APPENDIX G

Geologic and Hydrogeologic Information

MEMO

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Design

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From:

Jonathan Roller

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Date:

December 10, 2019

Arcadis Project No.:

30016349

Subject:

Groundwater Flow Model Development CSX Transportation, INC., Waycross Yard, Waycross, Georgia

MODEL OBJECTIVES

In order to further understand groundwater flow and potential impacts of remedy pumping operations at the CSX Transportation, Inc (CSXT). Waycross Yard located in Waycross, Georgia (Site) a numerical groundwater flow model was developed. The groundwater flow model was developed using available Site and regional data and was calibrated to recent observed water levels. The calibrated groundwater flow model was then utilized to evaluate the hydraulic control of the delineated groundwater impacts under current remedy horizontal and vertical pumping wells.

GROUNDWATER FLOW MODEL

Groundwater Flow Modeling Software

The groundwater flow component of the modeling task was performed using the Modular Three-Dimensional Finite-Difference Groundwater Flow Model, widely known as MODFLOW (McDonald and Harbaugh, 1988). MODFLOW was originally distributed by the USGS. The version of MODFLOW used in this modeling task was based on the 1988 version MODFLOW, updated to include the most recent packages from the USGS. Key packages included with the current version of MODFLOW are an integration of the BCF3 (Goode and Appel, 1993) and LPF (Harbaugh et al., 2000) packages, spatially varying anisotropy (Kladias and Ruskauff, 1997), evaporation 2 package (Niswonger, et al., 2011), parameter estimation, and updated solvers (Niswonger, et al., 2011; Mehl and Hill, 2001). Data input is formatted, similar to MODFLOW-88 and MODFLOW-SURFACT (HydroGeoLogic, 1996), to enhance portability to other versions of MODFLOW and to simplify QAQC of data input files.

Model Domain

The groundwater flow model domain covers an area of approximately 3.9 square miles. The model domain extents were located a sufficient distance from the area of concern to reduce the potential for boundary effects. The northwestern and southern model boundaries align with unnamed intermittent surface water features. The northeastern model boundary aligns with the City Drainage Canal. The northern and eastern model boundaries align with interpolated regional groundwater flow paths and isocontours, respectively. The model was not rotated as the finite difference grid is generally aligned with the primary direction of groundwater flow in the vicinity of the Site which minimizes the potential for numerical erroring of the groundwater flow model. The groundwater flow model domain is shown in **Figure 1.**

Model Structure

The model was vertically discretized into 5 layers to represent the hydrostratigraphic units (HSUs) present at the Site as shown in cross-sectional view in **Figure 2**. The three more transmissive units comprised of silty sands and loose silty sands, Zones I, III, and V, are represented by model layers 1, 3, and 5, respectively. The less transmissive units comprised primarily of silty clay or sandy clay, Zones II and IV, are represented by model layers 2 and 4, respectively. The base of the model represents the stiff green clay of the Hawthorn Formation, as minimal groundwater flow occurs between the Hawthorn Formation and the overlying sediments. Model layer elevations were interpolated based on available Site boring logs, and changes in hydraulic conductivity zones were applied in areas where specific units were not encountered.

The finite difference grid is a telescopic mesh with finer grid cell resolution in the area of concern (Site) that grades up to a coarser grid cell dimensions towards the model domain extents. The grid cell dimensions vary from 10 ft x 10 ft in the area of concern up to 200 ft x 200 ft at the model perimeter (**Figure 1**). Adjacent grid cell dimensions do not vary by greater than 50% to reduce the potential for numerical error. The finite difference grid consists of 376 rows, 506 columns, and 5 layers for a total of 951,280 grid cells.

Hydraulic Parameters and Boundary Conditions

Recharge

Typical recharge from precipitation values are approximately 5% to 25% of the annual average precipitation rates. The average annual precipitation for the city of Waycross, Georgia is 50 in/yr (https://www.usclimatedata.com/climate/waycross/georgia/united-states/usga0610). The simulated recharge value refined during the model calibration was at the lower end of the typical recharge range at a value of 2.5 in/yr (5% of the annual precipitation rate).

Hydraulic Conductivity

Initial estimates for hydraulic conductivity were guided by available Site aquifer testing data and lithologic descriptions of the 5 zones encountered at the Site. During the model calibration process, the hydraulic conductivities were refined based on professional judgement. The final calibrated hydraulic conductivity values simulated in the model are shown in **Table 1**:

Table 1. Simulated Hydraulic Conductivity Values

Model Layer	Corresponding HSU Zone	Horizontal Hydraulic Conductivity Range (ft/day)	Vertical / Horizontal Hydraulic Conductivity Ratio	Notes
1	Zone I	5.0	1 / 10	Limited monitoring well data available in Zone 1
2	Zone II	2.0	1 / 10	Higher than anticipated values supported by migration of mass through Zone II to Zone III
3	Zone III	5.0 to 15.0	1 / 10	Primary Zone of impacted groundwater
4	Zone IV	0.01	1 / 100	Holes in clay unit simulated where not present in boring logs; balance of unit relatively tight given the lack of response in Zone III when pumping HWW-5 in Zone V
5	Zone 5	3.0 to 7.0	1 / 10	Primarily characterized due to water level response near Zone V

Surface Water Features

The regional unnamed intermittent surface water features were simulated as drain cell boundary conditions that only allow removal of water from the model if groundwater levels exceed elevation of a drain feature. The City Drainage Canals were simulated as river cells to either serve as a drain to groundwater, or a recharge source depending on the groundwater elevation relative to the defined elevation of the canal. Elevations of both the unnamed intermittent surface water features and City Drainage Canals were estimated from topographic maps of the area. The simulated surface water features are shown in **Figure 3**.

Constant Head Boundaries

The constant head boundaries were simulated at the extents of the active model domain to represent the regional groundwater flow through the deeper Zones of the model. The elevations of these constant head cells were interpolated from the regional groundwater flow through the Site. The constant head cells were located a sufficient distance from the Site to minimize the potential for boundary effects. The simulated constant head cells are shown in **Figure 3**.

Extraction Wells

The only active extraction wells within the model are associated with the Site recovery system consisting of 5 horizontal wells and 11 vertical wells. The cumulative rate for the vertical wells was evenly distributed across all 11 vertical wells as individual vertical well flow rates are not available. The horizontal wells were simulated as a continuous series of wells located only along the screened portion of the horizontal extraction well. The horizontal well extraction rate for each of the horizontal wells were then evenly distributed across the cells representing the screened portion of the horizontal well. The locations of the simulated extraction wells are shown in **Figure 3**.

Groundwater Flow Model Calibration

Calibration of a groundwater flow model refers to the iterative process of systematically adjusting the model boundary conditions and input parameters within a justifiable and generally accepted range of values to obtain as close a match between observed and simulated water levels. The generally-accepted process for comparison of simulated and observed water levels is summarized in ASTM Standard D-5490-93 (ASTM 1994) and utilizes the concept of residuals – which is the difference between the simulated and observed water level.

The residuals are evaluated using standard statistical measures; residual sum-of-squares (RSS), variance, and mean. The standard deviation (the square root of the variance) is the median error and needs to be small compared to the range in observed data. A well calibrated model will reproduce observed water levels with a maximum median error of 10% or less of the difference between the largest and smallest observed water level (Anderson and Woessner, 1992). The calibration process also evaluates the residuals using the residual mean.

The groundwater modelling calibration was performed under steady-state conditions based on data from a synoptic water-level round conducted on October 21, 2019 representative of groundwater flow conditions under active remedy pumping. The calibration data set consists of 128 observed Site water levels under the following pumping rates shown in **Table 2**:

Table 2. Calibration extraction well rates

Well	Type	Rate (gpm)
HWW-1	Horizontal Well (Zone III)	34
HWW-2	Horizontal Well (Zone III)	10.3
HWW-3	Horizontal Well (Zone III)	5
HWW-4	Horizontal Well (Zone III)	6.4
HWW-5	Horizontal Well (Zone V)	6.5
Vertical Wells	11 Vertical wells	3.1

The resultant calibration is shown graphically in **Figure 4**. The scaled standard deviation is 10%, the residual mean is 0.1, and the scaled residual mean is 0.01. There is still local variation in the calibration residuals given the complexity and the heterogeneity of the hydrogeology encountered at the Site, but the overall residual statistics indicate a well calibrated groundwater flow model. The groundwater flow model calibration was also evaluated qualitatively by comparing the simulated and observed general groundwater flow directions and gradients. This qualitative assessment indicates that the model aligns with observed groundwater flow orientations. The groundwater flow model was run for both non-pumping conditions and recent active pumping rates as of November 2019 as summarized in **Table 3**.

Table 3. Current extraction well rates

Well	Type	Rate (gpm)
HWW-1	Horizontal Well (Zone III)	28
HWW-2	Horizontal Well (Zone III)	10
HWW-3	Horizontal Well (Zone III)	5
HWW-4	Horizontal Well (Zone III)	6
HWW-5	Horizontal Well (Zone V)	7
Vertical Wells	11 Vertical wells	3

gpm = gallons per minute

The simulated water levels under non-pumping conditions for Zones III and V are shown in **Figures 5 and 6**, respectively.

Hydraulic Capture Assessment

Upon completion of the calibration of the groundwater flow model, hydraulic control of Zone III and V groundwater by the remedy wells was assessed by utilizing the volumetric flux model MODular flow ALLocation (MODALL) program (Potter et al., 2008). MODALL uses the same MODFLOW-calculated cell-by-cell flow output as MODPATH (Pollock, 1989), but rather than tracking individual particle paths, it tracks the movement of groundwater in the model. This approach, also described as the volumetric-tracking method, is described in detail by Barlow et al. (2018). For the purpose of this analysis, the recent active pumping rates from November 25, 2019 were evaluated as shown in **Table 3**.

The simulated hydraulic capture under current conditions for Zones III and V are shown in **Figures 7 and 8**, respectively. These simulated water levels are consistent with the observed (October 2019) water levels in Zone III and Zone V strata, shown in **Figures 9 and 10** respectively, in that cones of depression develop around the active horizontal and vertical extraction wells influencing the flow directions in both hydrostratigraphic zones. It must be noted that horizontal wells HWW-1 and HWW-5, both screened in Zone V strata, capture a portion of groundwater from Zone III due to the lack of Zone IV aquitard strata at and upgradient of the well screens. In addition, HWW-5 also captures Zone V groundwater over a significant area despite the relatively low operational extraction rate of 7 gpm. The remaining Zone III wells (HWW-2, HWW-3, HWW-4, and the vertical wells) have minimal hydraulic influence on Zone V groundwater due to the presence of the competent Zone IV aquitard throughout the majority of the Site.

REFERENCES

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LEGEND

Finite Difference Grid Cell

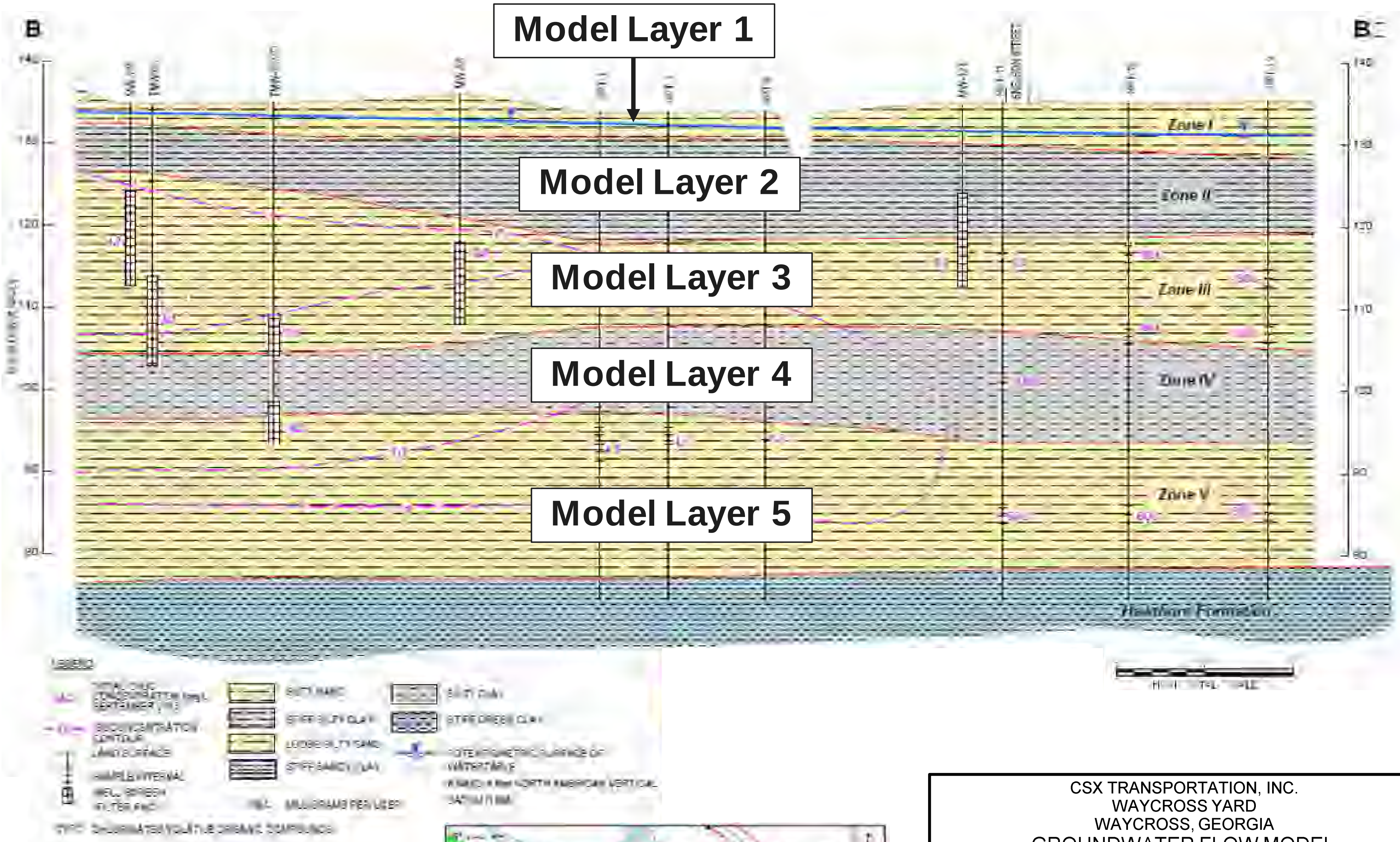
No Flow Cell

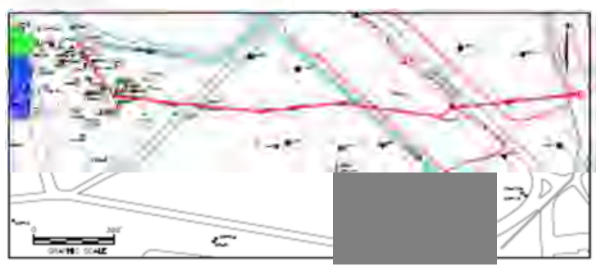
CSX TRANSPORTATION, INC.
WAYCROSS YARD
WAYCROSS, GEORGIA
GROUNDWATER FLOW MODEL

MODEL DOMAIN AND
FINITE DIFFERENCE GRID

ARCADIS

FIGURE
1



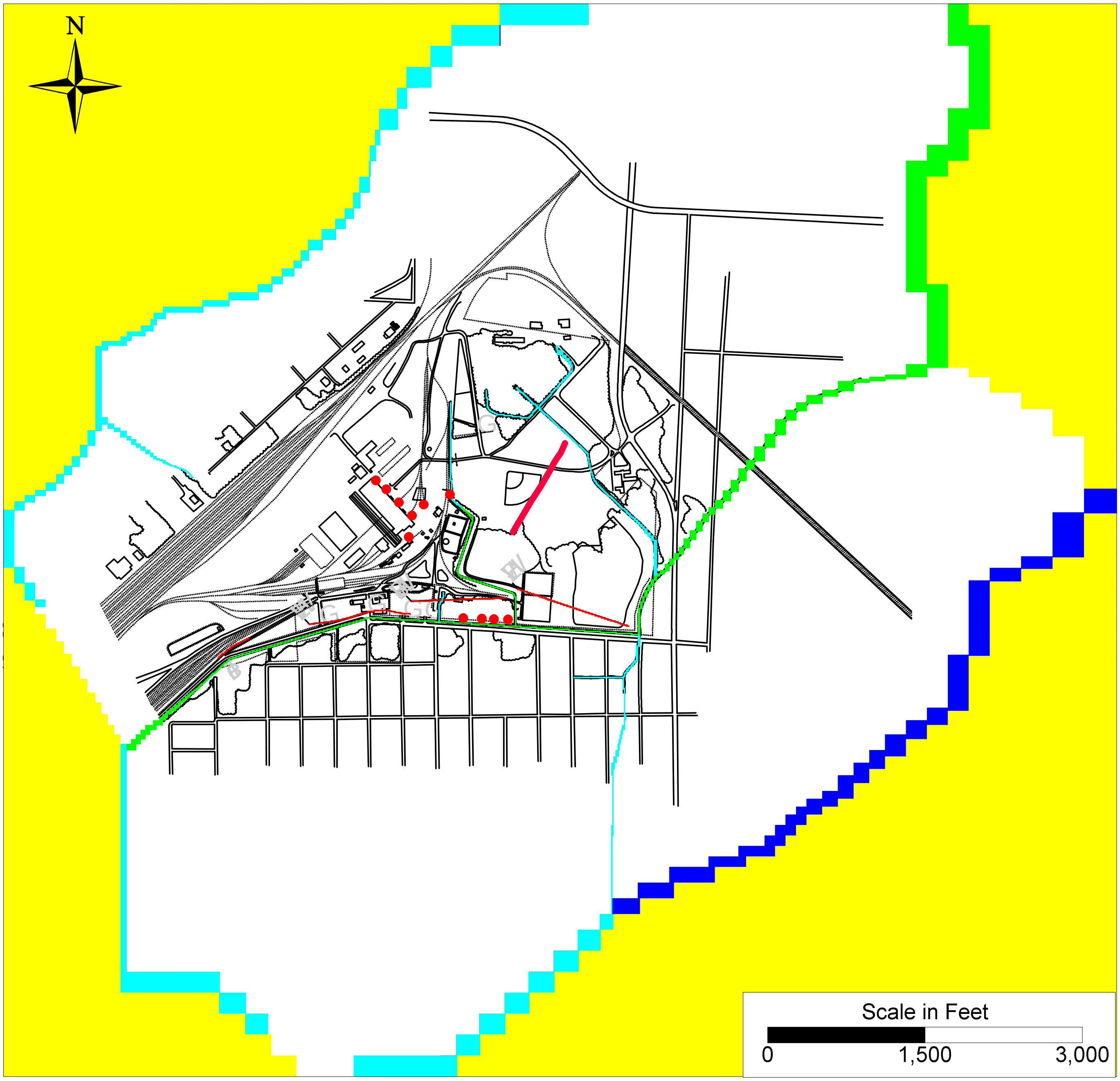


CSX TRANSPORTATION, INC.
WAYCROSS YARD
WAYCROSS, GEORGIA
GROUNDWATER FLOW MODEL

CONCEPTUAL
CROSS-SECTION

ARCADIS

FIGURE
2



LEGEND

- No Flow Cell
- Drain Cell
- River Cell
- Constant Head Cell
- Horizontal Well
- Vertical Well

CSX TRANSPORTATION, INC.
WAYCROSS YARD
WAYCROSS, GEORGIA
GROUNDWATER FLOW MODEL

BOUNDARY CONDITIONS

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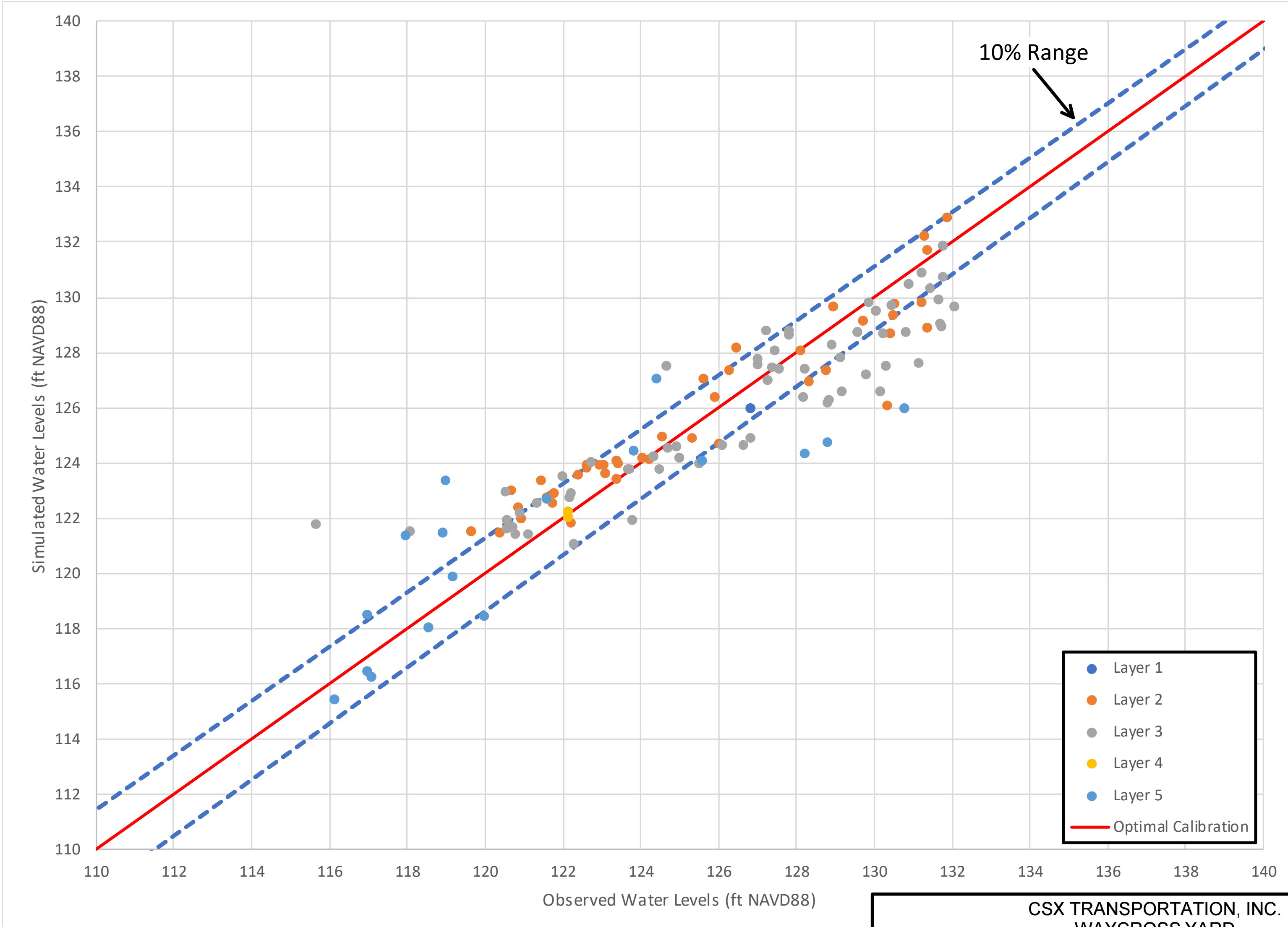
FIGURE
3



Residual Statistics	
Residual Mean	0.1
Residual Standard Deviation	1.7
Sum of Squares	386
Scaled Residual Standard Deviation	10%
Scaled Residual Mean	0.01

CSX TRANSPORTATION, INC.
WAYCROSS YARD
WAYCROSS, GEORGIA
GROUNDWATER FLOW MODEL

CALIBRATION GRAPH

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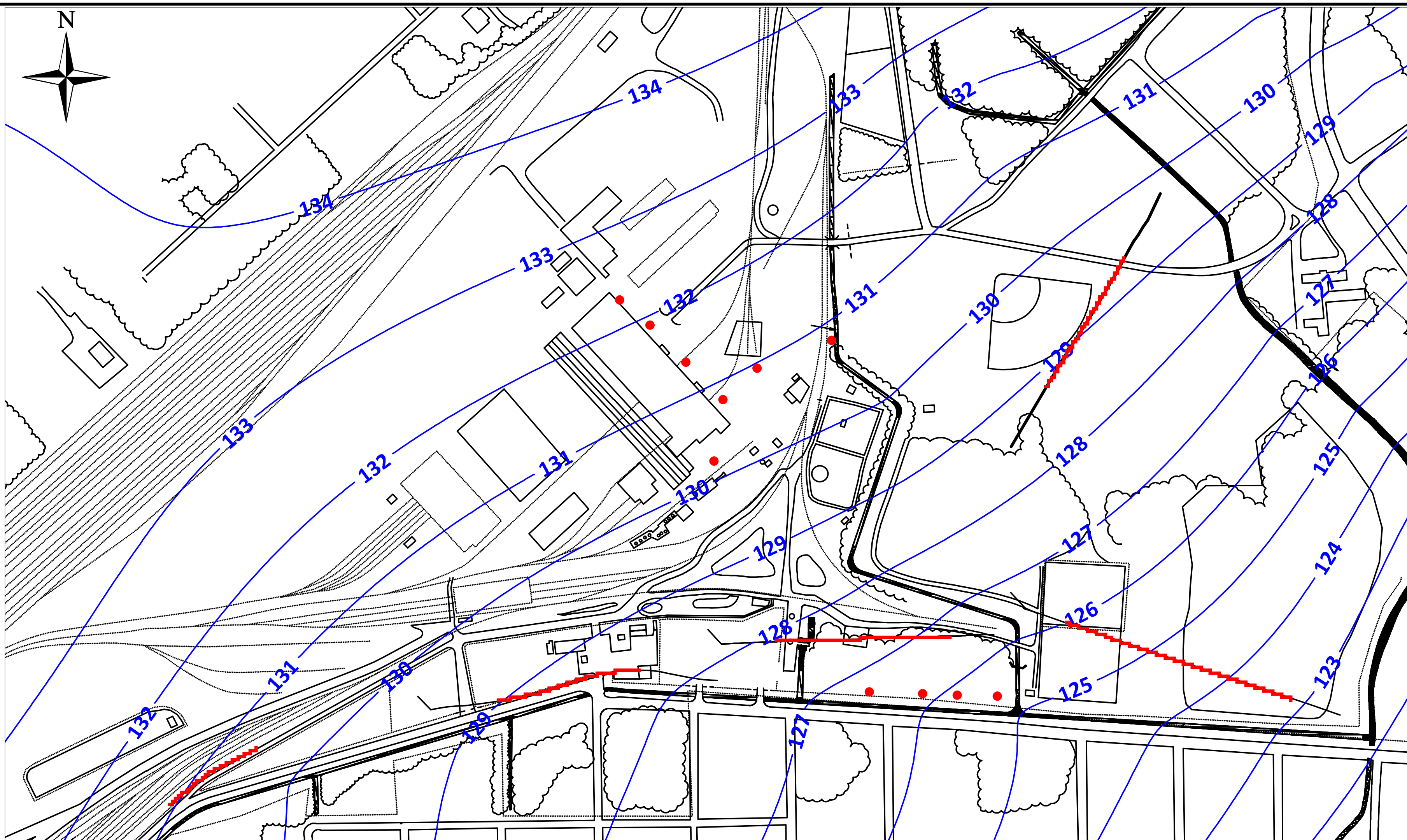
FIGURE
4



LEGEND

Horizontal Well

Vertical Well

120 Simulated Water Level (ft NGVD88)

Scale in Feet

0 500 1,000

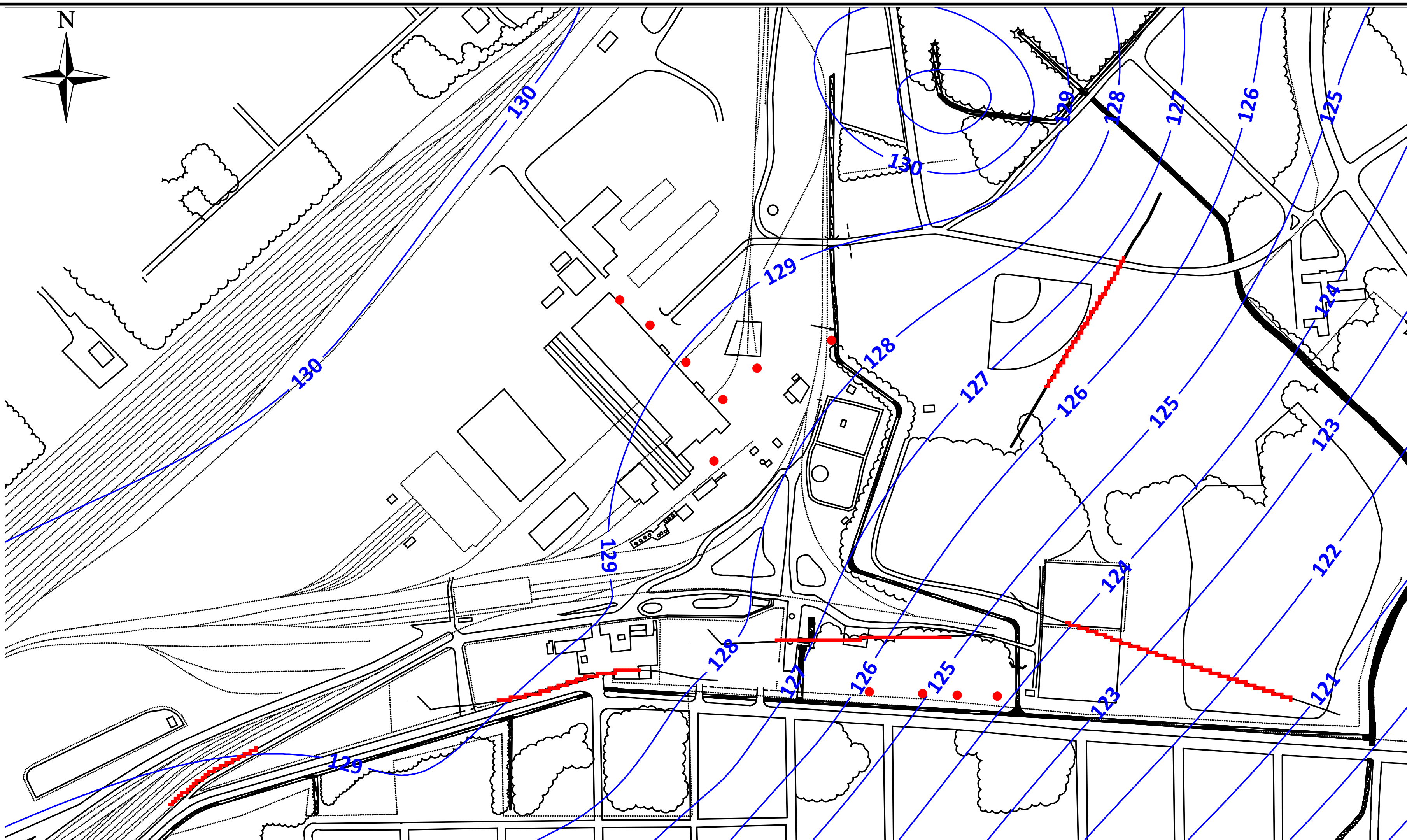
CSX TRANSPORTATION, INC.
WAYCROSS YARD
WAYCROSS, GEORGIA
GROUNDWATER FLOW MODEL

SIMULATED WATER LEVELS
UNDER NON-PUMPING CONDITIONS
IN ZONE III (MODEL LAYER 3)

ARCADIS

FIGURE

5



LEGEND

Horizontal Well

Vertical Well

120 Simulated Water Level (ft NGVD88)

Scale in Feet

0 500 1,000

CSX TRANSPORTATION, INC.
WAYCROSS YARD
WAYCROSS, GEORGIA
GROUNDWATER FLOW MODEL

SIMULATED WATER LEVELS
UNDER NON-PUMPING CONDITIONS
IN ZONE V (MODEL LAYER 5)

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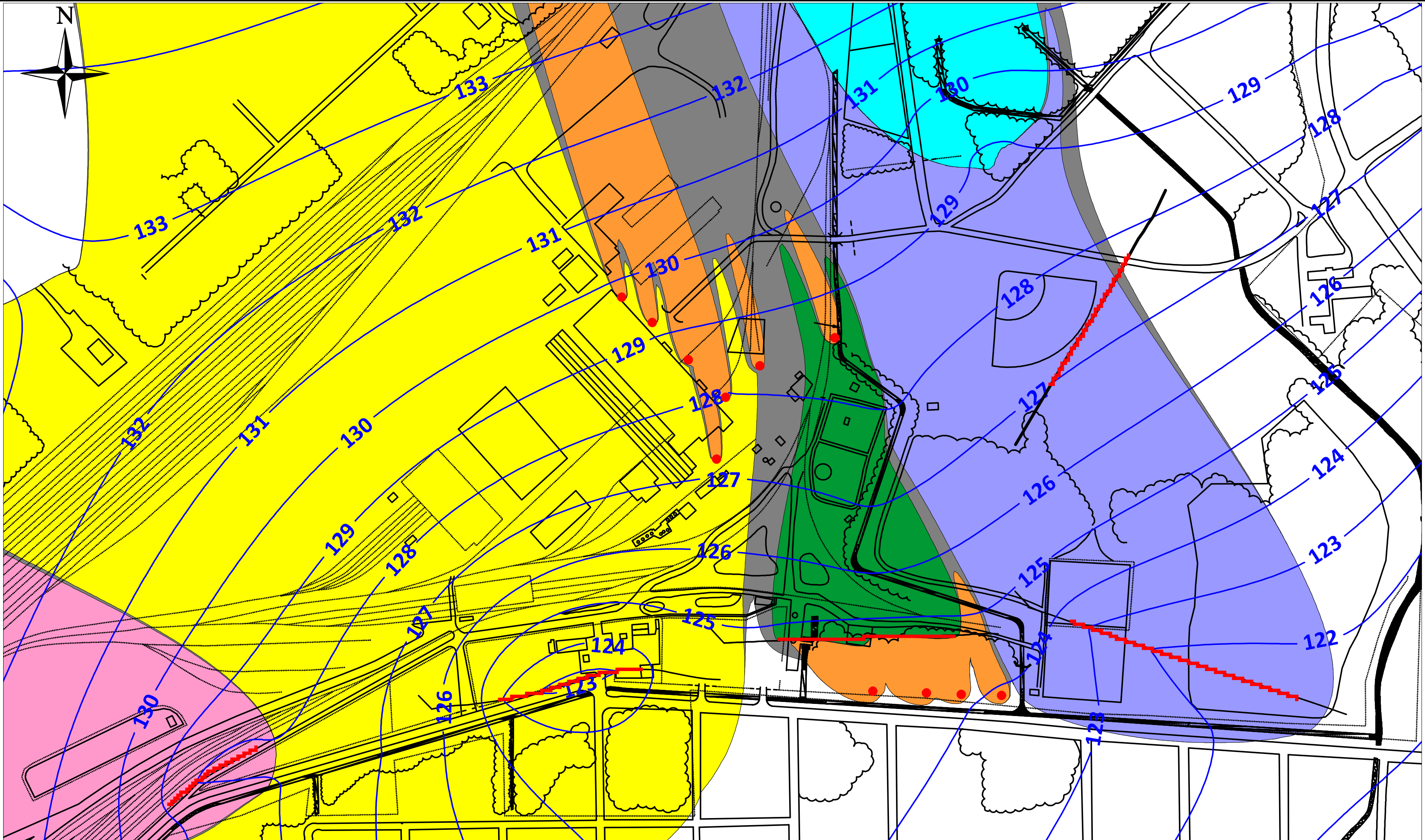
FIGURE
6



LEGEND

Capture Zones

- HWW-1
- HWW-2
- HWW-3
- HWW-4
- HWW-5
- Vertical Wells
- Multiple Well Capture

- Horizontal Well
- Vertical Well
- 120 Simulated Water Level (ft NGVD88)

Scale in Feet

0 500 1,000

CSX TRANSPORTATION, INC.
WAYCROSS YARD
WAYCROSS, GEORGIA
GROUNDWATER FLOW MODEL

SIMULATED HYDRAULIC CAPTURE
IN ZONE III (MODEL LAYER 3)

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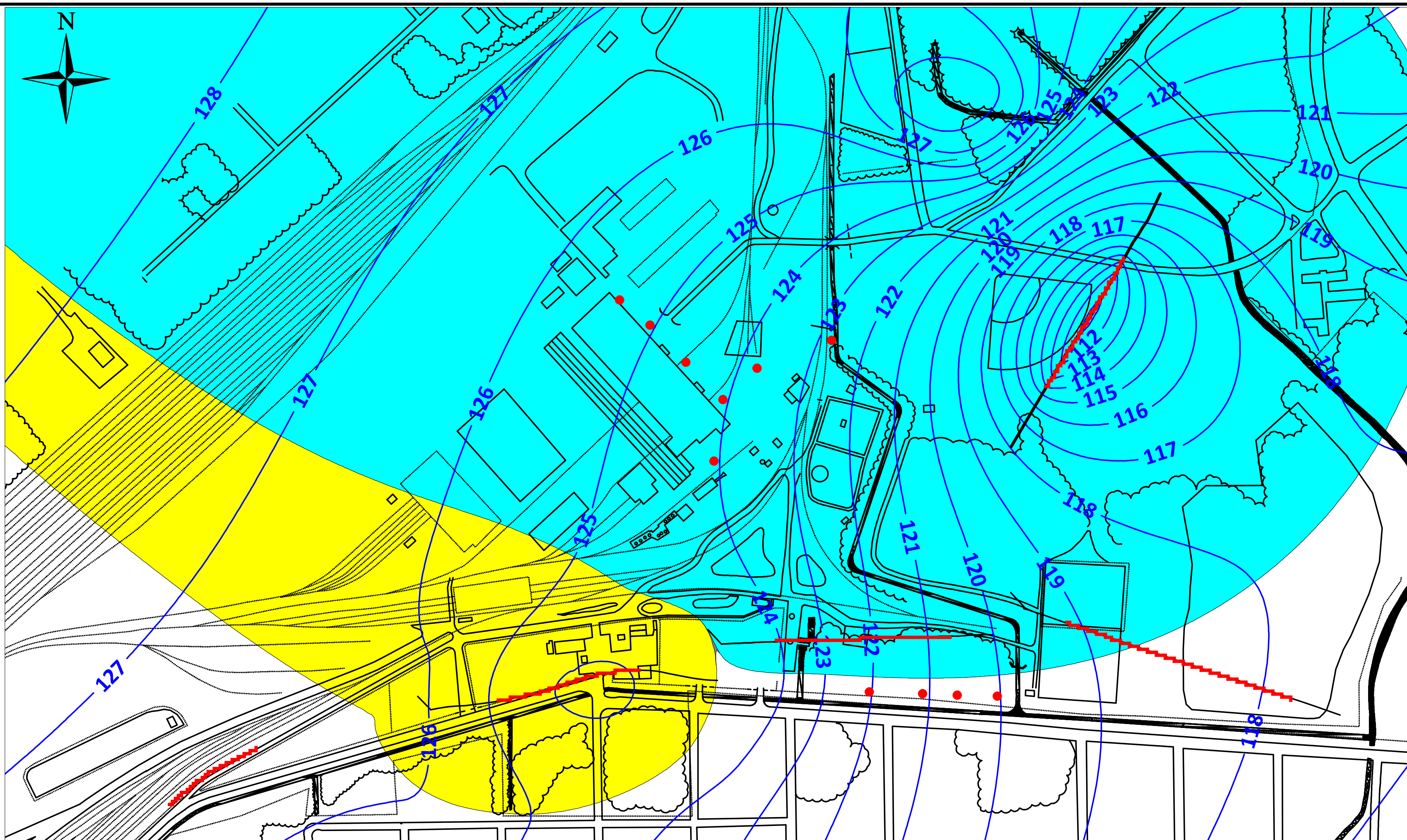
FIGURE
7



Capture Zones

- HWW-1
- HWW-5
- Multiple Well Capture

LEGEND

- Horizontal Well
- Vertical Well
- 120 Simulated Water Level (ft NGVD88)

*HWW-2, HWW-3, HWW-4, and the vertical wells do not have any significant hydraulic capture in Zone V (Model Layer 5)

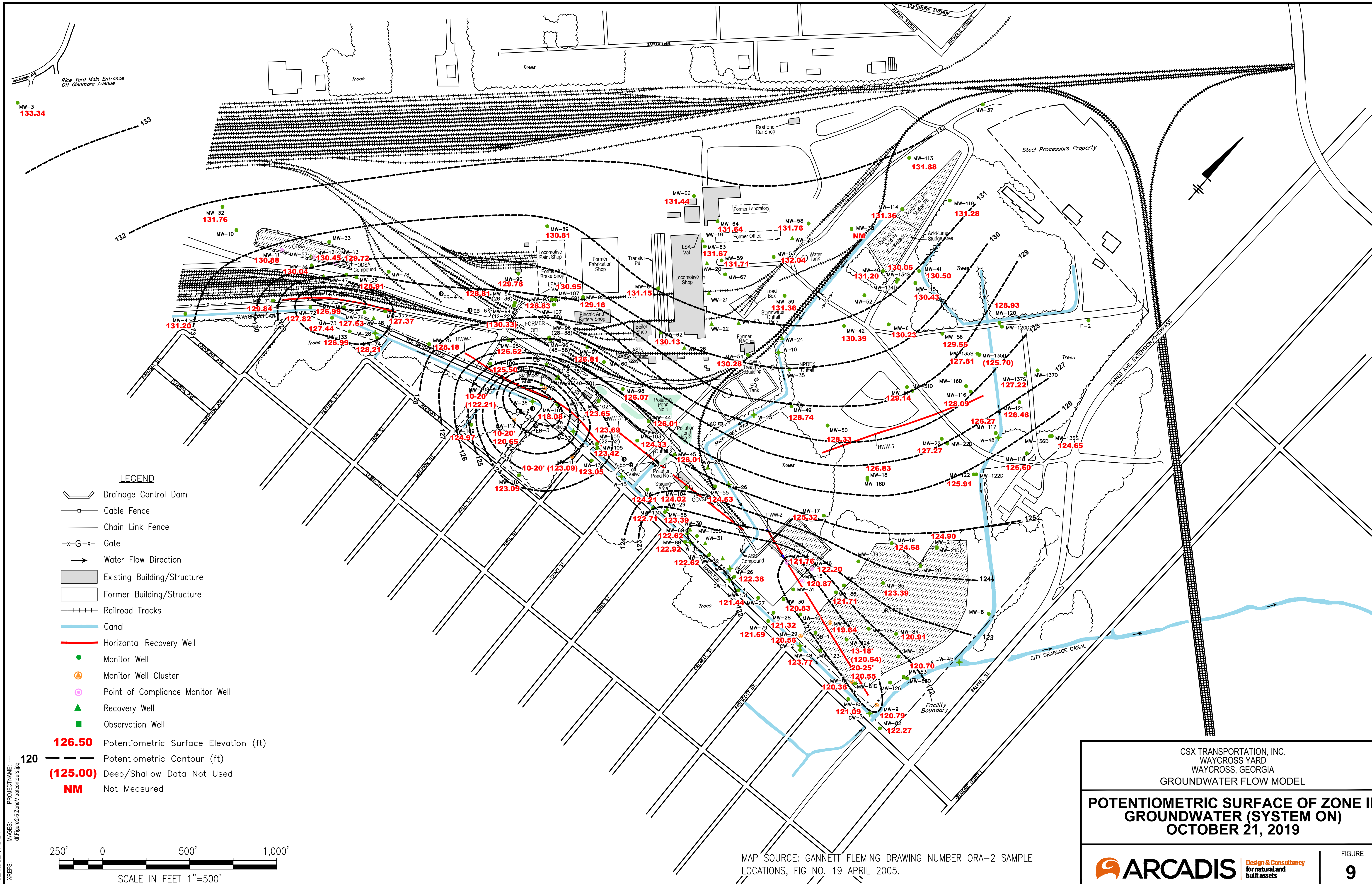
Scale in Feet
0 500 1,000

CSX TRANSPORTATION, INC.
WAYCROSS YARD
WAYCROSS, GEORGIA
GROUNDWATER FLOW MODEL

SIMULATED HYDRAULIC CAPTURE IN ZONE V (MODEL LAYER 5)

ARCADIS

FIGURE 8



CSX TRANSPORTATION, INC.
WAYCROSS YARD
WAYCROSS, GEORGIA
GROUNDWATER FLOW MODEL

POTENTIOMETRIC SURFACE OF ZONE III GROUNDWATER (SYSTEM ON) OCTOBER 21, 2019

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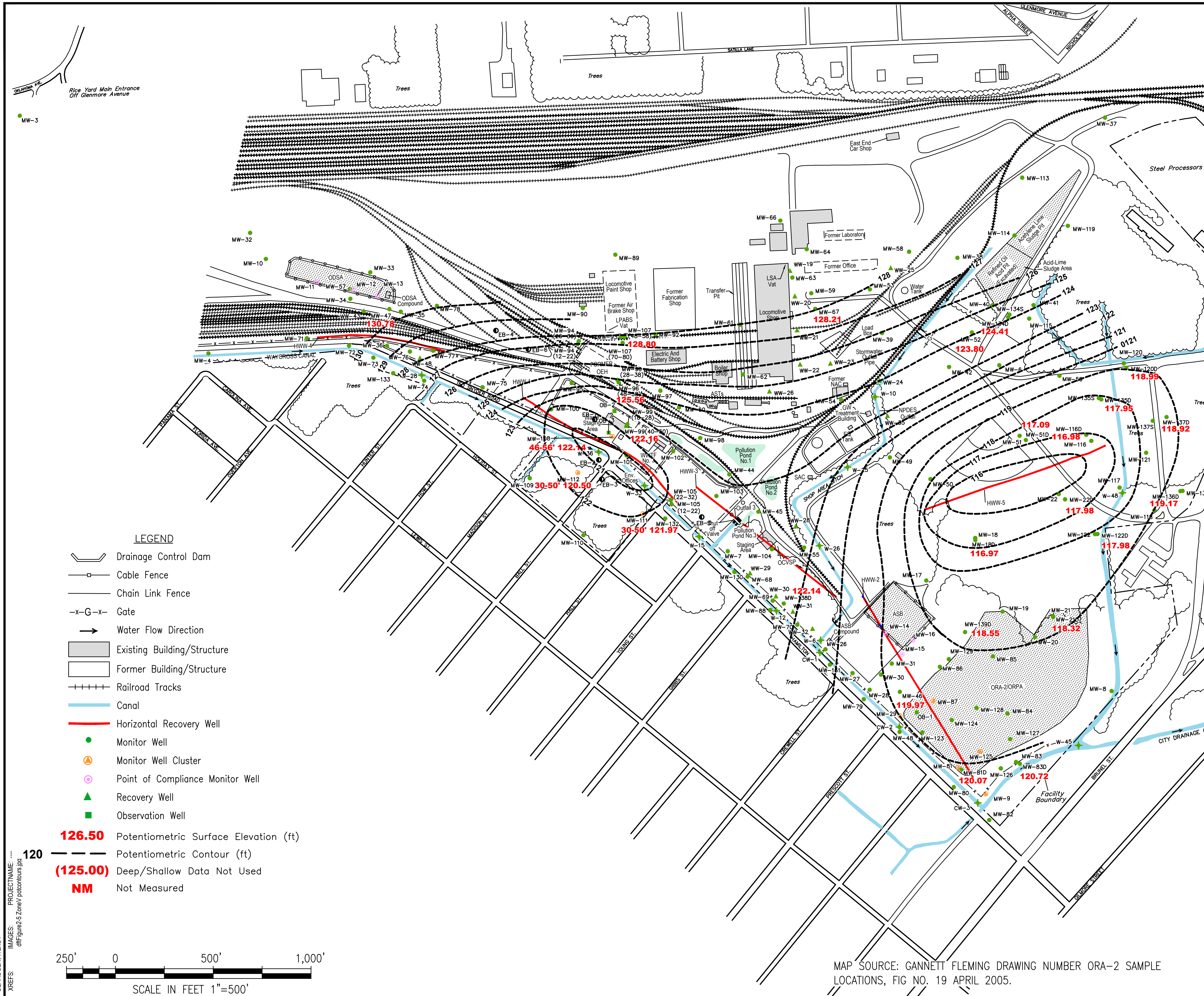
FIGURE
9



CSX TRANSPORTATION, INC.
WAYCROSS YARD
WAYCROSS, GEORGIA
GROUNDWATER FLOW MODEL

POTENTIOMETRIC SURFACE OF ZONE V GROUNDWATER (SYSTEM ON) OCTOBER 21, 2019

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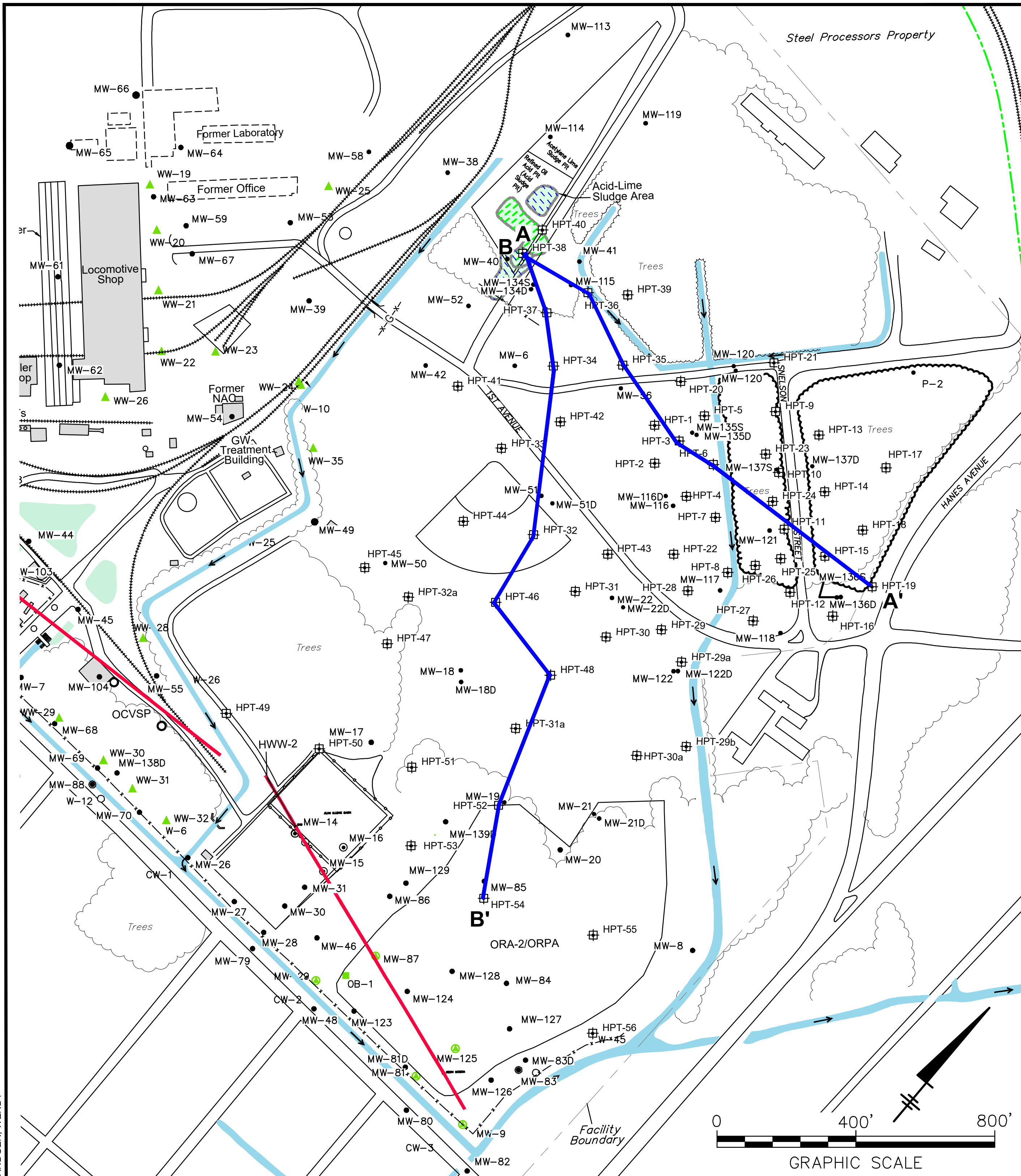
FIGURE 10



LEGEND

Drainage Ditch

Approximate 1993 Excavation Limits

Approximate 2004 Excavation Limits

Monitor Well

HPT/Sample

A — A' Hydrogeologic Transect Location

CSX TRANSPORTATION, INC.
WAYCROSS YARD
WAYCROSS, GEORGIA

INTERIM MEASURES WOR□PLAN
ACID LIME SLUDGE AREA

ALSA GROUNDWATER MONITORING LOCATIONS AND □□DROGEOLOGIC CROSS-SECTION TRANSECTS

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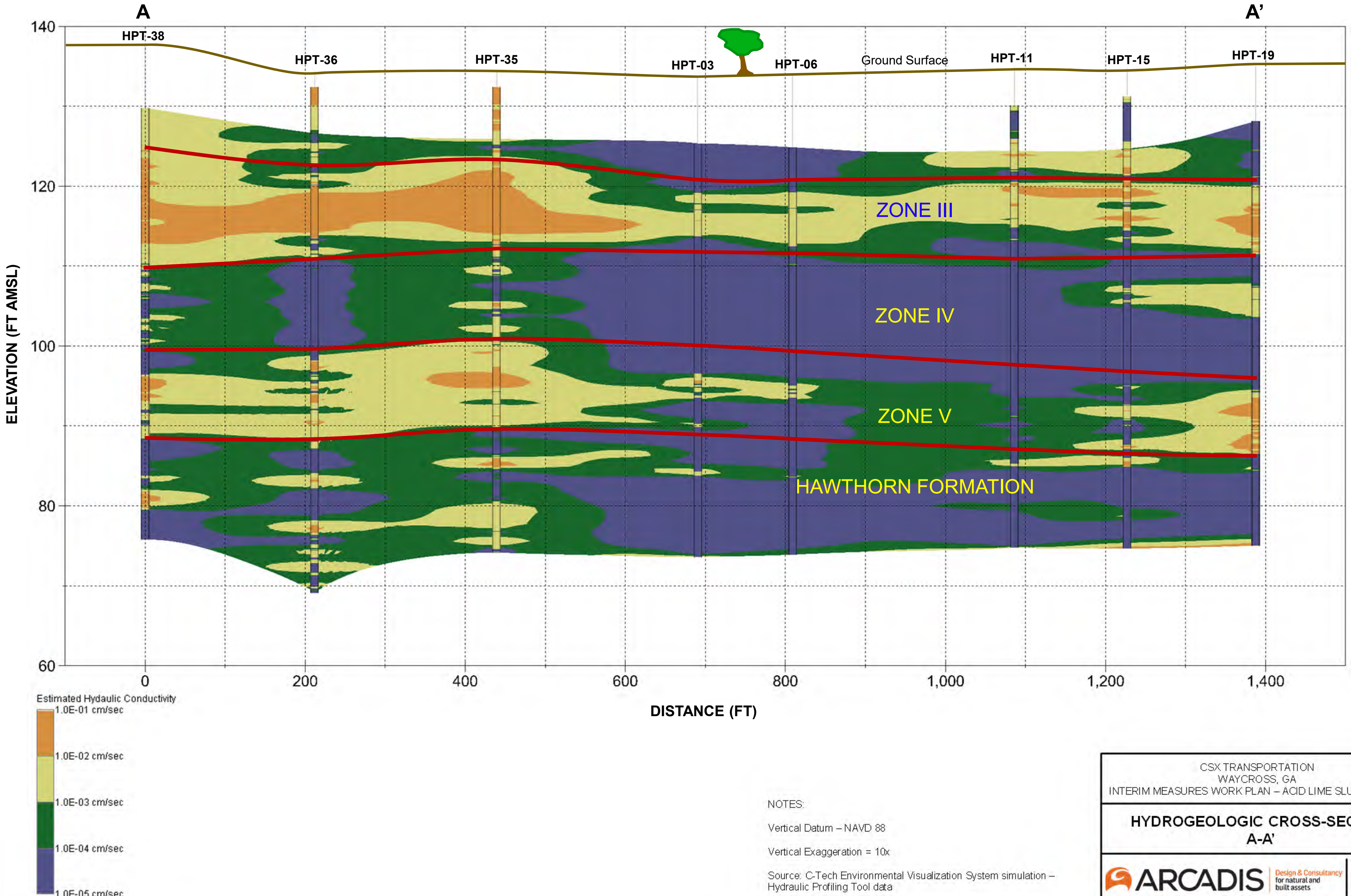
FIGURE
2



NOTES:

Vertical Datum – NAVD 88

Vertical Exaggeration = 10x

Source: C-Tech Environmental Visualization System simulation – Hydraulic Profiling Tool data

CSX TRANSPORTATION
WAYCROSS, GA
INTERIM MEASURES WORK PLAN – ACID LIME SLUDGE AREA

HYDROGEOLOGIC CROSS-SECTION A-A'

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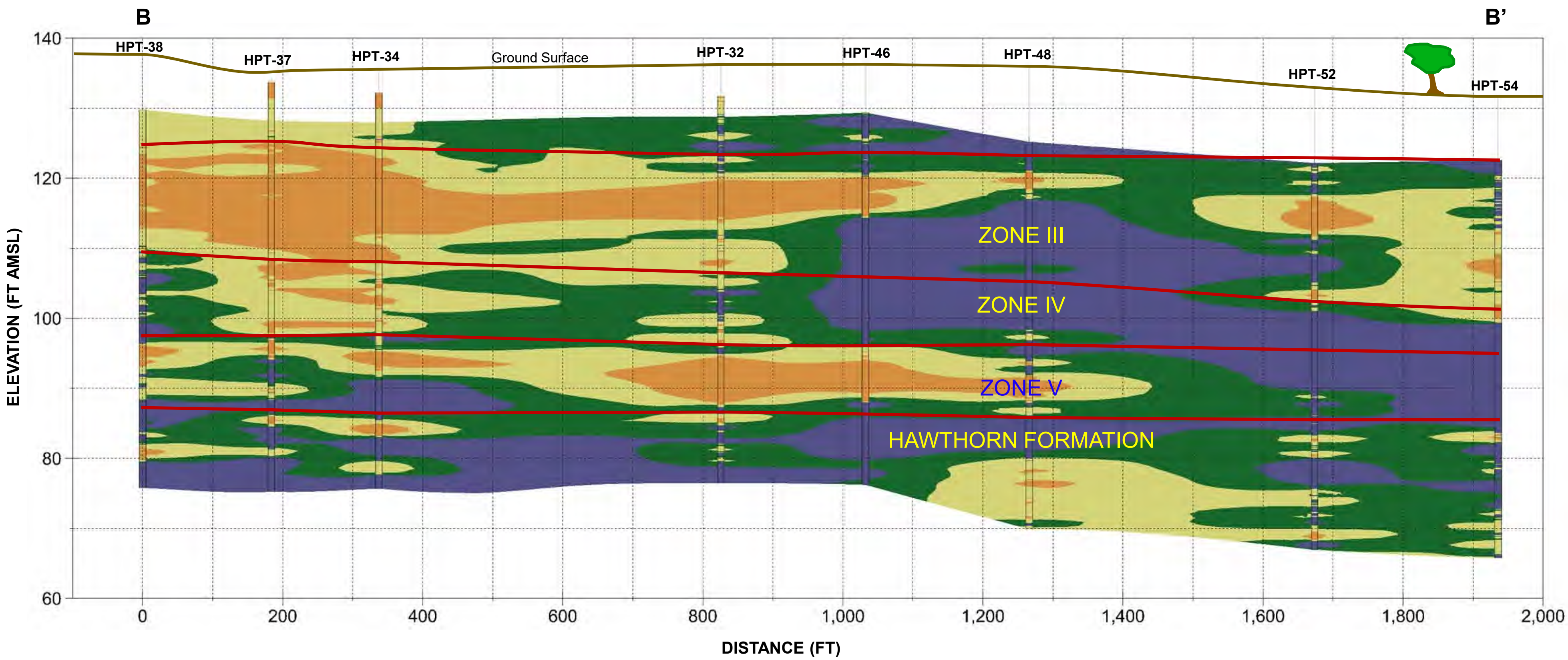
FIGURE **3**



Estimated Hydaulic Conductivity

1.0E-01 cm/sec
1.0E-02 cm/sec
1.0E-03 cm/sec
1.0E-04 cm/sec
1.0E-05 cm/sec

NOTES:

Vertical Datum – NAVD 88

Vertical Exaggeration = 10x

Source: C-Tech Environmental Visualization System simulation – Hydraulic Profiling Tool data

CSX TRANSPORTATION
WAYCROSS, GA
INTERIM MEASURES WORK PLAN – ACID LIME SLUDGE AREA

HYDROGEOLOGIC CROSS-SECTION B-B'

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FIGURE 4

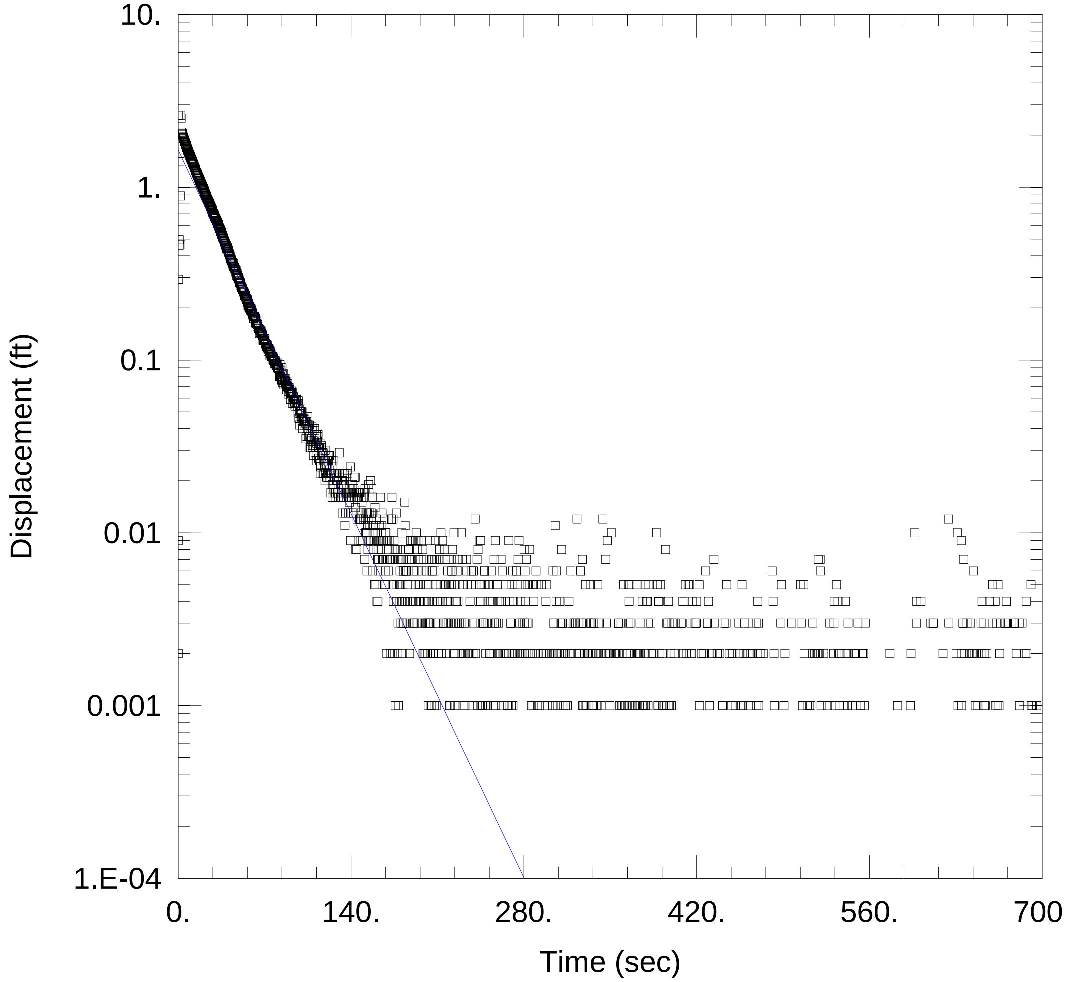
Table 1
Summary Hydraulic Conductivity-
Acid-Lime Sludge Area SWMU
CSX Transporation, Inc.
Waycross, Georgia

DRAFT ARCADIS Design & Consultancy for natural and built assets

ALSA Zone III Monitor Wells	Slug Out	
	cm/sec	ft/day
MW-6	0.003825	10.842536
MW-21	0.0005993	1.698806
MW-22	0.001488	4.217959
MW-56	0.001241	3.517801
MW-135S	0.001071	3.035910
Average Conductivity Zone III	0.00164486	4.662602

ALSA Zone V Monitor Wells		
MW-18D	0.0001299	0.368221
MW-21D	0.0002555	0.724253
MW-51D	0.002535	7.185838
MW-52D	0.005808	16.463647
MW-116D	0.001403	3.977014
MW-122D	0.0001176	0.333355
MW-134D	0.0009834	2.787595
MW-135D	0.002264	6.417648
MW-136D	0.001444	4.093235
MW-137D	0.002456	6.961900
Average Conductivity Zone V	0.00173964	4.931270526

Notes:
ALSA=Acid Lime Sludge Area Solid Waste Management Unit
cm/sec=centimeters per second
ft/day=feet per day
Coversion from cm/sec to ft/day is 1 cm/sec=2,834.65 ft/day



MW-6 SLUG OUT

Data Set: G:\AProject\CSXT\WaycrossRCRA\SC000239.0044 ALSA GW\Slug Tests\MW-6 Slugout.aqt
Date: 12/12/19 Time: 15:55:07

PROJECT INFORMATION

Company: ARCADIS
Client: CSX Waycross
Project: SC000239.0044
Test Location: Waycross, GA
Test Well: MW-6
Test Date: 6/3/2016

AQUIFER DATA

Saturated Thickness: 20.29 ft Anisotropy Ratio (Kz/Kr): 1.

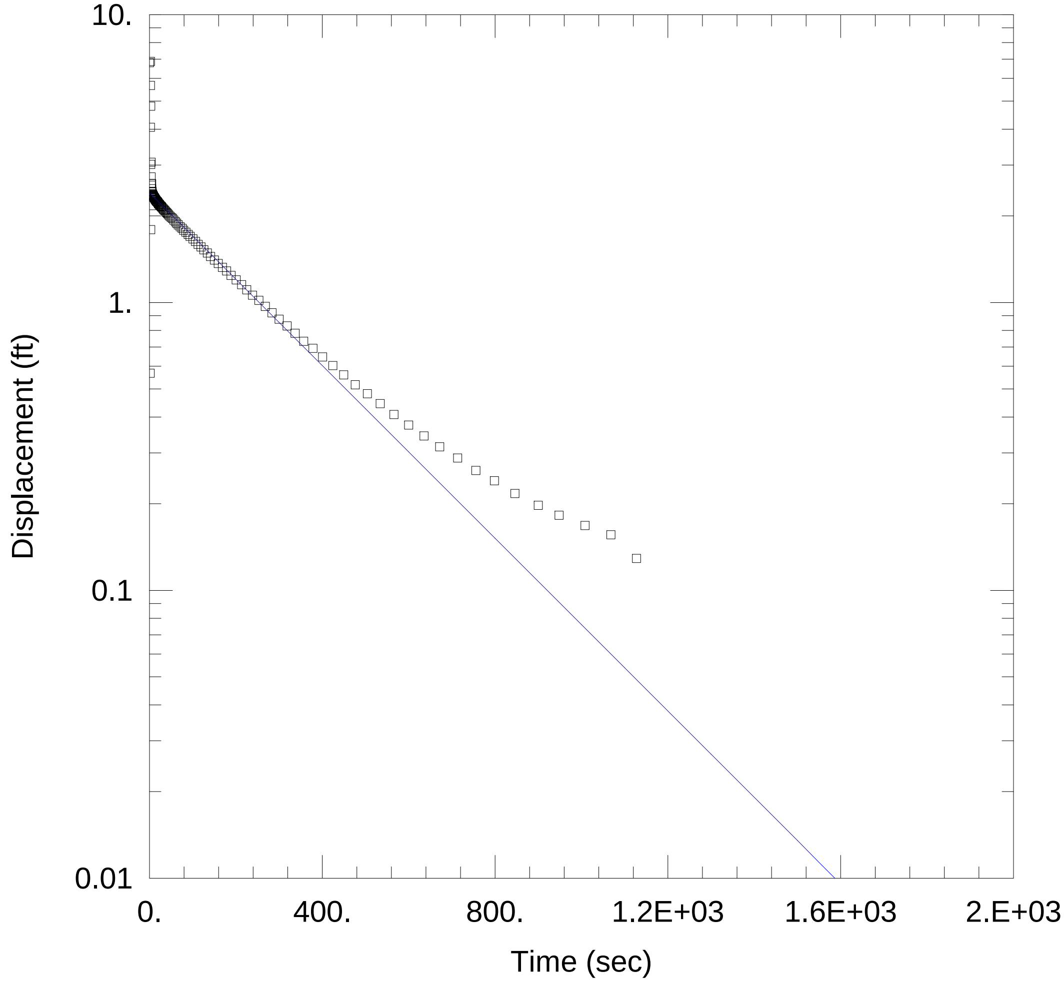
WELL DATA (MW-6 Slugout)

Initial Displacement: 2.6 ft Water Column Height: 20.29 ft
Casing Radius: 0.166 ft Wellbore Radius: 0.5 ft
Screen Length: 10. ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 0.003825 cm/sec y0 = 1.638 ft



MW-18D SLUG OUT

Data Set: G:\...\MW-18D Slug Out.aqt
Date: 12/12/19
Time: 16:03:23

PROJECT INFORMATION

Company: ARCADIS
Client: CSX Waycross
Project: SC000239.0051
Test Location: Waycross, GA
Test Well: MW-18 D
Test Date: 6/18/2017

AQUIFER DATA

Saturated Thickness: 20. ft
Anisotropy Ratio (Kz/Kr): 1.

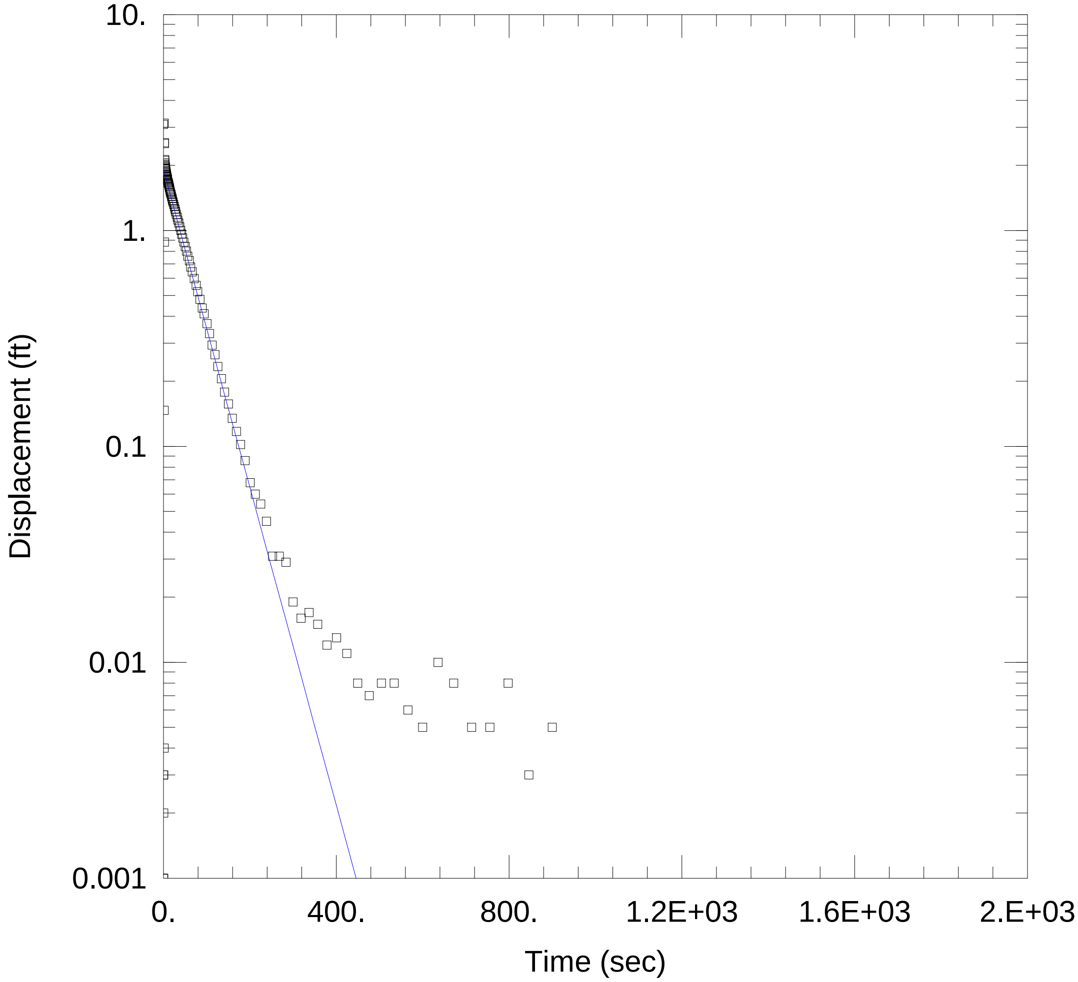
WELL DATA (MW-18D Out)

Initial Displacement: 6.8 ft
Water Column Height: 36.25 ft
Casing Radius: 0.0833 ft
Wellbore Radius: 0.26 ft
Screen Length: 10. ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 0.0001299 cm/sec
y0 = 2.404 ft



MW-21 SLUG OUT

Data Set: G:\...\MW-21 Slug Out.aqt
Date: 12/12/19 Time: 16:04:20

PROJECT INFORMATION

Company: ARCADIS
Client: CSX Waycross
Project: SC000239.0051
Test Location: Waycross, GA
Test Well: MW-21
Test Date: 6/18/2017

AQUIFER DATA

Saturated Thickness: 15. ft Anisotropy Ratio (Kz/Kr): 1.

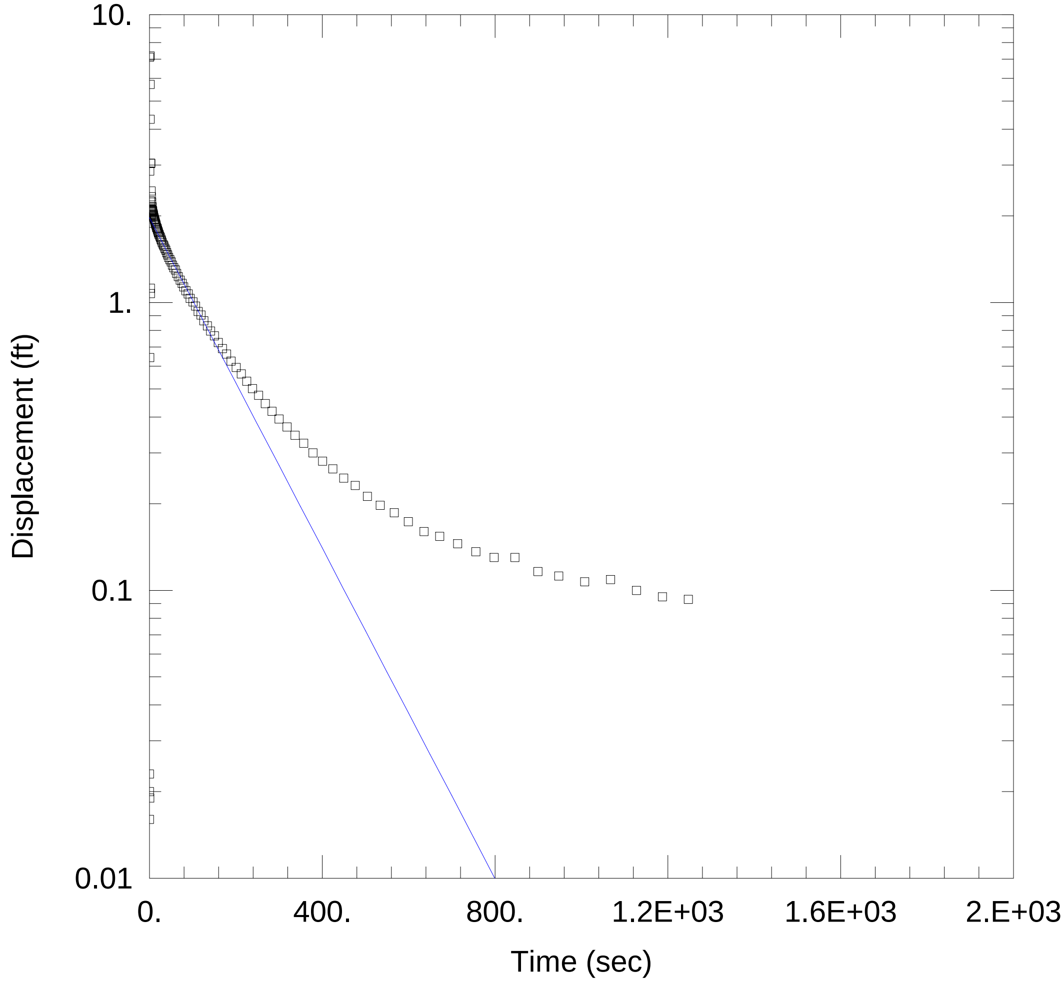
WELL DATA (MW-21 Out)

Initial Displacement: 3.1 ft Water Column Height: 25.1 ft
Casing Radius: 0.0833 ft Wellbore Radius: 0.26 ft
Screen Length: 10. ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 0.0005993 cm/sec y0 = 1.918 ft



MW-21D SLUG OUT

Data Set: G:\...\MW-21D Slug Out.aqt
Date: 12/12/19
Time: 16:04:51

PROJECT INFORMATION

Company: ARCADIS
Client: CSX Waycross
Project: SC000239.0051
Test Location: Waycross, GA
Test Well: MW-21 D
Test Date: 6/18/2017

AQUIFER DATA

Saturated Thickness: 20. ft
Anisotropy Ratio (Kz/Kr): 1.

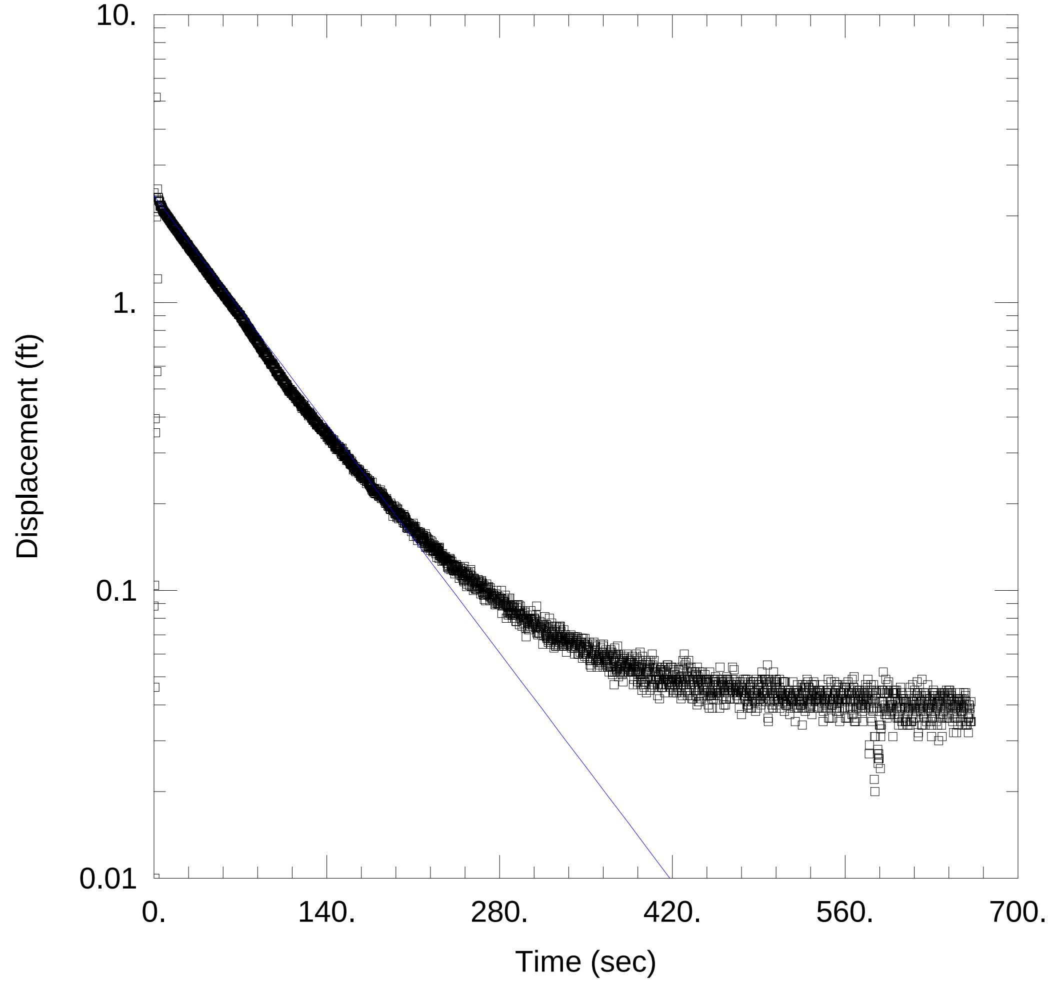
WELL DATA (MW-21D Out)

Initial Displacement: 7.1 ft
Water Column Height: 43.35 ft
Casing Radius: 0.0833 ft
Wellbore Radius: 0.26 ft
Screen Length: 10. ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 0.0002555 cm/sec
y0 = 1.968 ft



MW-22 SLUG OUT

Data Set: G:\...\MW-22 Slugout.aqt
Date: 12/12/19 Time: 15:54:22

PROJECT INFORMATION

Company: ARCADIS
Client: CSX Waycross
Project: SC000239.0044
Test Location: Waycross, GA
Test Well: MW-22
Test Date: 6/2/2016

AQUIFER DATA

Saturated Thickness: 23.58 ft Anisotropy Ratio (Kz/Kr): 1.

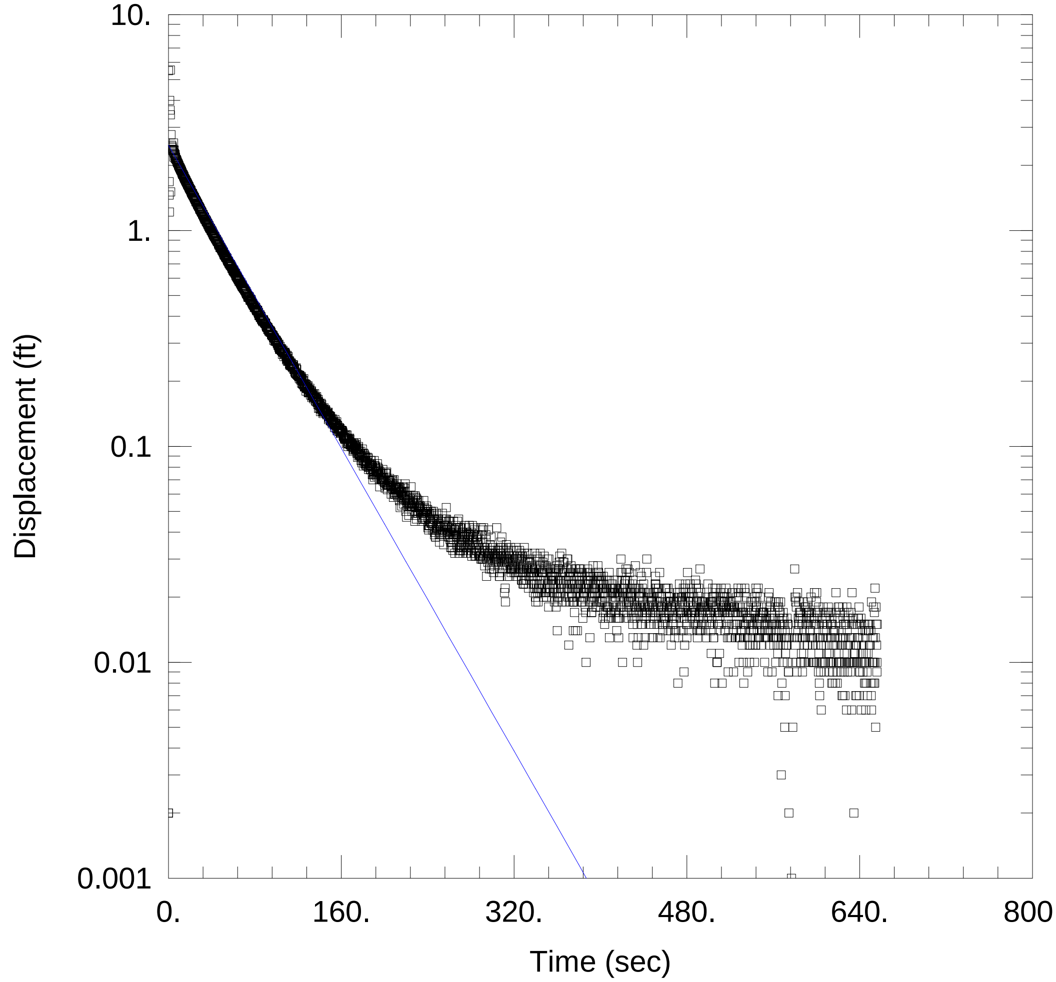
WELL DATA (MW-22 Slugou)

Initial Displacement: 2.4 ft Water Column Height: 23.58 ft
Casing Radius: 0.166 ft Wellbore Radius: 0.5 ft
Screen Length: 10. ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 0.001488 cm/sec y0 = 2.352 ft



MW-51 D SLUG OUT

Data Set: G:\...\MW-51D slug out.aqt
Date: 12/12/19 Time: 15:56:07

PROJECT INFORMATION

Company: ARCADIS
Client: CSX Waycross
Project: SC000239.0044
Test Location: Waycross, GA
Test Well: MW-51 D
Test Date: 6/3/2016

AQUIFER DATA

Saturated Thickness: 24.7 ft Anisotropy Ratio (Kz/Kr): 1.

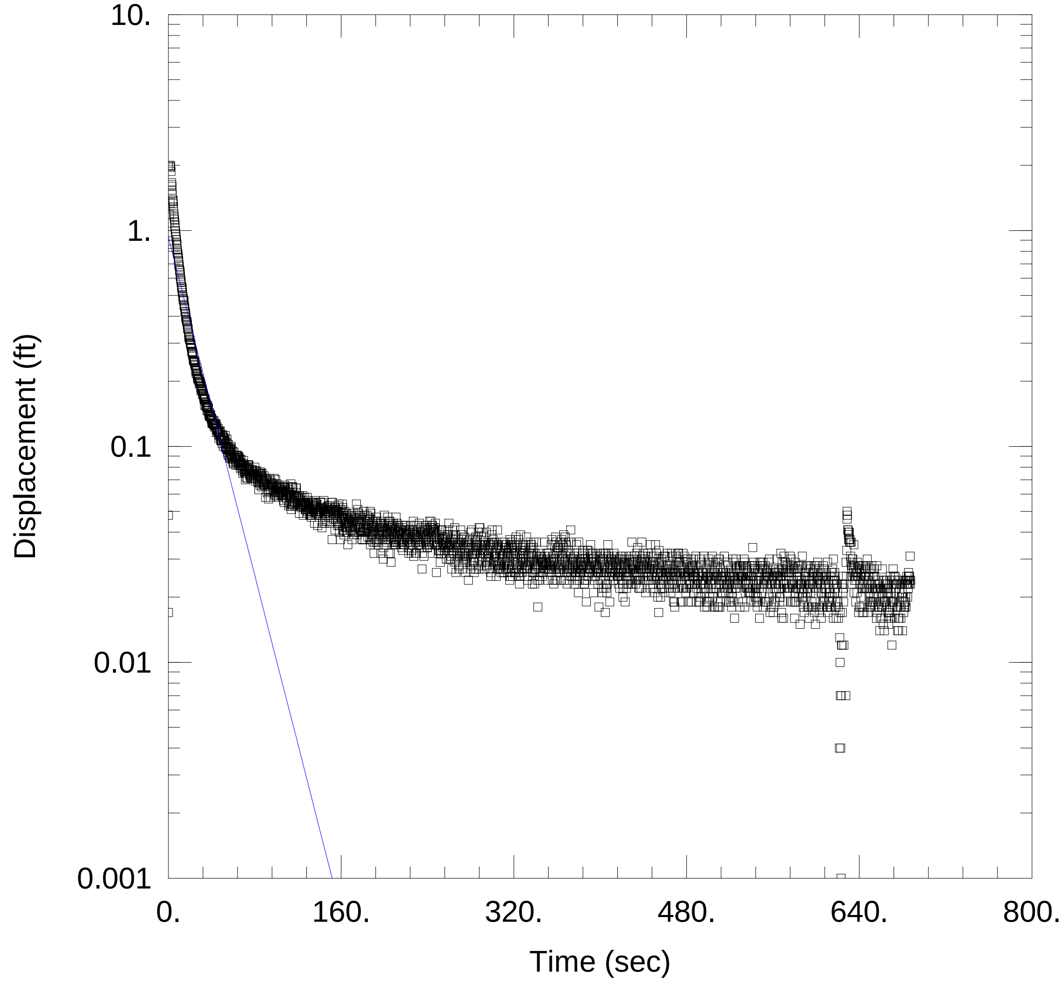
WELL DATA (MW-51Dslugou)

Initial Displacement: 5.5 ft Water Column Height: 39.65 ft
Casing Radius: 0.166 ft Wellbore Radius: 0.5 ft
Screen Length: 10. ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 0.002535 cm/sec y0 = 2.485 ft



MW-52 SLUG OUT

Data Set: G:\...\MW-52 Slug Out.aqt
Date: 12/12/19 Time: 15:56:37

PROJECT INFORMATION

Company: ARCADIS
Client: CSX Waycross
Project: SC000239.0044
Test Location: Waycross, GA
Test Well: MW-52
Test Date: 6/3/2016

AQUIFER DATA

Saturated Thickness: 30. ft Anisotropy Ratio (Kz/Kr): 1.

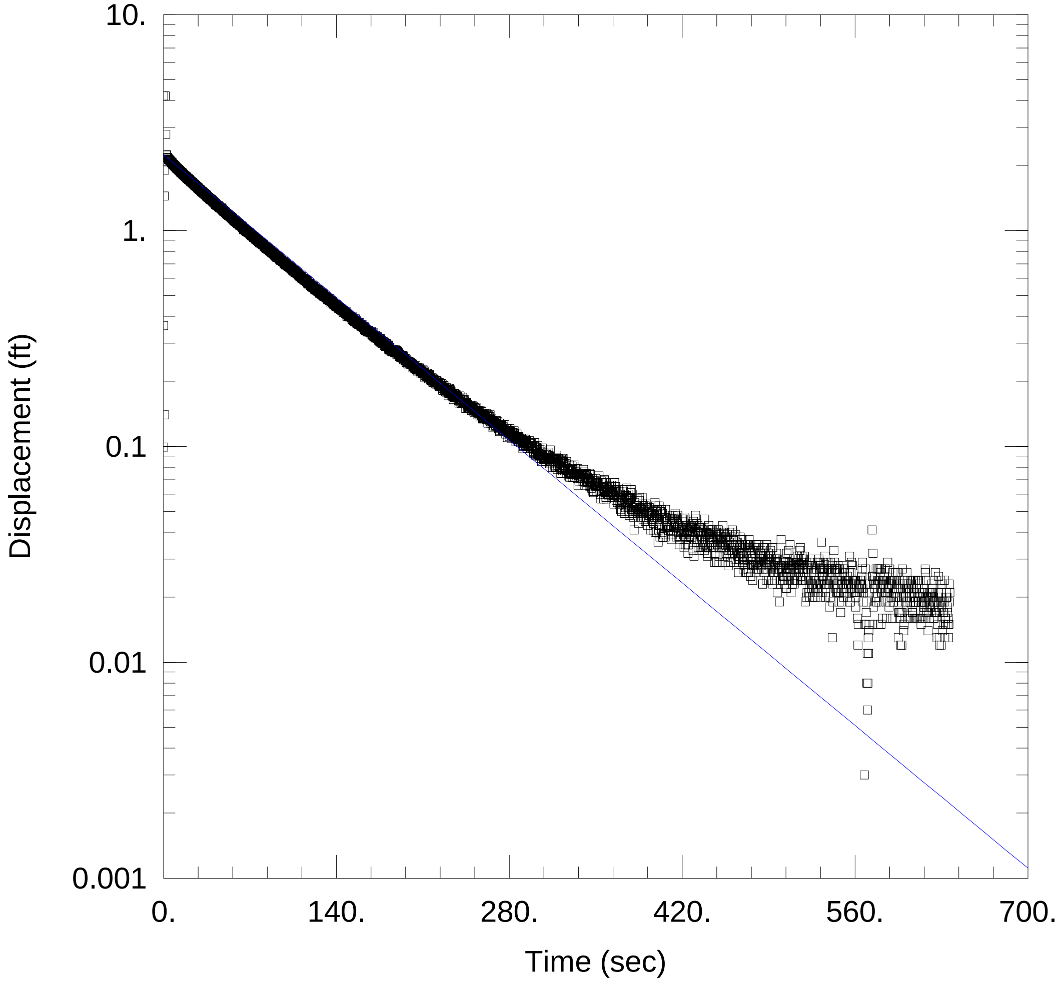
WELL DATA (MW-52)

Initial Displacement: 2. ft Water Column Height: 46.7 ft
Casing Radius: 0.166 ft Wellbore Radius: 0.5 ft
Screen Length: 10. ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 0.005808 cm/sec y0 = 0.9289 ft



MW-56 SLUG OUT

Data Set: G:\...\MW-56 Slug Out.aqt
Date: 12/12/19
Time: 15:57:09

PROJECT INFORMATION

Company: ARCADIS
Client: CSX Waycross
Project: SC000239.0044
Test Location: Waycross, GA
Test Well: MW-56
Test Date: 6/3/2016

AQUIFER DATA

Saturated Thickness: 23. ft
Anisotropy Ratio (Kz/Kr): 1.

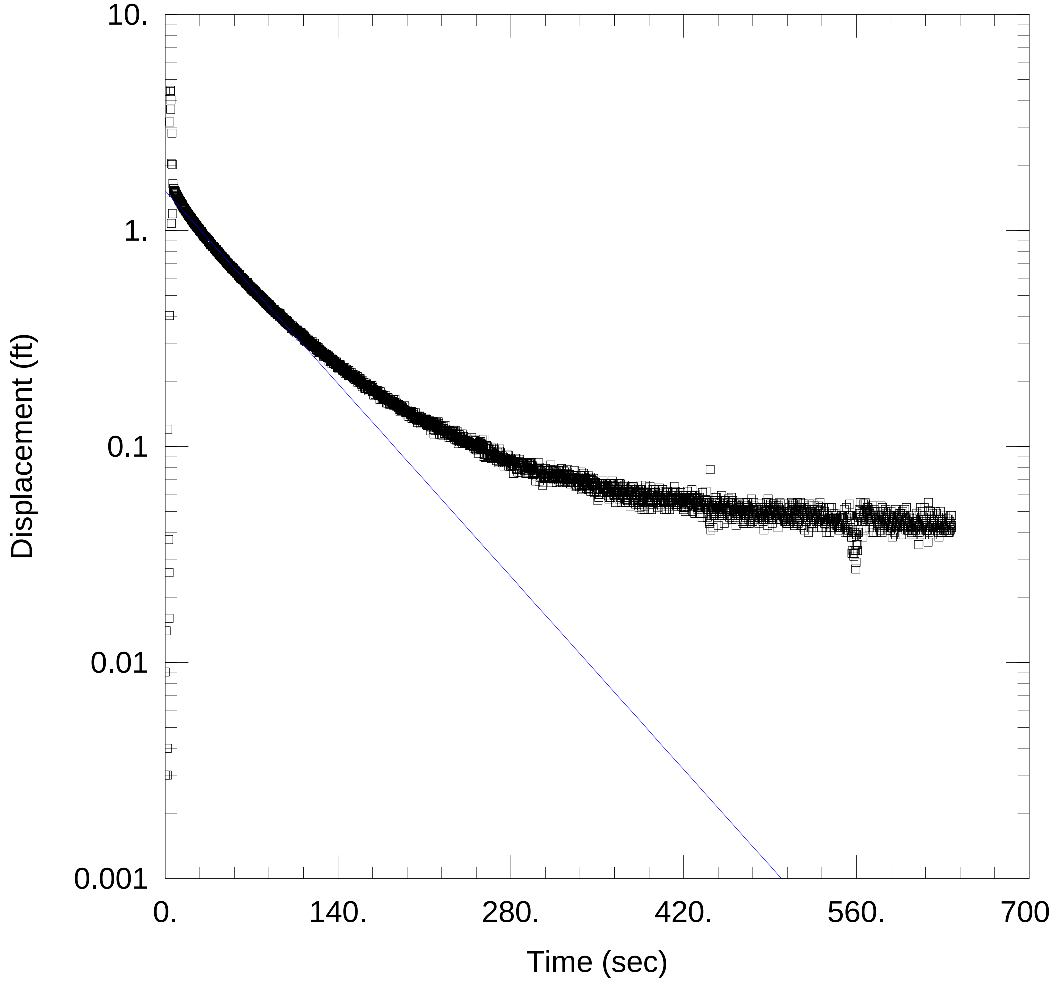
WELL DATA (MW-56 Slugou)

Initial Displacement: 4.2 ft
Water Column Height: 22.9 ft
Casing Radius: 0.166 ft
Wellbore Radius: 0.5 ft
Screen Length: 10. ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.001241 cm/sec
y0 = 2.244 ft



MW-88 SLUG OUT

Data Set: G:\...\MW-88 Slug Out.aqt
Date: 12/12/19
Time: 15:57:37

PROJECT INFORMATION

Company: ARCADIS
Client: CSX Waycross
Project: SC000239.0044
Test Location: Waycross, GA
Test Well: MW-88
Test Date: 6/3/2016

AQUIFER DATA

Saturated Thickness: 23. ft
Anisotropy Ratio (Kz/Kr): 1.

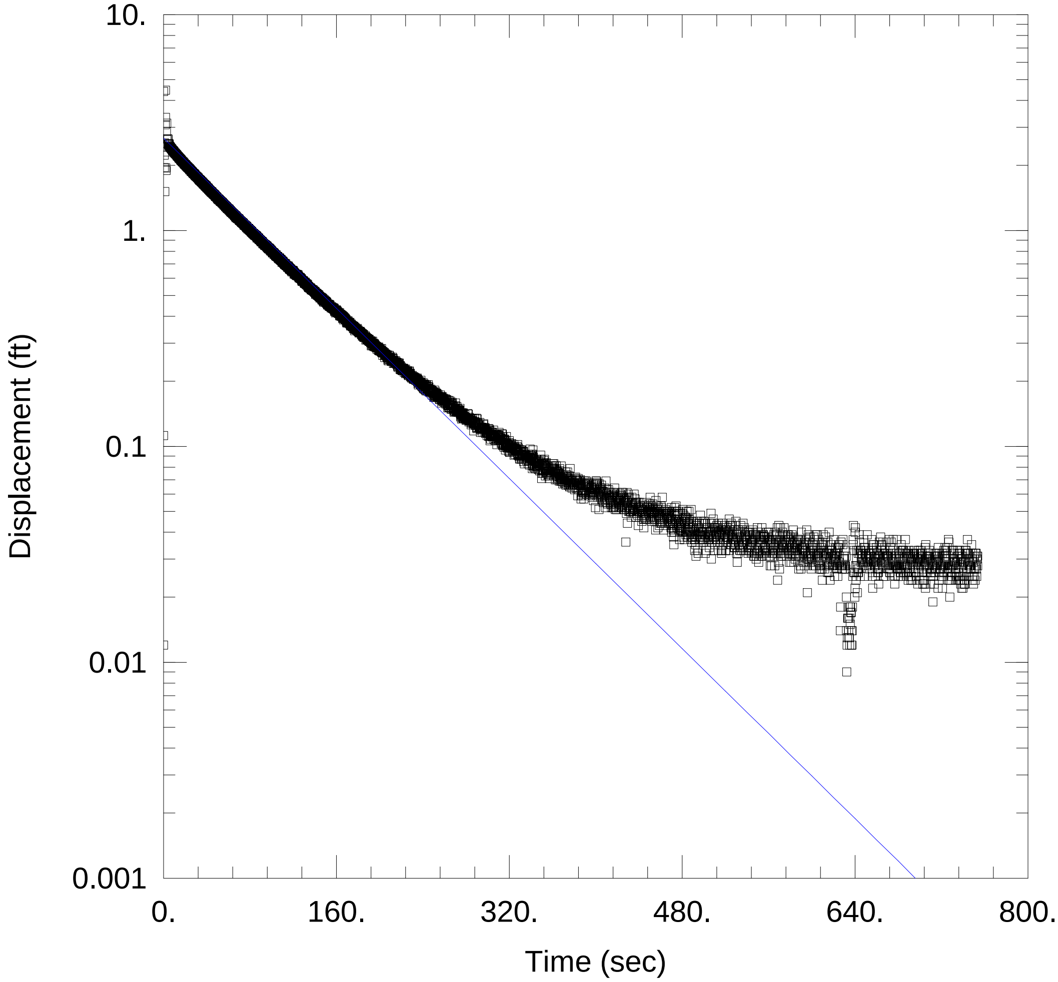
WELL DATA (MW-88 Slugou)

Initial Displacement: 4.4 ft
Water Column Height: 22.2 ft
Casing Radius: 0.166 ft
Wellbore Radius: 0.5 ft
Screen Length: 10. ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.001521 cm/sec
y0 = 1.525 ft



MW-116 D SLUG OUT

Data Set: G:\...\MW-116D slug out.aqt
Date: 12/12/19 Time: 15:58:06

PROJECT INFORMATION

Company: ARCADIS
Client: CSX Waycross
Project: SC000239.0044
Test Location: Waycross, GA
Test Well: MW-116 D
Test Date: 6/2/2016

AQUIFER DATA

Saturated Thickness: 25. ft Anisotropy Ratio (Kz/Kr): 1.

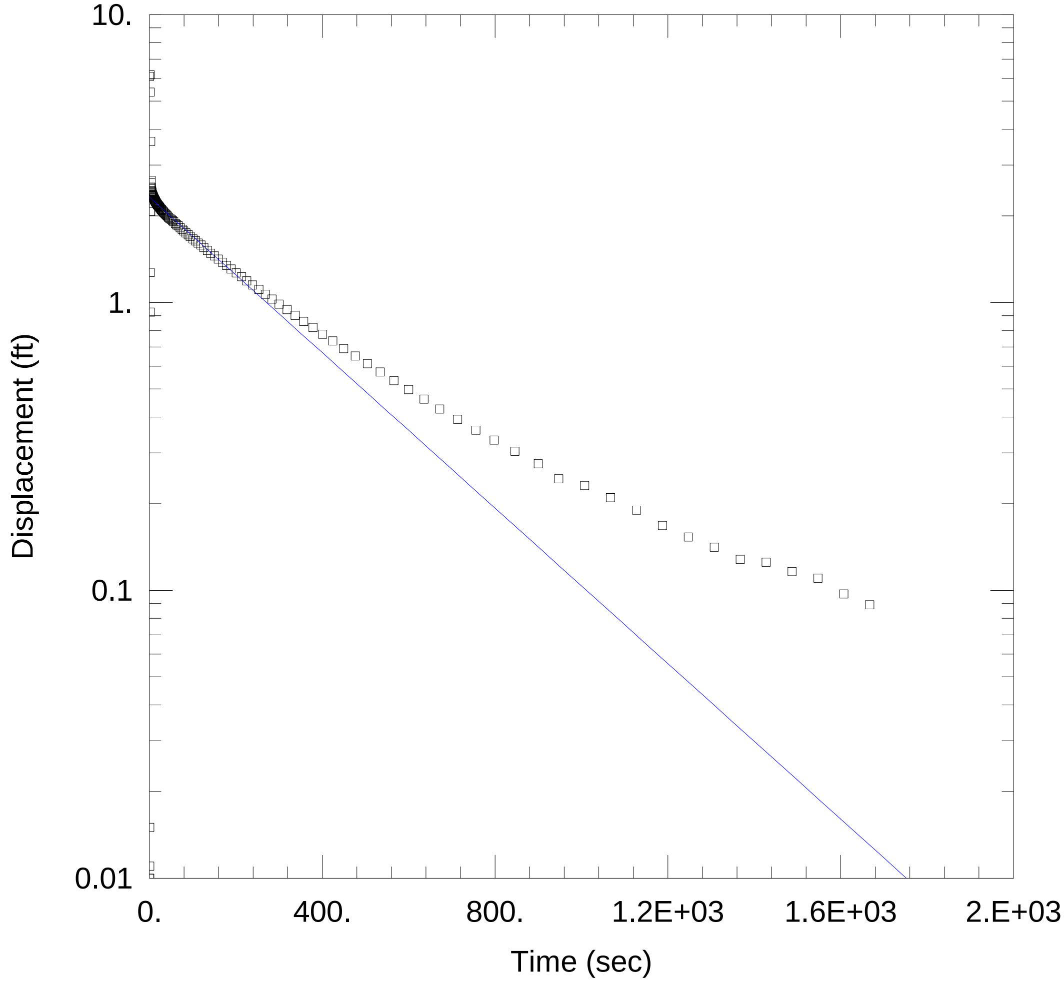
WELL DATA (MW-116Dslugo)

Initial Displacement: 4.4 ft Water Column Height: 36.55 ft
Casing Radius: 0.166 ft Wellbore Radius: 0.5 ft
Screen Length: 10. ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 0.001403 cm/sec y0 = 2.677 ft



MW-122 D SLUG OUT

Data Set: G:\...\MW-122D Slug Out.aqt
Date: 12/12/19 Time: 16:05:40

PROJECT INFORMATION

Company: ARCADIS
Client: CSX Waycross
Project: SC000239.0051
Test Location: Waycross, GA
Test Well: MW-122 D
Test Date: 6/18/2017

AQUIFER DATA

Saturated Thickness: 20. ft Anisotropy Ratio (Kz/Kr): 1.

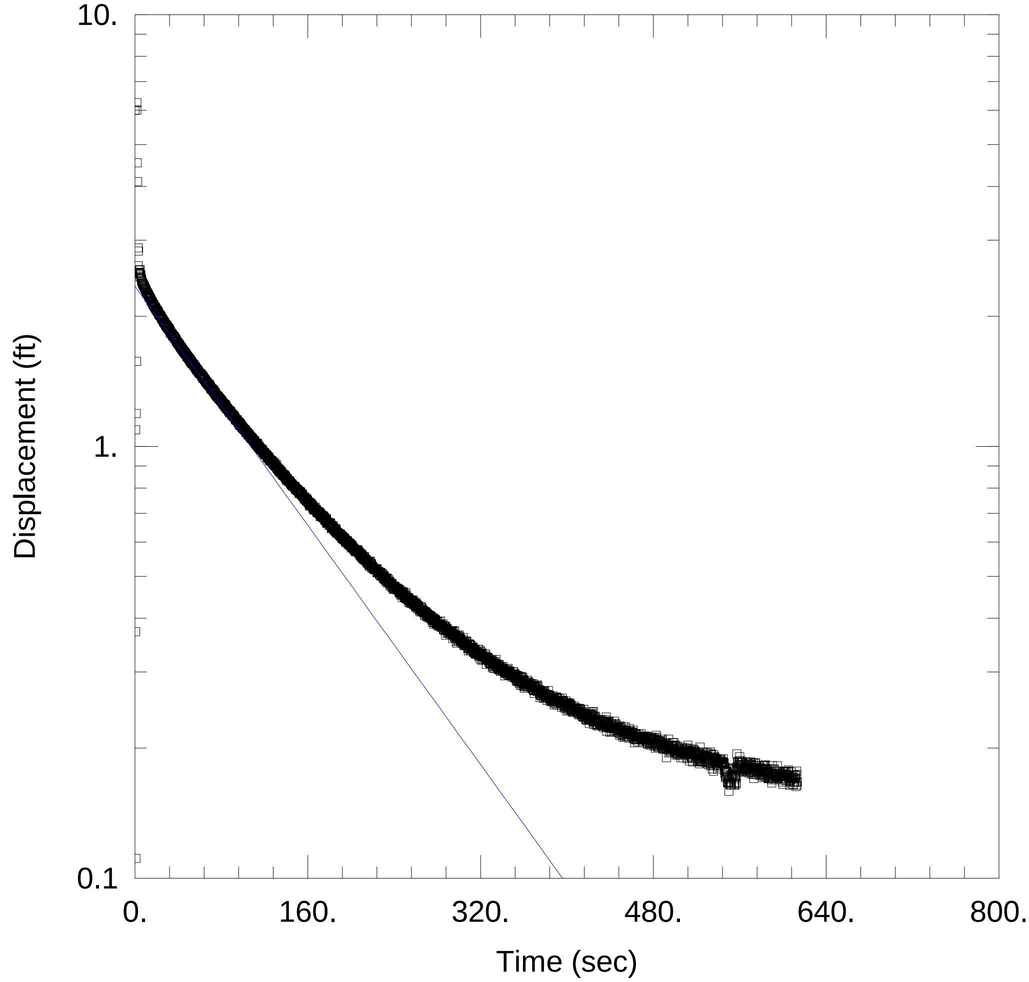
WELL DATA (MW-122 D In)

Initial Displacement: 6.1 ft Water Column Height: 37.5 ft
Casing Radius: 0.0833 ft Wellbore Radius: 0.26 ft
Screen Length: 10. ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 0.0001176 cm/sec y0 = 2.321 ft



MW-134 D SLUG OUT

Data Set: G:\...\MW-134D slug out.aqt
Date: 12/12/19 Time: 15:58:31

PROJECT INFORMATION

Company: ARCADIS
Client: CSX Waycross
Project: SC000239.0044
Test Location: Waycross, GA
Test Well: MW-134 D
Test Date: 6/3/2016

AQUIFER DATA

Saturated Thickness: 25. ft Anisotropy Ratio (Kz/Kr): 1.

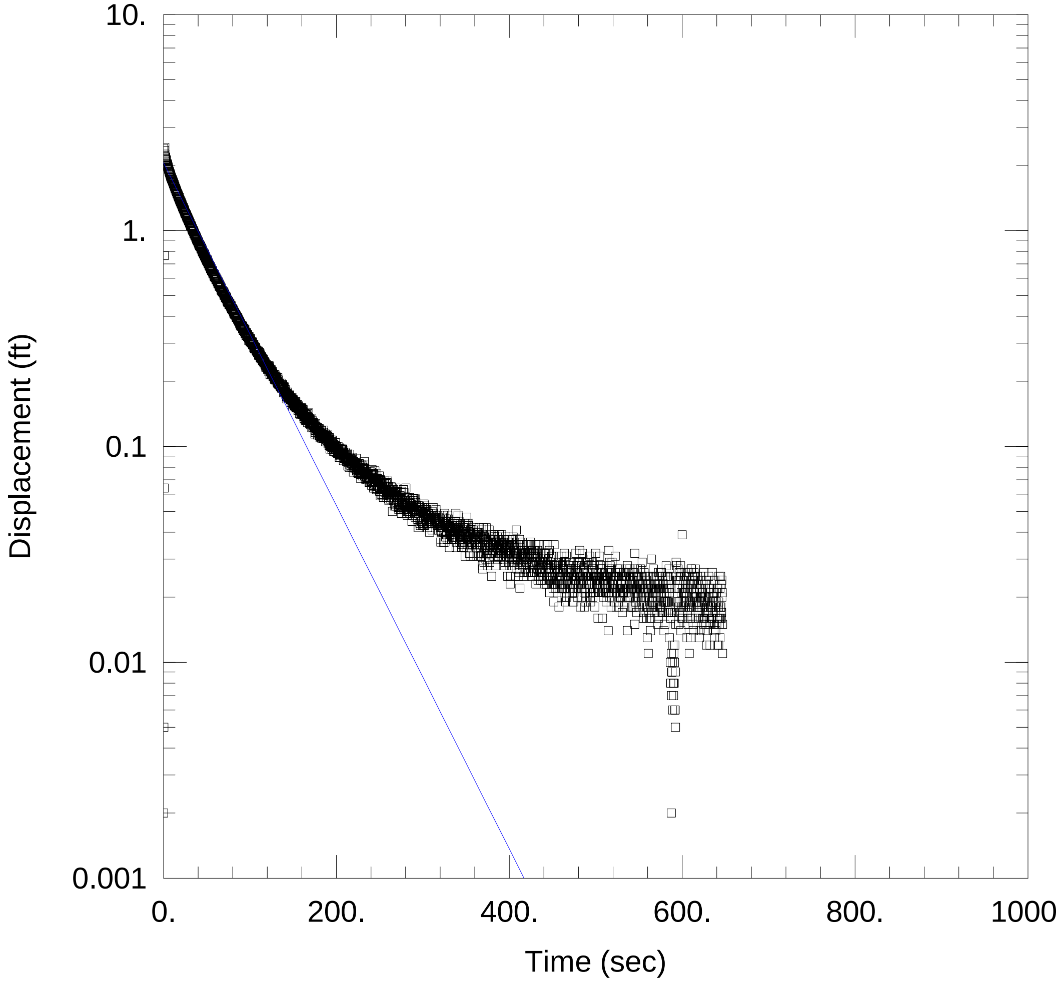
WELL DATA (MW-134Dslugo)

Initial Displacement: 6. ft Water Column Height: 35.88 ft
Casing Radius: 0.166 ft Wellbore Radius: 0.5 ft
Screen Length: 10. ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 0.0009834 cm/sec y0 = 2.35 ft



MW-135 D SLUG OUT

Data Set: G:\...\MW-135D slug out.aqt
Date: 12/12/19
Time: 15:59:01

PROJECT INFORMATION

Company: ARCADIS
Client: CSX Waycross
Project: SC000239.0044
Test Location: Waycross, GA
Test Well: MW-135 D
Test Date: 6/2/2016

AQUIFER DATA

Saturated Thickness: 25. ft
Anisotropy Ratio (Kz/Kr): 1.

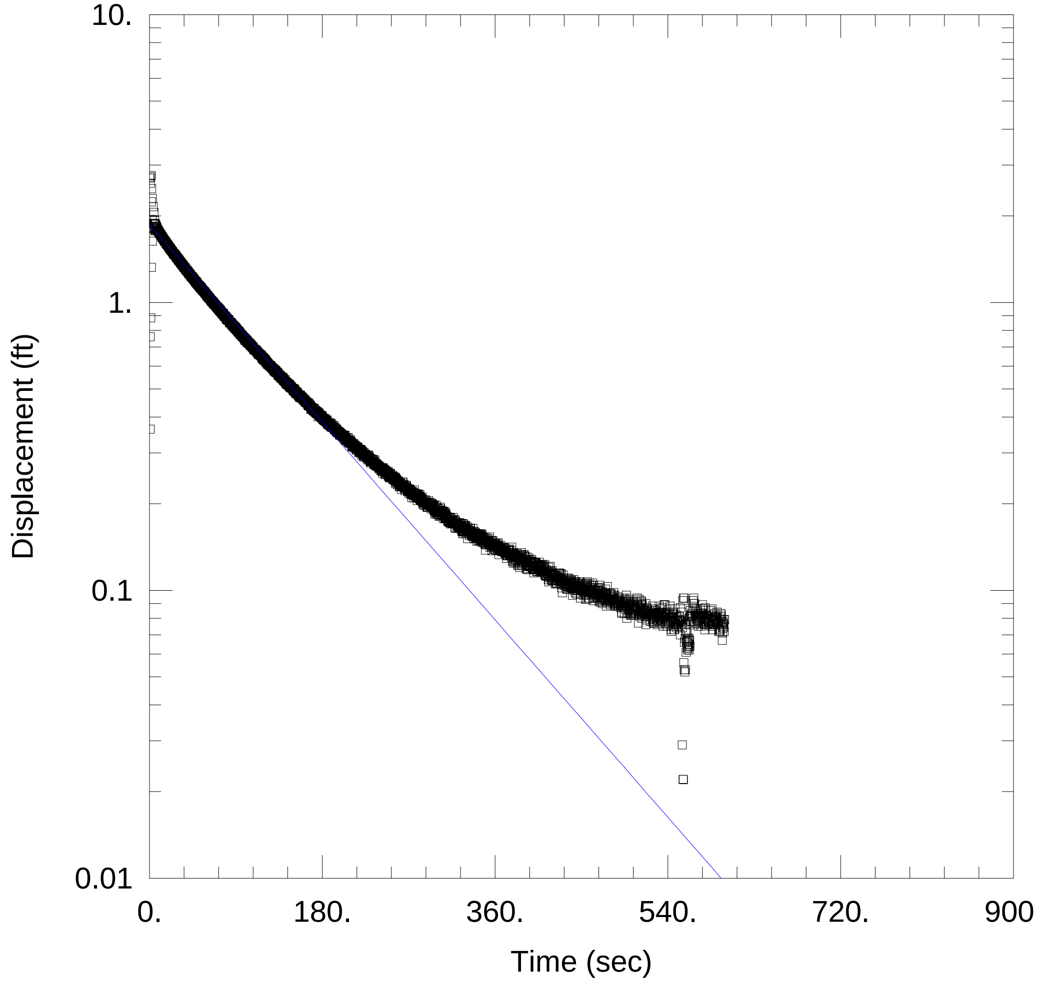
WELL DATA (MW-135Dslugo)

Initial Displacement: 2.4 ft
Water Column Height: 36.55 ft
Casing Radius: 0.166 ft
Wellbore Radius: 0.5 ft
Screen Length: 10. ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 0.002264 cm/sec
y0 = 2.061 ft



MW-135S SLUG OUT

Data Set: G:\...\MW-135S Slug Out.aqt
Date: 12/12/19 Time: 15:59:27

PROJECT INFORMATION

Company: ARCADIS
Client: CSX Waycross
Project: SC000239.0044
Test Location: Waycross, GA
Test Well: MW-135S
Test Date: 6/2/2016

AQUIFER DATA

Saturated Thickness: 22. ft Anisotropy Ratio (Kz/Kr): 1.

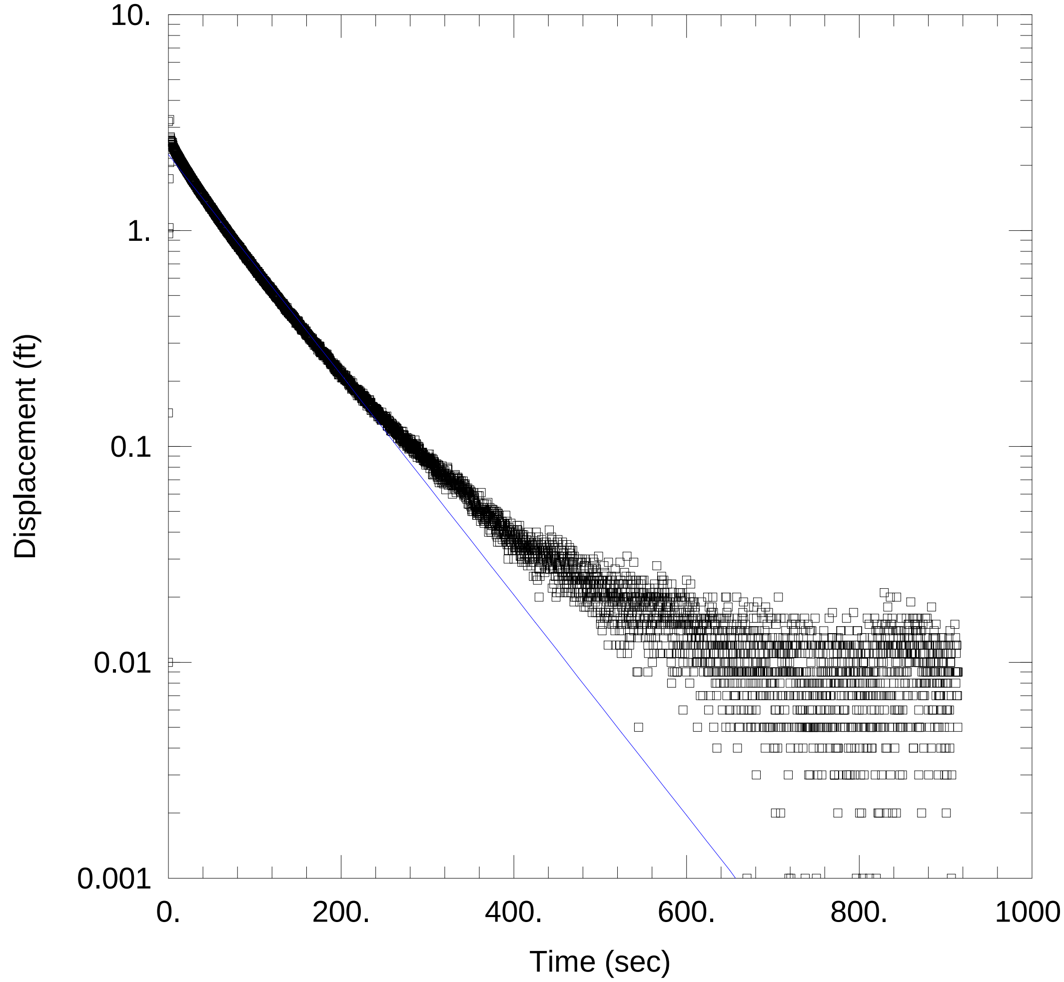
WELL DATA (MW135SSlugou)

Initial Displacement: 2.7 ft Water Column Height: 21.98 ft
Casing Radius: 0.166 ft Wellbore Radius: 0.5 ft
Screen Length: 10. ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 0.001071 cm/sec y0 = 1.859 ft



MW-136 D SLUG OUT

Data Set: G:\...\MW-136 D slug out.aqt
Date: 12/12/19
Time: 16:00:56

PROJECT INFORMATION

Company: ARCADIS
Client: CSX Waycross
Project: SC000239.0044
Test Location: Waycross, GA
Test Well: MW-136 D
Test Date: 6/2/2016

AQUIFER DATA

Saturated Thickness: 15. ft
Anisotropy Ratio (Kz/Kr): 1.

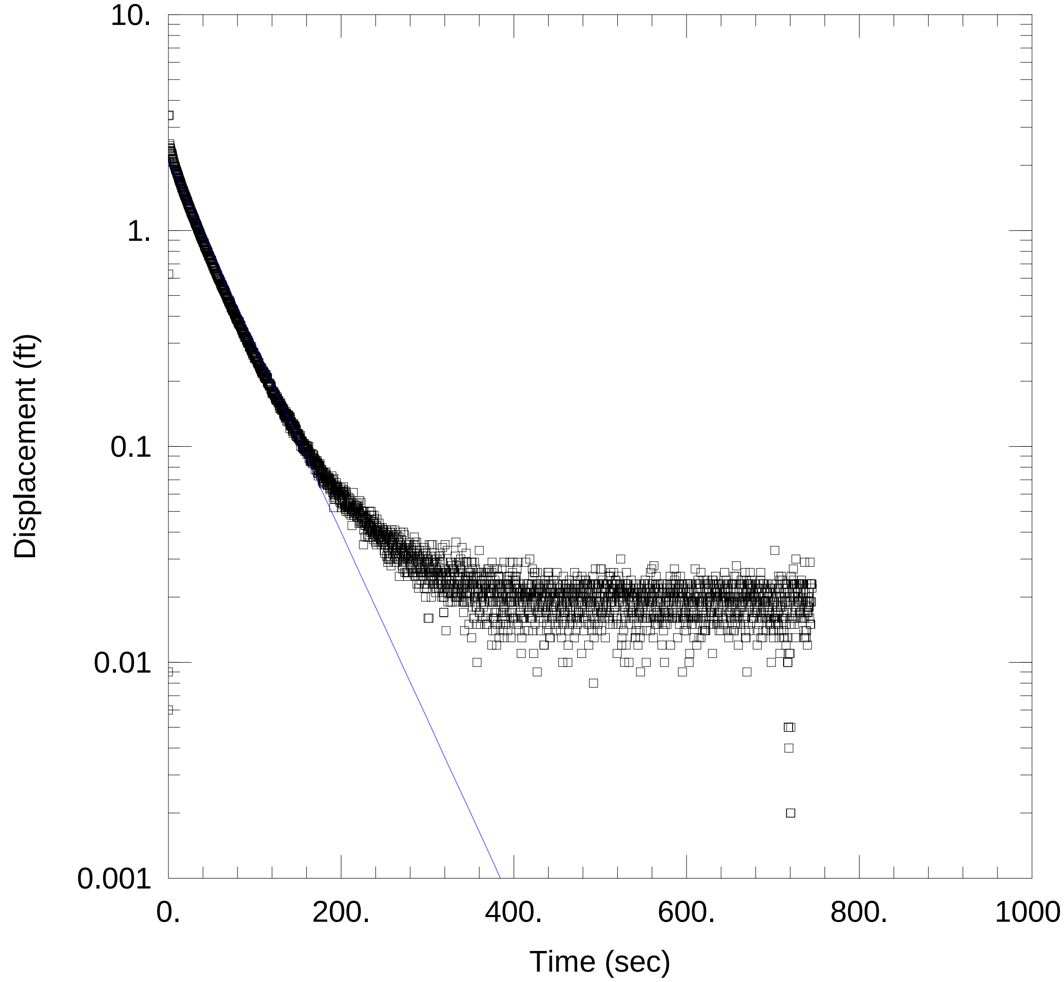
WELL DATA (MW136Dslugou)

Initial Displacement: 3.2 ft
Water Column Height: 35.12 ft
Casing Radius: 0.166 ft
Wellbore Radius: 0.5 ft
Screen Length: 10. ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 0.001444 cm/sec
y0 = 2.251 ft



MW-137 D SLUG OUT

Data Set: G:\...\MW-137 D slug out.aqt
Date: 12/12/19 Time: 16:01:27

PROJECT INFORMATION

Company: ARCADIS
Client: CSX Waycross
Project: SC000239.0044
Test Location: Waycross, GA
Test Well: MW-137 D
Test Date: 6/2/2016

AQUIFER DATA

Saturated Thickness: 15. ft Anisotropy Ratio (Kz/Kr): 1.

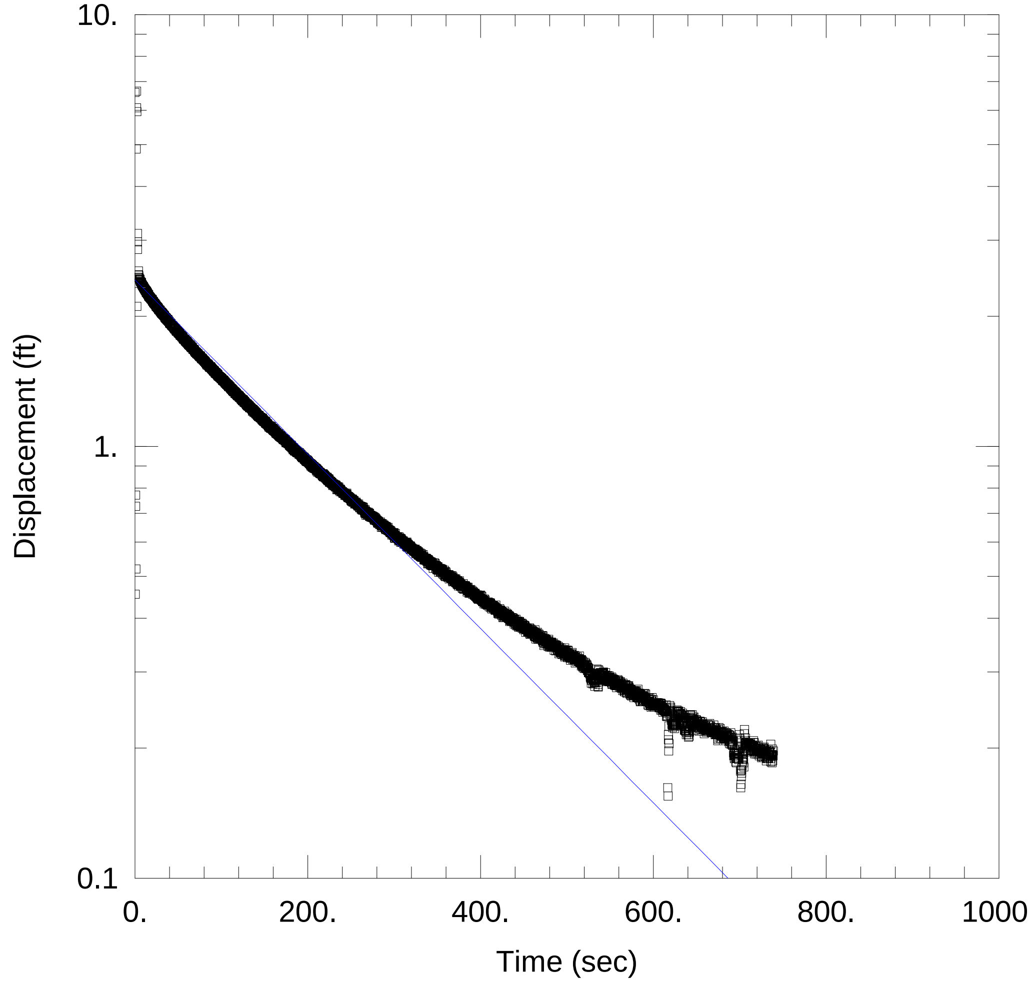
WELL DATA (MW137Dslugou)

Initial Displacement: 3.4 ft Water Column Height: 35.35 ft
Casing Radius: 0.166 ft Wellbore Radius: 0.5 ft
Screen Length: 10. ft

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 0.002456 cm/sec y0 = 2.165 ft



MW-138 D SLUG OUT

Data Set: G:\...\MW-138 D slug out.aqt
Date: 12/12/19
Time: 16:01:58

PROJECT INFORMATION

Company: ARCADIS
Client: CSX Waycross
Project: SC000239.0044
Test Location: Waycross, GA
Test Well: MW-138 D
Test Date: 6/3/2016

AQUIFER DATA

Saturated Thickness: 15. ft
Anisotropy Ratio (Kz/Kr): 1.

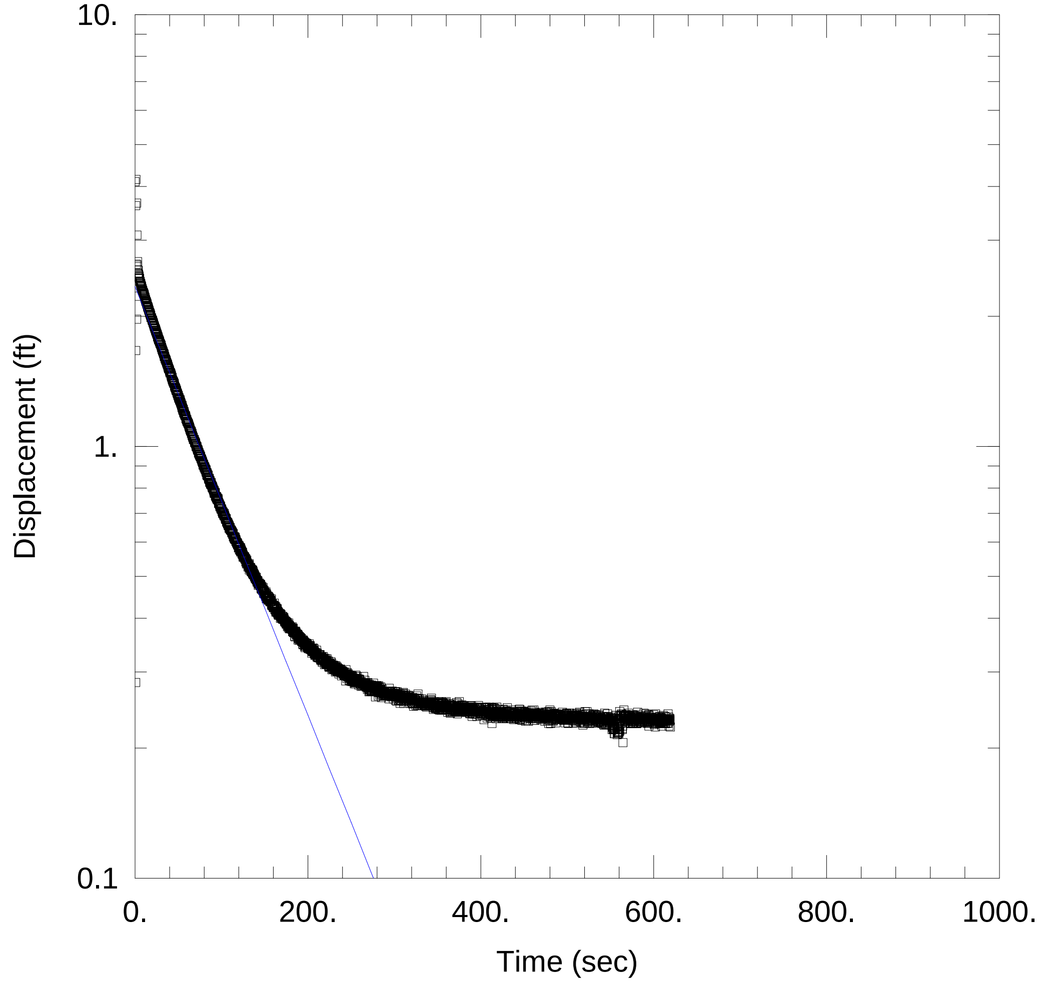
WELL DATA (MW138Dslugou)

Initial Displacement: 6.6 ft
Water Column Height: 41.1 ft
Casing Radius: 0.166 ft
Wellbore Radius: 0.5 ft
Screen Length: 10. ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 0.000587 cm/sec
y0 = 2.431 ft



TMW-4D SLUG OUT

Data Set: G:\...\TMW-4D slug out.aqt
Date: 12/12/19
Time: 16:02:22

PROJECT INFORMATION

Company: ARCADIS
Client: CSX Waycross
Project: SC000239.0044
Test Location: Waycross, GA
Test Well: TMW-4D
Test Date: 6/3/2016

AQUIFER DATA

Saturated Thickness: 15. ft
Anisotropy Ratio (Kz/Kr): 1.

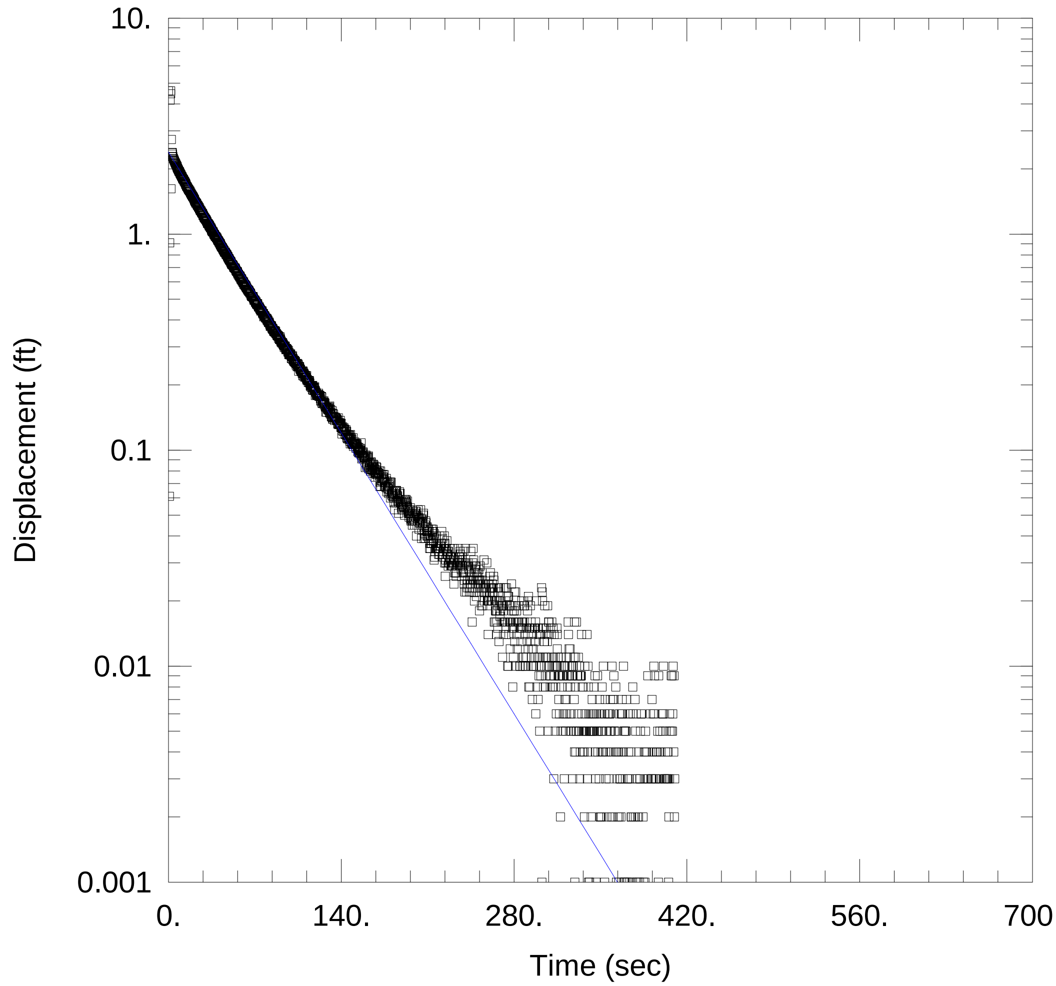
WELL DATA (TMW4Dslugout)

Initial Displacement: 4.1 ft
Water Column Height: 38.43 ft
Casing Radius: 0.166 ft
Wellbore Radius: 0.5 ft
Screen Length: 10. ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 0.001427 cm/sec
y0 = 2.343 ft



TMW-6S SLUG OUT

Data Set: G:\...\TMW-6S Slug out.aqt
Date: 12/12/19
Time: 16:02:50

PROJECT INFORMATION

Company: ARCADIS
Client: CSX Waycross
Project: SC000239.0044
Test Location: Waycross, GA
Test Well: TMW-6S
Test Date: 6/3/2016

AQUIFER DATA

Saturated Thickness: 23. ft
Anisotropy Ratio (Kz/Kr): 1.

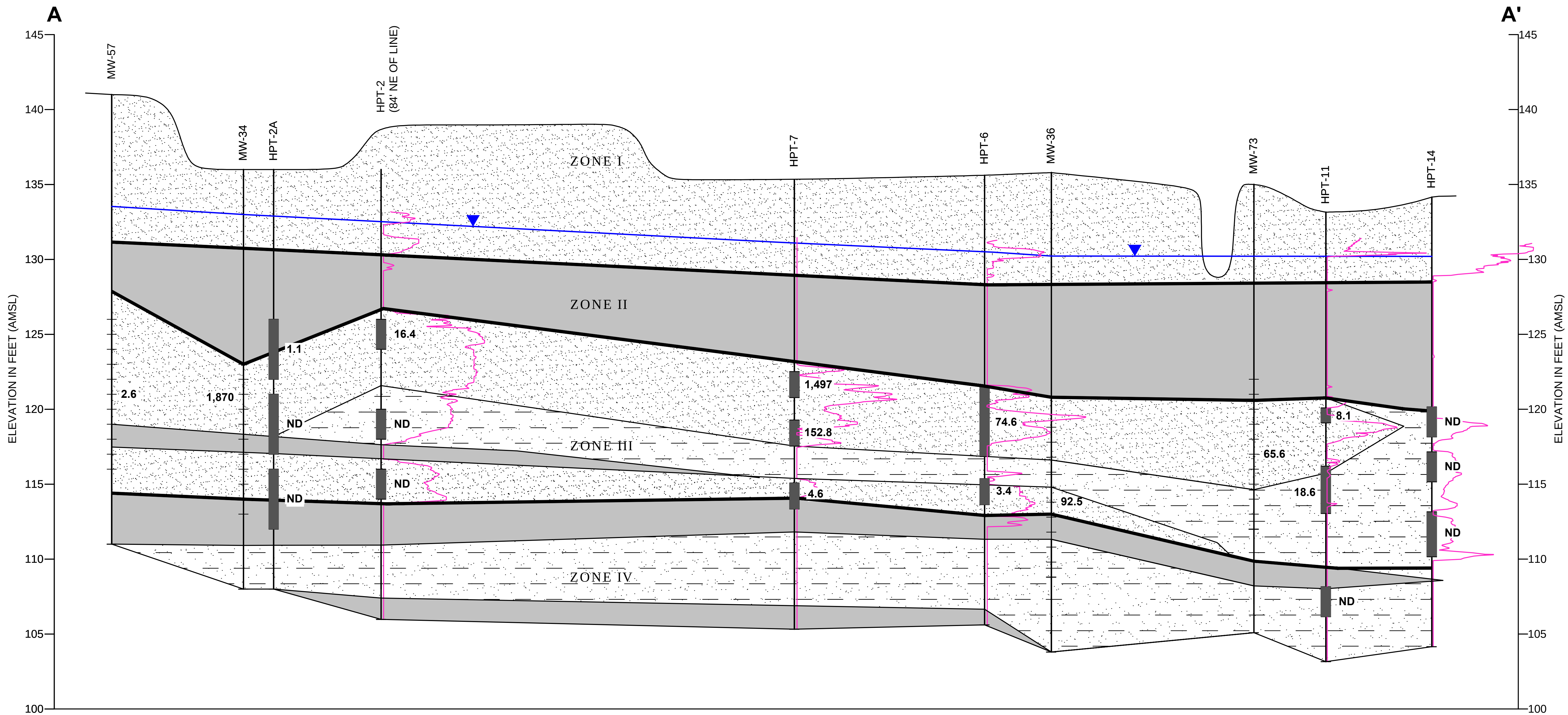
WELL DATA (TMW6S slugou)

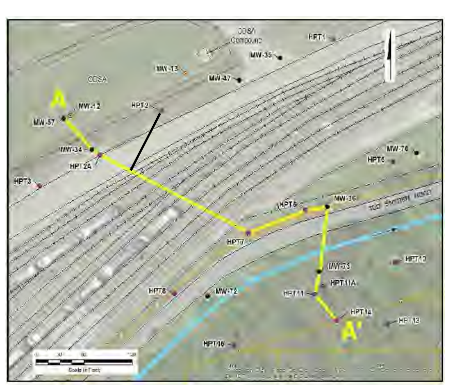
Initial Displacement: 4.6 ft
Water Column Height: 22.54 ft
Casing Radius: 0.166 ft
Wellbore Radius: 0.5 ft
Screen Length: 10. ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.002274 cm/sec
y0 = 2.395 ft





CROSS SECTION LOCATION

LEGEND:

	WATER SAMPLING INTERVAL
4.6	TOTAL CVOC (ug/L)
HPT-7	SAMPLING LOCATION
ND	NON-DETECT
ODSA	OLD DRUM STORAGE AREA
	ZONE BOUNDARY
CVOC	CHLORINATED VOLATILE ORGANIC COMPOUNDS
MW-57	MONITORING WELL
	SCREENED INTERVAL
	WATER TABLE
	BOTTOM OF BORING/WELL
AMSL	ABOVE MEAN SEA LEVEL
	SILTY SANDS
	CLAYEY SANDS AND SANDY CLAYS
	CLAYS
	ESTIMATED HYDRAULIC CONDUCTIVITY FROM HPT (ft/d)
(ft/d)	FEET PER DAY

0 40' 80'

HORIZONTAL SCALE: 1" = 40'

CSX TRANSPORTATION INC.
WAYCROSS YARD
WAYCROSS, GA
ODSA GROUNDWATER INVESTIGATION

TOTAL CVOC CONCENTRATIONS IN ODSA GROUNDWATER - CROSS SECTION SEPTEMBER 2013

ARCADIS

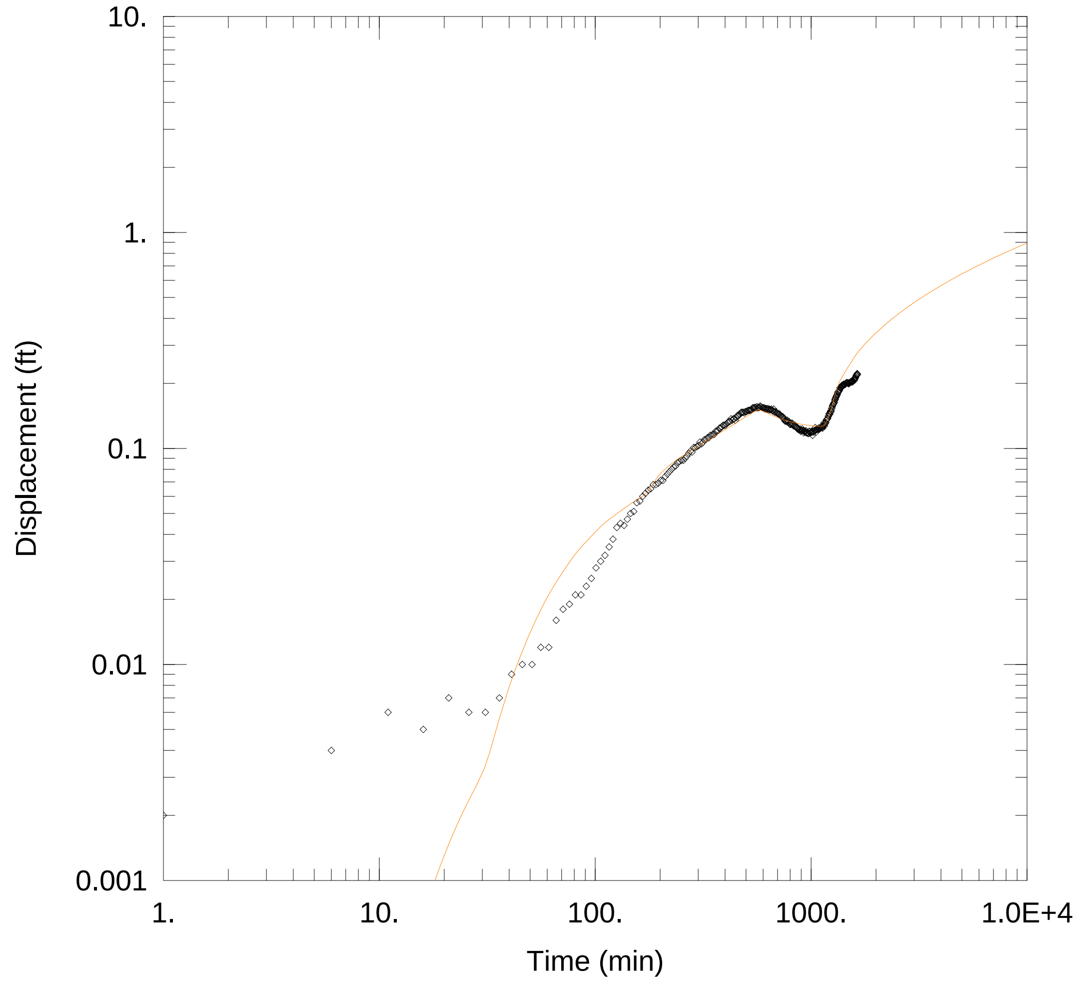
FIGURE
4

CSX Transportation, Inc. Old Drum Storage Area HWMU

Assumptions

- Anisotropy ratio (Kz/Kr) = 1
- Saturated Thickness = 19 feet based on pre-pumping water levels at WW-44, WW-45, WW-46, boring logs for those wells, and nearby HPT logs
- Overlying aquitard thickness (B') = 11 ft based on pre-pumping water levels at WW-44, WW-45, WW-46, boring logs for those wells, and nearby HPT logs
- Underlying aquitard thickness (B'') = 1 ft. Note: Results are insensitive to this parameter.
- All pumping and observation wells are fully penetrating based on boring logs and HPT logs
- Leaky confined aquifer

Observation Well	Storativity	Transmissivity	Saturated Thickness	Hydraulic Conductivity	Hydraulic Conductivity
(Well ID)	(dimensionless)	(ft2/min)	(ft)	(ft/day)	(cm/sec)
MW-36	3.00E-03	7.3E-03	19	0.55	1.9E-04
MW-72	1.15E-03	1.4E-02	19	1.03	3.6E-04
MW-73	3.59E-05	3.7E-02	19	2.83	1.0E-03
MW-74	9.42E-06	2.7E-02	19	2.07	7.3E-04
MW-76	2.81E-05	3.2E-02	19	2.41	8.5E-04
MW-77	1.04E-05	1.9E-02	19	1.46	5.1E-04
Maximum	3.00E-03			2.83	1.0E-03
Minimum	9.42E-06			0.55	1.9E-04
Geometric Mean	8.36E-05			1.51	5.3E-04



MW-74

PROJECT INFORMATION

Company: CSX Waycross
Test Date: July 1-2, 2013

AQUIFER DATA

Saturated Thickness: 19. ft
Aquitard Thickness (b'): 11. ft
Anisotropy Ratio (Kz/Kr): 1.
Aquitard Thickness (b"): 1. ft

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
WW44	591961	434577
WW45	592027	434669
WW46	592116	434670

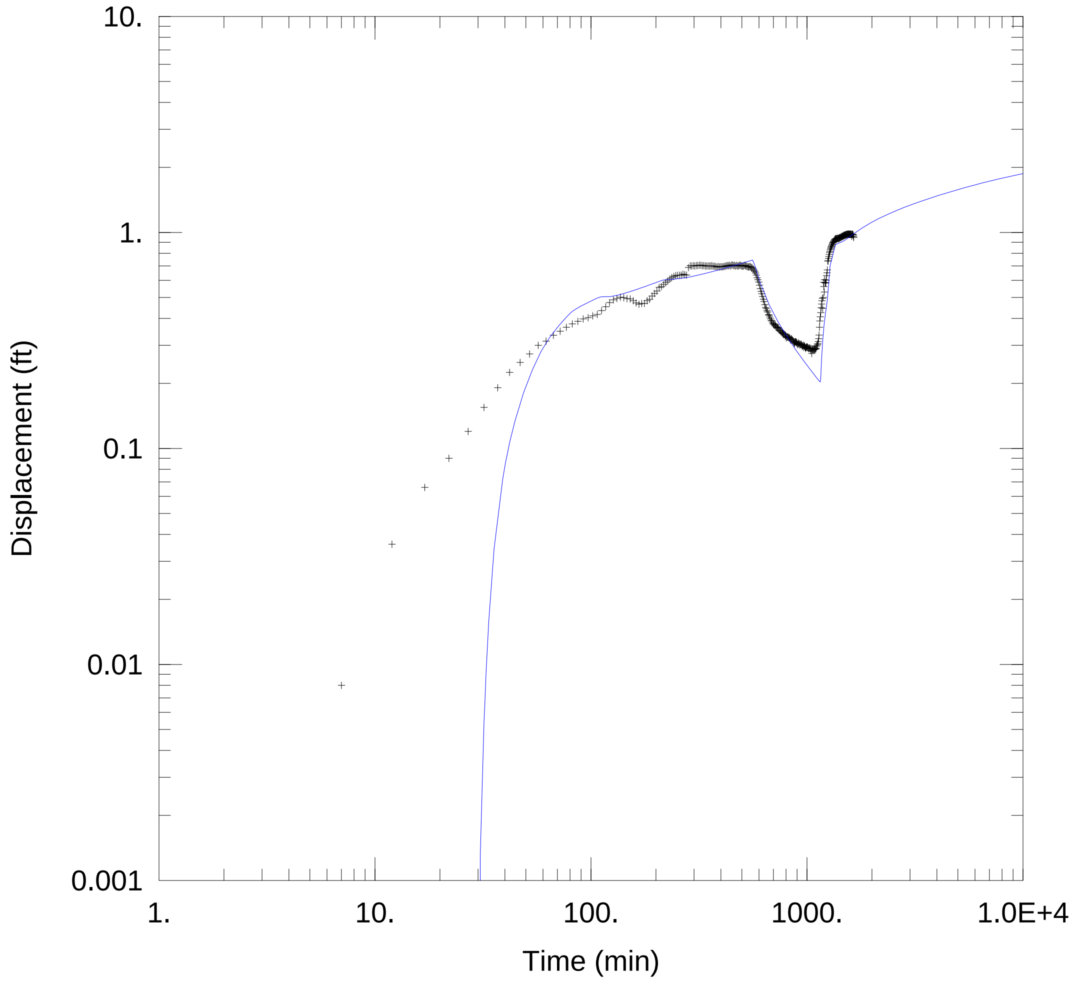
Observation Wells

Well Name	X (ft)	Y (ft)
◇ MW74	592392.211	434655.1179

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 0.02733 ft^2/min
1/B' = 8.678E-7 ft^{-1}
1/B" = 0.0005475 ft^{-1}
S = 9.424E-6
ß'/r = 0.01197 ft^{-1}
ß"/r = 0.002464 ft^{-1}



MW-36

PROJECT INFORMATION

Company: CSX Waycross
Test Date: July 1-2, 2013

AQUIFER DATA

Saturated Thickness: 19. ft
Anisotropy Ratio (Kz/Kr): 1.
Aquitard Thickness (b'): 11. ft
Aquitard Thickness (b"): 1. ft

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
WW44	591961	434577
WW45	592027	434669
WW46	592116	434670

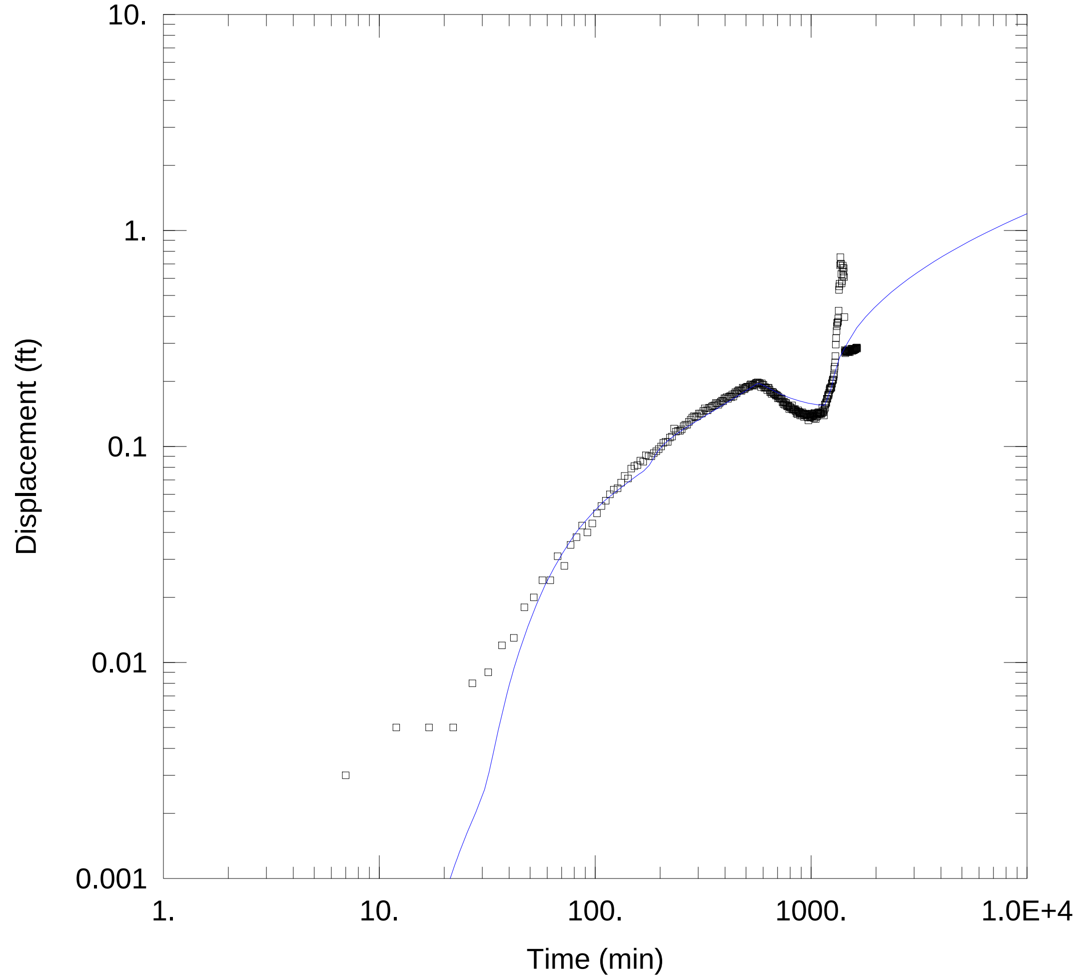
Observation Wells

Well Name	X (ft)	Y (ft)
+ MW36	592123.2516	434660.8387

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 0.007259 ft^2/min
S = 0.003244
1/B' = 1.144E-6 ft^{-1}
ß'/r = 0.006764 ft^{-1}
1/B" = 0.03098 ft^{-1}
ß"/r = 0.05475 ft^{-1}



MW-77

PROJECT INFORMATION

Company: CSX Waycross
Test Date: July 1-2, 2013

AQUIFER DATA

Saturated Thickness: 19. ft
Aquitard Thickness (b'): 11. ft
Anisotropy Ratio (Kz/Kr): 1.
Aquitard Thickness (b"): 1. ft

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
WW44	591961	434577
WW45	592027	434669
WW46	592116	434670

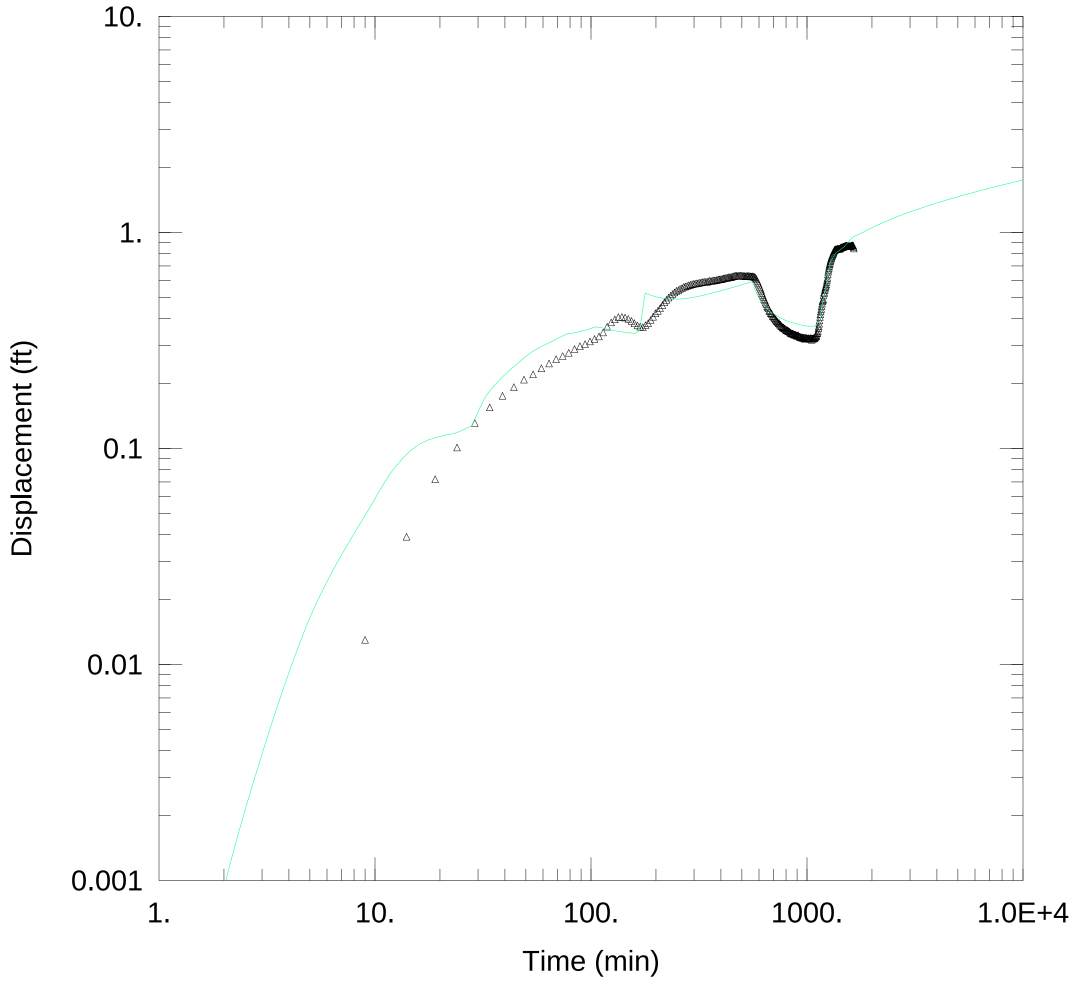
Observation Wells

Well Name	X (ft)	Y (ft)
□ MW77	592327.0838	434800.73

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 0.01922 ft^2/min
1/B' = 8.678E-7 ft^{-1}
1/B" = 0.0005475 ft^{-1}
S = 1.041E-5
ß'/r = 0.01197 ft^{-1}
ß"/r = 0.002464 ft^{-1}



MW-73

PROJECT INFORMATION

Company: CSX Waycross
Test Date: July 1-2, 2013

AQUIFER DATA

Saturated Thickness: 19. ft
Aquitard Thickness (b'): 11. ft
Anisotropy Ratio (Kz/Kr): 1.
Aquitard Thickness (b"): 1. ft

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
WW44	591961	434577
WW45	592027	434669
WW46	592116	434670

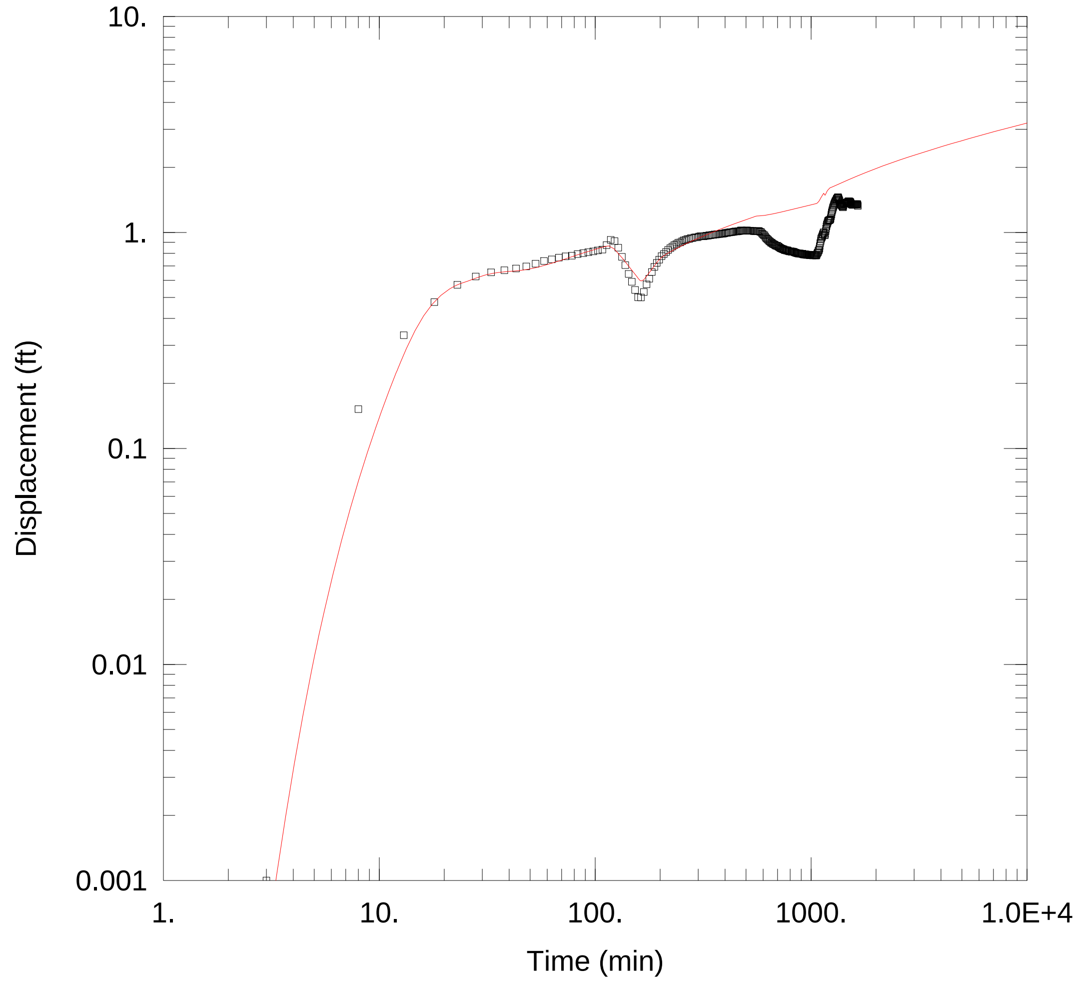
Observation Wells

Well Name	X (ft)	Y (ft)
△ MW73	592113.5052	434580.4275

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 0.03736 ft^2/min
1/B' = 8.678E-7 ft^{-1}
1/B" = 0.0005475 ft^{-1}
S = 3.585E-5
ß'/r = 0.01197 ft^{-1}
ß"/r = 0.002464 ft^{-1}



MW-72

PROJECT INFORMATION

Company: CSX Waycross
Test Date: July 1-2, 2013

AQUIFER DATA

Saturated Thickness: 19. ft
Aquitard Thickness (b'): 11. ft
Anisotropy Ratio (Kz/Kr): 1.
Aquitard Thickness (b"): 1. ft

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
WW44	591961	434577
WW45	592027	434669
WW46	592116	434670

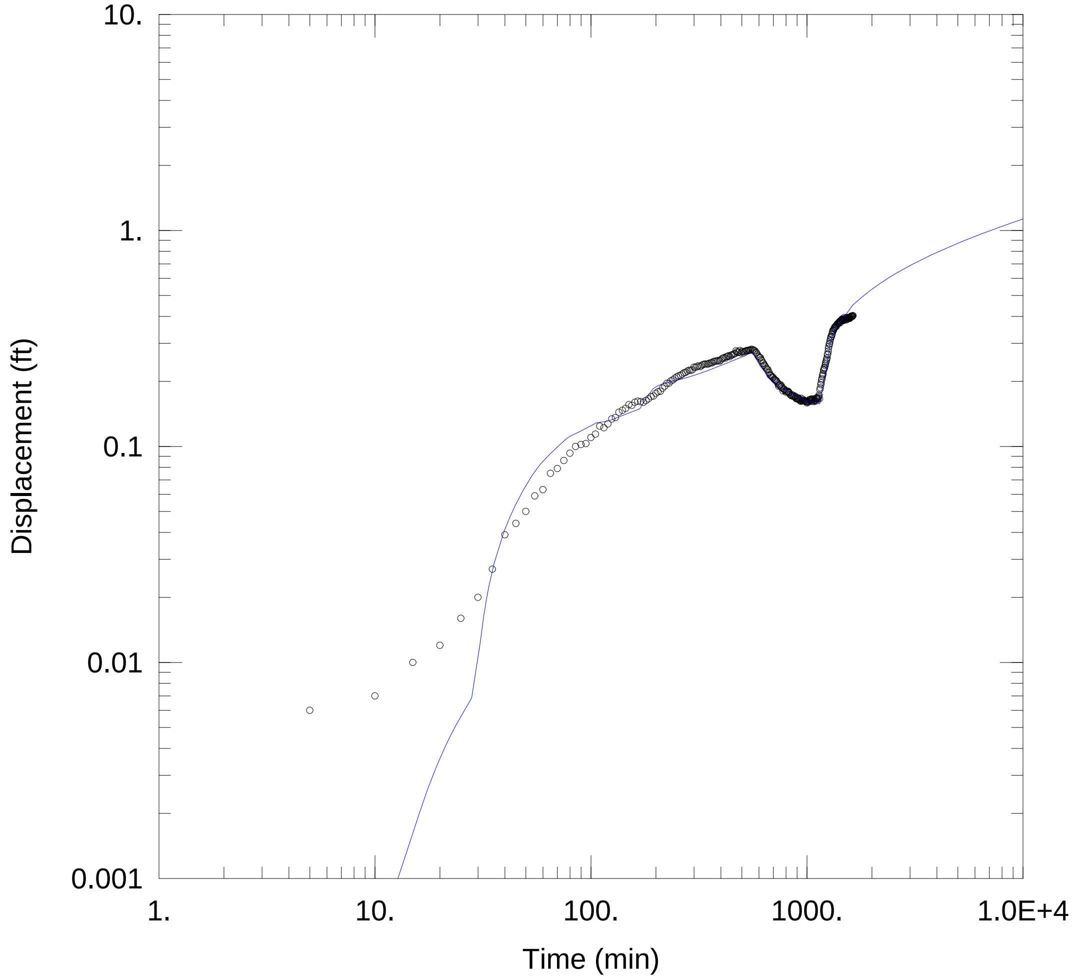
Observation Wells

Well Name	X (ft)	Y (ft)
□ MW72	591974.8281	434549.7468

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 0.01357 ft^2/min
1/B' = 9.964E-7 ft^{-1}
1/B" = 0. ft^{-1}
S = 0.001152
ß'/r = 0.01118 ft^{-1}
ß"/r = 0.00219 ft^{-1}



MW-76

PROJECT INFORMATION

Company: CSX Waycross
Test Date: July 1-2, 2013

AQUIFER DATA

Saturated Thickness: 19. ft
Aquitard Thickness (b'): 11. ft

Anisotropy Ratio (Kz/Kr): 1.
Aquitard Thickness (b"): 1. ft

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
WW44	591961	434577
WW45	592027	434669
WW46	592116	434670

Observation Wells

Well Name	X (ft)	Y (ft)
◦ MW76	592234.6574	434728.0581

SOLUTION

Aquifer Model: Leaky

$T = 0.03176$ ft^2/min
$1/B' = 8.678E-7$ ft^{-1}
$1/B'' = 0.0005475$ ft^{-1}

Solution Method: Hantush

$S = 2.807E-5$
$\beta'/r = 0.01197$ ft^{-1}
$\beta''/r = 0.002464$ ft^{-1}

ASB PUMP TEST DATA AND ANALYSIS

SEPTEMBER 16, 1987

Document No. 440-03-05

Aquifer Test Results
Waycross, Georgia Facility

JOH - received
10/12
B.

Prepared for:

Georgia Environmental Protection Division
Atlanta, Georgia

For:

CSX Transportation
Jacksonville, Florida

October 1987

351.02 Waycross
10-19-87

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AQUIFER TEST RESULTS
WAYCROSS, GEORGIA FACILITY

440-03-05
October, 1987

Prepared For:

CSX Transportation
Jacksonville, Florida

Prepared By:

ERT, A Resource Engineering Company
3000 Richmond
Houston, Texas 77098

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1.0 OBJECTIVES

On April 2, 1987, ERT performed a slug test at each of two hazardous waste management areas (HWMA) at CSX Transportation's Waycross, Georgia Facility. These slug tests were performed at the Old Drum Storage Area (ODSA) and the Alum Sludge Basin (ASB) to roughly define the hydraulic properties of the uppermost aquifer. From the slug test results, an estimated transmissivity, hydraulic conductivity, and average linear velocity of the aquifer were obtained for both units. Based on these slug test results the estimated hydraulic properties were calculated as follows:

Old Drum Storage Area (ODSA) Estimated Results

Transmissivity	T = 339 gpd/ft
Hydraulic Conductivity	K = 48.4 gpd/ft^2
Average Linear Velocity	V = 29.96 ft/year

Alum Sludge Basin (ASB) Estimated Results

Transmissivity	T = 641 gpd/ft
Hydraulic Conductivity	K = 64 gpd/ft^2
Average Linear Velocity	V = 177.23 ft/year

These properties were used in designing an aquifer pumping test. The results of that pumping test would enable ERT to calculate predicted drawdowns at the two HWMA during corrective action withdrawal and treatment. These predicted drawdowns are necessary for the determination of withdrawal well spacing and pumping rates.

2.0 WELL INSTALLATION

From August 8 to August 15, 1987, ERT conducted a pumping test well installation program at the Alum Sludge Basin, where the pumping test would be performed. A network of six pumping test wells was installed as shown in Figure 2-1. Well installation was carried out under direct supervision of ERT field geologists and in accordance with Standard Operating Procedures (SOP) presented in Appendix A of this report. This program was performed using a truck-mounted drill rig and standard geotechnical practice. All monitor well bore holes were drilled and advanced by the mud-rotary method using a mixture of Aqua-Gel and city water as a drilling fluid. The field geologist identified and recorded changes in lithology by a visual examination of soil samples and the drill cuttings. Soil samples were collected at five foot intervals and/or at changes in lithology using a standard split-barrel sampler in accordance with ASTM designation D-1586, "Penetration Test and Split Barrel Sampling of Soils". Soil samples were visually examined, classified, and logged by the field geologist according to the Unified Soil Classification System. Boring logs were prepared for each well/piezometer from this information and are provided in Appendix B of this report.

Each pumping test well receives groundwater through a Schedule 40 Tri-Loc threaded, polyvinyl chloride (PVC) screen placed in the wash boring drilled to a predetermined depth. Two wells in the pumping test network are six inches in diameter (PW-1 and OB-3); the remainder of the wells are two inches in diameter.

A sand filter was placed in the annulus around the screen. The filter was then sealed at the top with a bentonite seal and the annulus above was backfilled with a bentonite-cement grout

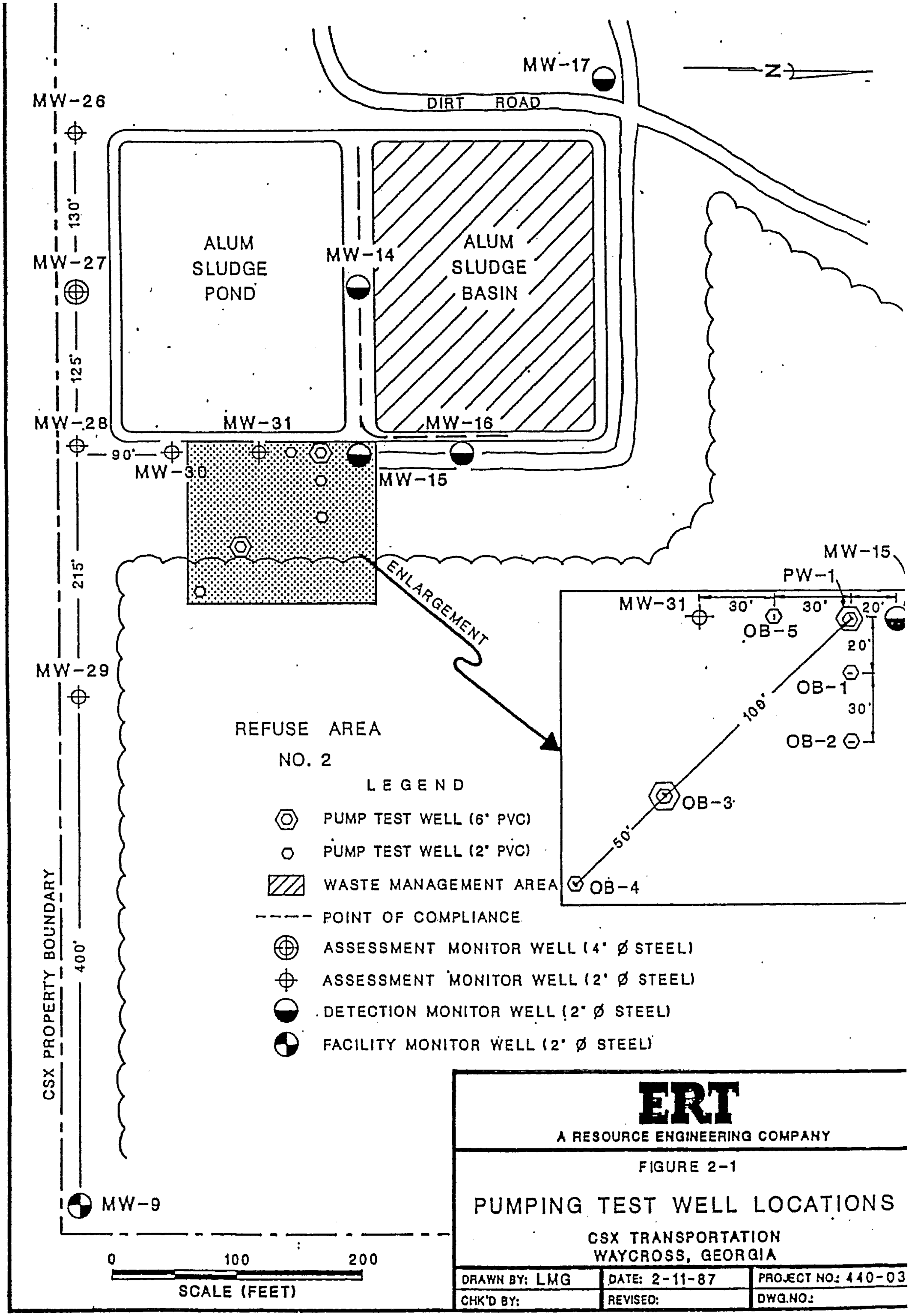

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FIGURE 2-1

PUMPING TEST WELL LOCATIONS

CSX TRANSPORTATION
WAYCROSS, GEORGIA

DRAWN BY: LMG	DATE: 2-11-87	PROJECT NO: 440-03
CHK'D BY:	REVISED:	DWG.NO:

mixture. All construction material and drilling/sampling equipment was decontaminated before each use in accordance with ERT's Standard Operating Procedures (SOP). The decontamination procedure included, in order: steam cleaning, isopropanol rinse, deionized water rinse and air drying.

A typical well design is shown in Figure 2-2. After completion, each well was developed using a hand pump to evacuate any drilling fluid and/or residual sediment. Construction details are summarized as follows in Table 2-1.

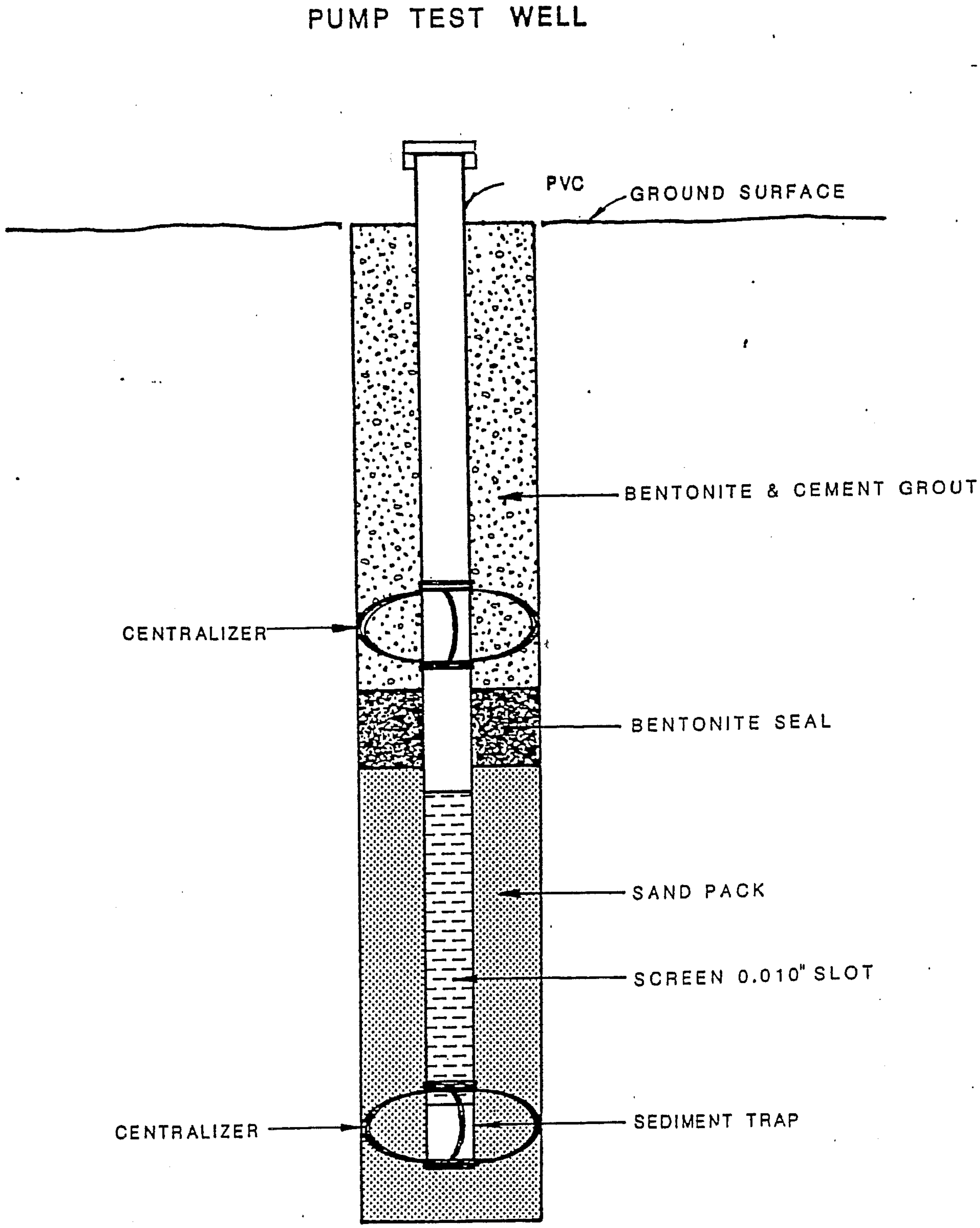

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FIGURE 2-2

TYPICAL WELL DESIGN

CSX TRANSPORTATION
WAYCROSS, GEORGIA

DRAWN BY: CC	DATE: 7-27-87	PROJECT NO.: 440-03
CHK'D BY:	REVISED:	DWG.NO.:

TABLE 2-1
PUMP TEST WELL CONSTRUCTION DETAILS
CSX TRANSPORTATION
WAYCROSS, GEORGIA

Well No.	Elevations + Top of Pipe msl (ft)	Casing Type	Casing Length*	Screen I.D. (in)	Screen Slot size (in)	Screen Length (ft)	Screen Depth (ft)	Filter Depth (ft)
PW-1	136.840	A	13.5	6	0.020	10	*17-27	15-27
OB-1	136.410	A	14.0	2	0.010	10++	17-27	14.8-32
OB-2	136.850	A	14.0	2	0.010	10++	17-27	14-32
OB-3	137.210	A	12.5	6	0.020	10++	16-26	14-31
OB-4	136.690	A	14.0	2	0.010	10++	17-27	15-32
OB-5	135.880	A	13.0	2	0.010	10++	17-27	14.5-32
MW-15	135.990	B	18.0	2	0.010	10++	18-28	17-33
MW-31	136.410	B	17.0	2	0.010	10++	17-27	14-32

A- 2-inch or 6-inch diameter Schedule 40 Tri-loc pvc pipe
B- 2-inch Type 304 Tri-loc stainless steel pipe
+- Elevations (msl) as reported by H: W. Williams & Assoc., Inc., Waycross, Georgia
*- Casing length from ground surface
++- 5-foot sediment trap attached at bottom of screen

3.0 AQUIFER TEST

3.1 Field Program

Two aquifer pumping tests were performed on September 16, 1987 using an In Situ model SE200 Hydrologic Analysis System. This system consists of a computer which receives water level data from several transducers (in this case, five) in observation wells while one well is being pumped at a constant rate to produce a drawdown. The data generated by the computer during the two tests are provided in Appendix C of this report. A diagram showing the piping used during the tests is provided in Figure 3-1. Discharge water was containerized using a tank truck and was disposed of, as per GAEPD approved procedure, at Wastewater Treatment Plant No. 3 on site.

Two tests were performed in order to confirm the data obtained. The first test was conducted with the submersible pump located near the top of the screen in the pumped well (PW-1). The second test was conducted with the submersible pump located near the bottom of the PW-1 screen. Each test consisted of a drawdown phase and a recovery phase (falling water levels were monitored while pumping, and rising water levels were monitored after pumping was terminated). Comparison between the two phases gives an idea of the degree of variation in the data.

3.2 Conclusions

From the data obtained during the tests, transmissivity and storage coefficient are calculated. This was accomplished using Jacob's approximation method. This method involves the plotting of data as a curve and measuring desired parameters from the curve. The curves plotted for ERT's data are presented in

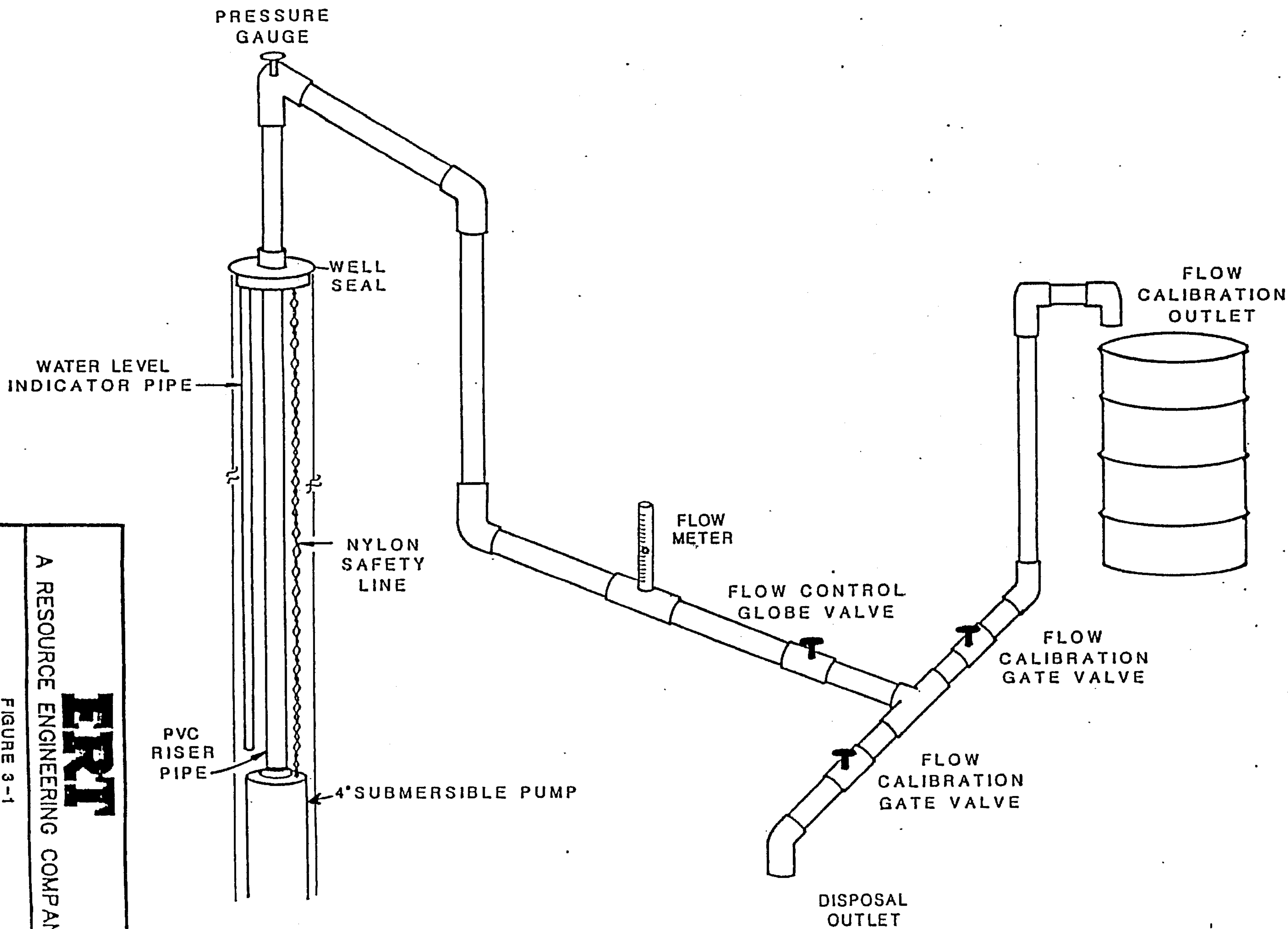

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FIGURE 3-1

PUMP TEST PIPING
CSX TRANSPORTATION

DRAWN BY.	DATE.	PROJECT NO
L.M.G.	8-22-86	440-01

Appendix C of this report (note that drawdown data for Test 2 Input 1 cannot be plotted due to the interfering effect of water cascading over the screen in the pumped well). Table 3-1 provides measured transmissivities and storage coefficients from those curves.

Theoretically, all calculations of transmissivity for these two tests should produce the same value. Due to variations in the aquifer, however, and slight fluctuations in factors such as pumping rate and even weather conditions, values normally show some range of variability. Considering that the hydraulic conductivity of an aquifer (proportional to the transmissivity) can vary over a range spanning more than 13 orders of magnitude, the values obtained from the September 16 aquifer tests are relatively consistent.

In order to predict drawdowns in the withdrawal wells, data was selected from that portion of the tests which most closely approximates the conditions which will exist in the withdrawal wells - that is, drawdown of water levels with the pump situated near the bottom of the screen. The values from Test 2, drawdown phase, represent such a situation, therefore those values were averaged to obtain a mean transmissivity of 1983 gpd/ft and a mean storage coefficient of 2.213×10^{-3}. These means were used to predict drawdowns for withdrawal wells at the Alum Sludge Basin as presented in Appendix D of this report. Based on ERT's initial slug tests, transmissivity at the Old Drum Storage Area is just over half that at the Alum Sludge Basin, so a transmissivity of 1,000 gpd/ft was assumed for the ODSA, and the same storage coefficient, 2.213×10^{-3}, was used (see Appendix D). These values can be used to calculate other aquifer characteristics as shown below:

TABLE 3-1

AQUIFER CHARACTERISTICS CALCULATED FROM PUMPING TEST DATA

Test #1
Pumping Rate Q = 1.8 gpm
Jacob's Approximation Method

	Transmissivity T, gpd/ft		Storage Coefficient S	
Well No.	Drawdown	Recovery	Drawdown	Recovery
OB-1	1218	1131	9.75×10^{-4}	1.06×10^{-3}
OB-5	1533	1760	5.03×10^{-4}	5.58×10^{-4}
MW-31	2160	2376	3.11×10^{-3}	4.89×10^{-3}
MW-15	848	969	1.64×10^{-3}	1.27×10^{-3}

Test #2
Pumping Rate Q = 3.5 gpm
Jacob's Approximation Method

	Transmissivity T, gpd/ft		Storage Coefficient S	
Well No.	Drawdown	Recovery	Drawdown	Recovery
OB-1	1200	943	1.41×10^{-3}	1.32×10^{-3}
OB-3	3787	*	1.10×10^{-3}	*
MW-31	2174	3029	7.51×10^{-4}	7.5×10^{-4}
MW-15	770	616	1.77×10^{-3}	1.64×10^{-3}

* Not enough response shown in well during test to obtain reliable data for this value.

Old Drum Storage Area

Transmissivity	T = 1,000 gpd/ft
Hydraulic Conductivity	K = 143 gpd/ft^2
Storage Coefficient	S = 2.213 x 10^{-3}
Average Linear Velocity	V = 58 ft/year

Alum Sludge Basin

Transmissivity	T = 1,983 gpd/ft
Hydraulic Conductivity	K = 198 gpd/ft^2
Storage Coefficient	S = 2.213 x 10^{-3}
Average Linear Velocity	V = 385 ft/year

4.0 CHANGES TO PART B PERMIT APPLICATION

Sections 3.4.1.3 and 4.4.1.3 of ERT's "Revised Part B Post-Closure Permit Application - Waycross, Georgia Facility" dated August, 1987 provide conceptual designs for the withdrawal well systems at the ASB and OSDA. The values for transmissivity, storage coefficient, pumping rate, and drawdowns given in the above mentioned sections are initial estimates and are now superseded by the values determined during the September 16 pumping tests.

The new values, however, still support the design presented in the Part B Permit Application; the number of wells, construction details, well spacings, locations, and withdrawal procedures remain as originally planned.

LSA PUMP TEST DATA AND ANALYSIS

APRIL 19, 1994 THROUGH APRIL 21, 1994

- three sets of 2-inch diameter, 0.02-inch slot, PVC wells to monitor different depth zones during the pilot test (MP-1S, MP-1M, MP-1D, MP-2S, MP-2D, MP-3S, and MP-3D); and

- one 2-inch diameter, 0.02-inch slot, PVC air sparging well screened in Zone III to be used if sufficient drawdown was obtained to allow soil vapor recovery (AS-1).

Continuous split-spoon samples were collected at each boring location (except AS-1) to determine soil lithology. Well boring logs are included in Appendix D. The cross sections on Figure 12 show the shallow lithology and the well screen intervals.

These wells were installed in accordance with GAEPD's "Manual for Groundwater Monitoring." Well construction logs are included in Appendix D. Upon completion of well construction, each well was developed using surge-block and pumping/purging techniques until clear water was obtained. VG-2 was developed for approximately six hours to ensure well efficiency.

10.5.4 48-Hour Aquifer Test

The 48-hour aquifer test was done to determine aquifer hydraulic characteristics in the Locomotive Shop Area. (April 19, 1994 through April 21, 1994)

Equipment used during the aquifer test included:

- an In-Situ eight channel data logger and depth transducer system for collecting groundwater level data;

- a Grundfos submersible pump; and

- a 6,000-gallon tanker for groundwater discharge storage and transport to the on-site air stripper system.

Before the 48-hour aquifer test, the data logger system was used to evaluate antecedent groundwater level fluctuations. No fluctuations were detected. Antecedent groundwater levels are included in Appendix E.

A step drawdown test was performed to determine a sustainable yield rate for the 48-hour aquifer test. Pumping rates of 1.0, 2.0, 2.1, 2.3, 2.5, 2.7, and 3.0 gpm were evaluated. The flow rate was set at a given step and an In-Situ Data logger and depth transducer were used to measure the water level drawdown at the given flow rate. At the 1.0 and 2.0 gpm flow rates, the water levels stabilized at a higher level than the maximum drawdown available in the recovery well. At flow rates higher than 2.1 gpm, the water level did not stabilize and there was clear evidence that continued pumping at that rate would result in dry well conditions. At the 2.1 gpm flow rate, the water level stabilized just above the intake of the withdrawal pump, allowing continued pumping at maximum drawdown for an indefinite period of time. The 2.1 gpm sustainable flow rate was confirmed during the 48-hour aquifer test.

During the 48-hour aquifer test, groundwater samples were collected from VG-2 at the beginning, middle, and end of the 48-hour period. Laboratory data for these samples are included in Appendix E. TCE groundwater concentrations increased from 44,000 µg/ℓ to 72,000 µg/ℓ during the test.

Barometric pressure data was also collected during the 48-hour aquifer test to determine if any correction factors needed to be applied. No significant fluctuations in barometric pressure were observed. The data logger results were confirmed throughout the test using a manual electronic water meter.

At the end of the 48-hour aquifer test, the pump was turned off and recovery data was collected until the groundwater returned to normal levels. This data is included in Appendix E.

The groundwater drawdown data indicated a very narrow cone of depression, with limited drawdown effect in monitoring points as close as 13 feet away. Detailed analysis of the aquifer test results are provided in Section 10.5.7.1.

10.5.5 Soil Vapor Extraction Test

The cone of depression of the water table at the recovery well was very narrow; consequently, insufficient drawdown was obtained to allow any significant or widespread SVE influence on Zone III soils. A limited SVE pilot test was conducted on Zone I soils by connecting a temporary blower to extraction well VG-2. VG-2 was pumped at 2.9 gpm to maintain drawdown. The blower used for the SVE test was a GAST Model R51250-50 with a 2.5 horsepower motor. The blower maintained a flow rate of approximately 100 standard cubic feet per minute (cfm) at a vacuum of 38 inches H_20. The vacuum was monitored during system operation at monitoring points MP-1S, MP-2S, and MP-3S. The system was operated for 98 minutes to allow the vacuum to stabilize. Vacuum response at MP-1S (16 feet from VG-2) and MP-2S (40 feet from VG-2) stabilized at 0.50-inches H_20 and 0.04-inches H_20, respectively. MP-3S (82 feet from VG-2) showed no response to the vacuum.

Based on the narrow cone of depression observed during the aquifer pump test and the results of the SVE pilot test, soil vapor extraction is not effective technology for accelerating the remediation of Zone III or for remediating the limited soil contamination in Zone I at the former parts cleaning vat location. Since the soil contamination in Zone I is minimal and is capped by the concrete floor of the Locomotive Shop, there is no pathway for human exposure and no significant driving force for downward migration of the contaminants into the water table.

10.5.6 Air Sparging Test

The air sparging well (AS-1) was not used since drawdown was insufficient during the SVE test to allow capture of vapors in Zone III. Vapor bubbles in the saturated conditions of Zone III would not be able to migrate upward through the relatively impermeable soils of Zone II. These vapors would migrate laterally and could not be effectively captured. This could cause the plume to migrate outward from the air sparging point. Generally, if the vapors cannot be captured, air sparging should not be used.

10.5.7 Pilot Study Results

10.5.7.1 Analysis of Aquifer Test Results

Aquifer test results were analyzed to determine hydrogeologic conditions and establish aquifer parameters for transmissivity (T), storativity (S), and hydraulic conductivity (K). Aquifer test solution software (Aqtesolv™) was used to analyze the 48-hour drawdown data. All appropriate models were applied to determine the best fit solution. A comparison of modeling results is included in Appendix F.

The best fit solution for this aquifer is the Hantush No-Storage Method (1955), which models a leaky, semi-confined aquifer system. In this case, Zone III is the aquifer and the less permeable Zones I and II create a confining leakage response. Aqtesolv™ solution printouts for the Hantush No-Storage Method, and the other methods used, are included in Appendix F. Calculations for leakage, aquitard, and aquifer characteristics are also included in

Appendix F. The following parameters were established:

- $T = 122\ ft^2/day$;
- $S = 1.49 \times 10^{-3}$; and
- $K = 6.1\ ft/day$.

These parameters were used to calculate capture zone boundaries for withdrawal wells pumping at yields of 2 gpm. The capture zone calculations are included in Appendix F. The capture zones of the proposed groundwater withdrawal wells are shown on Figure 13. The withdrawal well system is described in detail in Section 10.6.

10.5.7.2 Assessment of Soil Corrective Measures Options

Only one soil sample in the former parts cleaning vat area, LS-1 at 410 mg/kg, had excessive TCE concentrations. Sample LS-1 was collected above the concrete floor of the former vat. The vertical Geoprobe profiles confirmed that no DNAPLs are present. There is no evidence of excessively impacted soil outside the former parts cleaning vat concrete vault.

Due to the extremely limited extent of soil contamination underneath the building, the shallow groundwater depth, and the unlikelihood that the unsaturated soil is acting as a significant source of further groundwater contamination, the corrective action plan proposes to remediate this area using an aggressive groundwater withdrawal system immediately downgradient of the Locomotive Shop building. The groundwater flushing effects created by the aggressive groundwater withdrawal in this area will effectively remove the limited soil contaminant concentrations. This proposal is outlined in Section 10.6.

If the Locomotive Shop building is destroyed, CSXT will thoroughly sample and remediate, if necessary, the subsurface soils underlying the former building.

APPENDIX F

AQUIFER TEST DATA ANALYSIS

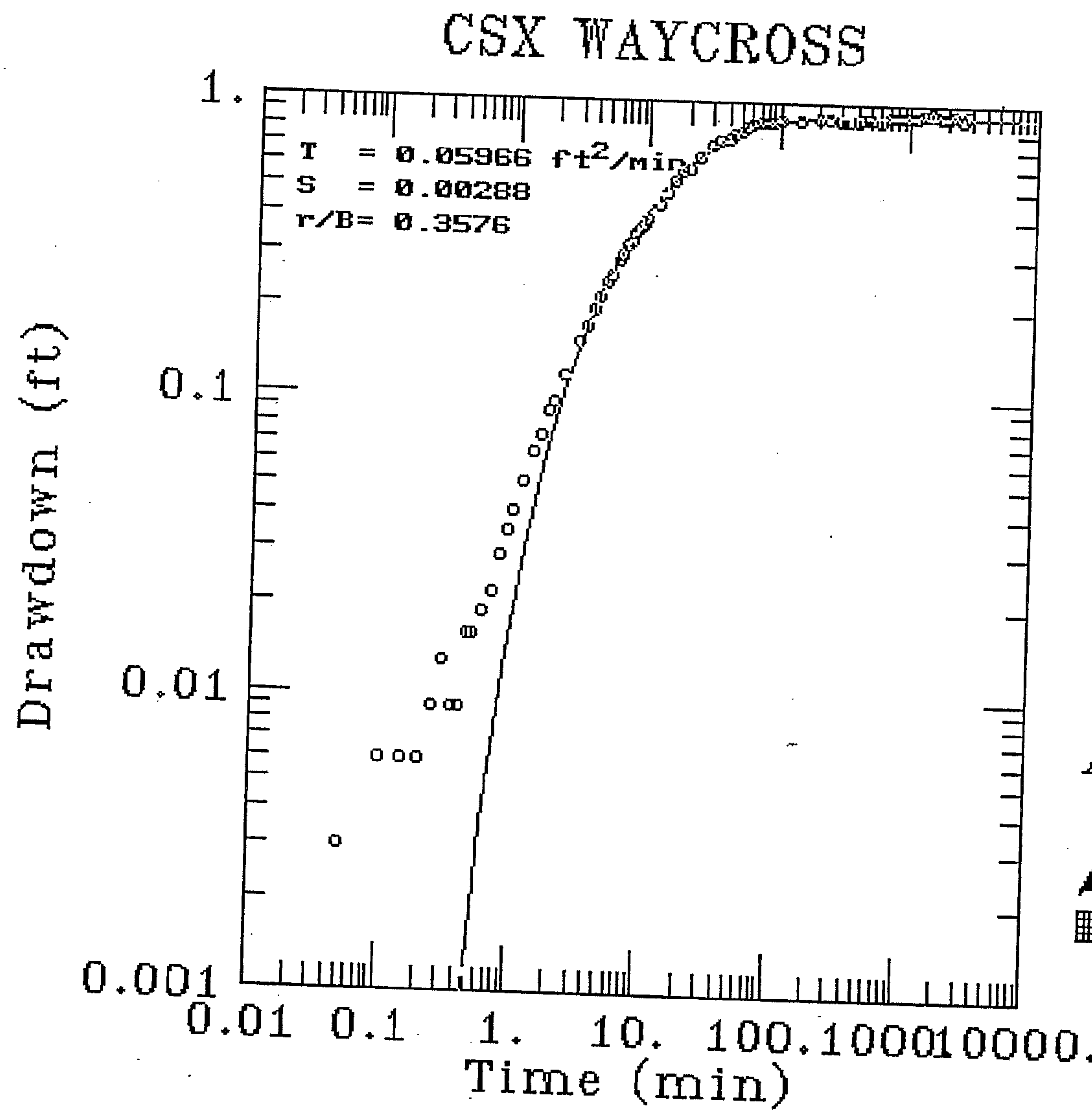
SUMMARY OF PUMPING TEST DATA ANALYSIS AT THE CSXT WAYCROSS, GEORGIA FACILITY

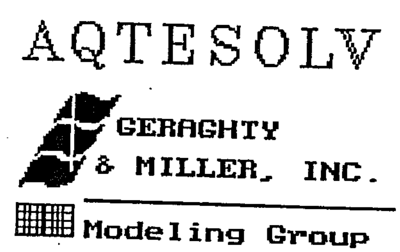
METHOD	WELL	T (ft^2/min)	S	COMMENTS
Hantush	MW-1D	0.0596	2.88×10^{-3}	Leaky aquifer solution excellent fit after T = 1.5 min. Possible influence from pumping well for very early data. Measurement accuracy early not as good as later. Variability possible due to highly variable aquifer.
	MW-2D	0.0795	1.02×10^{-3}	
	MW-3D	0.1163	5.57×10^{-4}	
Papadopolus-Cooper	MW-1D	0.309	7.51×10^{-6}	Confined aquifer solution. Good fit, but aquifer not expected to act confined. T is a little higher than other solution. S is totally unreasonable and inconsistent. Calls into question the validity of method.
	MW-2D	0.447	1.22×10^{-5}	
	MW-3D	0.616	1.12×10^{-5}	
Neuman	MW-1D	0.181	4.0×10^{-4}	Unconfined, delayed yield solution. Marginal fit; however, aquifer may have delayed yield type response.
Theis (early data)	MW-1D	0.0877	2.52×10^{-3}	Confined aquifer solution. Reasonably good fit for early data. Graph shows departure of later data that is typical for leaky aquifer.
	MW-2D	0.116	1.17×10^{-3}	
	MW-3D	0.175	6.41×10^{-4}	
Moench	MW-1D	0.162	1.36×10^{-4}	Leaky aquifer solution. Excellent fit. Method not strictly applicable to this situation, but aquifer may act this way due to complex, interbedded materials. More distant wells have values significantly different than other methods.
	MW-2D	0.223	1.73×10^{-4}	
	MW-3D	0.3698	3.70×10^{-5}	
Jacob Method (distance drawdown)	MW-1, 2, and 3D	0.131	9.1×10^{-3}	Confined aquifer solution. Excellent fit. Values are reasonable.

Conclusion: Hantush Method provides best fit and fairly consistent results in light of the complex and highly variable geology. Theis early data also has reasonable fit and reasonable results. Jacob Method has excellent fit and reasonable results. Other methods give poor fits, unreasonable results, or are not applicable. Recommend using Hantush Method results to model aquifer response.

Summary:	Hantush	T avg = 0.0851 ft^2/min	S avg = 1.49×10^{-3}
	Theis (Early)	T avg = 0.126 ft^2/min	S avg = 1.44×10^{-3}
	Jacob	T avg = 0.131 ft^2/min	S avg = 9.1×10^{-3}
	All	T avg = 0.114 ft^2/min	S avg = 4.01×10^{-3}

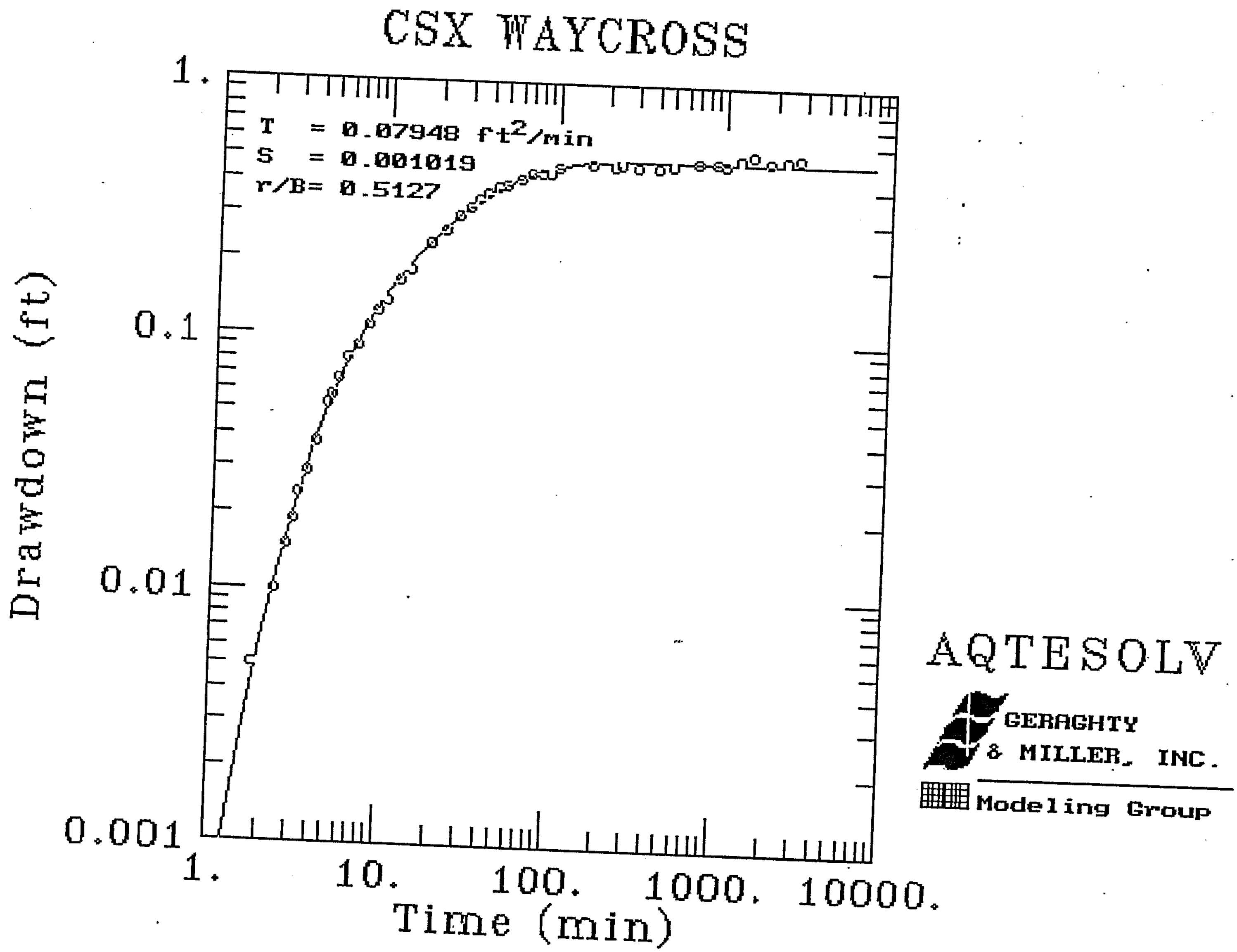
M[illegible]D
HANTUSH NO-STORAGE
METHOD (1955)





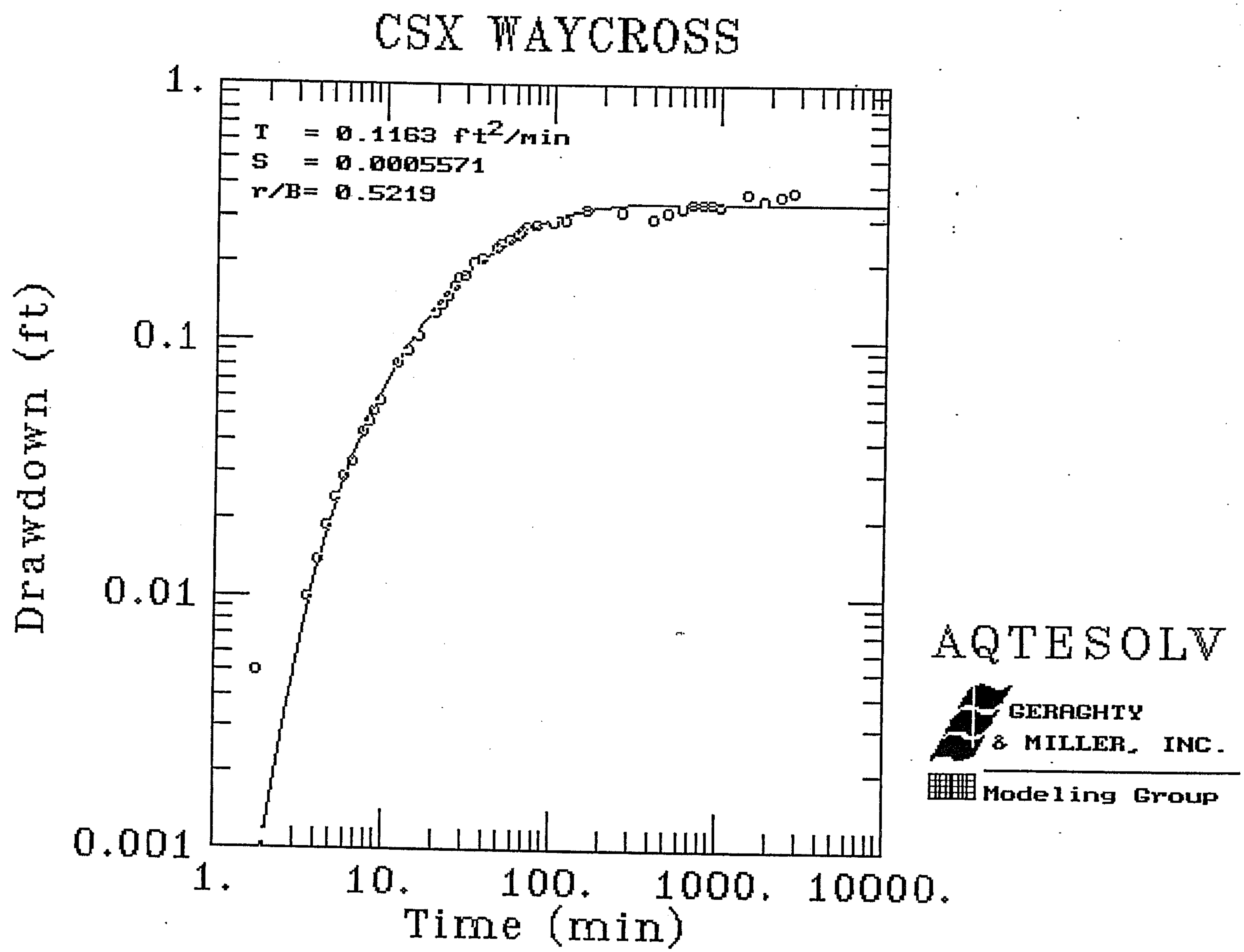
MW

HANTUSH NO-STORAGE METHOD (1955)

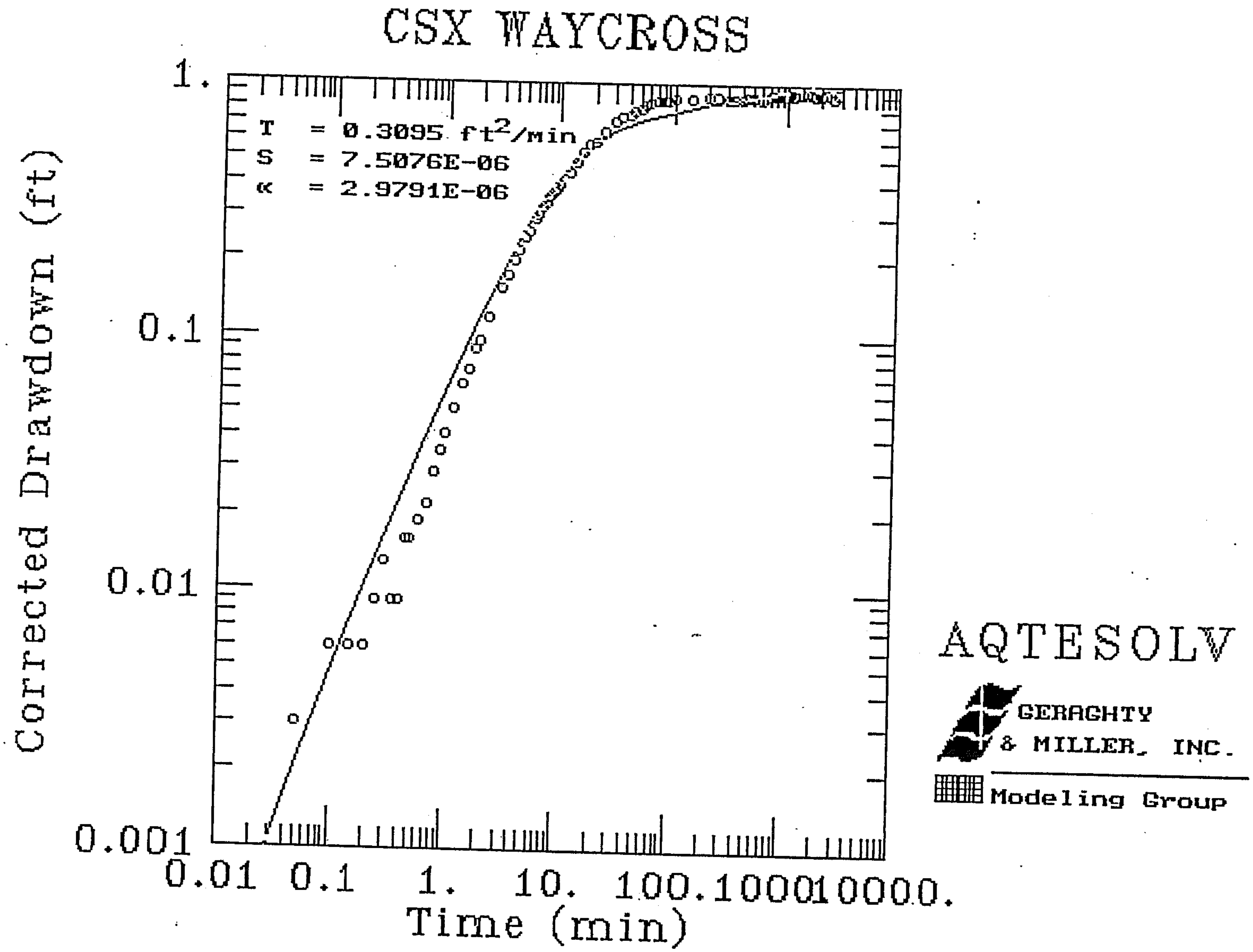


MW...D

HANTUSH NO-STORAGE
METHOD (1955)



M D
PAPADOPULIS-COOPER
METHOD
CONFINED SOLUTION



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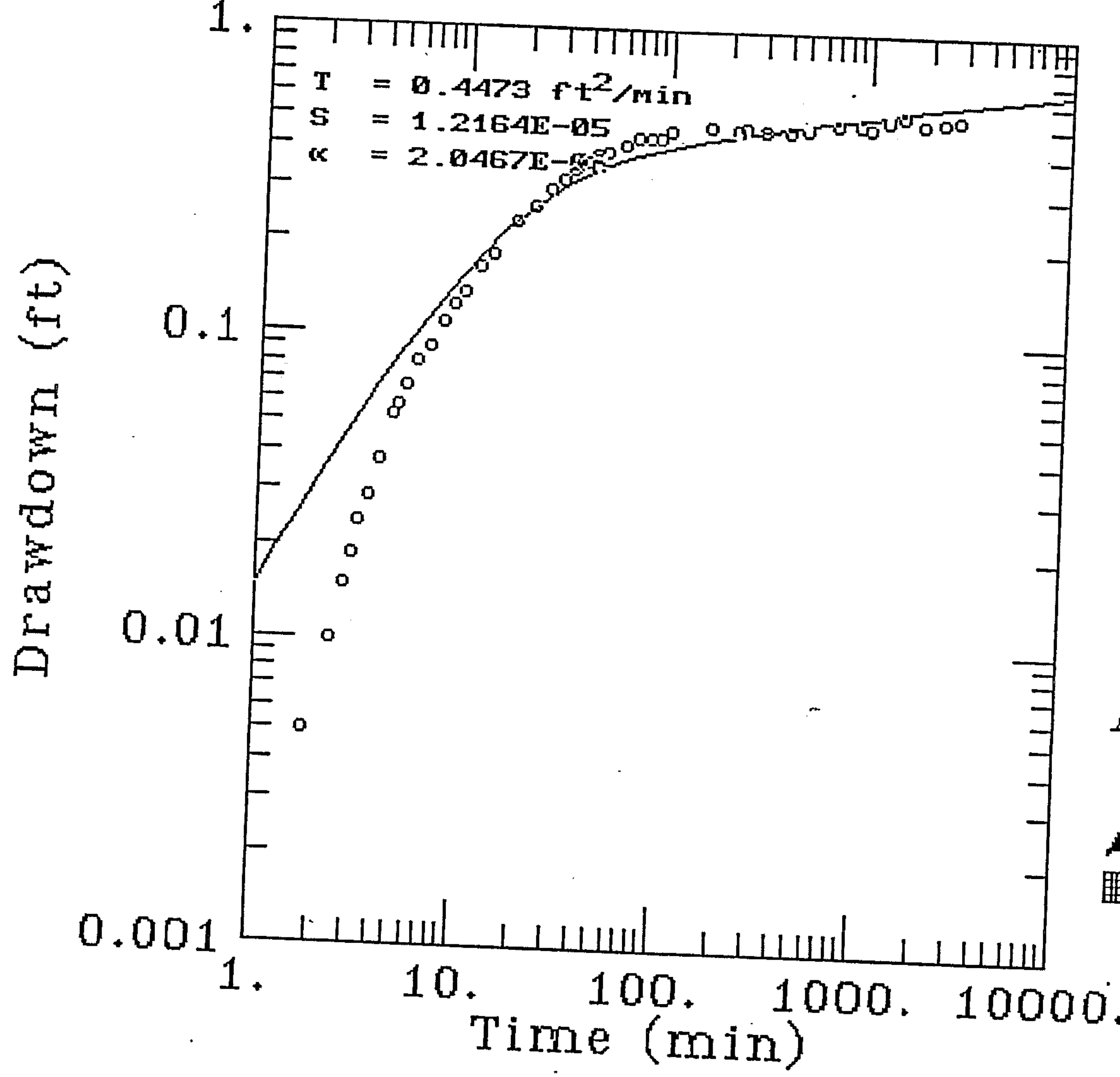
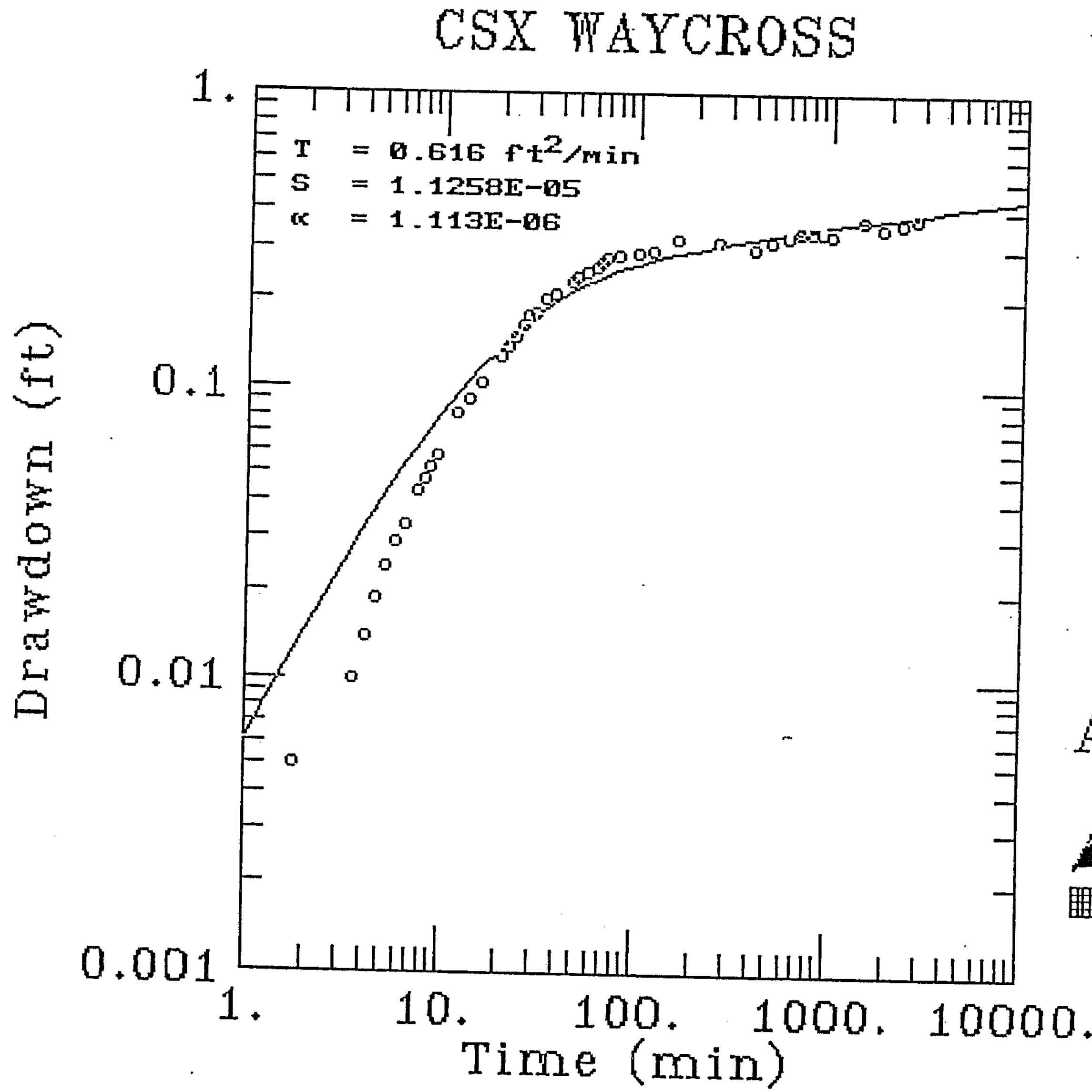
PAPADO[illegible]LIS-COOPER
METHOD
CONFINED SOLUTION

CSX WAYCROSS



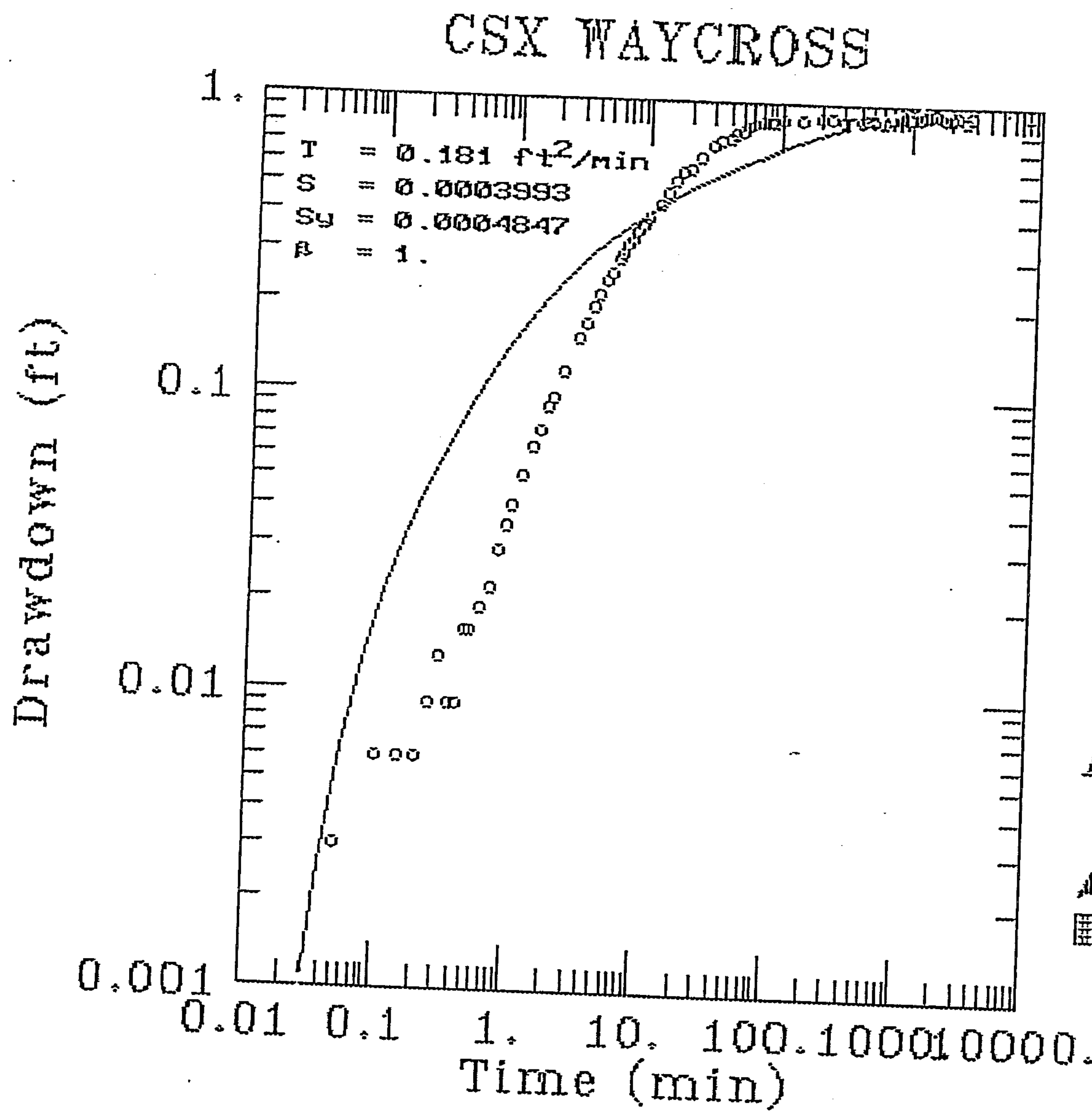
AQTESOLV
GERAGHTY & MILLER, INC.
Modeling Group

MIXED
PAPADOPULIS-COOPER
METHOD
CONFINED SOLUTION



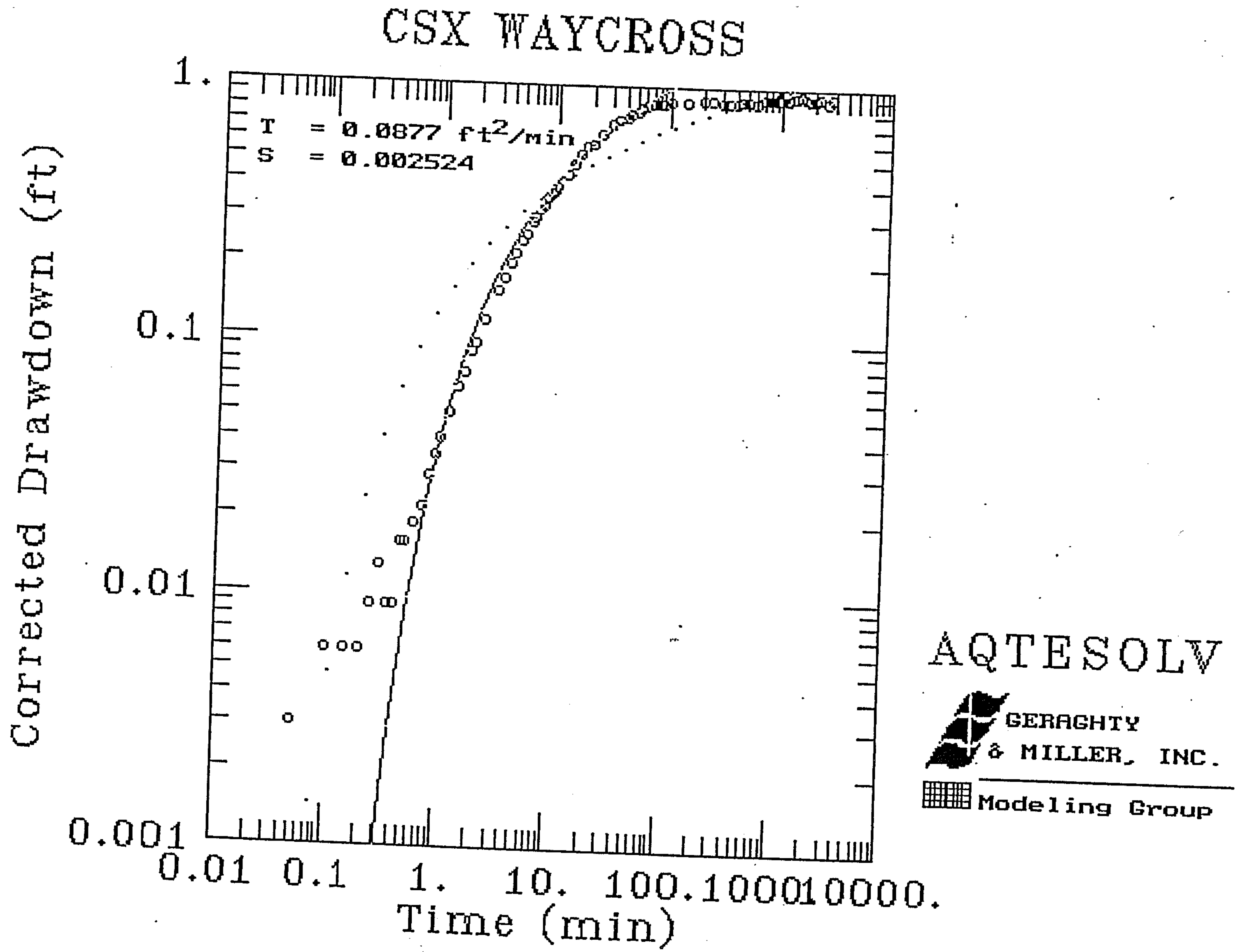
AQTESOLV
GERAGHTY & MILLER, INC.
Modeling Group

M[illegible]1D
NEUMAN METHOD
UNCONFINED, DELAYED
YIELD SOLUTION

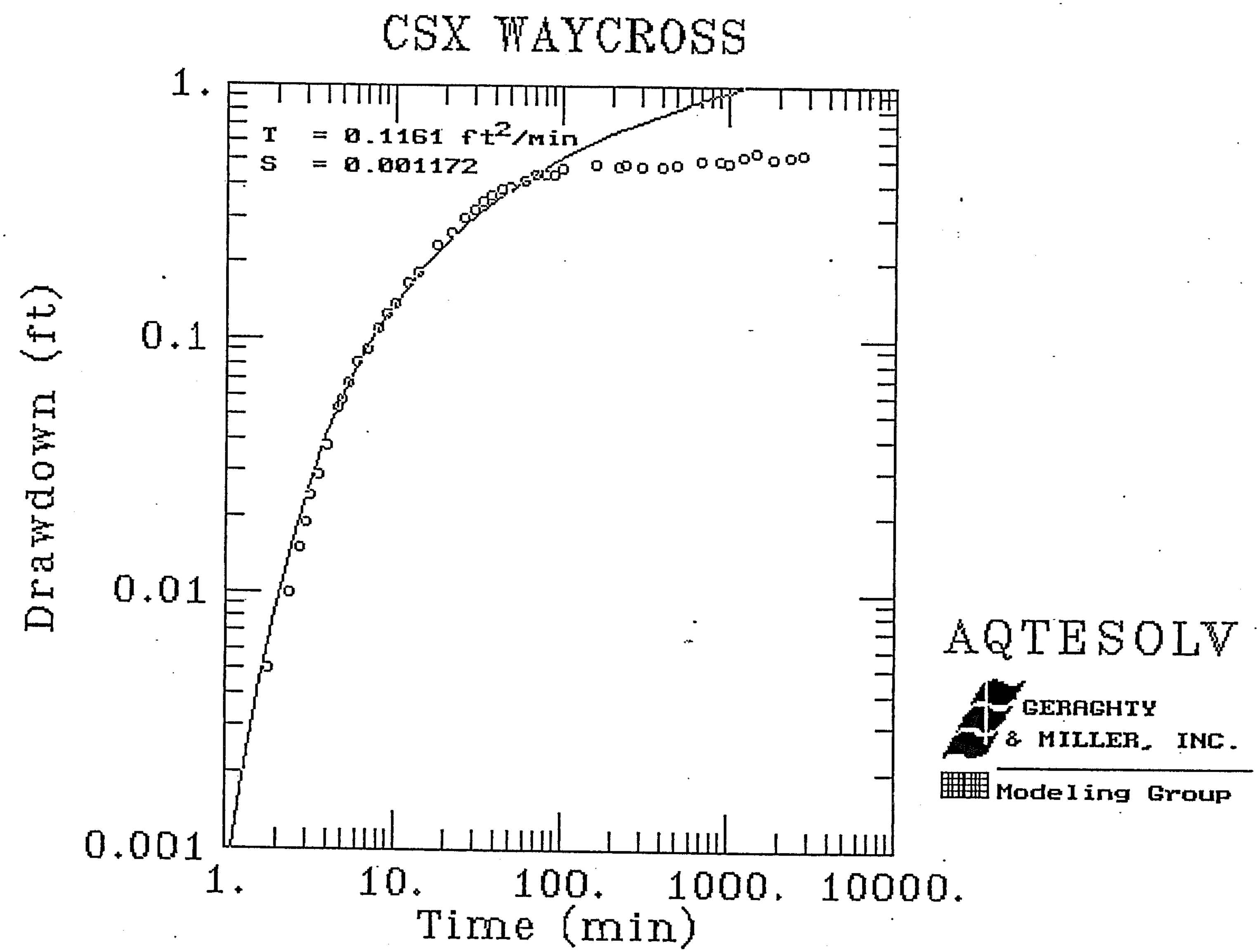


AQTESOLV
GERAGHTY & MILLER, INC.
Modeling Group

MI[illegible]D
THEIS [illegible]THOD
CONFINED SOLUTION



M 2D
THEI METHOD
CONFINED SOLUTION



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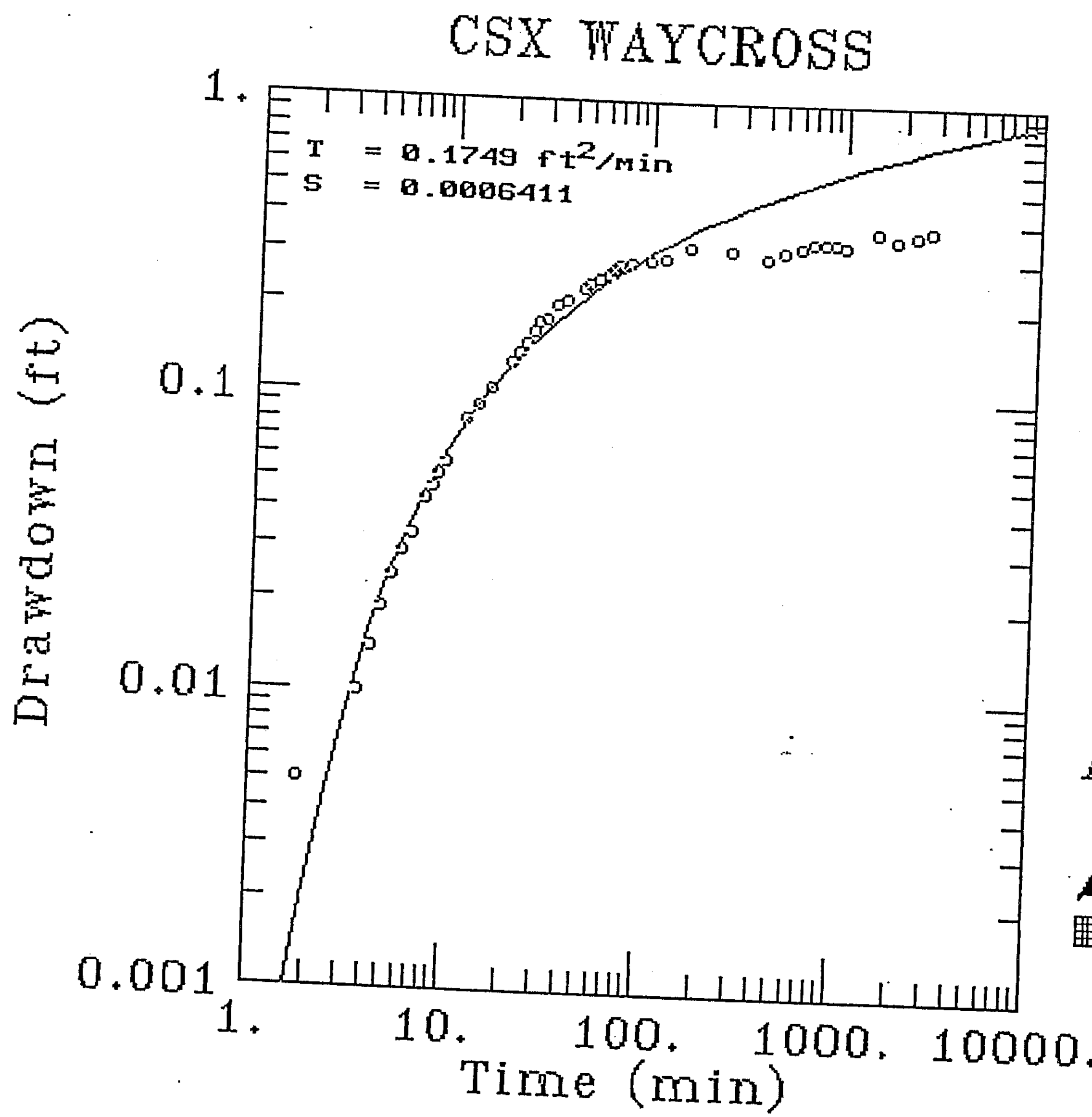
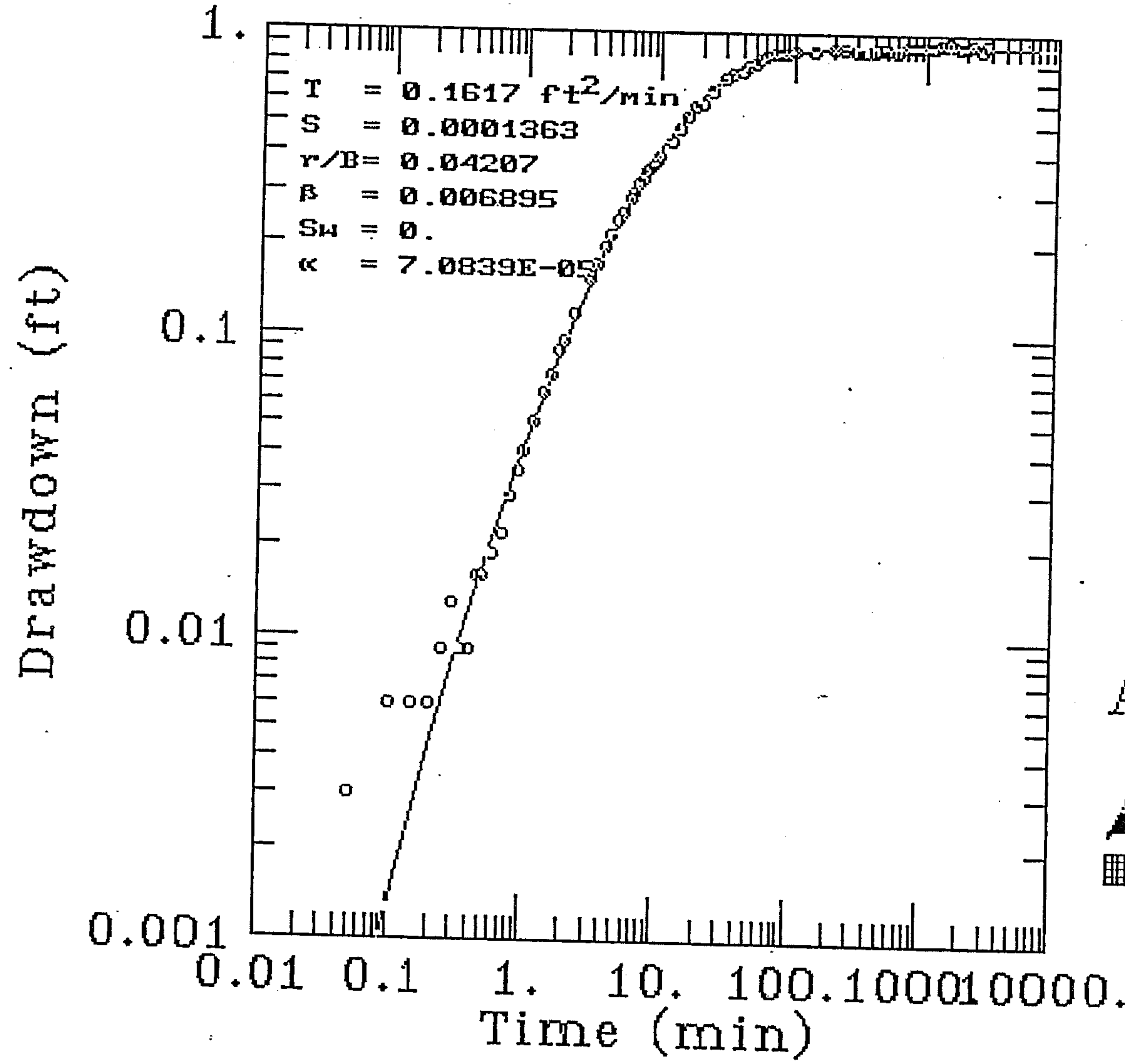
CONFINED SOLUTION



AQTESOLV
GERAGHTY & MILLER, INC.
Modeling Group

M[illegible]D
MOENCH METHOD
LEAKY AQUIFER
SOLUTION

CSX WAYCROSS

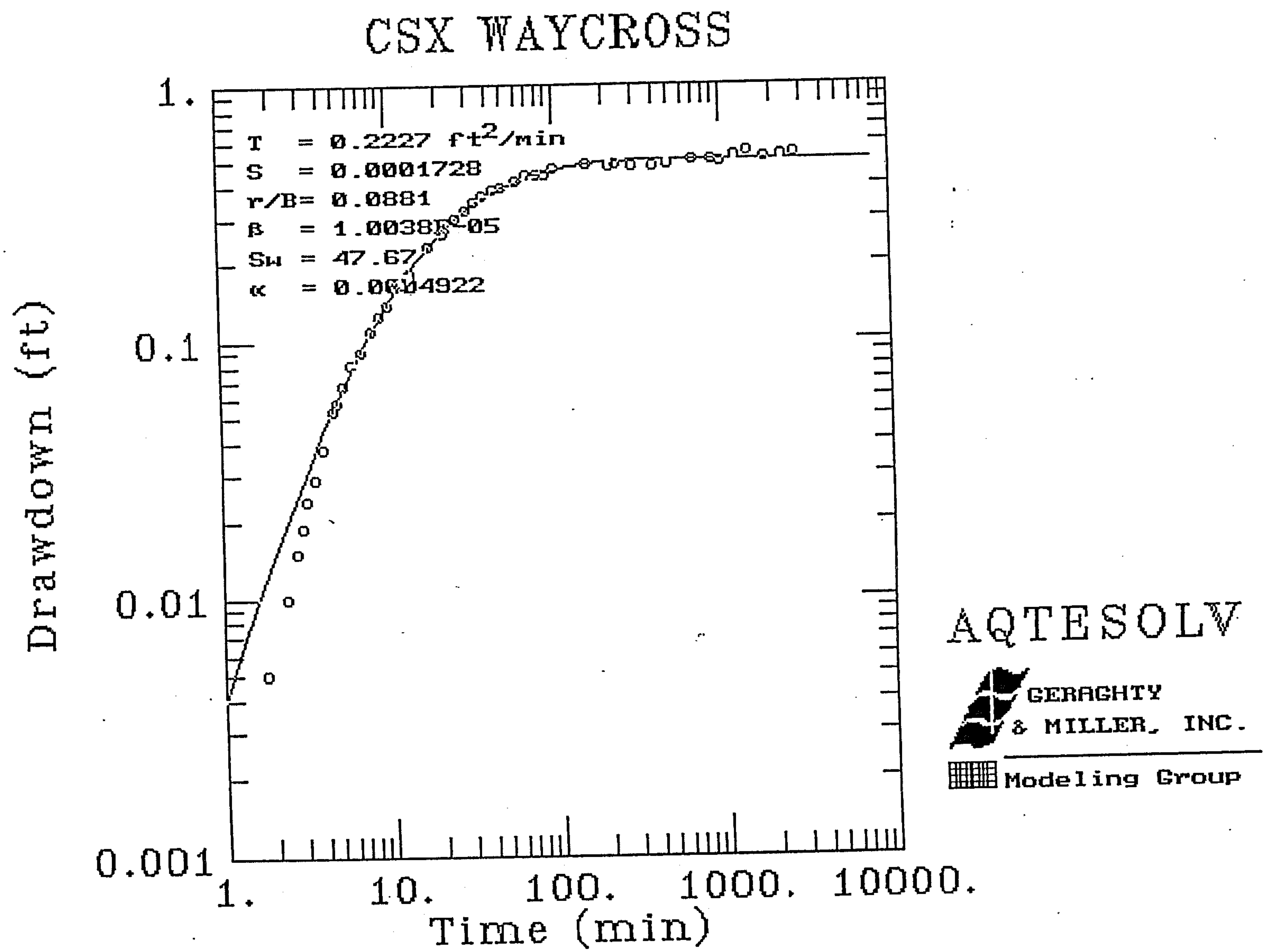


AQTESOLV

GERAGHTY & MILLER, INC.

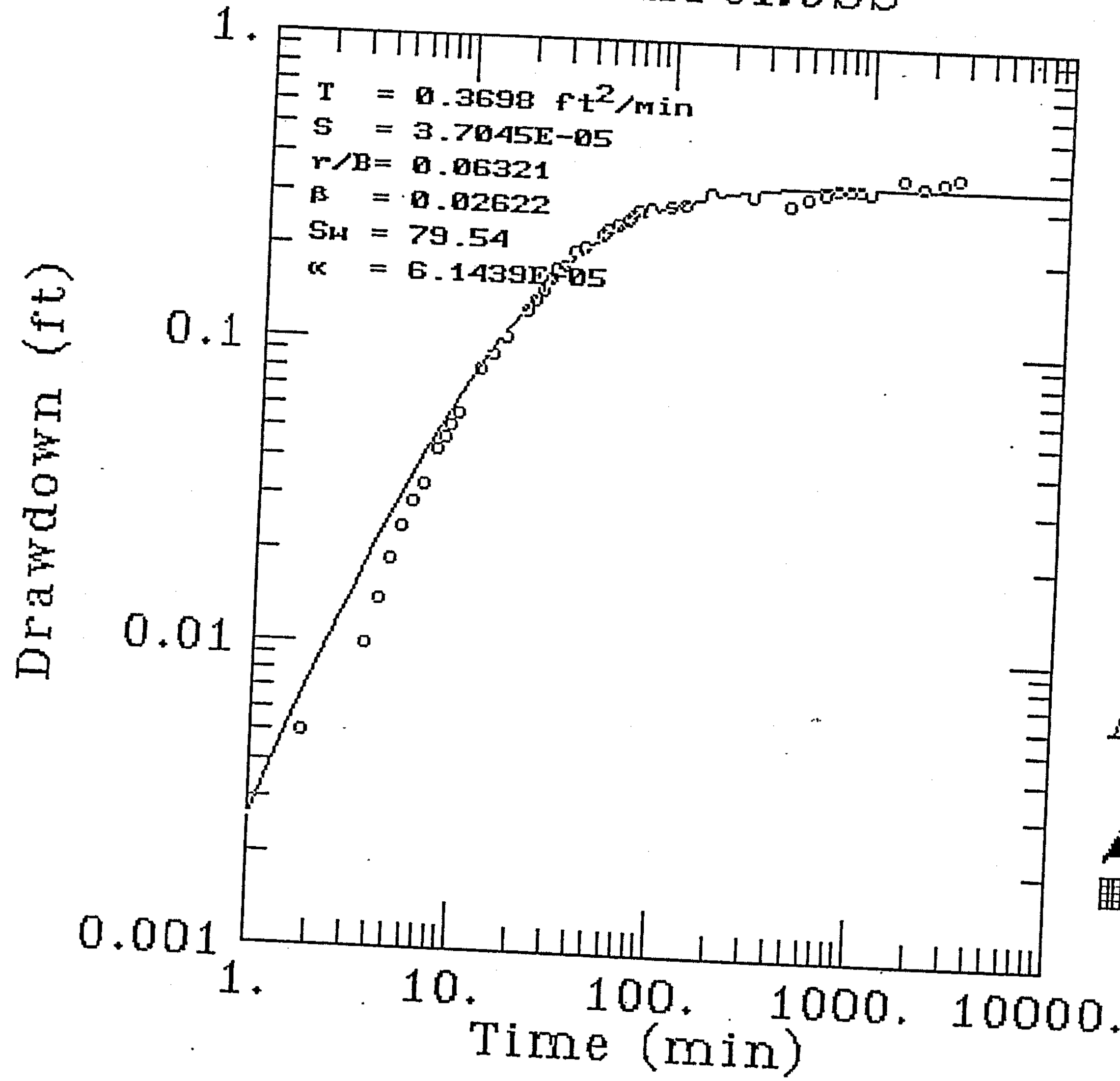
Modeling Group

MW)
MOENCH METHOD
LEAKY AQUIFER
SOLUTION



-3D
MOE[illegible] METHOD
LEAKY AQUIFER
SOLUTION

CSX WAYCROSS



AQTESOLV

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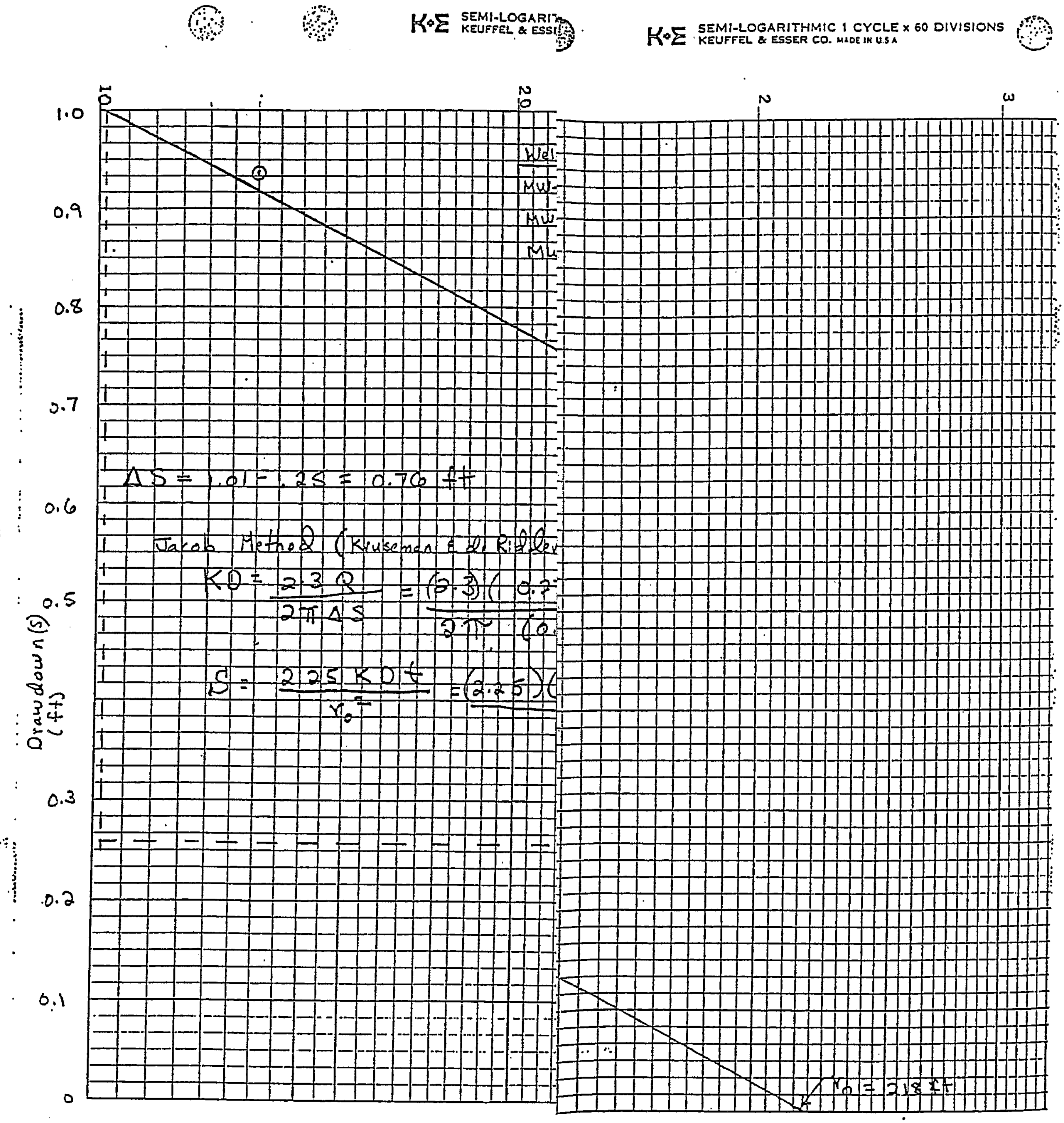
Modeling Group

JACOB METHOD
CONFINED SOLUTION



EVALUATION OF LEAKAGE AND AQUITARD CHARACTERISTICS FROM LOCOMOTIVE SHOP AQUIFER TEST DATA

Drawdown data was analyzed using a Hantush No-Storage Method (1955). From Aqtesolv output, the following characteristics were determined:

Well	T (ft^2/min)	S	r/B	r (ft)	B (ft)
MW-1D	0.0596	2.88×10^{-3}	0.358	13	36
MW-2D	0.0795	1.02×10^{-3}	0.513	40	78
MW-3D	0.1163	5.57×10^{-4}	0.522	78	149

$$\overline{T} = 0.0851\ ft^2/\text{min} = 122\ ft^2/day \quad \overline{S} = 1.49 \times 10^{-3} \quad \overline{B} = 88\ ft$$

$$LeakageFactor: \quad B = \sqrt{KDc}$$

KD = T in ft/min

c = $\frac{D'}{K'}$ = hydraulic resistance in minutes

D' = estimated thickness of aquitard in feet

K' = hydraulic conductivity of aquitard for vertical flow in ft/min

$$\overline{B^2} = \overline{KD}\ \overline{c} = \overline{T}\ \overline{c}$$

$$\overline{c} = \frac{\overline{B^2}}{\overline{T}} = \frac{(88\ ft)^2}{(0.0851\ ft.^2/\text{min})} = 91{,}000\ \text{min} = 63.2\ day$$

$$\frac{1}{\overline{c}} = \frac{K'}{D'} = 0.016\ day^{-1}$$

Assume D = Aquifer Thickness = 20 ft.

Assume H = H' = Head in Aquifer = 24 ft.

Assume K = $\frac{T}{D} = \frac{122\ ft^2/day}{20\ feet}$ = 6.1 ft/day = 45.6 gpd/ft^2

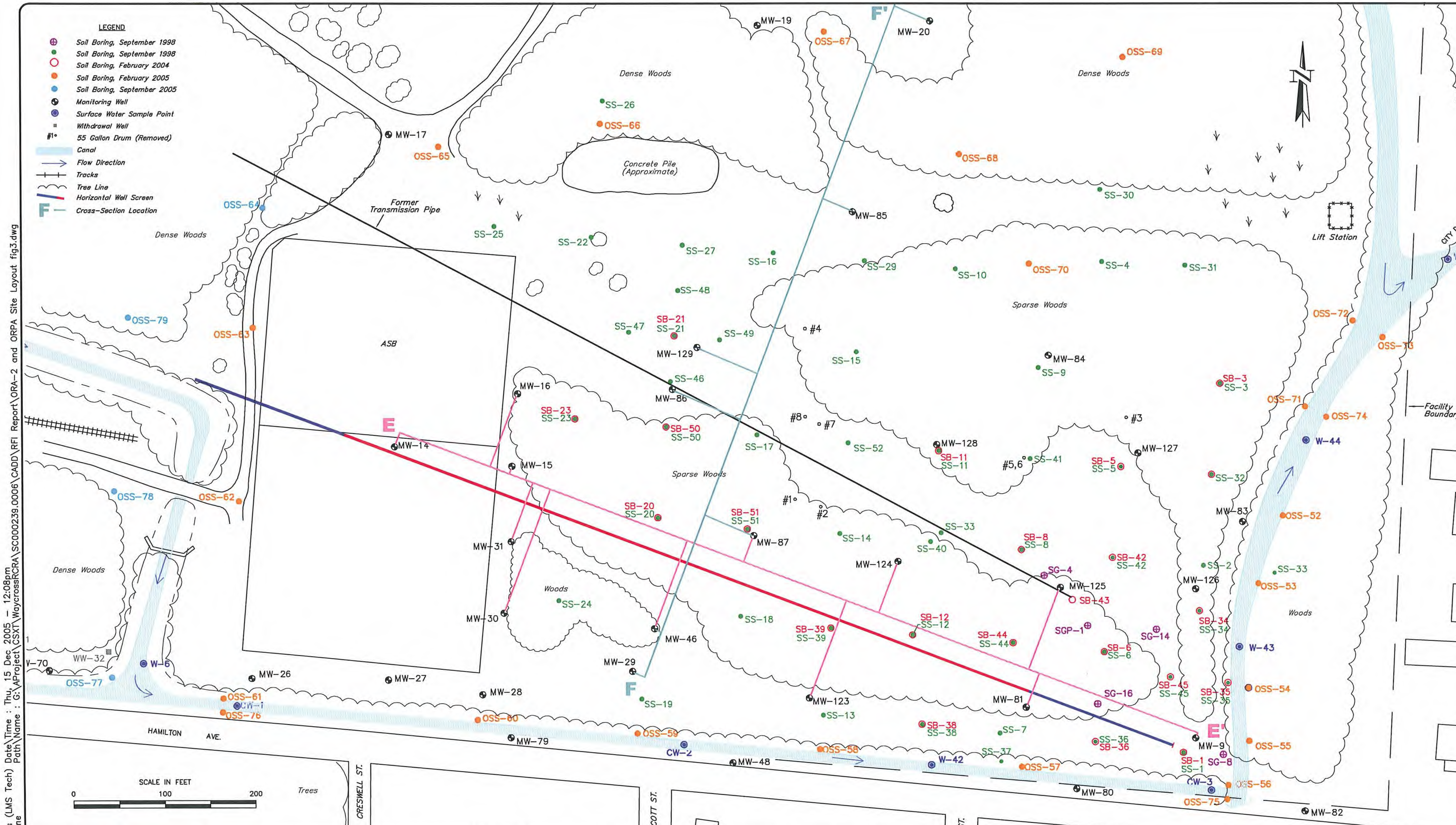
Gradient = 0.005 ft/ft

EVALUATION OF LEAKAGE AND AQUITARD CHARACTERISTICS FROM CSXT PUMPING TEST DATA (Continued)

$$\overline{Q} = 2.09\ gpm = 0.279\ ft^3/\text{min} = 402\ ft^3/day$$

$$K' = Aquitard\ Hydraulic\ Conductivity = 0.128\ ft/day = 0.000089\ ft/\text{min}$$

$$D' = Aquitard\ Thickness = 8\ ft$$



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User Name: Warren, Anne Path\Name : G:\AProject\CSXT\WaycrossRCRA\SC000239.0006\CADD\RFI Report\ORA-2 and ORPA Site Layout fig3.dwg

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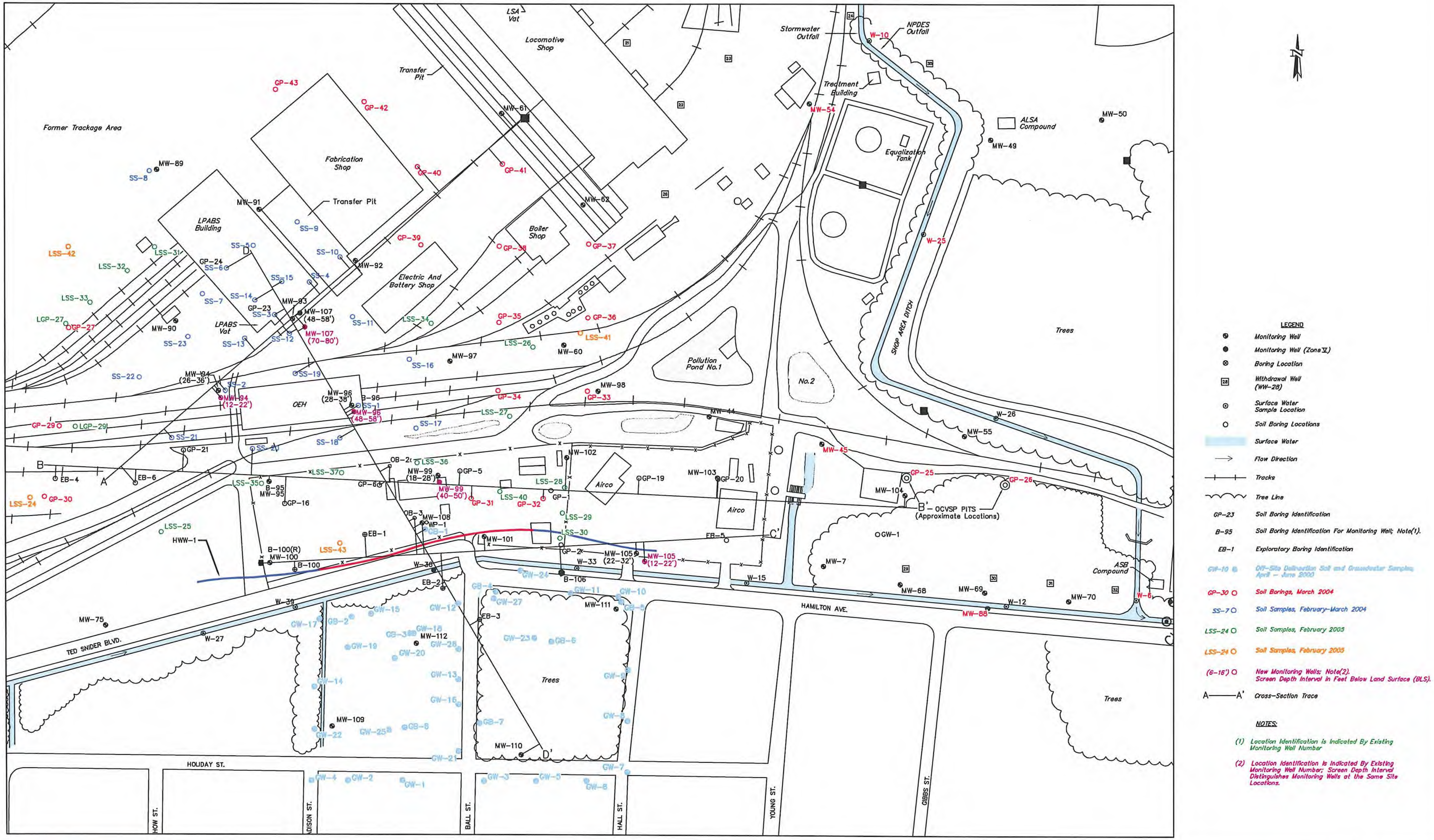
PRJT MANAGER: J. BECKNER	CHECKED BY:	DRAFTER:	PROJECT NUMBER: SC000239.0006.00002		FIGURE:
MAP SOURCE: GANNETT FLEMING, 2005.			CSX TRANSPORTATION, INC. WAYCROSS YARD WAYCROSS, GEORGIA	ORA-2 AND ORPA SITE LAYOUT	3



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User Name: Warren, Anne

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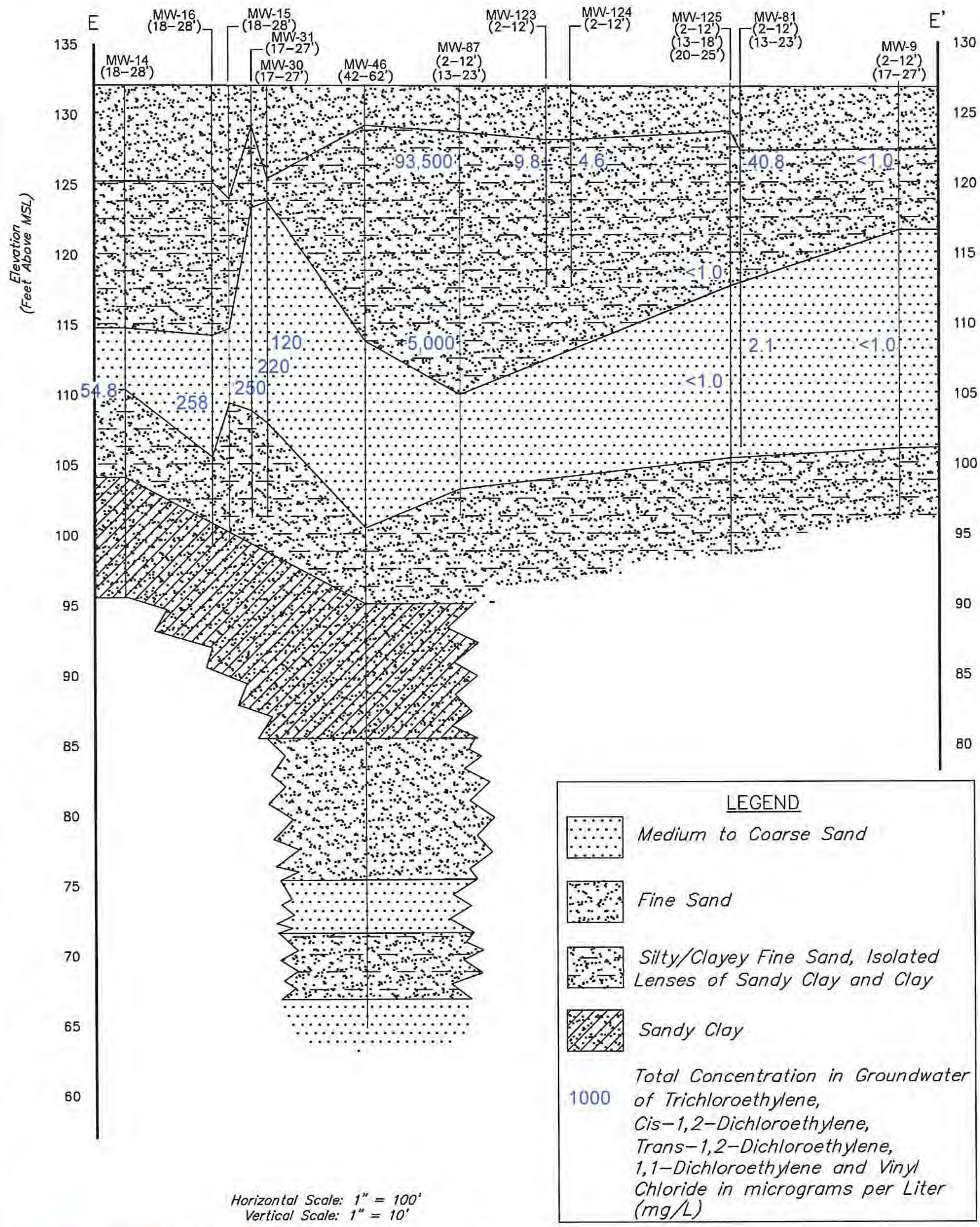
PRJT MANAGER: J. BECKNER	CHECKED BY:	DRAFTER:	PROJECT NUMBER: SC000239.0006.00002

MAP SOURCE: GANNETT FLEMING, 2005.

CSX TRANSPORTATION, INC.
WAYCROSS YARD
WAYCROSS, GEORGIA

LPABS, OEH AND OCVSP
SITE LAYOUT

FIGURE:
4



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PRJT MANAGER: J. BECKNER	CHECKED BY: C. LAWSON
DRAWING: CSX-WAYCROSS	
PRJT NO: SC000239.0006	
DRAFTER: A. WARREN	

CROSS-SECTION E - E'
ORA-2 AND ORPA

CSX TRANSPORTATION, INC.
WAYCROSS YARD
WAYCROSS, GEORGIA

FIGURE NO.
10

Acad Version : R16.1s (LMS Tech) Date\Time : Thu, 15 Dec 2005 - 2:20pm
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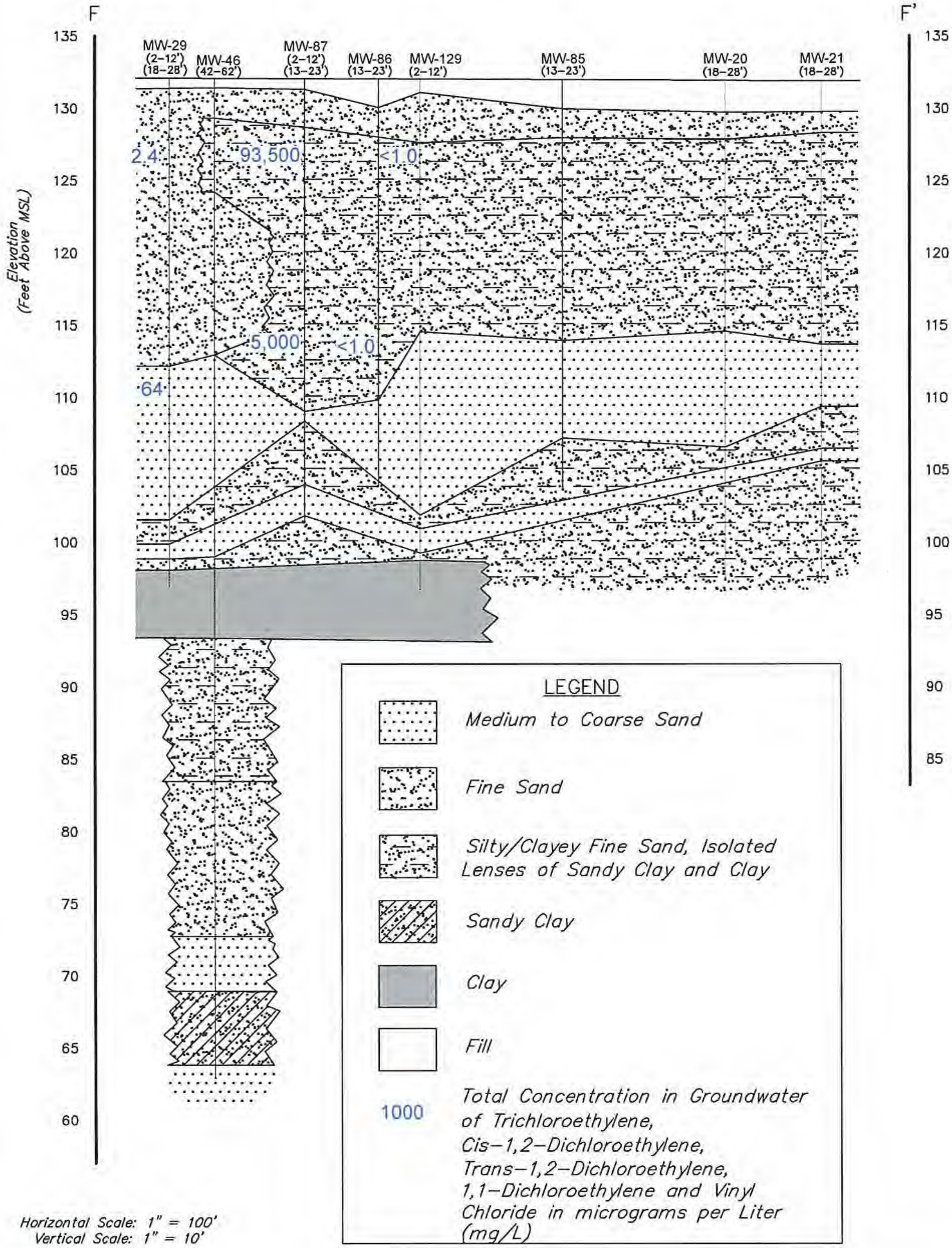

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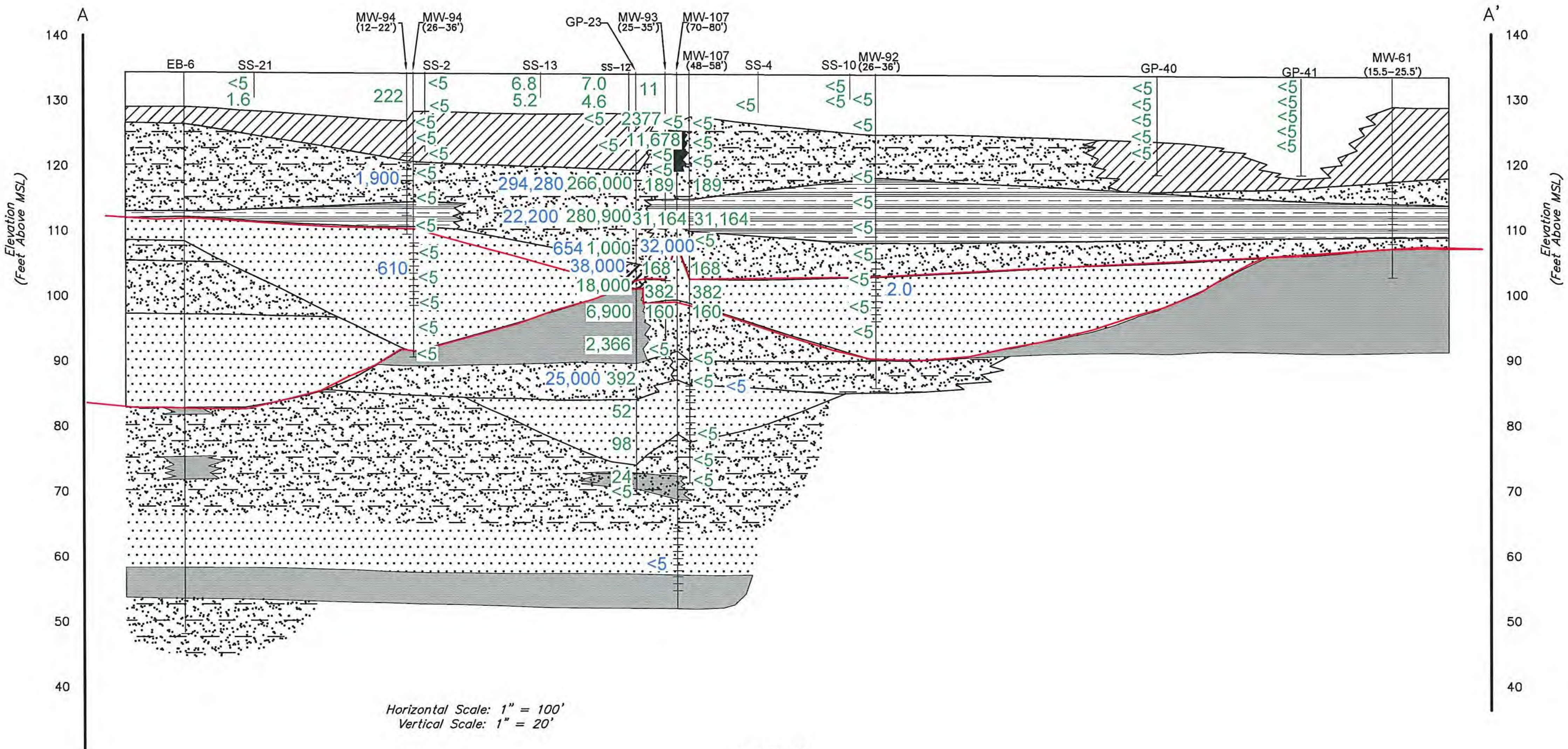
PRJT MANAGER: J. BECKNER	CHECKED BY: C. LAWSON
DRAWING:	
PRJT NO: SC000239.0006	
DRAFTER: A. WARREN	

CROSS-SECTION F - F'
ORA-2 AND ORPA

CSX TRANSPORTATION, INC.
WAYCROSS YARD
WAYCROSS, GEORGIA

FIGURE NO.

11



LEGEND

- Medium to Coarse Sand with Fine Gravel and Kaolinized Feldspars (Fluvial Channel Sand)
- Fine Sand
- Silty/Clayey Fine to Very Fine Sand, Isolated Lenses of Sandy Clay and Clay (Overbank/Floodplain)
- Alternating Lenses of Fine Sand and Clay
- Alternating Clays and Sandy Clays, with Organic Matter (Swamp Complex)
- Sandy Clay
- Clay
- Fill
- 1000 — Total Concentration in Soil of Trichloroethylene, Cis–1,2–Dichloroethylene, Trans–1,2–Dichloroethylene, 1,1–Dichloroethylene and Vinyl Chloride in micrograms per kilogram (mg/kg)
- 1000 — Total Concentration in Groundwater of Trichloroethylene, Cis–1,2–Dichloroethylene, Trans–1,2–Dichloroethylene, 1,1–Dichloroethylene and Vinyl Chloride in micrograms per Liter (mg/L)
- Boundary of Fluvial Channel System

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PRJT MANAGER: J. BECKNER	CHECKED BY:	DRAFTER: A. WARREN	PROJECT NUMBER: SC000239.0006.00002
NOTES:			CSX TRANSPORTATION, INC. WAYCROSS YARD WAYCROSS, GEORGIA

CROSS-SECTION A - A'
LPABS AND OEH

FIGURE: 12

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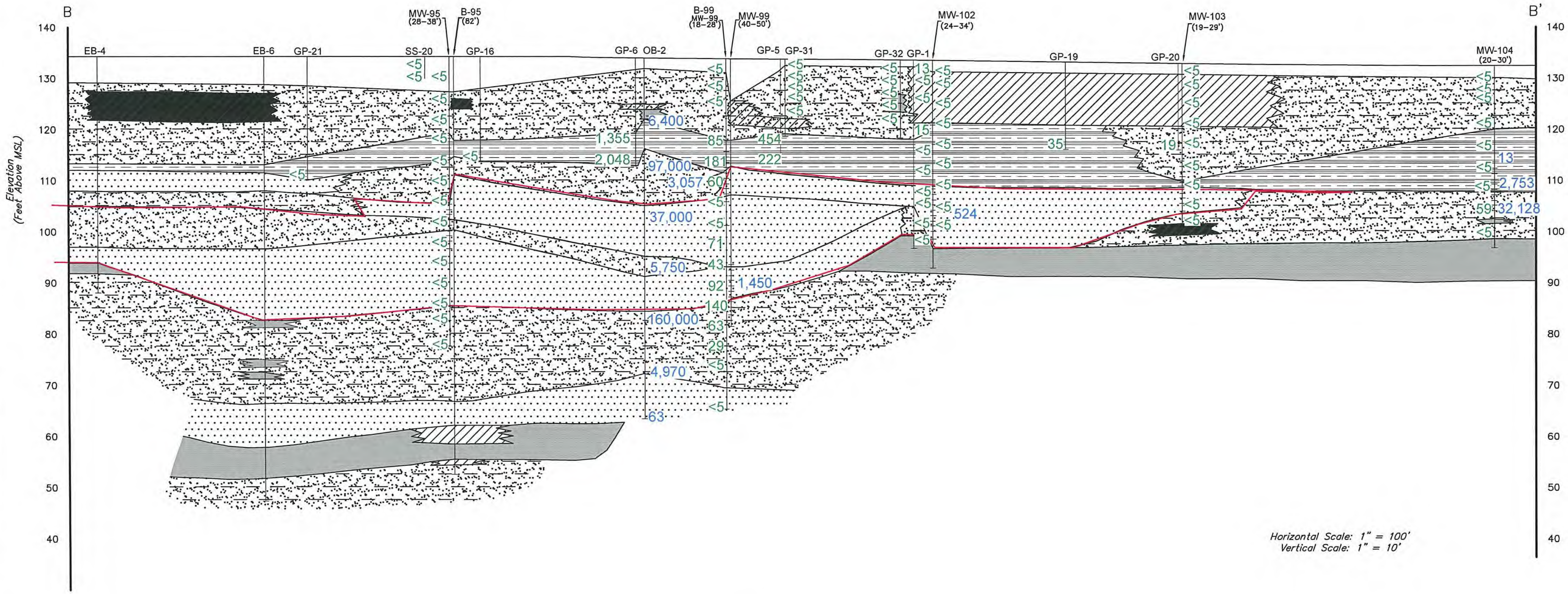

LEGEND

Medium to Coarse Sand with Fine Gravel and Kaolinized Feldspars (Fluvial Channel Sand)	Alternating Clays and Sandy Clays, with Organic Matter (Swamp Complex)
Fine Sand	Sandy Clay
Silty/Clayey Fine to Very Fine Sand, Isolated Lenses of Sandy Clay and Clay (Overbank/Floodplain)	Clay
Alternating Lenses of Fine Sand and Clay	Fill

1000 Total Concentration in Soil of Trichloroethylene, Cis–1,2–Dichloroethylene, Trans–1,2–Dichloroethylene, 1,1–Dichloroethylene and Vinyl Chloride in micrograms per kilogram (mg/kg)

1000 Total Concentration in Groundwater of Trichloroethylene, Cis–1,2–Dichloroethylene, Trans–1,2–Dichloroethylene, 1,1–Dichloroethylene and Vinyl Chloride in micrograms per Liter (mg/L)

Boundary of Fluvial Channel System

Acad Version : R16.1s (LMS Tech) Date\Time : Thu, 15 Dec 2005 – 12:13pm
User Name: Warren, Anne Path\Name : G:\AProject\CSXT\WaycrossRCRA\SC000239.0006\CADD\RFI Report\Cross Section B–B' fig13.dwg

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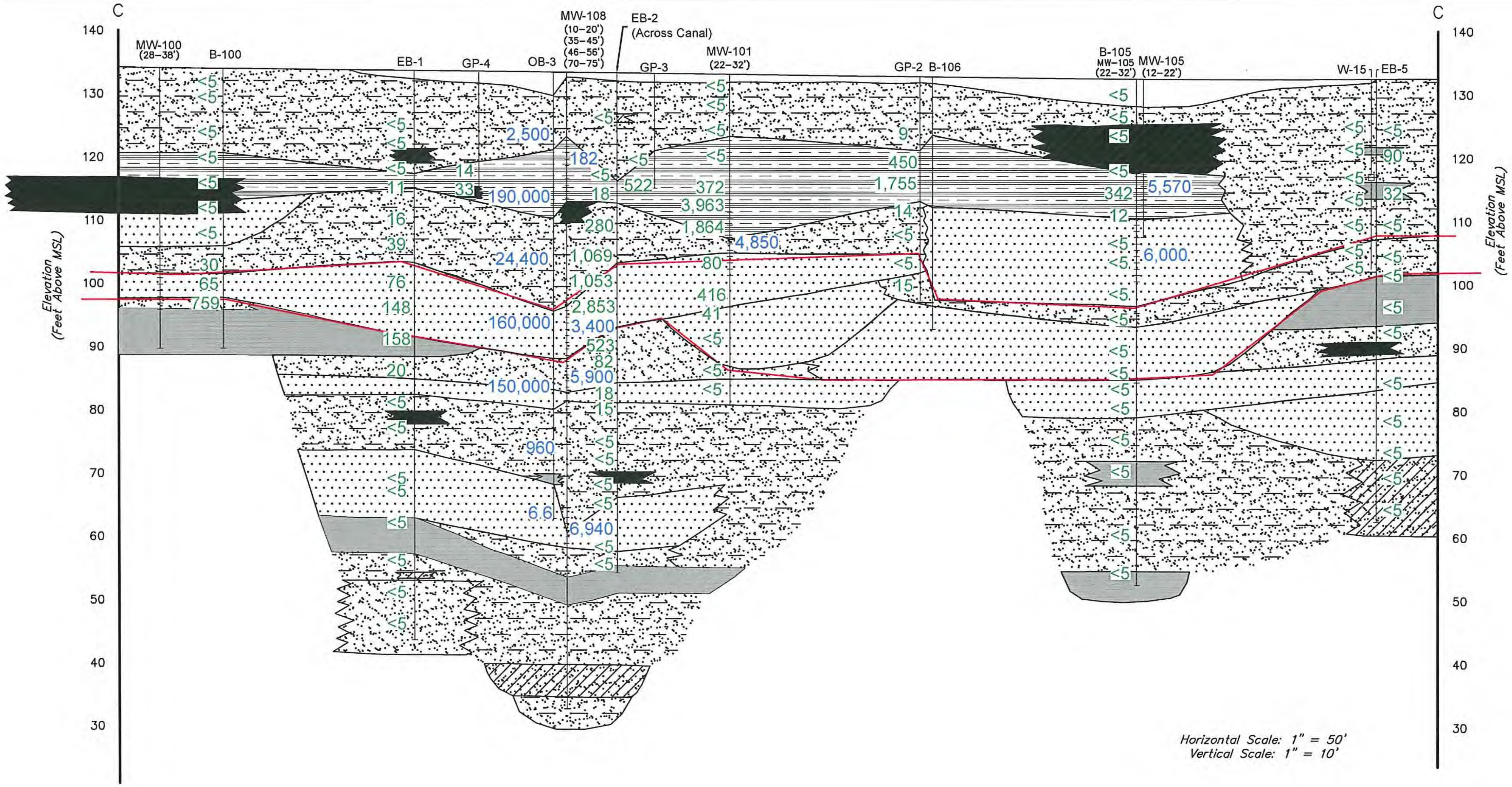
PRJT MANAGER: J. BECKNER	CHECKED BY:	DRAFTER: A. WARREN	PROJECT NUMBER: SC000239.0006.00002		FIGURE:
NOTES:			CSX TRANSPORTATION, INC. WAYCROSS YARD WAYCROSS, GEORGIA	CROSS-SECTION B - B' LPABS AND OEH	13



LEGEND

Medium to Coarse Sand with Fine Gravel and Kaolinized Feldspars (Fluvial Channel Sand)

Fine Sand

Silty/Clayey Fine to Very Fine Sand, Isolated Lenses of Sandy Clay and Clay (Overbank/Floodplain)

Alternating Lenses of Fine Sand and Clay

Alternating Clays and Sandy Clays, with Organic Matter (Swamp Complex)

Sandy Clay

Clay

Fill

1000 Total Concentration in Soil of Trichloroethylene, Cis-1,2-Dichloroethylene, Trans-1,2-Dichloroethylene, 1,1-Dichloroethylene and Vinyl Chloride in micrograms per kilogram (mg/kg)

1000 Total Concentration in Groundwater of Trichloroethylene, Cis-1,2-Dichloroethylene, Trans-1,2-Dichloroethylene, 1,1-Dichloroethylene and Vinyl Chloride in micrograms per Liter (mg/L)

Boundary of Fluvial Channel System

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PRJT MANAGER: J. BECKNER	CHECKED BY:	DRAFTER: A. WARREN	PROJECT NUMBER: SC000239.0006.00002		FIGURE:
NOTES:			CSX TRANSPORTATION, INC. WAYCROSS YARD WAYCROSS, GEORGIA	CROSS-SECTION C - C' LPABS AND OEH	14

Acad Version : R16.1s (LMS Tech) Date\Time : Thu, 15 Dec 2005 - 12:13pm
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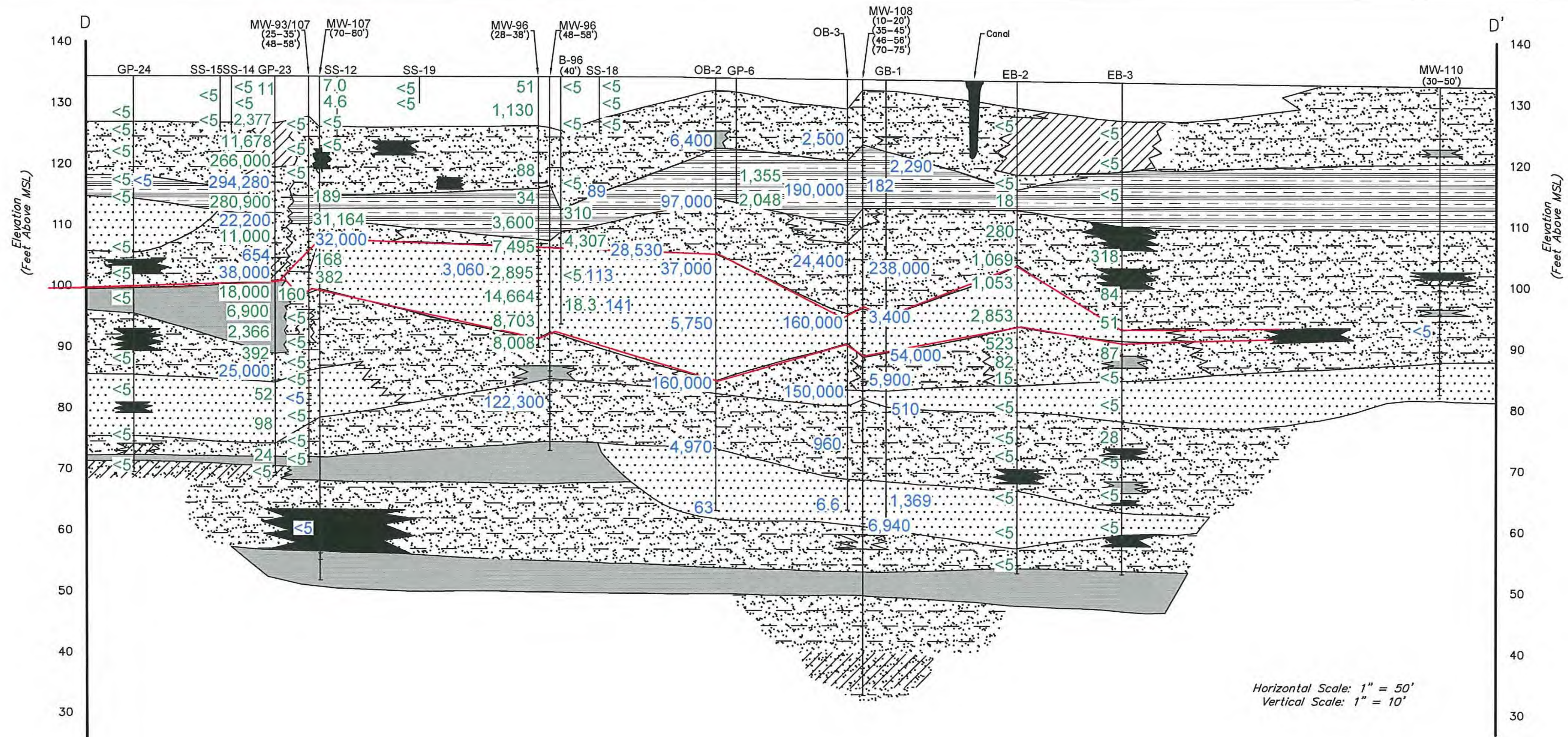

LEGEND

- Medium to Coarse Sand with Fine Gravel and Kaolinized Feldspars (Fluvial Channel Sand)
- Fine Sand
- Silty/Clayey Fine to Very Fine Sand, Isolated Lenses of Sandy Clay and Clay (Overbank/Floodplain)
- Alternating Lenses of Fine Sand and Clay
- Alternating Clays and Sandy Clays, with Organic Matter (Swamp Complex)
- Sandy Clay
- Clay
- Fill
- 1000 — Total Concentration in Soil of Trichloroethylene, Cis–1,2–Dichloroethylene, Trans–1,2–Dichloroethylene, 1,1–Dichloroethylene and Vinyl Chloride in micrograms per kilogram (mg/kg)
- 1000 — Total Concentration in Groundwater of Trichloroethylene, Cis–1,2–Dichloroethylene, Trans–1,2–Dichloroethylene, 1,1–Dichloroethylene and Vinyl Chloride in micrograms per Liter (mg/L)
- Boundary of Fluvial Channel System

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PRJT MANAGER: J. BECKNER	CHECKED BY:	DRAFTER: A. WARREN	PROJECT NUMBER: SC000239.0006.00002		FIGURE:
NOTES:			CSX TRANSPORTATION, INC. WAYCROSS YARD WAYCROSS, GEORGIA	CROSS-SECTION D - D' LPABS AND OEH	15

LAYNE ATLANTIC COMPANY

Albany, Georgia

LOG OF WELL For Atlantic Coast Line Railroad Company
Located at Repair Shops, Waycross in Ware County, State Georgia
Date Drilling Started Oct. 31 1960 Date Started Oct 26 1960
Finished Drilling Nov. 21 1960 Finished Nov. 28 1960

FORMATIONS AND DEPTH OF WELL

TOTAL DEPTH OF ALL STRATA FT.	IN.	DEPTH OF EACH STRATUM FT.	IN.	FORMATION FOUND AT EACH STRATUM
				WELL NO 1
2		2		Cinder Fill
17		15		Fine sand
28		11		Clay with coarse sand
32		4		Soft yellow clay
40		8		Yellow & white clay
62		22		Blue clay
71		9		Coarse gravel sand
75		4		Sandy blue clay soft
155		80		Sandy blue clay
196		41		Sandy blue clay with more sand than above
216		20		Coarse sand with clay
232		16		Sandy gray limerock
240		8		Chalky clay. Slow
247		7		Chalky clay with streaks of hard shale
267		20		Sandy clay with streaks of rock
277		10		Med. coarse sandy clay. Med. soft
329		52		Med. coarse pepper sand & streaks sandstone
341		12		Sandy brown limerock with shallow soft streaks hard
348		7		Sandy brown limerock with shallow streaks. Very hard
368		20		Coarse pepper sand. Soft
375		7		White limerock & shell
378		3		Med. coarse pepper sand soft
408		30		Brown limerock. Med.
424		16		Med. coarse sand with streaks of rock. Soft.
439		15		Brown limerock. Med soft
465		26		Limerock with stks. sand
478		13		as above but softer
492		14		Hard brown limerock
504		8		Med soft brown limerock with hard streaks.
532		28		Soft brown limerock
550		18		Brown limerock Hard-soft
605		55		White limerock. Soft
663		58		Brown limerock & shells Medium
671		8		Brown limerock. Med hard
677		6		Brown " Med. hard
725		48		Brown & white limerock med.
780		55		Brown limerock & shells Med hard
803		23		Brown limerock slow

DIMENSIONS OF CASING AND SCREEN

TOTAL LENGTH OF ALL SCREENS and CASINGS FT.	IN.	LENGTH OF EACH SEC. OF SCREEN OR CASING FT.	IN.	SPECIFY SCREEN OR CASING	SIZE OF SCREEN OR CASING IN.	GAUGE OF SCREEN	
~~37~~				~~casing~~			
482		482		Casing	12		Cemented in
		place entire length					
		Bottom of completed well 803'					

WELL DATA:

Preliminary Test

Date Tested 19 Static Level
Production GPM Pumping Level

Permanent Test

Date Tested Nov 23 1960 Static Level 83'
Production 1500 GPM Active St. Level
Drawdown 12' Pumping Level 95'
Remarks: Ran pumping test 10 hours.

PUMP DATA:

Shop No. 41986 Type Lubr. Oil
Type Head TF818 Size Suction 8"
Depth Setting 100' (BP to MB)
Size Column 8"x2"x1½" Length Suction 10'
Type Bowl 12" RKHC Length Air Line 101'
No. Stages 4 Discharge-
Cap'y and Head 1500 GPM Pressure 228'

MOTOR DATA:

Horsepower 100 Voltage 440
RPM 1750 Phase 3
Type OGK Cycles 60
Make Allis Chalmers Frame No. 504 PYTO

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Georgia State Plane East Zone (FIPS zone 1001). The **horizontal datum** was NAD83, GRS1980 spheroid. Differences in datum, spheroid, projection or State Plane zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov/ or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713-3242** or visit its website at http://www.ngs.noaa.gov/.

Base map information shown on this FIRM was derived from National Agriculture Imagery Program (NAIP) at a scale of 1:20,000 from photography dated 2007 or later.

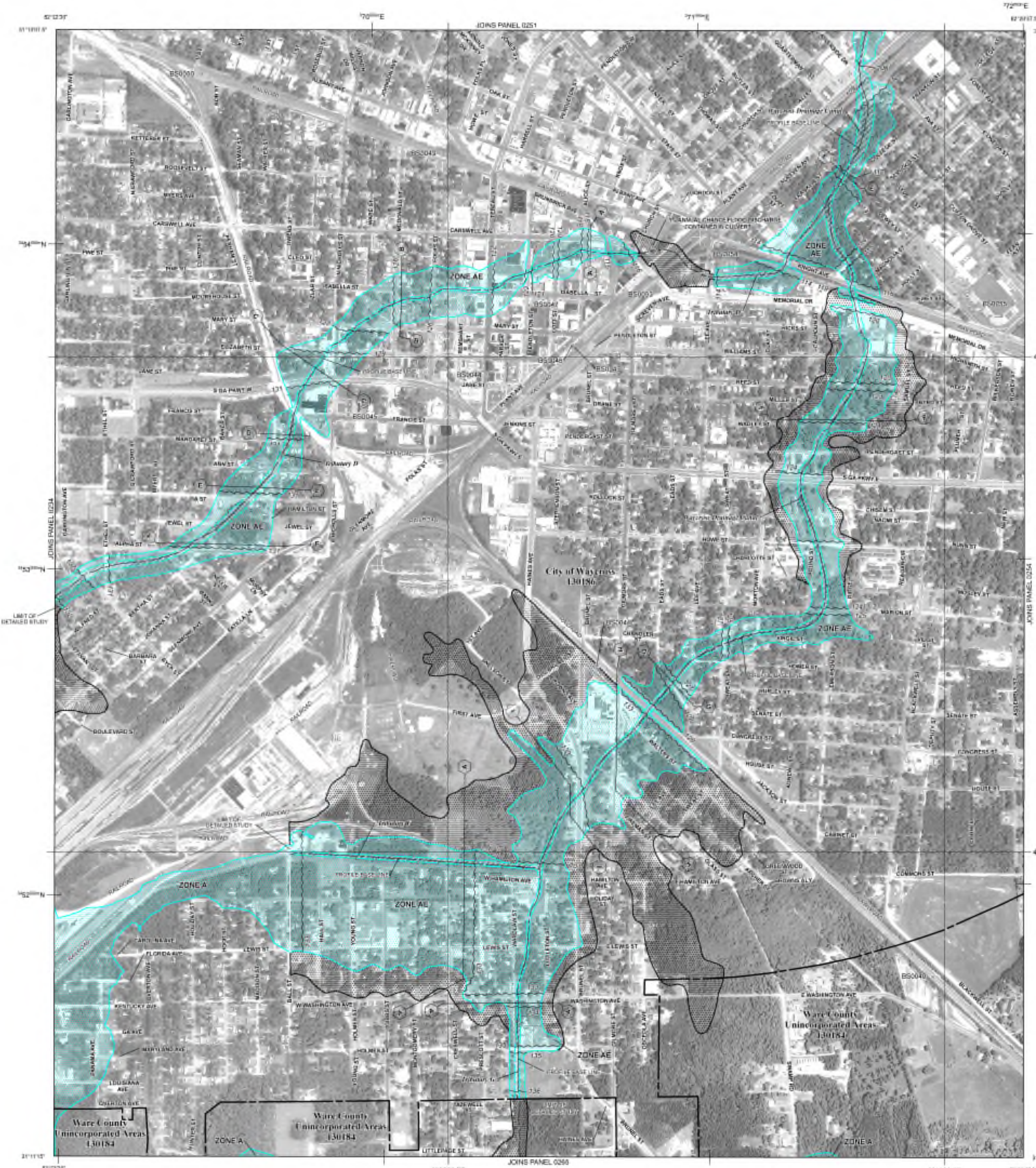
The **profile base lines** depicted on this map represent the hydraulic modeling baselines that match the flood profiles in the FIS report. As a result of improved topographic data, the profile base line, in some cases, may deviate significantly from the channel centerline or appear outside the SFHA.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

Contact the **FEMA Map Service Center** at 1-800-358-9616 for information on available products associated with this FIRM. Available products may include previously issued Letters of Map Change, a *Flood Insurance Study* report, and/or digital versions of this map. The FEMA Map Service Center may also be reached by Fax at 1-800-358-9620 and its website at http://www.msc.fema.gov/.

If you have **questions about this map** or questions concerning the National Flood Insurance Program in general, please call **1-877-FEMA MAP** (1-877-336-2627) or visit the FEMA website at http://www.fema.gov/business/nfip/.



LEGEND

SPECIAL FLOOD HAZARD AREAS SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Areas to be protected from 1% annual chance flood event by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X	Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X	Areas determined to be outside the 0.2% annual chance floodplain.
ZONE D	Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

	1% annual chance floodplain boundary
	0.2% annual chance floodplain boundary
	Floodway boundary
	Zone D boundary
	CBRS and OPA boundary
	Boundary dividing Special Flood Hazard Area Zones and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths, or flood velocities
513	Base Flood Elevation line and value; elevation in feet*
(EL 987)	Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988

(A)———(A)	Cross section line
(23)- - - - -(23)	Transect line
97°07'30", 32°22'30"	Geographic coordinates referenced to the North American Datum of 1983 (NAD 83), Western Hemisphere
4275000mE	1000-meter Universal Transverse Mercator grid ticks, zone 17
6000000 FT	5000-foot grid values: Georgia State Plane coordinate system, East Zone (FIPSZONE = 1001), Transverse Mercator projection
DX5510	Bench mark (see explanation in Notes to Users section of this FIRM panel)
• M1.5	River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
SEPTEMBER 25, 2009

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 500'

250 0 250 500 750 1,000 FEET
150 0 150 300 METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0253D

FIRM

FLOOD INSURANCE RATE MAP

WARE COUNTY, GEORGIA

AND INCORPORATED AREAS

PANEL 253 OF 680

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
WARE COUNTY	130184	0253	D
WAYCROSS, CITY OF	130186	0253	D

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
13299C0253D

EFFECTIVE DATE
SEPTEMBER 25, 2009

Federal Emergency Management Agency