EPA/540/R-08/005a
September 2008

Demonstration of Steam Injection/Extraction Treatment of a DNAPL Source Zone at Launch Complex 34 in Cape Canaveral Air Force Station

Final Innovative Technology

Appendix F: Surface Emissions Testing and Temperature Monitoring

F.1 Surface Emissions Testing Methods and Procedures

One of the concerns about the technology as a means of soil and groundwater remediation was the possibility of transferring chlorinated volatile organic compounds (CVOCs) to the atmosphere through the ground surface, injection wells, and monitoring wells. Emissions testing was performed to obtain a qualitative picture of VOC losses to the atmosphere. The sampling and analytical methodologies for the emissions tests are presented in the following subsections.

F.1.1 Dynamic Surface Emissions Sampling Methodology

A dynamic surface emissions sampling method was used at the LC34 site. This method involves enclosing an area of soil under an inert box designed to allow the purging of the enclosure with high-purity air (Dupont, 1987). The box was purged with high-purity air for two hours to remove any ambient air from the region above the soil and to allow equilibrium to be established between the VOCs emitted from the soil and the organic-free air. The airstream was then sampled by drawing a known volume of the VOC/pure air mixture through a 1-L Summa canister. The Summa canister captured any organics associated with surface emissions from the test plot. Emissions samples also were collected in the same manner near the drainage ditch in order to monitor organic concentrations in the infiltration gallery (see Figure F-1). Additionally, ambient air samples were collected using Summa canisters held at shoulder height for use as a reference of the existing air quality. The Summa canisters were then shipped to the off-site laboratory with a completed chain-of-custody form. The off-site laboratory quantified the organic concentrations in the Summa canisters according to EPA method TO-14 (EPA, 1989) or TO-14A (EPA, 1999).

A schematic diagram of the surface emissions sampling system is shown as Figure F-2. The system consists of a stainless steel box that covers a surface area of approximately 0.5 m^2. The box was fitted with inlet and outlet ports for the entry and exit of high-purity air, which is supplied via a gas cylinder. Inside the box was a manifold that delivered the air supply uniformly across the soil surface. The same type of manifold was also fitted to the exit port of the box. The configuration was designed to deliver an even flow of air across the entire soil surface under the box so that a representative sample was generated. To collect the sample, the air exiting the box was pulled by vacuum into the Summa canister.

In all testing cases, a totally inert system was employed. Teflon™ tubing and stainless steel fittings were used to ensure that there was no contribution to or removal of organics from the air stream. The Summa canister was located on the backside of the emissions box so that it would not be in a position to reverse the flow of air inside the box. The box was cleaned between each sample by rinsing with methanol and deionized water prior to purging with high-purity air for two hours.

F.1.2 Sampling Schedule

Multiple surface emissions sampling locations were selected in and around the steam injection plot for the technology demonstration (see Figure F-1). During the predemonstration phase sampling event, emissions samples were collected from inside the plot boundaries (samples SI-SE-33 through -35). After plenum was installed over the plot to minimize surface emissions during the demonstration, emissions sampling was limited to the perimeter of the steam injection plot. Two emissions sampling events were held during the active technology demonstration phase (samples SI-SE-1 through -15). After the demonstration, the plenum was removed and one emissions sampling event was held during the postdemonstration period, where emissions samples were collected inside the plot boundaries (samples SI-SE-16 through -19).

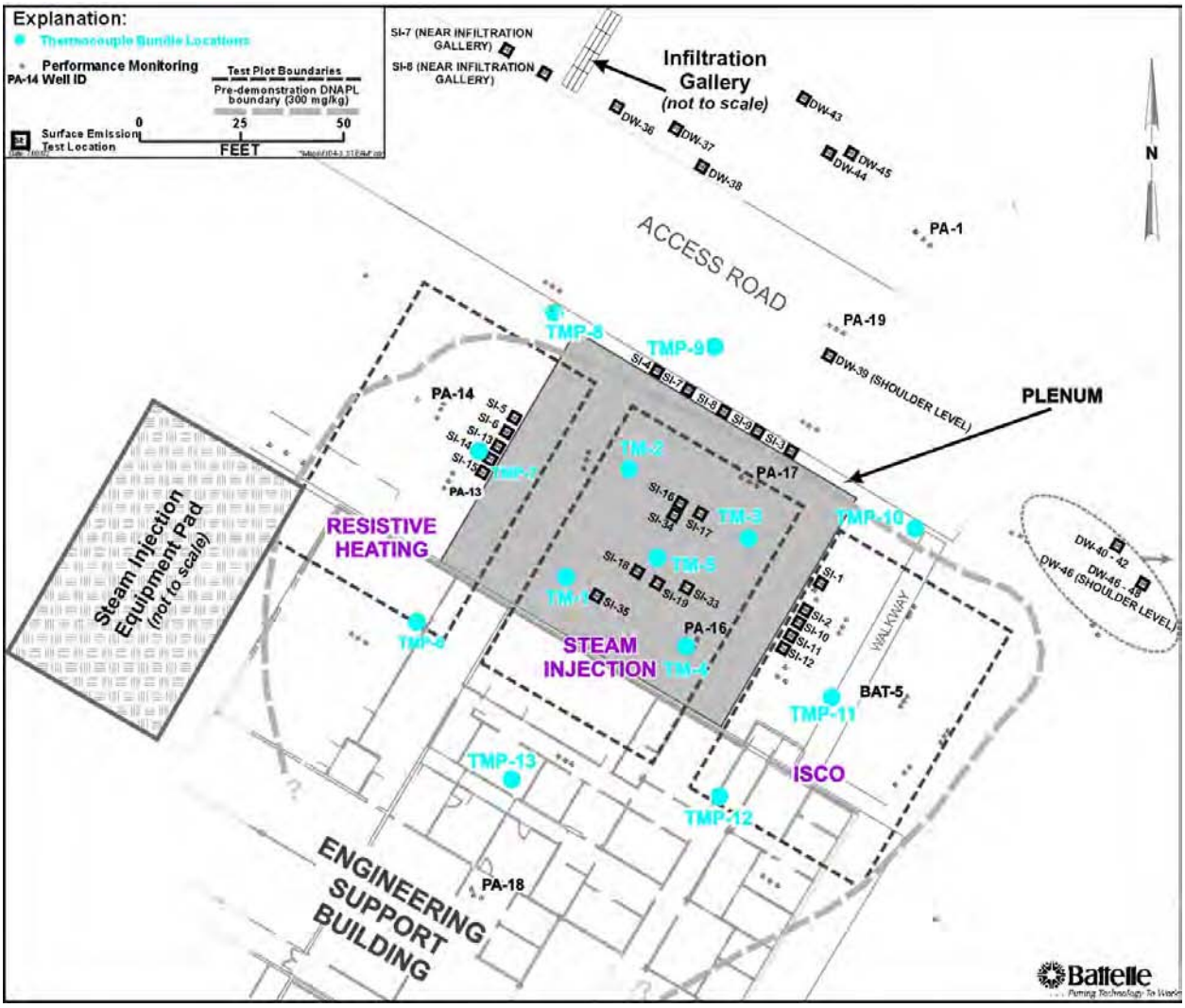


Figure F-1. Location map of surface emissions tests during steam injection demonstration at Launch Complex 34

In addition to these monitoring activities, emissions samples were collected in areas outside the DNAPL boundary during the predemonstration phase (samples DW-SE-36 through -38), the active technology demonstration phase (samples DW-SE-40 through -45), and the postdemonstration phase (samples DW-SE-47 and -48). During the first sampling event of the active technology demonstration phase, emissions samples were collected near the infiltration gallery to monitor the organic vapor concentration of the discharge water (samples SI-SE-7 and -8). Ambient air samples were collected as reference samples during the pre- and postdemonstration sampling events (samples DW-SE-39 and -46). Table F-1 contains a summary of the sample identifications and sampling dates of the surface emissions samples taken during the steam injection demonstration.

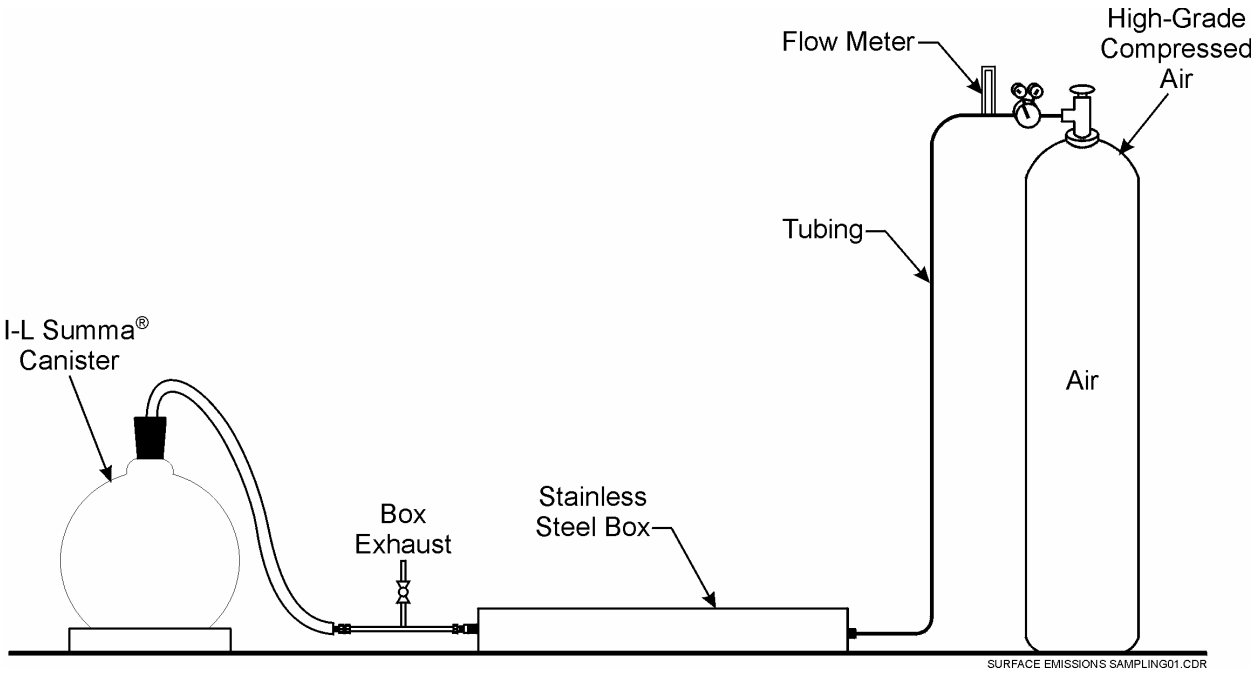


Figure F-2. Schematic Diagram of the Surface Emissions Sampling System

F.1.3 Analytical Results

The analytical results from the surface emissions sampling at LC34 are presented in Table F-1. Samples were analyzed for TCE concentrations in vapor. The data is represented temporally, reflecting the four sampling events at the site. The data indicates that TCE surface emissions were relatively low prior to beginning the technology demonstration. The samples taken in August 2001 during steam injection showed a general increase in TCE emissions, in particular on the west and east sides of the plot (samples SI-SE-1 through -6). The samples taken in November 2001 during the steam injection demonstration exhibited a significant decrease in TCE emissions on the north and east sides of the plot (samples SI-SE-7 through -12), and were relatively consistent with TCE concentrations in the ambient air sample taken at the same time (sample DW-SE-39). The data from the western edge of the plot during the November 2001 sampling event showed only minor decreases in TCE emissions (samples SI-SE-13 through -15), suggesting that TCE vapors were escaping around the edges of the plenum.

Table F-1. Surface Emissions Results from the Steam Injection Demonstration

Sample ID	Sample Date	TCE ppb (v/v)	Sample ID	Sample Date	TCE ppb (v/v)
Steam Plot					
Pre-Demonstration					
SI-SE-33	12/04/2000	1.2	SI-SE-35	12/05/2000	<0.40
SI-SE-34	12/05/2000	1.1			
During Demonstration					
SI-SE-1	08/27/2001	<37	SI-SE-9	11/06/2001	<0.060
SI-SE-2	08/27/2001	0.45	SI-SE-10	11/07/2001	<0.060
SI-SE-3	08/27/2001	<0.34	SI-SE-11	11/07/2001	<0.060
SI-SE-4	08/27/2001	<0.34	SI-SE-12	11/07/2001	<0.060
SI-SE-5	08/28/2001	51	SI-SE-13	11/08/2001	40
SI-SE-6	08/28/2001	<49	SI-SE-14	11/08/2001	45
SI-SE-7	11/06/2001	<0.060	SI-SE-15	11/08/2001	21
SI-SE-8	11/06/2001	<0.060			
Post-Demonstration					
SI-SE-16	02/18/2002	33	SI-SE-18	02/18/2002	280
SI-SE-17	02/20/2002	15	SI-SE-19	02/20/2002	180
Outside the Extent of TCE Plume			***Ambient Air at Shoulder Level[(a)]***		
DW-SE-36	12/06/2000	<0.40	DW-SE-39	11/06/2000	<0.060
DW-SE-37	12/06/2000	0.49	DW-SE-46	02/18/2002	<0.03
DW-SE-38	12/07/2000	<0.40	***Near the Infiltration Gallery***		
DW-SE-40	11/05/2001	<0.060	SI-SE-7	8/28/2001	110
DW-SE-41	11/05/2001	<0.060	SI-SE-8	8/28/2001	74
DW-SE-42	11/05/2001	<0.060			
DW-SE-43	11/06/2001	0.26			
DW-SE-44	11/06/2001	0.26			
DW-SE-45	11/06/2001	0.17			
DW-SE-47	02/18/2002	<0.03			
DW-SE-48	02/20/2002	<0.03			

ppb (v/v): parts per billion by volume.

(a) A Summa canister was held at shoulder level to collect an ambient air sample representative of the local air quality.

Surface emission samples collected in the plot during the postdemonstration period (samples SI-SE-16 through -19) after the plenum was removed exhibited a strong increase in TCE vapor concentrations. Figure F-3 displays the temperature of groundwater in the shallow wells and the locations of the post-demonstration surface emissions samples. The increase in vapor TCE concentrations suggests that the residual hot temperatures of the subsurface continued to enhance TCE volatilization to the atmosphere after the technology demonstration ended.

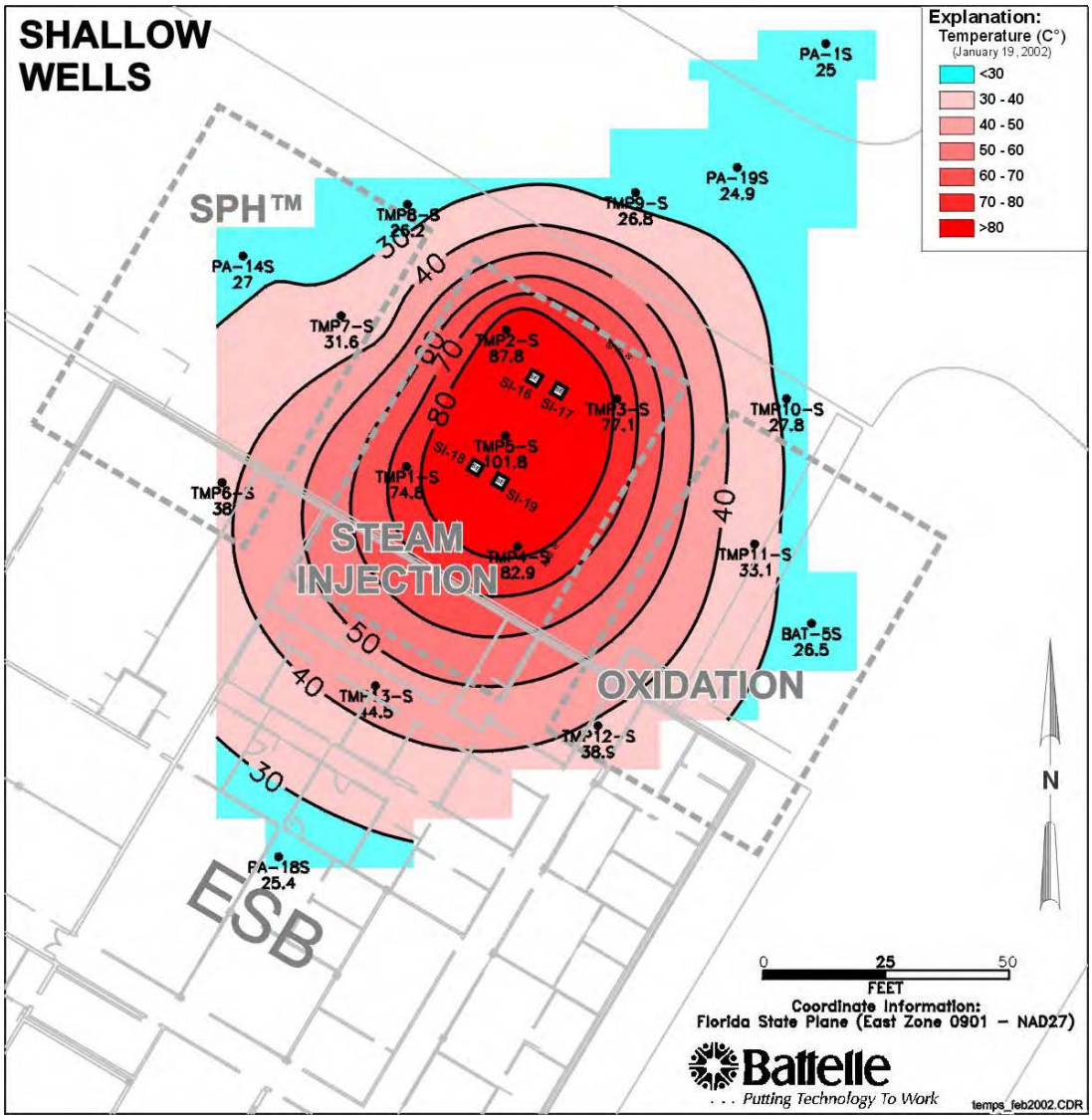


Figure F-3. Postdemonstration shallow well groundwater temperatures and surface emission sampling locations

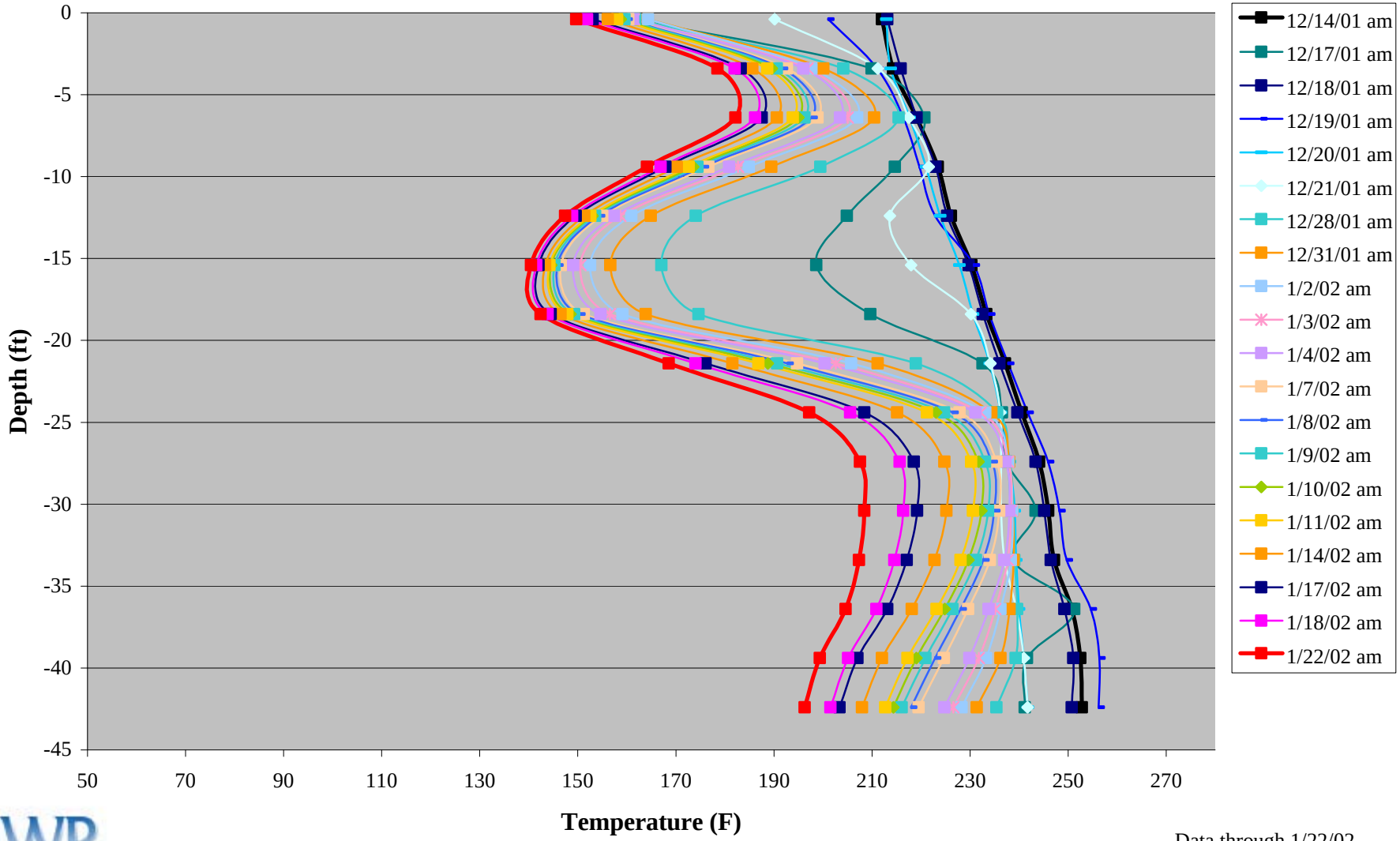
F.1.4 References

Dupont, R.R. 1987. "A Sampling System for the Detection of Specific Hazardous Constituent Emissions from Soil Systems." In *Hazardous Waste: Detection, Control, Treatment*, Amsterdam, The Netherlands. Elsevier Science Publishers, B.V. pp. 581-592.

EPA, 1989. "Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air," EPA/600/4-89/017, June 1988.

EPA, 1999. "Compendium Method TO-14A: Determination of Volatile Organic Compounds (VOCs) in Ambient Air Using Specially Prepared Canisters with Subsequent Analysis by Gas Chromatography," In *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition.* EPA/625/R-96/010b, January 1999.

Cape Canaveral Steam Demonstration TM-1 Temperature vs. Depth



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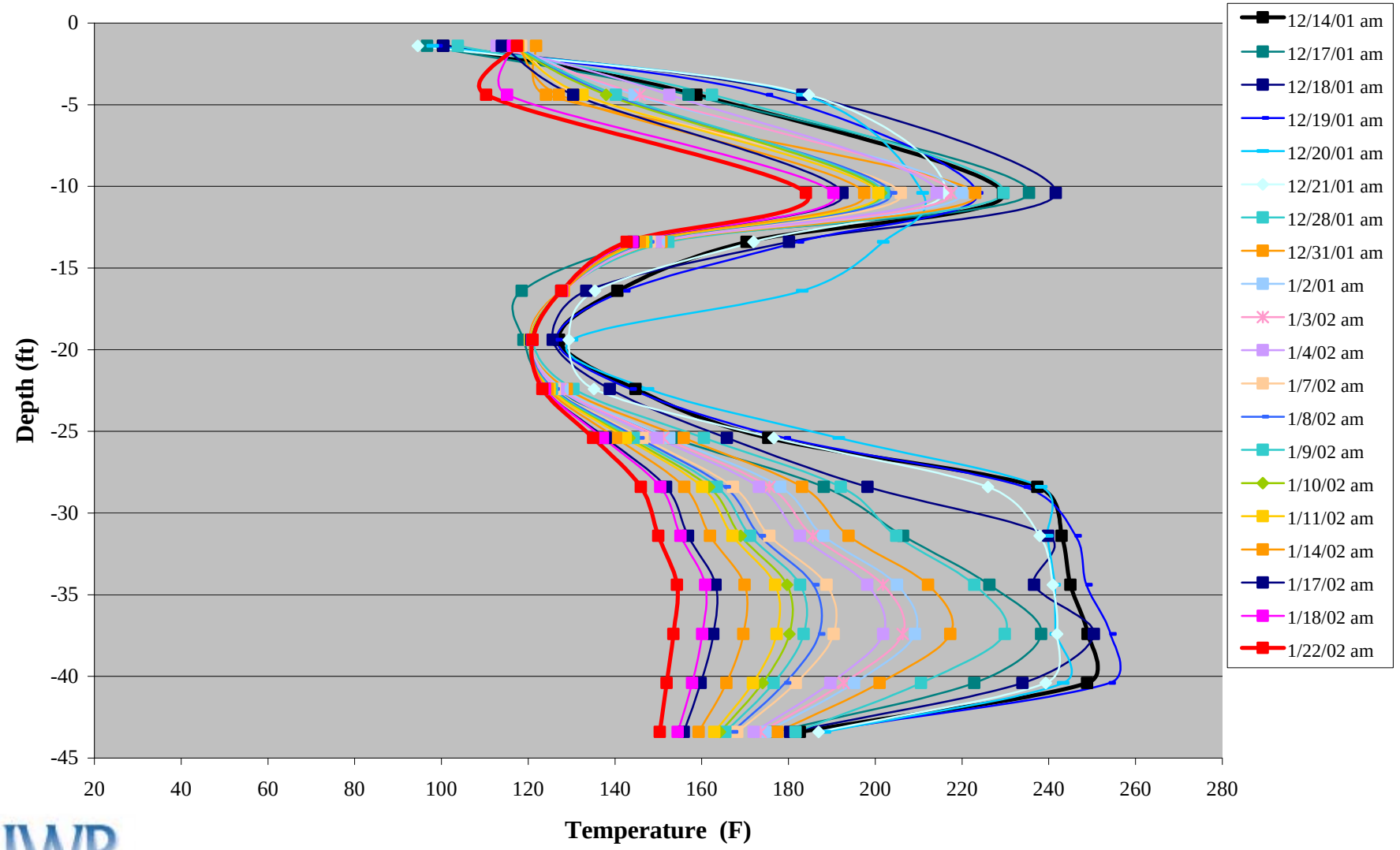
Data through 1/22/02

Cape Canaveral Steam Demonstration TM-2 Temperature vs. Depth



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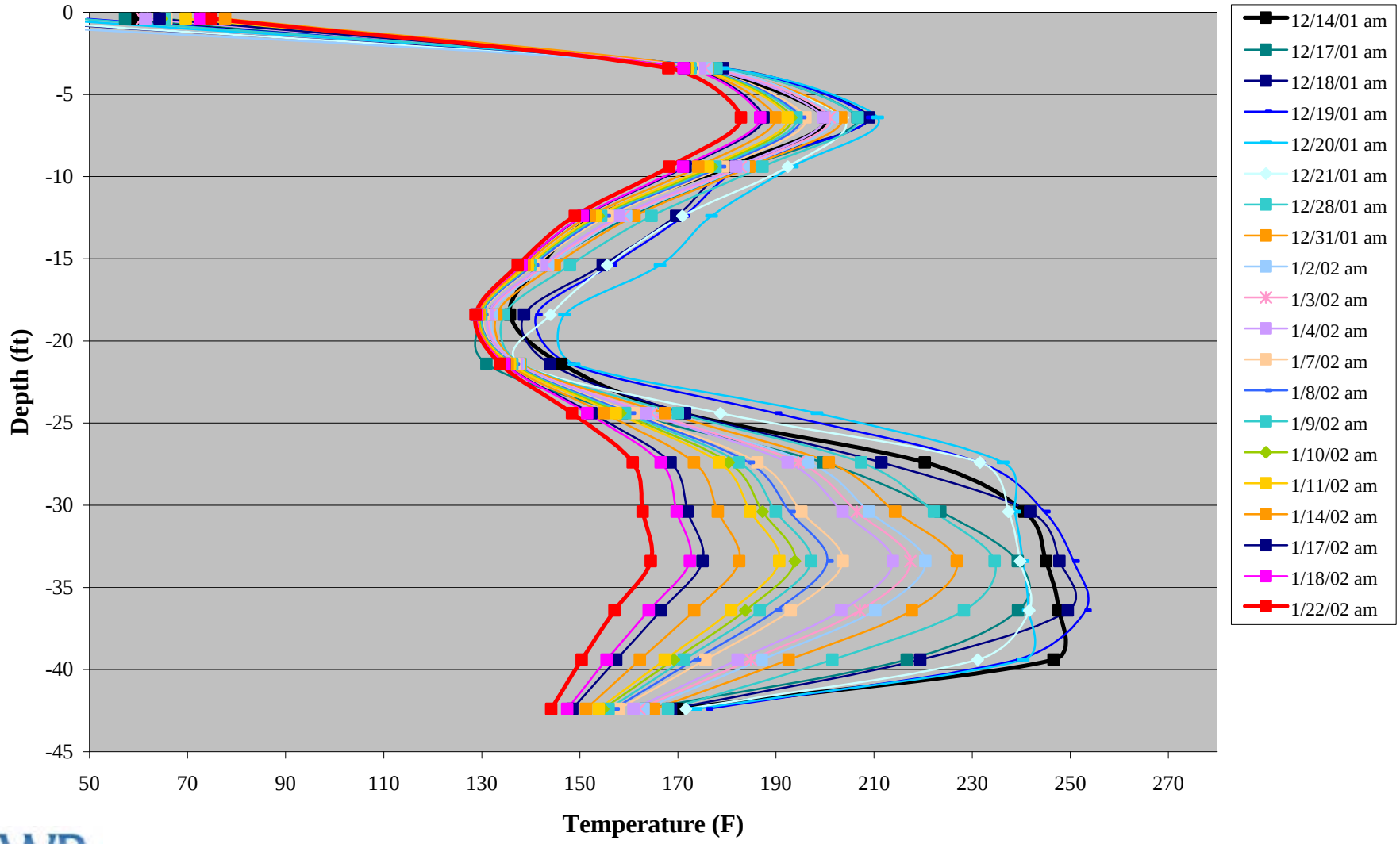
Cape Canaveral Steam Demonstration TM-3 Temperature vs. Depth



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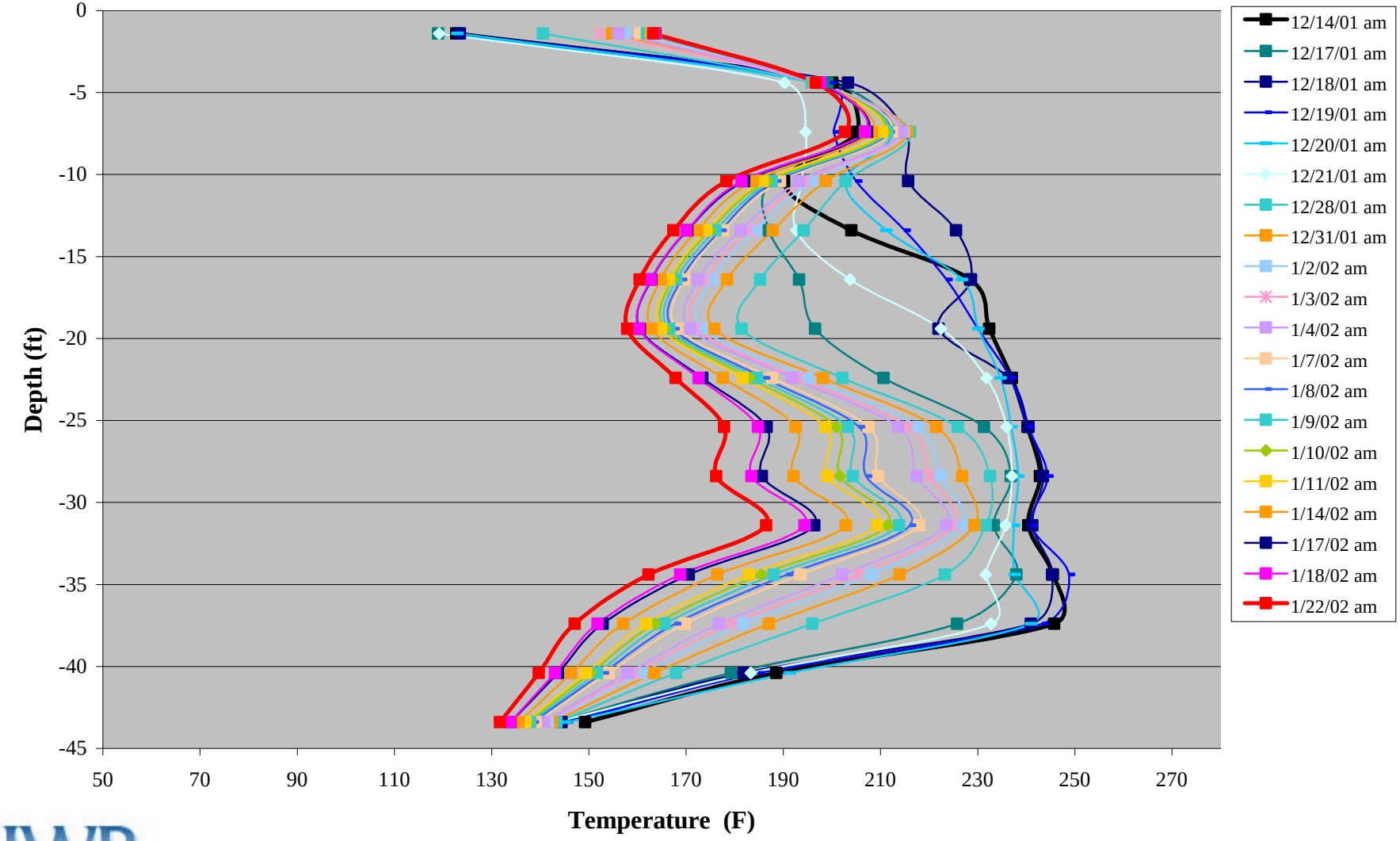
Cape Canaveral Steam Demonstration TM-4 Temperature vs. Depth



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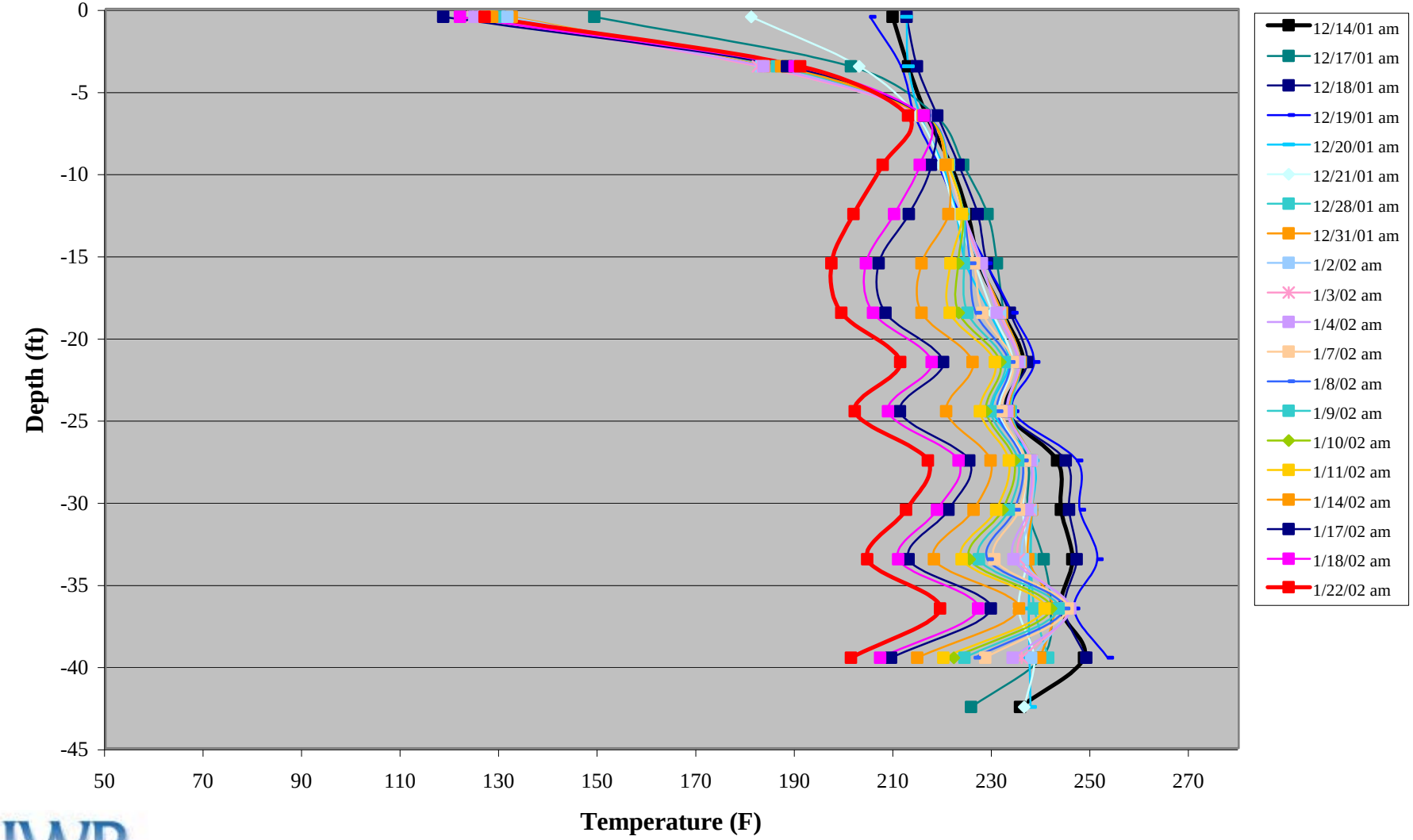
Cape Canaveral Steam Demonstration TM-5 Temperature vs. Depth



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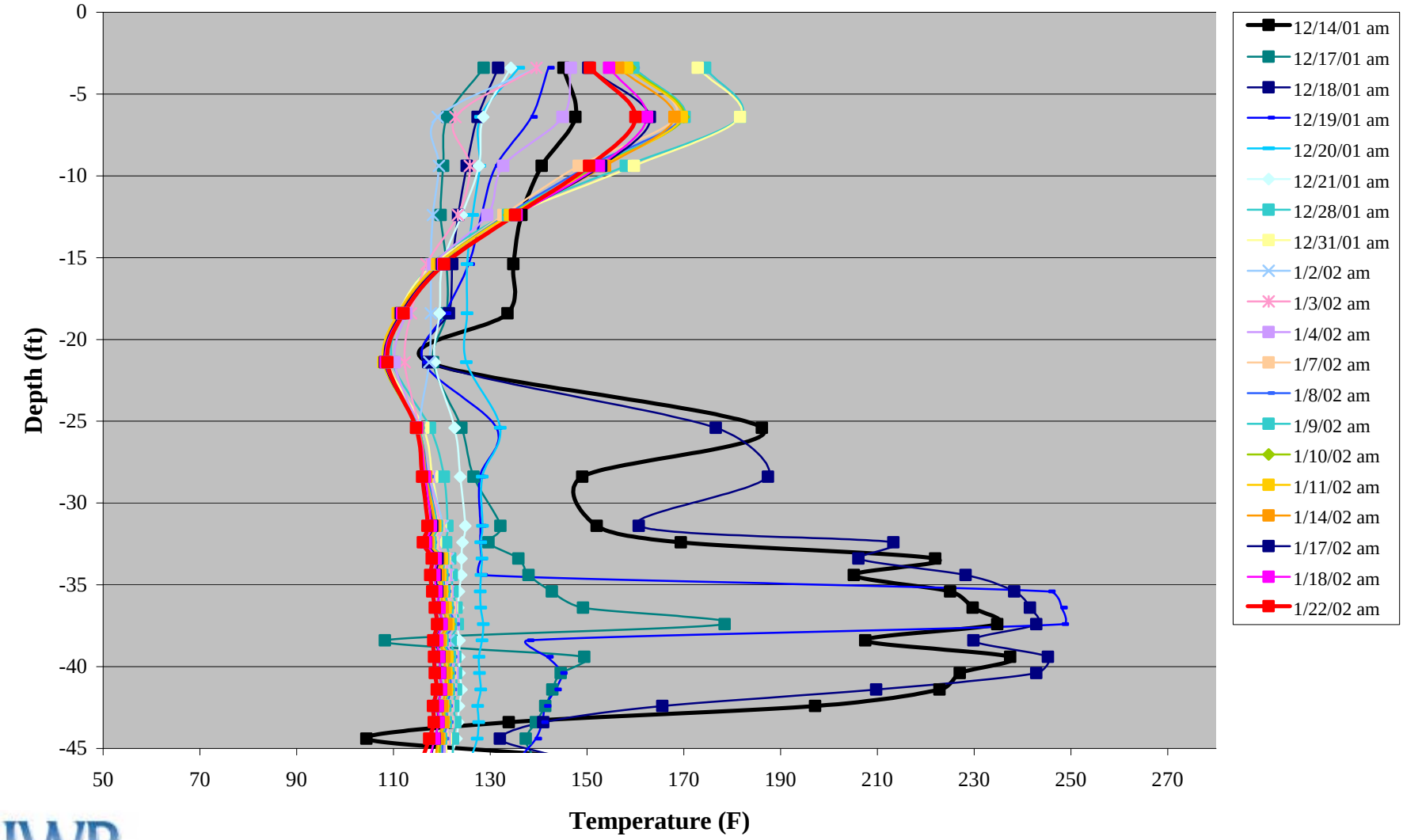
Cape Canaveral Steam Demonstration VE-1 Temperature vs. Depth



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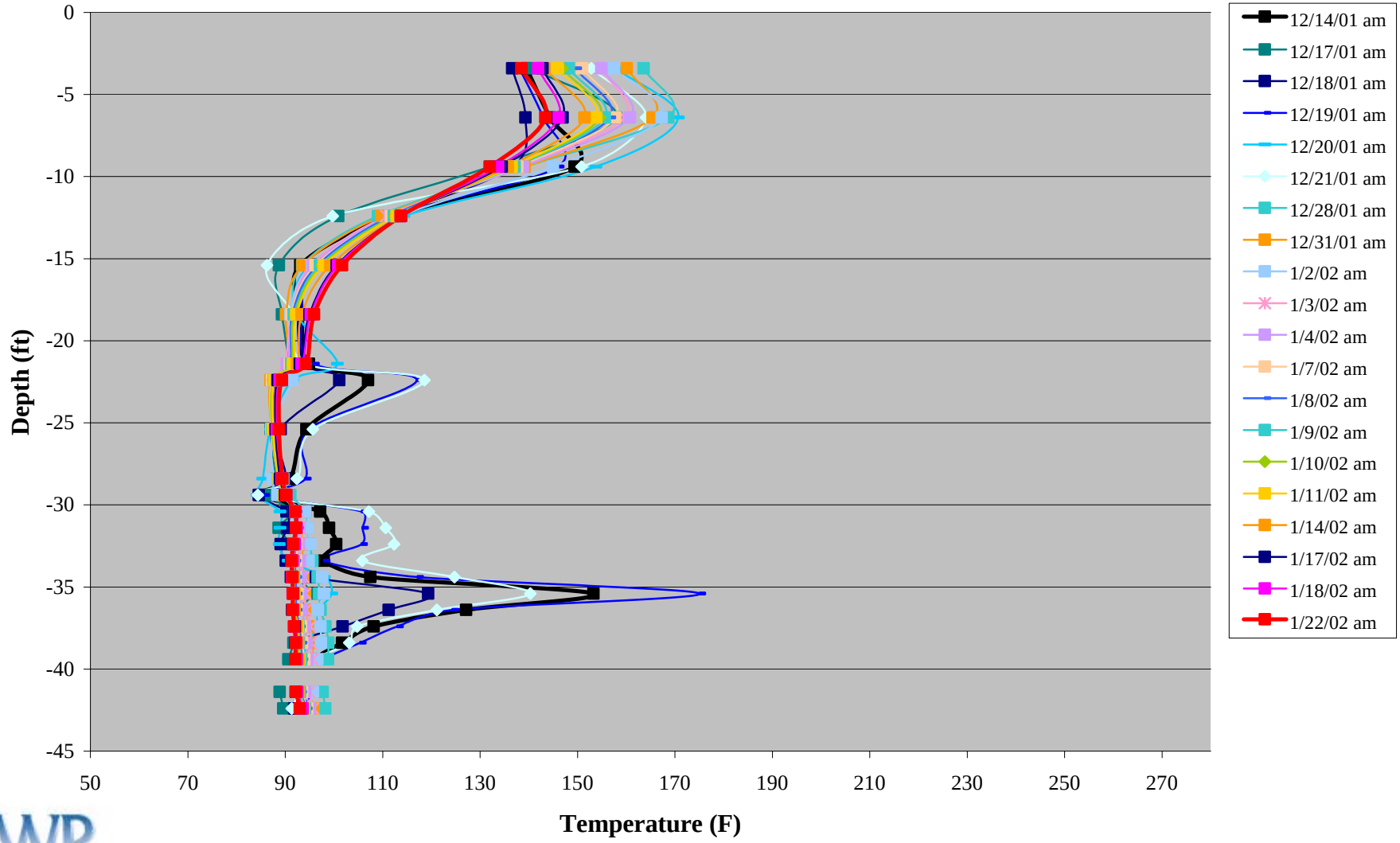
Cape Canaveral Steam Demonstration VE-2 S,D Temperature vs. Depth



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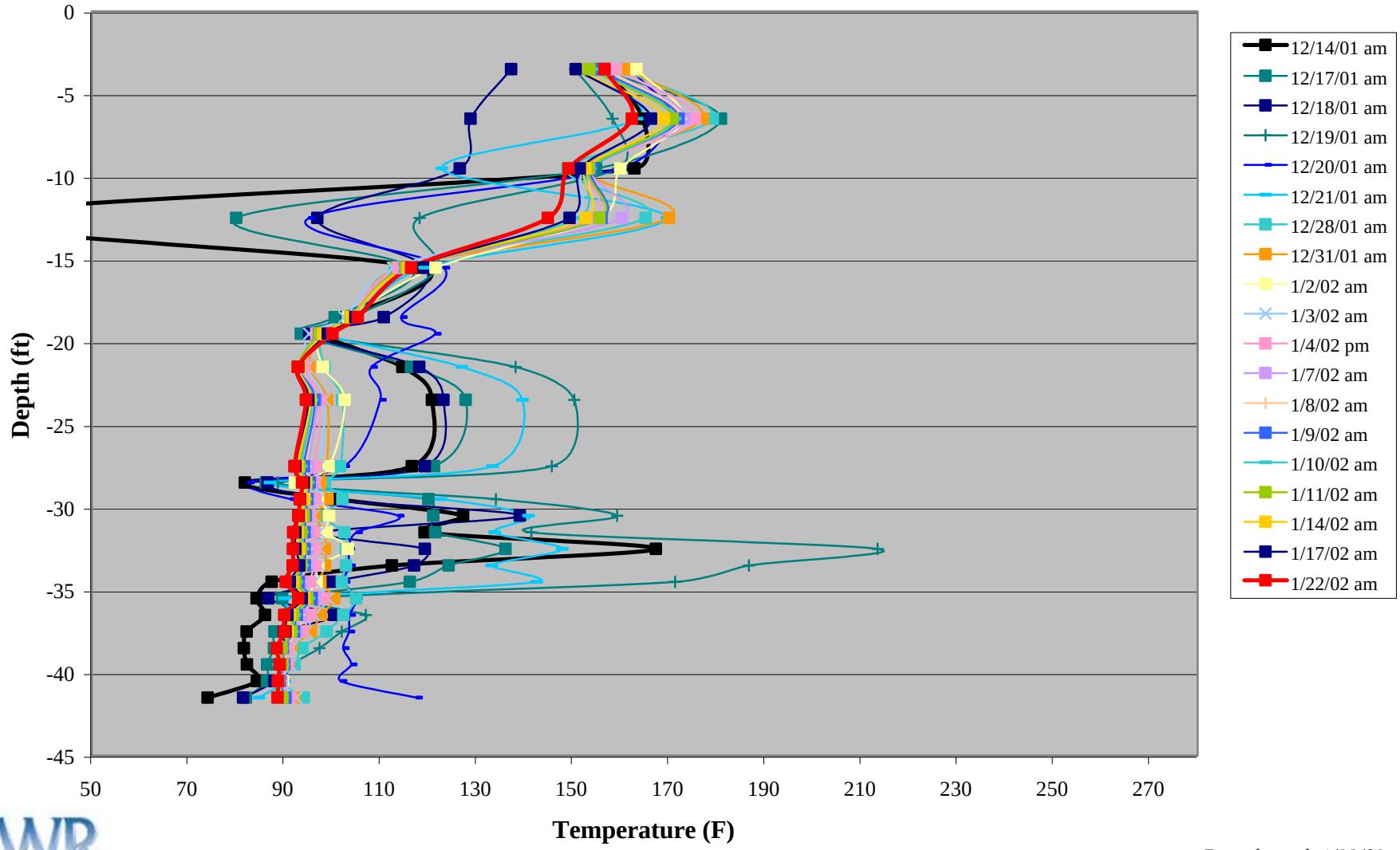
Cape Canaveral Steam Demonstration VE-3 S,D Temperature vs. Depth



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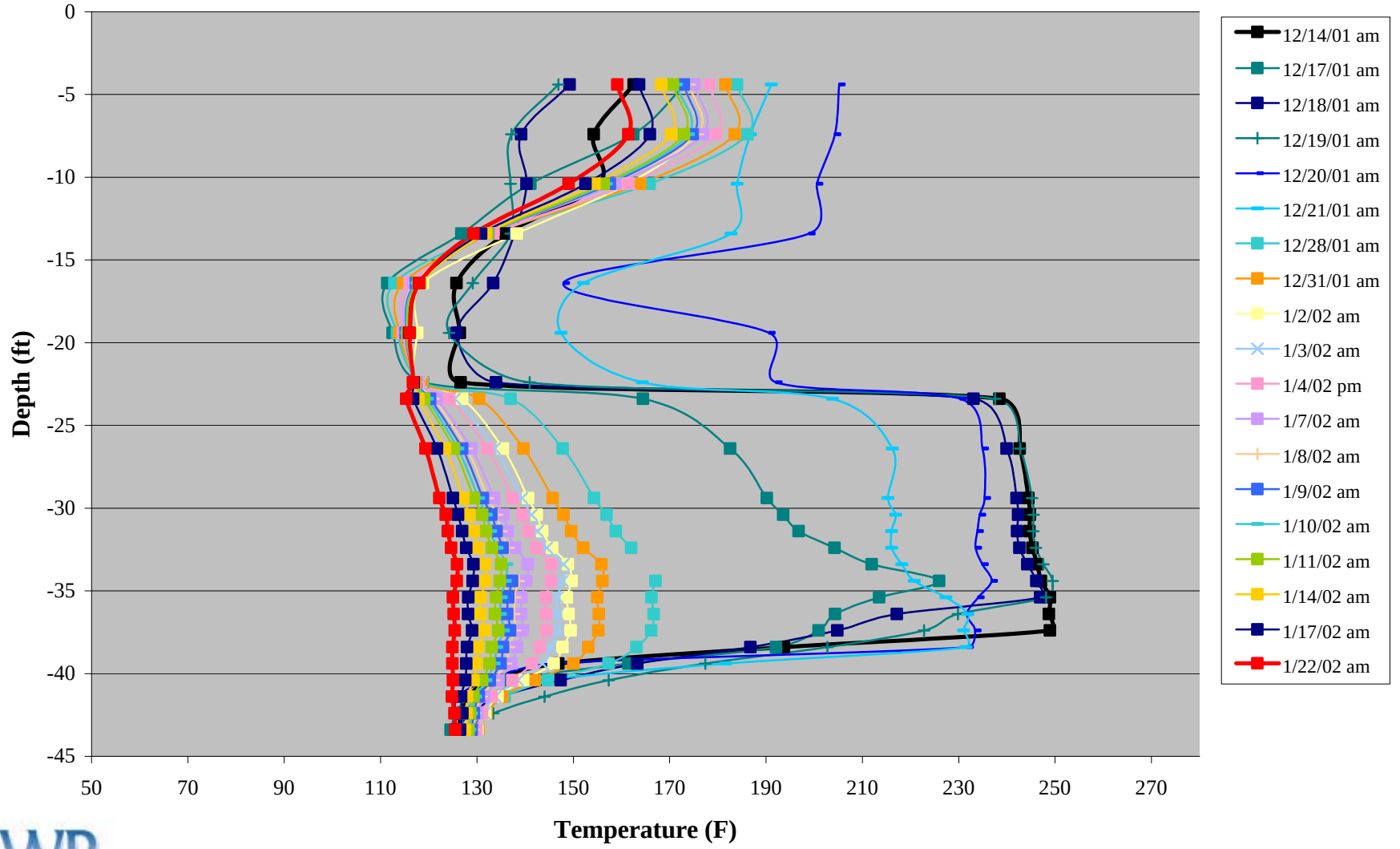
Cape Canaveral Steam Demonstration VE-6 Temperature vs. Depth



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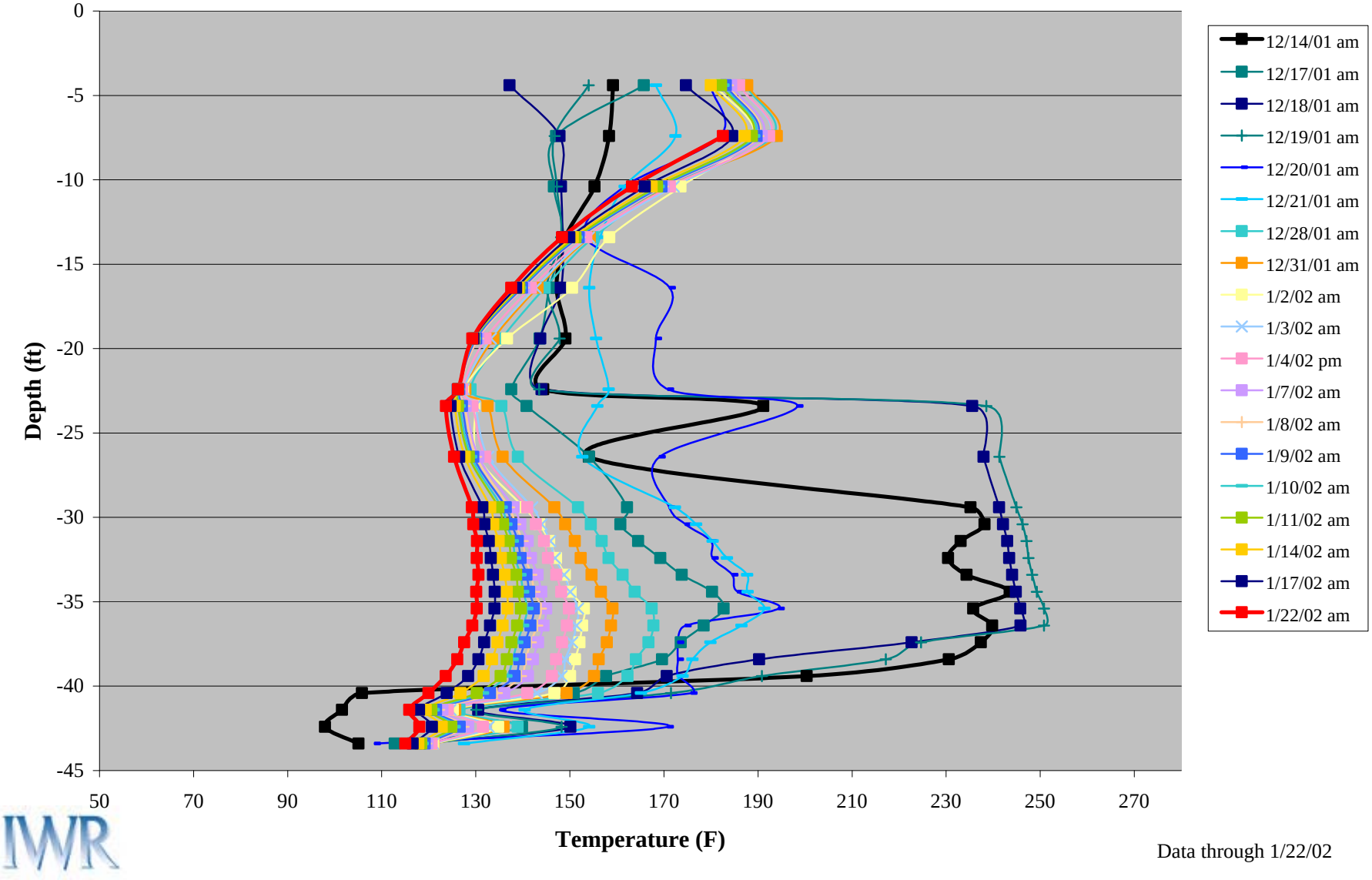

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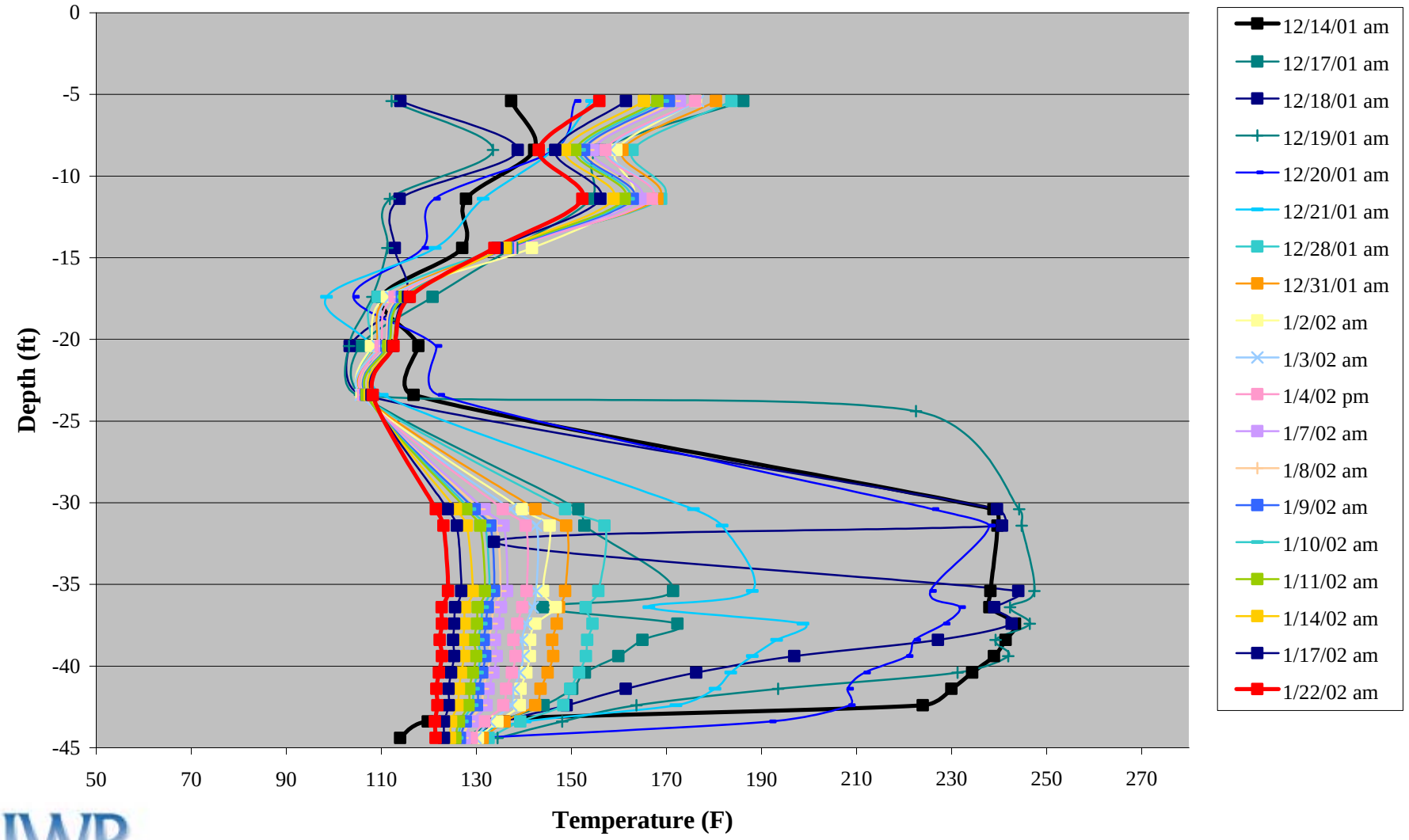
Cape Canaveral Steam Demonstration VE-8 Temperature vs. Depth



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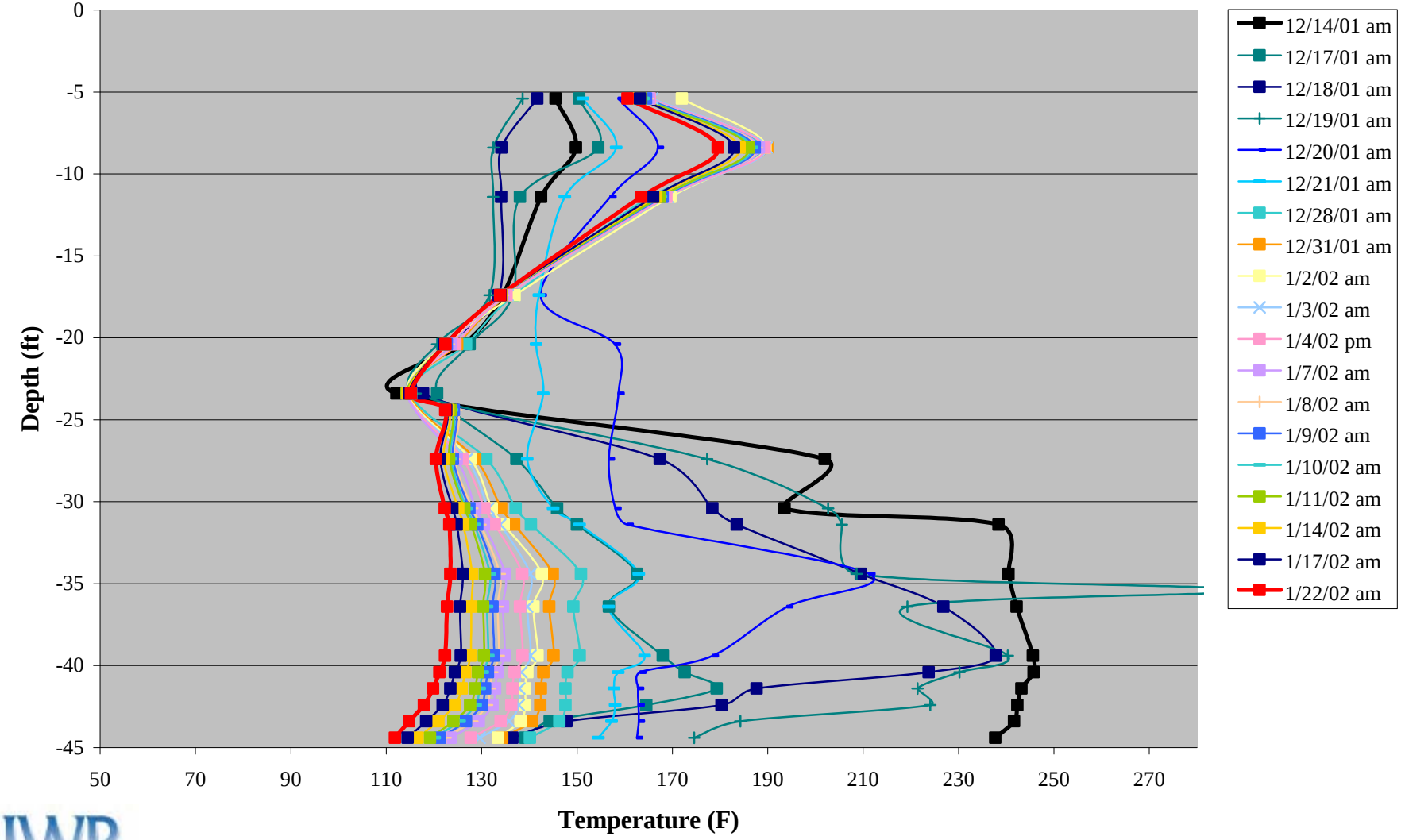
Cape Canaveral Steam Demonstration VE-9 Temperature vs. Depth



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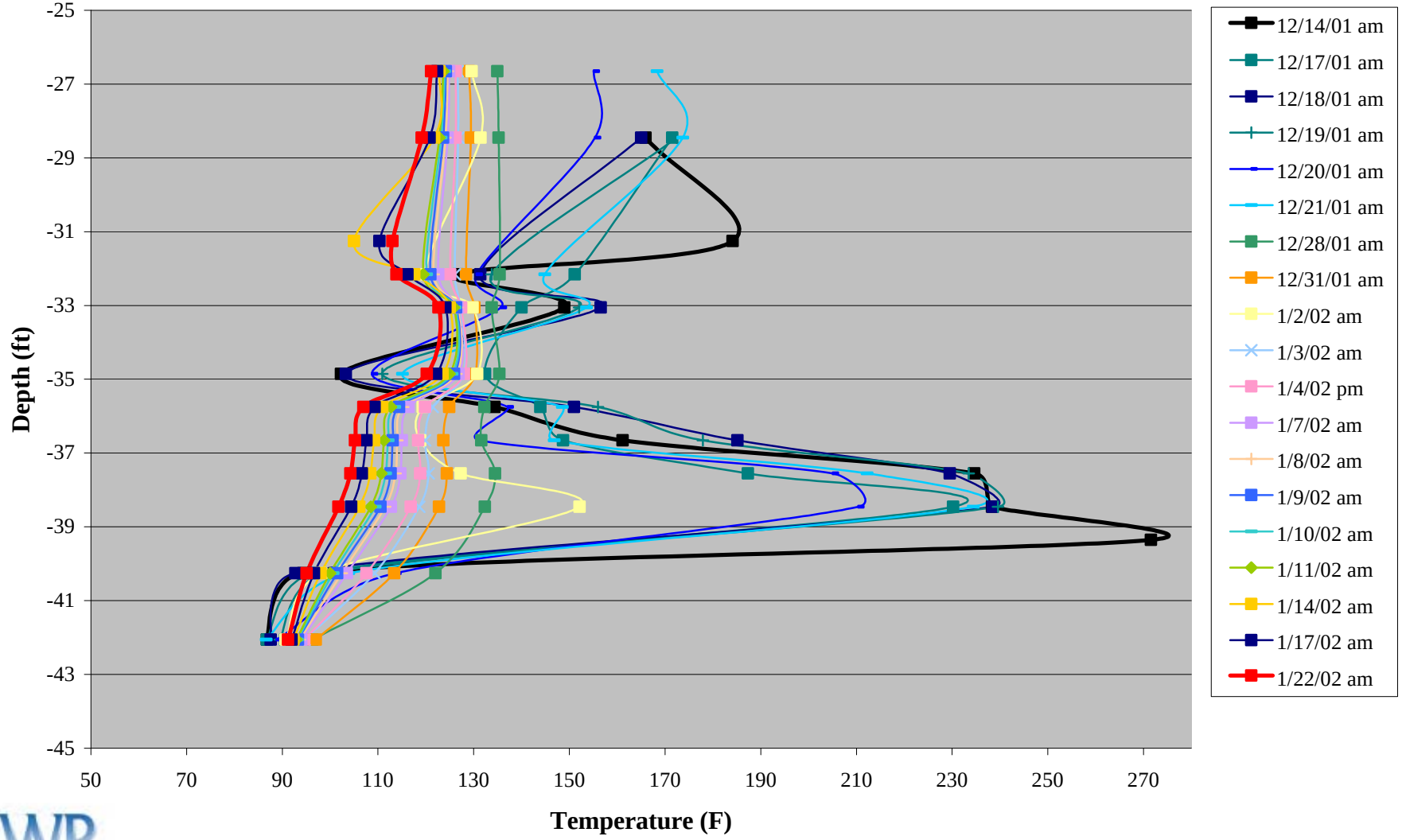
Cape Canaveral Steam Demonstration VE-13 S,D Temperature vs. Depth



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