LITHOSTRATIGRAPHIC AND HYDROSTRATIGRAPHIC CROSS SECTIONS THROUGH LEVY-MARION TO PASCO COUNTIES, SOUTHWEST FLORIDA

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By

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INTRODUCTION

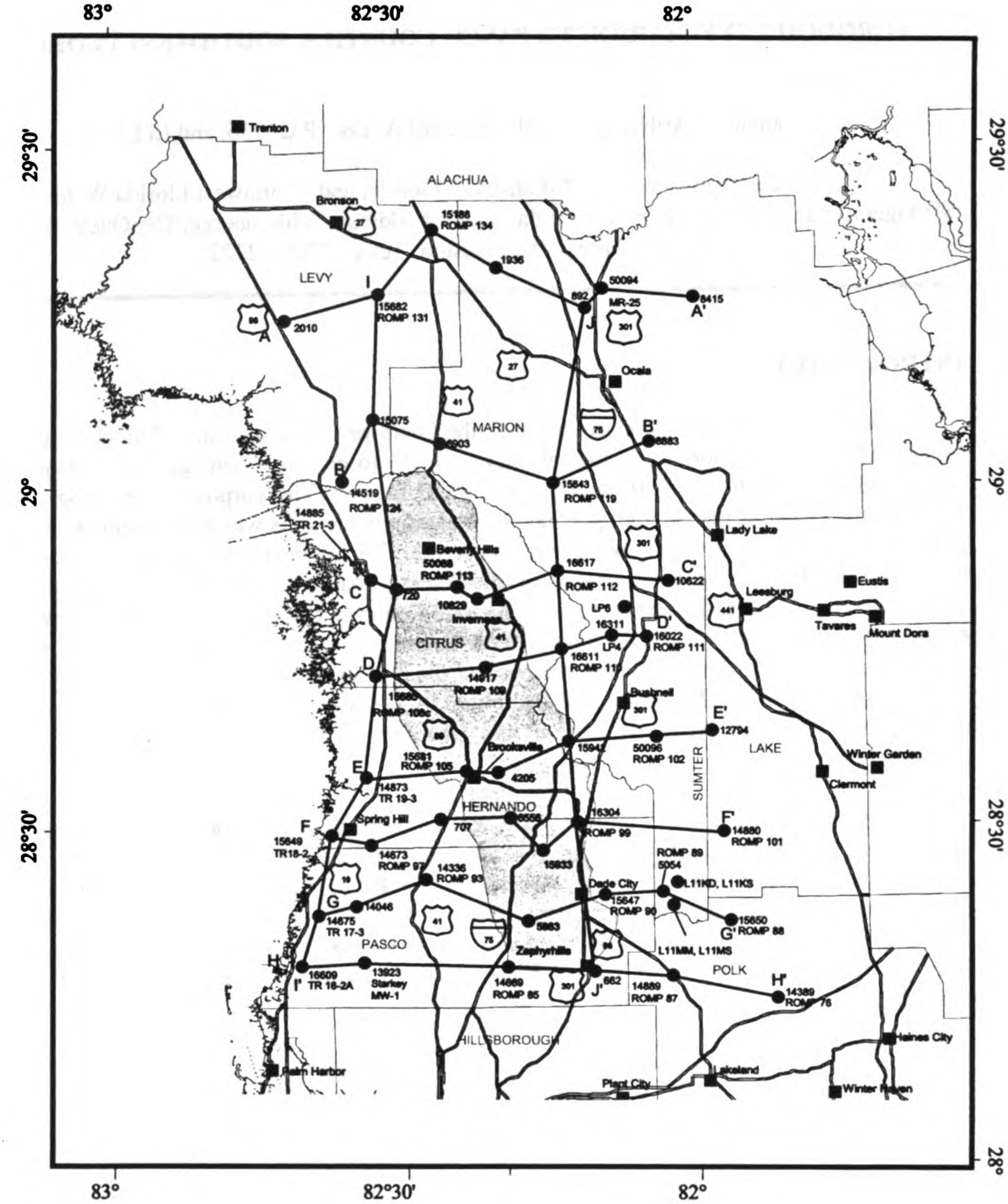
A cooperative program exists between the Southwest Florida Water Management District (SWFWMD) and the Florida Geological Survey (FGS) to construct geologic and hydrogeologic cross sections throughout the 16 county SWFWMD region. The purpose of the program is to delineate the extent of lithostratigraphic and hydrostratigraphic units within the region to aid in the management and protection of ground-water resources. To systematically accomplish these goals, the project is subdivided into four phases (or study areas): Phase I includes the southwest part of the District, from Pinellas and Hillsborough to Charlotte Counties; Phase II includes the northwest part of the District, from Levy and Marion to Pasco Counties (this study); and Phase III (Arthur and others, in review) includes the southeastern part of the District, encompassing all areas not covered in Phases I and II. Phase I is subdivided into Phase IA (Hillsborough and Pinellas Counties; Green and others, 1995) and Phase IB (Arthur and others, in review; Manatee, Sarasota, Charlotte Counties).

Interim reports on each project phase will be released as FGS Open File Reports (OFR). The present report (Phase II) includes the following counties: Levy, Marion, Citrus, Sumter, Hernando, Pasco and Polk. Similar reports for the Phase IB and Phase III regions are in preparation. Eight west-east cross sections and two north-south cross sections through the study area are presented in this report. The west-east cross sections spanning this region extend inland from the coast an average of 48 miles. Figure 1 shows locations for cross sections in Plates 1 through 10.

Each cross-section characterizes regional lithostratigraphy of Eocene through Pliocene formations, formation-specific gamma-ray log responses, and aquifer-system delineation within each study area. Most of the data used to construct the cross sections were taken from wells drilled as part of the SWFWMD Regional Observation and Monitor-Well Program (ROMP; Gomberg, 1975). In areas where ROMP data were not available, borehole data from the FGS and the United States Geological Survey (USGS) were utilized.

CROSS SECTION CONSTRUCTION

Detailed lithologic descriptions, gamma-ray logs and hydrologic data comprise the bulk of the information used to develop the cross sections shown in Plates 1 through 10. The dominant sources of information for cross-section control are SWFWMD ROMP wells; FGS wells are included to fill in appropriate data-point coverage for the cross sections. Where no lithologic data is available, borehole geophysical logs are used. Of these geophysical logs, gamma-ray logs are the most readily available and useful for correlative purposes within the study area. Gamma-ray logs



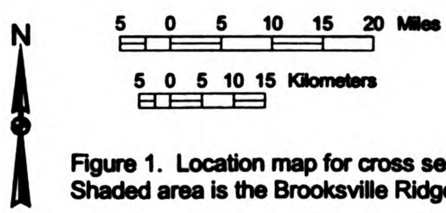


Figure 1. Location map for cross sections in Plates 1 through 10. Shaded area is the Brooksville Ridge (after White, 1970)

are included in the cross sections to allow comparison of the gamma-ray signatures relative to each stratigraphic unit. The following discussion outlines the methods used for construction of the cross sections for this study.

Topography

Topographic profiles are included on each cross section to facilitate comparison of surface relief with subsurface stratigraphy. Data used to construct these profiles were taken from U.S. Geological Survey 1:24,000 (7.5 minute) quadrangle maps. Land surface profiles are plotted above the cross sections, along with selected roads, cultural boundaries and landforms.

Lithology

For each well in a cross section, a stratigraphic column is used to represent borehole lithology. The column is based on either existing descriptions or new descriptions generated for this report. Hatching patterns depict primary lithologies in the columns, with accessory minerals shown on the right of the columns as text codes. Each cross section contains a legend that lists definitions of mineralogic and lithologic codes and patterns. Accessory-mineral codes are generally the same as those used in the FGS lithologic database (the Well Log Data System; GeoSys, Inc., 1992). If accessory sand-sized mineral percentages are available from the lithologic descriptions, a stippled sand pattern is used to denote greater than five percent quartz + phosphate. If the amount of accessory sand-sized minerals is less than five percent or if the amount is not known based on existing descriptions, the accessories are listed in the text codes. If the relative abundance of accessory minerals is known, the mineral text codes are listed in decreasing order of abundance.

Table 1 provides information on borehole location and sample type (e.g., cores, cuttings or both) available for this study. In general, more detailed lithologic descriptions exist for cores.

Minimum bed thicknesses represented on the stratigraphic columns are five feet due to graphical constraints. There are several examples where lithologies and accessory minerals have been averaged over a five to 10 foot interval to accommodate this graphical limitation. Detailed lithologic descriptions for all wells used in this study are available from the Florida Geological Survey (www.myflorida.com/environment/downloads/geology/index.html) or the Southwest Florida Water Management District.

Gamma-ray logs

Gamma-ray logs, when available, are plotted to the right of stratigraphic columns on the cross sections. These logs are used as a supplement to delineate formation boundaries and allow comparison of gamma-ray activity between the various lithostratigraphic and hydrostratigraphic units. The intensity units shown on the logs (horizontal axis) are in counts per second (CPS). Due to inconsistency between logs with respect to different logging-parameter settings and borehole characteristics (e.g., depth of casing and lack of caliper logs to determine wash-out of poorly consolidated units), quantitative comparison of the logs shown in Plates 1 through 10 is not possible. On the other hand, the logs are very useful for identifying correlative "packages" of gamma-ray peaks between wells and for comparing gamma-ray signatures between formations. Relatively high gamma-ray activity is generally correlative with phosphate, organics, heavy minerals and high-potassium clays. More subtle changes often reflect dolomite and accessory mineral content.

Table 1. Borehole data on all wells used in study. (1) Well ID is FGS "W" number; (2) Section quarters are coded as A= NW 1/4, B= NE 1/4, C= SW 1/4, D= SE 1/4;
(3) TD - total depth, BLS - below land surface (in feet), (4) NGVD - National Geodetic Vertical Datum of 1929 (in feet); (5) N/A - Not applicable; DMS - degrees, minutes, seconds.

WELL ID (1)	SITE NAME	COUNTY	TOWNSHIP, RANGE, SECTION (2)	LATITUDE (DMS)	LONGITUDE (DMS)	TD (BLS) (3)	ELEVATION (NGVD) (4)	GAMMA RAY LOG	SAMPLE	DESCRIPTION BY:
A-A'										
2010		LEVY	T14S R16E S05 BC	29 17 30	82 43 58	2173	17	NO	CUTTINGS	N. COOK
15682	ROMP 131	LEVY	T13S R17E S25 BB	29 20 03	82 33 26	354	72	YES	CORE	G. HENDERSON
15188	ROMP 134	LEVY	T12S R19E S19 AA	29 26 15	82 27 26	1185	65	NO	CUTTINGS	M. ENRIGHT
1936		MARION	T13S R20E S05 C	29 22 31	82 20 14	260	142	NO	CORE	M. SHAFIE
892		MARION	T13S R21E S35	29 18 44	82 10 36	400	91	NO	CUTTINGS	D. MACKENZIE
50094	MR-25	MARION	T13S R22E S19 DD	29 20 25	82 06 24	222	92	YES	N/A	N/A
8415		MARION	T13S R23E S26 CC	29 19 34	81 58 15	145	74	NO	CORE	D. MACKENZIE
B-B'										
14519	ROMP 124	LEVY	T17S R16E S06	29 02 00	82 43 25	254	5	YES	CORE	K. PREEDOM
15075		LEVY	T15S R17E S34 DD	29 07 45	82 34 15	965	73	NO	CUTTINGS	M. ENRIGHT
6903		MARION	T16S R18E S13	29 05 17	82 26 40	442	85	NO	CORE	B. REIK
15643	ROMP 119	MARION	T17S R21E S08 AC	29 01 28	82 14 02	500	76	YES	CUTTINGS	J. DECKER
8883		MARION	T16S R22E S24 BB	29 05 25	82 03 20	522	83	NO	CUTTINGS	R. GREEN
C-C'										
14885	TR 21-3	CITRUS	T18S R17E S34	28 52 30	82 34 19	370	10	YES	CORE	K. CAMPBELL
720		CITRUS	T19S R18E S06	28 51 07	82 31 51	300	170	NO	CUTTINGS	R. GODWIN
50088	ROMP 113	CITRUS	T19S R19E S09	28 51 21	82 24 54	182	132	YES	CUTTINGS	J. CLAYTON
10829		CITRUS	T19S R19E S14	28 50 10	82 22 41	274	76	NO	CUTTINGS	R. GREEN
16617	ROMP 112	SUMTER	T18S R21E S32 DA	28 52 50	82 13 41	704	54	YES	N/A	N/A
10622		SUMTER	T19S R23E S05 D	28 51 41	82 01 30	700	65	NO	CUTTINGS	R. GODWIN
D-D'										
15685	ROMP 108C	CITRUS	T20S R17E S26 DD	28 42 45	82 34 03	284.5	9	NO	CORE	G. HENDERSON
14917	ROMP 109	CITRUS	T20S R19E S24 DB	28 43 30	82 21 54	260	158	NO	CUTTINGS	G. HENDERSON
16611	ROMP 110	CITRUS	T20S R21E S17 BB	28 45 13	82 13 12	564	51	YES	CORE	T. SEAL
16311	ROMP LP-4	SUMTER	T20S R22E S05 AD	28 46 31	82 07 42	260	52	YES	CORE	J. ARTHUR
16022	ROMP 111	SUMTER	T20S R22E S01 DC	28 46 17	82 03 50	204.5	57	YES	CORE	G. HENDERSON

Table 1. (Continued).

WELL ID (1)	SITE NAME	COUNTY	TOWNSHIP, RANGE, SECTION (2)	LATITUDE (DMS)	LONGITUDE (DMS)	TD (BLS) (3)	ELEVATION (NGVD) (4)	GAMMA RAY LOG	SAMPLE	DESCRIPTION BY:
E-E'										
14873	TR 19-3	HERNANDO	T22S R17E S22 CD	28 32 50	82 35 15	603.5	20	YES	CUTTINGS	G. STRASSER
15681	ROMP 105	HERNANDO	T22S R19E S21 DB	28 33 21	82 24 16	714	102	YES	CORE	T. GILBOY
4205		HERNANDO	T22S R20E S19 BC	28 33 16	82 20 40	444	128	NO	CUTTINGS	C. COLEMAN
15942		SUMTER	T22S R21E S04	28 36 13	82 12 58	300	64	NO	DRILLERS LOG	K. CAMPBELL
50096	ROMP 102	SUMTER	T22S R23E S06 BA	28 36 35	82 02 55	338	88	YES	N/A	N/A
12794		LAKE	T21S R24E S31 CB	28 37 03	81 56 38	350	125	NO	CUTTINGS	R. HOENSTINE
F-F'										
15649	TR18-2	HERNANDO	T23S R16E S25 CD	28 26 59	82 39 11	814	7	YES	CUTTINGS	G. NEW & J. DECKER
14673	ROMP 97	HERNANDO	T23S R17E S35 CC	28 26 06	82 34 57	419	30	YES	CORE	R. GREEN
707		HERNANDO	T23S R19E S18	28 28 53	82 26 58	340	70	NO	CUTTINGS	E. APPLIN
6556		HERNANDO	T23S R20E S17 DD	28 28 26	82 19 18	223	106	NO	CUTTINGS	C. COLEMAN
15933		PASCO	T24S R20E S01	28 25 46	81 15 42	399	301	YES	CORE	T. SCOTT
16304	ROMP 99	PASCO	T23S R21E S22 DC	28 27 56	82 11 47	534	85	YES	CUTTINGS	J. DECKER
14880	ROMP 101	LAKE	T23S R24E S29	28 27 17	81 55 31	374	101	YES	CORE	K. PREEDOM
G-G'										
14675	TR 17-3	PASCO	T25S R16E S11 BC	28 19 20	82 40 38	525	29	YES	CUTTINGS	G. STRASSER
14046		PASCO	T25S R17E S04	28 20 20	82 36 30	515	35	NO	CUTTINGS	R. GREEN
14336	ROMP 93	PASCO	T24S R18E S23	28 22 53	82 28 45	700	78	YES	CUTTINGS	R. GREEN
5863		PASCO	T25S R20E S15 CD	28 18 37	82 17 28	640	112	NO	CUTTINGS	C. COLEMAN
15647	ROMP 90	PASCO	T24S R22E S31 BB	28 21 37	82 08 32	665	75	YES	CUTTINGS	J. DECKER
5054	ROMP 89	SUMTER	T24S R23E S31 AA	28 21 26	82 02 25	143	97	YES	CORE	K. CAMPBELL
15650	ROMP 88	POLK	T25S R24E S16	28 18 30	81 54 50	385	108	YES	CORE	G. HENDERSON
H-H'										
16609	TR 16-2A	PASCO	T26S R16E S09 DA	28 15 18	82 42 43	549	35	YES	CORE	D. DEWITT
13923	STARKEY MW1	PASCO	T26S R17E S03 DC	28 14 47	82 35 41	905	47	YES	CUTTINGS	R. GREEN
14669	ROMP 85	PASCO	T26S R20E S08	28 14 25	82 19 25	450	108	YES	CUTTINGS	K. PREEDOM
662		PASCO	T26S R21E S13 AA	28 13 45	82 10 10	330	81	YES	CUTTINGS	R. GREEN
14889	ROMP 87	POLK	T26S R23E S17 D	28 13 12	82 01 16	380	110	YES	CUTTINGS	G. HENDERSON
14389	ROMP 76	POLK	T26S R25E S32	28 10 52	81 49 50	315	135	YES	CUTTINGS	UNKNOWN GEOLOGIST

Table 1. (Continued).

WELL ID (1)	SITE NAME	COUNTY	TOWNSHIP, RANGE, SECTION (2)	LATITUDE (DMS)	LONGITUDE (DMS)	TD (BLS) (3)	ELEVATION (NGVD) (4)	GAMMA RAY LOG	SAMPLE	DESCRIPTION BY:
I-I'										
15682	ROMP 131	LEVY	T13S R17E S25 BB	29 20 03	82 33 26	354	72	YES	CORE	G. HENDERSON
15075		LEVY	T15S R17E S34 DD	29 07 45	82 34 15	950	73	NO	CUTTINGS	M. ENRIGHT
720		CITRUS	T19S R18E S06	28 51 07	82 31 51	300	170	NO	CUTTINGS	R. GODWIN
15685	ROMP 106C	CITRUS	T20S R17E S26 DD	28 42 45	82 34 03	284.5	9	NO	CORE	G. HENDERSON
14873	TR 19-3	HERNANDO	T22S R17E 22 CD	28 32 50	82 35 15	603.5	20	YES	CUTTINGS	G. STRASSER
15649	TR 18-2	HERNANDO	T23S R16E S25 CD	28 26 59	82 39 11	814	7	YES	CUTTINGS	G. NEW & J. DECKER
14675	TR 17-3	PASCO	T25S R16E S11 BC	28 19 20	82 40 38	525	29	YES	CUTTINGS	G. STRASSER
16609	TR 16-2A	PASCO	T26S R16E S09 DA	28 15 18	82 42 43	549	35	YES	CORE	D. DEWITT
J-J'										
892		MARION	T13S R21E S35	29 18 44	82 10 36	400	91	NO	CUTTINGS	D. MACKENZIE
15643	ROMP 119	MARION	T17S R21E S08 AC	29 01 33	82 14 09	500	73	YES	CUTTINGS	J. DECKER
16617	ROMP 112	SUMTER	T18S R21E S32 DA	28 52 50	82 13 41	704	54	YES	CORE	J. ARTHUR
16611	ROMP 110	CITRUS	T20S R21E S17 BB	28 45 13	82 13 12	564	51	YES	CORE	T. SEAL
15942		SUMTER	T22S R21E S04	28 36 13	82 12 58	300	64	NO	DRILLERS LOG	K. CAMPBELL
16304	ROMP 99	PASCO	T23S R21E S22 DC	28 27 56	82 11 47	534	85	YES	CUTTINGS	J. DECKER
662		PASCO	T26S R21E S13 AA	28 13 45	82 10 10	330	81	YES	CUTTINGS	R. GREEN

Delineation of boundaries

Formations

For the present study, all available borehole samples were inspected to determine formation boundaries. Gamma-ray logs and fossil assemblages are used only to supplement the lithologic data in the determination of the boundaries. Where uncertainty exists regarding the exact position of the formation boundary, or where the boundary is inferred within an interval of poor or no sample recovery, a dashed rather than solid line is shown on the cross sections (Plates 1 through 10). Dashed contacts are also drawn where only a gamma-ray log was used and no samples were available for inspection. In cases where sample quality is poor, as is sometimes true with cuttings, the gamma-ray logs become more important in the determination of formation boundaries.

Lithostratigraphic units shown on the cross sections include the Avon Park Formation through the Hawthorn Group (see **Lithostratigraphy**). On a regional basis, the post-Hawthorn Group units are components of the surficial aquifer system. For the purposes of this study, post-Hawthorn units are depicted as undifferentiated sand and clay (UDSC). Table 2 summarizes lithostratigraphic data for each well used in the study.

Aquifer systems

Delineated aquifer systems are shown on the cross sections (Plates 1 through 10) as hydrostratigraphic columns to the left of each lithologic column. Hatching patterns used in the hydrostratigraphic columns identify the three major aquifer systems present in the study area. Delineation of the aquifer systems are estimates based on the following: 1) available hydrogeologic data collected during drilling, 2) water-level differences in monitor-well clusters, 3) hydrogeologic characteristics of the samples (e.g., estimated porosity and permeability), and 4) correlation to lithostratigraphic units. A summary of aquifer-system intervals for wells utilized in the cross sections is given in Table 3. The **Hydrostratigraphy** section of this report describes hydrogeologic properties of aquifer systems present in the study area.

LITHOSTRATIGRAPHY

The deepest boreholes used in this study penetrate Middle Eocene lithostratigraphic units. Following is a discussion of lithologic characteristics of Eocene and younger units (Figure 2) and their general gamma-ray log characteristics, which are shown in the cross sections (Plates 1 through 10). Table 2 summarizes the tops of these units relative to National Geodetic Vertical Datum of 1929 (NGVD).

Eocene Series

Avon Park Formation

The Middle Eocene Avon Park Formation (Miller, 1986) locally crops out in southern Levy County and occurs in the subsurface throughout the study area. This unit varies from light gray to brown dolostone to cream to light-orange limestone with minor clay beds and dispersed organic laminations. Accessory minerals include chert, pyrite, and gypsum, with gypsum becoming more abundant with depth. Although the uppermost part of the Avon Park Formation within the study area varies between limestone and dolostone, dolostone predominates deeper within the unit,

Table 2. Upper boundaries of lithostratigraphic units delineated in cross-sections for this report; datum is NGVD, units are in feet. All estimated contacts are in parentheses, "--" indicates unit not present; "TD" - formation top is below total depth of well.

WELL ID	NAME	HAWTHORN GROUP (UNDIFF.)	TAMPA MEMBER (ARCADIA FM.)	SUWANNEE LIMESTONE	OCALA LIMESTONE	AVON PARK FORMATION
A-A'						
2010		--	--	--	--	-3
15682	ROMP 131	34	--	--	18	-75
15188	ROMP 134	--	--	--	62	-38
1936		--	--	--	93	(-67)
892		--	--	--	91	-74
50094	MR-25	--	--	--	(23)	(-83)
8415		--	--	--	-44	TD
B-B'						
14519	ROMP 124	--	--	--	-3	-25
15075		--	--	--	--	(-137)
6903		-2	--	--		-32
15643	ROMP 119		--	--	51	-24
8883		33	--	--	13	-107
C-C'						
14885	TR 21-3	--	--	--	(-26)	(-69)
720		--	--	--	80	-50
50088	ROMP 113	--	--	--	74	(-53)
10829		--	--	--		(-169)
16617	ROMP 112	--	--	--	34	-31
10622		--	--	--	-58	-118
D-D'						
15685	ROMP 108C	--	--	--	-6	-171
14917	ROMP 109	143	--	133	(103)	TD
16611	ROMP 110	--	--	--	32	(10)
16311	LP-4	--	--	--	(19)	(-2)
16022	ROMP 111	--	--	--	30	-82
E-E'						
14873	TR 19-3	--	--	--	(-45)	-275
15681	ROMP 105	--	--	84	18	-148
4205		--	--	(103)	38	-137
15942		--	--	--	(35)	-51
50096	ROMP 102		--	--	(41)	(-110)
12794		65	--	--	5	-135
F-F'						
15649	TR 18-2	--	--	2	-138	-278
14673	ROMP 97	--	--	(-1)	-116	-275
707		--	--	25	-35	-200
6556		--	--	76	-44	TD
15933		202	85	58	-42	TD
16304	ROMP 99	60	--	--	30	-105
14880	ROMP 101	--	--	--	(72)	7

Table 2. (Continued).

WELL ID	NAME	HAWTHORN GROUP (UNDIFF.)	TAMPA MEMBER (ARCADIA FM.)	SUWANNEE LIMESTONE	OCALA LIMESTONE	AVON PARK FORMATION
G-G'						
14675	TR 17-3	–	–	(-21)	-251	-426
14046		–	–	15	-135	-355
14336	ROMP 93	–	–	68	-112	-262
5863		–	–	62	-108	-248
15647	ROMP 90	–	–	(50)	40	-90
5054	ROMP 89	–	–	–	(73)	(-44)
15650	ROMP 88	–	–	–	98	-12
H-H'						
16609	TR 16-2A	–	0	-84	-285	-424
13923	STARKEY MW-1	–	32	22	-233	-413
14669	ROMP 85	–	48	-32	-187	-312
662		–	41	31	-94	TD
14889	ROMP 87	–	–	95	20	-145
14389	ROMP 76	95*	–	–	70	-150
I-I'						
15682	ROMP 131	34	–	–	18	-76
15075		–	–	–		(-137)
720		–	–	–	80	-50
15685	ROMP 106C	–	–	–	-6	-171
14873	TR 19-3	–	–	–	(-45)	-273
15649	TR 18-2	–	–	2	-138	-278
14675	TR 17-3	–	–	(-21)	-251	-426
16609	TR 16-2A	–	0	-84	-285	-424
J-J'						
892		–	–	–	90	-74
15643	ROMP 119	–	–	–	51	-24
16617	ROMP 112	–	–	–	34	-31
16611	ROMP 110	–	–	–	32	(10)
15942		–	–	–	(35)	-51
16304	ROMP 99	60	–	–	30	-105
662		–	41	31	-94	TD

*Peace River Formation of the Hawthorn Group.

Table 3. Estimated upper boundaries of aquifer-system units within the study area; datum is NGVD, units are in feet. "--" indicates unit not present, "N/A" - not applicable, well has gamma-ray log only.

WELL ID	NAME	SURFICIAL AQUIFER SYSTEM	INTERMEDIATE AQUIFER SYSTEM/CONFINING UNIT	FLORIDAN AQUIFER SYSTEM
A-A'				
2010		17	--	-3
15682	ROMP 131	72	34	18
15188	ROMP 134	--	--	62
1936		142	--	93
892		--	--	91
50094	MR-25	N/A	N/A	N/A
8415		74	--	-44
B-B'				
14519	ROMP 124	--	--	-3
15075		73	--	-137
6903		85	-2	-32
15643	ROMP 119	--	76	51
8883		83	33	13
C-C'				
14885	TR 21-3	10	--	-26
720		170	--	80
50068	ROMP 113	132	--	74
10829		76	--	-169
16617	ROMP 112	54	--	34
10622		65	--	-60
D-D'				
15685	ROMP 108C	--	--	-6
14917	ROMP 109	158	143	133
16611	ROMP 110	51	--	32
16311	LP-4	N/A	N/A	N/A
16022	ROMP 111	57	--	30
E-E'				
14873	TR 19-3	20	--	-45
15681	ROMP 105	102	--	84
4205		128	--	103
15942		64	--	35
50096	ROMP 102	N/A	N/A	N/A
12794		125	65	5
F-F'				
15649	TR 18-2	--	--	2
14673	ROMP 97	--	--	-1
707		70	--	25
6556		106	--	76
15933		301	202	58
16304	ROMP 99	85	60	30
14880	ROMP 101	101	--	72

Table 3. (Continued).

WELL ID	NAME	SURFICIAL AQUIFER SYSTEM	INTERMEDIATE AQUIFER SYSTEM/CONFINING UNIT	FLORIDAN AQUIFER SYSTEM
G-G'				
14675	TR 17-3	29	--	-21
14046		35	--	15
14336	ROMP 93	78	--	68
5863		112	--	62
15647	ROMP 90	75	--	50
5054	ROMP 89	N/A	N/A	N/A
15650	ROMP 88	108	--	98
H-H'				
16609	TR 16-2A	35	--	0
13923	STARKEY MW-1	47	--	32
14669	ROMP 85	108	--	48
662		81	--	41
14889	ROMP 87	110	--	95
14389	ROMP 76	135	95	70
I-I'				
15682	ROMP 131	72	34	18
15075		73	--	-137
720		170	--	80
15685	ROMP 108C	--	--	-6
14873	TR 19-3	20	--	-45
15649	TR 18-2	--	--	2
14675	TR 17-3	29	--	-21
16609	TR 16-2A	35	--	0
J-J'				
892		--	--	91
15643	ROMP 119	76	--	51
16617	ROMP 112	54	--	34
16611	ROMP 110	51	--	32
15942		64	--	35
16304	ROMP 99	85	61	30
662		81	--	41

System	Series	Lithostratigraphic unit		Hydrostratigraphic unit		Generalized lithology
Quaternary	Pleistocene	Undifferentiated sand, shell, and clay (UDSC)		Surficial Aquifer System (SAS)		Highly variable lithology ranging from unconsolidated sands to clay beds with trace amounts of shell fragments
Tertiary	Pliocene	Hawthorn Group	Peace River Formation	Intermediate Aquifer System Intermediate Confining Unit (IAS/ICU)		Peace River Formation contains interbedded sands clays and carbonates with siliciclastic component being dominant; variable phosphate sand content
	Miocene		Arcadia Formation; Tampa Member			Arcadia Formation is a fine-grained carbonate with low to moderate phosphate and quartz sand, variably dolomitic; Tampa Member is sandy, low phosphate wackestone
	Oligocene	Suwannee Limestone		Floridan Aquifer System	Upper Floridan Aquifer	Suwannee Limestone is a fine-to medium-grained packstone to grainstone with trace organics and variable dolomite and clay content
	Eocene	Ocala Limestone				Ocala Limestone is a chalky,very fine-to fine-grained wackestone/packstone varying with depth to a biogenic medium-to coarse-grained packstone grainstone; trace amounts of organic material, clay and variable amounts of dolomite
		Avon Park Formation				Avon Park is a fine-grained packstone with variable amounts of organic-rich laminations near top; limestone with dolostone interbeds typical in upper part, deeper beds are continuous dolostone with gypsum near base

Figure 2. Generalized lithostratigraphic and hydrostratigraphic column for the study area (Covington, 1993; Missimer and others, 1994; Scott and others, 1994; Wingard and others, 1994).

especially towards the south. Porosity in this formation is generally intergranular in the limestone section. Fracture porosity occurs in the more densely recrystallized dolostone, and intercrystalline porosity is characteristic of sucrosic textures. Pinpoint vugs and fossil molds are present to a lesser extent. The most diagnostic fossils include the foraminifers *Dictyoconus americanus* and *Coskinolina floridana*. The echinoid *Neolaganum (Peronella) dalli* is also common.

The Avon Park Formation is unconformably underlain by the Lower to Middle Eocene (Braunstein and others, 1988) Oldsmar Limestone. Miller (1986) reports the top of Early Eocene rocks (the approximate base of Avon Park Formation) at depths ranging from -1,100 feet to -1,850 feet NGVD. The Avon Park Formation varies in thickness across the study area, from 1,000 feet in Levy County to 1,500 feet in Pasco County (Miller, 1986). In the study area, the top of the formation ranges from approximately 10 feet above NGVD to a depth of -425 feet NGVD. Several units unconformably overly the Avon Park Formation, including the Ocala Limestone, the Hawthorn Group (undifferentiated) and undifferentiated sands and clays.

Gamma-ray log response for the Avon Park Formation is somewhat different from that of the overlying Ocala Limestone. In general, Avon Park lithologies give rise to a more variable signal with a slightly higher background count rate. This relative variability is primarily due to variations in dolomite or organic content. In many cases, high gamma-ray activity at the top of the Avon Park Formation is due to thin (<2 inches) layers of organic material.

Ocala Limestone

The Upper Eocene Ocala Limestone, first named by Dall and Harris (1892), consists of white to light-gray to light-orange limestone with a diverse fossil assemblage. More specifically, the lithology of this formation ranges from a variably chalky wackestone or packstone in the upper parts to a biogenic packstone to grainstone in the central and lower parts of the unit. Accessory constituents include organics, clay, dolomite and chert. Porosity is variable within this unit and is generally moldic and intergranular with occasional macrofossil molds. This formation contains characteristic fossils such as the foraminifers *Lepidocyclina* spp., *Nummulites* (*Operculinoides*) and echinoids such as *Eupatagus antillarum*. Other fossils observed in the unit include mollusks, bryozoans and corals.

The Ocala Limestone is typically bound by unconformities. Depths to the top of the formation range from land surface (W-892, for example; well-head elevation = +91 feet NGVD) to -285 feet NGVD (Plates 8 and 9). Subcrop extent of the Ocala Limestone includes the entire study area except for southeast Levy and southwest Marion Counties. Analysis of well cuttings and cores selected for this study indicates that the Ocala Limestone obtains a maximum thickness of 230 feet (W-14873). These maximum depths and thicknesses occur in regions on the flanks of the Ocala Platform, which trends south-southeast across the study area.

Gamma-ray logs for the Ocala Limestone consistently exhibit low gamma-ray activity (e.g., background-level count rates) and relatively fewer peaks than the overlying units. In some southern areas, (e.g., W-16609 and W-14669, Plate 8), the Ocala Limestone gamma-ray signature is "quiet" when compared to the underlying Avon Park Formation and the overlying Suwannee Limestone. In cases where the Ocala Limestone is dolomitized, the gamma-ray logs may exhibit a slightly higher and more sporadic signal. Many peaks in the gamma-ray logs correlate with the presence of organics.

Lower Oligocene Series

Suwannee Limestone

The Lower Oligocene Suwannee Limestone was first identified by Cooke and Mansfield, (1936). This unit ranges from a light-gray to yellowish-gray packstone to grainstone. These carbonates are variably moldic with trace amounts of sand and clay within the upper parts. Trace amounts of chert and organics occur throughout the unit. Fossils in the unit include mollusks, echinoids (primarily *Rhyncholampus gouldii*), abundant miliolids and other benthic foraminifers including *Dictyoconus cookei*.

This formation unconformably overlies the Ocala Limestone and is unconformably overlain either by Hawthorn Group units or UDSC sediments. In several areas within the southern part of the study area, the Suwannee Limestone is less than 20 feet below land surface. The maximum observed elevation for this unit is +132 feet NGVD (W-14917). This well, located in southern Citrus County (Plate 4) also marks the approximate northern limit of the Suwannee Limestone in the study area. Cross sections in this study indicate that this unit is present within southern Citrus, central Hernando and western and central Pasco Counties. W-14889 in northwest Polk County also encounters this unit. Although not observed in Sumter County wells, the Suwannee Limestone is reported to occur as exposed remnant boulders in Sumter County (Campbell, 1989). Elevation of the Suwannee Limestone ranges from -80 feet NGVD to +132 feet NGVD. The unit thickens to the south and west, ranging up to 255 feet thick (W-13923, Plate 8).

The Suwannee Limestone is characterized by gamma-ray activity that has an overall higher count rate than the underlying Ocala Limestone. In addition, there exists much more variability in its signature relative to the Ocala Limestone. This variability in the gamma-ray signature correlates with dolomite, clays and organics within the formation. Compared to gamma-ray activity in overlying Hawthorn Group sediments, the Suwannee Limestone signal is lower and less irregular.

Lower Oligocene to Pliocene Series

Hawthorn Group

Hawthorn Group sediments range in age from Lower Oligocene (Brewster-Wingard and others, 1997) to Lower Pliocene (Scott, 1988; Covington, 1993) and generally consist of phosphatic siliciclastics (sands, silts and clays) and carbonates. The Hawthorn Group in the study area consists of the Arcadia Formation and the Peace River Formation. The Tampa Member of the Arcadia Formation is also observed in wells in the study area. Hawthorn Group sediments lie unconformably above the Suwannee Limestone, Ocala Limestone or the Avon Park Formation in this region.

In the study area, the top of the Hawthorn Group ranges from approximately sea level to +200 feet NGVD, and ranges in thickness up to 145 feet. Wells used in this study generally encounter undifferentiated Hawthorn Group siliciclastics within two areas: the eastern edge of the study area (Plates 2, 5 and 6) and a prominent upland in the region, the Brooksville Ridge, which trends north-northwest through the center of the study area. Presence of Hawthorn Group sediments in many wells along the Brooksville Ridge indicates that this upland is underlain by an erosional remnant of the Hawthorn Group; two examples are W-6903 (Plate 2) and W-15933 (Plate 6).

Arcadia Formation (Tampa Member)

In the study area, all observed occurrences of the Arcadia Formation are part of the Tampa Member. The Upper Oligocene (Brewster-Wingard and others, 1997) to Lower Miocene Tampa Member of the Arcadia Formation is white to yellowish gray in color, and ranges from a wackestone to packstone with varying quartz sand and clay (Scott, 1988). Minor phosphate, dolomite and chert are also observed. Porosity of this unit is generally intergranular and moldic.

The top of the Tampa Member ranges from zero to +85 feet NGVD, and ranges in thickness up to 80 feet. The Tampa Member occurs beneath sediments of the UDSC and the Hawthorn Group (undifferentiated), and is underlain by the Suwannee Limestone. Plates 8 and 9 illustrate the northern limits of this unit, which pinches out in southern Hernando County beneath the Brooksville Ridge.

Tampa Member gamma-ray activity is variable. It is difficult to distinguish the Tampa Member from adjacent units in the section when the Tampa Member is thin (e.g., < 15 feet thick). Gamma-ray activity for thicker occurrences of the Tampa Member, however, can usually be distinguished from the underlying Suwannee Limestone – the Tampa Member has relatively higher, more variable count rates and more numerous gamma-ray peaks. Relative to the Hawthorn Group (undifferentiated), the Tampa Member gamma-ray response is generally lower and contains fewer peaks.

Peace River Formation

The Middle Miocene to Lower Pliocene (Scott, 1988; Covington, 1993) Peace River Formation is comprised of yellowish gray to olive gray, interbedded sands, clays and carbonates with the siliciclastic component being dominant (Scott, 1988). Variable amounts of phosphate sand and gravel, as well as minor carbonate beds, are interspersed throughout the unit. This formation was only encountered in one well (W-14389, Plate 8) located in the southeast part of the study area. The Peace River Formation is 25 feet thick in this well, which lies along the northern subcrop extent of the unit. Although not well represented in W-14389, the gamma-ray activity in the Peace River Formation is usually higher and contains one to three strong peaks. These characteristics readily allow distinction from most underlying units in the region, however, the log response may be difficult to distinguish from overlying undifferentiated sediments (see **Undifferentiated Sands and Clays**).

Post-Hawthorn Group

Undifferentiated Sands and Clays (USDC)

Post-Hawthorn Group sediments occur throughout the study area and range in thickness up to 125 feet (Plate 2). These undifferentiated sediments are primarily comprised of varying proportions of sand and clay. Unlike sediments further south in SWFWMD coastal counties, only one well (ROMP TR 17-3 [W-14675], Plate 7) contains shell fragments in this post-Hawthorn Group unit. The thickest sections of UDSC are found in cross sections B-B', C-C' and I-I' (Plates 2, 3 and 9) where borehole samples reveal probable infilling of karst features. These features, which are probably sinkholes, are included in the cross sections to represent karst that is characteristic of the northern part of the study area. Variable amounts of chert, organics and re-worked phosphate may occur in UDSC sediments.

Gamma-ray activity is variable in Post-Hawthorn Group sediments. Moderate to strong peaks are observed in some logs, reflecting concentrations of clay, organics, heavy minerals or reworked phosphorite. Sediments without these components have very low gamma-ray responses (W-16609, Plate 8). This variability limits the use of gamma-ray logs to help delineate UDSC sediments from underlying units.

HYDROSTRATIGRAPHY

Up to three aquifer systems comprise the hydrostratigraphic framework of the study area (Figure 2). Nomenclature used herein to describe these aquifer systems is based on recommendations of the Southeastern Geological Society (1986). The uppermost aquifer is usually the surficial aquifer system (SAS), however, it may be absent, leaving the Floridan aquifer system (FAS) exposed, or just below overlying unconsolidated, permeable surficial deposits. In the latter examples, the FAS is considered "unconfined." The intermediate aquifer system/intermediate confining unit (IAS/ICU), is discontinuous in the study area and functions more as a confining unit than an aquifer system in the region. Along the axis of the Brooksville Ridge, permeable zones locally exist within the IAS/ICU. The IAS/ICU lies between the SAS and the FAS.

The FAS occurs throughout the state and is often an artesian aquifer system. Artesian conditions may vary within parts of the study area according to seasonal rainfall. Flowing artesian conditions exist year-round along parts of coastal Pasco and Hernando Counties (Healy, 1974). Within the study area, the FAS is confined, semi-confined or unconfined, depending on the permeability of overlying deposits. Aquifer systems and geologic formations typically correlate with lithostratigraphic boundaries (Figure 2). The relation between lithostratigraphic and hydrostratigraphic units in the study area is evident in Plates 1 through 10.

Surficial Aquifer System (SAS)

The SAS correlates with Pliocene-Holocene unconsolidated siliciclastics referred to herein as undifferentiated sand and clay (UDSC) deposits (Plates 1 through 10). Surficial deposits may be missing, having been eroded away and exposing limestone at the surface (e.g., unconfined FAS). In contrast, these same deposits may exceed 100 feet thick where they infill karst features (including paleosinks represented by W-15075 and W-10829; Plates 2, 3 and 9). Depending on the composition of infilling sediments, the karst features may provide hydraulic connection between the SAS and the FAS. Moreover, discontinuous and variably sandy clay beds near the base of the SAS provide varying degrees of hydraulic separation from subjacent aquifer systems. As such, it is difficult to characterize large areas as either the SAS or unconfined FAS.

Delineation of the SAS is based not only on lithologic interpretation but also on water-level data. For example, ROMP 90 (W-15647) demonstrates a classic example of confinement between the SAS and the FAS. Water levels measured during drilling rose three feet when the basal clays of the SAS were fully penetrated and artesian conditions of the FAS took over.

Water levels in paired monitor wells provide valuable information regarding the presence of a SAS in the absence of an IAS/ICU. FAS water levels in ROMP 93 (W-14336, Plate 7), for example, are at least five feet lower than SAS water levels (US Geological Survey, 1990) indicating a well-defined hydraulic separation between the two aquifer systems. Hydrologic data from ROMP LP-6, located approximately two miles north of cross section D-D' (Figure 1) indicates that FAS water levels are typically more than one foot above the surficial water table. Twelve feet of clay and clayey sand provide sufficient confinement between the FAS and SAS at LP-6.

As noted above, effectiveness of the hydraulic separation between the SAS and the subjacent FAS varies locally. Water levels in the paired wells L11KD and L11KS (northeast of W-5054 in G-G'; Figure 1), are nearly indistinguishable, thus indicating poor to no confinement between the FAS and "water table" levels in surficial sediments (US Geological Survey, 1998). In local contrast, water levels from the monitor-well pair L11MM and L11MS (southeast of W-5054; Figure 1) confirm existence of an SAS because "water-table" elevations may be higher or lower than the FAS potentiometric surface due to seasonal fluctuations (US Geological Survey, 1998).

Depending on hydraulic conditions and the leakance of the basal SAS clays, the SAS may recharge the FAS and vice versa. Paired monitor wells with inconsistent trends in water levels suggest that there may be some degree of confinement of the FAS, either as low permeability horizons in the base of the SAS or in the uppermost carbonates of the FAS (e.g., mudstones/micrites or densely recrystallized zones). The different water levels may also represent a delayed seasonal recharge response between the SAS and the FAS, which would also indicate semi-confinement.

In summary, the extent of the SAS in this region is discontinuous due to site-specific hydrologic and lithologic conditions. In many cases, some degree of hydraulic connection between the SAS and the FAS exists. In moderate to poorly confined areas, (i.e., a "leaky" or discontinuous SAS) changes in the FAS potentiometric surface due to pumping may lower water-table elevations and therefore may affect lake and swamp water levels.

Intermediate Aquifer System/Intermediate Confining Unit (IAS/ICU)

The IAS/ICU includes all permeable or water-bearing units and all confining beds located beneath the SAS and above the FAS (Duerr and Enos, 1991). Sediments within the IAS/ICU in this region comprise erosional remnants of the Hawthorn Group, which at one time probably blanketed the region (Scott, 1988). These remnants function primarily as laterally discontinuous confining units. Where present, confining beds of the IAS/ICU generally promote artesian conditions within the FAS. Localized permeable zones exist within the IAS/ICU, especially along the axis of upland regions. One example located within the Brooksville Ridge, W-15933, contains relatively permeable sediments within the IAS/ICU. As shown in cross section C-C' (Plate 3), however, this is a geographically isolated occurrence.

The IAS/ICU sediments represented in the cross sections are comprised of interbedded siliciclastics of the Peace River Formation (W-14389, Plate 8), and the undifferentiated Hawthorn Group (W-15682, Plate 1; W-6903 and W-8883, Plate 2; W-12794, Plate 5; W-16304, Plate 6). In some areas (W-15933, Plate 6), the Tampa Member contains relatively higher amounts of clay and has a relatively lower permeability than the underlying Suwannee Limestone. Where these characteristics exist, the Tampa Member is not hydraulically well-connected to the FAS and is considered part of the IAS/ICU. Within the study area, the top of the ICU ranges from almost 200 feet above NGVD (W-15933, Plate 6) in Pasco County to just below NGVD (Plate 2, W-6903) in Marion County. Thickness of the ICU ranges from less than 10 feet (W-50088, Plate 3 and W-15650, Plate 7) to more than 140 feet (W-15933, Plate 6).

Floridan Aquifer System (FAS)

The FAS underlies all of Florida and parts of Georgia, Alabama and South Carolina. The FAS is divided into the "Upper" and "Lower Floridan Aquifer," generally separated by unnamed middle confining units (Miller, 1986, 1997). The upper FAS (i.e., "Upper Floridan Aquifer") supplies the region with potable water and varies from unconfined to confined, depending on the thickness and composition of the overlying sediments. The thickness of the upper FAS in the study area ranges from 600 feet to over 1400 feet (Wolansky and Garbode, 1981). The top of the FAS is typically considered the uppermost occurrence of vertically persistent permeable carbonates below the siliciclastics of the IAS/ICU or SAS. The highest elevation of the FAS based on wells presented in this report is 133 feet above NGVD. The lower extent of the upper FAS occurs within the lower Avon Park Formation, where vertically and laterally persistent evaporite minerals (gypsum and anhydrite) are present in the carbonate rocks (Ryder, 1985). These evaporites, which occur either as beds, vug fillings, or as intergranular minerals within the carbonate matrix, result in a significant decrease in permeability. Referred to as the "middle confining unit" of the FAS, these evaporites are of regional extent (Hickey, 1990). Wells included in this study generally do not extend into the middle confining unit or the lower FAS (i.e., "Lower Floridan Aquifer"). The top of the middle confining unit, however, may be represented by the gypsum observed in W-16611 and W-15649 (Plates 4, 6, 9 and 10) near the base of the Avon Park Formation.

In the study area, the upper FAS (Plates 1 through 10) typically consists of the Avon Park Formation, Ocala Limestone and Suwannee Limestone. Hydrogeologic data, however, suggest that in Pasco County (Plate 8) the Tampa Member is hydraulically connected to the FAS. For example, water levels measured at W-16609 (Plates 8 and 9) changed very little while coring through the Tampa Member into the Suwannee Limestone (DeWitt, 1990). Immediately south of the study area, in Hillsborough and Manatee Counties, the Tampa Member comprises the upper part of the FAS (Green and others, 1995).

Carbonates of the FAS occur at or near the surface in the north part of the study area and dip gently to the south-southeast. Confinement of the FAS in the northern region varies from confined to semi-confined (see **Surficial Aquifer System** section) to unconfined. Sediments overlying the FAS in the north part of the study area are primarily UDSC. Hydrologic data from wells in this region document the unconfined nature of the FAS. For example, water levels in FAS and shallow monitor wells at site ROMP LP-4 (W-16311, Plate 4) exhibit nearly identical elevations, suggesting that an unconfined FAS is present. Along the Brooksville Ridge and the eastern part of the study area, undifferentiated Hawthorn Group deposits comprise the IAS/ICU and provide increased confinement of the FAS. Karst features, such as sinkholes (and paleosinks) breach areas where clay deposits may otherwise have provided confinement of the underlying limestones (e.g., Plates 2, 3 and 9; Trommer, 1987).

In summary, the present study area is a region containing major stratigraphic changes due to erosion (including numerous karst features), non-deposition and re-worked sediments. As a result, determination of whether a particular well or area can be characterized as "unconfined FAS" or "SAS overlying FAS" is difficult. Aquifer system delineation can become more complicated when one takes into account the regional aspect of the definition of *aquifer system*, which states, in part, "... permeable and less permeable material that acts as a water-yielding hydraulic unit of regional extent" (Bates and Jackson, 1987). In the study area, the SAS and the IAS/ICU are not laterally continuous. For the purpose of this investigation we have delineated aquifer systems on the basis of local hydrogeologic characteristics and correlation with lithostratigraphy. This may be a topic worthy of further study or discussion as the hydrogeologic-unit definitions in Florida are refined and perhaps redefined.

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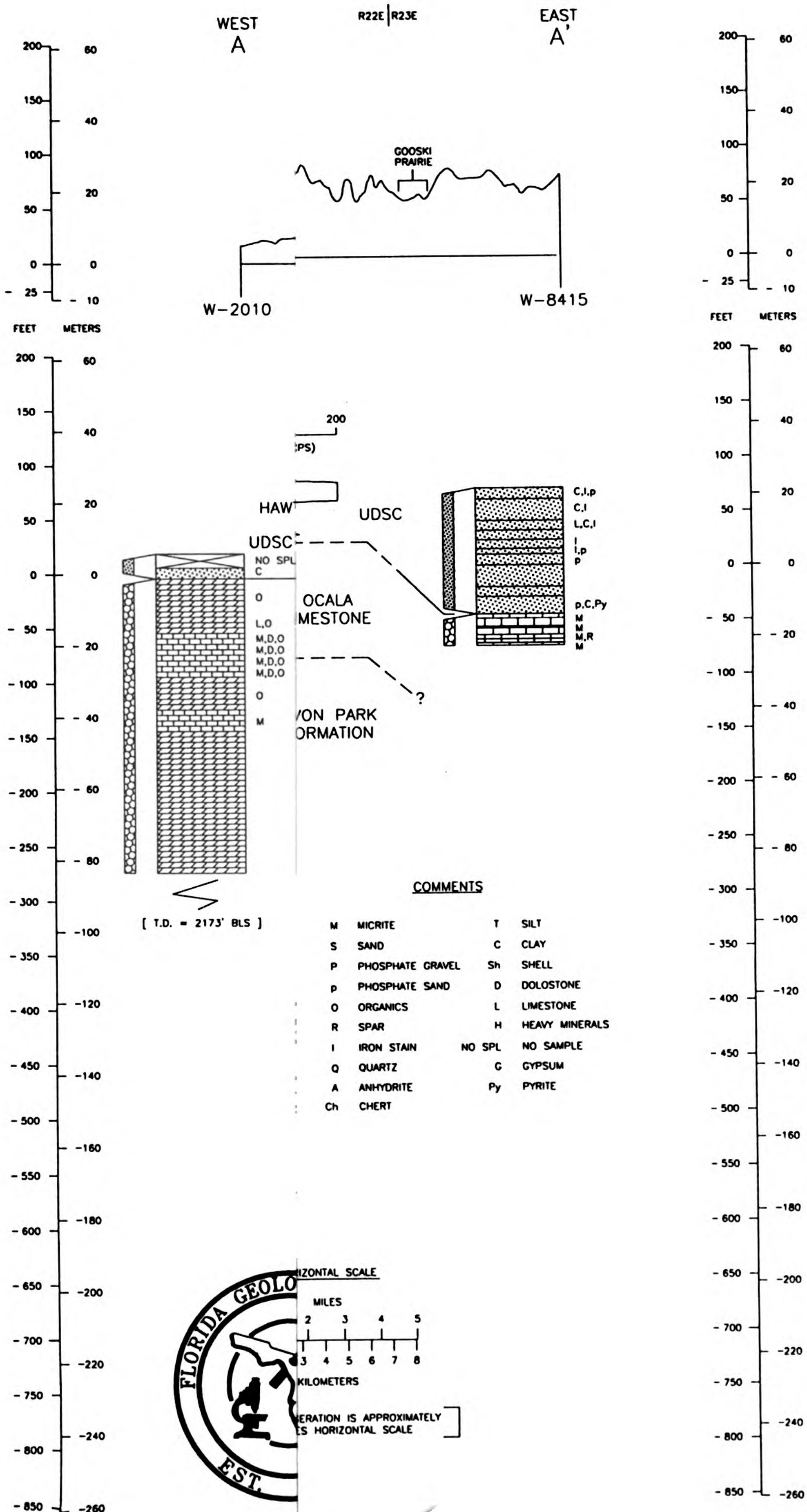
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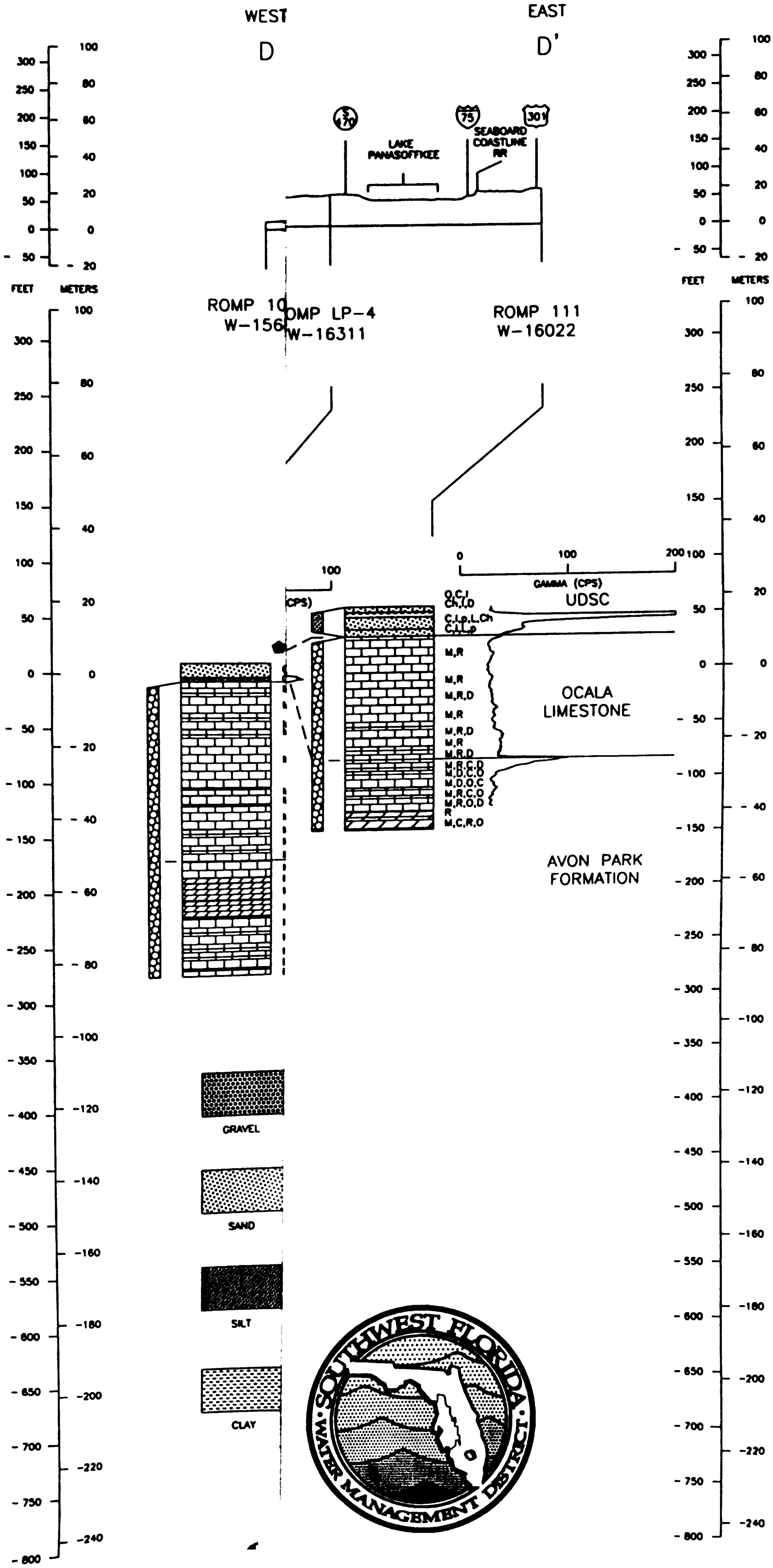
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LAKE PANASOFFKEE
SEABOARD COASTLINE RR
FEET
METERS
ROMP 10
W-156
OMP LP-4
W-16311
ROMP 111
W-16022
GAMMA (CPS)
(CPS)
UDSC
OCALA LIMESTONE
AVON PARK FORMATION
GRAVEL
SAND
SILT
CLAY
SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT

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