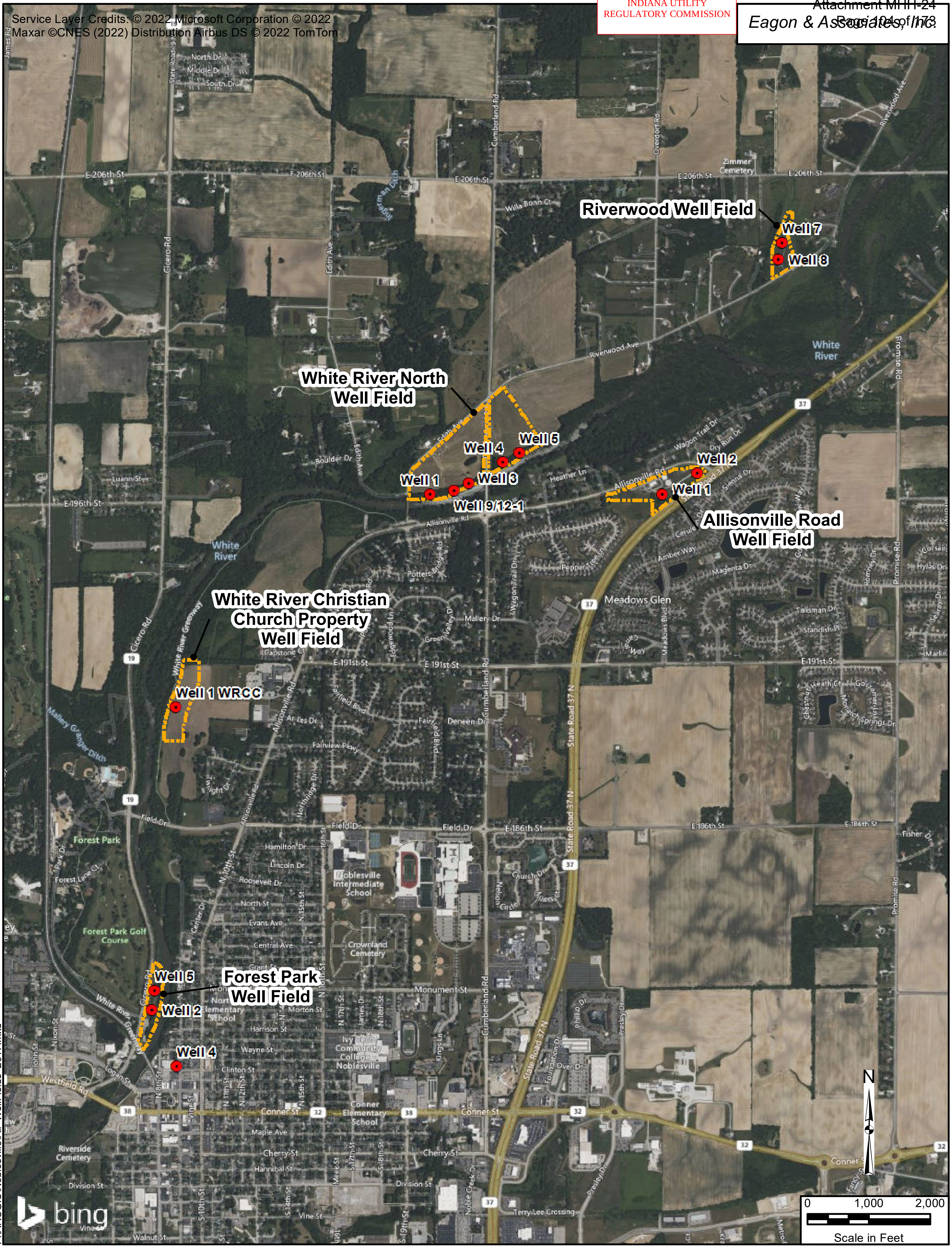


Figure 1. Well Field Location Map
INAW Noblesville

EAGON & ASSOCIATES, INC.

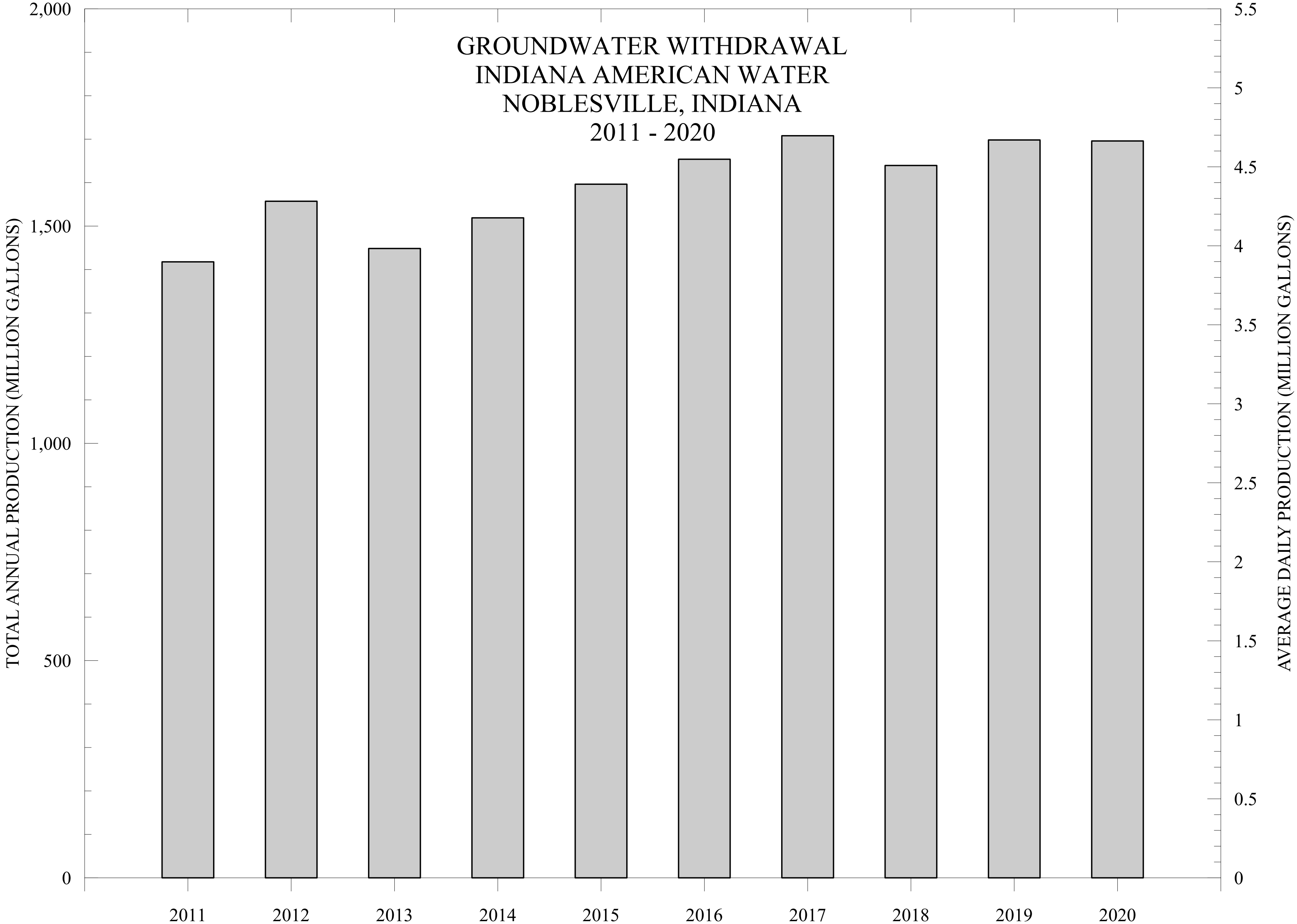


FIGURE 2.

Noblesville/Noblesville_Annual Withdrawal.grf
4/6/2022

EAGON & ASSOCIATES, INC.

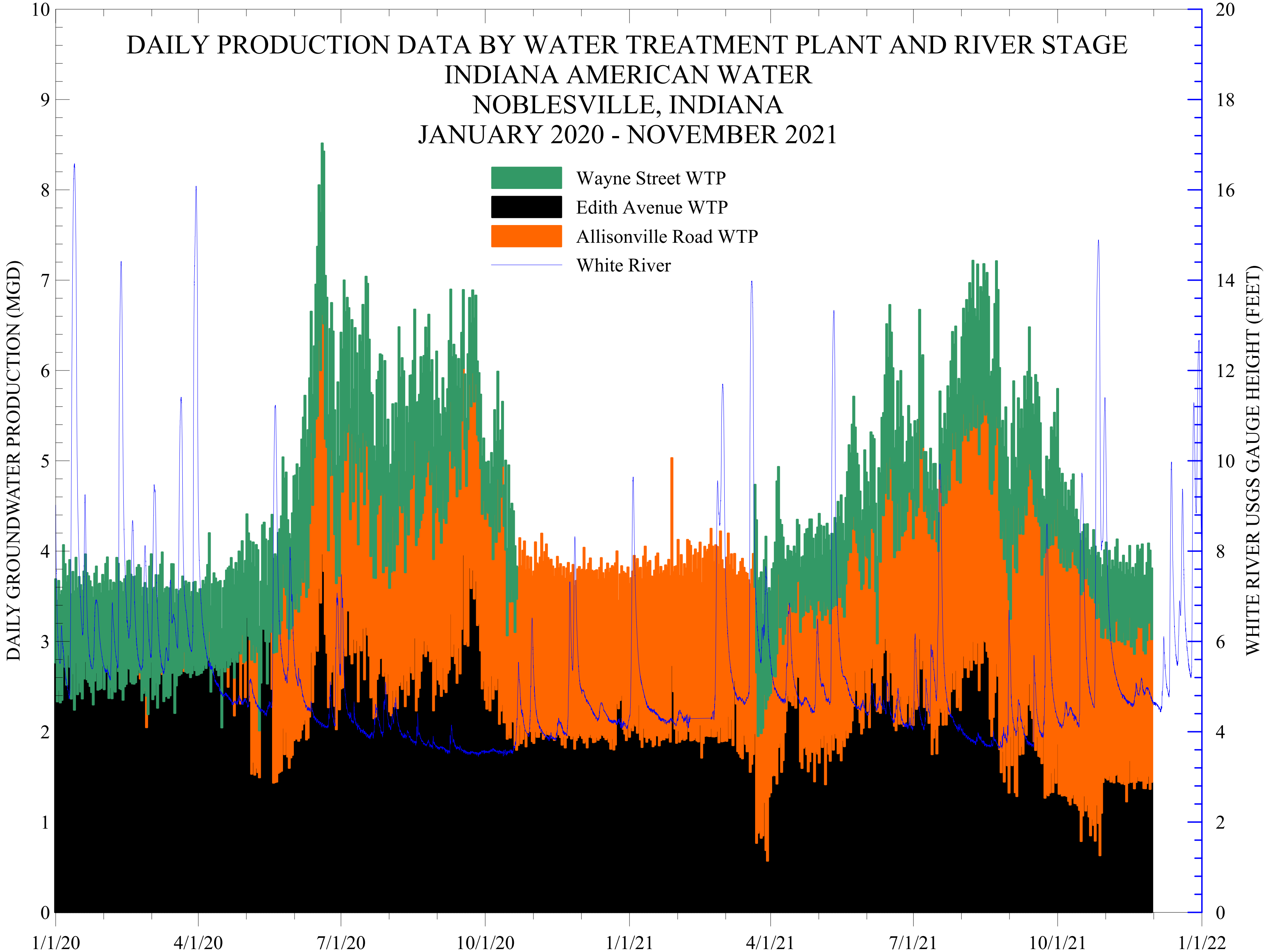


FIGURE 3.

Noblesville\2020-2021Production.grf
12/29/22

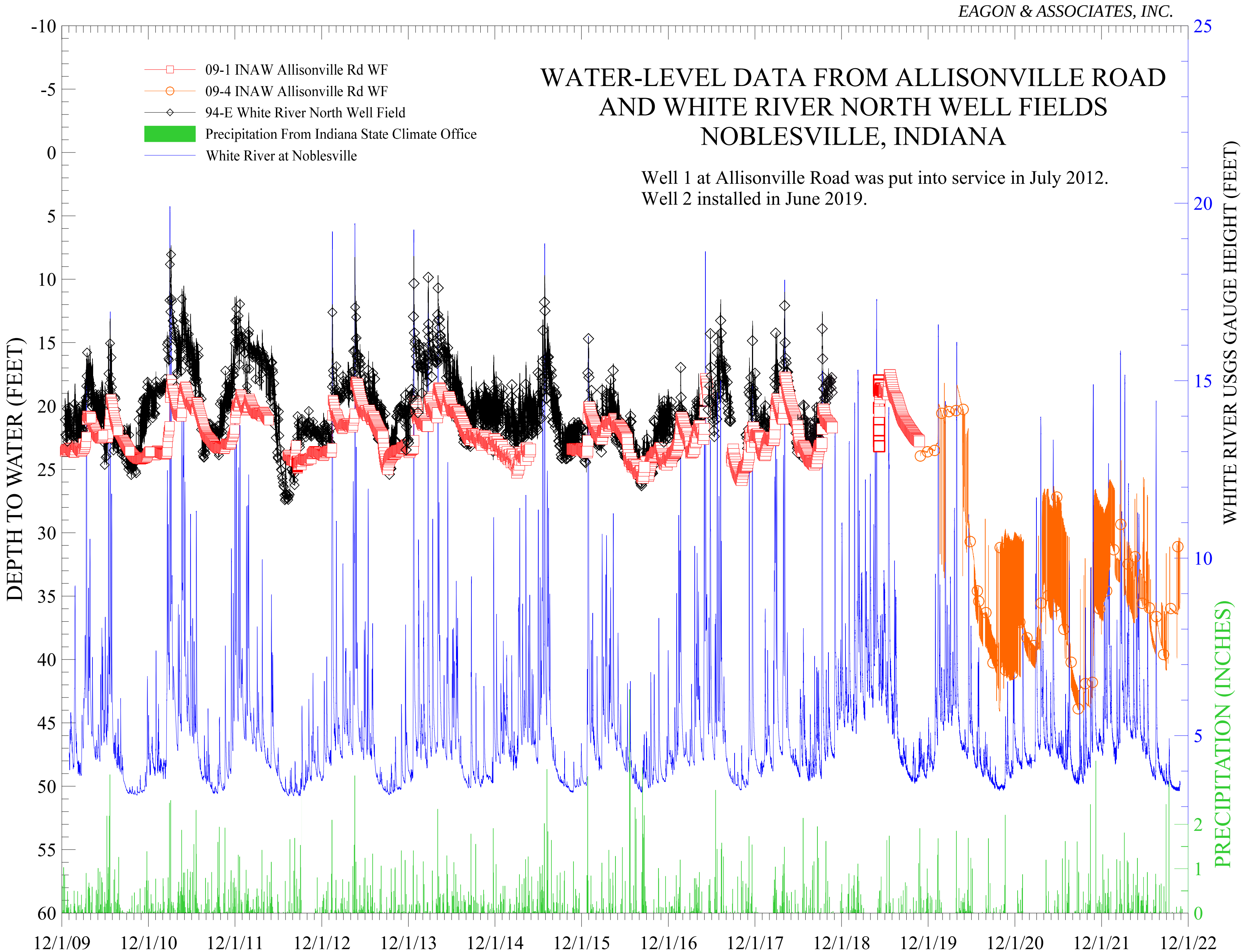


FIGURE 4.

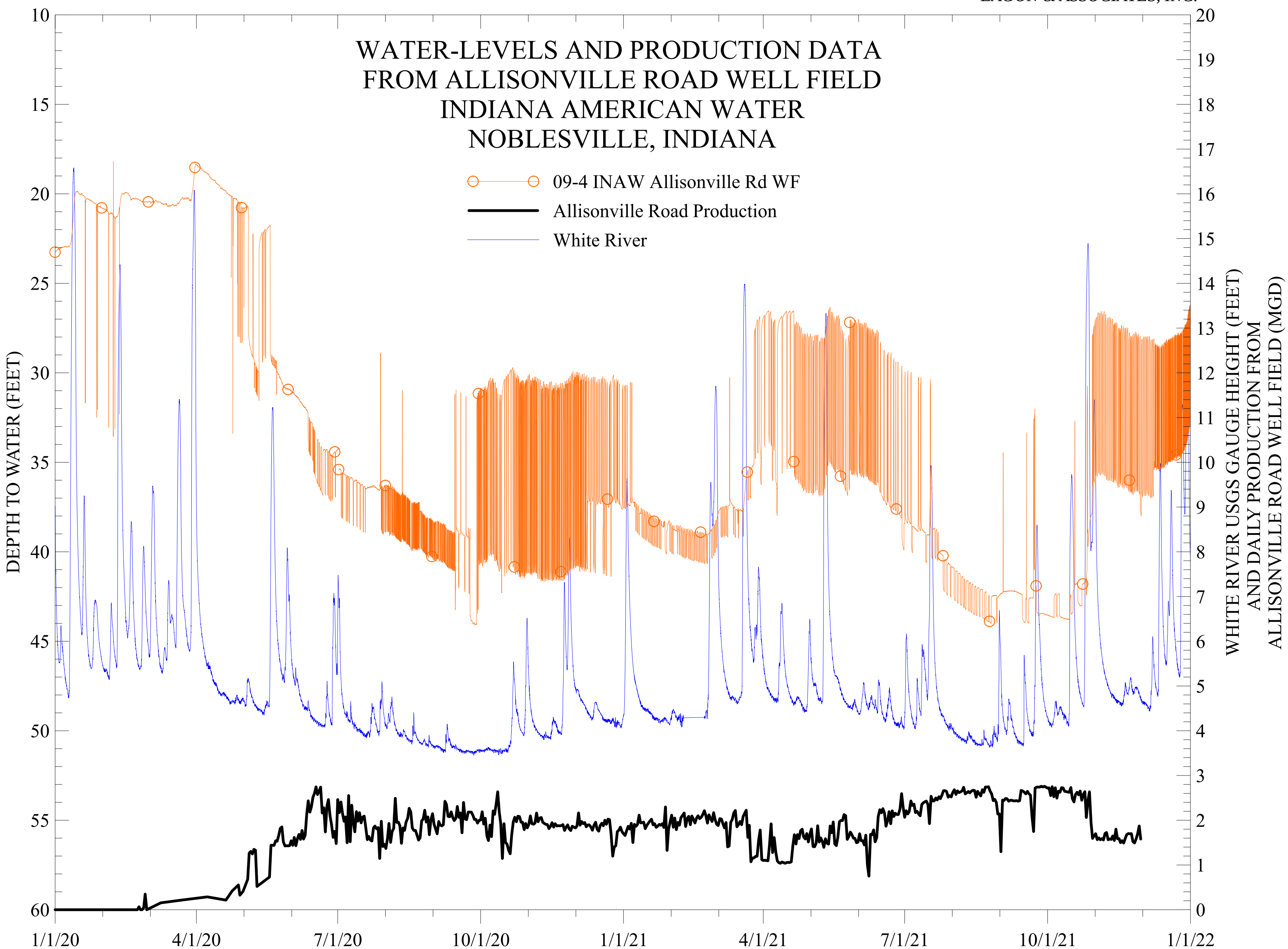
Noblesville\Grapher\Allisonville Rd\Allisonville and WRN.GRF
12/27/22

EAGON & ASSOCIATES, INC.

F:\ARCGIS\Noblesville\AllisonvilleRdWF.mxd

Figure 5. Well Location Map - Allisonville Road Well Field
INDIANA AMERICAN WATER

EAGON & ASSOCIATES, INC.



Noblesville\Allisonville Rd\AllisonvilleRd_WLsProduction.grf
12/27/22

FIGURE 6.

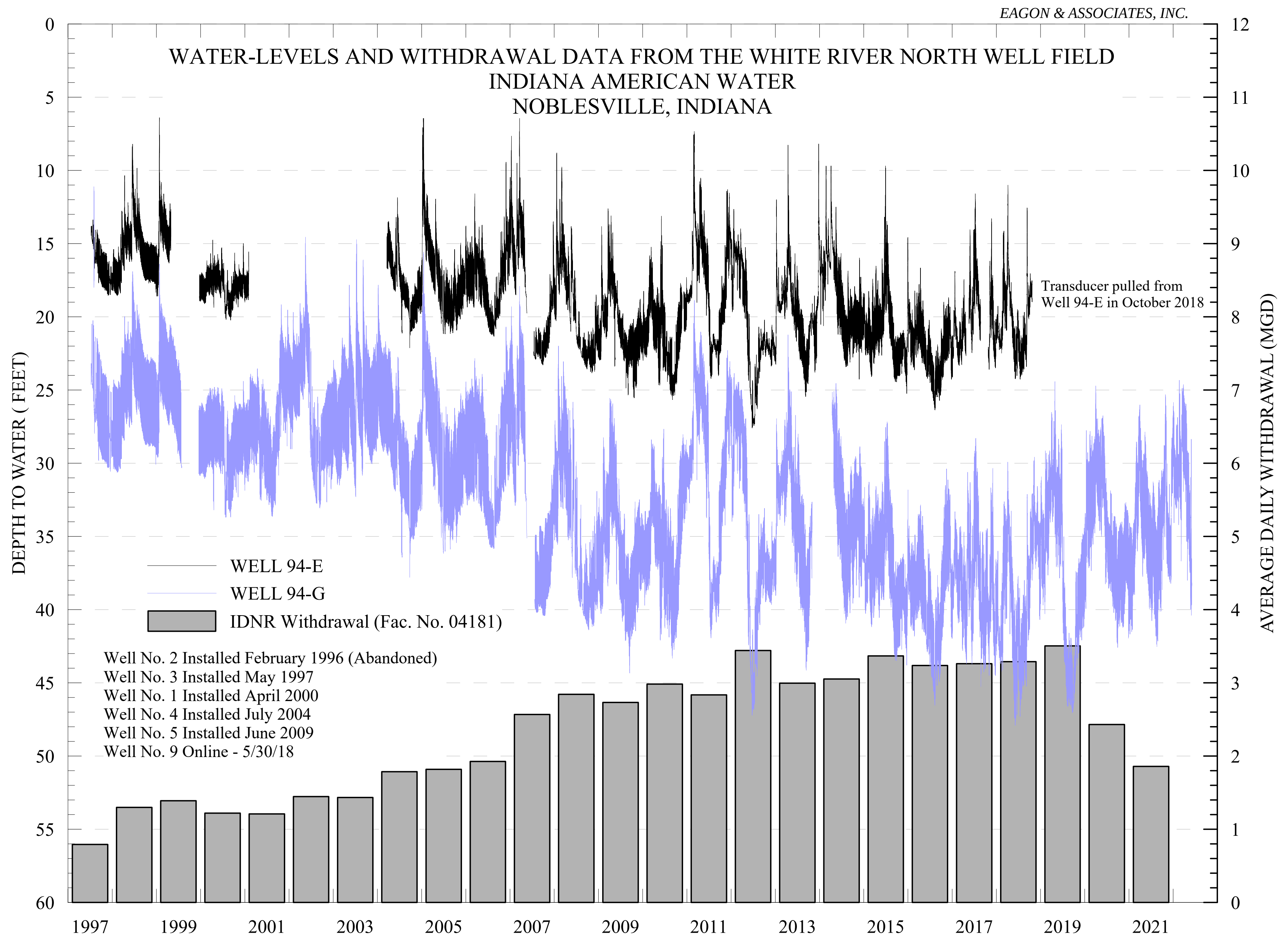


FIGURE 7.

Noblesville\Grapher\WLMON\WLMON.GRF
12/29/22

Eagon & Associates, Inc.

F:\ARCGIS\Noblesville\Fig 2.White River North Well Field Site Map.mxd

Figure 8. White River North Well Field Site Map

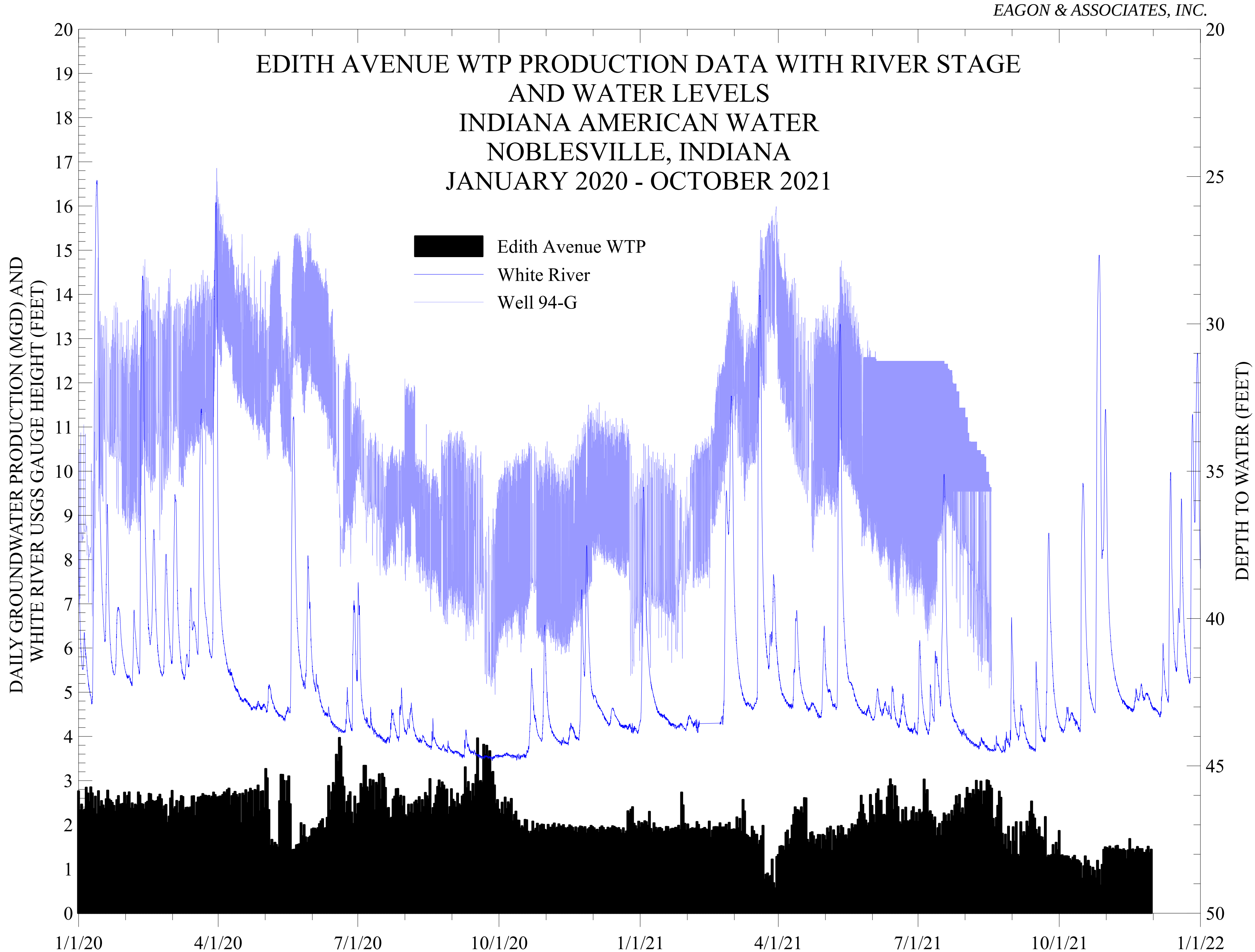
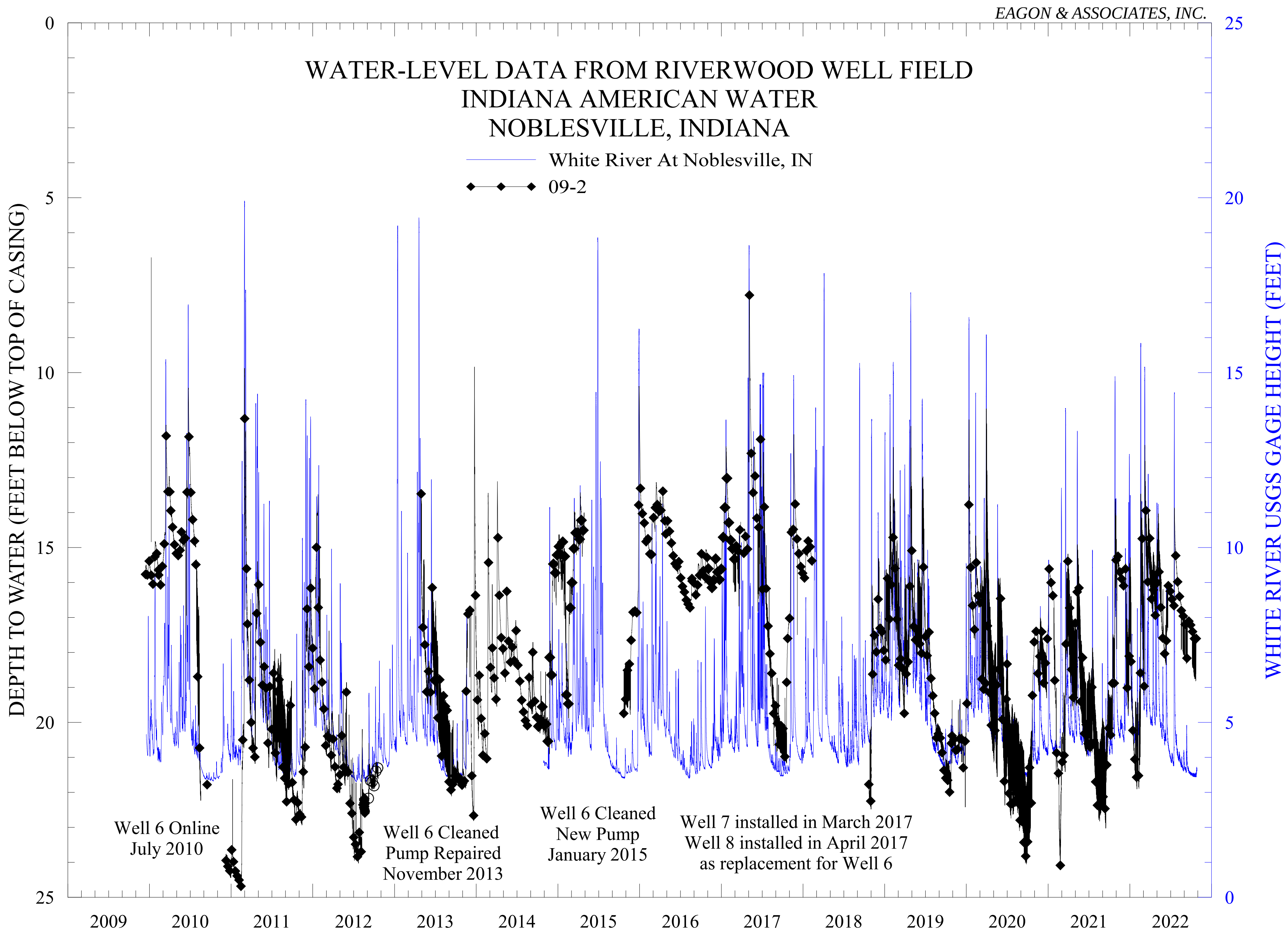


FIGURE 9.

Noblesville\WRN2020-2021ProductionWLs.grf
12/29/22



Noblesville\Grapher\Riverwood\09-2 and USGS data.GRF
12/29/22

FIGURE 10.

Eagon & Associates, Inc.

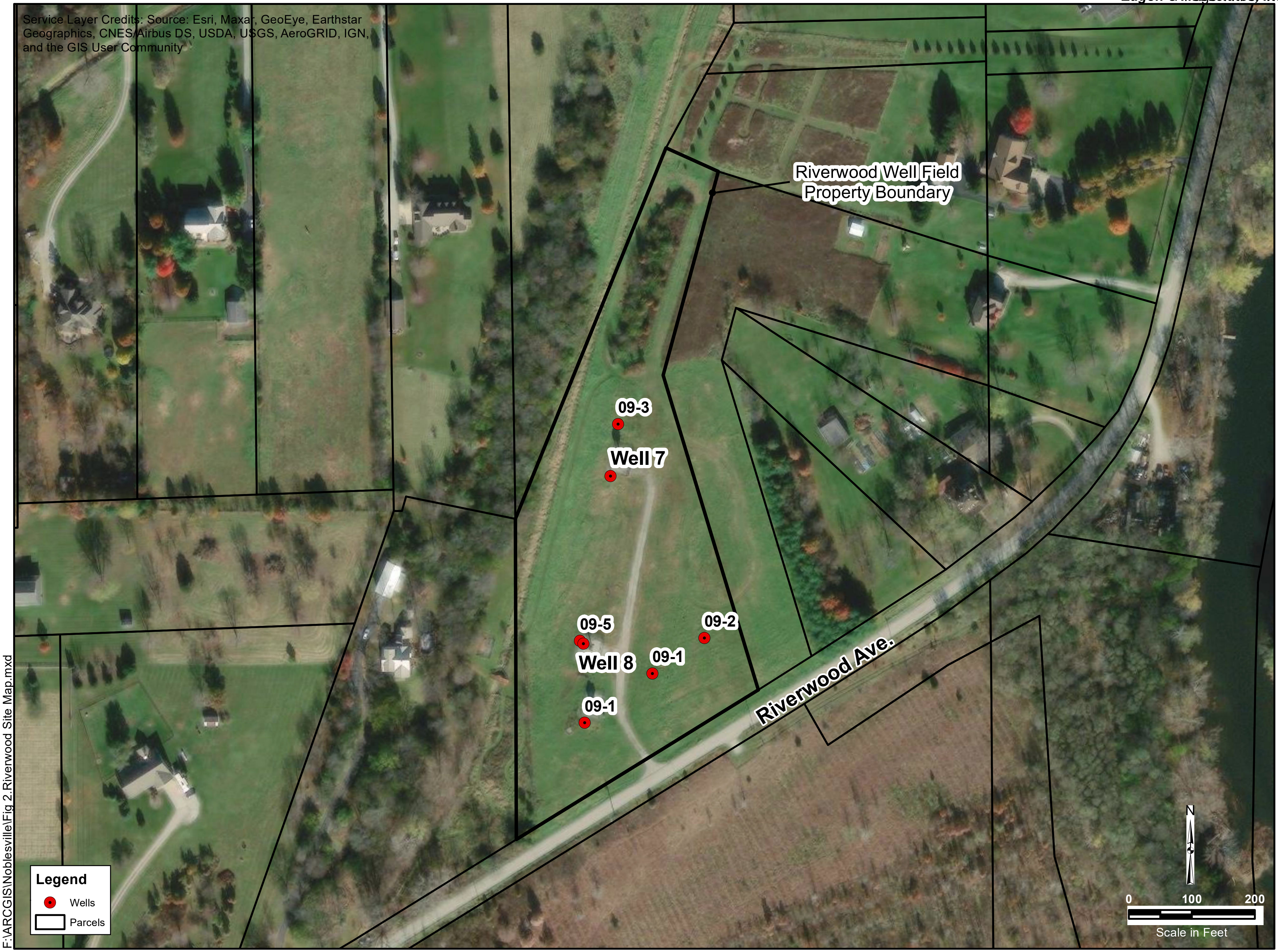


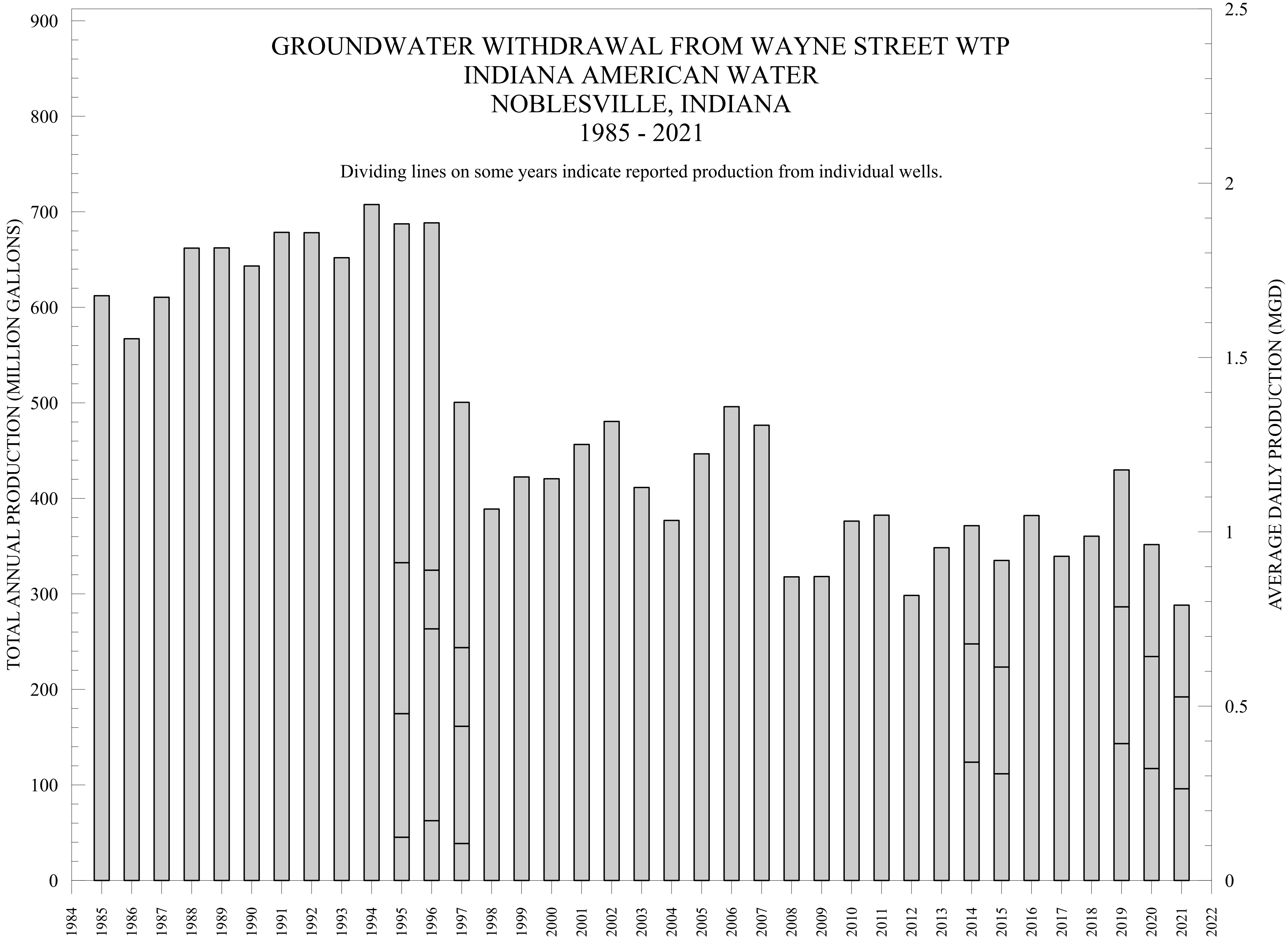
Figure 11. Riverwood Well Field Site Map

Eagon & Associates, Inc.

F:\ARCGIS\Noblesville\Fig 2.Forest Park Well Field Site Map.mxd

Figure 12. Forest Park Well Field Site Map

EAGON & ASSOCIATES, INC.



Noblesville/WayneStWTP Withdrawal 1985-2021.grf
12/29/2022

FIGURE 13.

TABLES

TABLE 1.
PRODUCTION WELL CONSTRUCTION SUMMARY
NOBLESVILLE WELL FIELDS
INDIANA AMERICAN WATER

Well ID	Date Installed	Well Status	Ground Surface Elevation (ft, MSL)	Top Of Casing Elevation (ft, MSL)	Total Well Depth (ft, bgl)	Well Depth Elevation (ft, MSL)	Borehole Diam. (in)	Well Casing Diam. (in)	Screen Diam. (in)	Screen/Open Borehole Interval (ft, bgl)	Screen Slot Size (in)	Screen Type[1]	Gravel Pack Interval (ft, bgl)	Gravel Pack Type	Original Depth to Water (ft, bgl)	Driller	24/72hr Pumping Rate (GPM)	Specific Capacity (GPM/ft)
Allisonville Road																		
1	10/7/09	In Service	772	778.5	80.83	691.2	20	20	20T	58 - 78.83	0.120	Johnson Hi-Q	NA	NA	24.6	Bastin Logan	1506	62.5
2	4/26/19	In Service	772.5	776	73	699.5	30	30	30T	53-58, 65-73 (13')	0.090 (TW: 58'-65')	Johnson Hi-Q	NA	NA	20.31	Bastin Logan	1500	70.0
White River North																		
1	3/2000	In Service	761	772	102	659	20	20	20T	71 - 102	0.100	Johnson Hi-Q	NA	NA	--	Reynolds, Inc	--	--
2	3/5/96	Abandoned	759	772	79.4	679.6	24	24	24T	49.3 - 79.3	0.120(49'-69'); 0.050(69'-79')	Johnson Hi-Q	NA	NA	6	Bastin Logan	1500	51.7
3	5/1997	In Service	759.5	772	87	672.5	24	24	24T	62 - 87	0.100	Johnson Hi-Q	NA	NA	21.7	Bastin Logan	1499	68.8
4	6/2004	In Service	758	772	87.5	670.5	24	24	24T	55-66, 78-87.5	0.070 (TW: 66'-78')	Johnson Hi-Q	NA	NA	18.28	Bastin Logan	1001	34.2
5	5/26/09	In Service	758	772	72	686	24	24	24T	58-63, 63-72 (14')	0.100(58'-63'); 0.120(63'-72')	Johnson Hi-Q	NA	NA	18.67	Bastin Logan	1022	31.8
9	8/2017	In Service	760.0	772.0	128	632	24	24	24T	85.5 - 128	0.070(85.5'-113'); .0100(113'-128')	Johnson Hi-Q	NA	NA	35	Bastin Logan	2420	102.4
Forest Park																		
2	11/22/91	Abandoned	756	767	51	705	6.75	6	5	45-50	0.060	PVC	NA	NA	17.5	Bastin Logan	--	40.1
2R	6/26/05	In Service	756	767	50	706	20	20	20T	38 -50	0.100	Johnson Hi-Q	NA	NA	--	Bastin Logan	--	--
3*	7/16/68	Abandoned	756	767	52	704	72	24	24P	42-52	#4	Layne Shutter	40 - 52	--	9	Layne Northern	1000	37.0
4 (Wayne St)	1961	In Service	768	769	334	434	16(0-135'); 12(135-300'); 8(300-334')	12	NA	135-334	NA	NA	NA	NA	24	Layne Northern	1110	12.9
5	4/20/17	In Service	754	767	280	474	12(0-280')	12	NA	110-280	NA	NA	NA	NA	9.74	Dilden Brothers	807	17.4
Riverwood																		
6	7/3/09	Abandoned	766	774	70	696	20	20	20T	52 - 70	0.130	Johnson Hi-Q	NA	NA	14.78	Bastin Logan	1507	47.3
7	1/31/17	In Service	757	774	68	689	24	16	16P	50 - 68	0.050	Johnson Hi-Q	35 - 68	0.050	7.27	Bastin Logan	550	15.8
8	3/28/17	In Service	763	774	71	692	24	24	24T	51 - 71	0.070	Johnson Hi-Q	NA	NA	9.25	Bastin Logan	1204	46.6
White River Christian Church																		
Test Well	3/13/14	Standby	753	755	89	664	20	20	20T	45 - 89	0.120(45-51'); 0.090(51-60'); TW(60-72'); 0.090(72-76'); 0.050(76-85'); 0.100(85-89')	Johnson Hi-Q	NA	NA	6.48	Bastin Logan	1718	44.4

TW = Tight wrap section of screen
20T = Telescoping screen; 20P = Pipe-size screen

NA = Not Applicable
-- = Unknown

*Well 3 at Forest Park was lined in 1992 with a 16P 0.120-inch screen in 9/1992 and later abandoned due to a hole in the screen.

TABLE 2.
2022 CAPACITY EVALUATION
ALLISONVILLE ROAD WELL FIELD
INDIANA AMERICAN WATER
NOBLESVILLE, INDIANA

	WELL 1 - 1400 GPM		WELL 1 - 1000 GPM WELL 2 - 700 GPM		Both @ 700 GPM		WELL 2 MAX - 800 GPM
	2.0 MGD		2.4 MGD		2.0 MGD		1.1 MGD
	WELL 1	WELL 2	WELL 1	WELL 2	WELL 1	WELL 2	WELL 2
Well Depth (feet, bgl)	81	73	81	73	81	73	73
Static Depth to Water (feet, bgl)	28.9	35.9	28.9	35.9	28.9	35.9	35.9
Depth to Top of Well Screen (feet, bgl)	58	53	58	53	58	53	53
Available Drawdown (feet)	29.1	17.1	29.1	17.1	29.1	17.1	17.1
Pumping Well Drawdown at 1400 gpm (feet)	20.70	--	--	--	--	--	--
Interference Drawdown from a Second Well Pumping 1400 gpm 650 feet from well	--	6.37	--	--	--	--	--
Pumping Well Drawdown at 1000 gpm (feet)	--	--	13.90	--	--	--	--
Interference Drawdown from a Second Well Pumping 1000 gpm 650 feet from well	--	--	--	4.55	--	--	--
Pumping Well Drawdown at 700 GPM (feet)	--	--	--	9.60	8.03	9.60	11.40
Interference Drawdown from a Second Well Pumping 700 gpm 650 feet from well	--	--	3.19	--	3.19	3.19	--
Remaining Available Drawdown (feet)	8.40	10.73	12.01	2.95	17.88	4.31	5.70
Percentage of Available Drawdown Remaining	28.9%	62.7%	41.3%	17.3%	61.4%	25.2%	33.3%

Notes: The static depth to water and pumping well drawdown at various rates are from flow testing results performed by Bastin Logan in September 2021. The static water level for Well 2 might be lower due to Well 1 being in operation at the time of testing. Status at time of testing is unknown.

Pumping well drawdowns are based on short-term stepped-rate pumping tests and do not account for long-term (i.e. 180-day) conditions

Interference drawdowns were calculated based on extrapolation of water-level data collected during the 24-hour pumping test of Well 2 in May 2019.

TABLE 3.
2022 CAPACITY EVALUATION
WHITE RIVER NORTH WELL FIELD
INDIANA AMERICAN WATER
NOBLESVILLE, INDIANA

Scenario 1 - 4,000 GPM (5.8 MGD)	WELL 1[1]	WELL 3[2]	WELL 4	WELL 5	WELL 9
Static Depth to Water - Fall 2021 (feet, TOC)	34.5	39.1	32.0	31.6	30.7
Depth to Top of Well Screen (feet, TOC)	82.0	74.5	69.0	72.0	97.5
Available Drawdown (feet)	47.5	35.4	37.1	40.4	66.8
Reported 2022 Operating Rates (gpm)	*2,000*	*900*	*450*	*450*	*2,000*
Scenario 1 Pumping Rates from 9/2021 Flow Tests (gpm)	**2,000**	--	--	--	**2,000**
Pumping Levels from 9/2021 Flow Tests (feet, TOC)	46.7	39.1	32.0	31.6	45.2
Interference Drawdown from Well 1 at 2,000 gpm (feet)	--	18.3	17.8	17.7	18.7
Interference Drawdown from Well 9 at 2,000 gpm (feet)	18.7	19.0	18.2	17.9	--
Pumping Levels with Interference Drawdown (feet, TOC)	65.4	76.4	68.0	67.2	63.9
Remaining Available Drawdown (feet)	16.6	-1.9	1.1	4.8	33.6
Percentage of Available Drawdown Remaining	35.0%	-5.2%	2.8%	11.9%	50.3%

Scenario 2 - 2,000 GPM (2.9 MGD)	WELL 1[1]	WELL 3[2]	WELL 4	WELL 5	WELL 9
Static Depth to Water - Fall 2021 (feet, TOC)	34.5	39.1	32.0	31.6	30.7
Depth to Top of Well Screen (feet, TOC)	82.0	74.5	69.0	72.0	97.5
Available Drawdown (feet)	47.5	35.4	37.1	40.4	66.8
Scenario 2 Pumping Rates from 9/2021 Flow Tests (gpm)	**2,000**	--	--	--	--
Pumping Levels from 9/2021 Flow Tests (feet, TOC)	46.7	39.1	32.0	31.6	30.7
Interference Drawdown from Well 1 at 2,000 gpm (feet)	--	18.3	17.8	17.7	18.7
Pumping Levels with Interference Drawdown (feet, TOC)	46.7	57.4	49.8	49.3	49.4
Remaining Available Drawdown (feet)	35.3	17.1	19.3	22.7	48.1
Percentage of Available Drawdown Remaining	74.3%	48.3%	52.0%	56.2%	72.0%

Scenario 3 - 1,450 GPM (2.1 MGD)	WELL 1[1]	WELL 3[2]	WELL 4	WELL 5	WELL 9
Static Depth to Water - Fall 2021 (feet, TOC)	34.5	39.1	32.0	31.6	30.7
Depth to Top of Well Screen (feet, TOC)	82.0	74.5	69.0	72.0	97.5
Available Drawdown (feet)	47.5	35.4	37.1	40.4	66.8
Scenario 3 Pumping Rates from 9/2021 Flow Tests (gpm)	--	**700**	**300**	**450**	--
Pumping Levels from 9/2021 Flow Tests (feet, TOC)	34.5	55.2	47.0	53.2	30.7
Interference Drawdown from Well 3 at 700 gpm (feet)	6.4	--	6.4	6.4	6.6
Interference Drawdown from Well 4 at 300 gpm (feet)	3.7	3.7	--	3.9	3.7
Interference Drawdown from Well 5 at 450 gpm (feet)	4.0	4.0	4.2	--	4.0
Pumping Levels with Interference Drawdown (feet, TOC)	48.6	62.9	57.6	63.5	45.0
Remaining Available Drawdown (feet)	33.4	11.6	11.4	8.5	52.5
Percentage of Available Drawdown Remaining	70.4%	32.7%	30.8%	21.1%	78.7%

[1] Adjusted SWL to 9/2020 SWL to account for inferred interference from Well 9.

[2] Well 3 SWL from 9/2020 (not tested in 2021)

TOC = Top of Well Casing

Interference drawdowns extrapolated from 180-day distance-drawdown data from constant-rate pumping test of Well 9.

TABLE 4.
2022 CAPACITY EVALUATION
RIVERWOOD WELL FIELD
INDIANA AMERICAN WATER
NOBLESVILLE, INDIANA

Scenario 1 - 650 GPM (0.94 MGD)	WELL 7	WELL 8
Well Depth (feet, bgl)	68.0	71.0
Static Depth to Water (feet, bgl)	15.3	15.2
Depth to Top of Well Screen (feet, bgl)	50.0	51.0
Available Drawdown (feet)	34.7	35.8
Reported 2022 Operating Rates (gpm)	*200-300*	*300-400*
Scenario 1 Pumping Rates from Fall 2021 Flow Tests (gpm)[1]	**280**	**370**
Pumping Levels from Fall 2021 Flow Tests (feet, bgl)	33.9	23.8
Interference Drawdown from the other Well Pumping 500 GPM (feet)[2]	3.0	4.3
Modeled Interference Drawdown from White River North Well Field (feet)	4.0	4.0
Pumping Levels with Interference Drawdown (feet, bgl)	40.9	32.1
Remaining Available Drawdown (feet)	9.1	18.9
Percentage of Available Drawdown Remaining	26.2%	52.8%

[1] Well 8 static depth to water, pumping rate, and pumping level were from November 2021 after well cleaning.

[2] Interference drawdown extrapolated from 180-day distance-drawdown data from constant-rate pumping tests of Well 7 and 8 (2017). 500 GPM pumping rate applied to slightly overestimate interference.

TABLE 5.
2022 CAPACITY EVALUATION
FOREST PARK WELL FIELD
INDIANA AMERICAN WATER
NOBLESVILLE, INDIANA

Scenario 1 - 1,300 GPM (1.9 MGD)	WELL 2	WELL 4[1]	WELL 5
Well Depth (feet, bgl)	50.0	334.0	280.0
Static Depth to Water (feet, bgl)	19.8	36.5	22.5
Depth to Top of Well Screen/Bottom of Casing (feet, bgl)	38.0	135.0	110.0
Available Drawdown (feet)	18.2	98.5	87.5
Reported 2022 Operating Rates (gpm)	*250-350*	*700*	*700*
Scenario 1 Pumping Rates from Fall 2021 Flow Tests (gpm)	--	**600**	**700**
Extrapolated Pumping Levels from Fall 2021 Flow Tests (feet, bgl)	19.8	96.5	49.4
Interference Drawdown from Well 4 Pumping 600 gpm (feet)	4.0	--	29.8
Interference Drawdown from Well 5 Pumping 700 gpm (feet)	4.0	34.7	--
Pumping Levels with Interference Drawdown (feet, bgl)	27.8	131.2	79.2
Remaining Available Drawdown (feet)	10.2	3.8	30.8
Percentage of Available Drawdown Remaining	56.0%	3.9%	35.2%

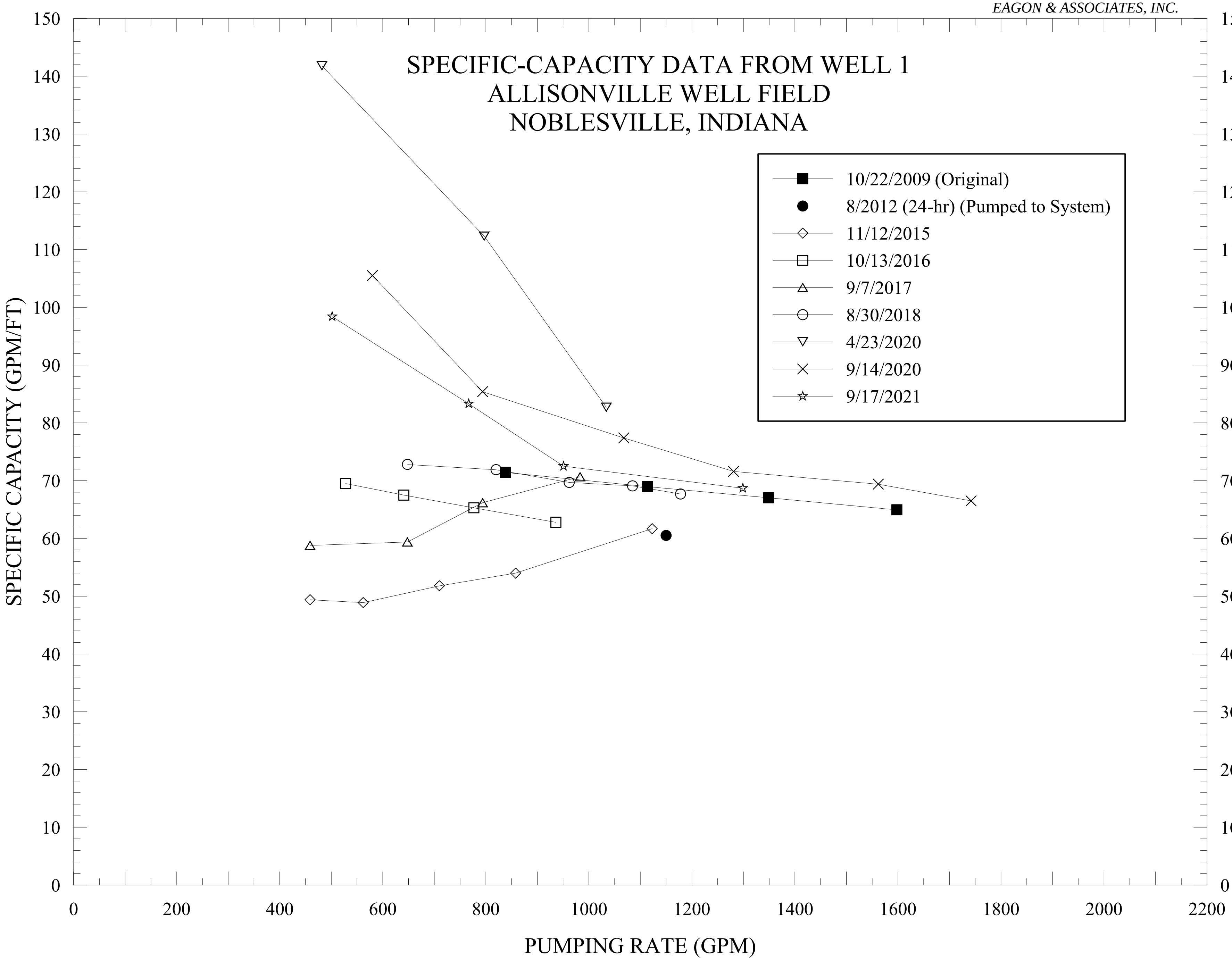
Scenario 2 - 850 GPM (1.2 MGD)	WELL 2	WELL 4[1]	WELL 5
Well Depth (feet, bgl)	50.0	334.0	280.0
Static Depth to Water (feet, bgl)	19.8	36.5	22.5
Depth to Top of Well Screen/Bottom of Casing (feet, bgl)	38.0	135.0	110.0
Available Drawdown (feet)	18.2	98.5	87.5
Scenario 2 Pumping Rates from Fall 2021 Flow Tests (gpm)	**150**	--	**700**
Extrapolated Pumping Levels from Fall 2021 Flow Tests (feet, bgl)	33.4	36.5	49.4
Interference Drawdown from Well 2 Pumping 150 gpm (feet)	--	1.1	1.1
Interference Drawdown from Well 5 Pumping 700 gpm (feet)	4.0	34.7	--
Pumping Levels with Interference Drawdown (feet, bgl)	37.4	72.3	50.5
Remaining Available Drawdown (feet)	0.6	62.7	59.5
Percentage of Available Drawdown Remaining	3.3%	63.7%	68.0%

[1] Well 4 static and pumping water levels adjusted 21.8 feet due to assumed interference from Well 5 operating.

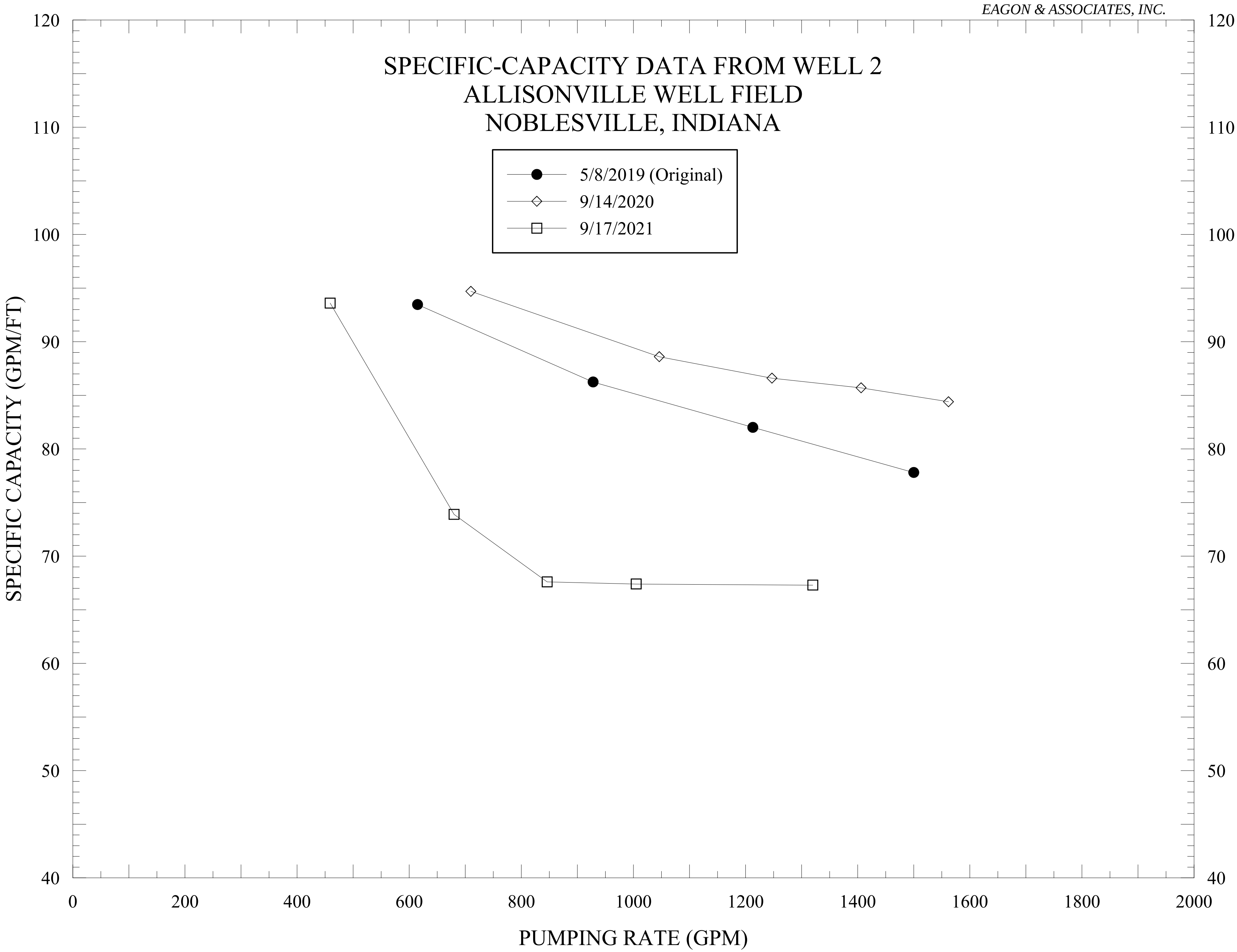
APPENDIX A.

WELL PERFORMANCE GRAPHS

EAGON & ASSOCIATES, INC.

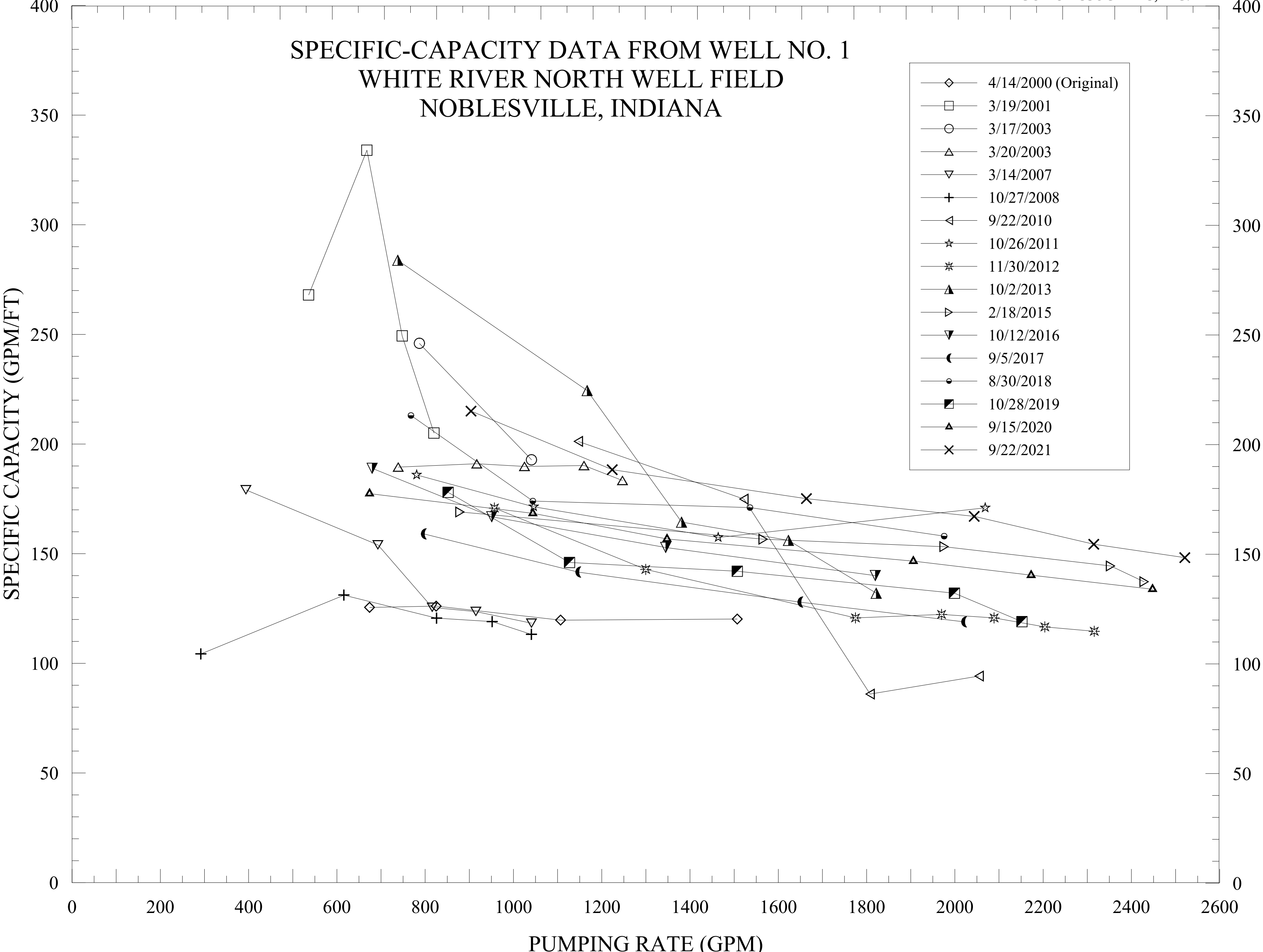


NOBLE/ALLISONVILLE ROAD/WELL1SPECCAP.GRF
1/20/22

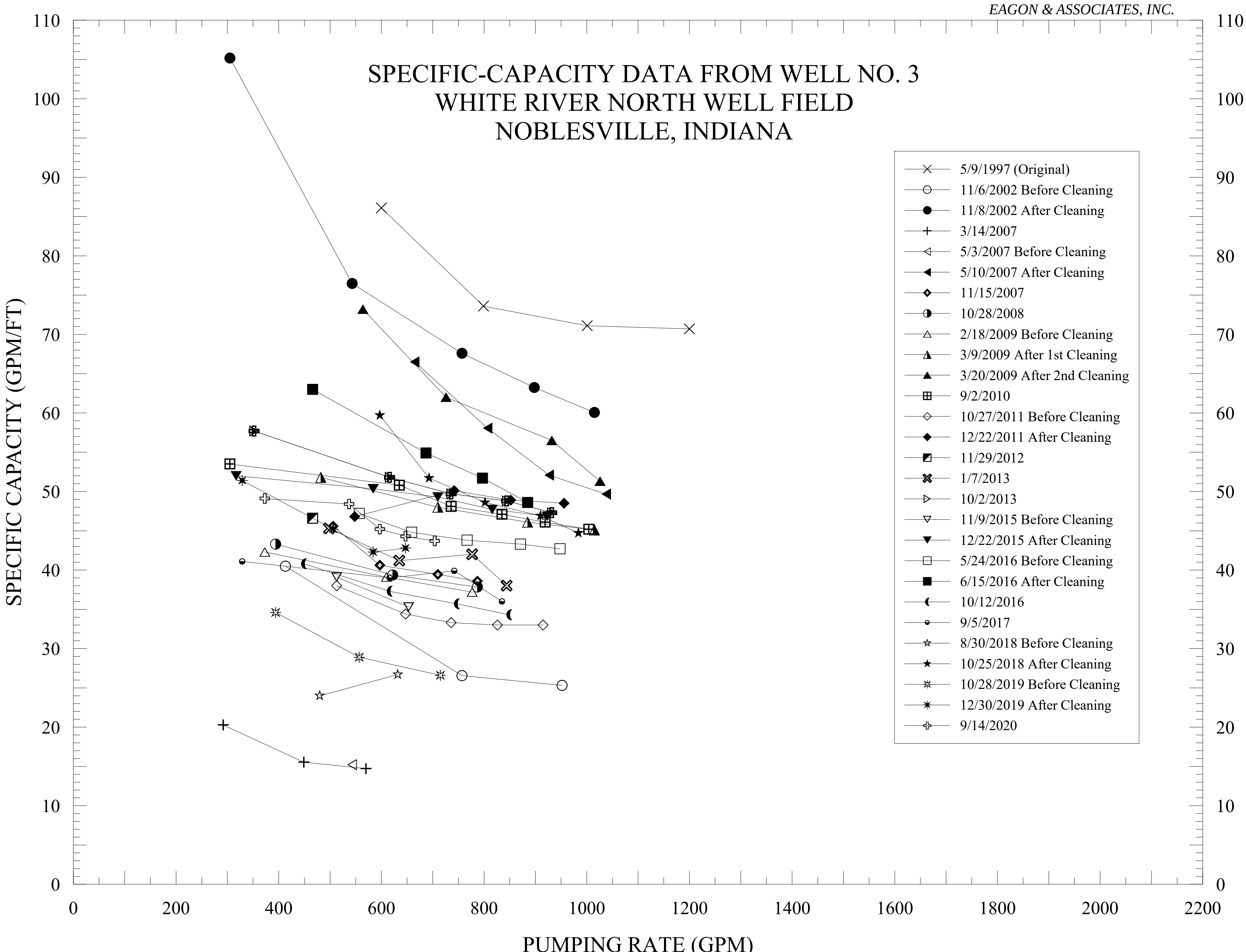


NOBLE/ALLISONVILLE ROAD/WELL2SPECCAP.GRF
1/20/22

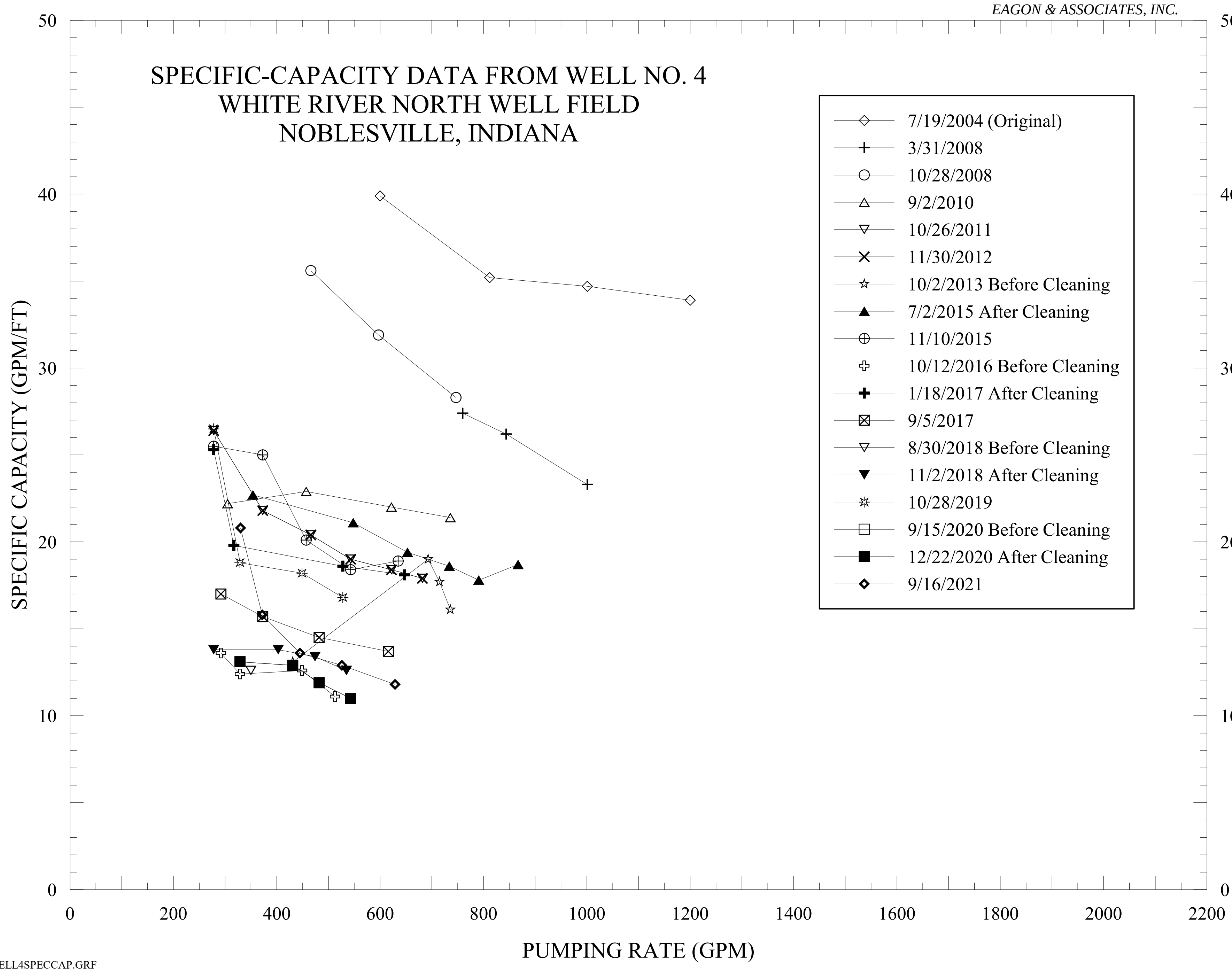
EAGON & ASSOCIATES, INC.



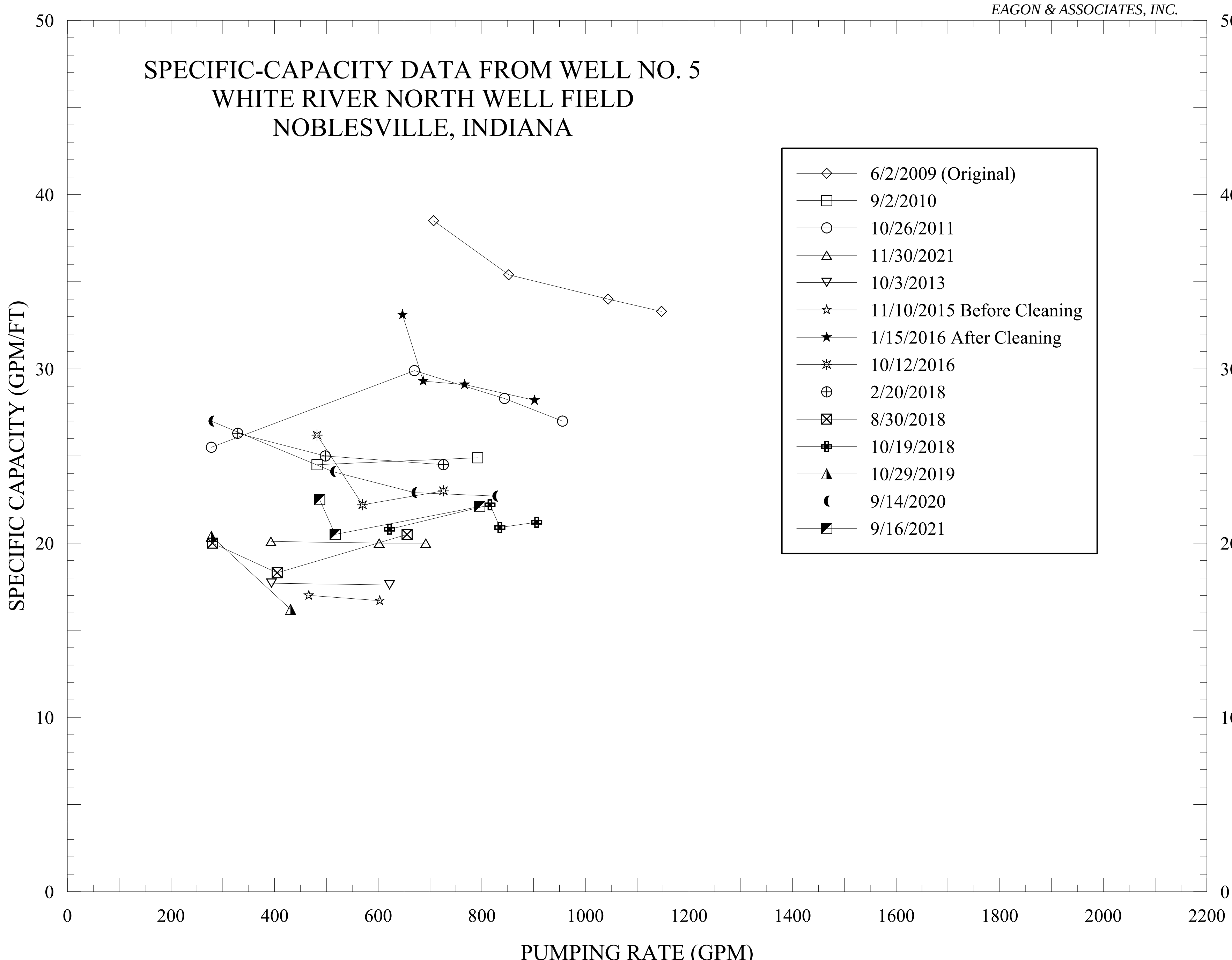
NOBLE/WELL1SPECCAP.GRF
11/18/21



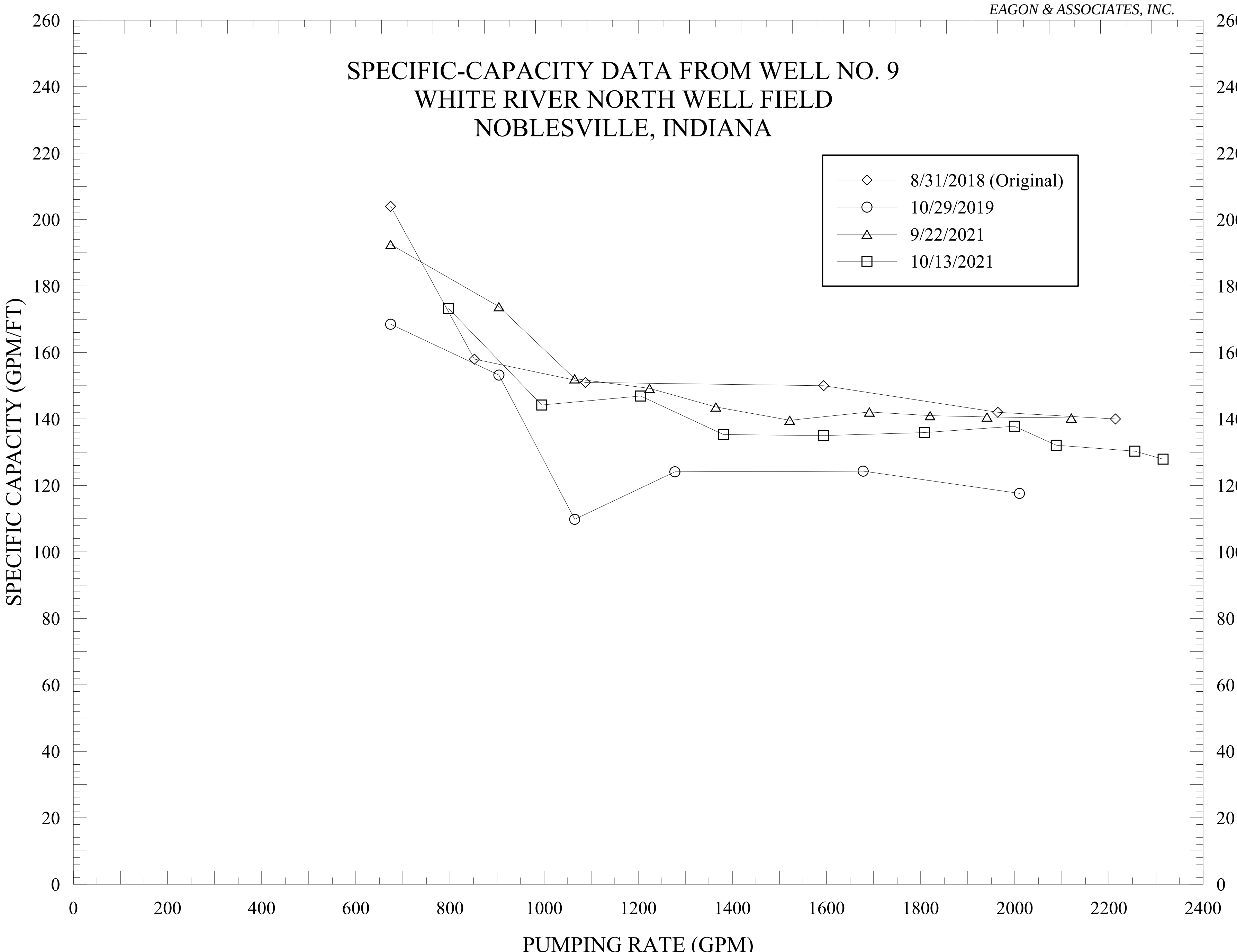
NOBLE/WELL3SPECCAP.GRF
11/18/21



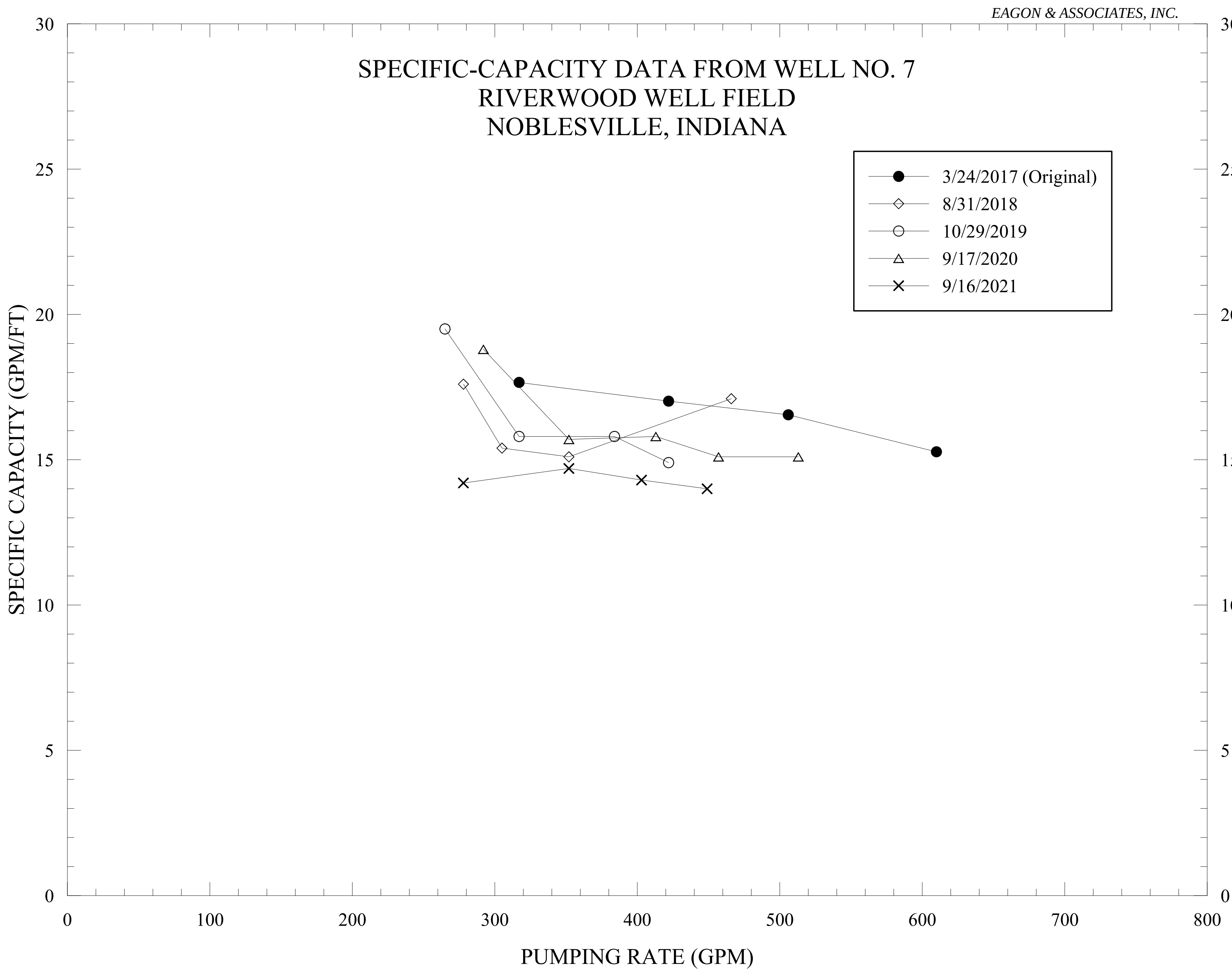
NOBLE/WELL4SPECCAP.GRF
11/18/21



NOBLE/WELL5SPECCAP.GRF
11/18/21

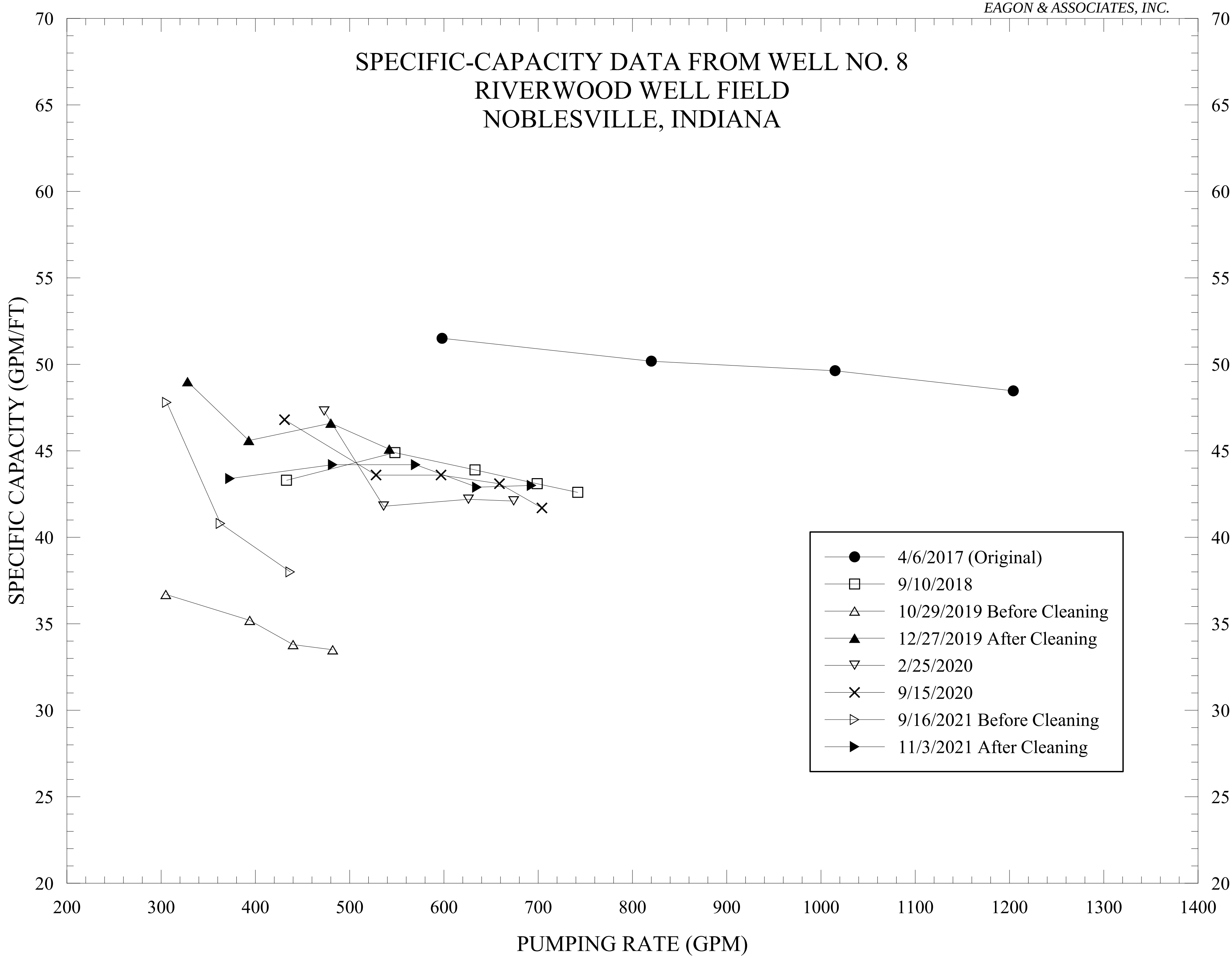


NOBLE/WRN/WELL9SPECCAP.GRF
11/18/21

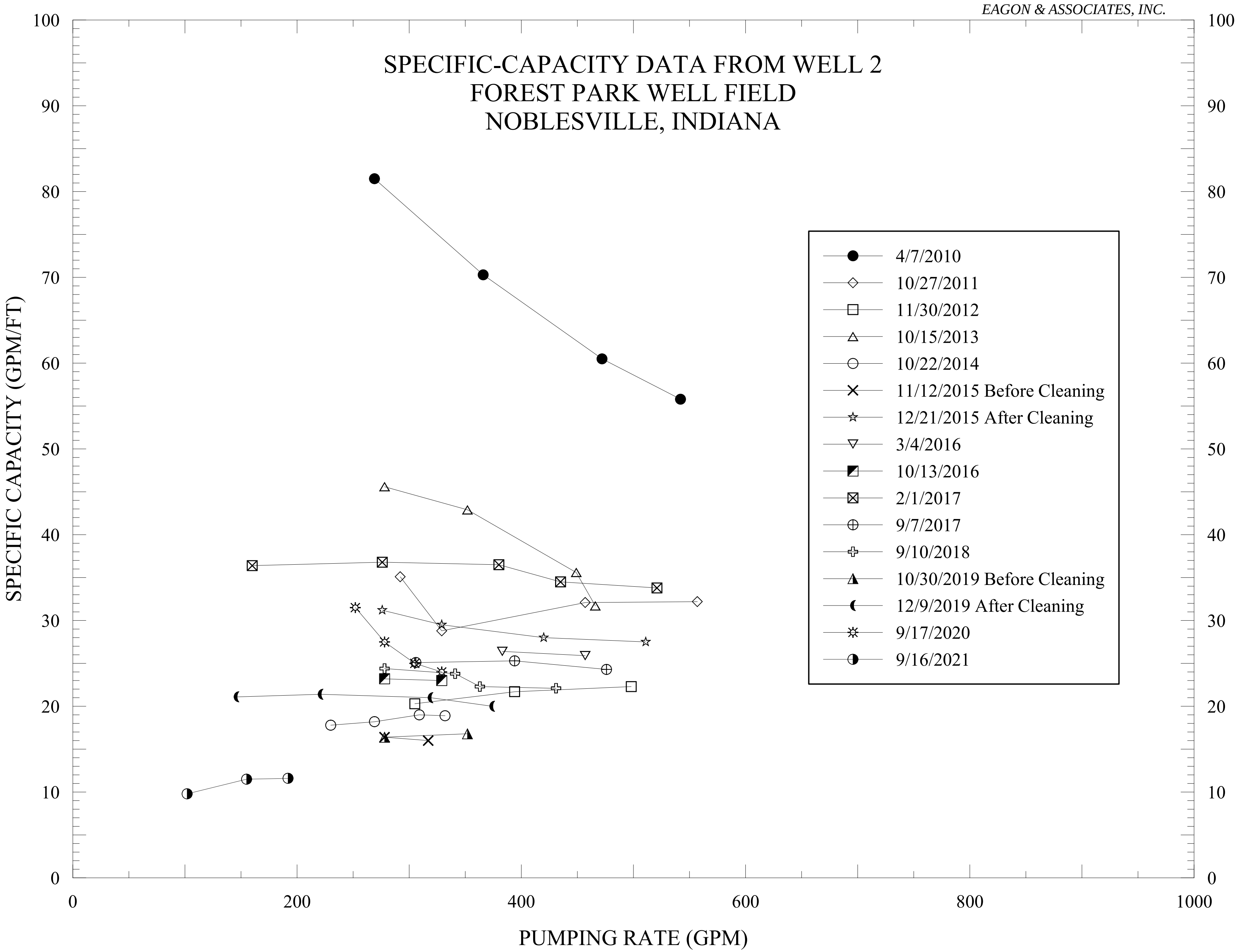


NOBLE/Riverwood/WELL7SPECCAP.GRF
1/21/22

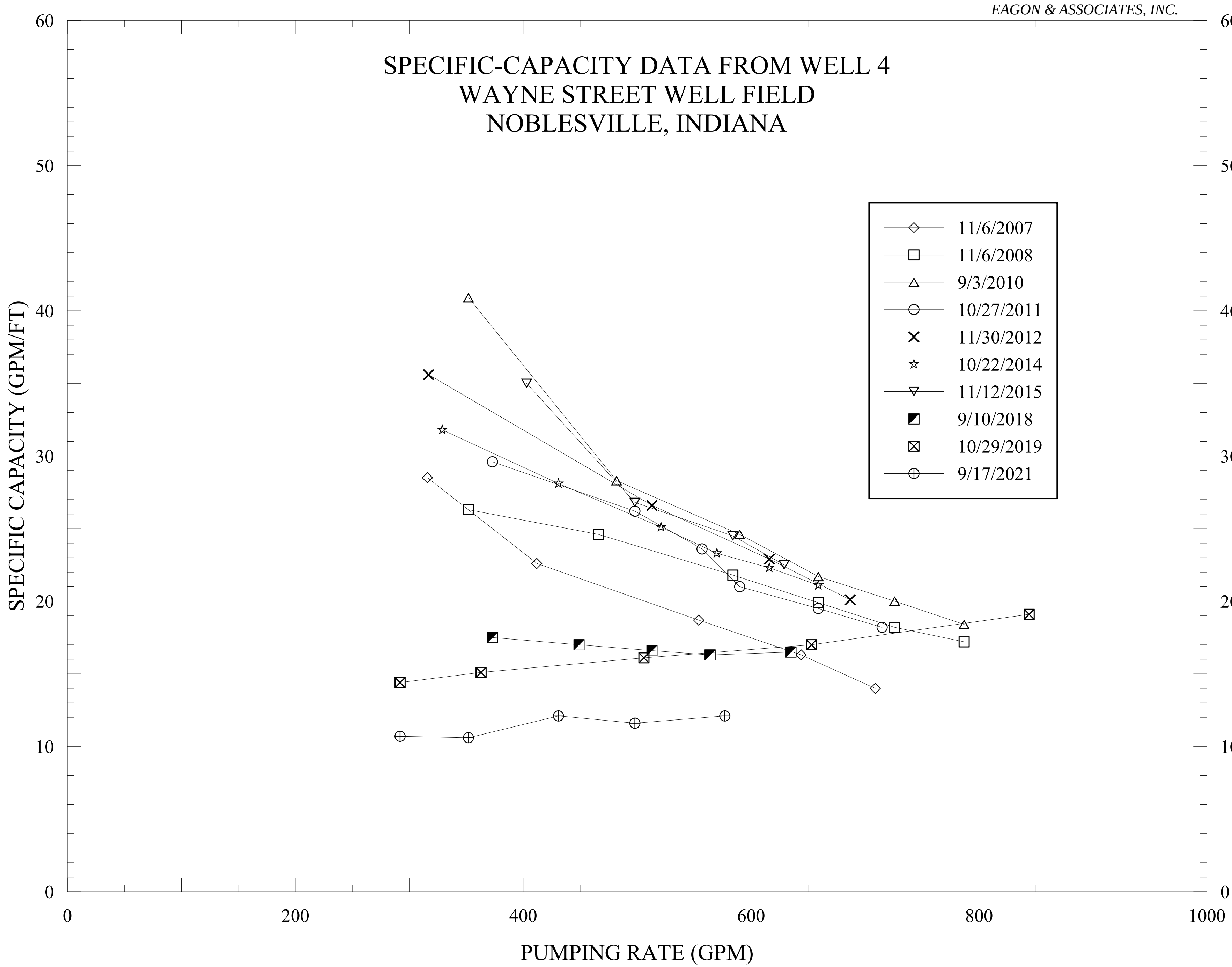
EAGON & ASSOCIATES, INC.



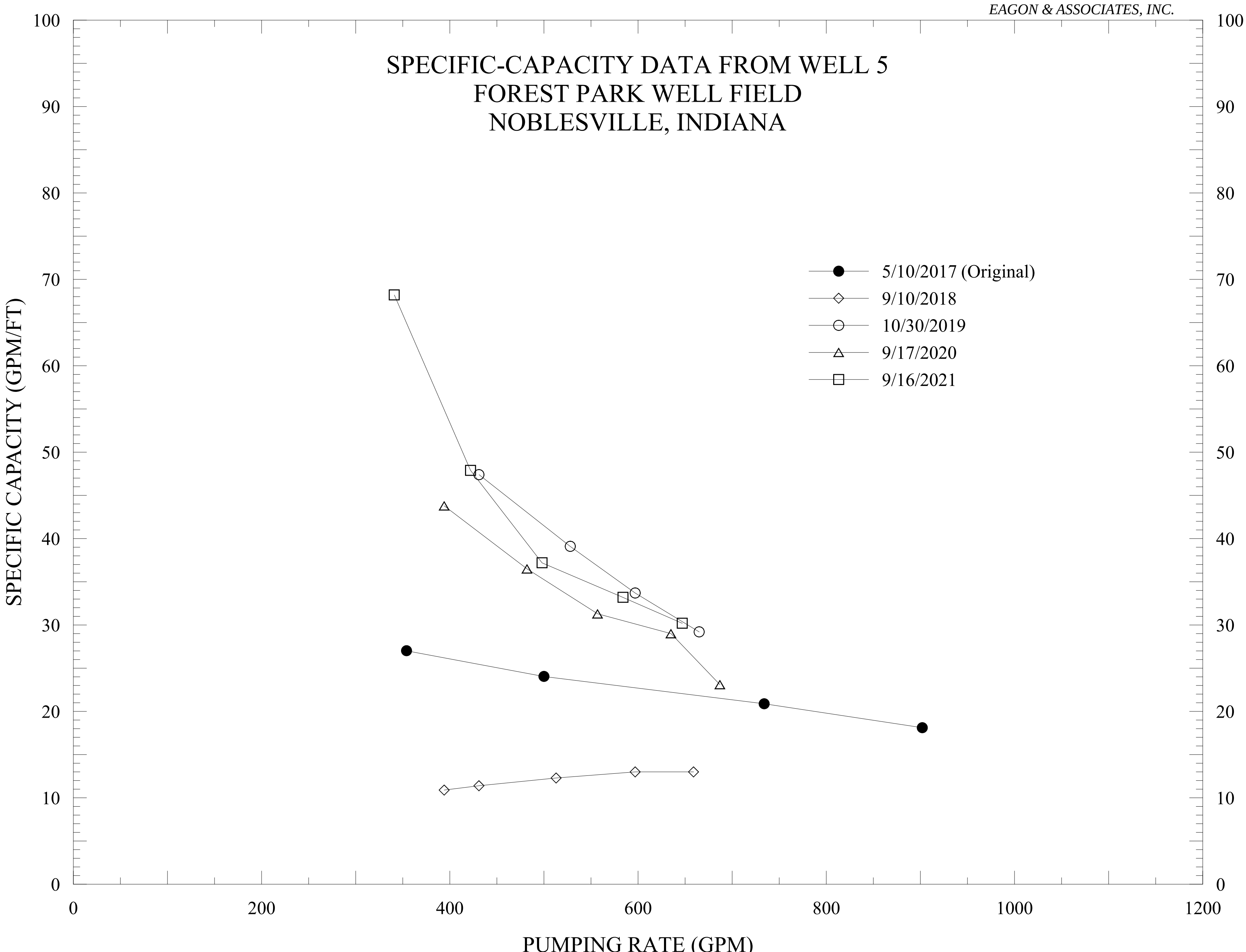
NOBLE/Riverwood/WELL8SPECCAP.GRF
1/21/22



NOBLE/ForestPark/WELL2SPECCAP.GRF
11/18/21

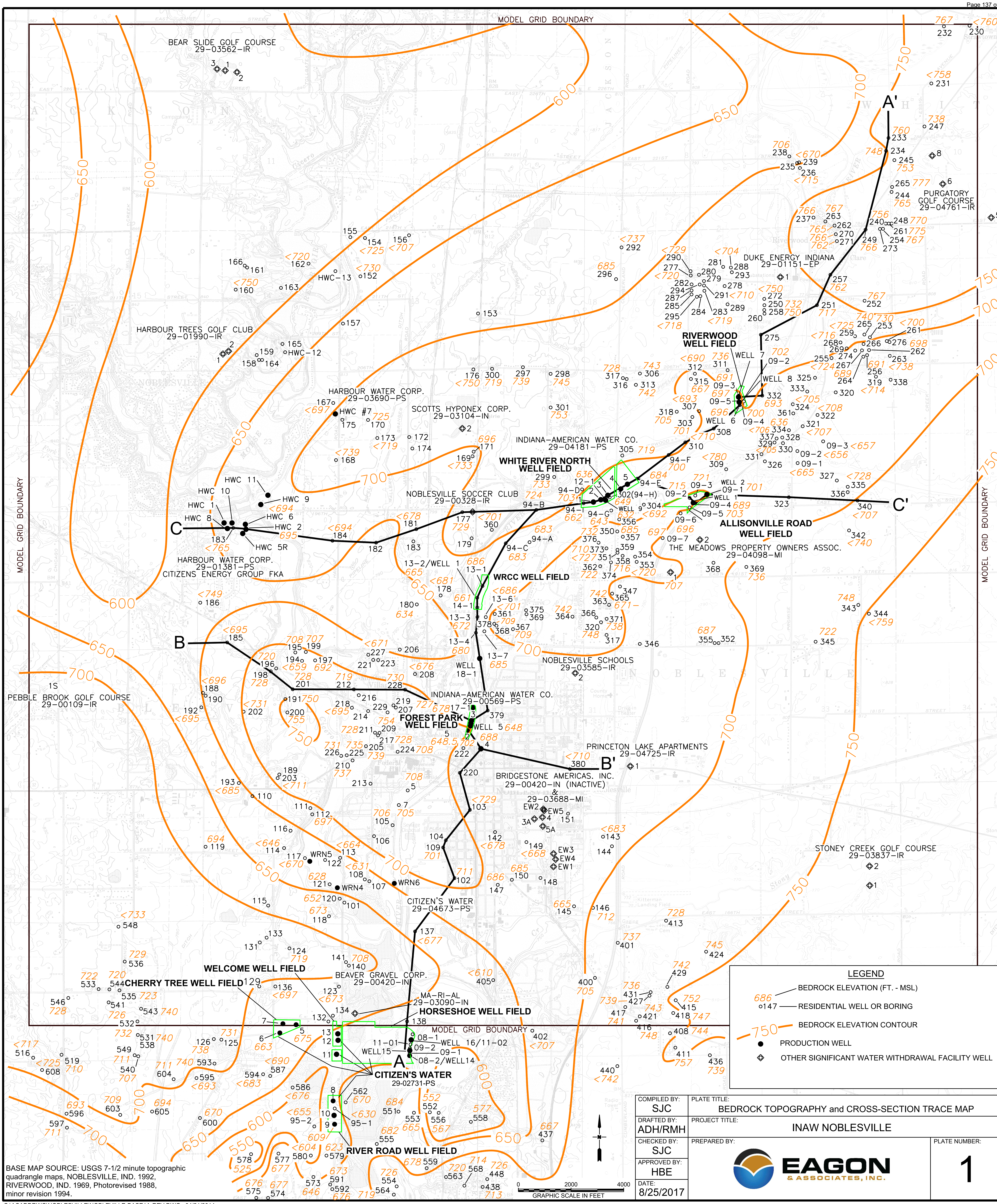


NOBLE/ForestPark/WELL4SPECCAP.GRF
4/8/22

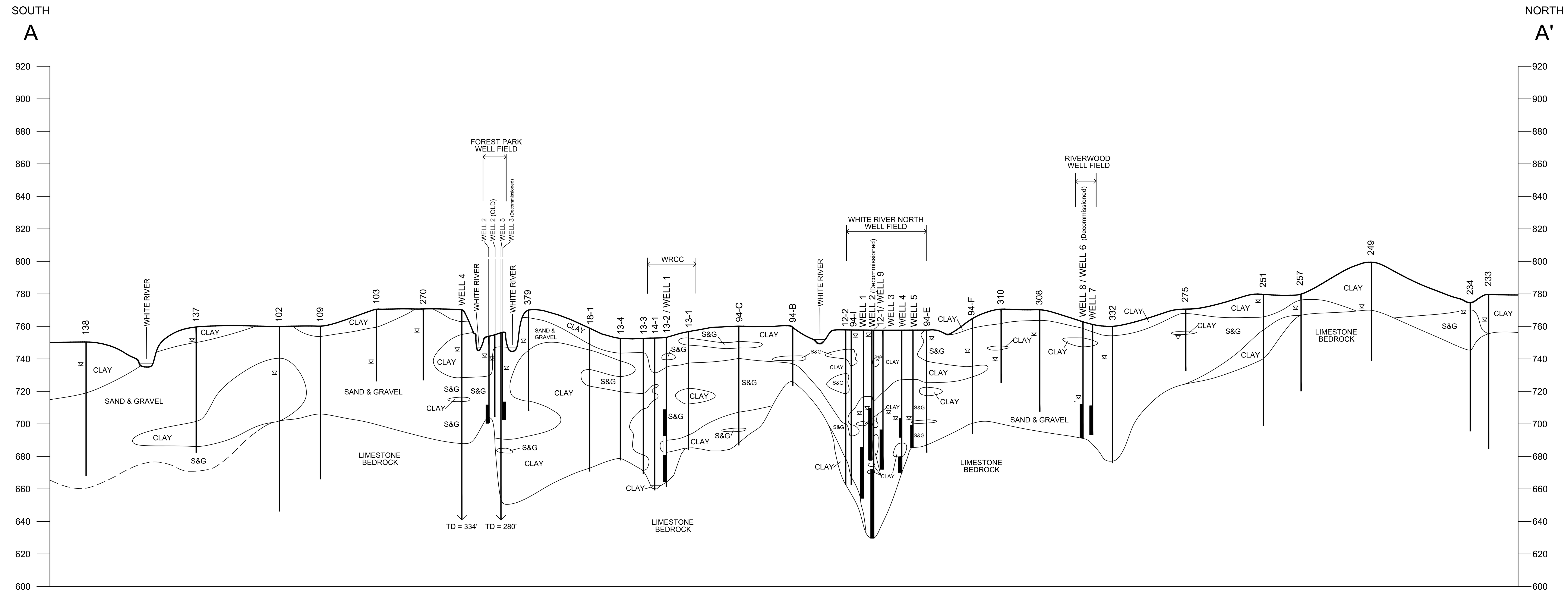


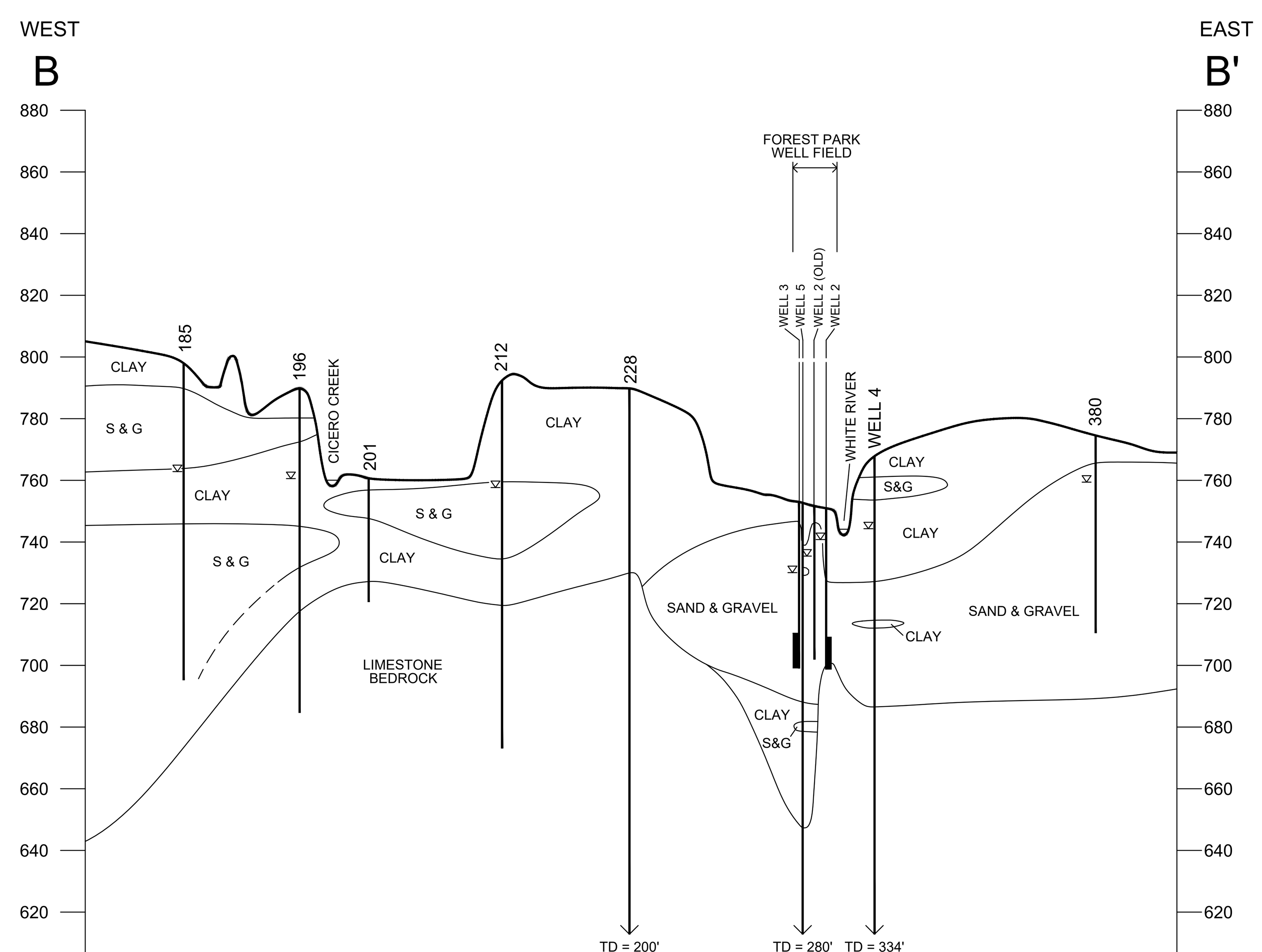
NOBLE/ForestPark/WELL5SPECCAP.GRF
11/18/21

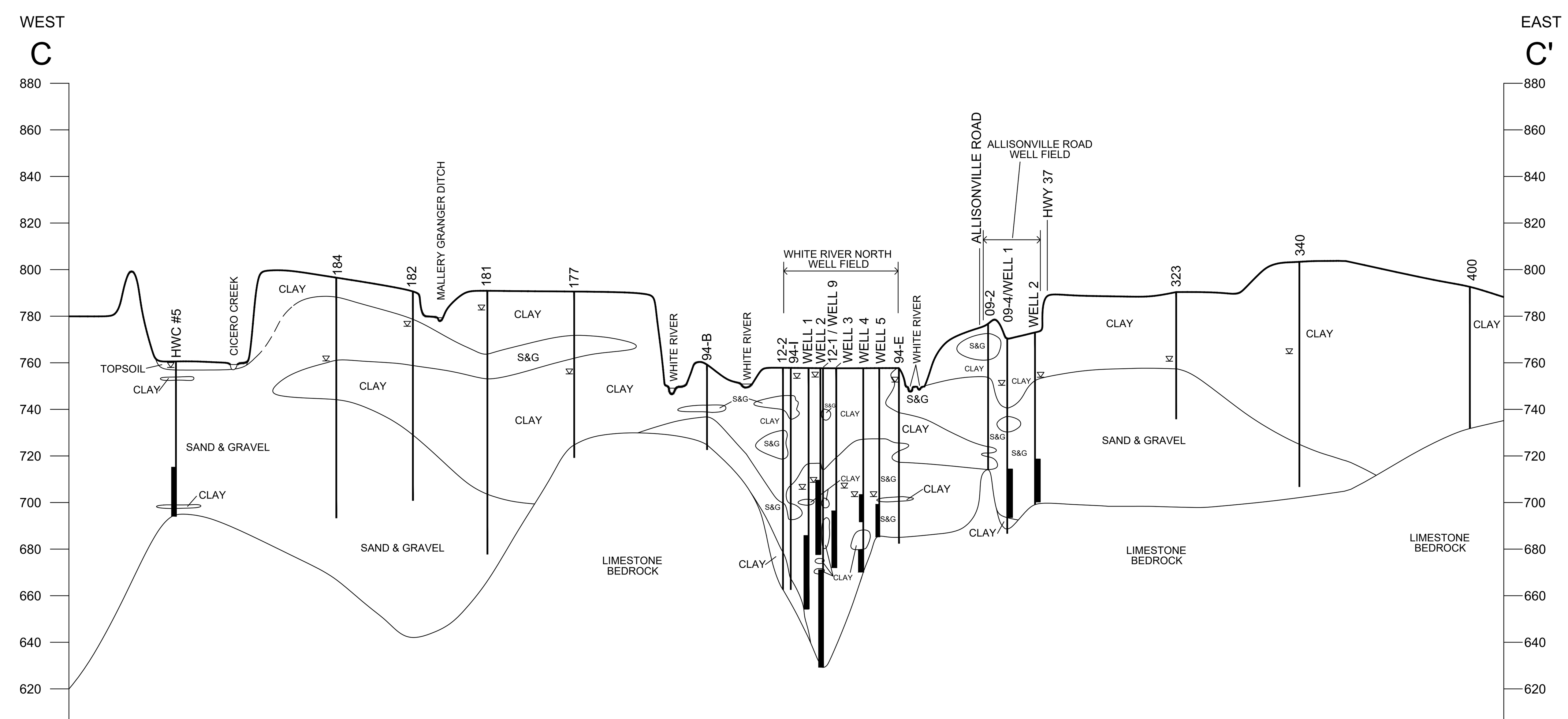
PLATES



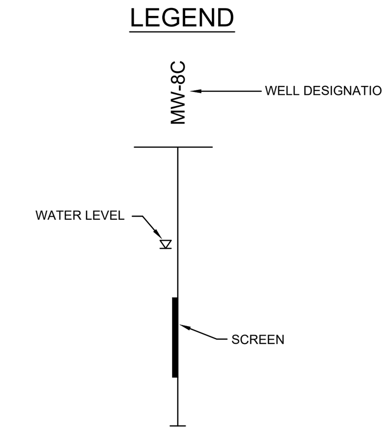
C:\ACADDRWG\NOBLESVILLE\NOBLEVILLE-BASE1A-REV.DWG 04/21/2014
C:\ACADDRWG\NOBLE\NOBLESVILLE.TIF & RIVERWOOD.TIF

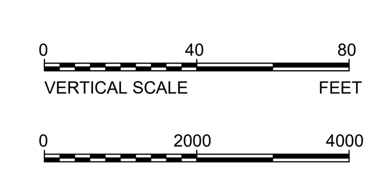






LEGEND





COMPILED BY: SJC	PLATE TITLE: HYDROGEOLOGIC CROSS-SECTIONS A-A', B-B', & C-C'	
DRAFTED BY: MAM	PROJECT TITLE: INAW NOBLESVILLE	
CHECKED BY: SJC	PREPARED BY: EAGON & ASSOCIATES, INC.	PLATE NUMBER: 2
APPROVED BY: SJC		
DATE: 03/24/21		

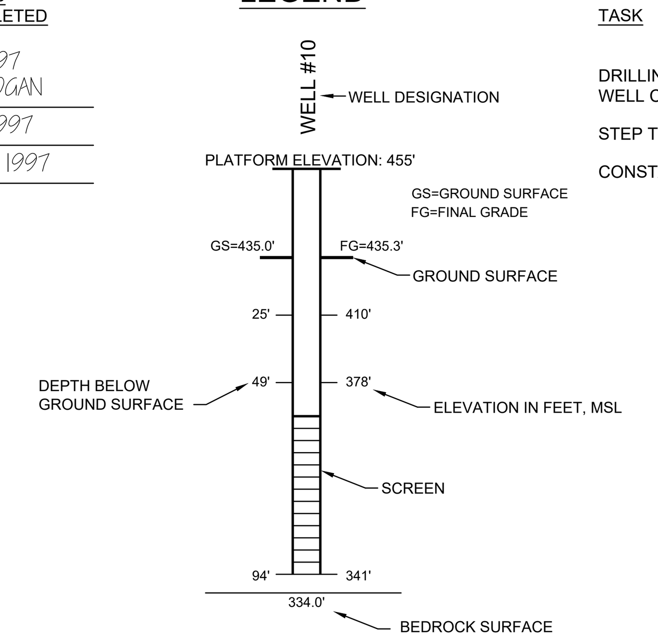
C:\ACAD\DWG\NOBLESVILLE\NOBLESVILLE-XSECT-REV.DWG 09/14/2017

TASK	WELL #1 DATE COMPLETED	WELL #2 DATE COMPLETED	WELL #9 DATE COMPLETED	WELL #3 DATE COMPLETED
DRILLING & WELL CONSTRUCTION	MARCH 2000 REYNOLDS, INC.	JANUARY 1996 BASTIN LOGAN	AUGUST 2017 BASTIN LOGAN	MAY 1997 BASTIN LOGAN
STEP TEST	APRIL 14, 2000	FEBRUARY 5, 1996	AUGUST 23, 2017	MAY 9, 1997
CONSTANT RATE TEST	APRIL 17-18, 2000	FEBRUARY 6-9, 1996	AUGUST 24-25, 2017	MAY 12-13, 1997

TASK	WELL #4 DATE COMPLETED	WELL #5 DATE COMPLETED
DRILLING & WELL CONSTRUCTION	JUNE 2004 BASTIN LOGAN	MAY 29, 2009 BASTIN LOGAN
STEP TEST	JULY 19, 2004	JUNE 2, 2009
CONSTANT RATE TEST	JULY 20-21, 2004	JUNE 3-4, 2009

TASK	WELL #6 DATE COMPLETED	WELL #8 DATE COMPLETED	WELL #7 DATE COMPLETED
DRILLING & WELL CONSTRUCTION	JULY 3, 2009 BASTIN LOGAN	MARCH 28, 2017 BASTIN LOGAN	FEBRUARY 20, 2017 BASTIN LOGAN
STEP TEST	AUGUST 3, 2009	APRIL 6, 2017	MARCH 24, 2017
CONSTANT RATE TEST	AUGUST 4-7, 2009	APRIL 10-11, 2017	MARCH 29-30, 2017

LEGEND



VERTICAL SCALE 0 10 20 FEET

HORIZONTAL SCALE 0 100 200 FEET

COMPILED BY: SJC	PLATE TITLE: WELL FIELD CROSS-SECTION	
DRAFTED BY: ADH	PROJECT TITLE: WHITE RIVER NORTH AND RIVERWOOD WELL FIELDS NOBLESVILLE, INDIANA	
CHECKED BY: SJC	PREPARED BY: EAGON & ASSOCIATES, INC.	PLATE NUMBER: 3
APPROVED BY: HBE		
DATE: 9/11/2017		

C:\ACADDRWG\NOBLESVILLE\WHITE-RIVER-N-XSECT.DWG 03/10/2010

GROUNDWATER CAPACITY EVALUATION
INDIANA AMERICAN WATER
SHERIDAN, INDIANA
WELL FIELD

Prepared for:

Indiana American Water
153 N. Emerson Avenue
Greenwood, Indiana 46143

Prepared by:

EAGON
& ASSOCIATES, INC.

DRAFT

October 2021

Stephen J. Champa, LPG
Associate Hydrogeologist
Indiana License No. 2247

Eagon & Associates, Inc.
100 West Old Wilson Bridge Road, Suite 115
Worthington, Ohio 43085
(614) 888-5760

Page

FIGURES

TABLES

APPENDICES

Appendix A. Well Logs – Sheridan Well Field and Cross-Sections

PLATES

Plate 1. East-West Cross-Section Trace A-A'
Plate 2. North-South Cross-Section Trace B-B'

INTRODUCTION

The purpose of this report is to present the results of an analysis of the groundwater capacity that may be available to the Indiana American Water (INAW) water supply system at the Sheridan Indiana Well Field. INAW currently operates three groundwater wells at the Sheridan Well Field. Well locations are shown on Figure 1. Well construction details are summarized on Table 1. Wells 4 and 5 were installed in 1961 and Well 6 was installed in 2010. In 2008, a test boring/observation well, 08-1, was installed for use during a 24-hour constant-rate pumping test of Well 5. The pumping-test and analyses are documented in the report *Pumping-Test Analysis and Well-Field Capacity Evaluation* (Eagon & Associates, 2008).

The groundwater capacity analysis presented in this report is an update of the analysis presented in the 2008 report and incorporates more recent water-level, water withdrawal and well performance data from INAW, Peerless Midwest, and the Indiana Department of Natural Resources (IDNR). Well and well-field capacity are evaluated using groundwater flow modeling. Construction and calibration of the model are documented in the 2008 report are not reiterated in this report. Review of recent data did not require modification of model boundaries, hydraulic conductivity or recharge distributions.

The report includes conclusions regarding well-field capacity and recommendations for well-field expansion, long-term groundwater-level monitoring and water-level data analysis to confirm the sustainability of increased groundwater withdrawal and inform appropriate management decisions.

HYDROGEOLOGIC SETTING

The Sheridan Well Field is located in northwestern Hamilton County in Section 32 of Township 20N, Range 3E. This area is within the Tipton Till Plain physiographic region (Fenelon et al., 1994). This region is characterized as an area of low relief with thick glacial deposits above bedrock. Wells at the Sheridan Well Field are completed in a sand and gravel aquifer in the lower part of the glacial deposits.

Hydrogeologic cross sections were constructed from the logs of municipal production wells, test borings, and residential wells. The cross-section traces are shown on Figure 2 and the cross-sections are shown on Plates 1 and 2. The logs of Sheridan Well Field wells, residential wells, and test borings used on the cross-sections are included in Appendix A.

Cross-Section A-A' (Plate 1) is oriented from west to east and Cross-Section B-B' (Plate 2) is oriented from north to south. The cross sections show that the aquifer is extensive, but is not present at all locations. The aquifer is thickest in the vicinity of the Sheridan Well Field where it is about 39 feet thick. Away from the well field the aquifer thickness is variable and averages approximately 10 feet. The cross sections show that the sand and gravel is generally not in direct contact with the underlying bedrock so recharge to the sand and gravel from the underlying bedrock will be minimal. Bedrock Topography is shown on Figure 2. The cross sections show that discontinuous deposits of sand and gravel are present in the glacial materials above the aquifer. However, most of the material above the aquifer is glacial till so recharge will be limited. A recharge rate of two inches per year from infiltration of precipitation was calculated by Arihood and Lapham (1982) for buried aquifers in the upper part of the White River Basin and is at the lower end of the range of recharge values for confined aquifers used by Arihood (1982) in modeling of the White River Basin.

Ground-water flow in the aquifer is generally from west to east in the Sheridan area. The hydraulic gradient ranges from about 4.8×10^{-4} to 3.4×10^{-2} within the study area.

Only three significant water withdrawal facilities are registered with the Indiana Department of Natural Resources (IDNR), Division of Water within the study area. Water withdrawal records from the Division of Water show that the Sheridan Water Works used approximately 225,000 gallons per day (gpd) in 2018 and 2019, primarily from Wells 5 and 6. EMC Precision Machining used approximately 2,600 gpd in 2019 and Entrust Group did not record any water usage in 2018 or 2019. Locations of these facilities relative to the well field are shown on Figure 2.

WATER USE

Annual average daily groundwater withdrawal by Sheridan from 1985 through 2020 is shown on Figure 3. Based on the IDNR data, water withdrawal peaked around 2004 to 2013 at approximately 0.3 million gallons per day (MGD). Water withdrawal since 2013 has declined to below 0.24 MGD and was at a historic low of 0.22 MGD in 2020. Based on information from the INAW Sheridan Operations Superintendent, the data from 2020 are from the treatment plant influent meter. Data reported by Sheridan prior to INAW purchase of the system are suspected to be overestimated. Overall demand for the Sheridan system has not declined and is expected to increase. Current well-field operating procedure is to use Well 5 as the lead well with Well 6 as the backup. Well 4 is only used if needed due to relatively high ammonia levels. Prior to the installation of Well 6 in 2010, Wells 4 and 5 were used as the lead wells and two other wells, Wells 2 and 3, were used very sparingly. Wells 2 and 3 were not used after 1995.

WATER LEVELS

Static (i.e., nonpumping water levels) from the Sheridan production wells are shown on Figures 4. These data are from well cleanings and flow tests performed at irregular intervals over the years and from the initial pumping test of each well. While the data were collected without the respective well pumping and data points are sparse, the graphs show fluctuations that are due to a combination of seasonal water-level variability and interference drawdown from the operation of other wells in the well field. While the frequency of water-level measurements is insufficient to determine consistent water level trends in the aquifer, the hydrographs for Wells 4 and 5 show apparent decreasing water levels over time. Installation of a pressure transducer and data logger in 08-1 (if it is still present), or Well 4, for long-term water-level monitoring would provide data to examine water level trends in better detail going forward. The groundwater flow model shows that the aquifer may have a limited extent. Recharge to the aquifer is likely to be the limiting factor in long-term sustainable capacity. A decreasing trend in groundwater levels could indicate that pumping withdrawals from the aquifer are exceeding available recharge.

Figure 5 shows the Palmer Hydrologic Drought Index data for the Central Indiana Region. The data show about a 10-year recurrence rate for severe to extreme drought conditions. Conditions have been generally wetter since the 1960s. The duration of dry to drought periods also seems to be less since the drought in 1988/1989. A short-duration drought may have little effect on water levels in the Sheridan wells due to the depth of the aquifer.

WELL PERFORMANCE

The average daily groundwater withdrawal for each well from 1985-2018 is shown on Figures 6 through 8 for Wells 4 through 6, respectively. Water withdrawal data reported after 2019 are from the influent meter to the treatment plant and individual well usage was not reported. Specific capacity data are shown on Figures 9 through 11. Measurements of static water levels, pumping rates, and drawdown for the three wells in the Sheridan Well Field were collected at their respective installation dates and during cleaning and inspections between 2010 and 2020. Although the frequency of these measurements is low (three to five measurements per well), this water level and pumping data was used to assess well performance.

Well 4

Well 4 was installed in 1961 and was constructed with 18 feet of 8-inch diameter, 0.040-inch slot well screen. The well screen transmitting capacity is approximately 470 gpm at the design entrance velocity of 0.1 foot/second or 235 gpm if 50 percent well screen blockage is assumed. Specific capacity data for Well 4 are shown on Figure 9. Well performance appeared to decline from installation in 1961 through 2007. The last reported cleaning of Well 4 was in 2007. Figure 6 shows that use of Well 4 since 2007 has been minimal. The specific capacity of Well 4 in 2020 was 17.6 gpm/ft at a pumping rate of 352 gpm. Well 4 was effectively replaced with the installation of Well 6 in 2011.

Well 5

Well 5 was installed in 1961 and was constructed with 10 feet of 10-inch diameter, 0.060-inch slot well screen. The well screen transmitting capacity is approximately 360 gpm at the design entrance velocity of 0.1 foot/second or 101 gpm if 50 percent well screen blockage is assumed. Figures 7 and 8 show that production from the Sheridan Well Field shifted from Well 4 to Well 5 and Well 5 was supplying nearly all of the groundwater from 2007 through 2009. The last reported cleaning of Well 5 was in 2010. Figure 10 shows that specific capacity declined from 17.3 gpm/ft at the time of installation in 1961 to 7.90 gpm/ft in 2019. The most recent measured specific capacity of Well 5 in 2020 was 12.3 gpm/ft at a pumping rate of 320 gpm.

Well 6

Well 6 was installed in 2010 and was constructed with 20 feet of 16-inch diameter, 0.050-inch slot well screen. The well screen transmitting capacity is approximately 950 gpm at the design entrance velocity of 0.1 foot/second or 475 gpm if 50 percent well screen blockage is assumed. Water withdrawal data on Figure 8 show that Well 6 was producing about 60,000 to 80,000 gallons per day between 2011 and 2018. Figure 11 shows that the original specific capacity of Well 6 in 2011 was 22.1 gpm/ft at a pumping rate of 500 gpm. Specific capacities were a little lower in 2019 (21.7 gpm/ft) and 2020 (20.0 gpm/ft), both at 500 gpm.

WELL FIELD CAPACITY EVALUATION

The capacity of the Sheridan Well Field was assessed using the groundwater flow model developed for the 2008 Pumping-Test Analysis and Well-Field Capacity Evaluation (Eagon, 2008). Cross-Section A-A' was updated to include Well 6. The IDNR well log database was checked and no other wells have been installed that required other revisions to the cross-sections. After review of the cross sections, no changes were made to the model hydraulic conductivity distribution. Since Well 6 has essentially replaced Well 4, only Wells 5 and 6 were used in the modelled capacity evaluation of the Sheridan Well Field. Multiple scenarios were modelled with the current wells and two proposed additional wells in order to achieve greater firm capacity while maintaining a minimum remaining available drawdown of at least 30 percent. Figure 12 shows the locations of Wells 5 and 6 and two additional well locations (Wells 7 and 8) that were used for model simulations.

The drawdowns calculated in this capacity evaluation only represent formation drawdown and do not account for well loss. The available flow test data from the wells are insufficient to calculate well loss. Drawdown at each pumping well is a combination of well loss, formation drawdown, and interference drawdown. Well loss is drawdown in a well that results from the turbulent flow of water in and near the well that causes the water level in a pumping well to be lower than the water level in the aquifer outside of the well. For sand and gravel wells, turbulence can be induced by the vertical flow of water in the well to the pump intake and by stratification and grain-size differences in the aquifer at the well screen/aquifer interface. The condition of the well screen and degree of mineral encrustation also affect the flow of water into the well and can create additional turbulence. Well loss is not a constant and varies with pumping rate and condition of the well. Formation drawdown is drawdown in the aquifer that varies with pumping rate and is dependent on aquifer characteristics. Interference drawdown is drawdown at a well that is induced by pumping of another well or wells.

Groundwater Flow Model Development

The groundwater flow model used for this analysis was MODFLOW, developed by the U.S. Geological Survey (USGS) (McDonald and Harbaugh, 1988) and modified by Environmental Simulations, Inc. The groundwater flow model analysis is able to account for the effects of variations in aquifer properties and available recharge on potential production from the well field. Presented in this section is a brief description of the groundwater flow model developed in 2008 including details of the model inputs, grid, boundary conditions, and properties. Details of model calibration were discussed in detail in the 2008 report and are not presented below.

Model Inputs

The ground-water flow model was constructed to represent ground-water flow from west to east in the confined sand and gravel aquifer. The aquifer materials appear to be discontinuous, but are extensive throughout the model area. Aquifer materials are thickest near the Sheridan Well Field and are thinner away from the well field. Since the cross sections show that the bedrock is generally not in direct contact with the sand and gravel, a no flow boundary was set at the base of the model. This is a conservative approach, because no contribution of water from the bedrock will be available to support pumping withdrawals in the model. Recharge to the aquifer is by slow percolation of precipitation through the predominantly clay soils that overlie the aquifer.

The model was constructed as a single layer. Layer type 1 was used so that the aquifer will be confined at all times. Since the significant water withdrawal facilities in the model area, other than the Sheridan Water Works, use a very small amount of ground water, only the Sheridan wells are included in the model. Since the aquifer is confined and is overlain by over 100 feet of predominantly clay soil, no surface-water bodies were included in the model.

Regional geologic information, the results of the 2008 pumping test of Sheridan Well 5, and the cross-sections on Plates 1 and 2 were used as the basis for defining the distribution of input values for the ground-water flow model.

Model Grid and Boundary Conditions

The model grid is 42,600 feet east to west and 47,400 feet north to south and is centered on the Sheridan Well Field. All model nodes are 200 feet square. The model bottom elevation is 780 feet and the model top elevation is 815 feet. The model layer thickness is a uniform 35 feet, which is the approximate thickness of the aquifer at the Sheridan Well Field.

Model boundaries are constant-head boundaries along the west and east edges of the model. The north and south model boundaries are generally perpendicular to the potentiometric contours so there will be little flow along these boundaries. Constant-head boundaries are used as necessary along the north and south boundaries to help control heads and gradients.

Hydraulic Conductivity

The hydraulic conductivity distribution is used to simulate the difference in aquifer thickness throughout the model area based on the hydrogeologic cross sections. The hydraulic conductivity in the central part of the model represents the thicker aquifer materials present in the vicinity of the Sheridan Well Field. The hydraulic conductivity of 300 gpd/ft^2 is based on the average transmissivity determined from the 2008 pumping test of Well 5 (approximately 78,800 gpd/ft). Hydraulic conductivities are reduced away from the well field to represent thinner aquifer materials. Initially a hydraulic conductivity of 86 gpd/ft^2 was used which equates to an aquifer thickness of 10 feet. However, calibration of the model to the drawdown from the 2008 pumping test of Well 5 was better using a hydraulic conductivity of 172 gpd/ft^2 which equates to an aquifer thickness of 20 feet.

Recharge from Precipitation

Recharge applied to the model is one inch per year. Initial simulations were performed using recharge of two inches per year, but aquifer heads were too high. Using the initial hydraulic conductivity distribution, with a hydraulic conductivity of 86 gpd/ft^2 away from the well field, one-half of an inch of recharge per year yielded the best results. After the hydraulic conductivity of the aquifer away from the well field was increased, it was also necessary to increase recharge to one inch per year.

Model Simulations

Four scenarios were modelled to examine the potential aquifer capacity at the Sheridan Well Field and the drawdown at simulated production wells. All simulations were run to steady-state, meaning that head change within the model between model iterations was extremely small and pumping withdrawals were balanced by available recharge. The models were evaluated to determine the pumping and interference drawdowns of each well under each scenario and to calculate the percentage of available drawdown remaining at each well. The results of each model scenario are shown on Table 2.

Scenario 1 simulates the average pumping conditions from 2018. Wells 5 and 6 were assigned pumping rates of 111 gpm and 46 gpm, respectively. The pumping rate used for Well 6 is the combined pumping rate of Wells 4 and 6. As shown on Table 2, drawdown for this simulation was minimal and the percentage of remaining available drawdown for both wells exceed 90 percent.

Scenario 2 simulates Wells 5 and 6 pumping at rates of 400 gpm each, 800 gpm total. Under this pumping condition, both wells exhibited pumping drawdown of approximately 14.5 feet and interference drawdown of approximately 11 feet. As shown on Table 2, at these pumping rates, the remaining available drawdown is greater than 65 percent for both wells.

Scenario 3 includes a simulated production well (Well 7) located between Wells 5 and 6. Pumping rates of 400 gpm were assigned to all three wells for a total capacity of 1,200 gpm. The construction characteristics for Well 7 were based on an average of Wells 5 and 6. Pumping well drawdowns for this simulation are similar to those for Scenario 2 and interference drawdown at each well increased to between 22.63 feet and 23.55 feet, due to the influence of Well 7. The percentage of available drawdown remaining under this scenario for each well was between 48% and 54.5%. This amount of available drawdown should be sufficient to account for well loss, if well performance is maintained with routine rehabilitation.

Scenario 4 includes a well, Well 8, located approximately 1200 ft north and 400 ft west of Well 6. This location is on property owned by the Marion-Adams Schools Board of Trustees and is in a location with a reasonable potential of encountering suitable aquifer materials for installation of a new well. The simulation was performed with all four wells (5, 6, 7 and 8) pumping 400 gpm each (1,600 gpm total). Under this scenario, pumping drawdown at each well again remained in the vicinity of 14.5 ft, but interference increased to between 30.16 ft and 33.61 ft. This resulted in percentage of available drawdown remaining at each well to drop to between

34.2% and 41.9% for Wells 5, 6, and 7, and to 61.3% for Well 8 to the northwest. The remaining available drawdown for Well 5, 6 and 7 is close to the lower limit of acceptability and the model drawdowns do not account for drawdown due to well loss.

The model simulations indicate a potential to develop a firm 800 gpm with installation of a third well between wells 5 and 6. A higher capacity may be achievable with a an additional well located away from the well field property. The key to sustainable production of 800 gpm or more is the interconnectedness of aquifer materials away from the well field and the availability of adequate recharge to sustain pumping withdrawals. Long-term groundwater monitoring at the well field would provide data that can aid in the evaluation of well-field capacity and in understanding recharge to the aquifer.

ADDITIONAL EXPLORATION

Test borings should be completed at potential new well locations to verify the thickness and grain-size characteristics of the aquifer. As shown, by the modeling performed for this study, there is the potential for installing a third well on the well-field property that would increase the firm capacity of the groundwater supply. Well log data also suggest that an adequate thickness of aquifer may be present at locations within about 0.25 miles north and south of the existing well field. Well log data outside of that area are sparse and location of good aquifer materials outside of that area will require additional exploration and test drilling. The aquifer in which the Sheridan wells are completed is called the "Complex" aquifer system by IDNR. The name is appropriate because thicker aquifer materials are difficult to locate and aquifer depth and thickness can change significantly within short distances.

CONCLUSIONS AND RECOMMENDATIONS

1. Available water withdrawal data indicate that the average daily demand in 2020 was about 180,000 gpd. Higher average daily demands reported in the past may have been overestimated.

2. Water-level data over time from the production wells are very sparse, but do seem to indicate that current water levels are lower than water levels reported when Wells 4 and 5 were installed in the early 1960s. If accurate, the declining water levels could indicate that the aquifer is very limited in extent and the available capacity may likewise be limited. A pressure transducer and datalogger should be installed at the well field to gather long-term groundwater level data that can reveal seasonal variability in water levels and changes in water levels relating to changes in water withdrawal. If observation well 08-1 is no longer present, Well 4 could be maintained for use as a monitoring well.

3. Pumping and static water levels in the production wells should be measured on a regular basis so that declines in well efficiency can be identified and well maintenance can be performed before the condition of the wells deteriorates to unacceptable levels. A routine cleaning schedule should be developed.

4. Routine flow testing and flow tests during rehabilitation should include measurement of drawdown at more than one pumping rate to facilitate calculation of well loss. Well loss cannot be calculated with one drawdown measurement at a single pumping rate. Drawdowns at multiple pumping rates also provide a more complete picture of variations in well performance over time.

5. Based on the groundwater flow model results, a firm capacity of 800 gpm may be available from the aquifer at the Sheridan Well Field while maintaining acceptable pumping levels. Installation of a third well between Wells 5 and 6 is possible. As much as 1,200 gpm could be possible with installation of a fourth well away from the existing well field. The main concerns impacting sustainable capacity are the interconnectedness of aquifer materials away from the well field and the availability of sufficient recharge to support increased withdrawals. Long-term water-level monitoring as capacity is increased will provide data that can be used to verify or refine the capacity estimates provided in this report. The viability of any proposed new well locations should be determined by test drilling.

REFERENCES

Arihood, Leslie D., 1982, Ground-Water Resources of the White River Basin, Hamilton and Tipton Counties, Indiana, U.S. Geological Survey, Water Resources Investigations 82-48.

Arihood, Leslie D., and W.W. Lapham, 1982, Ground-Water Resources of the White River Basin, Delaware County, Indiana, U.S. Geological Survey, Water Resources Investigations 82-47.

Eagon & Associates, Inc., 2008, Pumping-Test Analysis and Well-Field Capacity Evaluation, Sheridan, Indiana, consultants report for Bastin-Logan Water Services, Inc.

Fenelon, Joseph M.; Kieth E. Bobay, and others, 1994, Hydrogeologic Atlas of Aquifers in Indiana, U.S. Geological Survey Water Resources Investigations Report 92-4142.

Herring, William C., 1971, Water Resources of Hamilton County with Emphasis on Ground-Water Availability, Indiana Department of Natural Resources, Division of Water.

McDonald, Michael G. and Harbaugh, Arlen W., 1988. A Modular Three-Dimensional Finite Difference Ground-Water Flow Model, U.S. Geological Survey Techniques of Water-Resources Investigations, Book 6, Chapter A1. (Provided by Geraghty & Miller, Inc.).

FIGURES

EAGON & ASSOCIATES, INC.

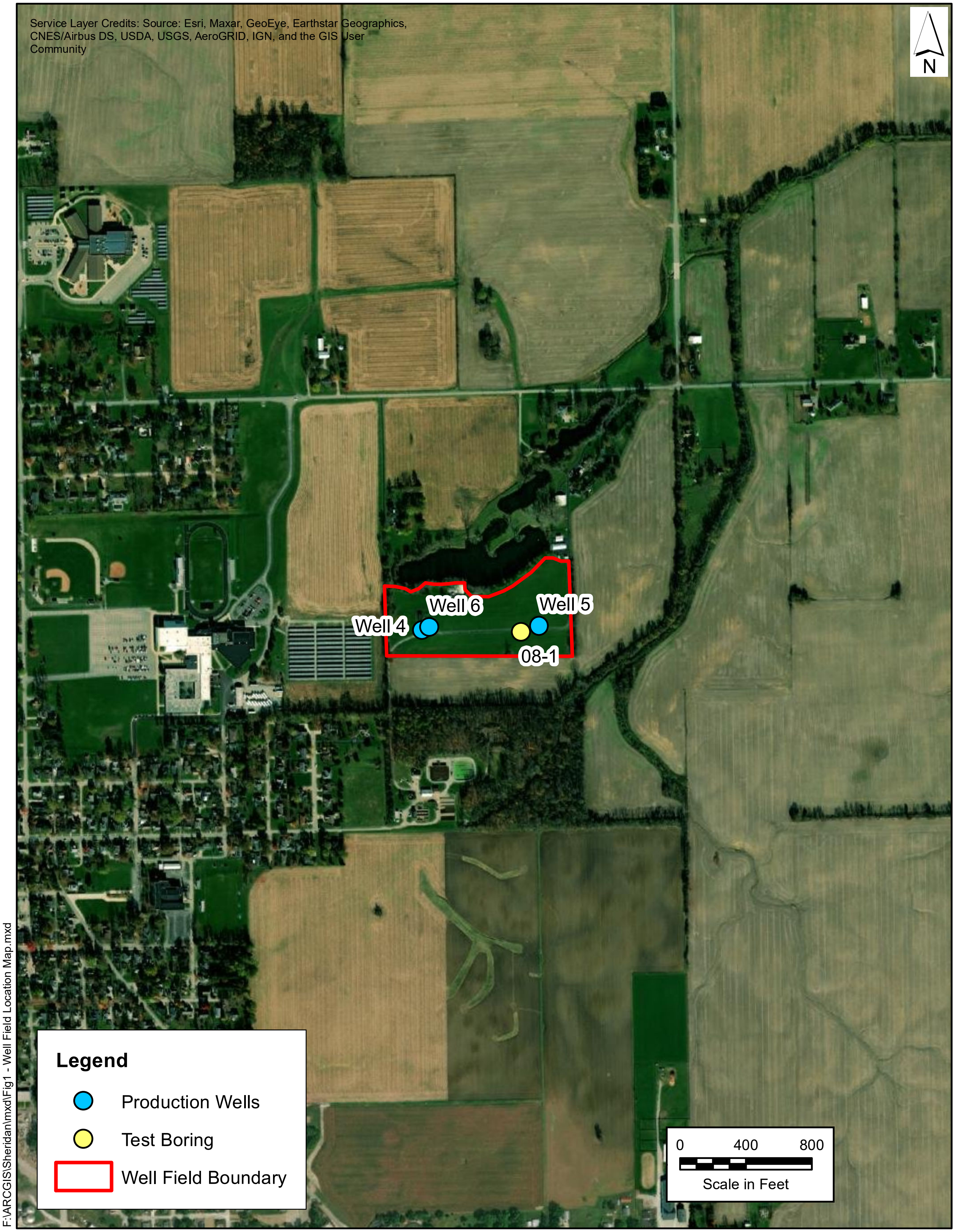
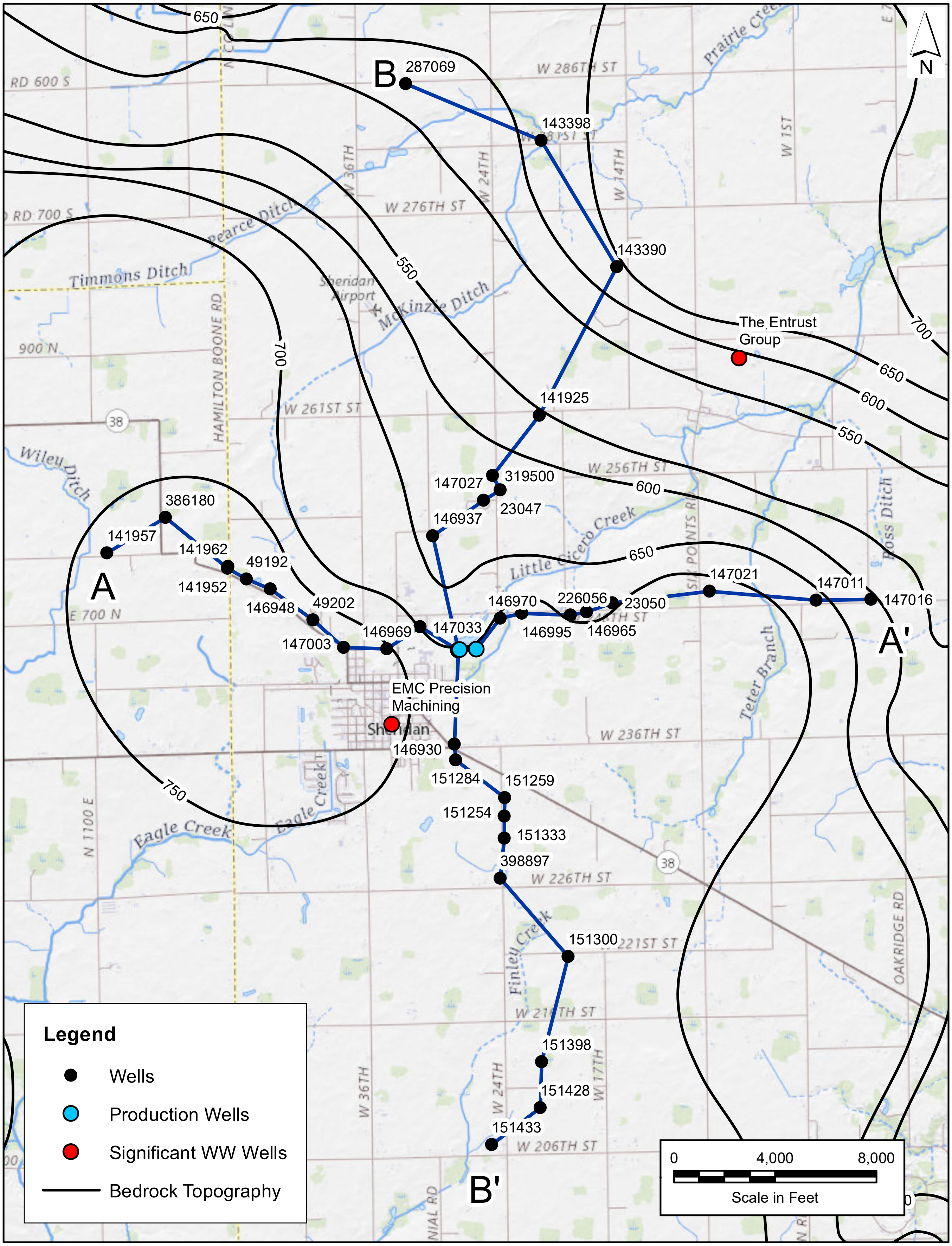


Figure 1. Well Field Location Map – INAW Sheridan Well Field

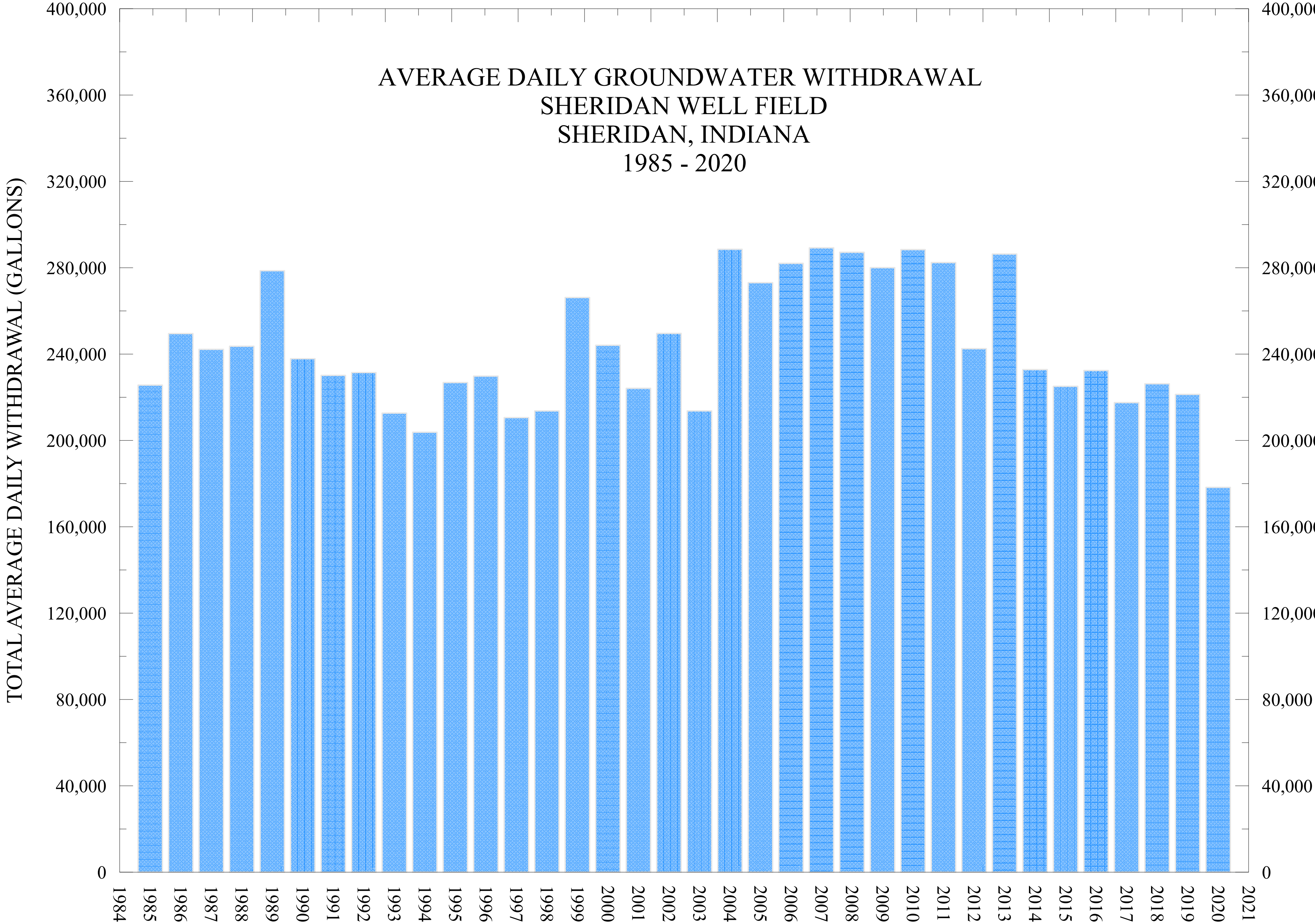
EAGON & ASSOCIATES, INC.



F:\ARCGIS\Sheridan\mxd\IDNR Well Record_XSections.mxd

Figure 2. Bedrock Topography and Cross-Section Traces
INAW Sheridan Well Field

EAGON AND ASSOCIATES INC.



Sheridan/Average Daily Withdrawal.grf
9/23/2021

FIGURE 3.

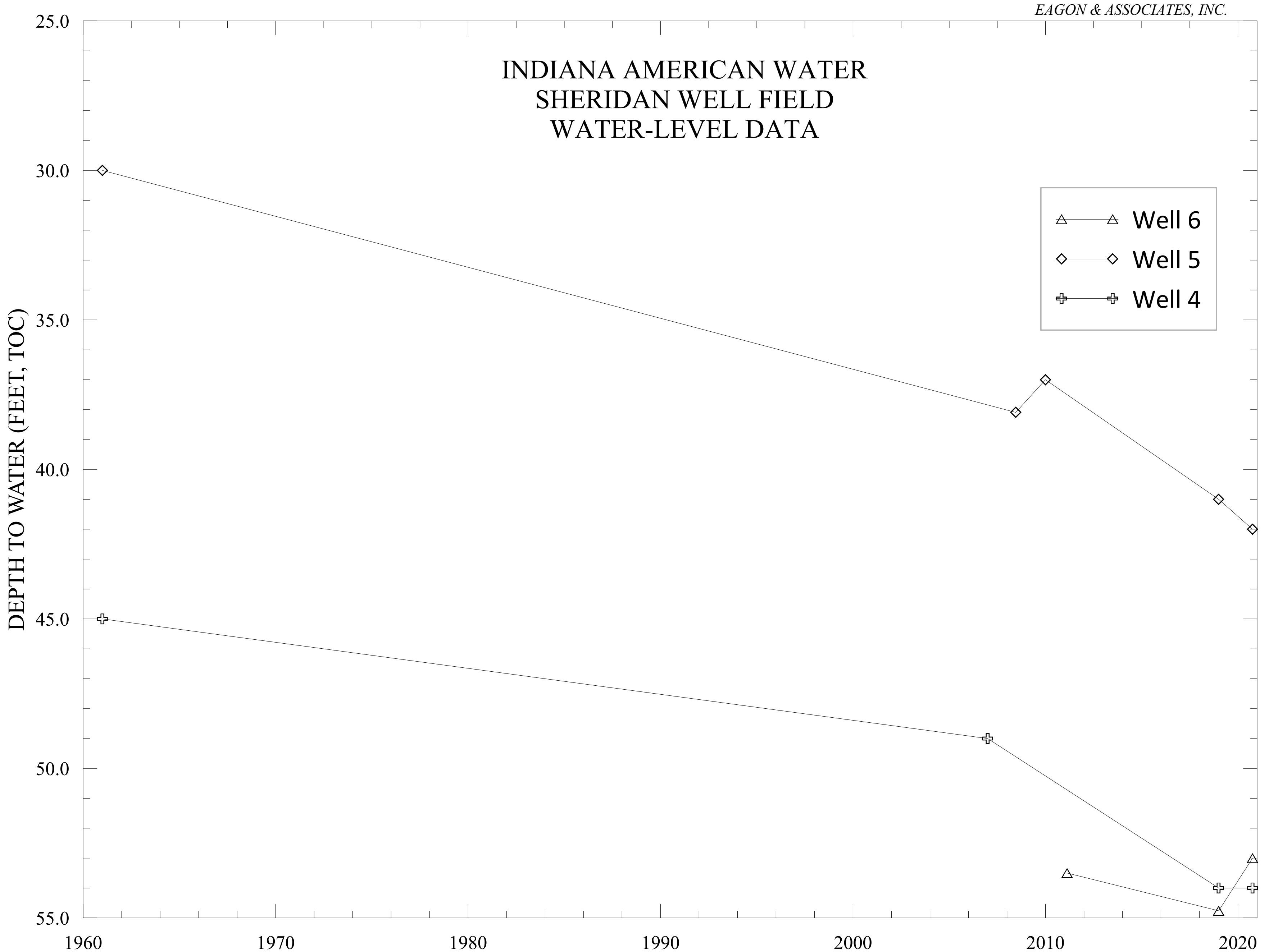
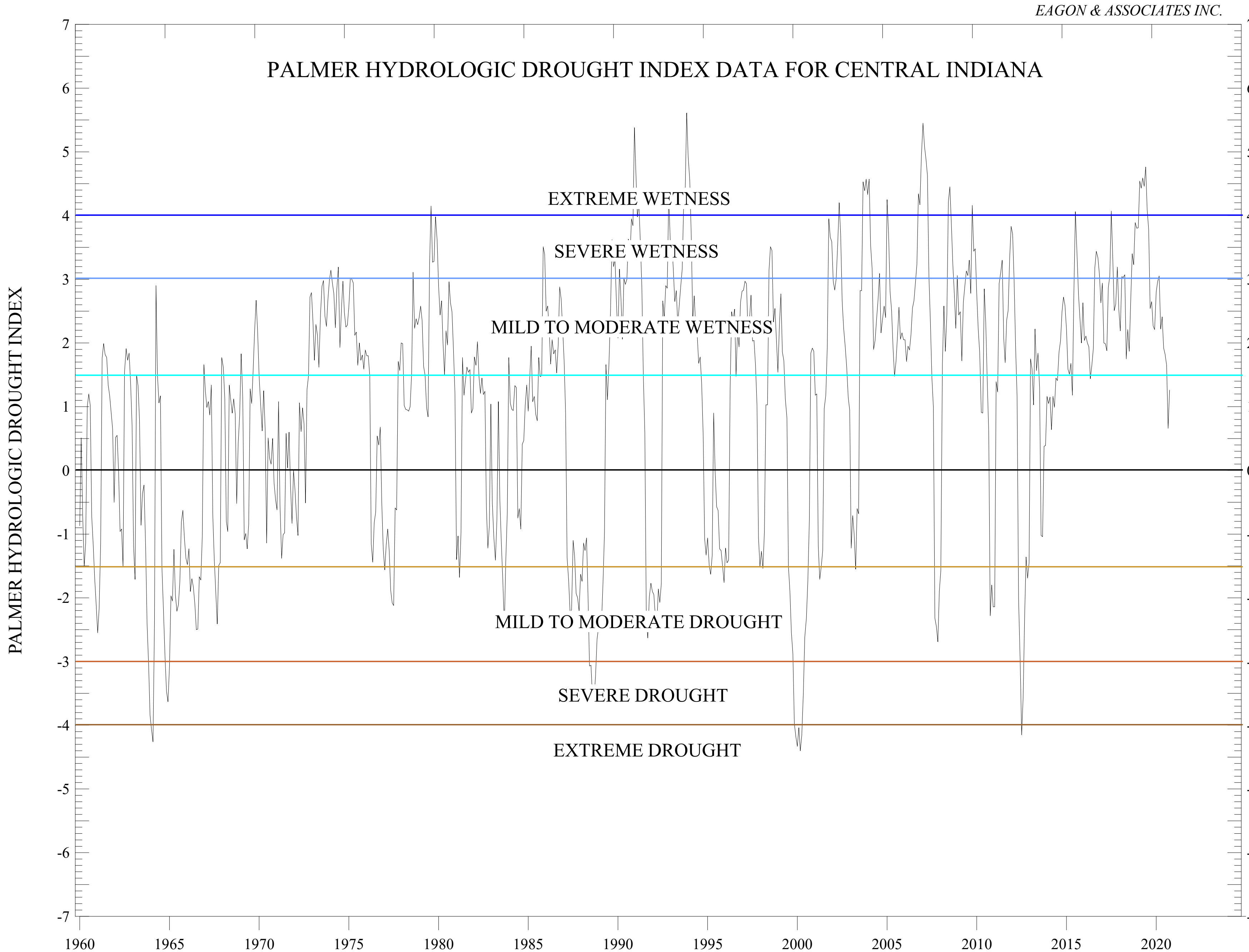


FIGURE 4.

SHELBYVILE\WELLS DTW.grf
10/1/21



SHERIDAN/CENTRAL INDIANA DROUGHT DATA 1960-2020.GRF
10/1/21

FIGURE 5.

EAGON AND ASSOCIATES INC.

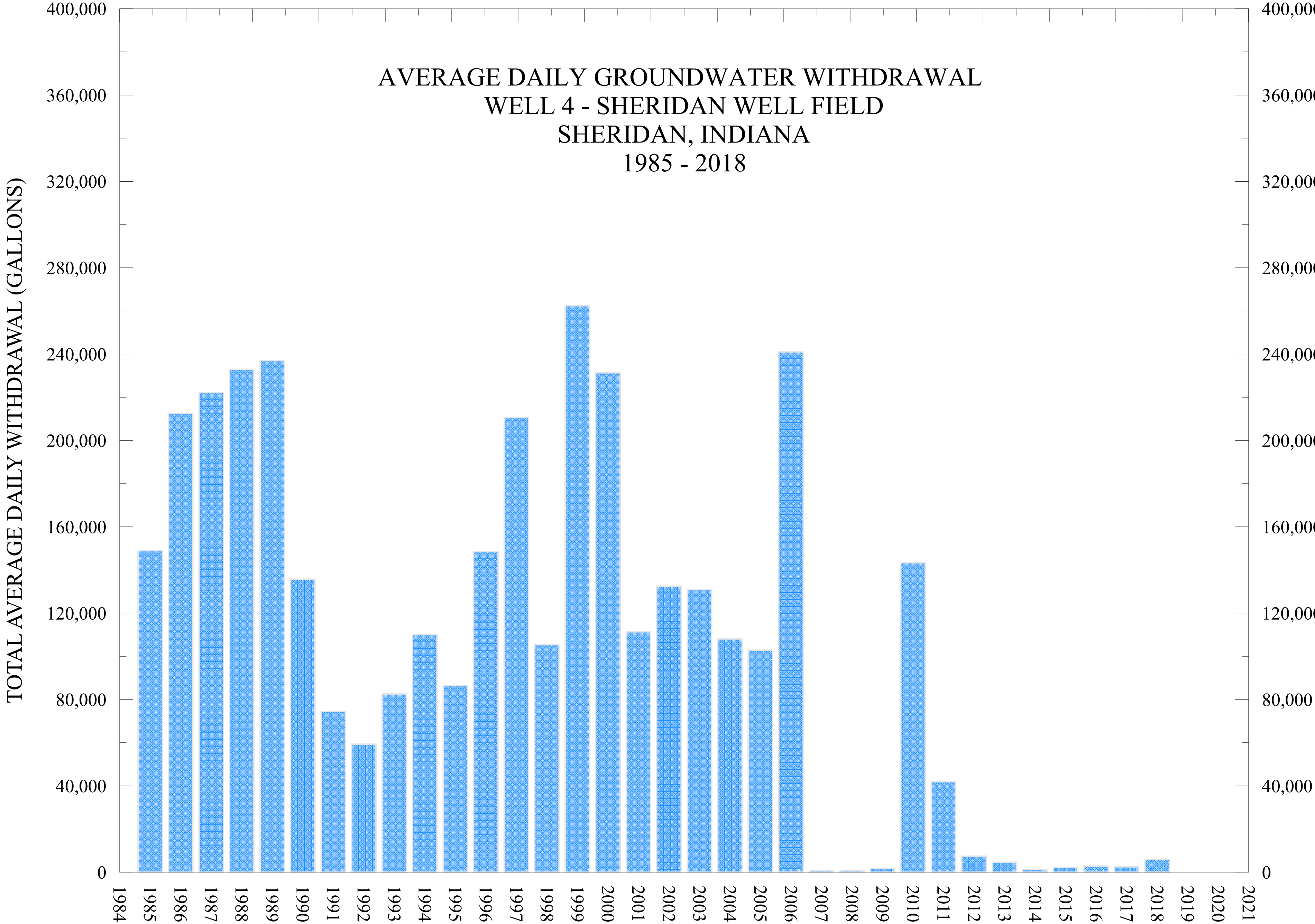
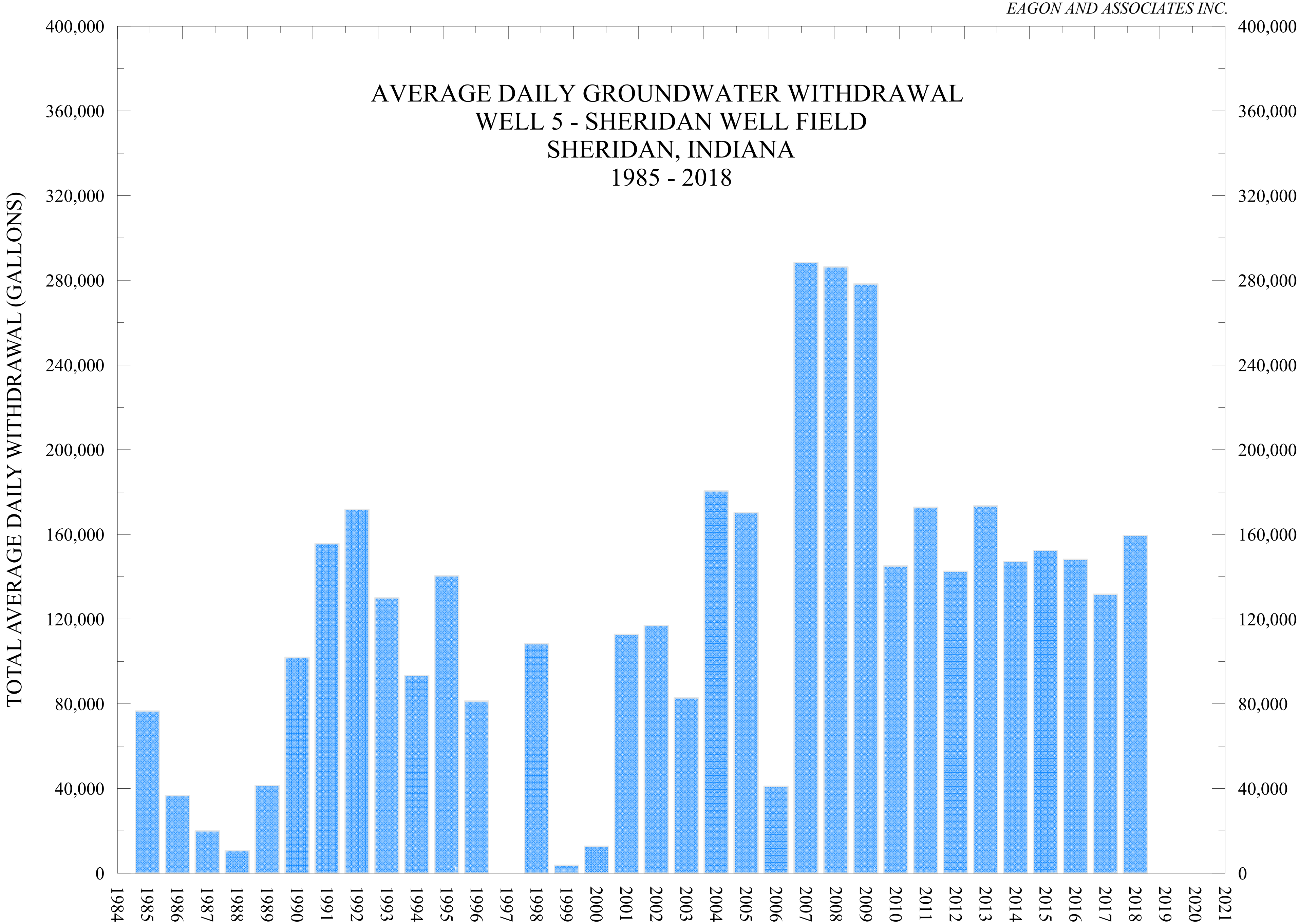


FIGURE 6.

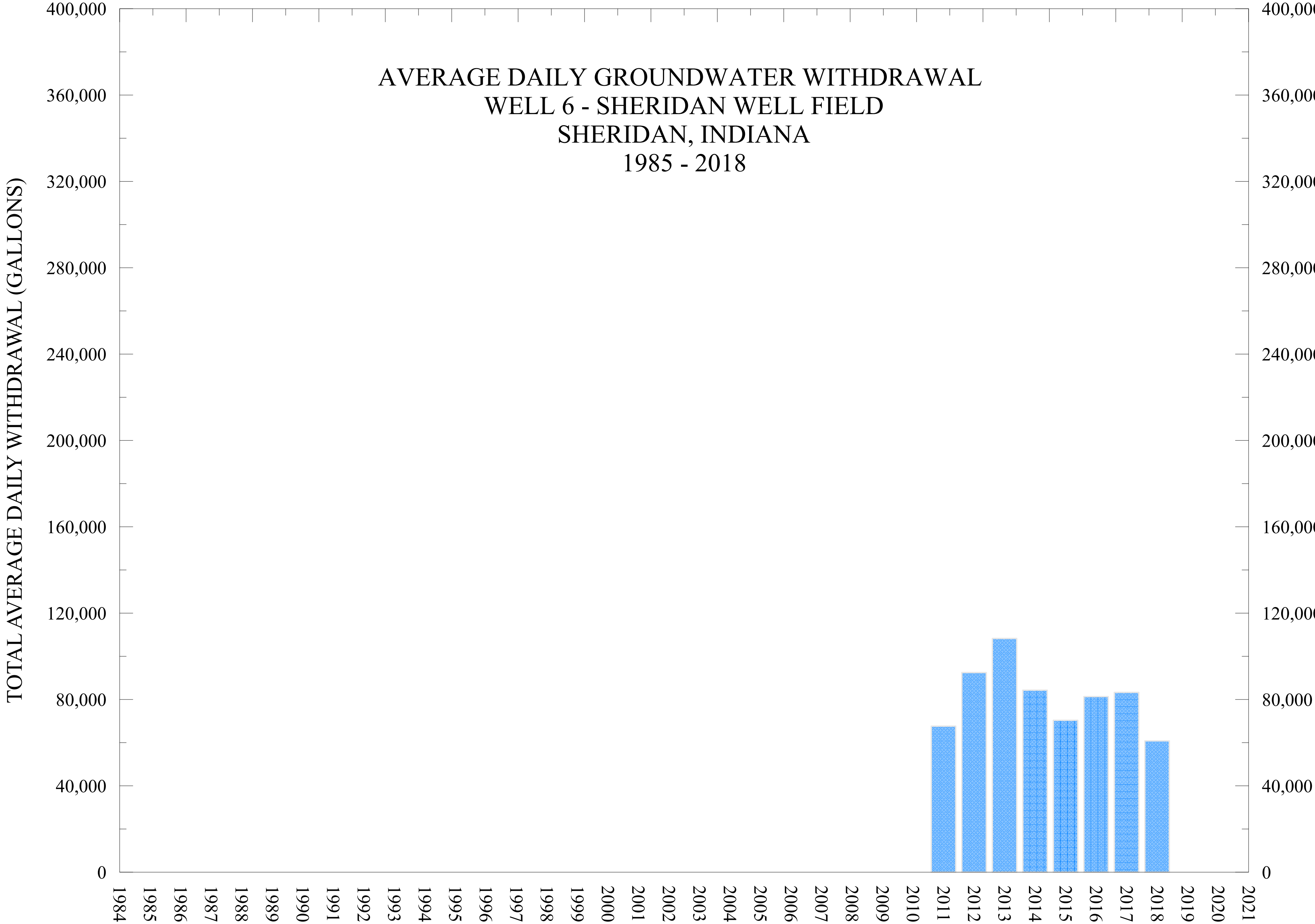
Sheridan/Average Daily Withdrawal_Well 4.grf
10/1/2021



Sheridan/Average Daily Withdrawal_Well 5.grf
10/1/2021

FIGURE 7.

EAGON AND ASSOCIATES INC.



Sheridan/Average Daily Withdrawal_Well 6.grf
10/1/2021

FIGURE 8.

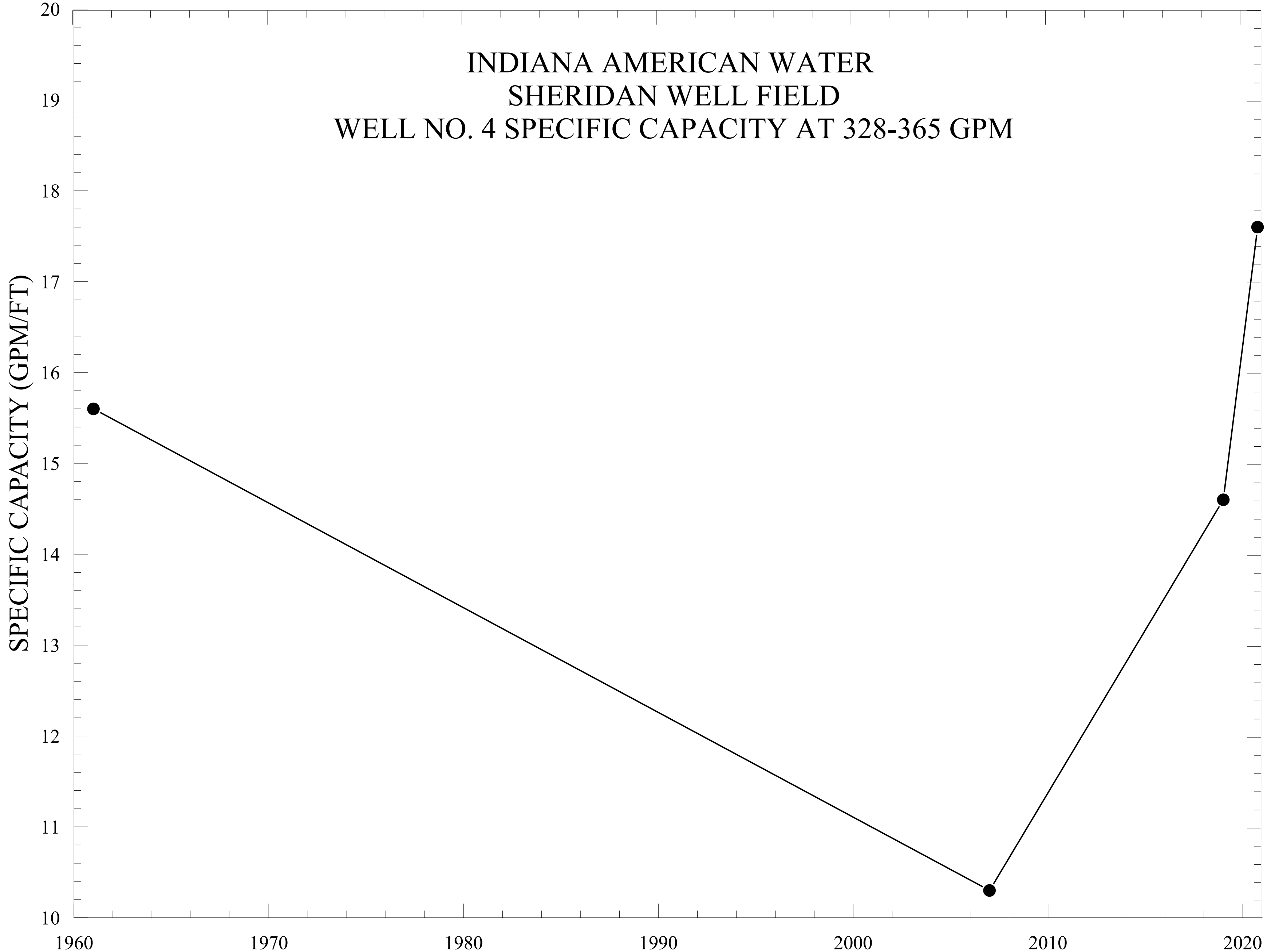


FIGURE 9.

Shelbyville/ Well 4 Specific Capacity.grf
10/1/2021

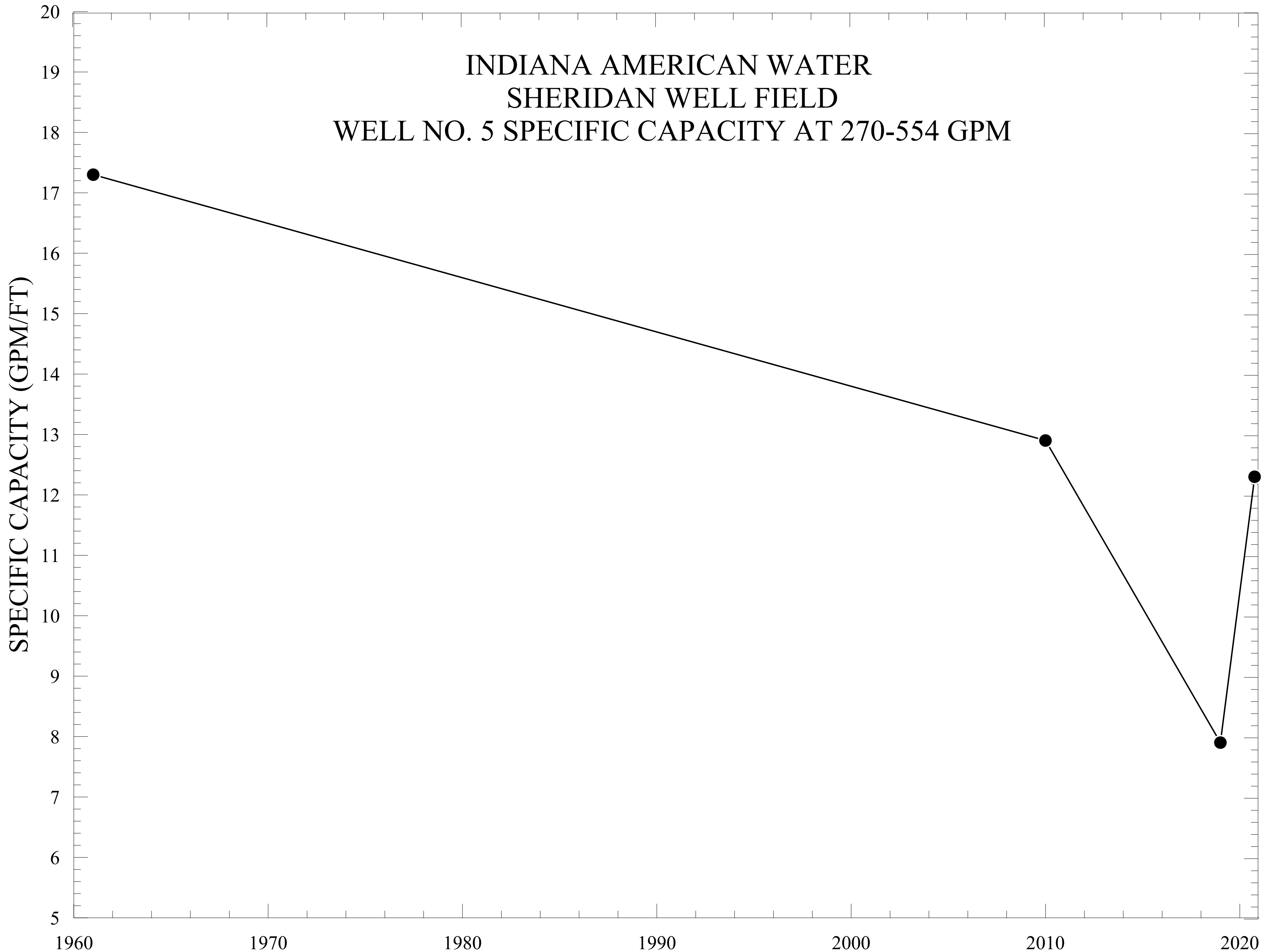


FIGURE 10.

Shelbyville/ Well 5 Specific Capacity.grf
10/1/2021

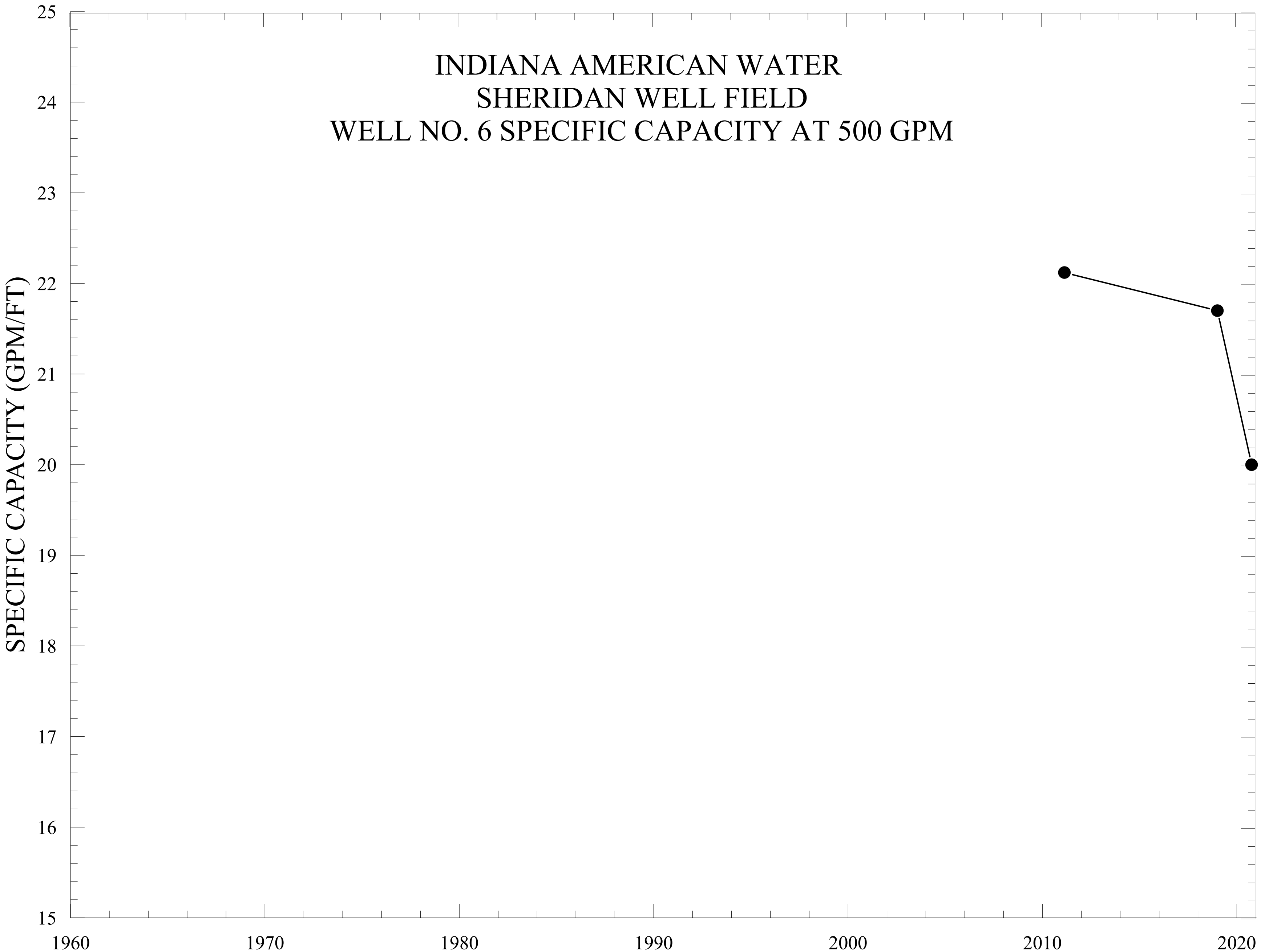


FIGURE 11.

Shelbyville/ Well 6 Specific Capacity.grf
10/1/2021

EAGON & ASSOCIATES, INC.

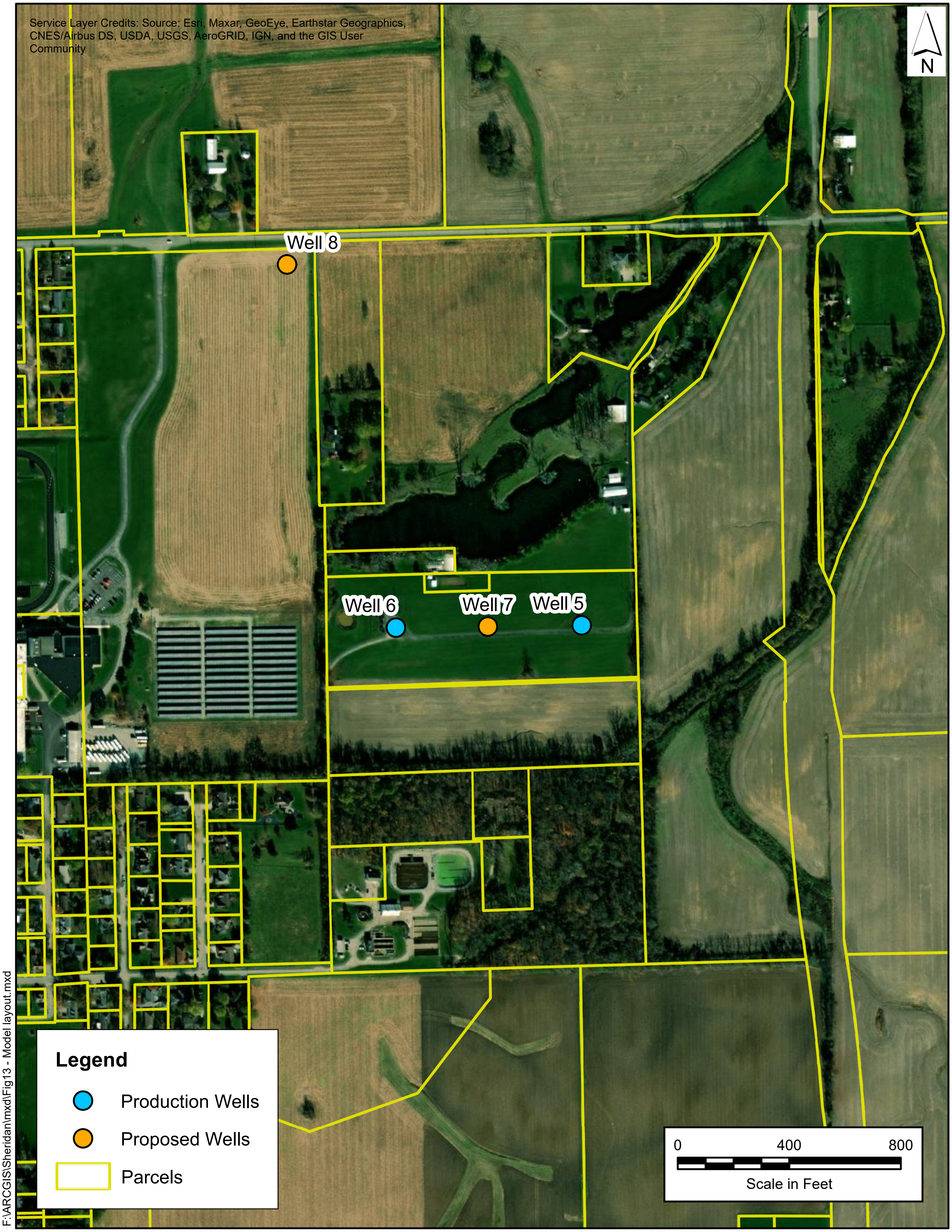


Figure 12. Model Well Locations – INAW Sheridan Well Field

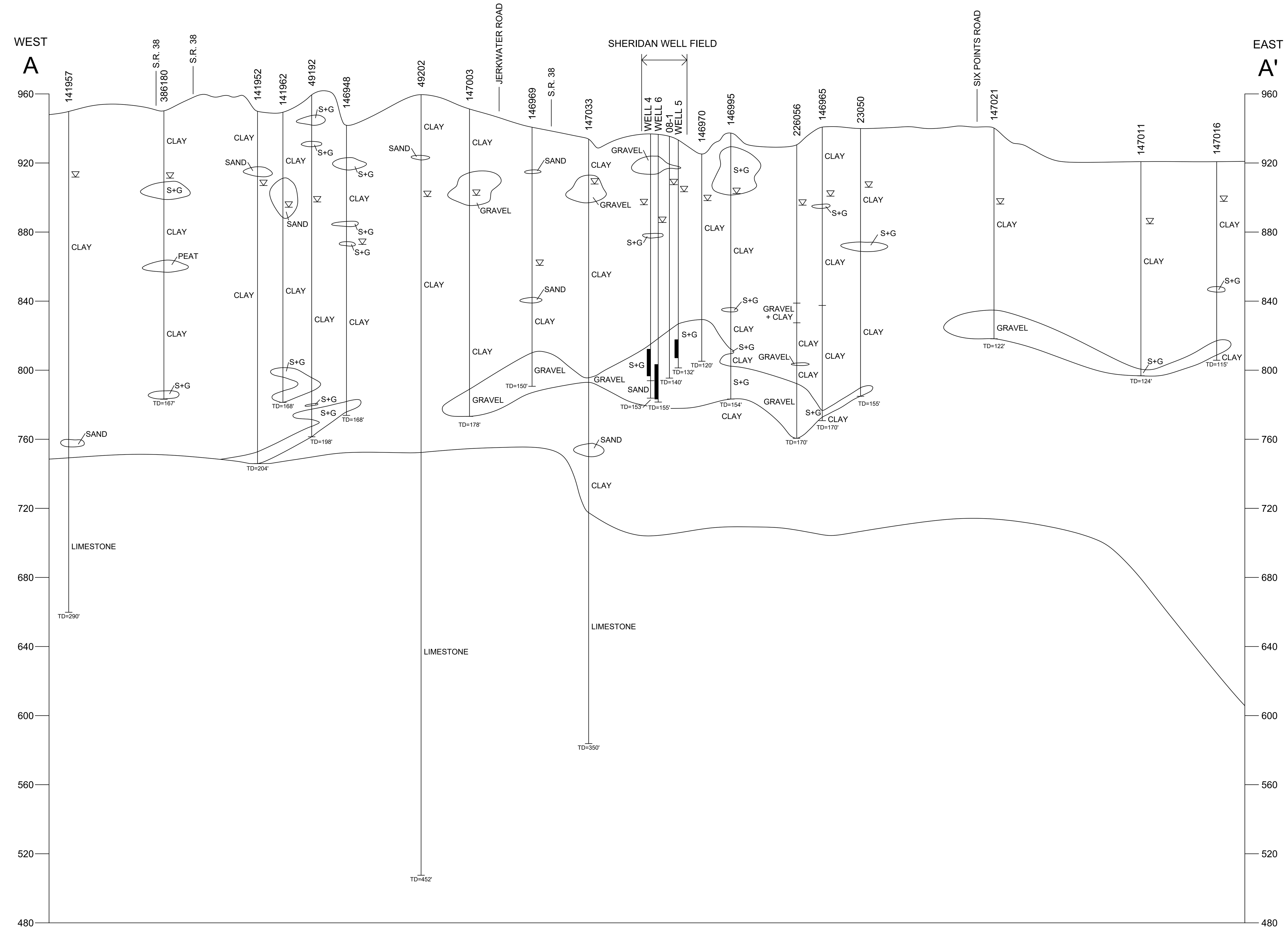
TABLES

APPENDIX A.

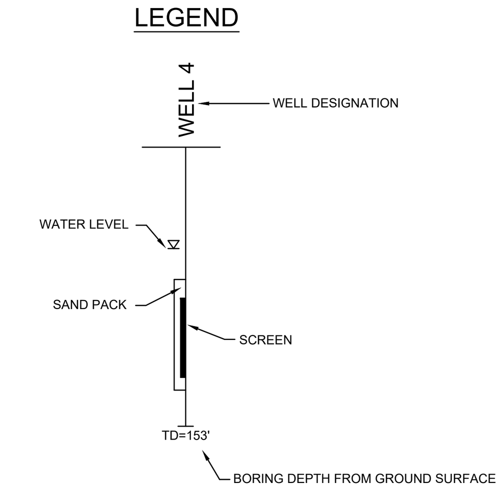
WELL LOGS
SHERIDAN WELL FIELD AND CROSS-SECTIONS

PLATES

9/22/2021 1:58:08 PM



LEGEND



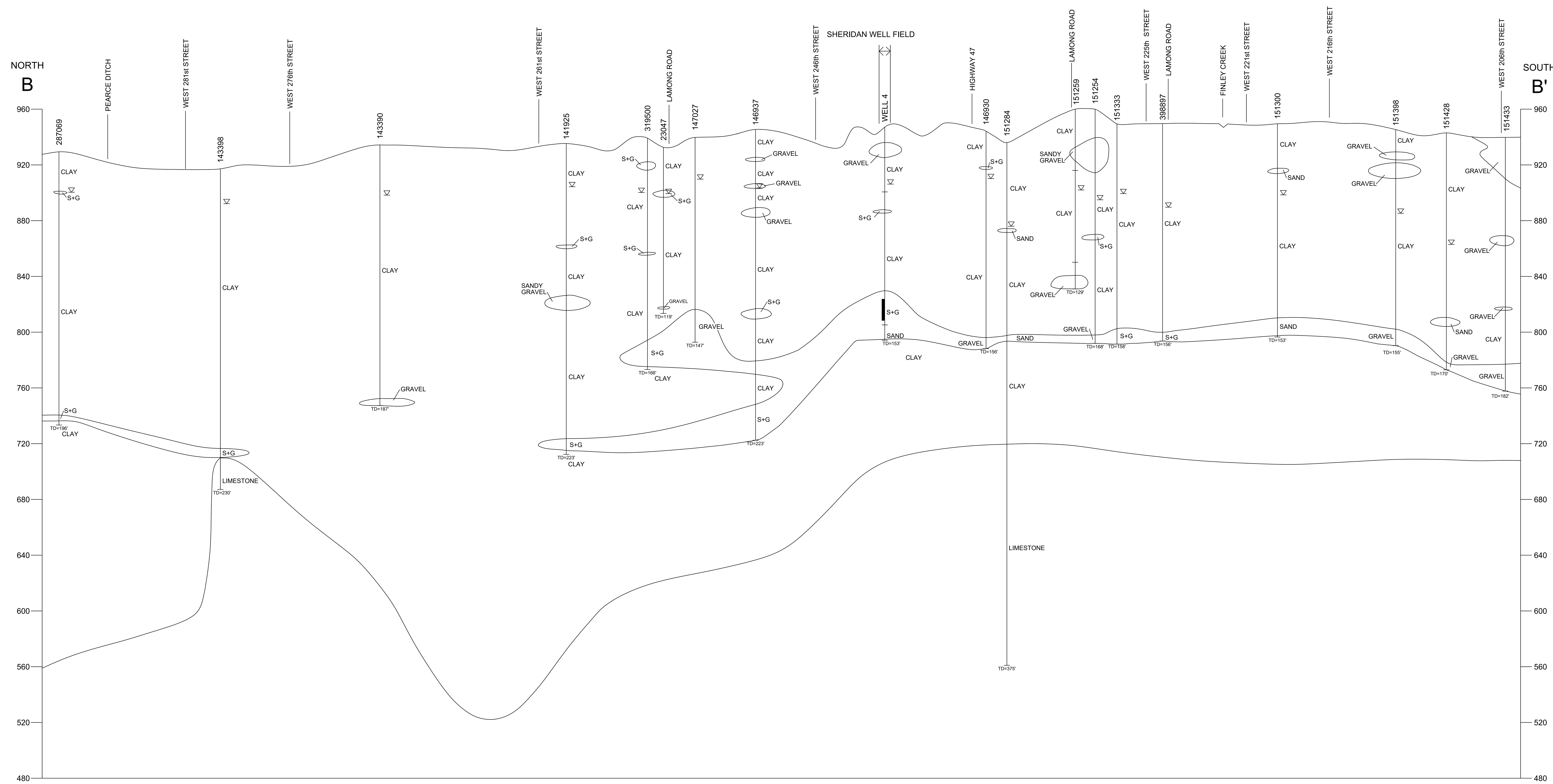
0 40 80
VERTICAL SCALE FEET

0 2000 4000
HORIZONTAL SCALE FEET

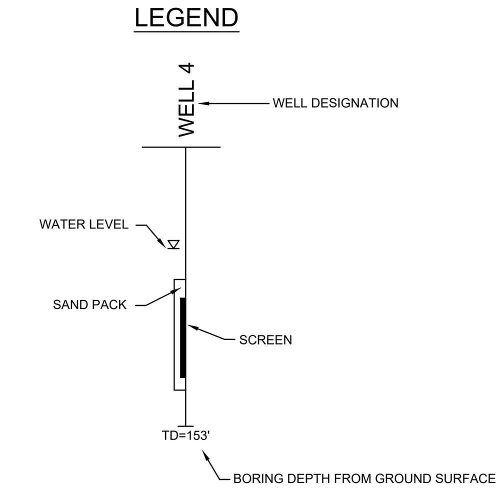
COMPILED BY: SJC	PLATE TITLE: GEOLOGICAL CROSS-SECTION TRACE A-A'	
DRAFTED BY: RMH	PROJECT TITLE: SHERIDAN, INDIANA	
CHECKED BY: SJC	PREPARED BY: EAGON & ASSOCIATES, INC.	PLATE NUMBER: 1
APPROVED BY: HBE		
DATE: OCT. 2, 2008		

F:\AUTOCAD\SHERIDAN\SHERIDAN-XSECTA.DWG

9/22/2021 1:59:13 PM



LEGEND



0 40 80
VERTICAL SCALE FEET

0 2000 4000
HORIZONTAL SCALE FEET

COMPILED BY: SJC	PLATE TITLE: GEOLOGICAL CROSS-SECTION TRACE B-B'	
DRAFTED BY: RMH	PROJECT TITLE: SHERIDAN, INDIANA	
CHECKED BY: SJC	PREPARED BY: EAGON & ASSOCIATES, INC.	PLATE NUMBER: 2
APPROVED BY: HBE		
DATE: OCT. 2, 2008		

F:\AUTOCAD\SHERIDAN\SHERIDAN-XSECTB.DWG