HYDROLOGICAL STUDY
OF THE 859 ACRE
LIMONAR DEVELEPMENT / WONDERLY HOLDINGS
PARCEL PROPOSED FOR INCLUSION IN THE
MIAMI-DADE COUNTY URBAN DEVELOPMENT BOUNDARY
SECTIONS 30 & 31, TOWNSHIP 54 SOUTH, RANGE 39 EAST
MIAMI-DADE FLORIDA

PREPARED FOR:

LIMONAR DEVELOPMENT AND WONDERLY HOLDINGS
C/O FRANCISCO PINES, ESQ.
3301 PONCE DE LEAON BOULEVARD
SUITE 220
CORAL GABLES, FLORIDA 33134

PREPARED BY:

CRB GEOLOGICAL & ENVIRONMENTAL SERVICES, INC.
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(305) 447-9777

JUNE 25, 2014

INTRODUCTION

CRB Geological & Environmental Services, Inc. (CRB) was retained by Limonar Development and Wonderly Holdings to evaluate historical hydrologic conditions at a 859 – acre parcel of land located within Sections 30 and 31, Township 54 South, Range 39 East (the Site). The purpose was to evaluate the findings of this study within the framework of wetland hydrologic constraints and to determine whether or not Site hydrology favors and supports wetland conditions. The location of the Site is shown in Figure 1.

The evaluation of hydrological conditions at the Site consisted of assembling, analyzing and interpreting historical data to more or less the present day from a) existing wells installed and monitored by the United States Geological Survey (USGS), b) piezometers installed and monitored by CRB, c) West Well Field (WWF) pumping records maintained by the Miami-Dade Water and Sewer Department (MDWSD), d) canal stage data in the vicinity of the Site maintained by the South Florida Water Management District (SFWMD) and rainfall data in the vicinity of the Site maintained by SFWMD.

SITE DESCRIPTION

The subject property is located in central Miami-Dade County and comprises approximately 859 acres of land that is primarily used as agricultural land since the 1970s. The WWF is situated in the central-northern portion of the Site and has been actively extracting groundwater since 1994 from three (3) production wells (W-29, W-30, and W-31).

SITE HYDROGEOLOGY

Highly permeable limestone of the Miami, Fort Thompson, Tamiami formations comprise the Biscayne aquifer at the Site (Fish and Stewart 1991). These limestones have very high hydraulic conductivities of up to 20,000 ft/day and are characterized by large scale vuggy and in some instances cavernous porosities. Land surface within the site area generally ranges between approximately 5 to 8 feet above sea level with an average of 6.3 feet.

The groundwater table elevation at the site fluctuates primarily in response to a) rainfall in the short-term (hours to days), and cyclical, seasonal rain variability in the intermediate-term (months to years). The long-term groundwater elevation variability and trends at the Site are the targets of this study.

DATA SOURCES

In order to evaluate long-term hydrological trends and their causes at the Site, several data sources were consulted. The sources were evaluated individually and collectively as to their appropriateness and applicability in characterizing the long-term hydrologic variability and suitability for determining and evaluating the causes for the observed changes through time.

USGS MONITORING WELL NETWORK

The USGS maintains a nationwide network of groundwater monitoring stations. There are several USGS groundwater monitoring wells located within the boundaries of the Site that were used in this study. Data available from these stations consist of periodic measurements of groundwater elevations (hourly, daily) relative to 29 NGVD, generally over the last 20 years or so. In that regard these data are well suited to document long-term hydrologic changes at the Site. USGS wells used for this study are identified as G-3552, G3553, G-3554, G-3556, and G-3560. Their locations are shown in Figure 2.

WEST WELL FIELD PUMPING RECORDS

The WWF started operation (groundwater extraction) in 1994. Extraction of groundwater occurs via three extraction wells (W-29, W-30, W-31). Their locations are shown in Figure 2. The combined design rated capacity for the WWF is 16 million gallons per day (MGD). Production data were obtained from the Miami-Dade Water and Sewer Department (MDWSD) several years ago and span the period between January 1994 and February 2011. Attempts were made to obtain more recent data (i.e. 2011 through the present day), however, for some reason requests were not honored by the MDWSD citing security reasons and non-availability of data in electronic digital format.

CANAL STAGE DATA

Water levels in South Florida are managed by the SFWMD via a large number of drainage canals and an extensive network of water control structures that are being carefully managed and monitored. The monitoring data consist, among other parameters, of water elevation in various segments of canals separated by control structures. Discharge of water through this network of canals facilitated by the operation of control structures has a direct and profound effect on the groundwater elevations throughout large areas of Miami-Dade County. A major canal, the Tamiami Canal, is located approximately 3.8 miles to the north of the Site. Another major canal is the L-31N canal. It is located approximately 1 mile to the west of the Site.

Long-term stage data from canal stage monitoring stations S336T, 2290766, and 2290767 (Figure 3) were obtained and evaluated for purposes of documenting any long-term groundwater elevation trends that could be attributed to area wide water level control strategies.

RAINFALL DATA

Where infiltration rates are high, and groundwater is relatively close to the ground surface, rainfall has an almost instantaneous effect on groundwater levels. Rainfall data collected by the SFWMD in the vicinity of the Site (station S336-R) (Figure 4) and other historical rainfall data were analyzed as to the effects that precipitation has on observed groundwater fluctuations in order to be better able to qualify groundwater elevation fluctuations and trends, and distinguish between potential causes for the observed fluctuations.

CRB PIEZOMETERS

CRB installed piezometers A through H at various locations (Figure 5) to monitor groundwater elevations at the Site and document any potential effects of the West Well field on groundwater elevations at the Site. Dedicated data loggers were installed in all piezometers with one data logger dedicated to monitor barometric pressure for compensation purposes during data analysis. Data from these piezometers span from 2011 through 2014.

GROUND SURFACE ELEVATION

A site elevation survey was conducted by CH Perez & Associates, Inc. in 2011. Two hundred and forty two (242) elevations were surveyed throughout the Site on an irregular grid. Figure 6 is a depiction of the Site's topography based on this survey and includes locations and elevations of all survey points. An average ground surface height of 6.3 feet 29 NGVD was calculated from the elevation data generated by CH Perez & Associates. Verbal communications with Mr. Steve Carney have indicated that the county may have data indicating an average land surface of 6.5 feet which would further reduce the likelihood of wetland hydrology. For this study, the more conservative elevation of 6.3 feet 29NGVD was used.

GROUNDWATER ELEVATIONS

Groundwater in south Florida is relatively flat with a mild easterly to southeasterly regional gradient. The groundwater gradient at the Site generally follows the regional gradient with higher groundwater elevations to the west, supported / recharged by the L-31N canal. The groundwater gradient is periodically masked by overprints of localized precipitation events and groundwater withdrawal associated with West Well Field. Figure 7 shows pumping rates at WWF to have been ranging from about 300 to 500 million gallons per month or approximately 10 to 16 million gallons per day (MGD). Precipitation by far exerts the most dominant influence on short term groundwater fluctuations and can completely mask the effects of groundwater withdrawal associated with the well field as shown in Figure 8. As can be seen in this figure, an increase in water production from below 100 MGM to 500 MGM within the time period of February 1997 to April 1997 had no apparent effect on groundwater elevations recorded in G-3553. Precipitation, events on the other hand, are directly linked to marked groundwater fluctuation and can be seen to directly cause a significant groundwater level rise while pumping is at its peak (May 1997 to August 1997).

Long-term groundwater elevation data are available from USGS wells at the Site, generally from 1994 to the present. Data are reported for the most part as daily maximum readings obtained from hourly recorded values. In some cases, hourly recorded values are available as well.

Data collected by CRB through a network of piezometers shows the well field to have a relatively subtle influence on groundwater levels. Cross sections of groundwater elevations from west to east, show the effect of water withdrawal from three production wells on water levels as the presence of a shallow cone of depression which is partially depicted in Figure 9. This shallow configuration of the cone of depression is consistent with very high hydraulic conductivities at the Site of approximately 20,000 ft/day (Figure 10) (Brakefield *et. al*., 2013). From the piezometers C, B, A, and H, along a west-east transect, the cone of depression in the upgradient as well as downgradient directions associated with the West Well Field water extraction was estimated and is shown in Figure 11. The greatest groundwater depression associated with the West Well Field can be expected east of the well field center line i.e. in the downgradient direction and was estimated at approximately one-half (0.5) feet at a distance of approximately 500 feet from the well field. The drawdown observed in CRB piezometers and resulting from well field pumping appears to be somewhat less than previously modeled results.

Over the period of available data, ground water elevations across the Site have dropped perceptibly. Anecdotal evidence from interviews with farmers farming the Site support the notion that groundwater levels are significantly lower today than they were in the past.

Figures 12 through 14 contain hydrographs from USGS wells G-3552, G-3553, and G-3554, respectively. The average drop in ground water levels during the period of monitoring (i.e. from 1994 to present) was obtained by fitting a linear regression lines to the data. The magnitude in ground water elevation drop ranged from 0.74 feet to 0.81 feet. USGS well G-3560 which is at the southern boundary of the Site, adjacent to Kendall Drive, and is much farther removed from any potential influence to the well field shows a decline in groundwater elevation (-0.75 ft) over the same time (Figure 15) within the range of the other three wells discussed above.

When comparing groundwater elevations within the monitoring period during dry and wet seasons, one finds very similar trends. Figure 16 depicts average groundwater elevations during wet and dry seasons and shows the rates of decline to be almost identical.

LOWERING OF REGIONAL GROUNDWATER

Water elevation data in drainage canals maintained by the SFWMD are available for similar time periods as groundwater data in wells maintained by the USGS. Regional groundwater elevations are controlled to a predominant degree by maintaining drainage canal stages in the area through the operation of control structures that either allow water to pass and be discharged further downstream, thus lowering groundwater tables, or hold water back to raise groundwater levels. Groundwater levels at the Site and surrounding areas are subject to canal stages maintained by the SFWMD in the Tamiami Canal that runs west to east, north of the Site and the L-31N canal that runs north to south, west of the site. As the Tamiami canal is further from the site, data from two canal gauge stations along L-31N (02290766 and 02290767) were chosen for evaluation in order to gain a better understanding of long-term groundwater trends exhibited at the Site. Figure 17 shows hydrographs for L-31N stations 02290766 and 0229767, approximately one mile west of the Site. Short-term fluctuation in water elevation recorded at these two station are primarily related to precipitation in and around the area of the stations and are similar in character to fluctuations observed in hydrographs from monitoring wells. Evaluation of the long-term water elevation in L-31N canal reveals a lowering of canal stage of over 0.5 feet over the last 20 years.

Long-term groundwater lowering recorded in USGS monitoring wells at the Site to lowering of water levels in canal L-31N reveal similar trends. However, groundwater lowering in the USGS wells 3552 and 3553 occurred over the last 20 years a rate that is greater than the rate of water level lowering in L-31N. Consequently, the difference between water levels in L-31N and groundwater levels (G-3552 and G-3553) at the Site from 1994 to the present time has increased by an average of 0.26 feet. Figure 18 depicts hydrographs for station 02290767 and USGS wells G-3552 and G-3553 showing lowering trends in water elevations in both systems, albeit at varying rates. It can be concluded therefore that the long-term lowering of the groundwater table at the Site of approximately 0.8 feet over the past two decades is a composite result of the lowering of canal stages and the consequent decrease in recharge to the groundwater at the Site and the extraction of groundwater at West Well Field. According to Figure 18, it appears that two thirds of the overall decline in groundwater elevation at the Site is attributable to lower water

tables maintained in the canal system in the vicinity of the Site and the remaining one third to the extraction of groundwater from the Site by the well field.

RAINFALL

Long-term trends in rainfall in south Florida in general and in Miami specifically do not appear to be consistent with lowering groundwater table at the Site. Rainfall over the last twenty years appears to have been fairly steady with a distinct increase in yearly precipitation over the last ten years (Figure 19). Similar trends can be seen in the data from station S 336-R. It would appear therefore that the decline documented in groundwater levels at the Site over the past two decades are not related to rainfall variability.

WETLAND HYDROLOGY

Pursuant to chapter 62-340.550 for the Florida Administrative Code, wetland delineation may be refuted by reliable, long-term hydrologic records that can reasonably show the possible loss of wetland function through excessive drainage. Of specific interest are the terms "inundation" and "saturation" employed by the regulation. Inundation is defined as "…a condition in which water from any source regularly and periodically covers a land surface". The term saturation is defined as "…a water table six inches or less from the soil surface for soils with a permeability equal to or greater than six inches per hour in all layers within the upper 12 inches, or a water table 12 inches or less from the soil surface for soils with a permeability less than six inches per hour in any layer within the upper 12 inches". As no permeability data are available for the soils at the Site, for purposes of this study, the more conservative case of a water table 12 inches or less from the land surface was used as the criterion for the presence of saturation that under certain conditions would indicate wetland hydrology. It could well be that upon determining permeability at the Site, the less stringent case of 6 inches could be applied.

Hydrologic data suitable to determine that an inundation (flooding) or saturation conditions exist would be any accepted methodology applied to data collection that with reasonable accuracy and precision can determine absolute elevation of ground water and compare it to the absolute elevation of the land surface. If the ground water elevation exceeds the elevation of the land, a

condition of inundation would exist. Likewise, if groundwater levels rose to within twelve inches of the land surface, a condition of saturation would exist. Chapter 62-340 F.A.C. further defines hydrology consistent with the presence of wetlands or wetland function by a condition of inundation lasting at least seven consecutive days or saturation lasting at least twenty consecutive days during conditions which represent long-term hydrologic conditions.

In order to evaluate the presence or absence of hydrology consistent with wetland conditions as defined in chapter 62-340 F.A.C. inundation conditions and saturation conditions over the last two decades were analyzed. The gradual decline in water elevations at the Site documented through long-term ground water elevation monitoring discussed under previous headings indicates at least a decline in wetland function if not the absence of wetland hydrology entirely. USGS monitoring well G3560 specifically was chosen for this purpose because it is farthest from the well field and therefore is likely to exhibit the least influence of water extraction at the well field.

Groundwater levels from years 1995 through 1999, representing the earliest five years of available groundwater elevation data were compared to years 2010 through 2014, representing the most recent five years of data. Daily maximum groundwater elevations within the period of each year were searched for conditions during which saturation and inundation occurred. The frequency and chronology of these occurrences during each of the studied years are represented in Figures 20 through 24 (1995 through 1999) and Figures 25 through 29 (2010 through 2014). Only days that exceeded the saturation criterion are shown in these figures.

During the time period 1995 through 1999 saturation occurred during 582 days compared to 160 days during 2010 through 2014. Inundation occurred during 57 days during the earlier period as compared to 4 days during the later period. Furthermore, hydrology consistent with the presence of wetlands or wetland function was documented by a condition of inundation lasting at least seven consecutive days or saturation lasting at least twenty consecutive days during four out of the five years during the time period 1995 through 1999 (Figures 20, 21, 22, and 24). Conversely, during the period 2010 through 2014 hydrology consistent with the presence of wetlands or wetland function never occurred. This profound difference in hydrology at the Site

documented over the last 20 years strongly suggests the loss of at least significant wetland function.

CONCLUSION

This study shows that there have been significant and profound changes in hydrology at the Site over the last two decades that have resulted in at least considerable loss of wetland function. We feel that the data used in this study are consistent with the regulatory intent and meaning of conditions that represent long-term hydrologic conditions for the study of wetland hydrology as expressed in chapter 62-340 F.A.C., and that further study and data analysis to support the findings to date show considerable promise in further evaluating the existence of wetlands over large portions of the Site. It seems to us prudent and worthwhile based on the promising results of this preliminary study to meet with the regulatory agency in order to agree upon specific requirements and expectations for the further development of hydrological documentation in support of the findings presented herein.

REFERENCES

Brakefield, L., Hughes, J.D., Langevin, C.D., and Chartier, K. 2013. Estimation of Capture Zones and Drawdown at the Northwest and West Well Fields, Miami-Dade County, Florida, Using an Unconstrained Monte Carlo Analysis: Recent (2004) and Proposed Conditions. USGS Open-File Report 2013-1086

Florida Climate Center. http://climatecenter.fsu.edu/products-services/data/precipitation/miami

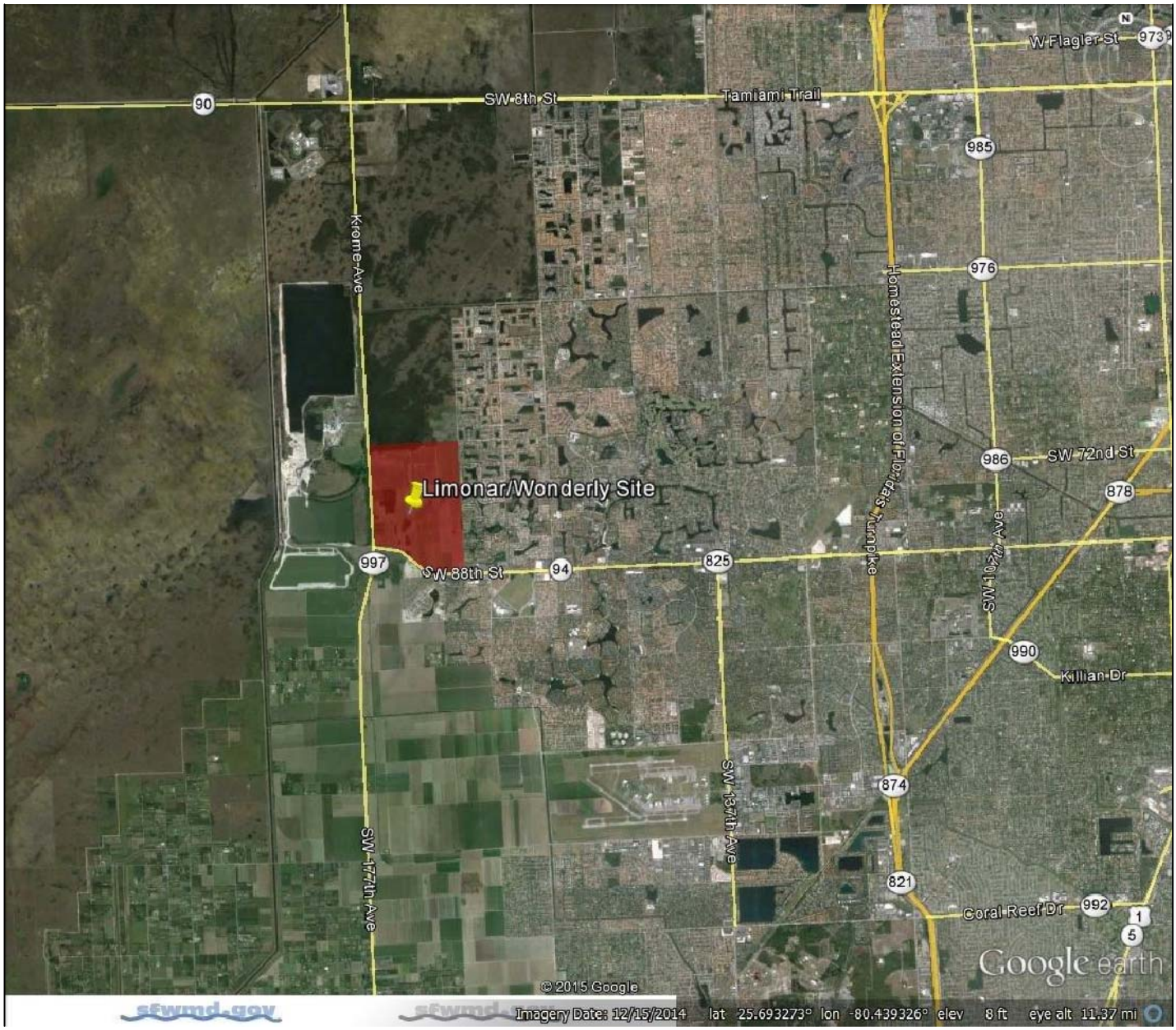
Fish, J.E., and Stewart, M., 1991. *Hydrogeology of the Surficial Aquifer System*, *Dade County Florida*. U.S. Geological Survey, Water-Resources Investigations Report 90-4108.

Randazzo, Anthony F. and Douglas S. Jones, eds., 2000. *The Geology of Florida*. University Press of Florida, Gainesville

Solo-Gabriele, H.M., 1998. *Sources of Water to the West Wellfield*. Interim Technical Report for Isotope Study, Phase I. University of Miami, Coral Gables, FL. Submitted to the South Florida Water Management District, West Palm Beach, FL

Brakefield, L., Hughes, J.D., Langevin, C.D., and Chartier, K. 2013. Estimation of Capture Zones and Drawdown at the Northwest and West Well Fields, Miami-Dade County, Florida, Using an Unconstrained Monte Carlo Analysis: Recent (2004) and Proposed Conditions. USGS Open-File Report 2013-1086

FIGURES



SITE LOCATION MAP SHOWING THE LIMONAR/WONDERLY SITE AND SURROUNDING AREAS.

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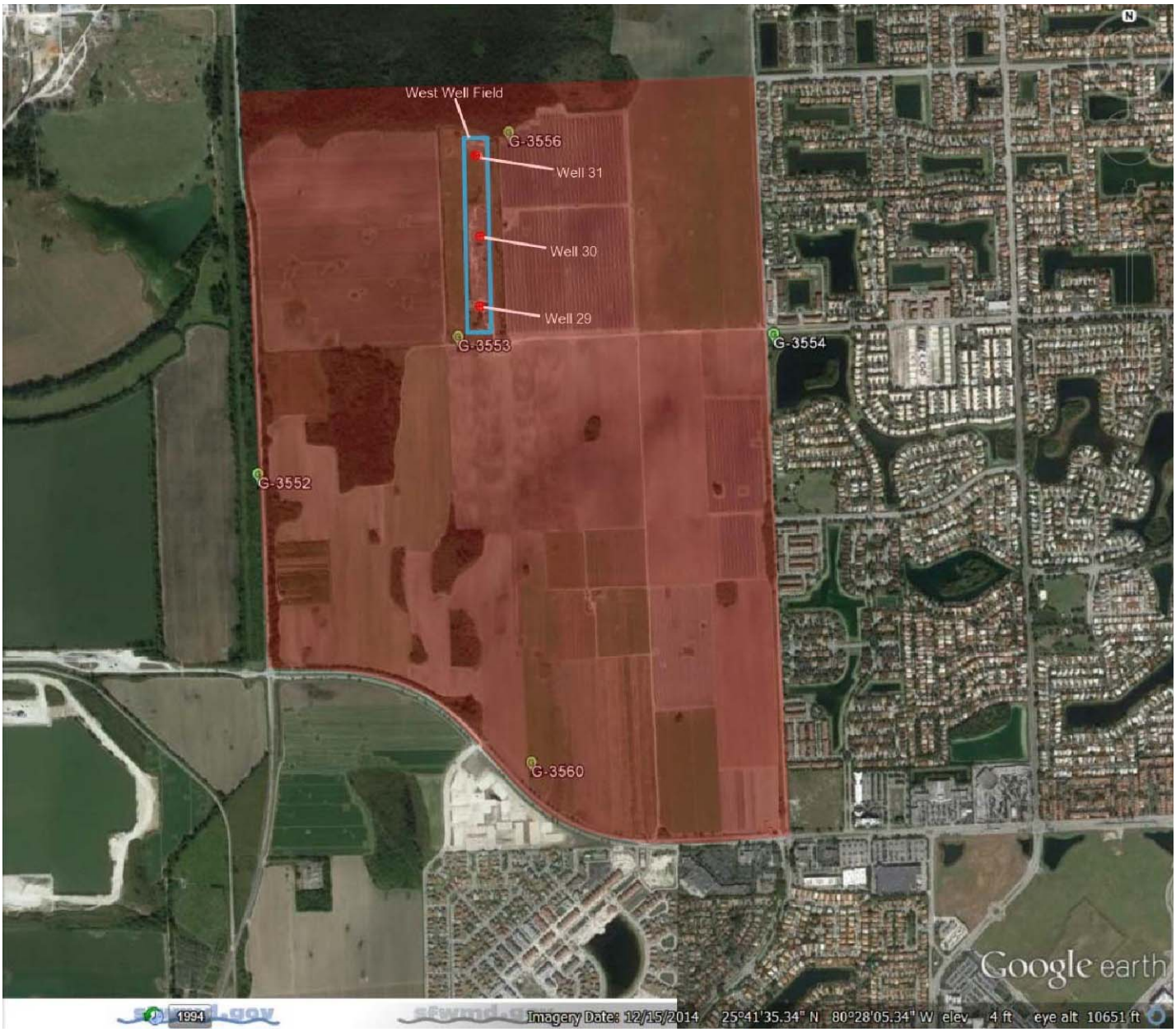
TITLE: SITE LOCATION MAP LIMONAR/WONDERLY SITE NORTHEAST CORNER OF INTERSECTION OF SW 177th AVE AND NORTH KENDALL DRIVE MIAMI-DADE COUNTY, FLORIDA			FIGURE 1
REV'D DATE: JUN 23, 2015		PROJECT NO. CLI 1040-01	
DRAWN DATE: JUN 23, 2015		SCALE: AS NOTED	
DRAWN BY: LA		APPROVED BY: VR	

CLI 1040…\01…\Reports\Hydrologic Stusy of Limonar…\CAD\F1- Site Location Map



SITE MAP SHOWING LOCATIONS OF SELECT USGS MONITORING WELLS (G-3552, G-3553, G3554, G-3556 & G-3560) AND PRODUCTION WELLS (WELL 29, 30 AND 31) AT WEST WELLFIELD.

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TITLE: SITE MAP LIMONAR/WONDERLY SITE NORTHEAST CORNER OF INTERSECTION OF SW 177th AVE AND NORTH KENDALL DRIVE MIAMI-DADE COUNTY, FLORIDA			FIGURE 2
REV'D DATE: JUN 23, 2015		PROJECT NO. CLI 1040-01	
DRAWN DATE: JUN 23, 2015		SCALE: AS NOTED	
DRAWN BY: LA		APPROVED BY: VR	

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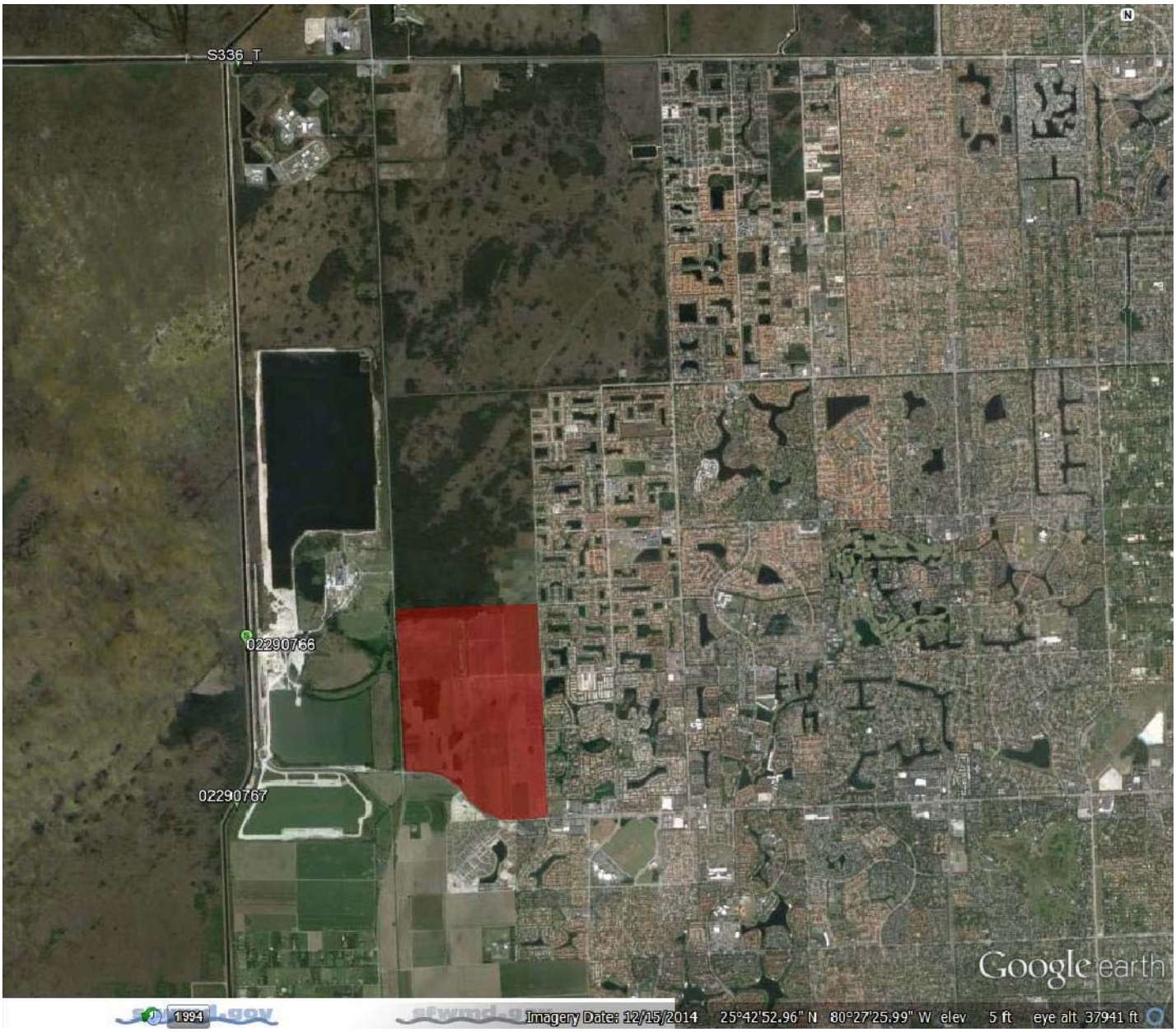

SITE VICINITY MAP SHOWING CANAL STAGE MONITORING STATIONS 02290766 AND 02290767

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TITLE: SITE VICINITY MAP-SMS 02290766 & 022900767
LIMONAR/WONDERLY SITE
NORTHEAST CORNER OF INTERSECTION OF SW 177th AVE
AND NORTH KENDALL DRIVE
MIAMI-DADE COUNTY, FLORIDA

REV'D DATE:	JUN 23, 2015	PROJECT NO. CLI 1040-01	FIGURE 3
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DRAWN BY:	LA	APPROVED BY: VR	

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SITE VICINITY MAP SHOWING RAIN GAUGE S336_R USED IN THIS STUDY

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TITLE: SITE VICINITY MAP SHOWING RAIN GAUGE S336_R
LIMONAR/WONDERLY SITE
NORTHEAST CORNER OF INTERSECTION OF SW 177th AVE
AND NORTH KENDALL DRIVE
MIAMI-DADE COUNTY, FLORIDA

REV'D DATE:	JUN 23, 2015	PROJECT NO. CLI 1040-01	FIGURE 4
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DRAWN BY:	LA	APPROVED BY: VR	

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AERIAL VIEW OF SITE SHOWING LOCATION OF GROUNDWATER PIEZOMETERS INSTALLED AND MONITORED BY CRB

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TITLE: AERIAL VIEW SHOWING GW CRB PIEZOMETERS LIMONAR/WONDERLY SITE NORTHEAST CORNER OF INTERSECTION OF SW 177th AVE AND NORTH KENDALL DRIVE MIAMI-DADE COUNTY, FLORIDA			FIGURE 5
REV'D DATE: JUN 23, 2015		PROJECT NO. CLI 1040-01	
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DRAWN BY: LA		APPROVED BY: VR	

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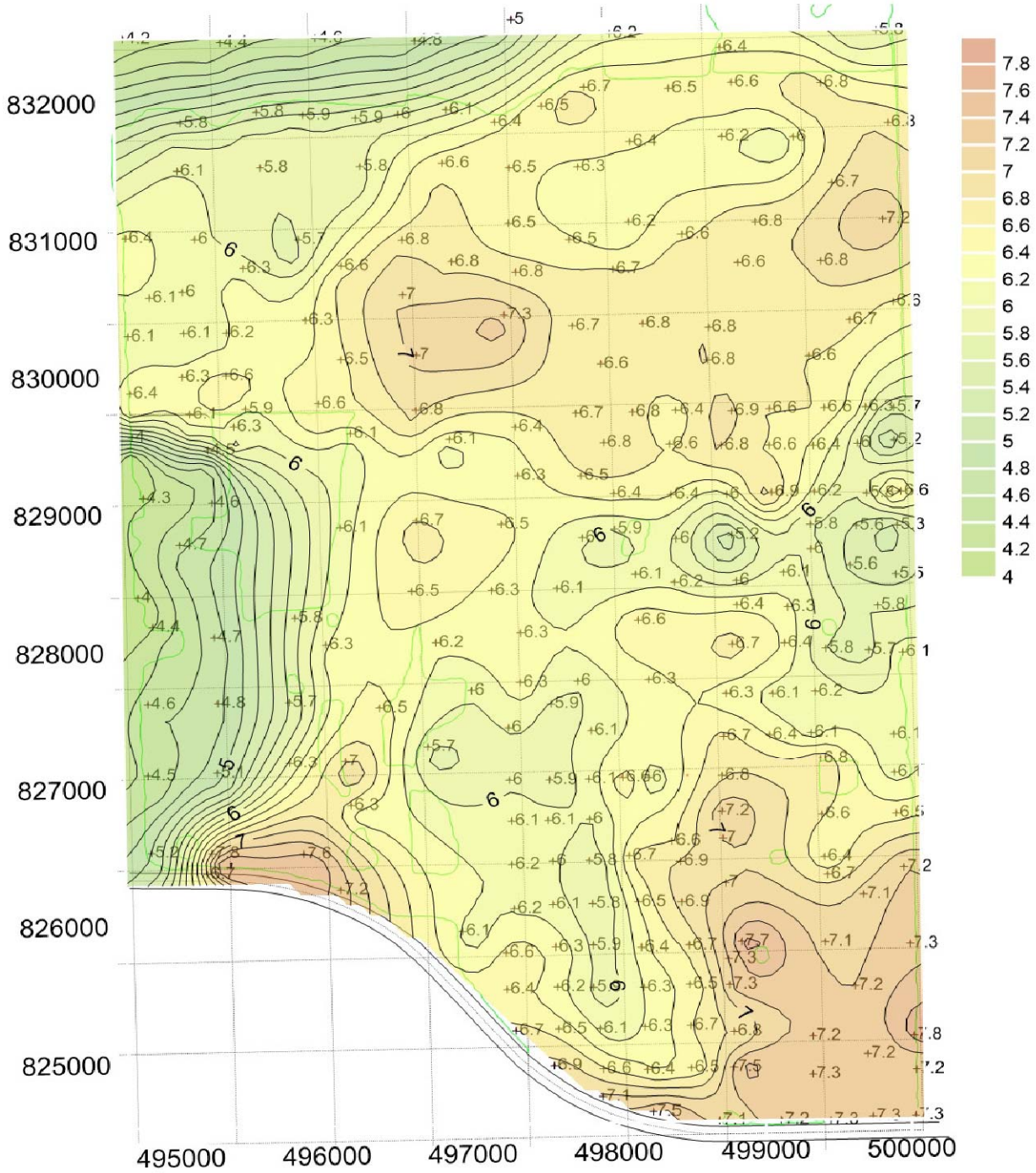

SURFACE ELEVATION MAP OF SITE (ELEVATION SHOWN IN FEET)

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TITLE:	SURFACE ELEVATION MAP LIMONAR/WONDERLY SITE NORTHEAST CORNER OF INTERSECTION OF SW 177th AVE AND NORTH KENDALL DRIVE MIAMI-DADE COUNTY, FLORIDA		
REV'D DATE: JUN 23, 2015		PROJECT NO. CLI 1040-01	FIGURE 6
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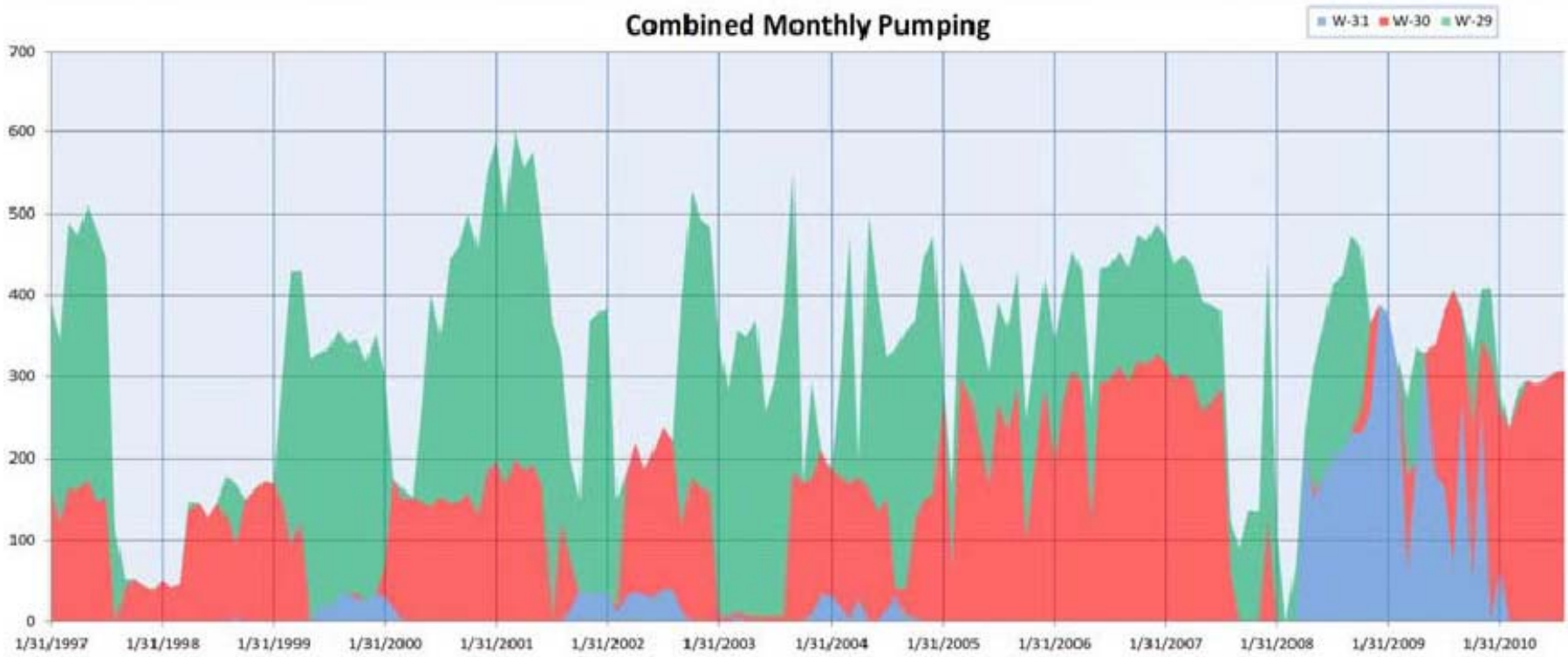

WEST WELL FIELD PUMPING RECORD (MONTHLY VALUES) FOR PRODUCTION WELLS W-29, W-30 AND W-31

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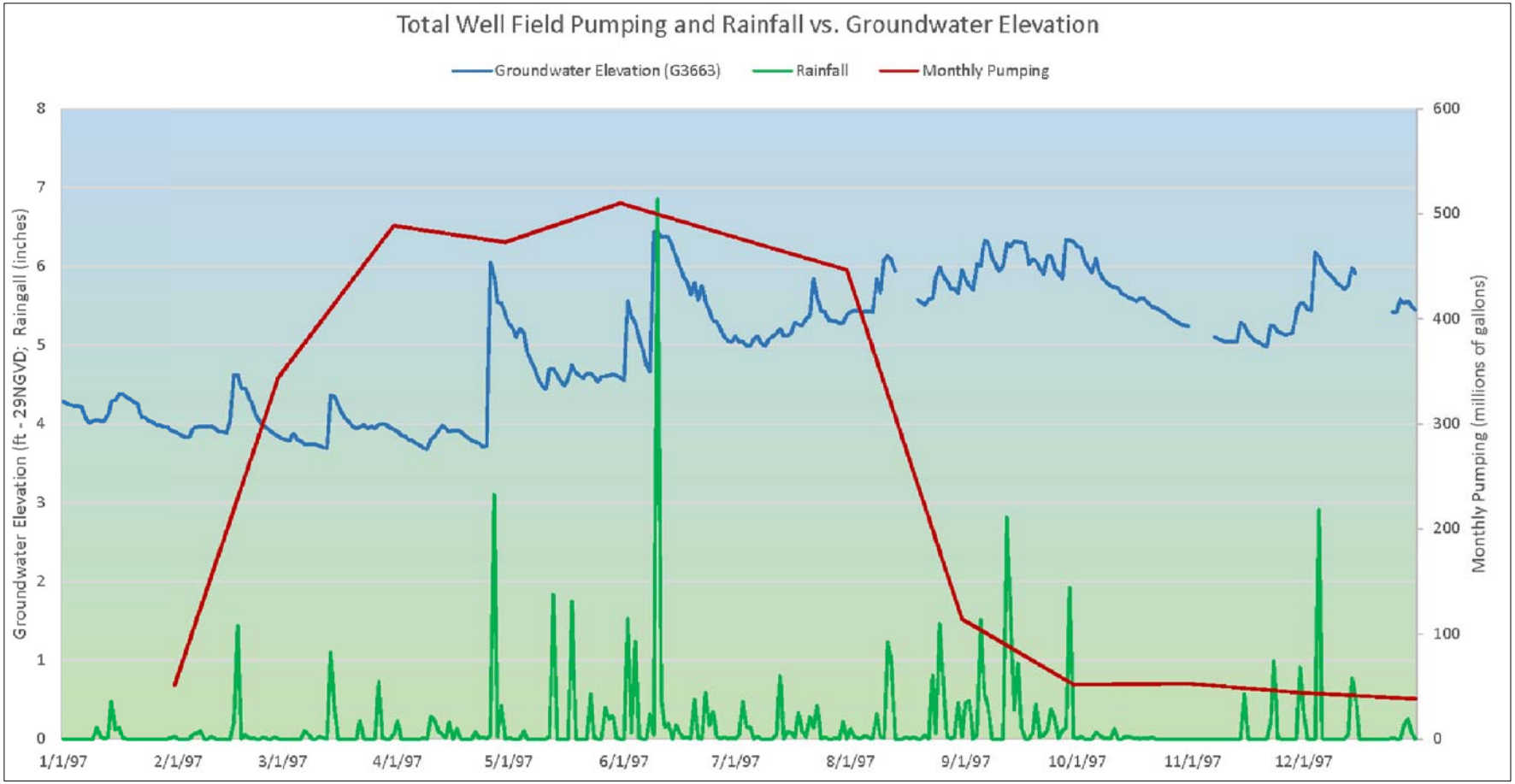
TITLE:	COMBINED MONTHLY PUMPING LIMONAR/WONDERLY SITE NORTHEAST CORNER OF INTERSECTION OF SW 177th AVE AND NORTH KENDALL DRIVE MIAMI-DADE COUNTY, FLORIDA		
REV'D DATE:	JUN 23, 2015	PROJECT NO. CLI 1040-01	FIGURE 7
DRAWN DATE:	JUN 23, 2015	SCALE: AS NOTED	
DRAWN BY:	LA	APPROVED BY: VR	

CLI 1040…\01…\Reports\Hydrologic Stusy of Limonar…\CAD\F7- West Well Field Pumping Record



GROUNDWATER ELEVATION RESPONSE TO PRECIPITATION AND WEST WELL FIELD PUMPING. PRECIPITATION CAN BE SEEN TO BE THE DOMINANT FACTOR IN PRODUCING GROUNDWATER FLUCTUATIONS IN THE SHORT-TERM AND CAN MASK EFFECTS OF GROUNDWATER WITHDRAWAL ASSOCIATED WITH PUMPING ACTIVITIES.

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TITLE:	GROUNDWATER ELEVATION LIMONAR/WONDERLY SITE NORTHEAST CORNER OF INTERSECTION OF SW 177th AVE AND NORTH KENDALL DRIVE MIAMI-DADE COUNTY, FLORIDA		FIGURE 8
REV'D DATE: JUN 23, 2015		PROJECT NO. CLI 1040-01	
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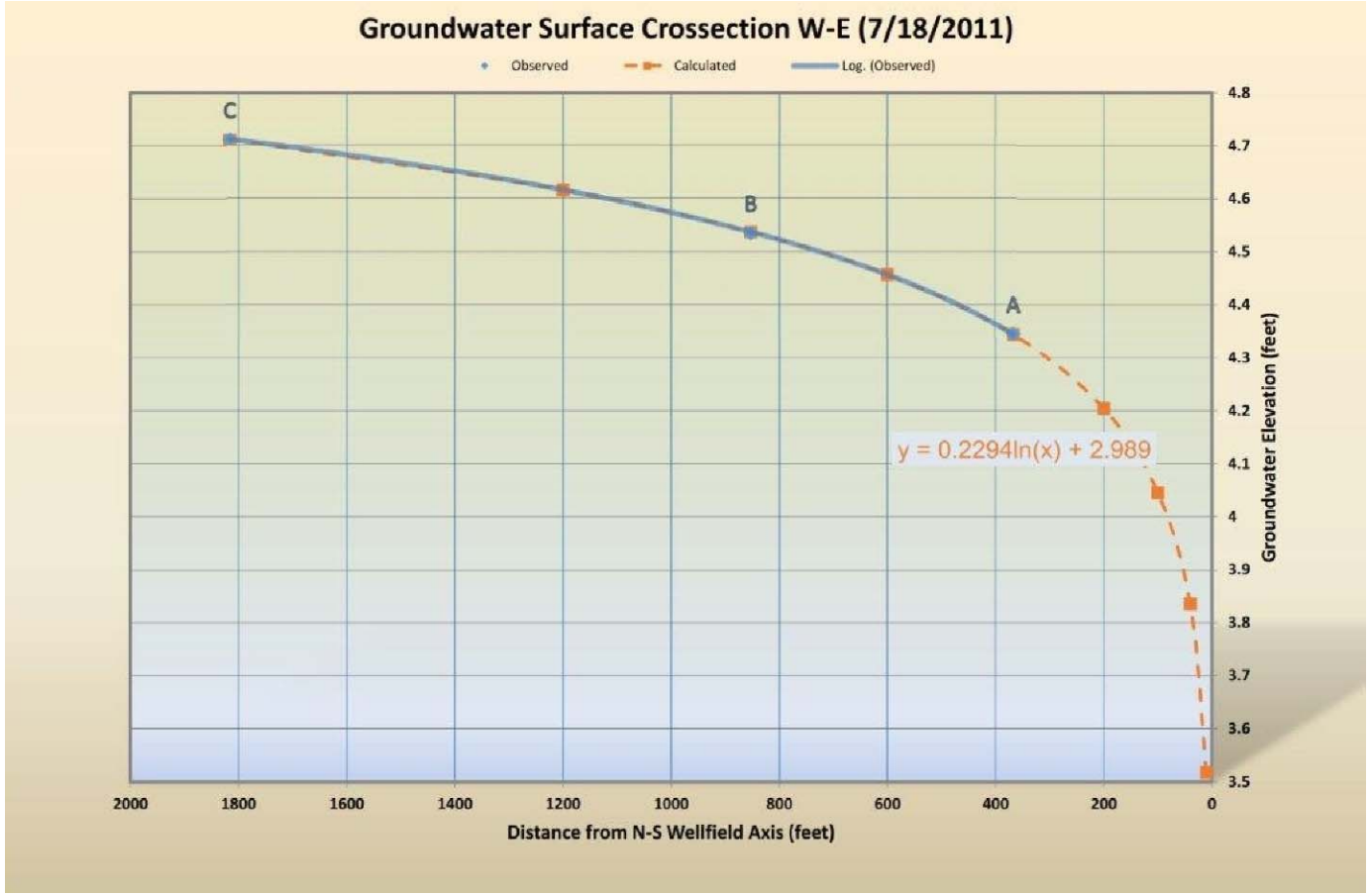

PARTIAL CONE OF DEPRESSION RECORDED FROM CRB PIEZOMETERS C, B, AND A SHOWN IN BLUE.
EXTENDED CONE OF DEPRESSION OUTLINE WAS CALCULATED BY FITTING A LOGARITHMIC FUNCTION (SHOWN IN RED) TO THE OBSERVED DATA.

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TITLE:
GROUNDWATER SURFACE CROSSECTION W-E
LIMONAR/WONDERLY SITE
NORTHEAST CORNER OF INTERSECTION OF SW 177th AVE
AND NORTH KENDALL DRIVE
MIAMI-DADE COUNTY, FLORIDA

REV'D DATE:	JUN 25, 2015	PROJECT NO. CLI 1040-01	FIGURE 9
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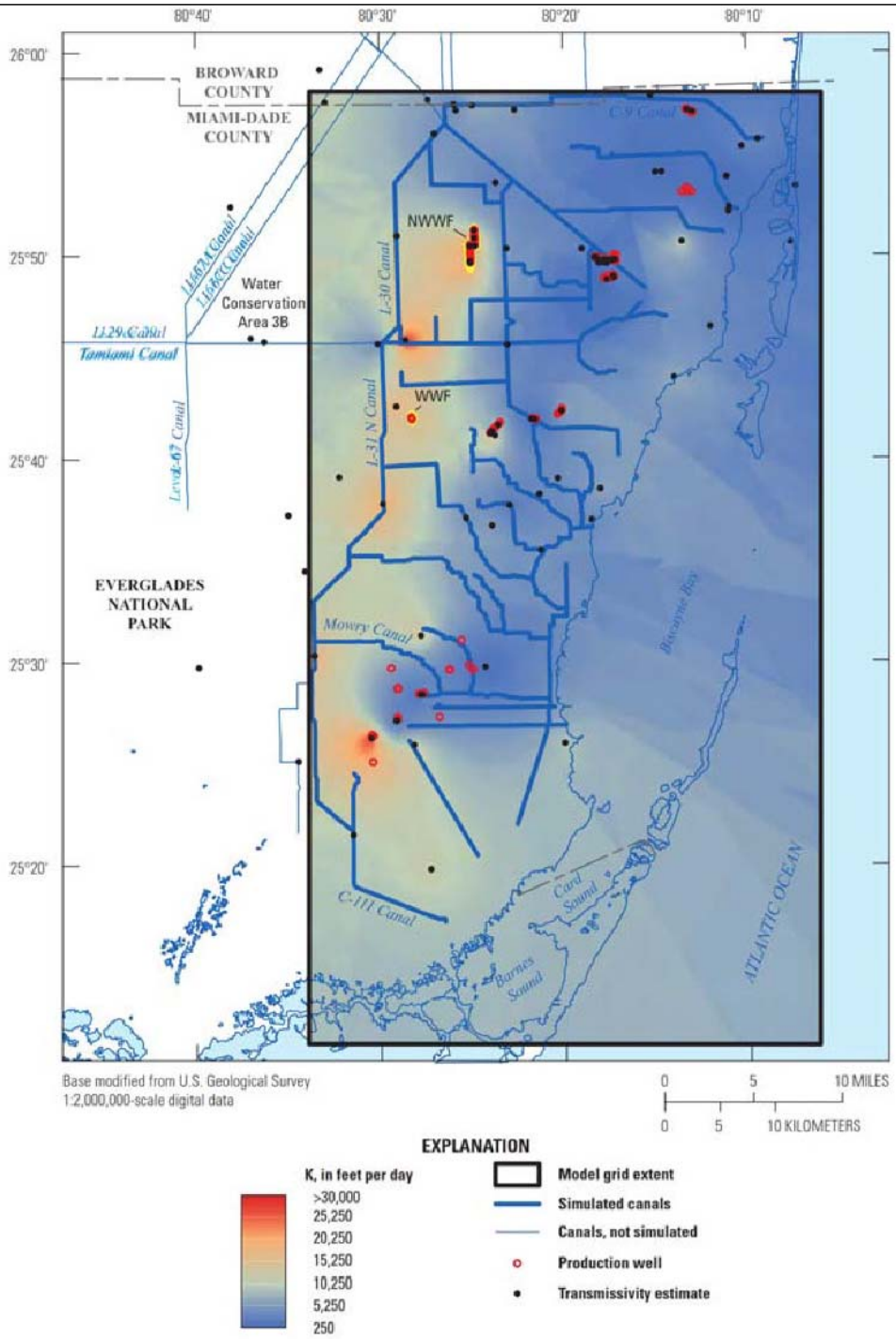
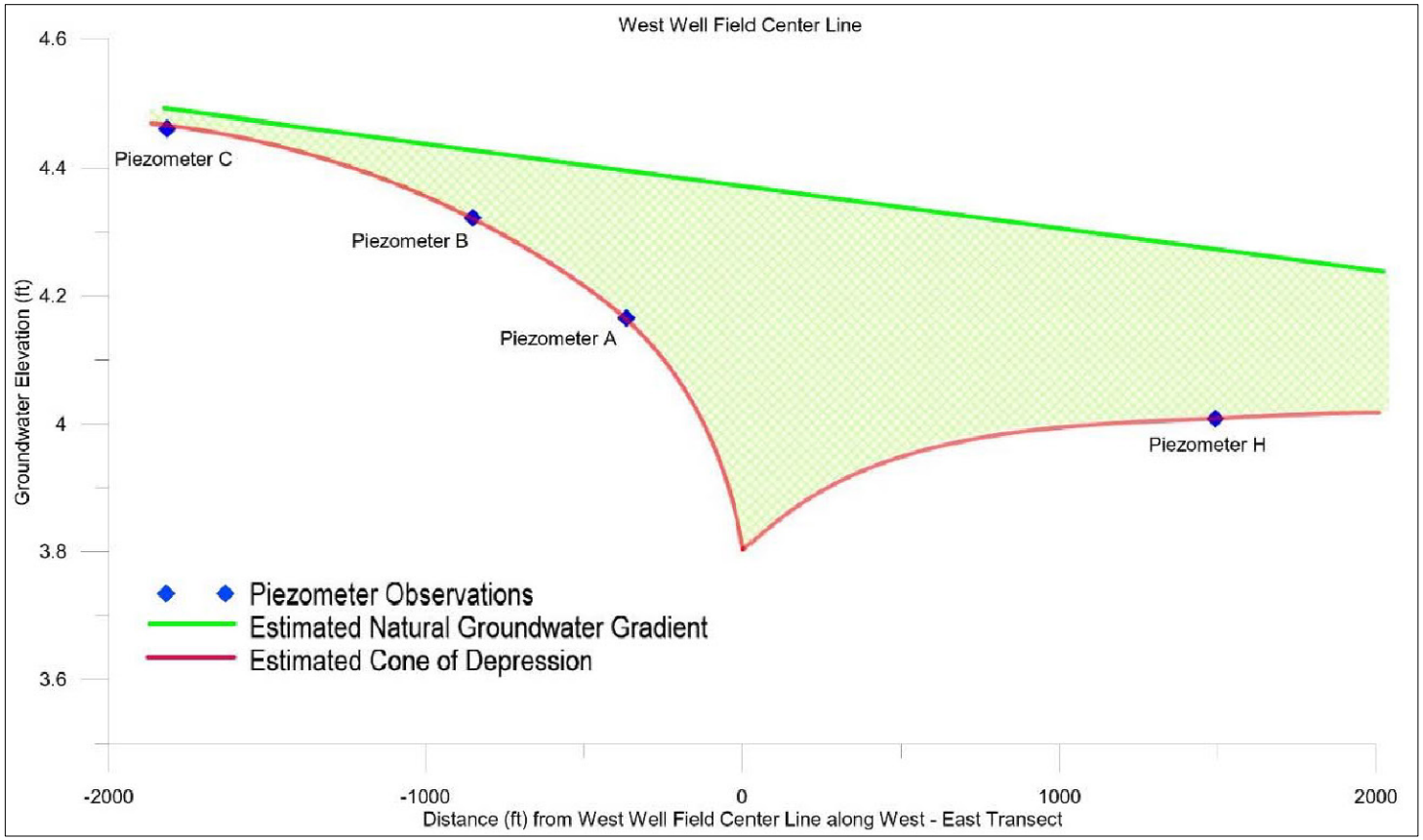


Figure 11. Hydraulic conductivity field for the base-case simulation and locations of transmissivity estimates derived from aquifer performance tests. Area shown is Base map 1 (fig. 1).

HYDRAULIC CONDUCTIVITY DISTRIBUTION MAP FOR SITE AND SURROUNDING AREAS.
(USGS OPEN-FILE REPORT 2013-1086)

CRB Geological & Environmental Services, Inc. 8744 SW 133rd Street Miami, Florida 33176 Tel: (305) 447-9777 Fax: (305) 567-2853	TITLE: HYDRAULIC CONDUCTIVITY DISTRIBUTION MAP LIMONAR/WONDERLY SITE NORTHEAST CORNER OF INTERSECTION OF SW 177th AVE AND NORTH KENDALL DRIVE MIAMI-DADE COUNTY, FLORIDA		
	REV'D DATE: JUN 23, 2015	PROJECT NO. CLI 1040-01	FIGURE 10
	DRAWN DATE: JUN 23, 2015	SCALE: AS NOTED	
	DRAWN BY: LA	APPROVED BY: VR	

CLI 1040…\01…\Reports\Hydrologic Stusy of Limonar…\CAD\F10- Hydraulic Distribution Map



PIEZOMETER OBSERVATIONS AT PIEZOMETERS C, B, A, AND H ALONG WEST-EAST TRANSECT ACROSS WEST WELL FIELD CENTER LINE. CONE OF DEPRESSION ASSOCIATED WITH WELL FIELD PUMPING IS ESTIMATED BASED ON PIEZOMETER READINGS AND IS SHOWN IN RED. GREEN LINE INDICATES ESTIMATED POSITION OF GROUNDWATER WITHOUT THE INFLUENCE OF PUMPING.

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TITLE: PIEZOMETERS OBSERVATION C, B, A & H
LIMONAR/WONDERLY SITE
NORTHEAST CORNER OF INTERSECTION OF SW 177th AVE
AND NORTH KENDALL DRIVE
MIAMI-DADE COUNTY, FLORIDA

REV'D DATE:	JUN 25, 2015	PROJECT NO. CLI 1040-01	FIGURE 11
DRAWN DATE:	JUN 25, 2015	SCALE: AS NOTED	
DRAWN BY:	LA	APPROVED BY: VR	

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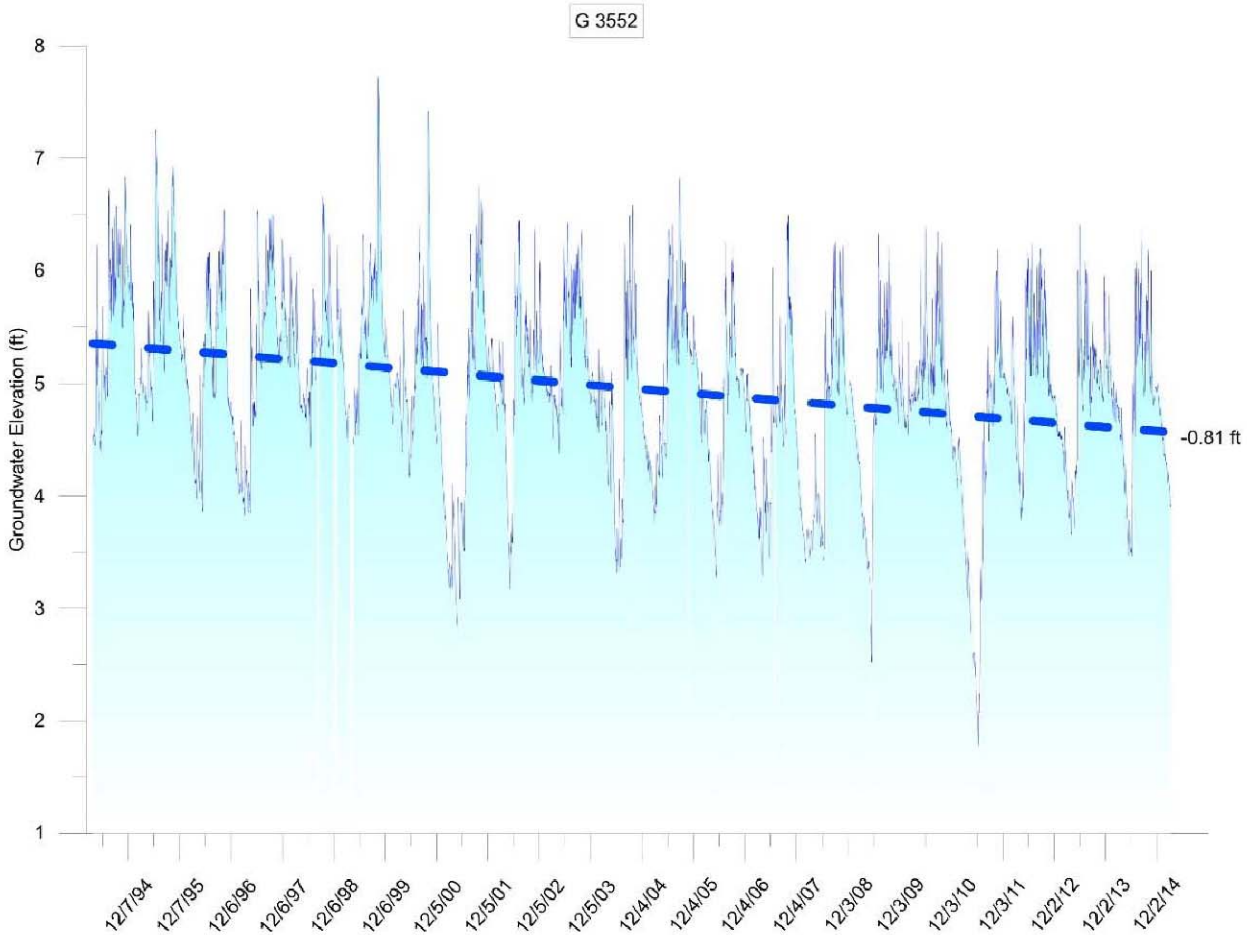

G-3552 HYDROGRAPH WITH FITTED LINEAR REGRESSION LINE SHOWING A 0.81 FT DROP IN GROUNDWATER ELEVATION OVER THE LAST TWO DECADES

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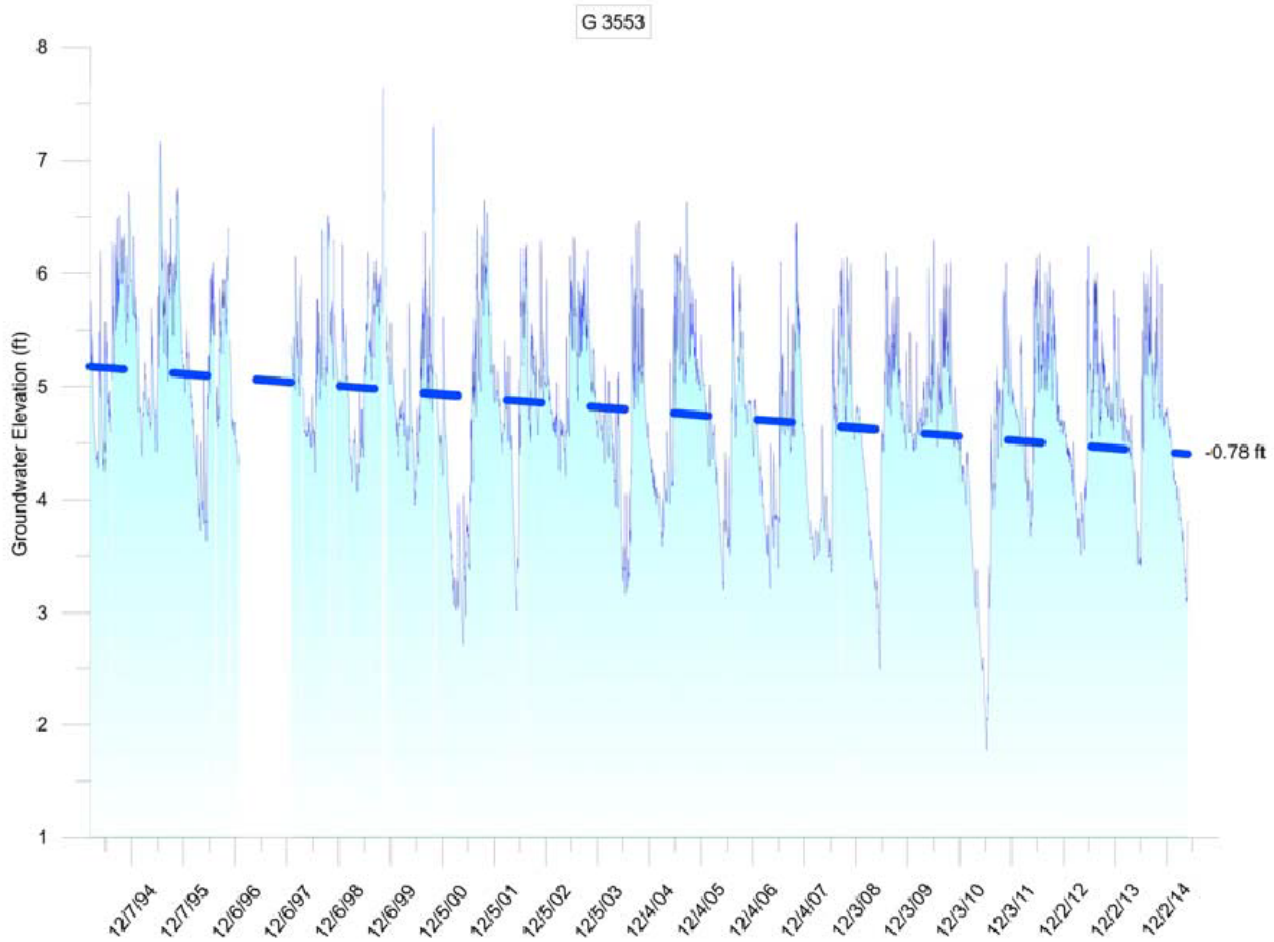
TITLE:	G-3552 HYDROGRAPH-0.81 FT DROP LIMONAR/WONDERLY SITE NORTHEAST CORNER OF INTERSECTION OF SW 177th AVE AND NORTH KENDALL DRIVE MIAMI-DADE COUNTY, FLORIDA		FIGURE 12
REV'D DATE: JUN 25, 2015		PROJECT NO. CLI 1040-01	
DRAWN DATE: JUN 25, 2015		SCALE: AS NOTED	
DRAWN BY: LA		APPROVED BY: VR	

CLI 1040…\01…\Reports\Hydrologic Stusy of Limonar…\CAD\F12- G-3552 Hydrograph-0.81 Ft Drop



G-3553 HYDROGRAPH WITH FITTED LINEAR REGRESSION LINE SHOWING A 0.78 FT DROP IN GROUNDWATER ELEVATION OVER THE LAST TWO DECADES

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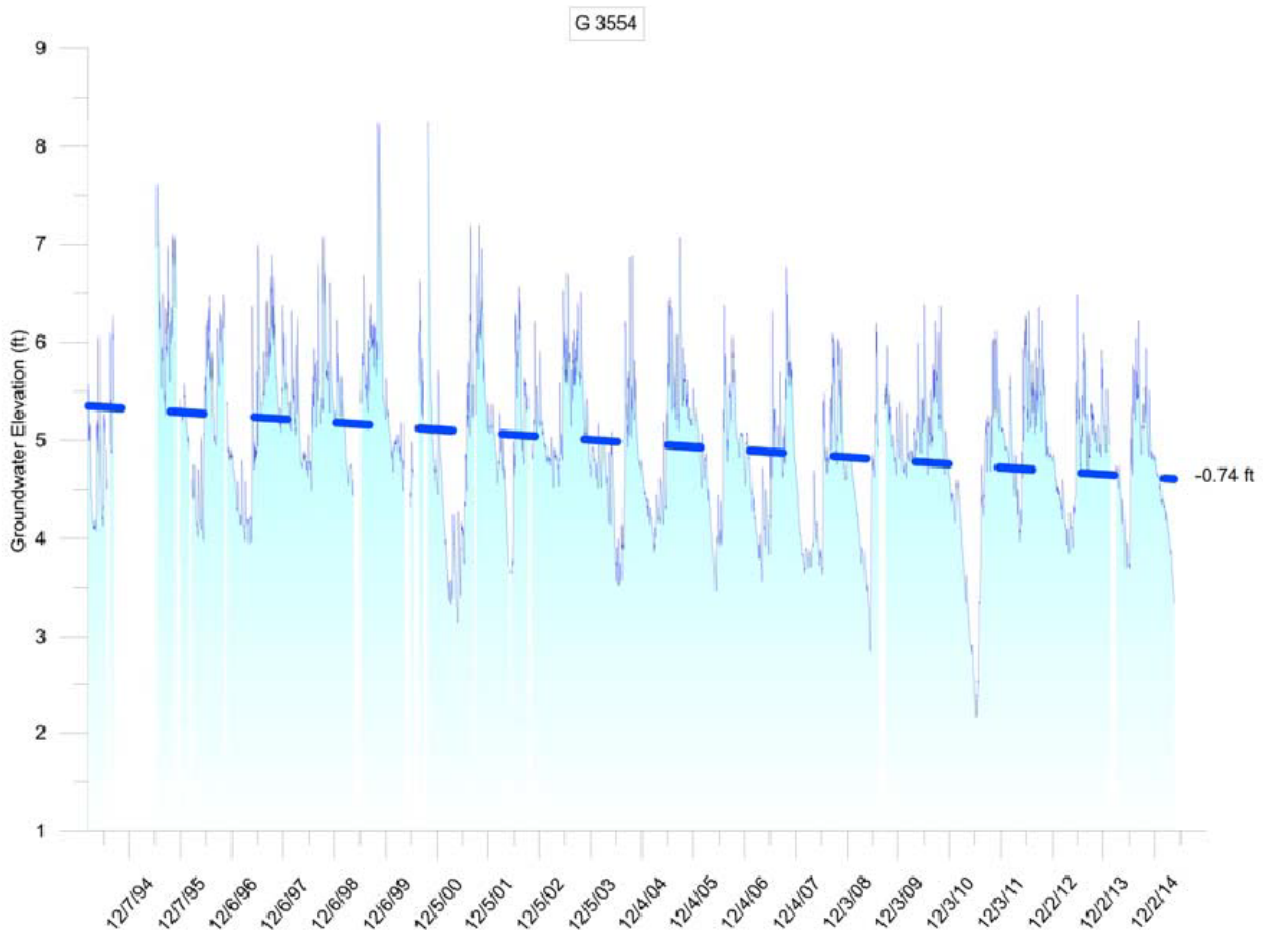
TITLE:	G-3553 HYDROGRAPH-0.78 FT DROP LIMONAR/WONDERLY SITE NORTHEAST CORNER OF INTERSECTION OF SW 177th AVE AND NORTH KENDALL DRIVE MIAMI-DADE COUNTY, FLORIDA		FIGURE 13
REV'D DATE: JUN 25, 2015		PROJECT NO. CLI 1040-01	
DRAWN DATE: JUN 25, 2015		SCALE: AS NOTED	
DRAWN BY: LA		APPROVED BY: VR	

CLI 1040…\01…\Reports\Hydrologic Stusy of Limonar…\CAD\F13- G-3553 Hydrograph-0.78 FT DROP



G-3554 HYDROGRAPH WITH FITTED LINEAR REGRESSION LINE SHOWING A 0.74 FT DROP IN GROUNDWATER ELEVATION OVER THE LAST TWO DECADES

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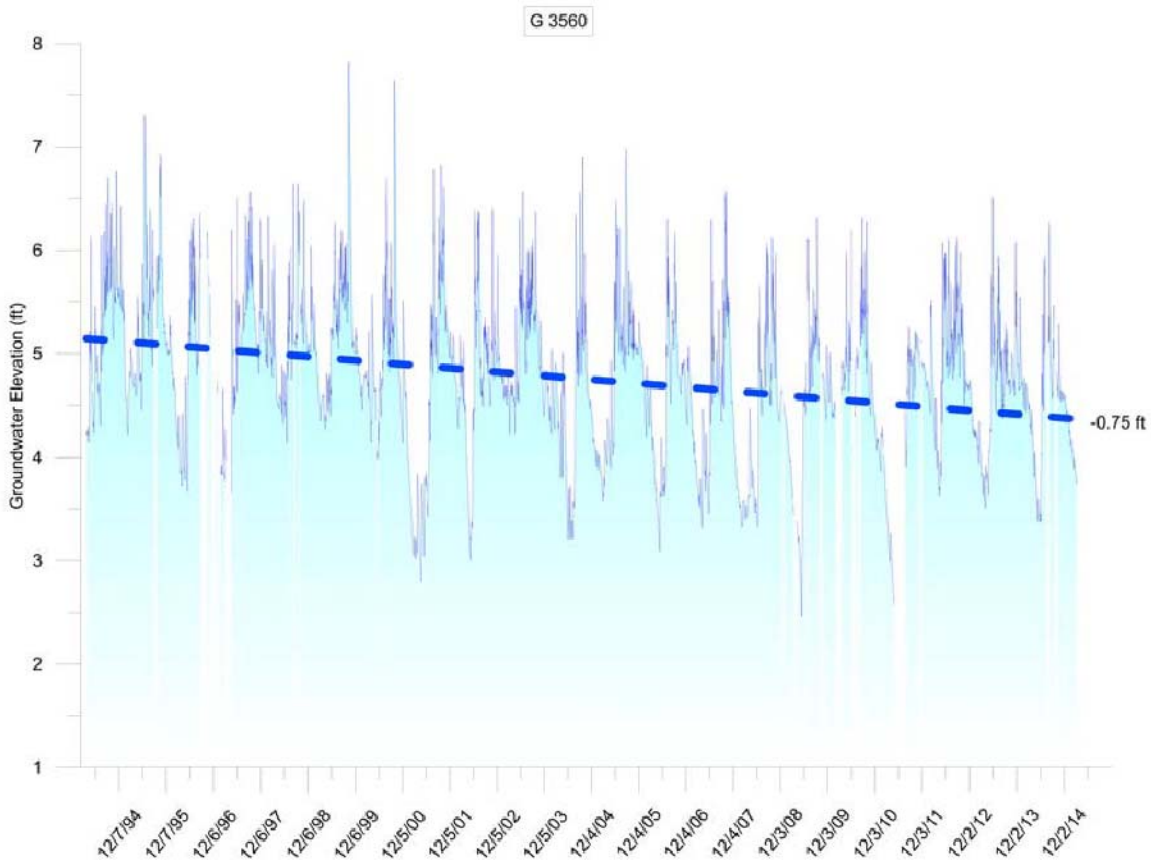
TITLE:	G-3554 HYDROGRAPH-0.74 FT DROP LIMONAR/WONDERLY SITE NORTHEAST CORNER OF INTERSECTION OF SW 177th AVE AND NORTH KENDALL DRIVE MIAMI-DADE COUNTY, FLORIDA		FIGURE 14
REV'D DATE: JUN 25, 2015		PROJECT NO. CLI 1040-01	
DRAWN DATE: JUN 25, 2015		SCALE: AS NOTED	
DRAWN BY: LA		APPROVED BY: VR	

CLI 1040…\01…\Reports\Hydrologic Stusy of Limonar…\CAD\F14- G-3554 Hydrograph-0.74 FT DROP



G-3560 HYDROGRAPH WITH FITTED LINEAR REGRESSION LINE SHOWING A 0.75 FT DROP IN GROUNDWATER ELEVATION OVER THE LAST TWO DECADES

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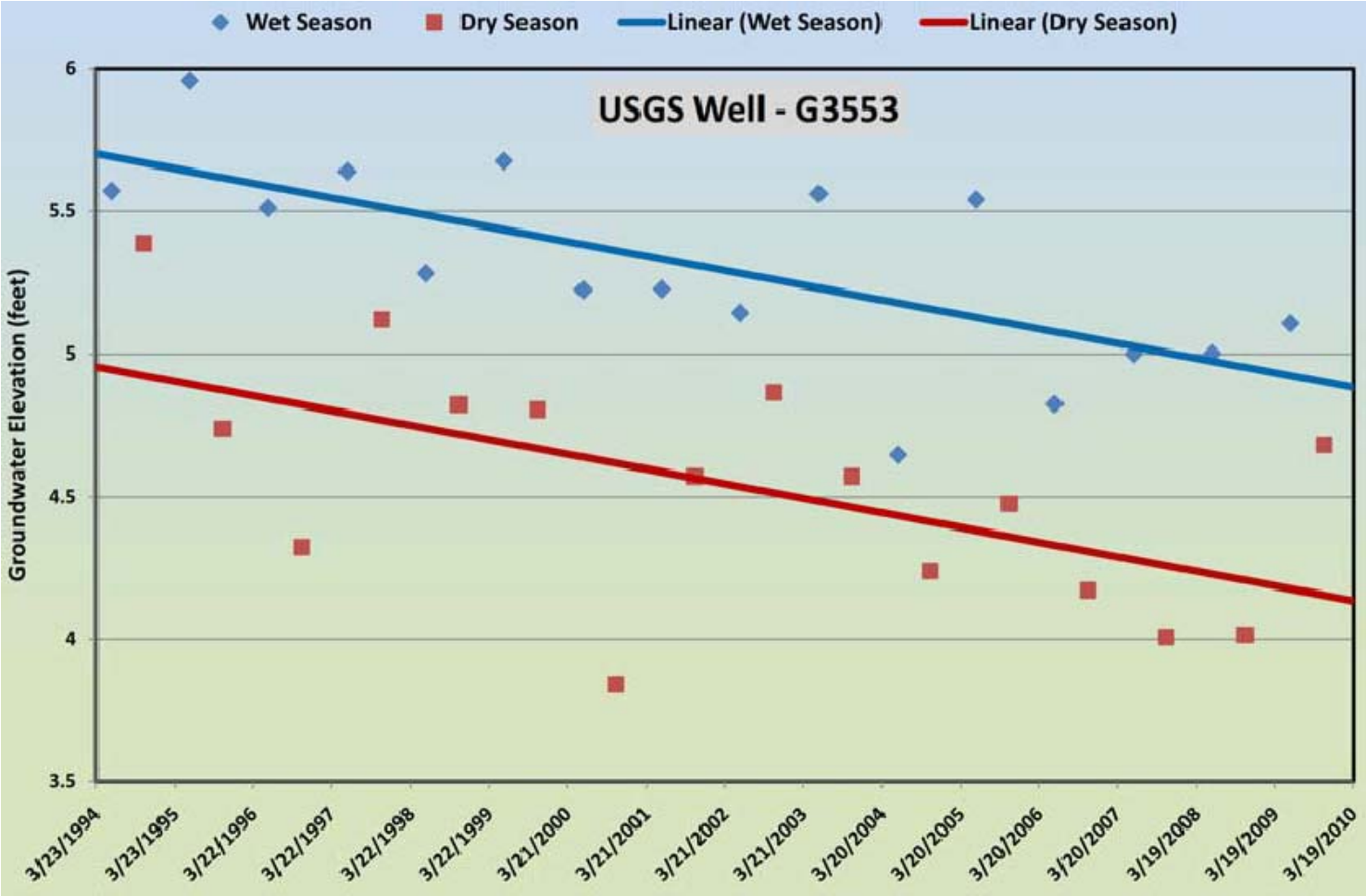
TITLE:	G-3560 HYDROGRAPH-0.75 FT DROP LIMONAR/WONDERLY SITE NORTHEAST CORNER OF INTERSECTION OF SW 177th AVE AND NORTH KENDALL DRIVE MIAMI-DADE COUNTY, FLORIDA		
REV'D DATE: JUN 25, 2015		PROJECT NO. CLI 1040-01	FIGURE 15
DRAWN DATE: JUN 25, 2015		SCALE: AS NOTED	
DRAWN BY: LA		APPROVED BY: VR	

CLI 1040…\01…\Reports\Hydrologic Stusy of Limonar…\CAD\F15- G-3560 Hydrograph-0.75 FT DROP



COMPARISON OF WET SEASON AND DRY SEASON GROUNDWATER LEVEL DECLINE OVER THE LAST TWO DECADES.

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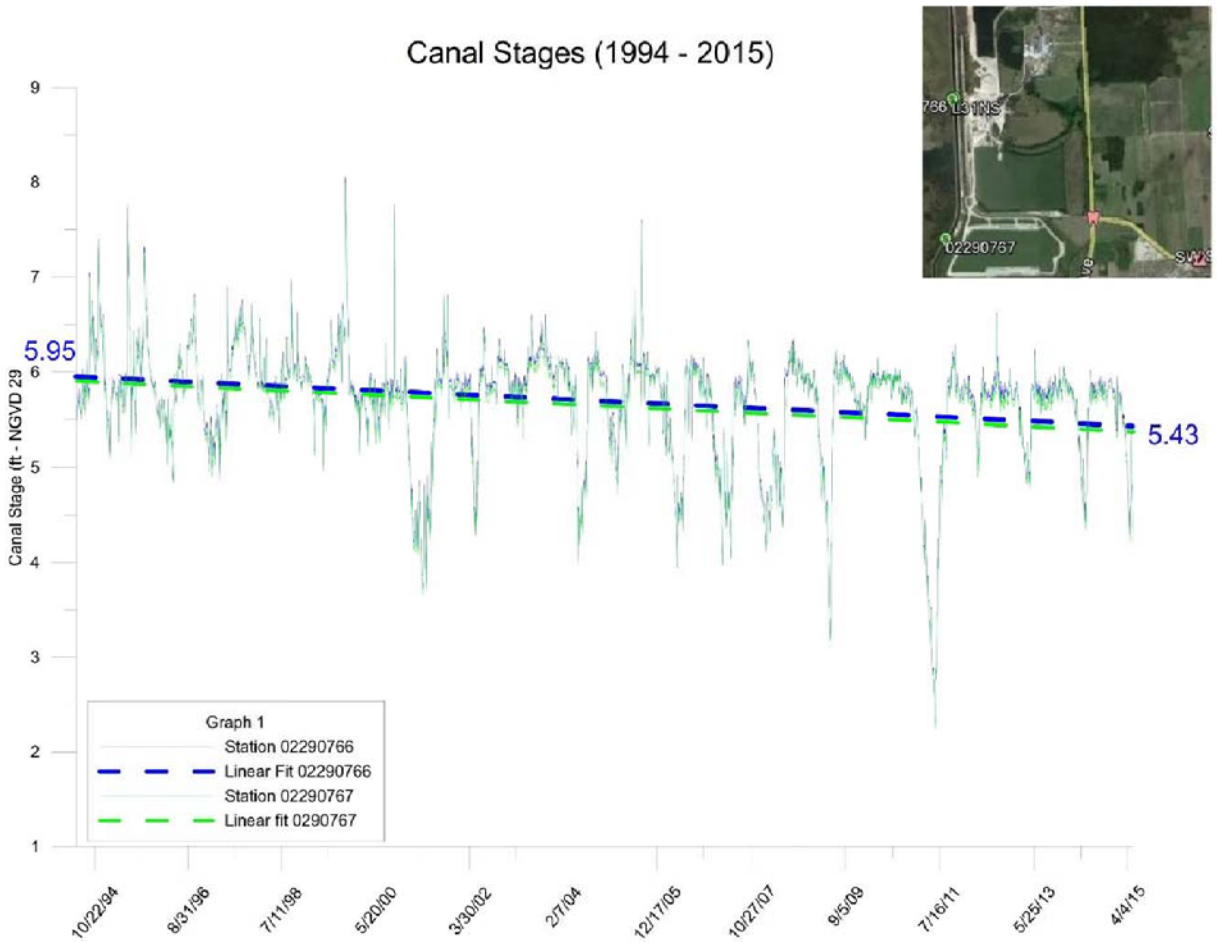
TITLE:	COMPARISON OF WET & DRY SEASON LIMONAR/WONDERLY SITE NORTHEAST CORNER OF INTERSECTION OF SW 177th AVE AND NORTH KENDALL DRIVE MIAMI-DADE COUNTY, FLORIDA		
REV'D DATE: JUN 25, 2015		PROJECT NO. CLI 1040-01	FIGURE 16
DRAWN DATE: JUN 25, 2015		SCALE: AS NOTED	
DRAWN BY: LA		APPROVED BY: VR	

CLI 1040…\01…\Reports\Hydrologic Stusy of Limonar…\CAD\F16- Comparison of Wet & Dry Season



CANAL STAGES FOR L-31N STATIONS 02290766 AND 02290767

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Tel: (305) 447-9777
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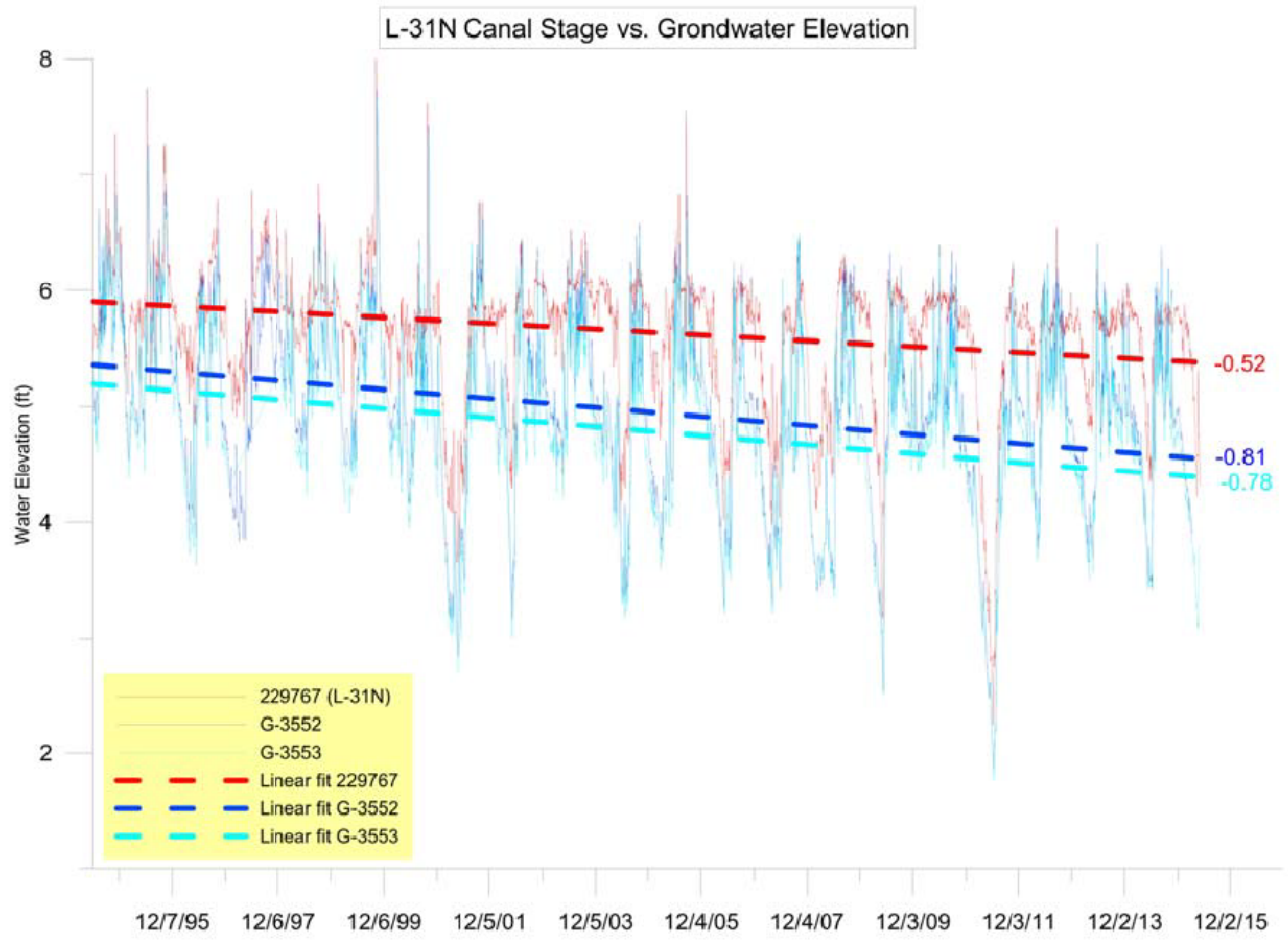
TITLE:	CANAL STAGES FOR L-31N LIMONAR/WONDERLY SITE NORTHEAST CORNER OF INTERSECTION OF SW 177th AVE AND NORTH KENDALL DRIVE MIAMI-DADE COUNTY, FLORIDA		
REV'D DATE: JUN 25, 2015		PROJECT NO. CLI 1040-01	FIGURE 17
DRAWN DATE: JUN 25, 2015		SCALE: AS NOTED	
DRAWN BY: LA		APPROVED BY: VR	

CLI 1040…\01…\Reports\Hydrologic Stusy of Limonar…\CAD\F17- Canal Stages for L-31N



COMPARISON OF CANAL STAGE IN L-31N WITH GROUNDWATER ELEVATIONS IN G-3552 AND G-3553

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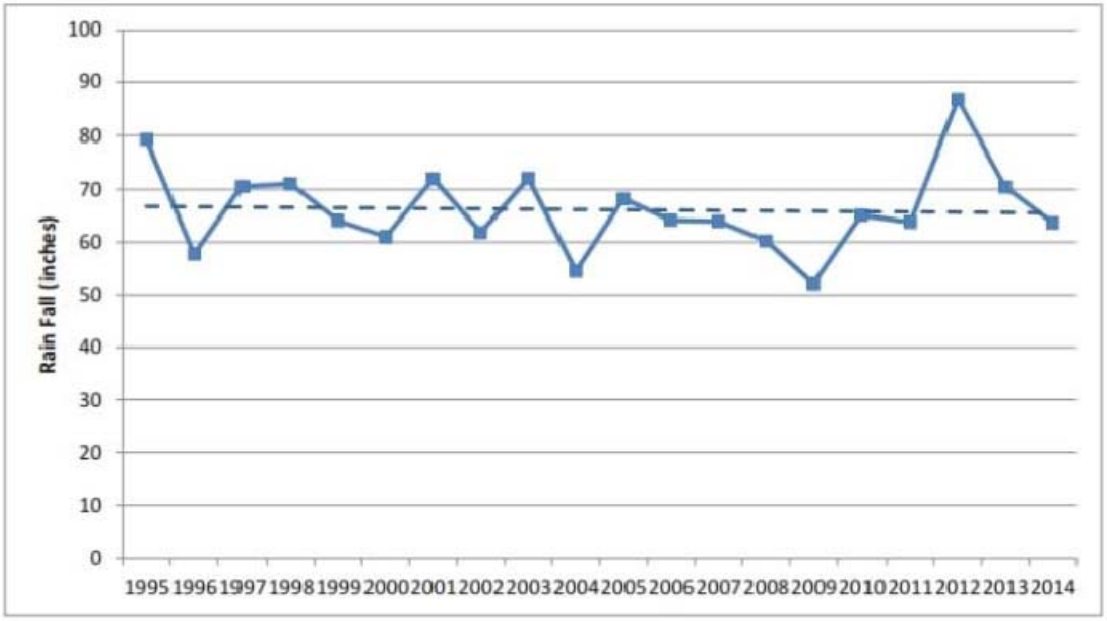
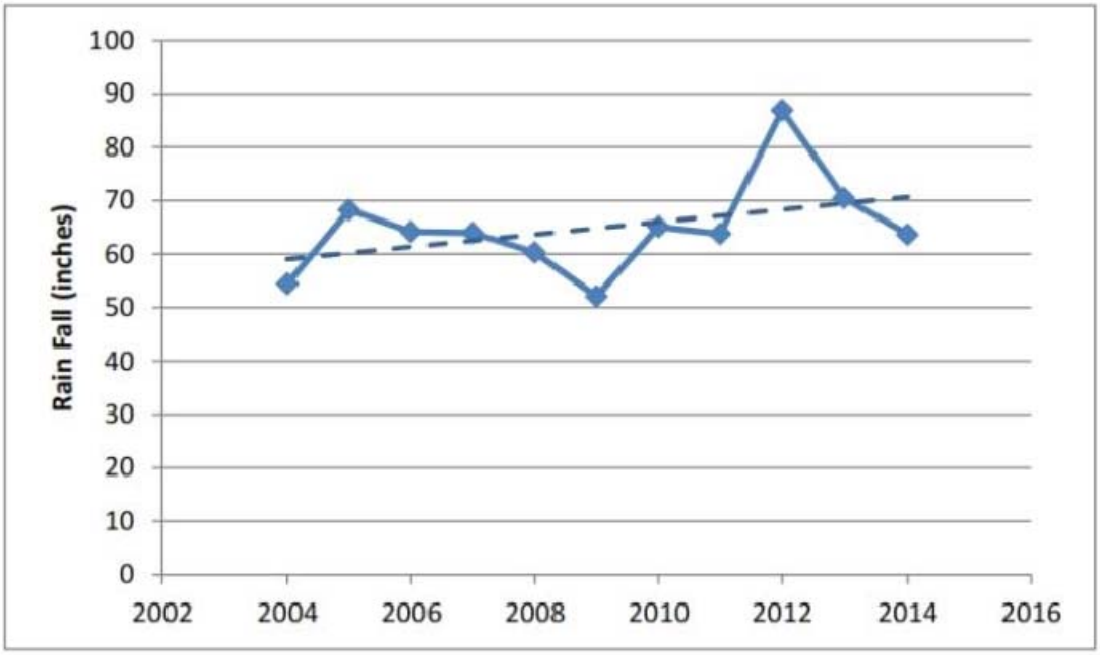
TITLE: COMPARISON OF CANAL STAGES IN L-31N
LIMONAR/WONDERYLY SITE
NORTHEAST CORNER OF INTERSECTION OF SW 177th AVE
AND NORTH KENDALL DRIVE
MIAMI-DADE COUNTY, FLORIDA

REV'D DATE:	JUN 25, 2015	PROJECT NO. CLI 1040-01	FIGURE 18
DRAWN DATE:	JUN 25, 2015	SCALE: AS NOTED	
DRAWN BY:	LA	APPROVED BY: VR	

CLI 1040…\01…\Reports\Hydrologic Stusy of Limonar…\CAD\F18- Comparison of Canal Stages in L-31N





YEARLY RAIN FALL IN MIAMI IN INCHES OVER THE LAST TWENTY AND THE LAST 10 YEARS.
(SOURCE: FLORIDA CLIMATE CENTER)

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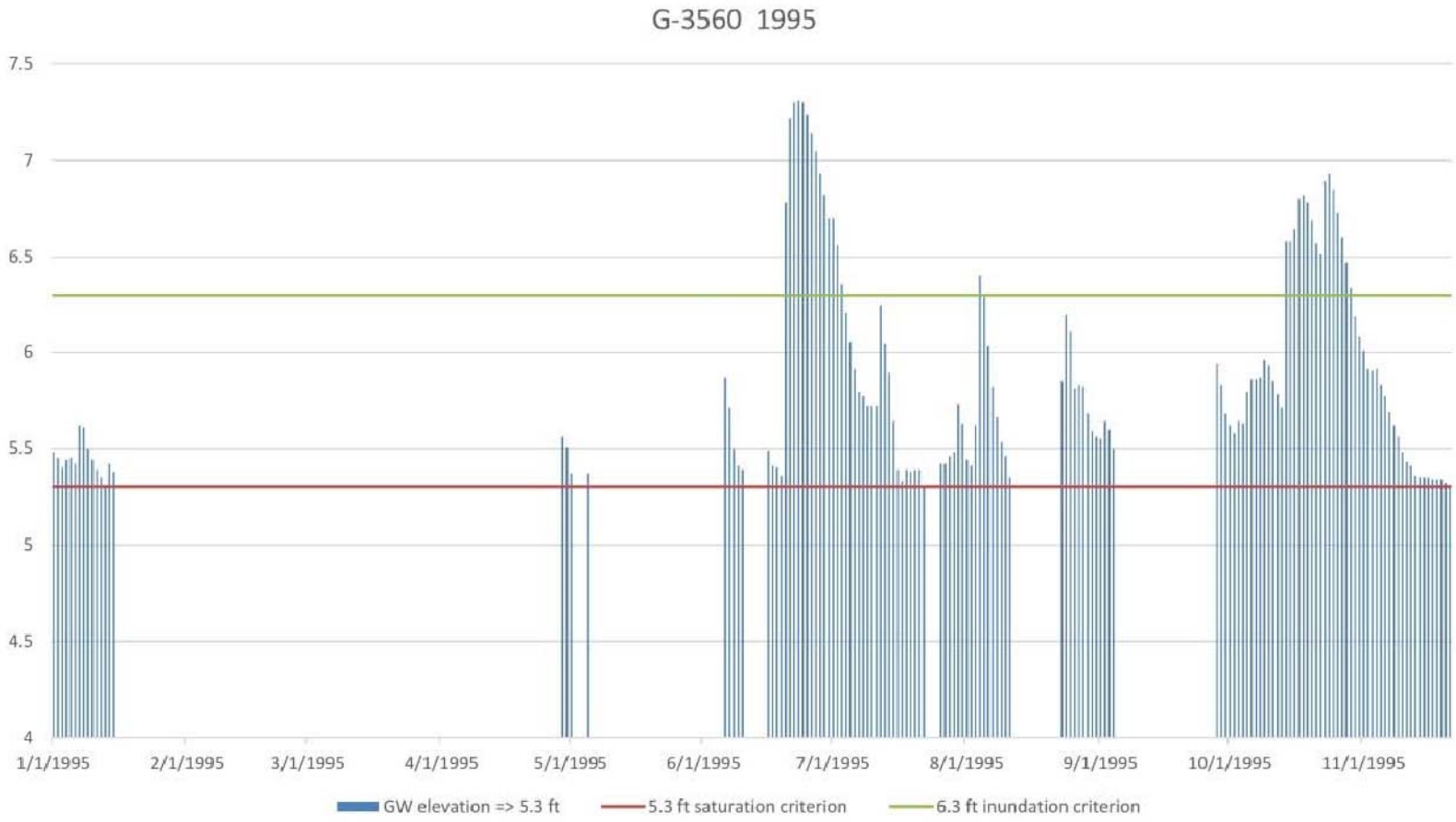
TITLE:	YEARLY RAIN-LAST 20 & 10 YEARS LIMONAR/WONDERLY SITE NORTHEAST CORNER OF INTERSECTION OF SW 177th AVE AND NORTH KENDALL DRIVE MIAMI-DADE COUNTY, FLORIDA		
REV'D DATE: JUN 29, 2015		PROJECT NO. CLI 1040-01	FIGURE 19
DRAWN DATE: JUN 29, 2015		SCALE: AS NOTED	
DRAWN BY: LA		APPROVED BY: VR	

CLI 1040…\01…\Reports\Hydrologic Stusy of Limonar…\CAD\F19- Yearly Rain -10 Years



WETLAND HYDROLOGY CRITERIA MET IN 1995 AS DETERMIINED BY GROUNDWATER ELEVATIONS IN G-3560 EXCEEDING CONSECUTIVE 20 DAYS OF SATURATION (MOST CONSECUTIVE CASE OF WITHIN 1 FT. OF SURFACE I.E. BETWEEN 5.3 AND 6.3 FT. AND 7 CONSECUTIVE DAYS OF INUNDATION I.E. 6.3 FT. OR HIGHER).

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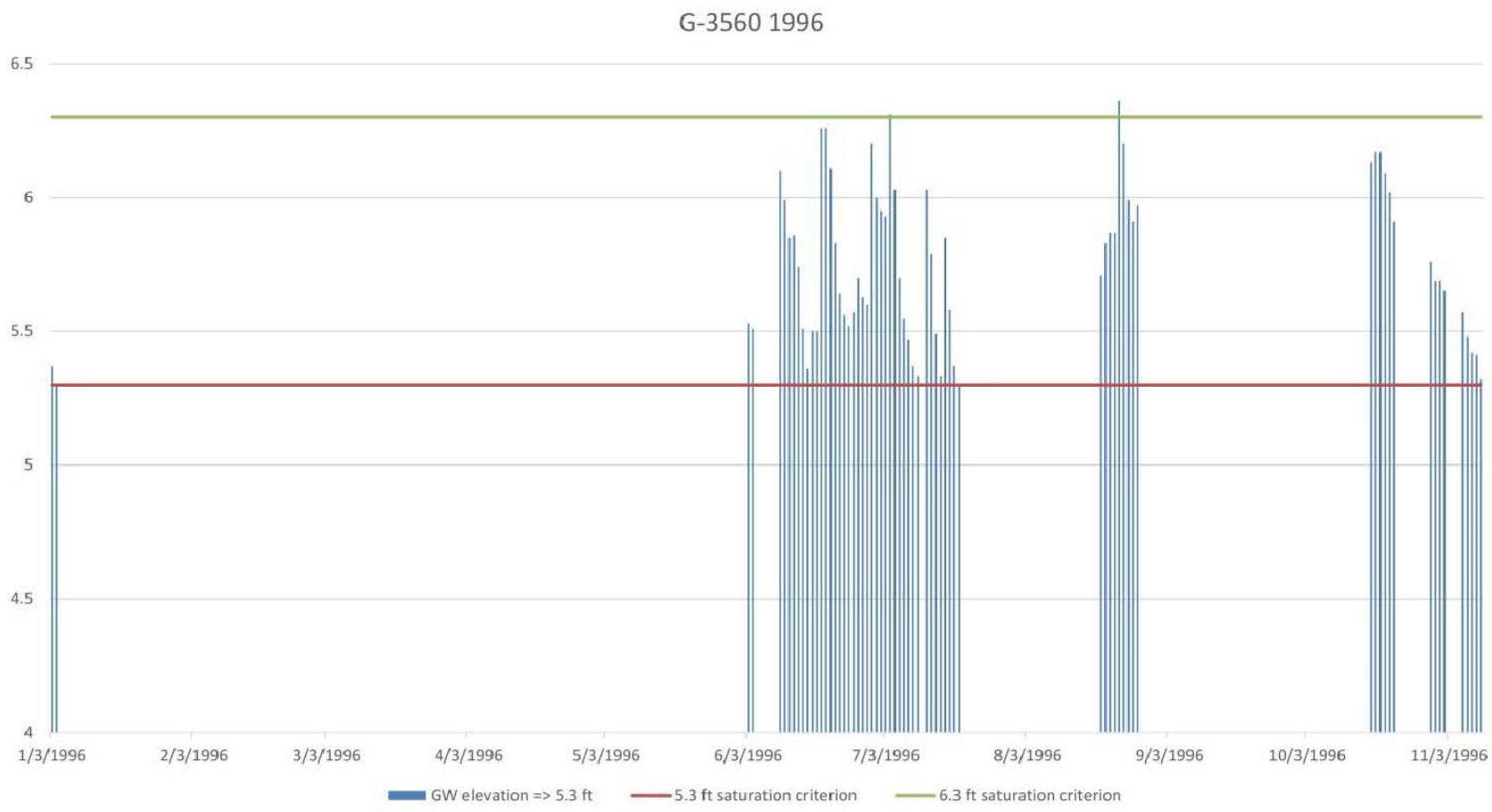
TITLE: WETLAND HYDROLOGY 1995-GW ELEVATIONS G-3560
LIMONAR/WONDERYLY SITE
NORTHEAST CORNER OF INTERSECTION OF SW 177th AVE
AND NORTH KENDALL DRIVE
MIAMI-DADE COUNTY, FLORIDA

REV'D DATE:	JUN 29, 2015	PROJECT NO. CLI 1040-01	FIGURE 20
DRAWN DATE:	JUN 29, 2015	SCALE: AS NOTED	
DRAWN BY:	LA	APPROVED BY: VR	



WETLAND HYDROLOGY CRITERIA MET IN 1996 AS DETERMIINED BY GROUNDWATER ELEVATIONS IN G-3560 EXCEEDING CONSECUTIVE 20 DAYS OF SATURATION (MOST CONSECUTIVE CASE OF WITHIN 1 FT. OF GROUND SURFACE; I.E. BETWEEN 5.3 AND 6.3 FT)

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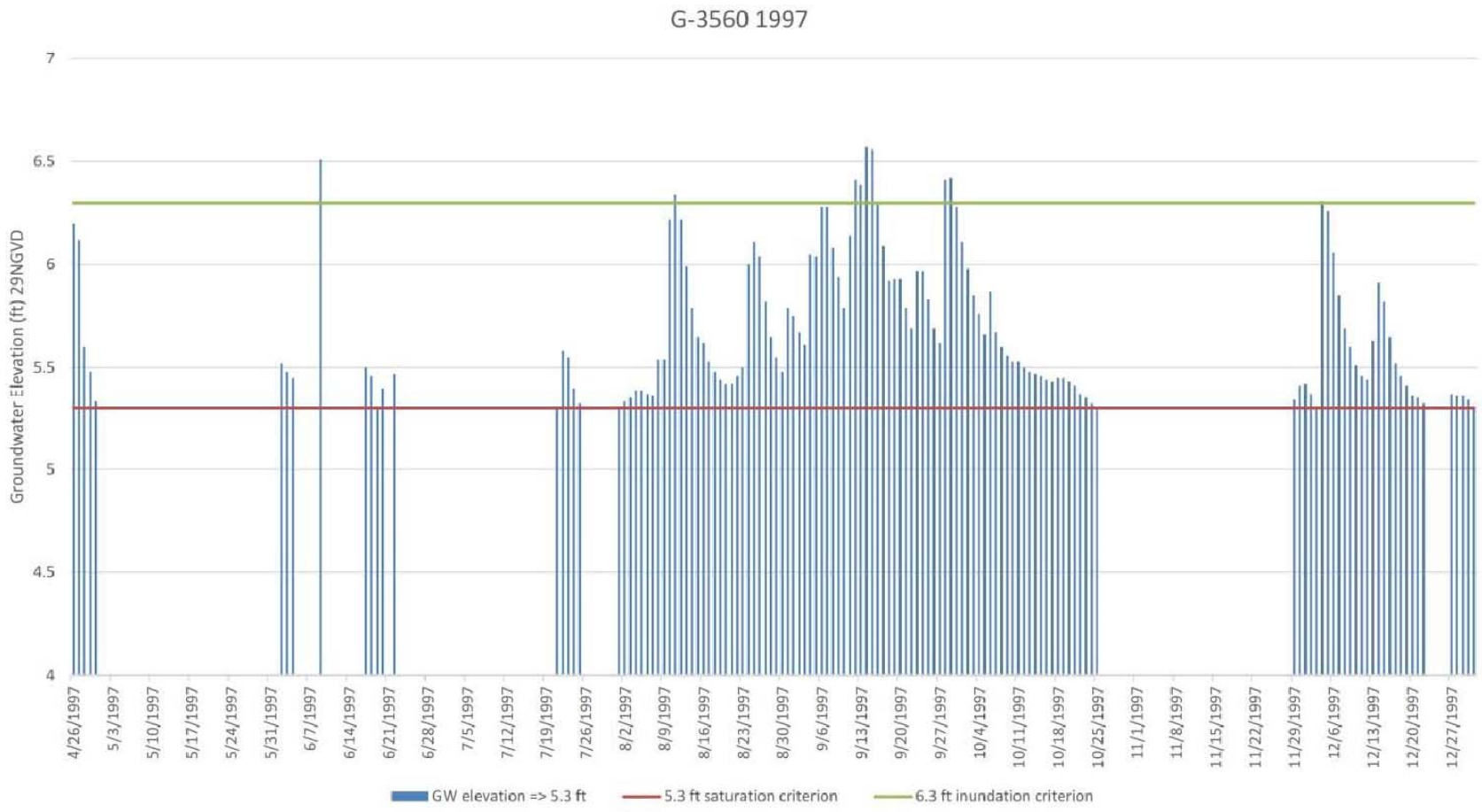
TITLE: WETLAND HYDROLOGY 1996-GW ELEVATIONS G-3560
LIMONAR/WONDERYLY SITE
NORTHEAST CORNER OF INTERSECTION OF SW 177th AVE
AND NORTH KENDALL DRIVE
MIAMI-DADE COUNTY, FLORIDA

REV'D DATE:	JUN 29, 2015	PROJECT NO. CLI 1040-01	FIGURE 21
DRAWN DATE:	JUN 29, 2015	SCALE: AS NOTED	
DRAWN BY:	LA	APPROVED BY: VR	

CLI 1040…\01…\Reports\Hydrologic Stusy of Limonar…\CAD\F21- Wetland Hydrology 1996-GW Elevations G-3560



WETLAND HYDROLOGY CRITERIA MET IN 1997 AS DETERMIINED BY GROUNDWATER ELEVATIONS IN G-3560 EXCEEDING CONSECUTIVE 20 DAYS OF SATURATION (MOST CONSECUTIVE CASE OF WITHIN 1 FT. OF GROUND SURFACE; I.E. BETWEEN 5.3 AND 6.3 FT)

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TITLE: WETLAND HYDROLOGY 1997-GW ELEVATIONS G-3560
LIMONAR/WONDERYLY SITE
NORTHEAST CORNER OF INTERSECTION OF SW 177th AVE
AND NORTH KENDALL DRIVE
MIAMI-DADE COUNTY, FLORIDA

REV'D DATE:	JUN 29, 2015	PROJECT NO. CLI 1040-01	FIGURE 22
DRAWN DATE:	JUN 29, 2015	SCALE: AS NOTED	
DRAWN BY:	LA	APPROVED BY: VR	

CLI 1040…\01…\Reports\Hydrologic Stusy of Limonar…\CAD\F22- Wetland Hydrology 1997-GW Elevations G-3560

WETLAND HYDROLOGY CRITERIA ARE NOT MET IN 1998 AS DETERMIINED BY GROUNDWATER ELEVATIONS IN G-3560 NOT EXCEEDING CONSECUTIVE 20 DAYS OF SATURATION (MOST CONSECUTIVE CASE OF WITHIN 1 FT. OF GROUND SURFACE; I.E BETWEEN 5.3 AND 6.3 FT)

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TITLE: WETLAND HYDROLOGY 1998-GW ELEVATIONS G-3560
LIMONAR/WONDERYLY SITE
NORTHEAST CORNER OF INTERSECTION OF SW 177th AVE
AND NORTH KENDALL DRIVE
MIAMI-DADE COUNTY, FLORIDA

REV'D DATE:	JUN 29, 2015	PROJECT NO. CLI 1040-01	FIGURE 23
DRAWN DATE:	JUN 29, 2015	SCALE: AS NOTED	
DRAWN BY:	LA	APPROVED BY: VR	

WETLAND HYDROLOGY CRITERIA MET IN 1999 AS DETERMIINED BY GROUNDWATER ELEVATIONS IN G-3560 EXCEEDING 20 CONSECUTIVE DAYS OF SATURATION (MOST CONSECUTIVE CASE OF WITHIN 1 FT. OF SURFACE I.E. BETWEEN 5.3 AND 6.3 FT. AND 7 CONSECUTIVE DAYS OF INUNDATION I.E. 6.3 FT. OR HIGHER).

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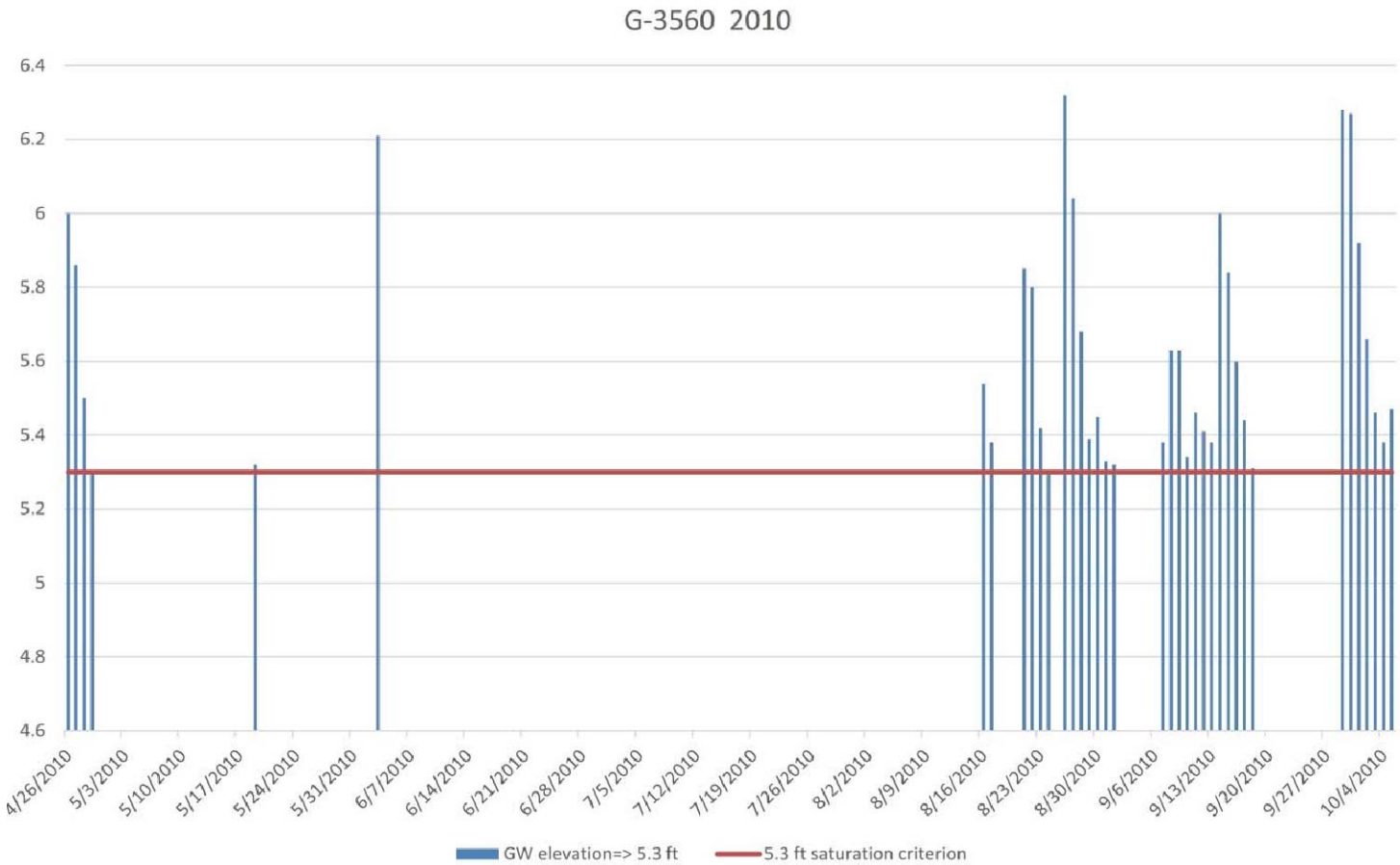
TITLE: WETLAND HYDROLOGY 1999-GW ELEVATIONS G-3560
LIMONAR/WONDERYLY SITE
NORTHEAST CORNER OF INTERSECTION OF SW 177th AVE
AND NORTH KENDALL DRIVE
MIAMI-DADE COUNTY, FLORIDA

REV'D DATE:	JUN 29, 2015	PROJECT NO. CLI 1040-01	FIGURE 24
DRAWN DATE:	JUN 29, 2015	SCALE: AS NOTED	
DRAWN BY:	LA	APPROVED BY: VR	

CLI 1040…\01…\Reports\Hydrologic Stusy of Limonar…\CAD\F24- Wetland Hydrology 1999-GW Elevations G-3560



WETLAND HYDROLOGY CRITERIA ARE NOT MET IN 2010 AS DETERMIINED BY GROUNDWATER ELEVATIONS IN G-3560 NOT EXCEEDING 20 CONSECUTIVE DAYS OF SATURATION (MOST CONSECUTIVE CASE OF WITHIN 1 FT. OF GROUND SURFACE; I.E. BETWEEN 5.3 AND 6.3 FT.)

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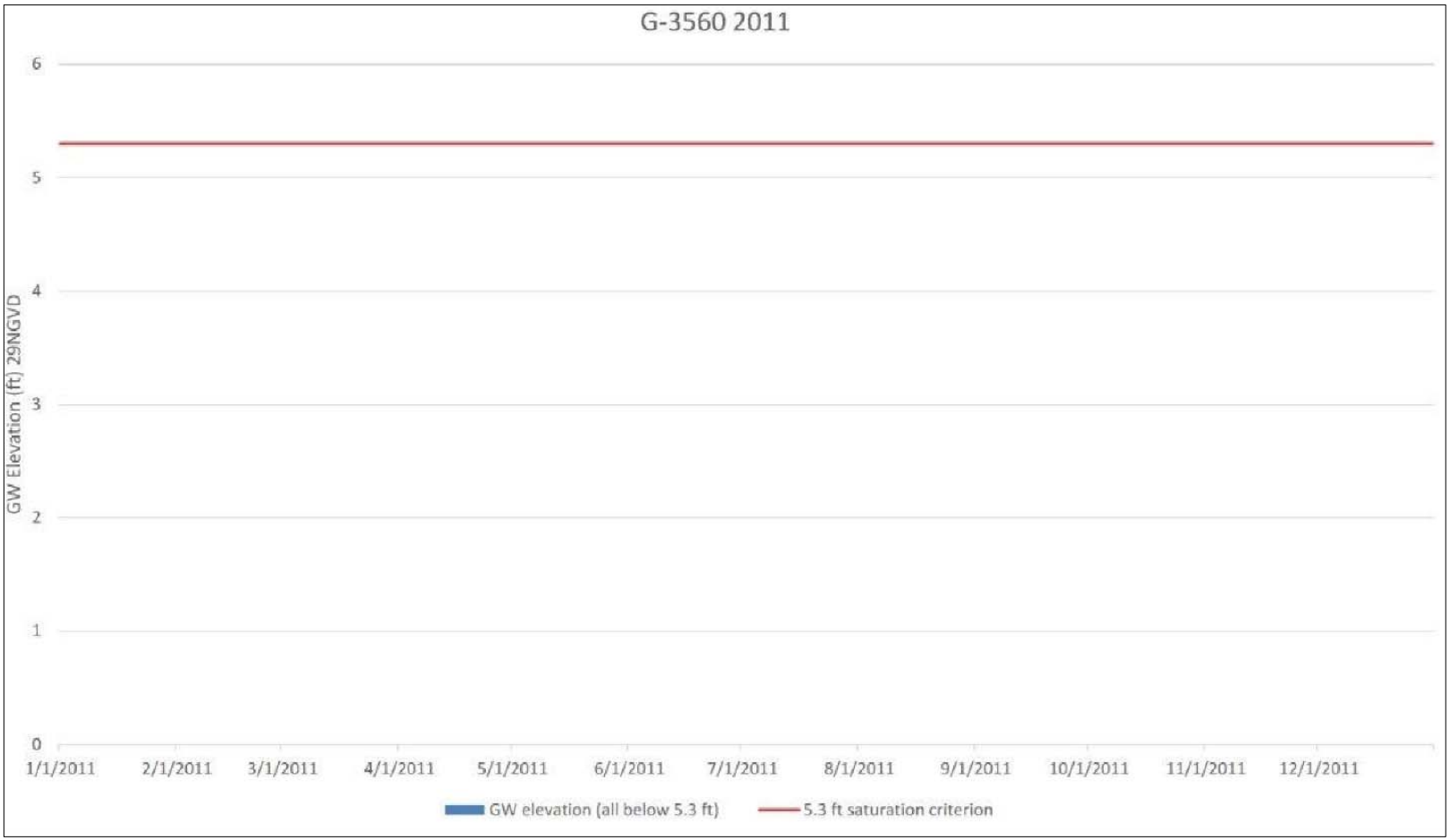
TITLE: WETLAND HYDROLOGY 2010-GW ELEVATIONS G-3560
LIMONAR/WONDERYLY SITE
NORTHEAST CORNER OF INTERSECTION OF SW 177th AVE
AND NORTH KENDALL DRIVE
MIAMI-DADE COUNTY, FLORIDA

REV'D DATE:	JUN 29, 2015	PROJECT NO. CLI 1040-01	FIGURE 25
DRAWN DATE:	JUN 29, 2015	SCALE: AS NOTED	
DRAWN BY:	LA	APPROVED BY: VR	

CLI 1040…\01…\Reports\Hydrologic Stusy of Limonar…\CAD\F26- Wetland Hydrology 2010-GW Elevations G-3560



WETLAND HYDROLOGY CRITERIA ARE NOT MET IN 2011 AS DETERMIINED BY GROUNDWATER ELEVATIONS IN G-3560 NOT EXCEEDING 20 CONSECUTIVE DAYS OF SATURATION (MOST CONSECUTIVE CASE OF WITHIN 1 FT. OF GROUND SURFACE; I.E. BETWEEN 5.3 AND 6.3 FT.)

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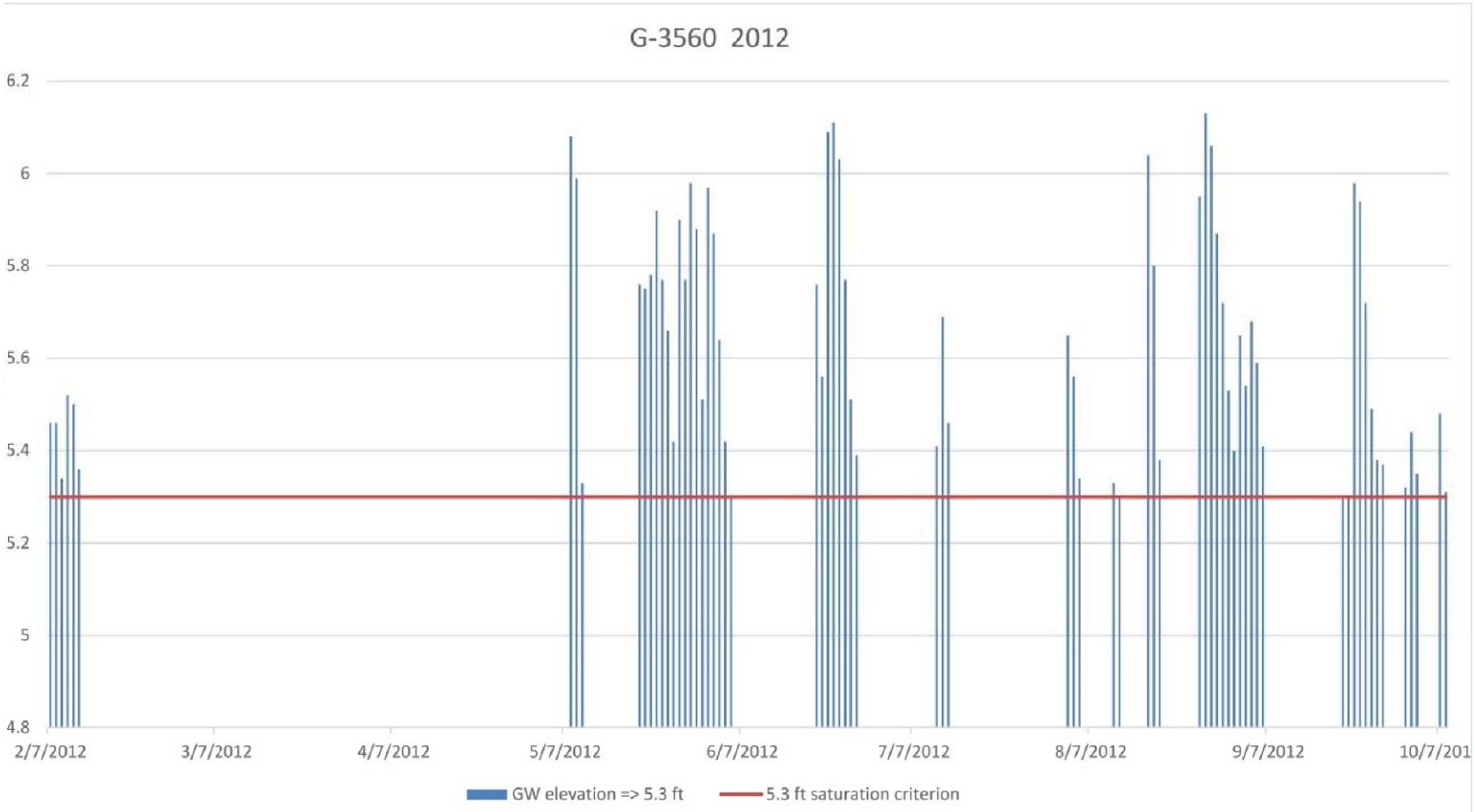
TITLE: WETLAND HYDROLOGY 2011-GW ELEVATIONS G-3560
LIMONAR/WONDERYLY SITE
NORTHEAST CORNER OF INTERSECTION OF SW 177th AVE
AND NORTH KENDALL DRIVE
MIAMI-DADE COUNTY, FLORIDA

REV'D DATE:	JUN 29, 2015	PROJECT NO. CLI 1040-01	FIGURE 26
DRAWN DATE:	JUN 29, 2015	SCALE: AS NOTED	
DRAWN BY:	LA	APPROVED BY: VR	

CLI 1040…\01…\Reports\Hydrologic Stusy of Limonar…\CAD\F26- Wetland Hydrology 2010-GW Elevations G-3560



WETLAND HYDROLOGY CRITERIA ARE NOT MET IN 2012 AS DETERMIINED BY GROUNDWATER ELEVATIONS IN G-3560 NOT EXCEEDING 20 CONSECUTIVE DAYS OF SATURATION (MOST CONSECUTIVE CASE OF WITHIN 1 FT. OF GROUND SURFACE; I.E. BETWEEN 5.3 AND 6.3 FT.)

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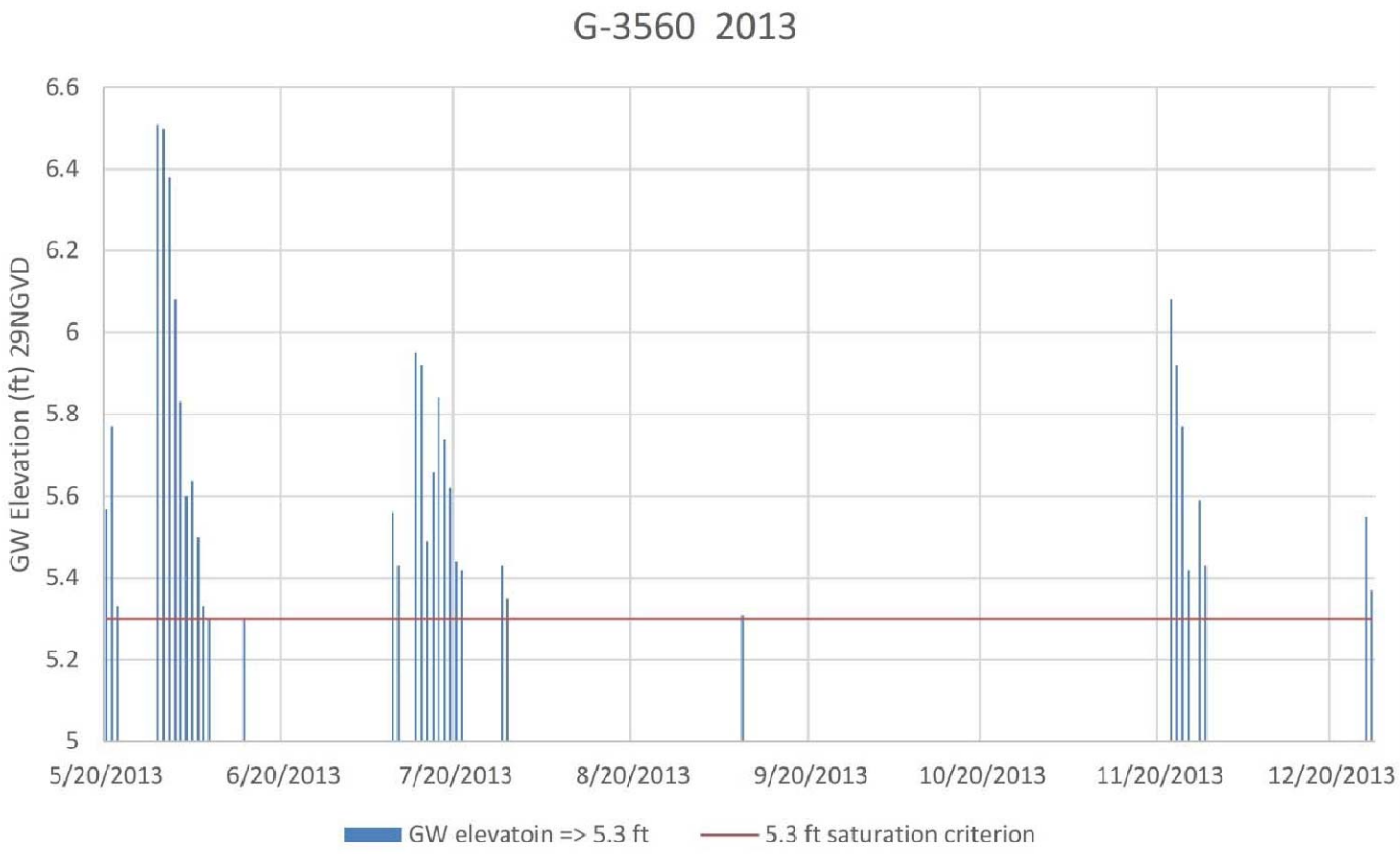
TITLE: WETLAND HYDROLOGY 2012-GW ELEVATIONS G-3560
LIMONAR/WONDERYLY SITE
NORTHEAST CORNER OF INTERSECTION OF SW 177th AVE
AND NORTH KENDALL DRIVE
MIAMI-DADE COUNTY, FLORIDA

REV'D DATE:	JUN 29, 2015	PROJECT NO. CLI 1040-01	FIGURE 27
DRAWN DATE:	JUN 29, 2015	SCALE: AS NOTED	
DRAWN BY:	LA	APPROVED BY: VR	



WETLAND HYDROLOGY CRITERIA ARE NOT MET IN 2013 AS DETERMIINED BY GROUNDWATER ELEVATIONS IN G-3560 NOT EXCEEDING 20 CONSECUTIVE DAYS OF SATURATION (MOST CONSECUTIVE CASE OF WITHIN 1 FT. OF GROUND SURFACE; I.E. BETWEEN 5.3 AND 6.3 FT.)

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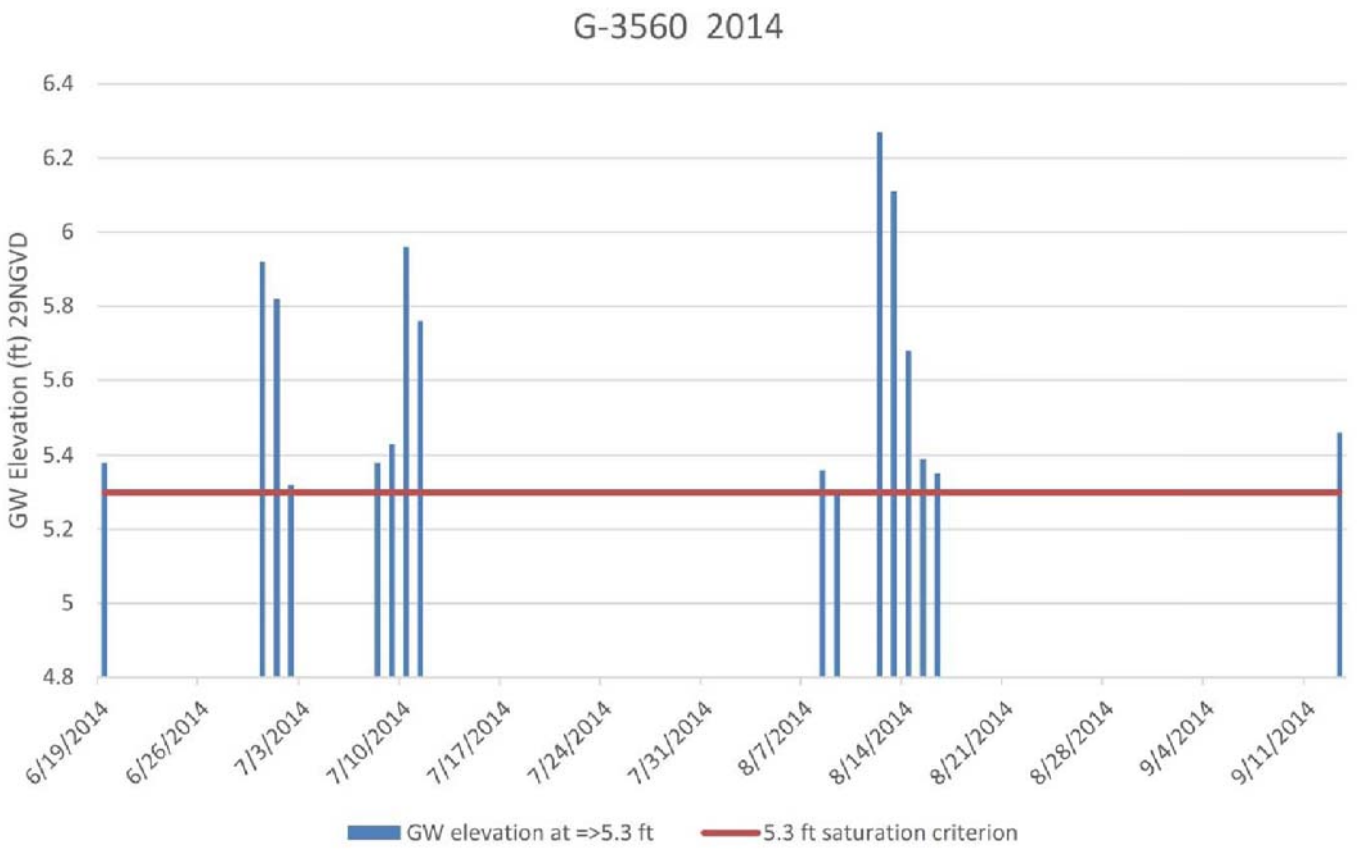
TITLE: WETLAND HYDROLOGY 2013-GW ELEVATIONS G-3560
LIMONAR/WONDERYLY SITE
NORTHEAST CORNER OF INTERSECTION OF SW 177th AVE
AND NORTH KENDALL DRIVE
MIAMI-DADE COUNTY, FLORIDA

REV'D DATE:	JUN 29, 2015	PROJECT NO. CLI 1040-01	FIGURE 28
DRAWN DATE:	JUN 29, 2015	SCALE: AS NOTED	
DRAWN BY:	LA	APPROVED BY: VR	

CLI 1040…\01…\Reports\Hydrologic Stusy of Limonar…\CAD\F28- Wetland Hydrology 2013-GW Elevations G-3560



WETLAND HYDROLOGY CRITERIA ARE NOT MET IN 2013 AS DETERMIINED BY GROUNDWATER ELEVATIONS IN G-3560 NOT EXCEEDING 20 CONSECUTIVE DAYS OF SATURATION (MOST CONSECUTIVE CASE OF WITHIN 1 FT. OF GROUND SURFACE; I.E. BETWEEN 5.3 AND 6.3 FT.)

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TITLE: WETLAND HYDROLOGY 2014-GW ELEVATIONS G-3560
LIMONAR/WONDERYLY SITE
NORTHEAST CORNER OF INTERSECTION OF SW 177th AVE
AND NORTH KENDALL DRIVE
MIAMI-DADE COUNTY, FLORIDA

REV'D DATE:	JUN 29, 2015	PROJECT NO. CLI 1040-01	FIGURE 29
DRAWN DATE:	JUN 29, 2015	SCALE: AS NOTED	
DRAWN BY:	LA	APPROVED BY: VR	

CLI 1040…\01…\Reports\Hydrologic Stusy of Limonar…\CAD\F29- Wetland Hydrology 2014-GW Elevations G-3560