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RECONNAISSANCE OF THE GROUND-WATER RESOURCES OF THE FERNANDINA AREA, NASSAU COUNTY, FLORIDA

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TABLE OF CONTENTS

ILLUSTRATIONS

RECONNAISSANCE OF THE GROUND-WATER RESOURCES OF THE FERNANDINA AREA, NASSAU COUNTY, FLORIDA

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ABSTRACT

This report describes an area approximately $8\frac{1}{2}$ miles long and 6 miles wide, adjacent to the Atlantic Ocean in northeastern Florida. Sand and alluvium of Pleistocene and Recent age are exposed at the surface. They are immediately underlain by undifferentiated deposits of marl, sand, and shell of undetermined age. These, in turn, are underlain by the Hawthorn formation of middle Miocene age which consists predominantly of clay beds. The Hawthorn formation is underlain by limestones of Eocene age whose top was found to be 550 feet below land surface in one well.

The limestones of Eocene age contain water under artesian pressure and are the principal source of water in the area. The artesian aquifer is recharged to the north and west of the area where the limestones crop out or are hydrologically connected to bodies of surface water.

Water is discharged from the aquifer in the Fernandina area by municipal and industrial wells. This discharge has created a depression in the piezometric surface in the

Fernandina area. Since 1946, there has been a decline in the piezometric surface of about 10 to more than 20 feet and the area in which the altitude of the piezometric surface is at or below mean sea level has approximately tripled. Hydrographs of water levels show that in the area of discharge, the artesian pressure has declined more than 50 feet since 1939.

The chloride content of water in 1959 ranged from 26 to 41 ppm (parts per million) from wells less than 1,400 feet deep and from 50 to 1,060 ppm from wells more than 1,400 feet deep. Recently there has been a general increase in the chloride content of water from wells tapping the artesian aquifer. This increase averaged less than 10 ppm since 1940 in wells less than 1,400 feet deep, and from 20 to 640 ppm since 1952 in wells more than 1,400 feet deep.

Possible sources of salt-water contamination may be salt zones in the lower part of the aquifer below the fresh-water zone or thin zones of mineralized water within the fresh-water zone. Most water samples collected did not indicate sufficient saline content to endanger municipal and industrial supplies. However, as more water is withdrawn from the artesian aquifer and wells are drilled deeper into the lower part of the aquifer, it is possible that increasing amounts of saline water may move into the fresh-water zones and make them unsuitable for domestic and industrial use.

INTRODUCTION

Practically all water for municipal and industrial use in the Fernandina area is supplied by artesian wells. In recent years, the use of artesian water in the area has increased to meet the needs of expanding industry and increasing population. The total industrial and municipal pumpage has increased from approximately 35 million gallons per day in 1941 to approximately 50 million gallons per day in 1959. Correlated with the increase in water use is the constant decline in the artesian pressure in the area. In many other areas in Florida, such a decline in artesian pressure has resulted in salt-water intrusion into the fresh-water supply.

An intrusion of salt water in the Fernandina area would contaminate the existing fresh-water supply and would result in a hardship for the population and seriously injure the economy.

Recognizing the threat to the fresh-water supplies of this area, the U. S. Geological Survey in cooperation with the Florida Geological Survey made a reconnaissance to determine if there has been any intrusion of salt water into the fresh-water supply or if there is any danger of future intrusion.

This report presents the information collected during October and November, 1959, and discusses the results of this reconnaissance. The major phases of the reconnaissance included the following:

(1) Collection and compilation of existing ground-water data.

(2) An inventory of wells to determine their number, distribution, depths, diameters, yields, artesian pressure, and other pertinent information.

(3) The study of existing geologic information to determine the thickness, character, and extent of the different geologic formations.

(4) The collection and study of artesian-pressure data to determine the seasonal fluctuations and progressive trends.

(5) A study of the quality of the artesian water to determine if the decline in artesian pressure had caused an intrusion of salt water into the artesian aquifer.

The investigation was made under the general supervision of Philip E. LaMoreaux, chief, Ground Water Branch, U. S. Geological Survey, and under the immediate supervision of M. I. Rorabaugh, district engineer for Florida.

Previous Investigations

Detailed studies of the ground-water resources and geology of the Fernandina area were made by Cooper (1944, p. 169-185) and Derragon (1955). Much of the field data collected during these earlier studies were used in preparing this report.

Chemical analyses of water from a number of wells in the area are included in a report by Black and Brown (1951, p. 81-82).

Numerous reports by the U. S. Geological Survey and the Florida Geological Survey have included general information on the ground-water resources and geology of the Fernandina area.

Acknowledgments

The writer wishes to express his appreciation to Mr. T. Oliver, power superintendent, Container Corporation of America; Mr. H. G. Taylor, chief chemist, Rayonier Inc.; and to Mr. Revells, engineer, Florida Public Utilities Co., all of whom supplied valuable data and permitted the measuring and sampling of wells.

Well-numbering System

Wells inventoried during this investigation were each assigned an identifying well number. The well number was determined by first locating each well on a map which was divided into 1-minute quadrangles of latitude and longitude, then numbering consecutively each inventoried well in a quadrangle. The well number is composed of the last three digits of the degrees and minutes of latitude south of the well, followed by the last three digits of the degrees and minutes of longitude east of the well, followed by the number of the well in the quadrangle. For example, well 039-128-2 is the well numbered 2 in the quadrangle bounded by latitude 30°39' on the south and longitude 81°28' on the east. With this system, a well referred to by number in the text can be located on figure 3.

GEOGRAPHY

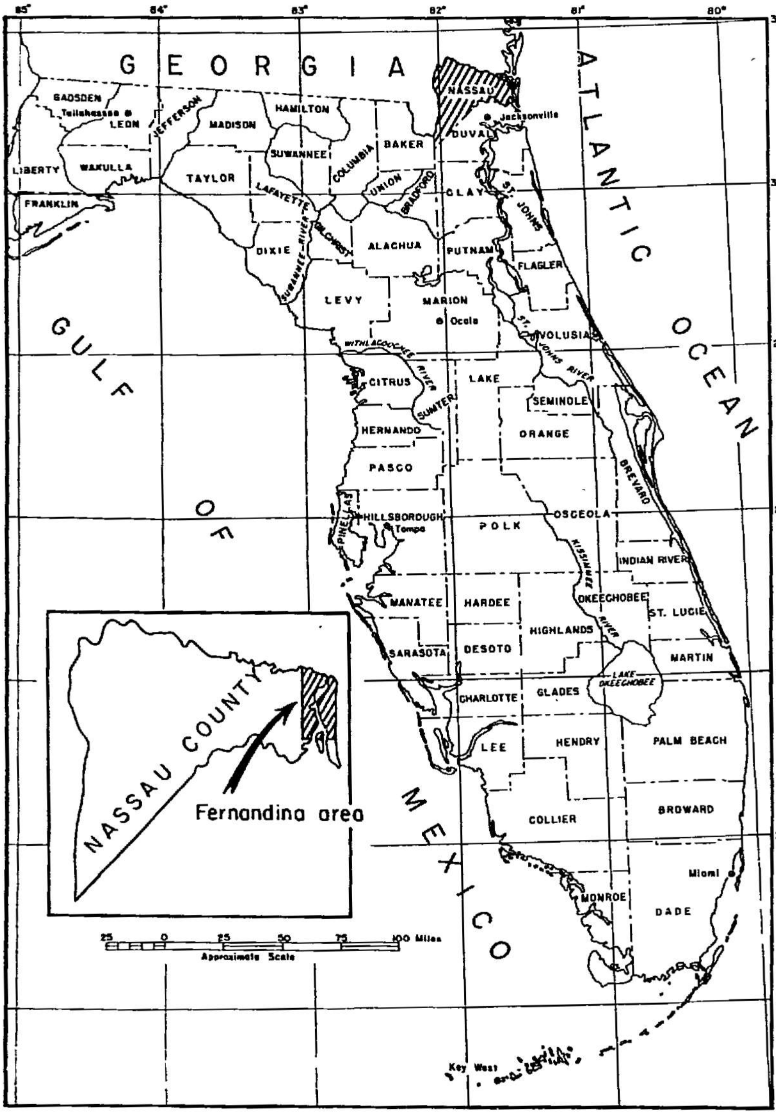
This report describes an area approximately 8½ by 6 miles adjacent to the Atlantic Ocean in northeastern Florida (fig. 1). It includes the city of Fernandina and adjacent parts of Nassau County.

The eastern part of the area, which includes the city of Fernandina, is an offshore bar separated from the mainland by the Amelia River and its tributaries. The western part of the area is a dissected plain which slopes irregularly eastward toward the ocean.

The land surface is relatively low and flat, ranging in altitude from sea level to about 20 feet. Small scattered sand hills and dunes in the eastern part attain altitudes of more than 50 feet.

Surface drainage is principally by the Amelia River and its tributaries. Drainage is sluggish in the stream valleys and on the irregular marsh plain west of the river.

Figure 1. Map of the Florida Peninsula showing the location of Nassau County and the Fernandina area.



GEOLOGIC FORMATIONS AND THEIR WATER-BEARING PROPERTIES[1]

The principal source of water in the Fernandina area is permeable limestones of Eocene age. As shown in figure 2, the top of the limestone section is about 550 feet below the land surface, and more than 1,500 feet thick in well 038-127-4.

The lower three Eocene formations, the Oldsmar, Lake City, and Avon Park limestones, consist of alternating beds of soft, porous limestone and hard, dense crystalline limestone and dolomite. The upper three Eocene formations, the Inglis, Williston, and Crystal River formations, consist of a homogeneous sequence of soft, porous limestone containing a few dolomite lenses near the base.

The Hawthorn formation of middle Miocene age overlies the Crystal River formation throughout the area. It consists of greenish gray, phosphatic, calcareous clay containing lenses of dolomite, limestone, and sand.

Undifferentiated deposits of greenish gray sandy, shelly marl overlie the Hawthorn formation. The author did not attempt to determine the exact age of these beds. As shown in figure 2, they are referred to as post-Hawthorn deposits.

The relatively impermeable clay, marl, and dolomite beds in the Hawthorn formation and the post-Hawthorn deposits serve as confining beds for the artesian water in the underlying limestones of Eocene age. The combined thickness of these confining beds is more than 500 feet in well 038-127-4 (fig. 2).

Sand and alluvium of Pleistocene and Recent age cover the surface of the area. The sand is 40 feet thick in well 038-127-4 (fig. 2).

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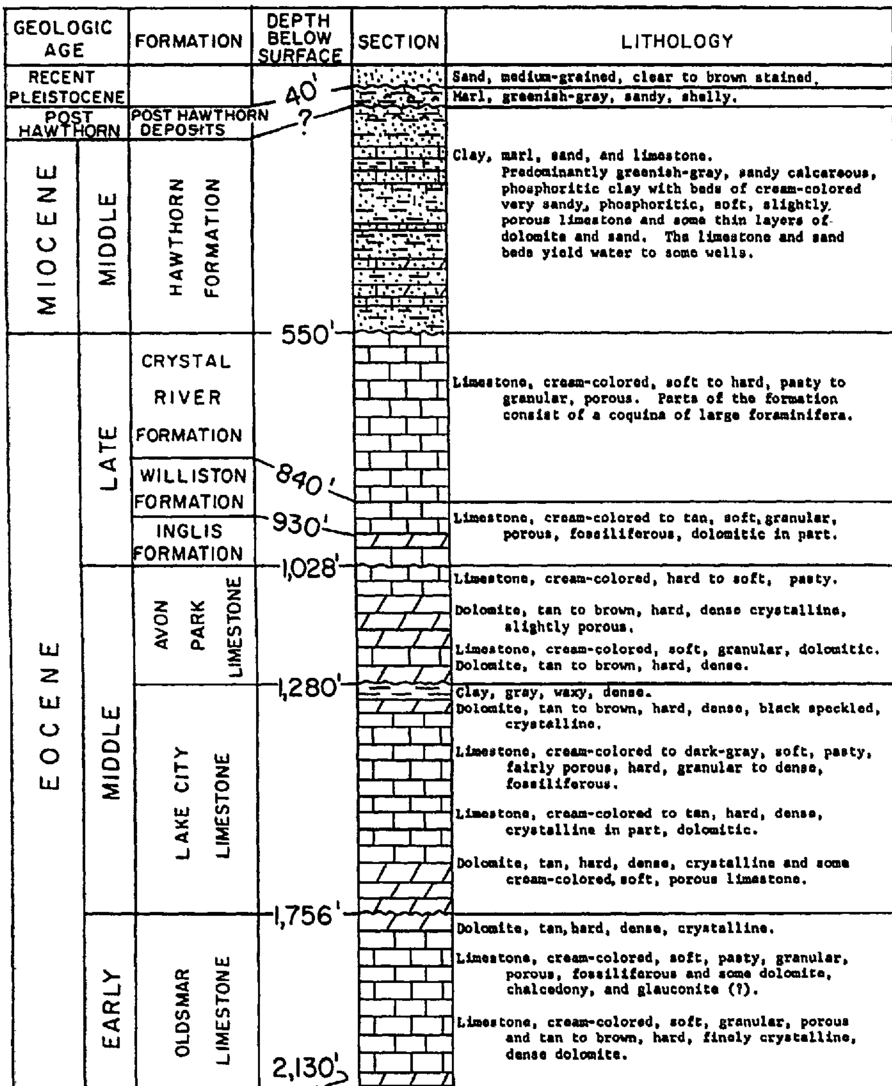
[1] The classification and nomenclature of the rock units used in this report conform to the usage of the Florida Geological Survey and are not necessarily those of the U. S. Geological Survey.

Figure 2. Geologic section showing the formations penetrated by well 038-127-4 at Fernandina.



Many domestic wells obtain water from the Pleistocene and Recent sand and from the thin sand, limestone, and shell lenses in the Hawthorn and post-Hawthorn deposits. However, the small quantity of water available from these beds necessitates the drilling of deeper wells into the more productive limestones of Eocene age for municipal and industrial purposes.

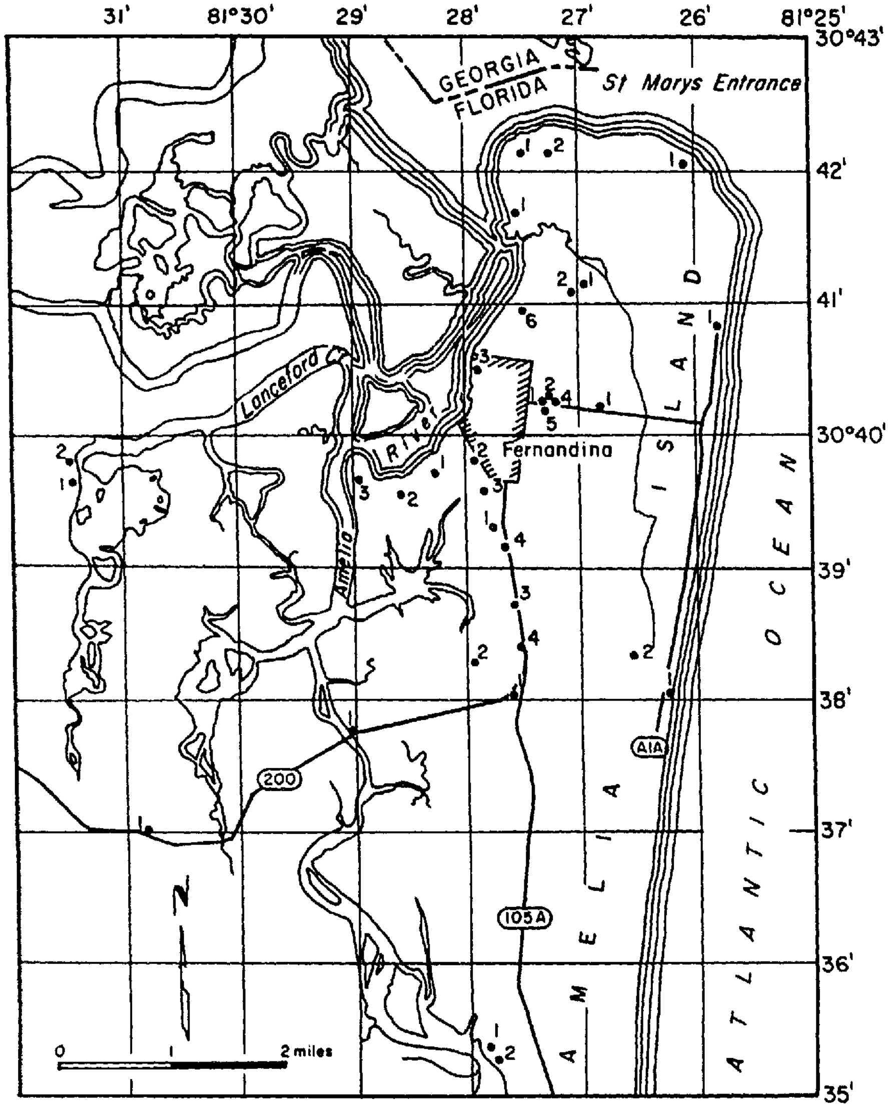
GROUND WATER

Ground water is that part of the subsurface water that is in the zone of saturation, in which all pore spaces in the rock are filled with water. It is derived almost entirely from precipitation but not all precipitation becomes ground water. Part of it is returned to the atmosphere by evapotranspiration and part of it drains overland into lakes, streams, and the ocean.

Ground water may occur under either nonartesian or artesian conditions. Where the ground water is not confined and its surface is free to rise and fall, it is said to be under nonartesian conditions. Where the water is confined in a permeable bed that is overlain by impermeable beds so that its surface is not free to rise and fall, it is said to be under artesian conditions. The term "artesian" is applied to ground water that is confined under sufficient pressure to rise in a well above the top of the permeable bed that contains it. The artesian pressure head is the height to which water will rise in an artesian well and the piezometric surface is the imaginary surface to which water will rise in tightly cased wells that penetrate the artesian aquifer. The location of the wells inventoried in the area are shown on figure 3.

An aquifer is a formation, group of formations, or part of a formation in the zone of saturation that is permeable enough to transmit usable quantities of water. Areas in which aquifers are replenished are called recharge areas and areas in which water is lost from the aquifer are called discharge areas.

Figure 3. Map of the Fernandina area showing the location of wells.



Artesian Aquifer

The artesian aquifer is the principal source of water in the Fernandina area, therefore nearly all of the information collected and studied during this investigation concerns the artesian aquifer.

The artesian aquifer in the Fernandina area consists of the limestone beds of Eocene age. Water is confined under pressure in the limestones by beds of clay, marl, and dolomite in the overlying Hawthorn formation and post-Hawthorn deposits.

The artesian aquifer is recharged to the north and west of the Fernandina area in southeastern Georgia and north-central Florida. In the recharge area the limestones of Eocene age either crop out at the surface and are recharged directly by rainfall or the formations are hydrologically connected to lakes, streams, sinkholes, and the nonartesian aquifer.

Ground water moves laterally away from the recharge areas through the permeable limestones toward areas where discharge is occurring. In the Fernandina area, water is discharged by numerous wells that penetrate the artesian aquifer.

Figure 2 shows that below the Inglis formation, the artesian aquifer contains beds of hard, dense, crystalline dolomite and limestone. These relatively impermeable beds tend to restrict the vertical movement of water in the aquifer. Differences in static head and chloride content of the water at different depths indicate that there are several separate zones within the artesian aquifer in the Fernandina area.

In the past, the Inglis, Williston, and Crystal River formations have supplied sufficient quantities of water to industrial and municipal wells and the underlying formations were not used as a source of water. Recently, because of increasing demands for water a number of municipal and industrial wells have been drilled into the underlying formations.

Piezometric Surface

Since 1939, large quantities of ground water have been withdrawn in the Fernandina area, principally by industrial and municipal wells. This withdrawal has reduced the artesian pressure and has created a depression in the piezometric surface in the area. The contours in figure 4 show the piezometric surface in the Fernandina area in 1946 and 1959. As the piezometric surface fluctuates continuously in response to changes in pressure within the artesian aquifer, figure 4 can only approximate the piezometric surface during these years.

Within the O-contour in figure 4, the piezometric surface has been depressed to or below mean sea level. The maps show that between 1946 and 1959 the area enclosed by the O-contour line has approximately tripled. The slope of the piezometric surface toward the discharge area represents the hydraulic gradient created by the discharging wells in the Fernandina area. The maps reveal that the gradient has decreased slightly, and that there has been a general decline in the altitude of the piezometric surface of about 10 to more than 20 feet since 1946.

Periodic measurements of the artesian pressure have been made since 1939 in well 040-126-1 in Fernandina. The hydrograph (fig. 5) of this well shows the progressive trends of the artesian pressure and the effect of withdrawal of artesian water by nearby industrial and municipal wells. The artesian pressure has declined more than 50 feet since 1939. Fluctuations in the artesian pressure indicate periods of increased or decreased pumpage by the nearby industrial and municipal wells. The artesian pressure in the well increases when discharge decreases and vice versa. Fluctuations of more than 10 feet are common, especially during periods when the industrial wells are shut down.

QUALITY OF WATER

The chemical character of ground water largely depends upon the type of material with which the water has

Figure 4. Maps of the Fernandina area showing the piezometric surface in 1946 and 1959.

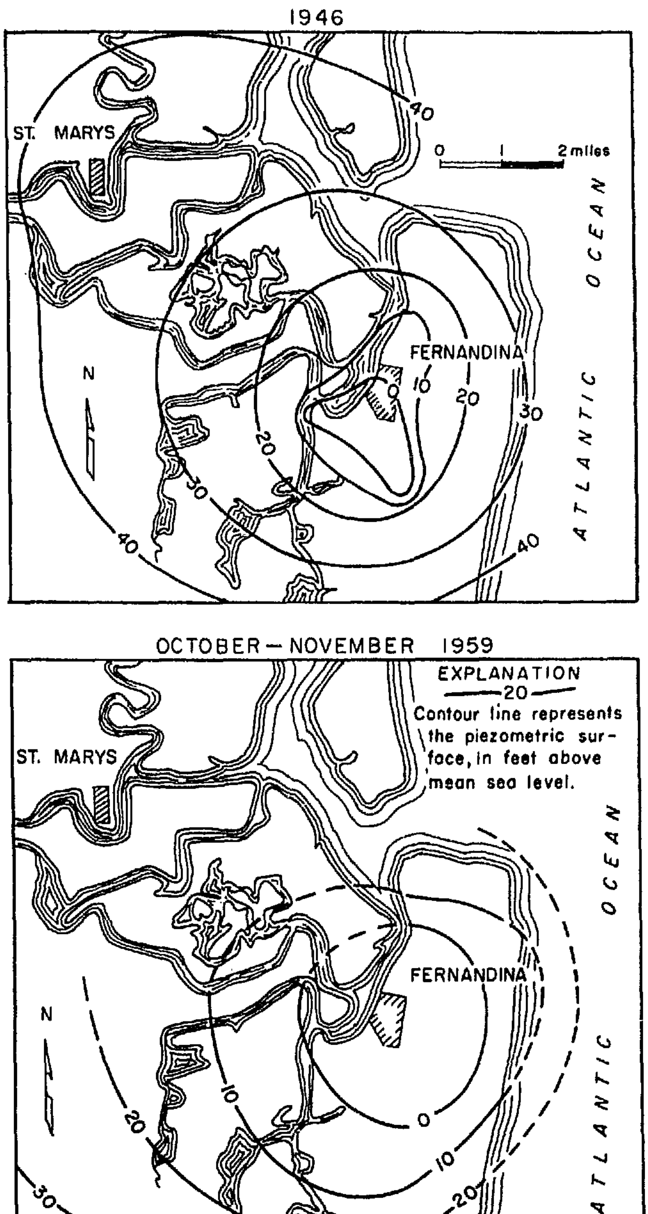
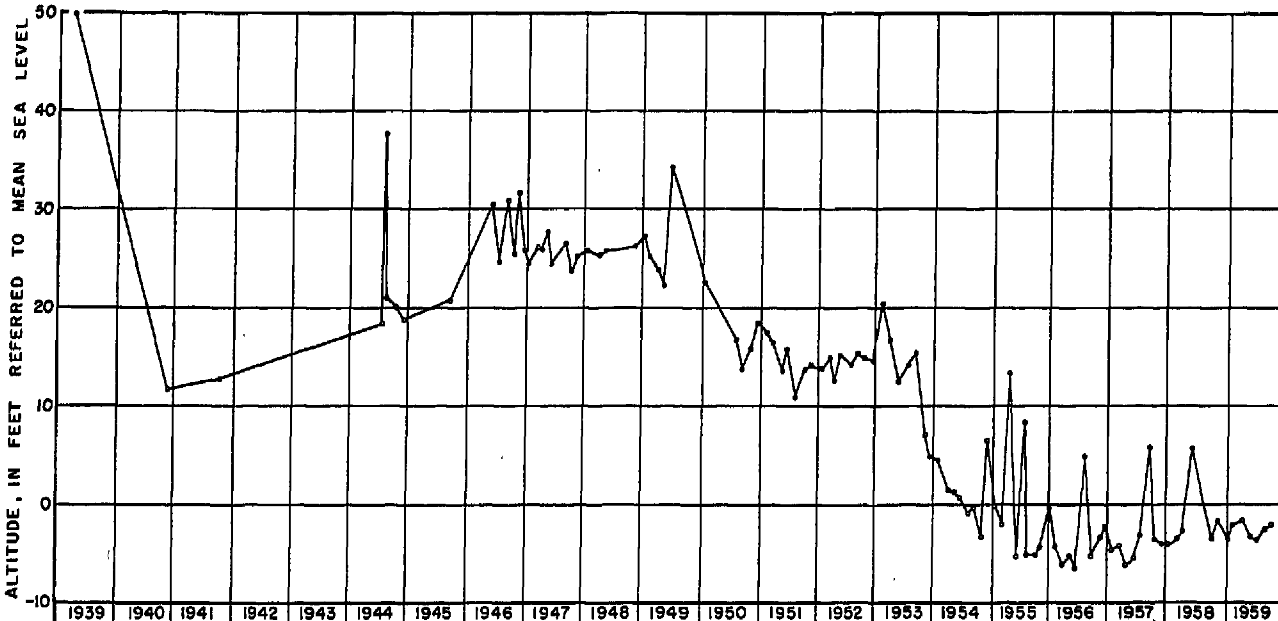


Figure 5. Hydrograph of well 040-126-1 in Fernandina.



come in contact or by contamination with sea water. When the water first enters the ground it is only slightly mineralized. As it moves through the ground it may become more mineralized by dissolving mineral matter from the rocks and by mixing with mineralized water already in the rocks.

Chemical analyses of water from 14 artesian wells of various depths in the Fernandina area are shown in table 1. The degree of mineralization, expressed by the dissolved-solid content, generally does not differ significantly among wells less than 1,400 feet deep. Water from wells more than 1,400 feet deep generally show a higher degree of mineralization than the shallower wells. The dissolved-solid content of water from well 038-127-4, which is 1,826 feet deep, was found to be 5 to 6 times as great as water from wells less than 1,400 feet deep.

Salt-water Contamination

In many parts of Florida, where there has been a decline in artesian pressure, the existing fresh-water supply has been contaminated by intrusions of salt water. These intrusions have occurred in various ways, depending upon the location and the geologic and hydrologic characteristics of the different areas. In some areas, particularly near the coast, salt water from the ocean has moved laterally or vertically into the zones of reduced pressure. In other areas, salt water has moved upward from deeper, highly mineralized zones or laterally from relatively thin mineralized zones within the aquifer into the fresh-water zones.

Table 2 shows the chloride content by years of water from wells of different depths that penetrate the artesian aquifer in the Fernandina area. The chloride content, which is an index of salt-water contamination, generally increases with depth. In 1959, the chloride content of water from wells less than 1,400 feet deep ranged from 26 to 41 ppm and in wells more than 1,400 feet deep the chloride content ranged from 50 to 1,060 ppm.

Table 1. Chemical Analyses of Water from Artesian Wells in the Fernandina Area

(Chemical constituents in parts per million)

Well number	Depth (feet)	Cased (feet)	Date sampled	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na-K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Hardness as $CaCO_3$	pH
Wells less than 1,000 feet deep														
039-127-1	750	-----	1- 8-24	496	37	0.06	73	40	28	194	173	31	346	---
			4- 1-59	527	--	.0	80	37	--	192	163	33	354	7.4
040-127-5	731	-----	9-28-37	---	22	.31	60	44	19	195	159	33	330	7.3
			4- 2-50	480	33	.01	71	39	21	200	166	33	334	7.4
			4- 1-59	509	--	.06	72	28	--	202	144	29	300	7.4
042-126-1	800	550	5-15-59	583	--	.06	76	37	--	192	228	36	344	7.2
042-127-1	800	534	5-15-59	535	--	.0	72	32	--	190	198	33	316	7.7
042-127-2	800	520	5-15-59	552	--	.06	72	34	--	180	193	32	320	7.3
Wells 1,000 to 1,400 feet deep														
038-126-2	1203	572	6-25-37	---	--	.40	64	37	37	198	177	33	312	7.2
			5-30-50	478	34	----	68	38	25	195	168	30	326	7.5
			4-17-56	504	--	----	79	35	--	---	158	34	343	---
			12- 6-56	504	--	----	64	38	--	---	141	23	317	---
			8- 7-57	679	--	----	67	37	--	---	145	34	319	---
			8-20-57	471	--	.0	63	34	--	197	153	27	300	7.4
			4- 1-59	464	--	.0	69	34	--	192	134	29	316	7.3
039-128-2	1054	549	5-30-50	490	36	----	69	38	20	198	161	30	326	7.5
			4-17-56	540	--	----	40	51	--	---	152	32	311	---
			12- 6-56	533	--	----	64	37	--	---	126	30	312	---
			3- 7-58	520	--	----	68	36	--	---	157	37	318	---
			12- 1-58	500	--	----	68	49	--	---	161	41	372	---
			3-10-59	518	--	----	65	38	--	---	163	41	318	---
			6-18-59	562	--	----	66	40	--	---	165	38	332	---
			9- 3-59	653	--	----	65	38	--	---	182	38	320	---
039-128-3	1065	550	1- 8-24	470	--	----	66	29	41	193	167	29	284	---
			8- 7-57	621	--	----	67	37	--	---	145	35	319	---
			3- 7-58	487	--	----	66	35	--	---	131	32	308	---
			12- 1-58	514	--	----	67	38	--	---	156	40	323	---
			3-10-59	527	--	----	63	38	--	---	152	35	316	---
			6-18-59	613	--	----	66	38	--	---	152	37	323	---
			9- 3-59	540	--	----	67	36	--	---	149	34	315	---

Table 1. (Continued)

(Chemical constituents in parts per million)

Well number	Depth (feet)	Cased (feet)	Date sampled	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na-K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Hardness as $CaCO_3$	pH
040-127-1	1100	552	9-28-37	---	22	0.32	60	44	19	195	159	33	330	7.3
			9-27-49	570	--	.0	82	35	14	205	162	30	350	7.4
			4- 2-50	467	34	.01	66	39	27	204	160	36	326	7.3
			5-15-59	524	--	.04	61	34	--	192	224	29	296	7.4
040-127-2	1025	500	9-27-49	520	--	.10	80	35	16	205	161	30	344	7.4
			4- 2-50	463	34	.0	69	41	23	204	168	34	338	7.3
			4- 1-59	520	--	.0	72	42	--	190	153	33	356	7.3
040-127-4	1203	550	4- 1-59	570	--	.09	77	40	--	192	157	38	360	7.3
Wells more than 1,400 feet deep														
038-127-4	1826	---	4-17-56	1955	--	----	178	86	--	---	360	644	790	---
			12- 6-56	2475	--	----	166	96	--	---	375	687	808	---
			8- 7-57	2805	--	----	163	85	--	---	355	770	758	---
			3- 7-58	2375	--	----	170	94	--	---	364	790	812	---
			12- 1-58	2365	--	----	168	104	--	---	379	865	849	---
			3-10-59	2748	--	----	170	101	--	---	372	860	841	---
			6-18-59	3095	--	----	172	105	--	---	382	960	864	---
			9- 3-59	3048	--	----	170	101	--	---	403	864	841	---
039-127-2	1700	545	4-17-56	694	--	----	62	37	--	---	169	44	308	---
			12- 6-56	579	--	----	79	35	--	---	168	38	341	---
			8- 7-57	611	--	----	70	39	--	---	152	47	334	---
			3- 7-58	605	--	----	72	35	--	---	177	47	324	---
			12- 1-58	622	--	----	74	38	--	---	184	52	344	---
			3-10-59	629	--	----	73	41	--	---	172	50	351	---
			6-18-59	548	--	----	73	41	--	---	184	51	352	---
			9- 3-59	622	--	----	74	44	--	---	177	50	367	---
039-127-4	1820	545	4-17-56	820	--	----	92	36	--	---	190	107	376	---
			12- 6-56	730	--	----	80	45	--	---	185	99	388	---
			8- 7-57	874	--	----	80	45	--	---	197	112	386	---
			3- 7-58	788	--	----	84	43	--	---	206	112	387	---
			12- 1-58	760	--	----	85	48	--	---	197	127	409	---
			3-10-59	754	--	----	85	46	--	---	198	121	400	---
			6-18-59	800	--	----	92	48	--	---	203	126	436	---
			9- 3-59	860	--	----	84	48	--	---	182	125	409	---

Table 2. Chloride Content of Water from Artesian Wells in the Fernandina Area

(Definition of use: A, abandoned; D, domestic; I, industrial; PS, public supply; S, stock)

Well number	Depth (feet)	Cased (feet)	Use	Chloride content in parts per million 1937	1938	1940	1948	1949	1950	1952	1953	1954	1955	1956	1957	1958	1959
Wells less than 1,000 feet deep																	
035-127-1	580	350	D	----	----	25	26-31	----	----	-----	-----	-----	-----	------	-----	-----	30
035-127-2	540	---	D	----	----	----	-----	----	----	-----	-----	-----	26	------	-----	-----	27
037-129-1	578	---	D,S	----	----	27	-----	----	----	-----	-----	-----	27	------	-----	-----	28
037-130-1	540	504	D	----	----	27	28	----	----	-----	-----	-----	-----	------	-----	-----	33
038-126-1	550-	---	A	----	----	28	-----	----	----	-----	-----	-----	29	------	-----	-----	36
039-127-1	750	---	I	----	----	26	-----	----	----	-----	-----	-----	-----	------	-----	-----	33
039-131-2	550-	---	D	----	----	----	-----	----	----	-----	-----	-----	29	------	-----	-----	33
040-127-6	940	550	I	----	----	----	-----	----	----	-----	-----	-----	-----	54-58	52-56	-----	32
042-126-1	800	550	PS	----	----	32	-----	----	----	-----	-----	-----	-----	------	-----	-----	36-40
042-127-1	800	550	PS	----	----	28	-----	----	----	-----	-----	-----	-----	------	-----	-----	33
042-127-2	800	520	PS	----	----	----	-----	----	----	-----	-----	-----	30	------	-----	-----	32
Wells between 1,000 and 1,400 feet deep																	
038-126-2	1203	572	PS	----	----	----	-----	----	----	-----	-----	-----	-----	------	27	-----	29-30
039-128-1	1054	549	I	----	34	30	-----	----	----	-----	-----	33	30-35	29-32	26	38-40	37-38
039-128-2	1054	549	I	33	----	30	-----	----	30	-----	-----	-----	-----	23-34	34	37-41	37-41
039-128-3	1065	625	I	----	----	----	-----	----	30	-----	-----	-----	30-32	30-32	35	32-40	33-37
040-127-1	1100	552	PS	33	----	29	-----	30	36	-----	-----	-----	-----	------	-----	-----	26-29
040-127-2	1100	---	PS	39	----	30	-----	30	34	-----	-----	-----	-----	------	-----	-----	33-35
Wells over 1,400 feet deep																	
038-127-4	1826	---	I	----	----	----	-----	----	----	420-450	480-580	-----	560-630	644-687	770	790-865	860-1060
039-127-2	1700	545	I	----	----	----	-----	----	----	32-38	36-43	40-43	37-43	38-44	47	47-52	50-52
039-127-3	1840	551	I	----	----	----	-----	----	----	65-68	70-77	77-85	82-96	89-90	99	102-116	109-130
039-127-4	1820	545	I	----	----	----	-----	----	----	104	106-127	-----	-----	99-107	112	112-127	121-140
041-126-1	1404	550	I	----	----	----	-----	----	----	-----	-----	-----	-----	142-148	112-118	-----	120

The graphs (fig. 6) and the analyses (table 2) show that in the past few years there has been a general increase in the chloride content of water from wells that penetrate the artesian aquifer in the Fernandina area. In wells less than 1,400 feet deep this increase has been small, averaging less than 10 ppm since 1940. The increase in chloride content of the water has been much greater in wells more than 1,400 feet deep. During 1952-59 the chloride content has increased from 31 to 52 ppm in well 039-127-2 (1,700 feet deep), and it has increased from 420 to 1,060 ppm in well 038-127-4 (1,826 feet deep).

The increase in salt content of water from artesian wells in the Fernandina area indicates that salty water is entering the zone of reduced pressure and gradually contaminating the zone. The higher chloride content in water from the deeper wells indicates that the salty water is being drawn from deeper, highly mineralized zones. If this is true, the recent drilling and deepening of artesian wells in the Fernandina area may tend to hasten contamination of the water in the upper zones. The deeper wells have penetrated relatively impermeable beds in the lower part of the aquifer that restricted vertical movement of water. When these impermeable barriers are penetrated by wells, it is possible that the salty water in the lower part of the aquifer will flow up the well bore and into the zone of reduced artesian pressure in the upper part of the aquifer.

An indication that salt water may also be present in the upper zones of the artesian aquifer was found during the construction of well 041-127-2. The chloride content of water samples taken at 10-foot intervals in this well indicated a zone of relatively salty water between 1,230 feet and 1,450 feet. As shown graphically in figure 7, the chloride content of the water in this depth zone increases from less than 100 ppm to more than 500 ppm. The graph also shows a gradual increase in the chloride content of the water in the zone below 2,020 feet.

Most water samples collected during this investigation did not indicate sufficient saline content to endanger the municipal or industrial supplies. However, as more fresh

Figure 6. Graphs showing chloride content of water from wells 039-128-3, 039-127-2, and 038-127-4 in the Fernandina area.

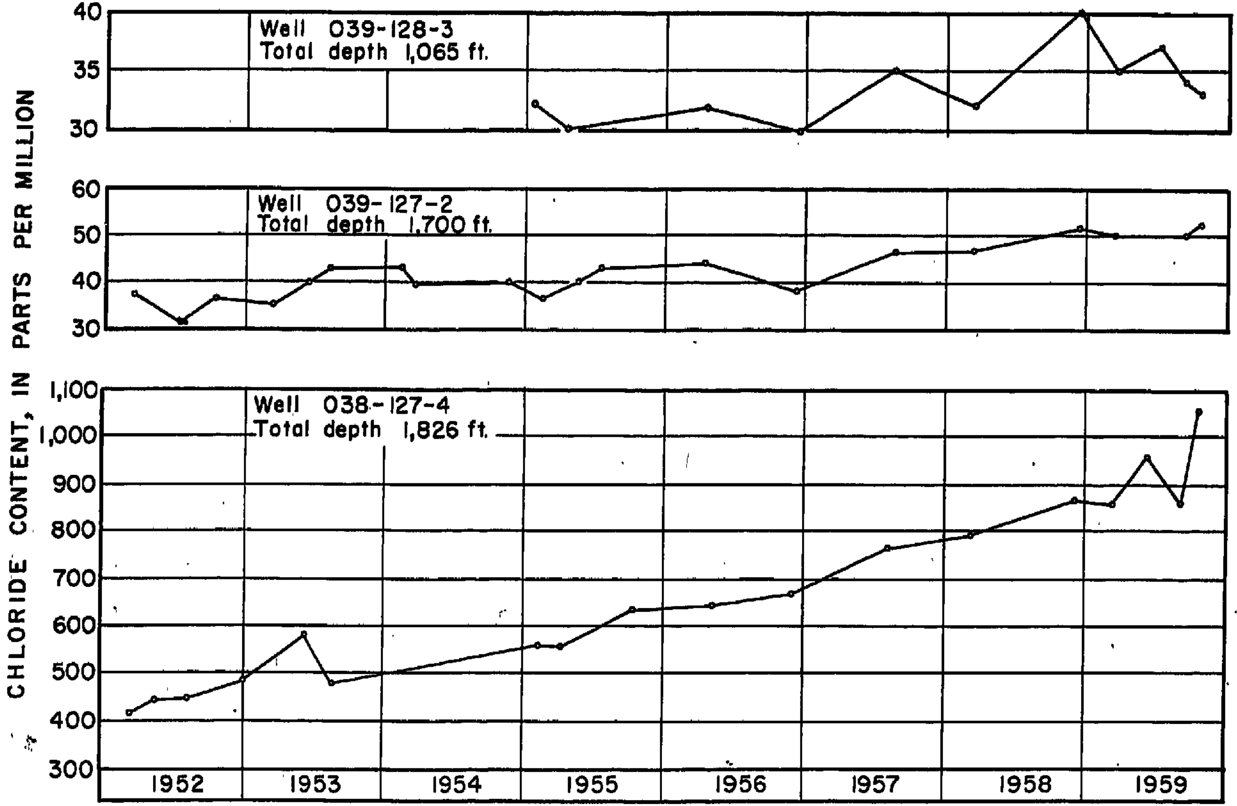
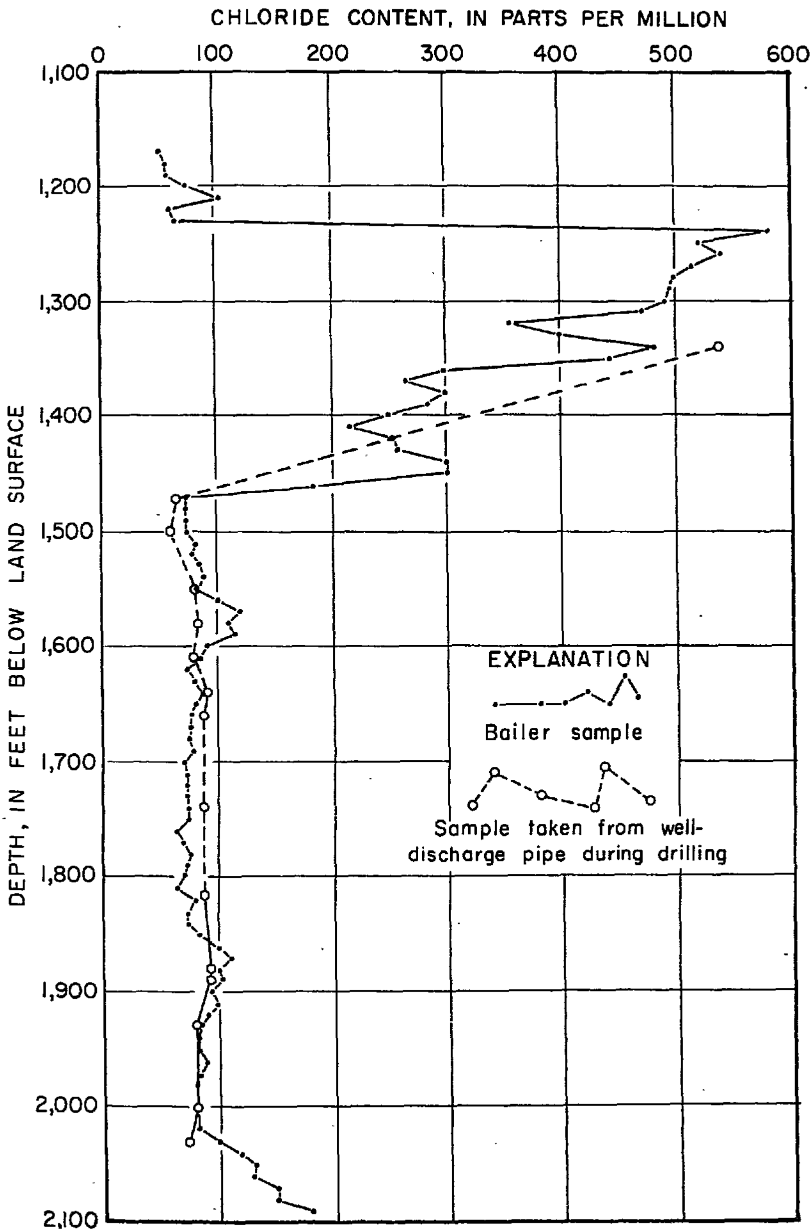


Figure 7. Graph showing the chloride content of water sampled at different depths in well 041-127-2.



water is withdrawn from the artesian aquifer, it is likely that increasing amounts of salty water may move into the fresh-water zones and make them unsuitable for domestic or industrial use.

CONCLUSIONS

The following conclusions can be made as a result of this reconnaissance.

The principal source of water in the Fernandina area is permeable limestone of Eocene age whose top was found to be 550 feet below land surface in well 038-127-4. These limestones are overlain by the Hawthorn formation of middle Miocene age which consists of beds of clay containing dolomite, limestone, and sand lenses. The Hawthorn formation is overlain by undifferentiated deposits of marl, sand, and shell of undetermined age. The impermeable beds in the Hawthorn formation and post-Hawthorn deposits confine artesian water in the underlying limestones of Eocene age. Sand and alluvium of Pleistocene and Recent age cover the surface of the area.

The piezometric surface has declined in the Fernandina area because of withdrawals of artesian water by municipal and industrial wells. Between 1946 and 1959 the piezometric surface declined about 10 to 20 feet and the area in which the piezometric surface was at or below mean sea level approximately tripled. Water-level records show that in the discharge area the artesian pressure has declined more than 50 feet since 1939 and commonly fluctuations of more than 10 feet occur in response to variations in discharge of industrial and municipal wells.

The chloride content of water from wells in the artesian aquifer generally increases with depth. In 1959, the chloride content of water from wells less than 1,400 feet deep ranged from 26 to 41 ppm and in wells more than 1,400 feet deep ranged from 50 to 1,060 ppm.

Recently there has been a general increase in the chloride content of water from artesian wells. In wells less than 1,400 feet deep this increase has been small, averaging less than 10 ppm since 1940. In wells more than 1,400 feet deep this increase has been much greater, ranging from 20 to 640 ppm since 1952.

The higher chloride content of water from deeper wells indicates that salty water is entering the fresh-water zone from mineralized zones in the lower part of the aquifer. It is possible that deep wells penetrating relatively impermeable beds in the lower part of the aquifer will allow salty water to move up into the fresh-water zones at a fast rate. A relatively salty zone within the fresh-water zone was found during the construction of well 041-127-2.

Most water samples collected did not indicate sufficient saline content to endanger municipal or industrial supplies. However, the increase in chloride content of water from wells in the past years shows that salty water is gradually contaminating the fresh-water supplies. If this trend continues the water from the artesian aquifer in the Fernandina area could become progressively saltier than at present. It is then conceivable that at some future date it may become unsuitable for domestic and industrial use.

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