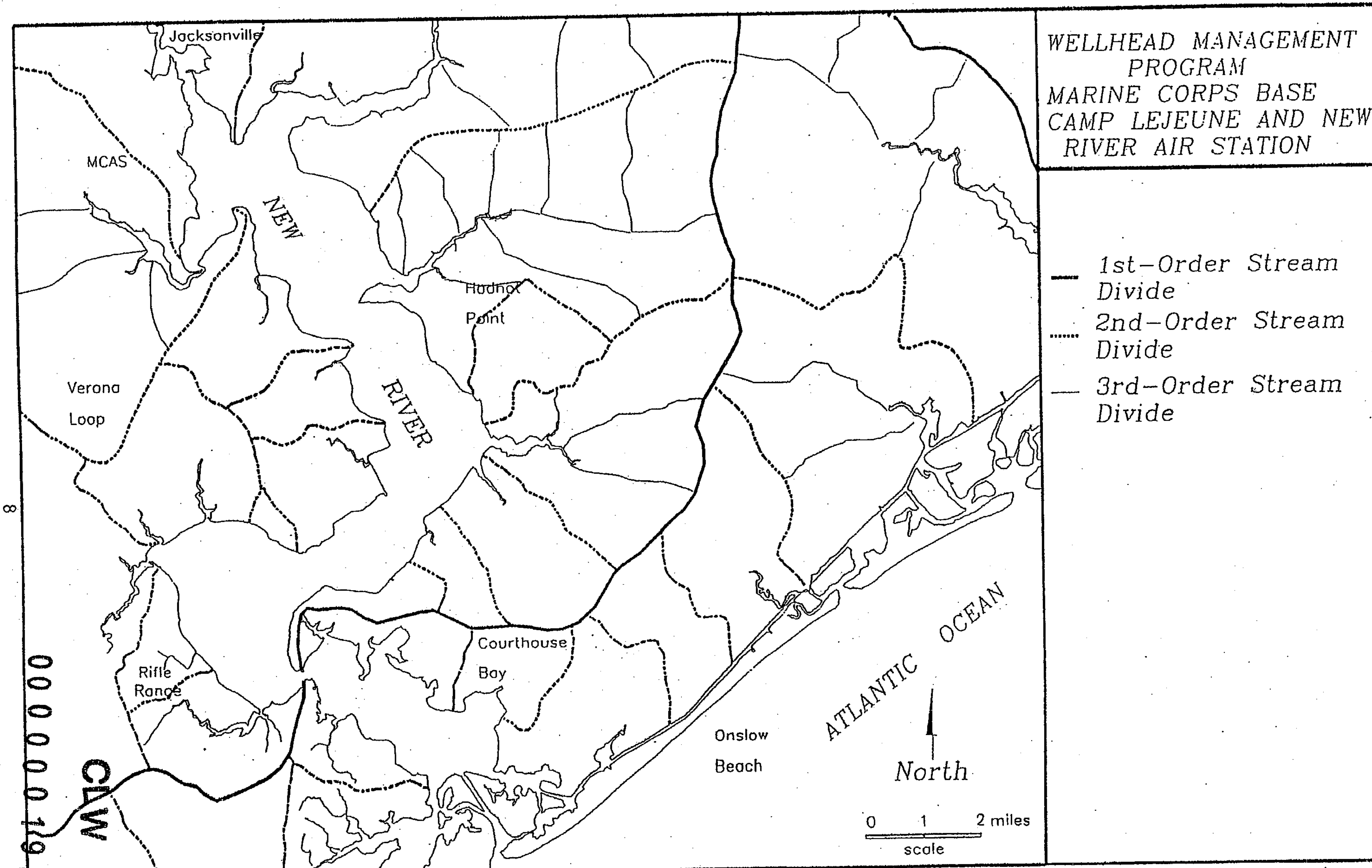

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Figure 3. Location of First-, Second-, and Third-Order Drainage Divides.

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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.

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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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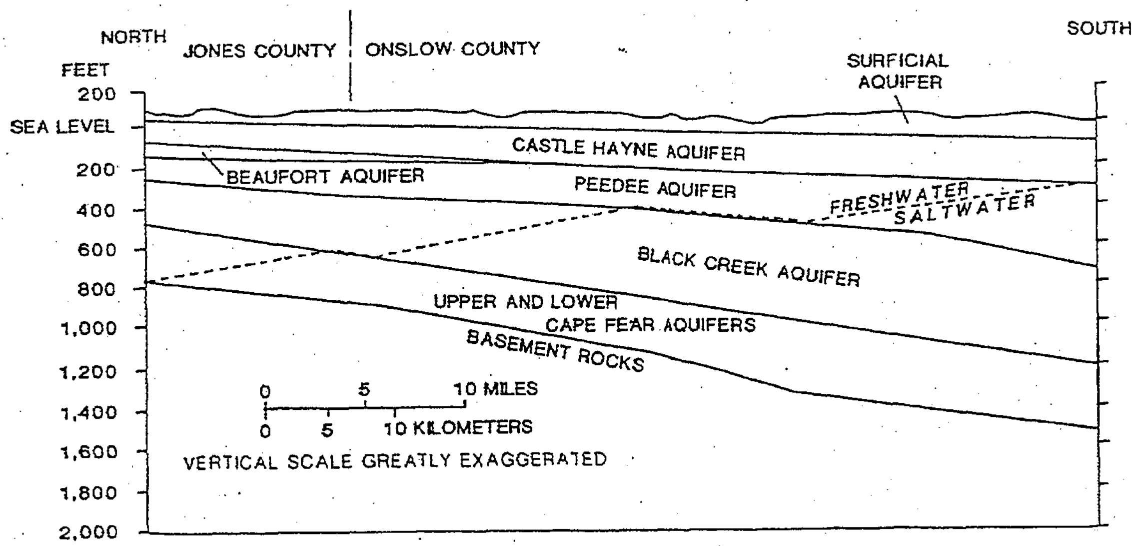

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Figure 4. Geologic Cross-Section Showing the Relationship Between Six Major Aquifer Systems.

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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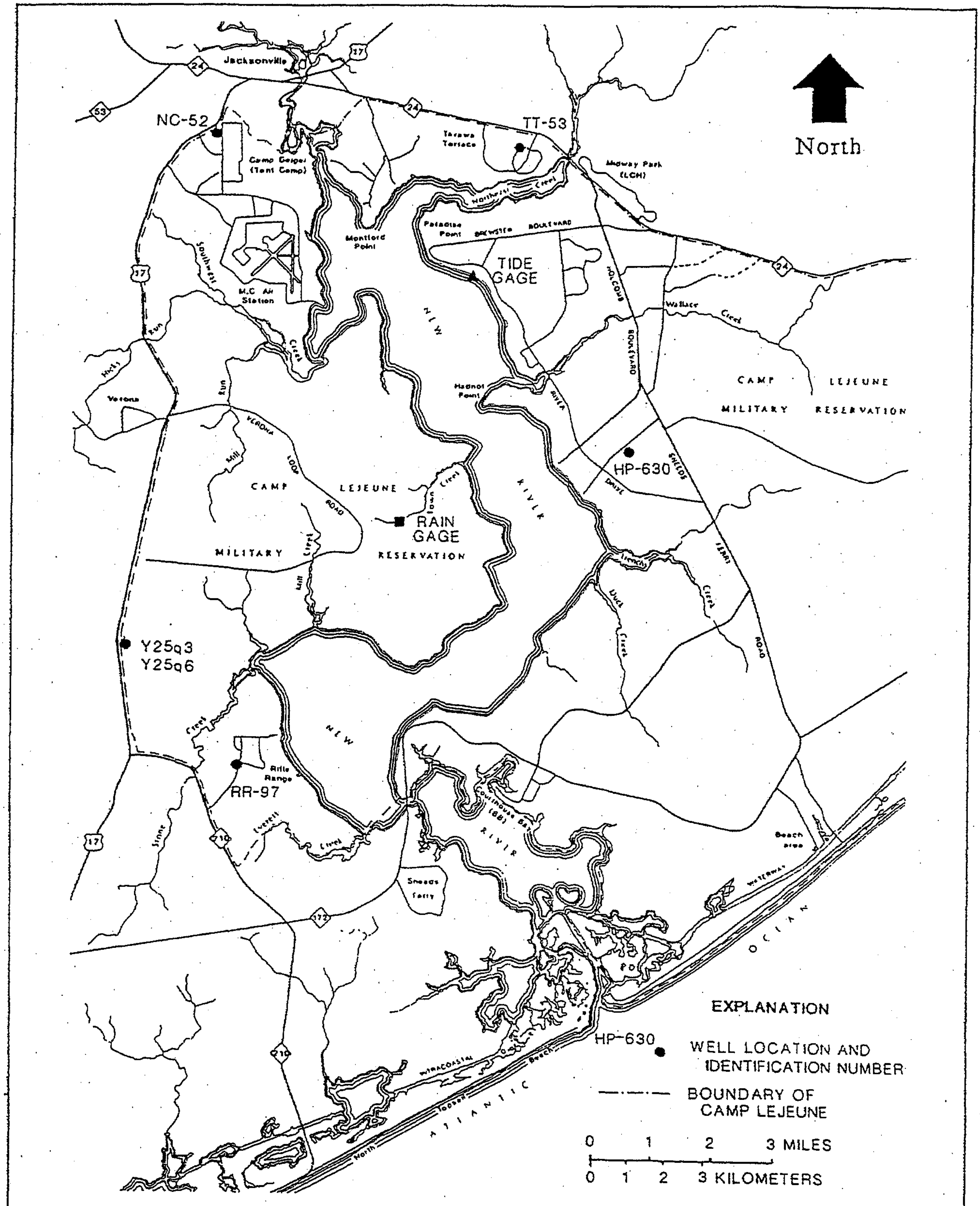

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Figure 5. Location of USGS and NC DEM monitoring stations (from Harned and others, 1989).

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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.

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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

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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

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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

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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 /93	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.

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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	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
		Volatile Organic Compounds (ug/l)											
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

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Table 2 - Continued

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

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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).

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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.

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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.

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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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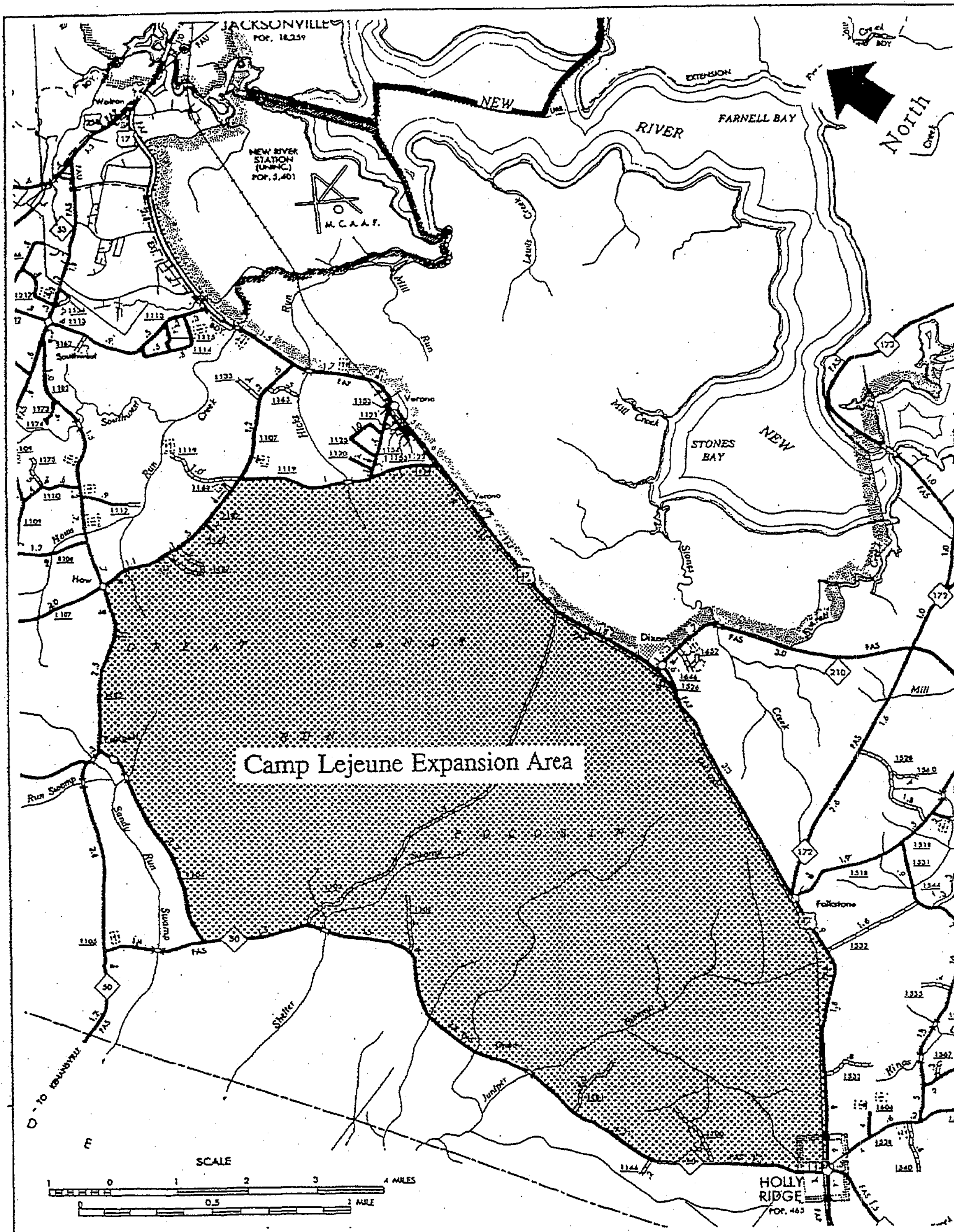

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Figure 6. Location of Newly Acquired MCB Land Area

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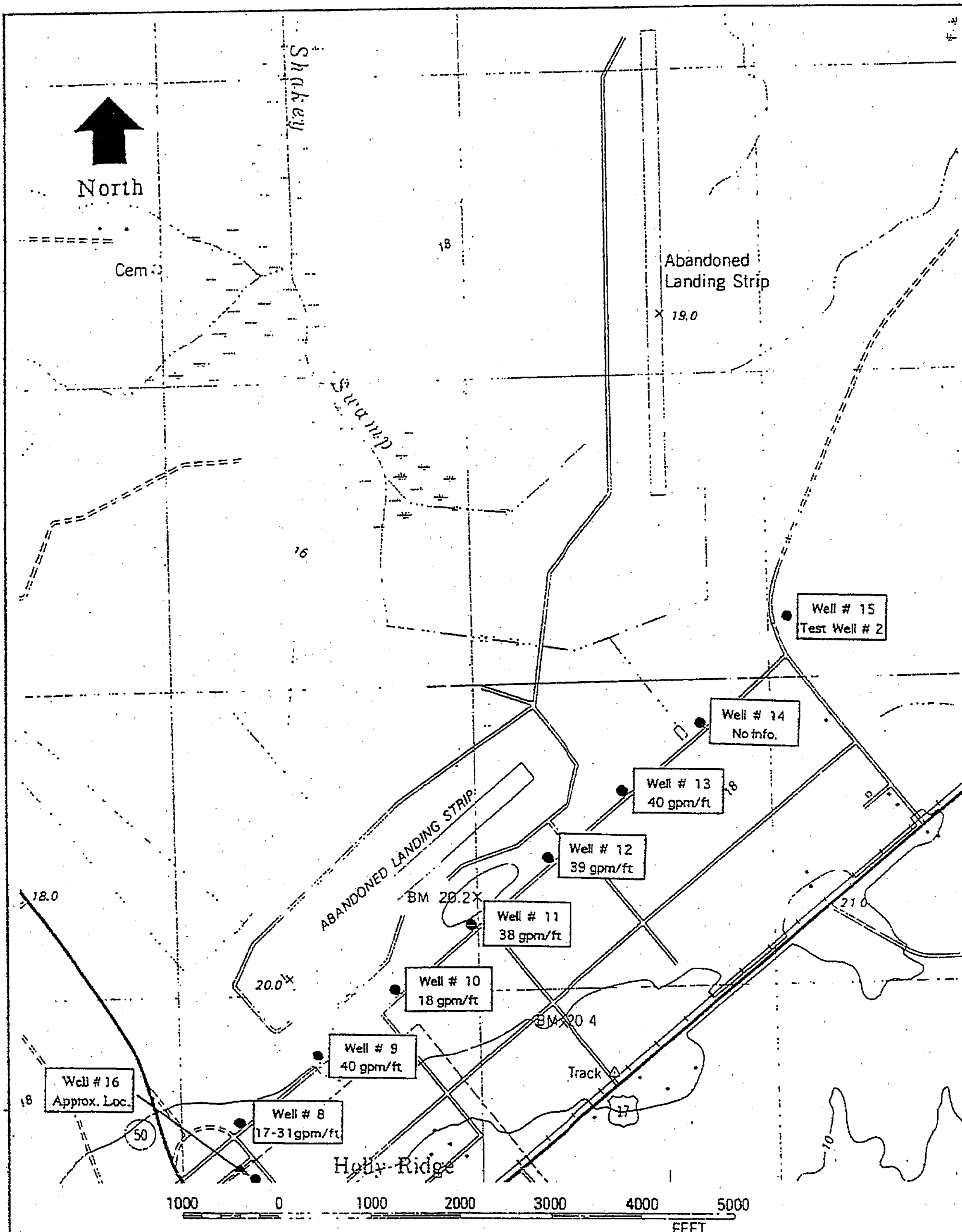

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Figure 7. Location of Abandoned Well on MCB, Formerly Camp Davis.

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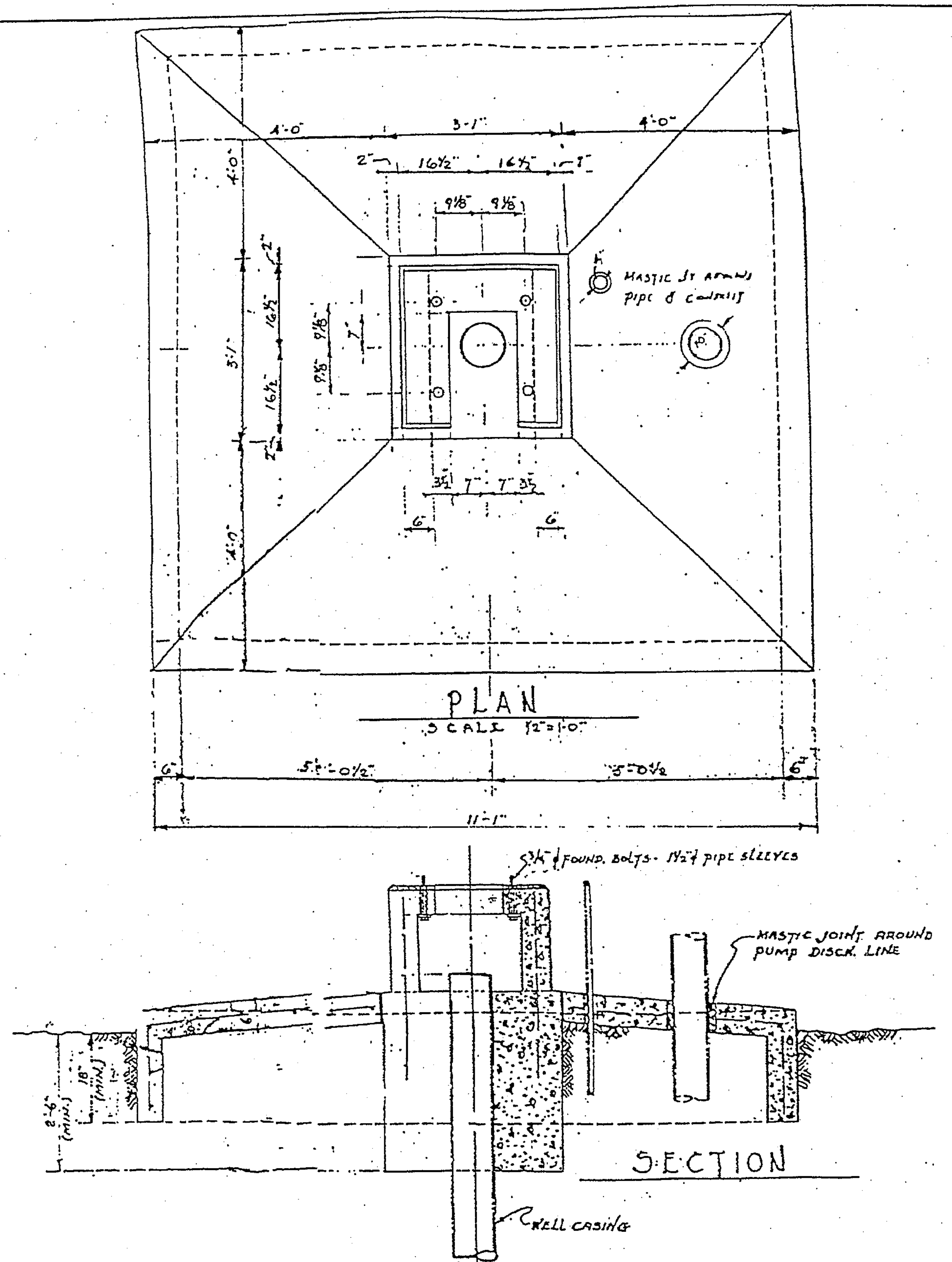

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Figure 8. Typical Well Construction for water supply wells at Former Camp Davis.

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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.

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- 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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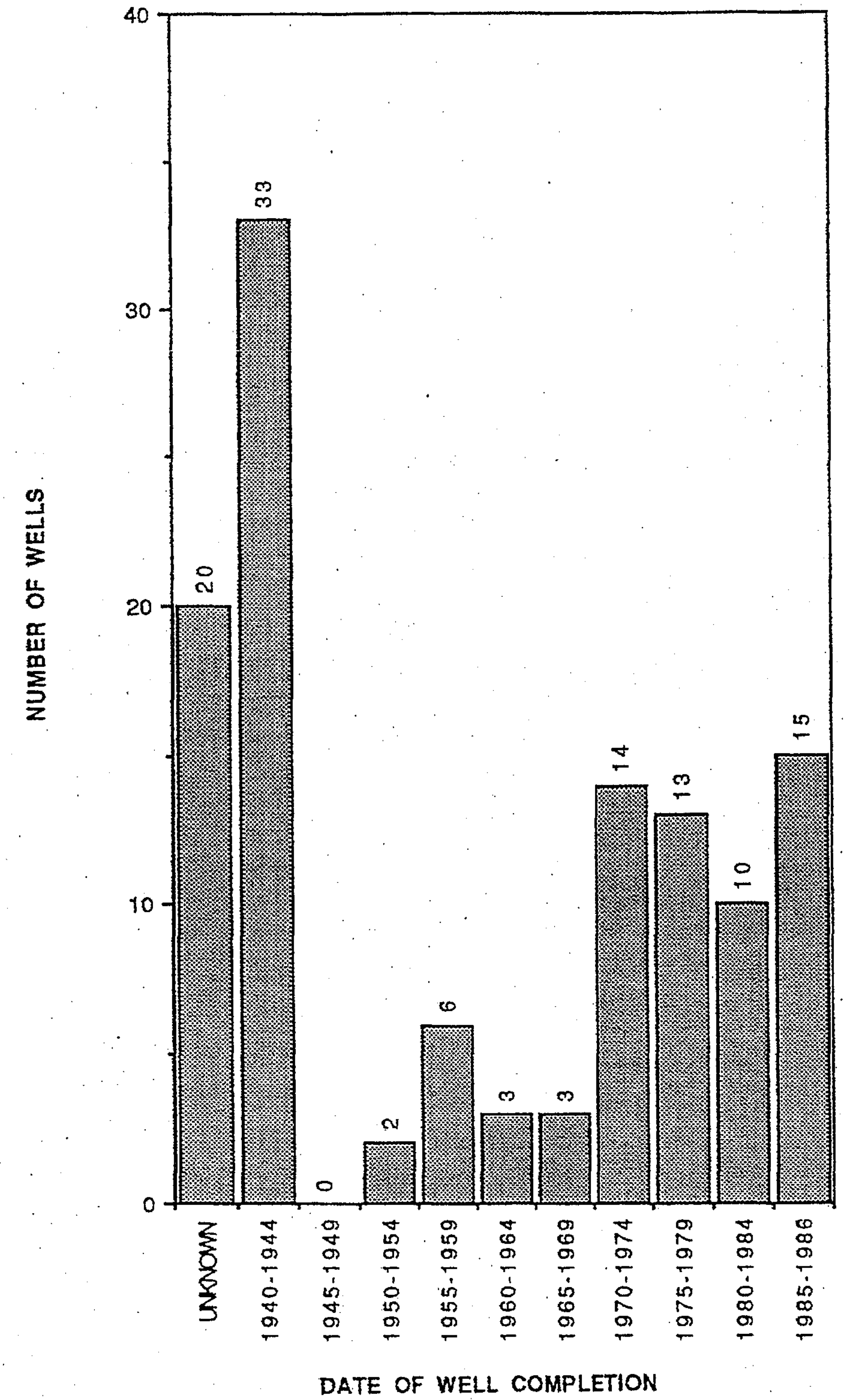

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Figure 9. Distribution of Date-of-Well Completion Versus Cummulative Percent of 83% of MCB Water Wells.

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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.

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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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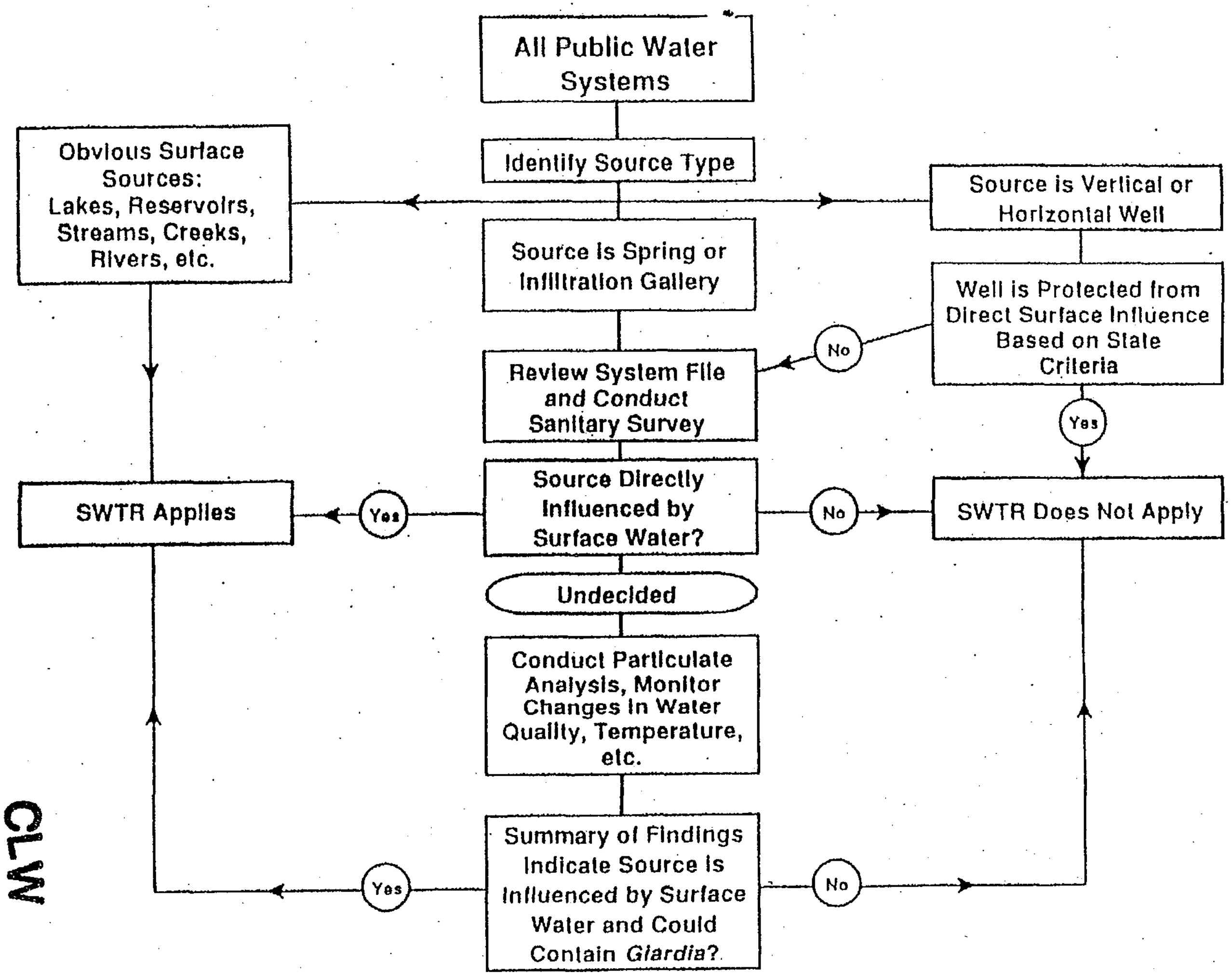

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Figure 10. EPA Flow Diagram Illustrating The Method of Determining If A Water Treatment System is Affected by SWTR.(from EPA, 1991)

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.

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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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- 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.

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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.

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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

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.

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