HAZEN AND SAWYER
Environmental Engineers & Scientists

Hazen and Sawyer, P.C.
2101 NW Corporate Blvd., Suite 301
Boca Raton FL 33431
OFFICE (561) 997-8070
FAX (561) 997-8159

MEMORANDUM DATE: June 15, 2007

FOR: Project Delivery Team

FROM: Albert Muniz / Hazen and Sawyer, P.C.

SUBJECT: Floridan Aquifer Test Wells and Conceptual Plan for the Peele-Dixie WTP

WELL COMPLETION

Construction of the Floridan Aquifer Test Wells began on March 12, 2007. To date, the drilling and testing has progressed in general accordance with the anticipated plan. This memorandum presents a brief summary of the drilling and testing conducted to date at Floridan Aquifer Test Well No. 1 (i.e., FAS-1). The information is being presented to assist in formulation of a basis for completion of the test wells. As originally designed, the test data from the first well will be used to select the final casing depth and the total depth of the wells.

Comments from PEER reviewers have been used as well as comments from internal professionals to determine suitable well completion. There are three critical factors which impact the final well design. These factors include water quality, yield, and consistency of water quality on a long-term basis. Optimizing water quality is essential to minimize treatment costs. Waters with elevated total dissolved solids (TDS) concentrations required additional energy to adequately treat the water. Hence, a maintaining total TDS below a threshold of approximately 8,000 mg/L is vital. A second parameter for consideration is well yield. Maximizing yield is important to minimize the number of wells needed to meet reliable raw water demands. The third and final component is to provide a design that minimizes the potential for deterioration of water quality due to up-coning and/or encroachment of more saline water. Saline water, which is water with a TDS concentration greater than 10,000 mg/L is present at a depth of approximately 1,630 feet below land surface in this area (Based on testing results from the Peele-Dixie Concentrate Disposal Well). The latter factor is difficult to assess as little data is available on the long-term use of upper Floridan Aquifer raw water supply wells. Although groundwater modeling will be used for predictive purposes and design of a Floridan Aquifer wellfield, questions related to the long-term consistency of the raw water supply will remain a concern. Operation of a Floridan Aquifer wellfield will hopefully assist in confirming performance of such a wellfield. A discussion of the criteria used in formulating a design decision is presented in the sections that follow.

FLOW HORIZONS

Identifying and quantifying the location of flow horizons was the first step in determining final well design. A suite of geophysical logs were run on the open borehole from the bottom of the 30-inch diameter casing to the total depth of the test hole. The logs have been reduced and summarized on one exhibit which is attached for reference. The 30-inch diameter (0.375-inch wall thickness) casing was set at the approximate interface of the Hawthorn Group and Upper Floridan Aquifer at 1,015 feet below land surface. Flow logs were conducted at a rate of 1,125 gpm to locate and quantify production zones. Results from the flow log analysis suggest that approximately 60% of the total flow occurs between the bottom of the 30-inch diameter casing at 1,015 feet and 1,060 feet (see modified Figure 2 attached). There is little flow contribution between 1,060 feet and 1,160 feet. The temperature log and flow log (percent flow) show that approximately 20% of the total flow occurs from an interval between 1,160 feet and 1,180 feet. Minor flow is seen from 1,180 feet to 1,300 feet. A gradual contribution of flow is then seen from 1,300 feet to the total depth at 1,500 feet. Based on the flow log, it appears that approximately 80% of the flow occurs between depths of 1,015 and 1,202 feet below land surface.

Copies of the flow log analysis, geologic log, and the other geophysical logs for FAS-1 were evaluated to assist in identifying the main production horizons encountered at FAS-1. Additional analyses were then performed to further confirm the specific capacity of productive horizons and water quality with respect to depth.

PACKER TESTS

Several intervals were identified for further evaluation using the data collected during geophysical logging, including the flow log analysis. Intervals selected for testing were as follow:

- ✓ 1,015 to 1,060 feet
- ✓ 1,060 to 1,160 feet
- ✓ 1,160 to 1,202 feet
- ✓ 1,202 to 1,300 feet
- ✓ 1,300 to 1,500 feet
- ✓ 1,015 to 1,202 feet
- ✓ 1,015 to 1,500 feet

Specific capacity and water quality data collected during these tests is attached. A summary of the key data and selected water quality is presented in Table 1 below:

TABLE 1 – Summary of Testing

Interval	**Thickness**	**Specific Capacity**	**Flowrate**	**Water Quality**	
	(feet)	(gpm / ft)	(gpm)	TDS (mg/L)	Chloride (mg/L)
1,015' – 1,060'	45	15.5	212	4,520	1,720
1,060' – 1,160'	100	2.3	78	5,520	3,070
1,160' – 1,202'	42	18.4	79	5,340	3,000
1,202' – 1,300'	98	2.0	78	6,340	2,470 ?

1,300' – 1,500'	200	10.0	150	6,930	2,550 ?
1,015' – 1,202'	185	16.9	215	N / A	N / A
1,015' – 1,500'	485	24.7	240	5,120	999 ?

The results of the packer testing confirm the preliminary hydraulic data indicated by the flow log and provided depth specific water quality information. Flow zones were confirmed to have higher specific capacities than the low flow zones as anticipated. The horizon from 1,015' – 1,060' had a specific capacity of 15.5 gpm/ft at a flow rate of 212 gpm. The interval from 1,160' – 1,202' had a specific capacity of 18.4 gpm/ft at a flow rate of 79 gpm. Both of these zones had significantly higher specific capacities when compared to the low production zones (i.e., 1,060' – 1,160' and 1,202' – 1,300'). The lower production zone (1,300' – 1,500') had a specific capacity of 10.0 gpm/ft at a rate of 150 gpm.

Testing was also conducted on potential combination of production horizons for comparison and evaluation with emphasis on yield, water quality, and potential of up-coning. One test was designed to maximize both water quality and yield, and to minimize the potential for upcoming of saline water. This test was conducted over a horizon between 1,015' – 1,202'. The test revealed a specific capacity of 16.9 gpm/ft at a flow rate of 215 gpm, which is considered good when compared to the other values.

A test was also conducted for the horizon from 1,015' – 1,500' feet to evaluate the maximum yield option. As anticipated, since this horizon utilizes the largest open-hole section, the horizon produced the highest yield with a specific capacity of 24.7 gpm/ft at a flow rate of 240 gpm. A concern related to this option is proximity to seawater as the 10,000 mg/L TDS interfaces occurs at a depth of approximately 1,603 feet below land surface in this area.

WATER QUALITY

In addition to hydraulic data, water quality information was obtained to assess changes with respect to depth. The specific horizons tested show a gradual deterioration of water quality with TDS concentrations varying from 4,520 mg/L to 6,930 mg/L. Testing of multiple zones indicated TDS concentrations of ___ mg/L for the interval from 1,015' – 1,202', and 5,120 mg/L for the interval from 1,015' – 1,500'. The value for the latter zone may be a little misleading since the potential for up-coning is significantly higher with this option. A summary of key water quality parameters is included in Table 2 (attached).

CONCLUSIONS

The purpose of the detailed testing of the upper Floridan Aquifer is to confirm hydrogeologic characteristics. Geophysical logs, packer testing, and water sampling was conducted as part of the evaluation. Data collected suggest the following:

- Three production zones were identified between 1,015' and 1,500'
  - √ Zone 1 1,015' – 1,060'
  - √ Zone 2 1,160' – 1,202'

    - √ Zone 3 1,300' – 1,500'
- Water quality was declined with depth for the three production zones (TDS varied from 4,520 mg/L, 5,340 mg/L, and 6,930 mg/L, for Zones 1, 2 and 3, respectively)
- Two composite zones were tested to assess maximization of yield
    - √ Zone A 1,015' – 1,202'
    - √ Zone B 1,015' – 1,500'
- Both Zone A and B showed improved yield over individual horizons (i.e., Zone 1, 2, or 3)
- Water quality for Zone A was good (TDS = ___ mg/L)
- Water quality for Zone B was fair (TDS = 5,120 mg/L)
- Zone A provides a separation of <u>428 feet</u> from the 10,000 mg/L TDS interface
- Zone B provides a separation of <u>130 feet</u> from the 10,000 mg/L TDS interface

RECOMMENDATIONS

The City of Fort Lauderdale test well program is designed to gather information for use in designing, including groundwater modeling, a Floridan Aquifer wellfield. Hydrogeologic information was collected and evaluated to select a design that balances maximization of yield and water quality while minimizing the potential for deterioration of water quality due to up-coning and/or encroachment. Saline water occurs at depths of approximately 1,630 feet below land surface in this area. Based on the information collected to date, the following design is suggested:

1. Set final casings (i.e., FRP) to a depth of approximately 1,015 feet below land surface
2. Complete the Floridan Aquifer test production wells to a depth of 1,200 feet below land surface
3. Plug back FAS-1 to a depth of 1,200 feet below land surface

The above design will provide a reasonable yield and good water quality. The design will also provide good separation between the production horizon and saline water. Additional testing including an aquifer performance test and groundwater modeling will need to be performed. Long-term performance of a Floridan Aquifer wellfield cannot be known until long-term operational history is obtained and assessed.

Distribution:

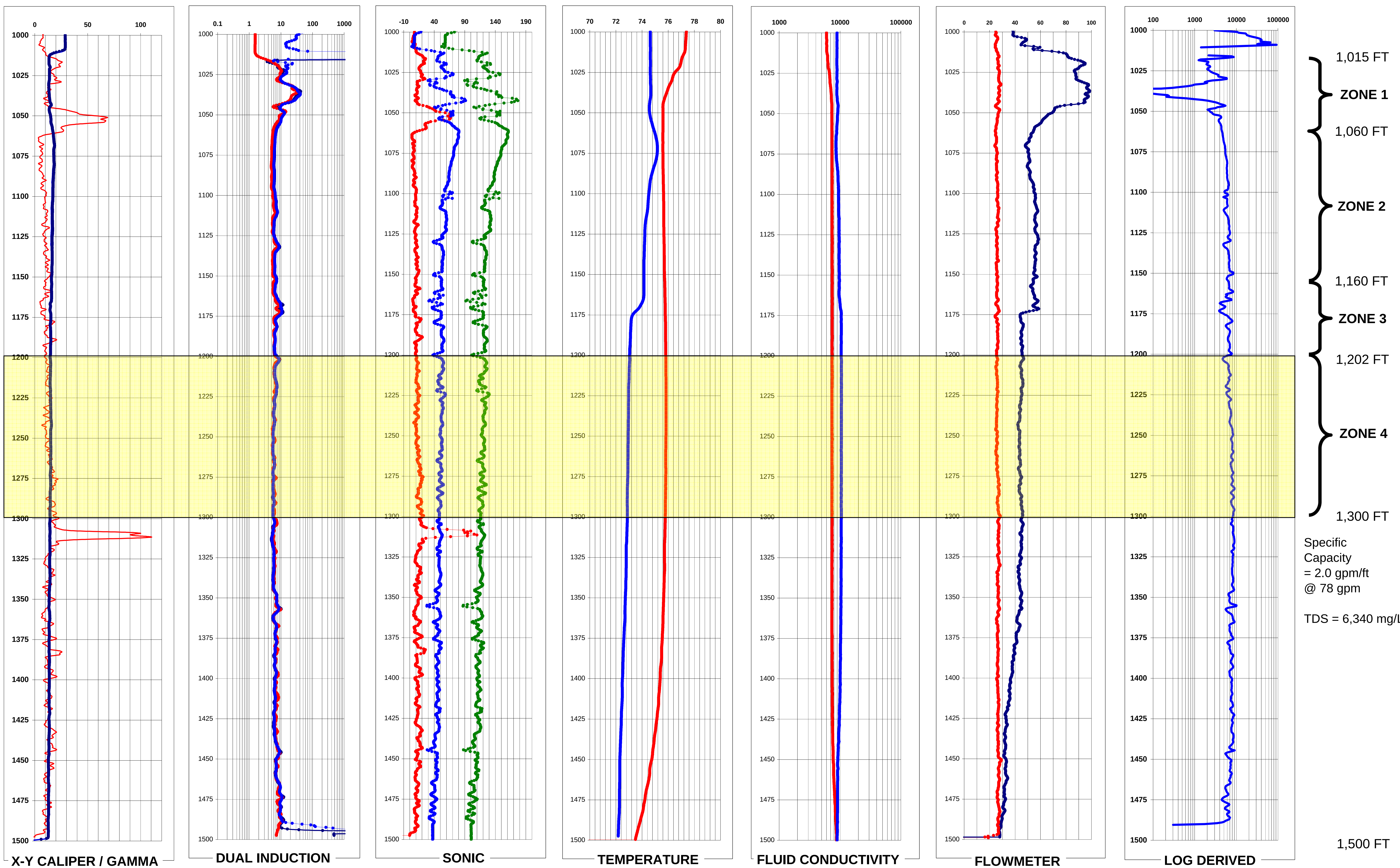
Maurice Tobon / City of Fort Lauderdale	Ed McCullers / Youngquist Brothers
Greg Duty / City of Fort Lauderdale	Craig Brugger / Youngquist Brothers
Rick Johnson / City of Fort Lauderdale	Kevin Greuel / Youngquist Brothers
John Largey / Hazen and Sawyer	Clay Ferguson / Youngquist Brothers
Pat Davis / Hazen and Sawyer	Albert Muniz / Hazen and Sawyer
George Brown / Hazen and Sawyer	Jim Wheatley / WTA
Steve Lamb / MacVicar Federico & Lamb	Geoff Hart / Hazen and Sawyer

CITY OF FORT LAUDERDALE - Floridan Aquifer Test Wells and Conceptual Plan for the Peele-Dixie WTP

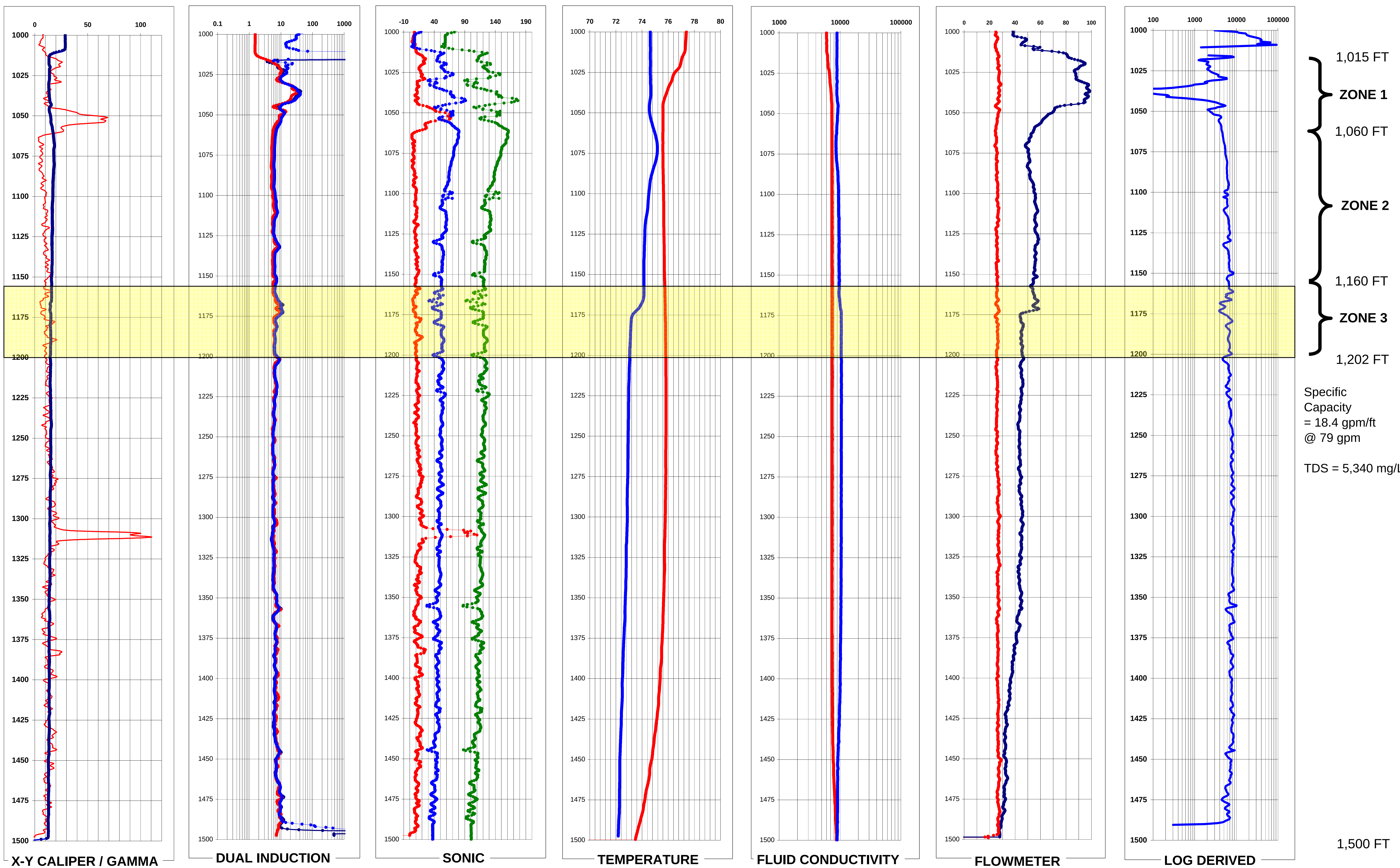
WATER QUALITY SUMMARY

PARAMETER	UNITS	INTERVAL 1,015 to 1,060	INTERVAL 1,060 to 1,160	INTERVAL 1,160 to 1,202	INTERVAL 1,202 to 1,300	INTERVAL 1,300 to 1,500	INTERVAL 1,015 to 1,202	INTERVAL 1,015 to 1,500
Ammonia	mg/L	0.999	0.664	0.547	1.07	1.13		1.10
Chloride	mg/L	1,720	3,070	3,000	2,470	2,550		999
Conductivity	(µmhos/cm)	7,900	9,330	8,980	10,800	11,500		8,800
Nitrogen, Total Kjeldahl (TKN)	mg/L	0.654	2.73	1.18	1.19	1.04		1.01
Total Dissolved Solids (TDS)	mg/L	4,520	5,520	5,340	6,340	6,930		5,120
Sulfate	mg/L	375	589	584	478	470		293
Sulfide	mg/L	0.028	0.031	0.025	0.040	0.043		0.033
Barium	mg/L	0.29	0.04	0.03	0.02	1.47		17.0
Strontium	mg/L	9.35	12.5	12.4	11.3	13.7		10.6
Alkalinity	mg/L	118	122	124	114	114		116
Flouride	mg/L	1.11	0.789	0.909	1.23	1.12		1.26
Hardness (as Calcium)	mg/L	370	362	347	477	494		412
Hardness (total)	mg/L	1,086	1,235	1,228	1,453	1,573		1,207
pH	---	7.68	7.95	7.97	7.70	7.53		7.57
Silica (dissolved)	mg/L	13.8	11.6	11.8	13.5	11.5		13.4
Iron	mg/L	0.09	0.11	0.12	0.10	0.10		0.30
Total Organic Carbon (TOC)	mg/L	17.7	22.1	20.1	20.3	16.8		15.4
Color	s.c.u.	20	15.0	15.0	10	10		20
Sodium	mg/L	1,202	1,724	1,754	1,787	1,844		1,380

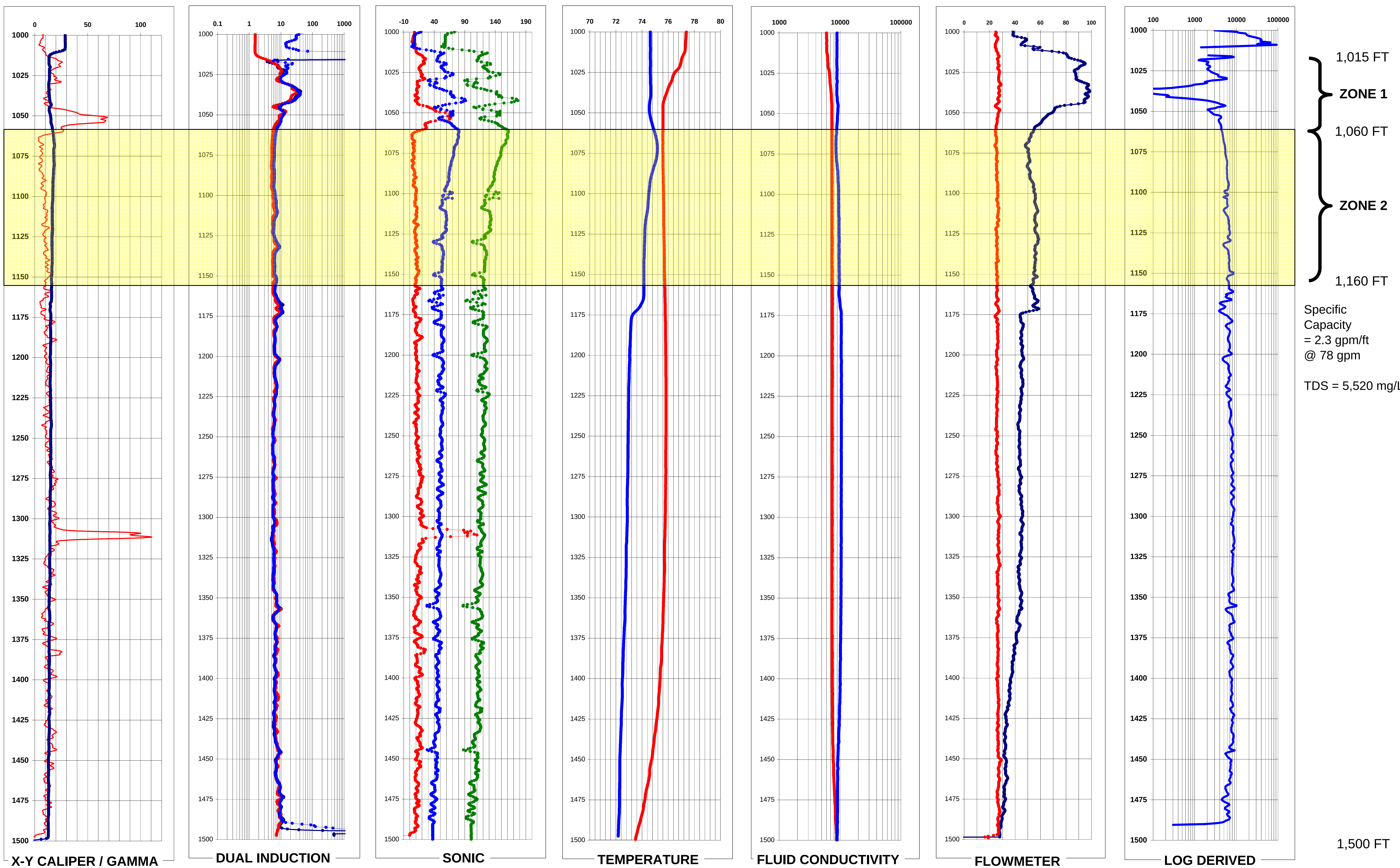
City of Fort Lauderdale FAS-1 Geophysical Logs (1,000' - 1,500')



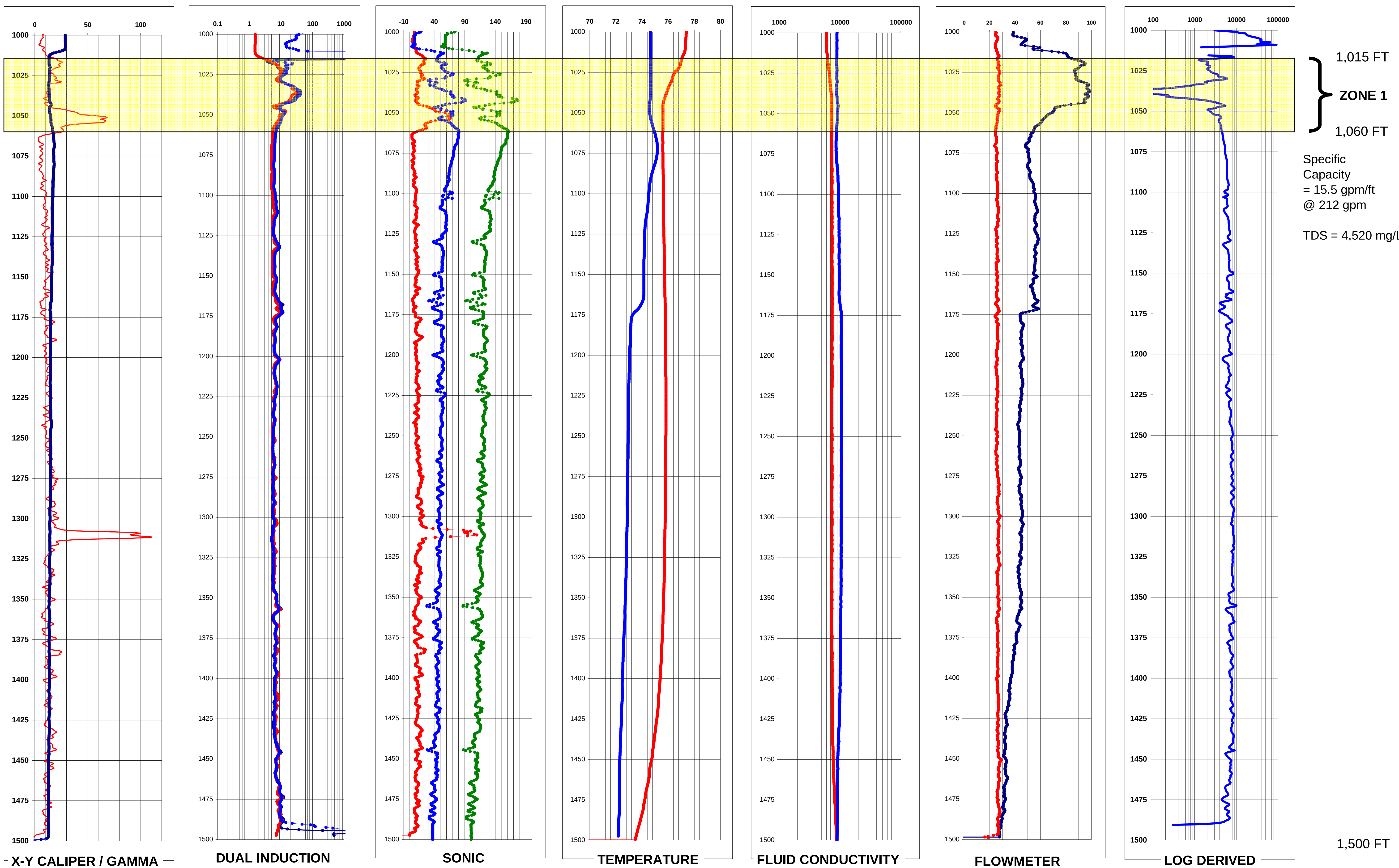
City of Fort Lauderdale FAS-1 Geophysical Logs (1,000' - 1,500')



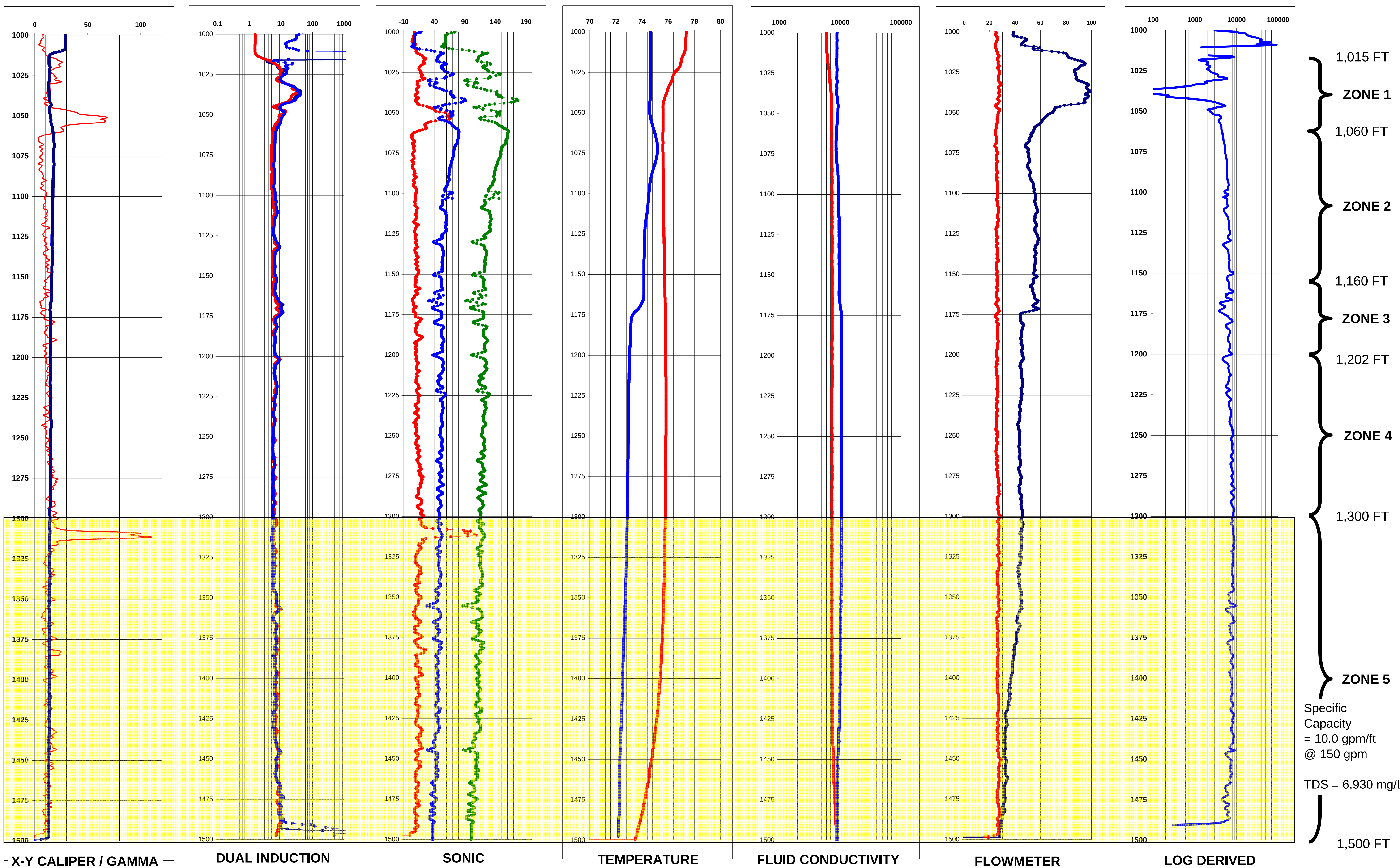
City of Fort Lauderdale FAS-1 Geophysical Logs (1,000' - 1,500')



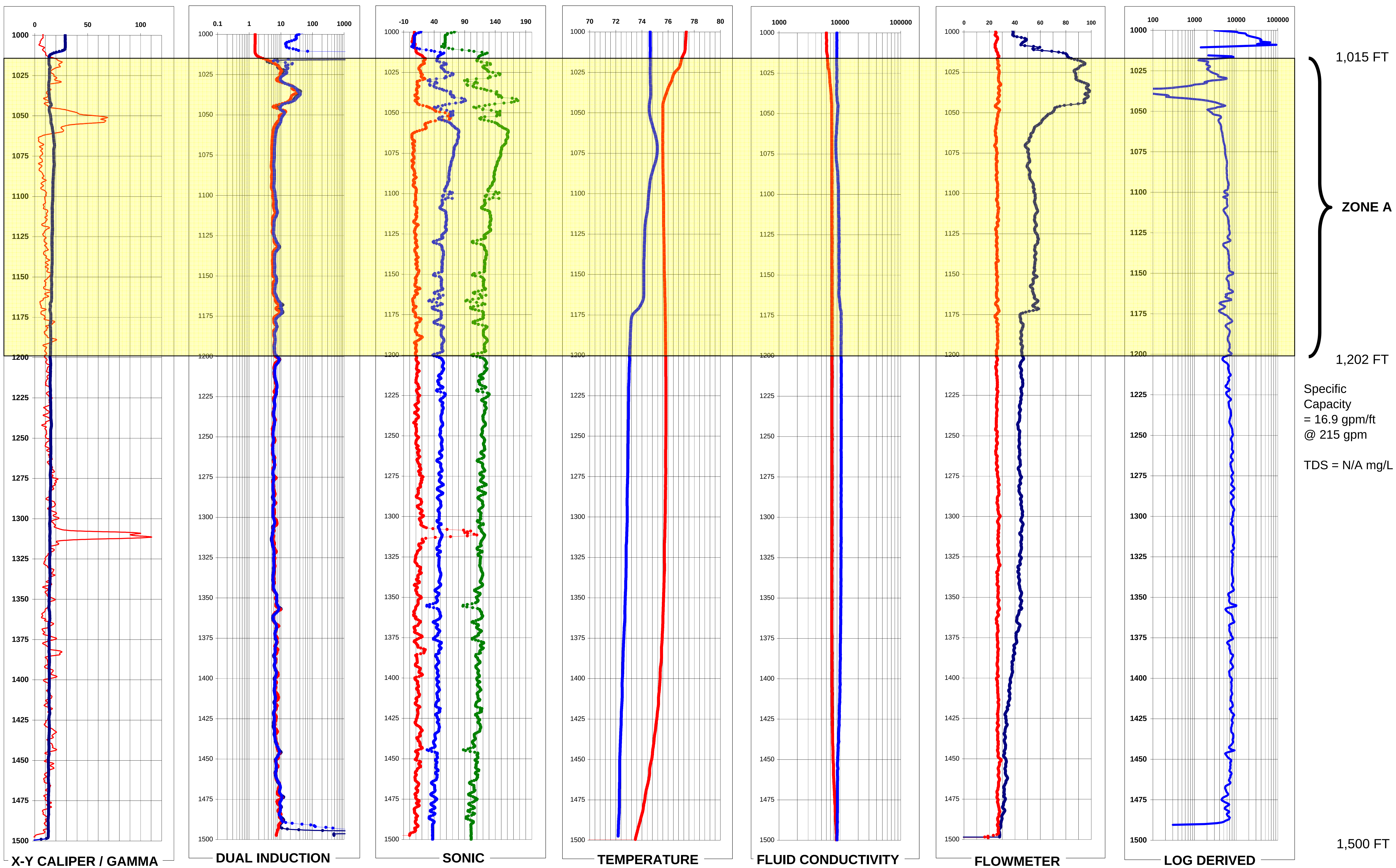
City of Fort Lauderdale FAS-1 Geophysical Logs (1,000' - 1,500')



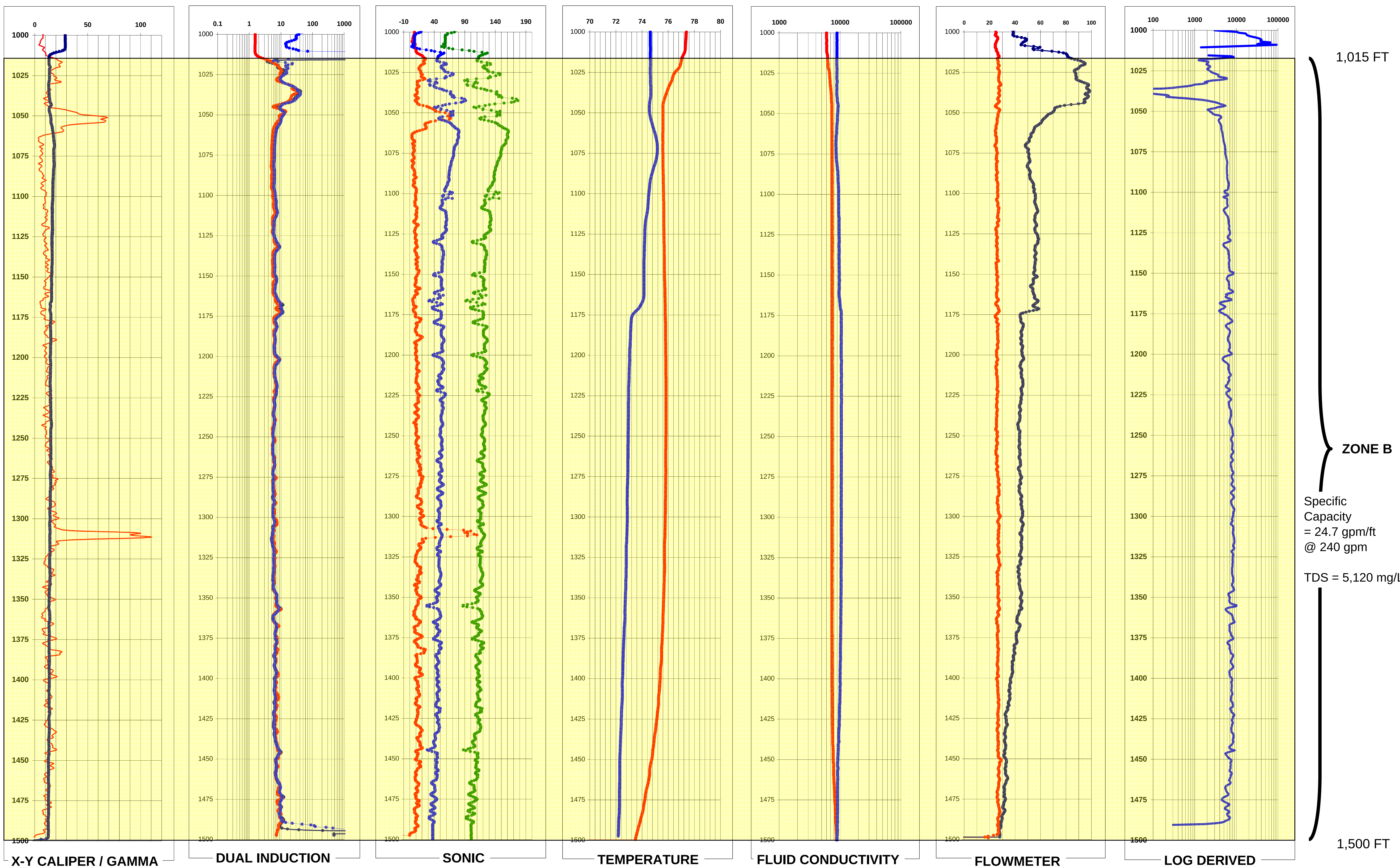
City of Fort Lauderdale FAS-1 Geophysical Logs (1,000' - 1,500')



City of Fort Lauderdale FAS-1 Geophysical Logs (1,000' - 1,500')



City of Fort Lauderdale FAS-1 Geophysical Logs (1,000' - 1,500')



GEOLOGIC LOG
(Drill Cuttings)

CITY OF FORT LAUDERDALE

FLORIDAN AQUIFER TEST WELLS

FAS - 1

Depth (ft)	Thickness (ft)	Sample Description
0 - 60	60	SAND – 100% Colorless, very fine to fine grained, unconsolidated quartz with trace Limestone.
60 – 70	10	LIMESTONE AND LIMEY SANDSTONE – Limestone 60% pale yellowish gray (10YR 6/2), fine grained, moderately soft, pelloidal packstone. Limey Sandstone 30% pale yellowish brown (10YR 6/2), very fine grained, quartz, moderately cemented, with abundant detrital carbonate. Few shell fragments at 70 feet.
70 – 90	20	SANDY LIMESTONE – 100% Very pale (10YR 6/6) to dark yellowish orange (10YR 8/2) fine grained, moderately soft, fossiliferous, very weakly phosphatic packstone with abundant fine grained quartz sand Trace crystalline carbonate.
90 – 100	10	SANDY LIMESTONE – 100% Grayish orange (10YR 7/4) to pale yellowish brown (10YR 6/2) medium to coarse grained, hard, very weakly phosphatic wackestone to rarely grainstone with crystalline carbonate matrix and abundant very fine grained quartz sand.
100 – 120	20	LIMEY SANDSTONE – 100% Grayish orange (10YR 7/4) to pale yellowish brown (10YR 6/2) very fine grained, very hard, very weakly phosphatic, cemented with calcite, with detrital carbonate common.
120 – 130	10	LIMESTONE AND MARL – Limestone 80% grayish orange (10YR 7/4) fine to coarse grained, moderately soft to soft, very weakly phosphatic packstone. MARL 20% white (N9) very soft.
130 – 150	20	LIMESTONE – 100% Pale yellowish brown (10YR 6/2) fine to coarse grained, hard, highly sparry, pelloidal, fossiliferous, very weakly phosphatic packstone with little medium grained quartz sand. Shell fragments common. Trace replacement crystalline carbonate.
150 – 170	20	LIMESTONE – 100% Pale yellowish brown (10YR 6/2) fine grained, hard, locally sparry, very weakly phosphatic packstone.
170 – 180	10	SANDY LIMESTONE – 100% Very pale orange (10YR 8/2) medium to fine grained, hard, fossiliferous, very weakly phosphatic, packstone to wackestone with abundant very fine to fine grained quartz sand.
180 – 190	10	LIMESTONE – 100% Very pale orange (10YR 8/2) medium grained, moderately hard, pelloidal, slightly sand packstone.
190 – 220	30	LIMESTONE AND SANDY CLAYEY LIMESTONE – Limestone 70% Pale yellowish brown (10YR 6/2) medium grained, moderately hard, slightly sandy packstone. Sandy Clayey Limestone 30% Light olive gray (5Y 6/1) medium grained, moderately soft, clayey, packstone/wackestone with abundant very fine to fine rarely coarse grained quartz sand with few shell fragments and molds.

Depth (ft)	Thickness (ft)	Sample Description
220 – 250	30	LIMEY SANDY CLAY AND SHELL FRAGMENTS – Limey Sandy Clay 70%-60% light olive gray (5Y 6/1) soft, non-plastic, non-cohesive, weakly phosphatic with abundant detrital carbonate and abundant very fine grained quartz sand. Shell Fragments 30%-40%.
250 – 270	20	SANDY CLAY AND LIMESTONE – Sandy Clay 60% light olive gray (5Y 6/1) very soft, non-plastic, non-cohesive, highly calcareous with abundant very fine to fine grained quartz sand. Limestone 40% very pale orange (10YR 8/2) fine grained, hard, very weakly phosphatic packstone. Fossils and Shell Fragments common.
270 – 300	30	SANDY CLAY – 100% Yellowish gray (5Y 7/2) moderately plastic, non-cohesive, highly calcareous, weakly phosphatic with abundant very fine grained quartz sand.
300 – 320	20	SANDY CLAY – 100% Light olive gray (5Y 5/2) moderately plastic, moderately cohesive, highly calcareous, slightly phosphatic with abundant very fine grained quartz sand and detrital carbonate.
320 – 360	40	SANDY CLAY – 100% Pale olive (10Y 6/2) moderately soft trending to moderately firm with depth, moderately plastic, non-cohesive, highly calcareous, weakly phosphatic with abundant very fine grained quartz sand.
360 – 490	130	CLAY – 100% Olive gray (5Y 4/1) soft, highly plastic, moderately cohesive, dominantly very slightly to moderately calcareous, weakly phosphatic with abundant very fine grained quartz sand.
490 – 500	10	CLAYEY LIMESTONE - 100% Light olive gray (5Y 6/1) hard, weakly phosphatic mudstone with abundant clay. Trace white (N9) very soft Marl.
500 – 520	20	LIMEY CLAY – 100% Light olive gray (5Y 6/1) moderately cohesive, moderately plastic with abundant detrital carbonate.
520 – 530	10	SANDY CLAY AND MARL – Sandy Clay 80% light olive gray (5Y 6/1) highly plastic; cohesive; weakly phosphatic with abundant very fine grained sand. Marl 20% yellowish gray, very soft.
530 – 540	10	SANDY CLAY – 100% As above.
540 – 550	10	SANDY CLAY – 100% Dark greenish gray (5Y 6/1) stiff, highly plastic, cohesive, very weakly phosphatic with abundant very fine grained quartz sand.
550 – 560	10	SANDY CLAY – 100% Pale olive (5Y 7/1) soft, highly plastic, highly cohesive with abundant very fine grained quartz sand and little very coarse grained phosphorite.
560 - 570	10	CLAY – 100% Greenish gray (5GY 6/1) soft to moderately stiff, highly plastic, highly cohesive, slightly calcareous with very fine grained quartz sand.
570 – 600	30	CLAY – 100% Pale olive (10Y 6/2) soft to moderately stiff, highly plastic, highly cohesive slightly calcareous with very fine grained sand common.

Depth (ft)	Thickness (ft)	Sample Description
600 – 630	30	CLAY – 100% Pale olive (10Y 6/2) soft, highly plastic, highly cohesive, highly calcareous, very weakly phosphatic with very fine grained quartz sand.
630 – 650	20	SANDY CLAY – 100% Yellowish gray (5Y 7/2) moderately soft, highly plastic, highly cohesive, highly calcareous with abundant very fine grained quartz sand.
650 – 680	30	SANDY CLAY – 100% Pale olive (10Y 6/2) moderately soft to soft, highly plastic, highly cohesive, calcareous with abundant fine grained quartz sand.
680 – 690	10	SAND, CLAY, AND CLAYEY SANDY LIMESTONE – Sandy Clay 90% as above. Clayey Sandy Limestone 10% yellowish gray (5Y 7/2) medium grained, moderately soft boundstone with abundant clay and very fine grained quartz sand.
690 – 700	10	CLAY AND LIMESTONE – Clay 70% pale olive (10Y 6/2) soft, highly plastic, highly cohesive, highly calcareous with very fine grained quartz sand. Limestone 30% yellowish gray (5Y 8/1) medium grained, hard, highly sparry, locally clayey packstone.
700 – 750	50	LIMEY CLAY – 100% Yellowish gray (5Y 8/1) soft, cohesive, moderately plastic, very weakly phosphatic with abundant detrital carbonate.
750 – 760	10	CLAY AND CHERT – Clay 80% pale olive (10Y 6/2) plastic, cohesive, highly calcareous. Chert 20% olive gray (5Y 3/2) very hard.
760 – 790	30	CLAY – 100% Pale olive (10Y 6/2) soft moderately plastic, cohesive, calcareous, weakly phosphatic with very fine grained quartz sand.
790 – 800	10	CLAY AND LIMESTONE – Clay 60% as above. Limestone 40% pale yellowish brown (10YR 6/2) microcrystalline, moderately soft, silty, clayey slightly sparry, packstone.
800 – 830	30	CLAY – 100% Light olive gray (5Y 5/2) firm to very firm, plastic, cohesive highly calcareous with very fine grained quartz sand.
830 – 870	40	CLAY – 100% Yellowish gray (5Y 7/2) moderately stiff, highly plastic, highly cohesive, highly calcareous with very fine grained quartz sand.
870 – 900	30	CLAY AND CLAYEY LIMESTONE – Clay 70% As above. Clayey Limestone 20% yellowish gray (5Y 7/2) fine grained, moderately soft, wackestone/packstone with abundant Clay
900 – 950	50	CLAY – 100% Pale olive (10Y 6/2) moderately firm, plastic, cohesive, calcareous.
950 – 980	30	CLAY AND LIMESTONE – Clay 70%, as above. Limestone 30-50% light olive gray (5Y 5/2) fine grained, moderately hard, phosphatic packstone with fine grained quartz sand. Limestone content increasing with depth.
980 – 990	10	SANDY LIMESTONE – 100% Light olive gray (5Y 6/2) to pale yellowish brown (10YR 6/2) fine to medium grained, moderately soft to moderately hard, weakly to highly phosphatic packstone with abundant very fine grained quartz sand.

Depth (ft)	Thickness (ft)	Sample Description
990 – 1000	10	LIMEY CLAY, LIMEY CLAYEY SANDSTONE AND MARL – Limey Clay 60% yellowish gray (5Y 7/2) non-plastic, non-cohesive. Limey Clayey Sandstone 30% yellowish gray (5Y 7/2) very fine to fine grained, poorly cemented, highly phosphatic with abundant clay. Marl 10% white (N9) very soft.
1000 - 1010	10	CLAYEY SANDY LIMESTONE AND LIMNESTONE – Clayey Sandy Limestone 60% light olive gray (5Y 5/2) fine to medium grained, soft, phosphatic packstone with abundant clay and fine grained quartz sand. Limestone 40%.medium light gray (N6) very fine to fine grained, hard, micritic mudstone with casts and molds.
1010 - 1030	20	LIMESTONE – 100%; 60% Yellowish gray (5Y 7/1) fine grained, moderately soft packstone. 30% yellowish gray (5Y 8/1) fine to medium grained, hard, fossiliferous, locally sandy, locally micritic wackestone to mudstone with trace molds. 10% Light olive gray (5Y 6/1) fine grained, hard micritic mudstone. Trace tests.
1030 – 1040	10	LIMESTONE – 100%; 50% Grayish orange (10YR 7/4) fine to medium grained, soft, silty packstone to grainstone. 50% Pale yellowish brown (10YR 6/2) very fine grained, hard mudstone.
1040 – 1050	10	SANDSTONE – 100% Olive gray (5Y 4/1) very fine to fine grained, moderately well cemented, weakly phosphatic.
1050 – 1060	10	LIMESTONE AND MARL – Limestone 90% very pale orange (10YR 8/2) medium grained, moderately soft, pelloidal packstone. Marl 10% Light olive gray (5Y 6/1) very soft, phosphatic, sandy.
1060 – 1080	20	LIMESTONE – 100% very pale orange (10YR 8/2) medium grained, moderately soft, fossiliferous packstone with abundant forams occasionally to 10mm in diameter.
1080 – 1100	20	LIMESTONE AND SANDSTONE – Limestone 60%-80% Yellowish gray (5Y 8/1) to medium light gray (N6) fine grained, hard, fossiliferous, locally sparry packstone with abundant tests and trace crystalline carbonate.
1100 – 1150	50	LIMESTONE – 100% Yellowish gray (5Y 8/1) fine grained, moderately hard packstone with abundant forams.
1150 – 1170	20	LIMESTONE – 100%; 70% Pale yellowish brown (10YR 7/2) very fine to fine grained, moderately soft, fossiliferous packstone. 30% Yellowish gray (5Y 8/1) fine grained, hard, weakly vuggy mudstone. Few forams.
1170 – 1180	10	LIMESTONE – 100%; Very pale orange (10YR 9/2) very fine grained, hard, weakly vuggy mudstone with few molds.
1180 – 1210	30	LIMESTONE – 100%; 50% Very pale orange (5Y 8/2) as above with trace fossil casts. 50% Very pale orange (10Y 8/2) fine grained, soft, locally silty packstone.
1210 – 1230	10	LIMESTONE – 100%; 40% Light olive gray (5Y 7/1) fine to very fine grained, hard, micritic, wackestone with few shell fragments. 40% Very pale orange (10YR 8/2) very fine grained, moderately hard, very weakly vuggy mudstone to wackestone. 20% Very pale orange (10YR 8/2) medium grained, moderately soft pelloidal packstone.

Depth (ft)	Thickness (ft)	Sample Description
1230 – 1240	10	LIMESTONE – 100%; 70% Yellowish brown (10YR 6/4) fine grained, moderately soft, locally micritic, packstone with trace fossils. 30% Very pale orange (10YR 8/2) medium to fine grained, moderately soft, pelloidal packstone. Echinoids to 10mm in diameter common.
1240 – 1260	20	LIMESTONE – 100%; 80% Pale yellowish brown (10YR 6/2) medium to fine grained, moderately hard, well indurated packstone. 20% Pale yellowish brown (10YR 6/2) medium to fine grained, soft, locally weakly dolomitic, packstone to grainstone with forams common. Trace white (N9) soft, chalky mudstone.
1260 – 1270	10	LIMESTONE – 100%; 90% Grayish orange (10YR 7/4) fine to medium grained, moderately soft, fossiliferous packstone with forams common. 10% Pale yellowish brown (10YR 6/2) fine grained, hard, locally weakly vuggy fossiliferous mudstone. Trace pale yellowish brown (10YR 6/2) dominantly fine to coarse grained moderately hard packstone with shell fragments.
1270 – 1320	50	LIMESTONE – 100%; 70% Pale yellowish brown (10YR 6/2) fine grained, moderately hard to moderately soft packstone with few forams. 20% Very pale orange (10YR 8/2) very fine grained, moderately soft mudstone. 10% Medium gray (N5) to medium dark gray (N4) cryptocrystalline, hard micritic mudstone. Trace yellowish gray (5Y 8/1) coarse grained, moderately hard, shelly packstone.
1320 – 1340	20	LIMESTONE – 100%; 70% Pale yellowish brown (10YR 6/2) fine to medium grained, moderately hard, packstone. 20% Grayish orange (10YR 7/4) medium grained, soft grainstone. 10% Light gray (N7) fine grained, hard, locally sandy mudstone. Forams common.
1340 – 1370	30	LIMESTONE – 100%; 70% Yellowish gray (5Y 8/1) to pale yellowish brown (10YR 6/2) very fine grained to cryptocrystalline, hard, very weakly vuggy mudstone. 30% Grayish orange (10YR 7/4) fine to very fine grained, soft, pelloidal packstone/grainstone. Trace crystalline carbonate.
1370 – 1380	10	LIMESTONE – 100%; 80% Pale yellowish brown (10YR 7/2) very fine grained, moderately hard, wackestone. 20% Grayish orange (10YR 7/4) fine grained, moderately soft packstone. Few forams.
1380 – 1390	10	LIMESTONE – 100%; 60% Grayish orange (10YR 7/4) fine to very fine grained, moderately soft packstone to grainstone. 40% Very pale orange (10YR 8/2) very fine grained, moderately hard, weakly vuggy mudstone. Trace olive black (5Y 2/1) microcrystalline, very hard, limey Dolomite.
1390 – 1420	30	LIMESTONE – 100%; 60% Grayish orange (10YR 7/4) very fine to medium grained, moderately hard to moderately soft locally micritic packstone with few forams. 40% Pale yellowish brown (10YR 6/2) to very pale orange (10YR 8/2) very fine grained, hard, micritic weakly vuggy mudstone.
1420 – 1450	30	LIMESTONE – 100%; 60% Very pale orange (10YR 8/2) very fine grained, moderately hard wackestone. 20% Pale grayish orange (10YR 8/4) fine grained, moderately soft to soft, pelloidal packstone to rarely grainstone. 20% Pale yellowish brown (10YR 6/2) very fine grained, hard, micritic mudstone. Trace fossils.

Depth (ft)	Thickness (ft)	Sample Description
1450 – 1470	20	LIMESTONE – 100%; 80% Yellowish gray (5Y 8/1) cryptocrystalline, hard, micritic locally weakly vuggy mudstone. 20% Grayish orange (10YR 7/2) very fine to fine grained, moderately soft packstone to wackestone. Few forams.
1470 – 1480	10	LIMESTONE – 100%; 50% Very pale orange (10YR 8/2) to pale yellowish brown (10YR 7/2) very fine to fine grained, hard, micritic mudstone to wackestone. 30% Grayish orange (5Y 8/1) fine grained, micritic packstone to grainstone. 20% Very pale orange (10YR 8/2) very fine to fine grained, moderately soft packstone.
1480 – 1500	20	LIMESTONE – 100%; 50% Grayish orange (10YR 7/4) fine to medium grained, moderately soft, pelloidal fossiliferous, packstone/grainstone. 30% Very pale orange (10YR 8/2) very fine grained, moderately hard, mudstone. 20% Light gray (N7) cryptocrystalline, very hard, micritic mudstone.