Ardaman & Associates, Inc.
Geotechnical, Environmental and
Materials Consultants

September 5, 2019
File Number 19-66-5466

CAPTEC Engineering, Inc.
301 N.W. Flagler Avenue
Stuart, Florida 34994

Attention: Ms. Teri Andre, P.E.

Subject: Groundwater Modeling Services for McCarty Ranch Extension Area 3 Water Farm, City of Port St. Lucie, Florida

Dear Ms. Andre:

Ardaman & Associates, Inc. (Ardaman) has completed the groundwater modeling services to analyze the performance of the proposed Water Farm Area 3 located on the McCarty Ranch Extension property. The transient MODFLOW model constructed for Water Farm Area 2 was modified and used for this analysis. The model was modified for this evaluation based on onsite soil investigation and testing, and the water farm pond construction design. As proposed in the scope of work, two scenarios were simulated to evaluate the effects of loading the proposed pond up to the control elevation of 4 feet above the pond bottom.

Previous Soil Investigation

A Subsurface Soil Exploration was conducted by Ardaman and detailed in the August 2019 report titled Subsurface Soil Exploration McCarty Ranch – Phase III Water Farm. The exploration included eight (8) Standard Penetration Test (SPTs) borings, ten (10) auger borings, and eight (8) shallow piezometers as located in Figure 1. The piezometers were installed adjacent to the SPT boring locations to perform slug tests to determine the hydraulic conductivity of the soils penetrated. Results of the slug tests show horizontal hydraulic conductivity (k_h) values ranged from 10 to 39 feet/day in the upper 25 feet of sediment and averaged 27.6 feet/day as presented in Table 1. In the upper 15 feet of sediment, the average hydraulic conductivity was 23.5 feet/day. In the next 10 feet of sediment, the average hydraulic conductivity was 29 feet/day.

The shallow hydraulic conductivity values are within the range of permeabilities stated in the St. Lucie County Soil Survey for the five onsite soil types. The onsite soils include Arents, Floridana sand, Nettles and Oldsmar sands, Pineda sand, Pople sand, Riviera fine sand, Wabasso sand, Wabasso fine sand, and Winder loamy sand, as shown in Figure 1. Depending on the soil horizon, the onsite soils permeabilities range from <0.4 to 40 feet/day. The weighted average hydraulic conductivity of the soil is 12.6 ft/day for the approximate upper 7 feet of sediment in the Area 3.

Groundwater Model

The transient MODFLOW model constructed for the Water Farm Area 2 was modified for this analysis. Modifications were made to the existing model based on the farm pond design and onsite testing. The first modification included grid refinement in the pond area to more accurately simulated the proposed berm, pond, and drainage canals. Cell size for the berm was reduced to 5 feet, and the pond and canal cells were reduced to 50 feet. The horizontal hydraulic conductivity value for layer 1 was changed to 22.5 feet/day in Area 3 based on the range of onsite slug tests and general onsite soil properties. The average slug test result for layer 2 of 27.6 feet/day was used for k_h. The properties for layer 3 were the model derived result from the previous reservoir model calibration simulation. The model layer details are provided in the below table.

Model Layer Properties – Area 3

Model Layer	k_h (ft/day)	k_v (ft/day)	Thickness (feet)
1	22.5	2.25	20
2	27.6	2.76	7
3	24	0.1	13

The berm was added to the model by increasing the land surface elevation in the appropriate cells to a maximum height of 35 ft NGVD. The proposed drainage canals located 50 feet from the north, east and south sides of the pond were also entered into the model with a drain elevation of 22 feet NGVD. The portion of the modified grid in the water farm area is shown in Figure 2. The estimated water volume available in the water farm at operating capacity (4 feet of water – 31 feet NGVD) is approximately 378 million gallons.

Model Simulations

The modified model was used for all of the modeled scenarios. The purpose of the first scenario was to determine the rate of water level decline from aquifer infiltration and evapotranspiration (ET), assuming the farm pond was loaded four feet above land surface to a height of 31 feet NGVD. This scenario simulates a full water farm situation. In the model, the pond was loaded for 100 days at a rate of 0.0487 feet/day to bring the elevation from the simulated groundwater elevation of approximately 23.2 feet NGVD to the proposed elevation of 31 feet NGVD. The total volume of water required was approximately 461 million gallons. Following the loading period, only average annual recharge from rainfall was added to the pond area for a period of one year to record to the rate of water level decline. Based on this simulation, the estimated rate of pond level decline is approximately 0.467 feet/week or 2.0 feet/month, with the water level declining to ground level (27 ft NGVD) in approximately two (2) months. A hydrograph showing the simulated water levels in the pond is provided in Figure 3. The hydrograph location and resulting groundwater contours for the full pond are provided in Figure 4. The potential impact of the water table mound on surrounding properties is small due to the presence of the perimeter ditches surrounding the water farm, which helps lower the water table and keeps the mound on the water farm site as shown in Figure 4. However, the water

does daylight through the western berm periodically through the loading cycle. The amount of water that flows through the aquifer directly back to the C-23 canal is estimated at approximately 1.5% through the loading cycle.

The second scenario was constructed to cycle the pond and determine the fluctuation throughout the years and the average stage over the period of operation. The resulting heads from the first scenario, when the water table elevation was at land surface, was used as the starting heads for the second scenario. The model was modified to run at monthly time steps for 10 years with three loading cycles per year. In this simulation the Area 3 pond was loaded in April, August, and December at rates of 0.0740 feet/day (approximately 7.00 MGD), 0.0900 feet/day (approximately 8.52 MGD), and 0.0695 feet/day (approximately 6.58 MGD), respectively. The rates were adjusted to load the pond level up to 31 feet at the end of each cycle based on the recharge and ET rates during the cycle month. The recharge and ET rates were varied monthly based on the 30-year Normal Fort Pierce NOAA data from 1981 to 2010 (Table 2). Based on this simulation, the heads drop below the pond bottom between loading events. The total volume of water required to cycle the water level for the year was approximately 685 million gallons. A graph showing the cycle fluctuations for the pond is provided on Figure 5. Locations of the model hydrograph monitoring points are provided on Figure 4.

To estimate the effects of loading Area 3 while Area 1 and Area 2 are fully loaded, an additional 10- year simulation was run with Area 1 held at an elevation of 32 feet and Area 2 held at an elevation of 31 feet. The loading rates were reduced in Area 3, so the water level did not exceed 31 feet. In this simulation the Area 3 pond was loaded in April, August, and December at rates of 0.0629 feet/day (approximately 5.95 MGD), 0.0805 feet/day (approximately 7.62 MGD), and 0.0585 feet/day (approximately 5.54 MGD), respectively. The rates were reduced from the previous simulation of approximately 1.05 MGD in April, 0.90 MGD in August, and 1.04 MGD in December. Based on this simulation, the heads drop below the pond bottom between loading events. The total volume of water required to cycle the water level for the year was approximately 592 million gallons. A graph showing the cycle fluctuations for the pond is provided on Figure 5. A summary of volumes of water required to fill and then maintain the pond for various scenarios are provided in the following table:

Volume Summary

Condition	Volume (Million Gallons)
Available at Operating Level	378
Required to Initially Fill Pond to Operating Level	461
Required to Maintain Pond for One Year (No Area 1)	685
Required to Maintain Pond for One Year (With Area 1)	592

Conclusions

Ardaman has completed the groundwater modeling services to analyze the performance of the proposed Water Farm Area 3 located on the McCarty Ranch Extension property

and has concluded the following:

- Based on the full pond loading simulation, the estimated rate of pond level decline is approximately 0.467 feet/week or 2.0 feet/month, with the water level declining to ground level (27 ft NGVD) in approximately 2 months.
- The potential impact of the water table mound on surrounding properties is small due to the presence of the perimeter ditches surrounding the water farm, which helps lower the water table and keeps the mound on the water farm site. However, the water does daylight through the western berm periodically through the loading cycle.
- The amount of water that flows through the aquifer directly back to the C-23 canal is estimated at approximately 1.5% through the loading cycles.
- The modeling results of the 10-year cycle testing with three loading cycles per year indicate that the heads drop below the pond bottom between loading events.
- The average stage in the pond is 28 feet over the period of operation in the simulation, or 1 foot above grade in the three cycles per year simulation.
- The estimated annual volume of water required to maintain Water Farm 3 without Water Farm 2 loaded is 685 MG.
- The estimated annual volume of water required to maintain Water Farm 3 with Water Farm 2 fully loaded is 592 MG.

We appreciate the opportunity to provide these hydrogeological services to CAPTEC and the City of Port St. Lucie, and we look forward to the next phase of the project. Please do not hesitate to call us should you have any questions or need additional information.

Very truly yours,

ARDAMAN & ASSOCIATES, INC.

Douglas P. Dufresne, P.G.
Project Director/Senior Hydrogeologist
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Valerie Davis, P.G.
Project Hydrogeologist III

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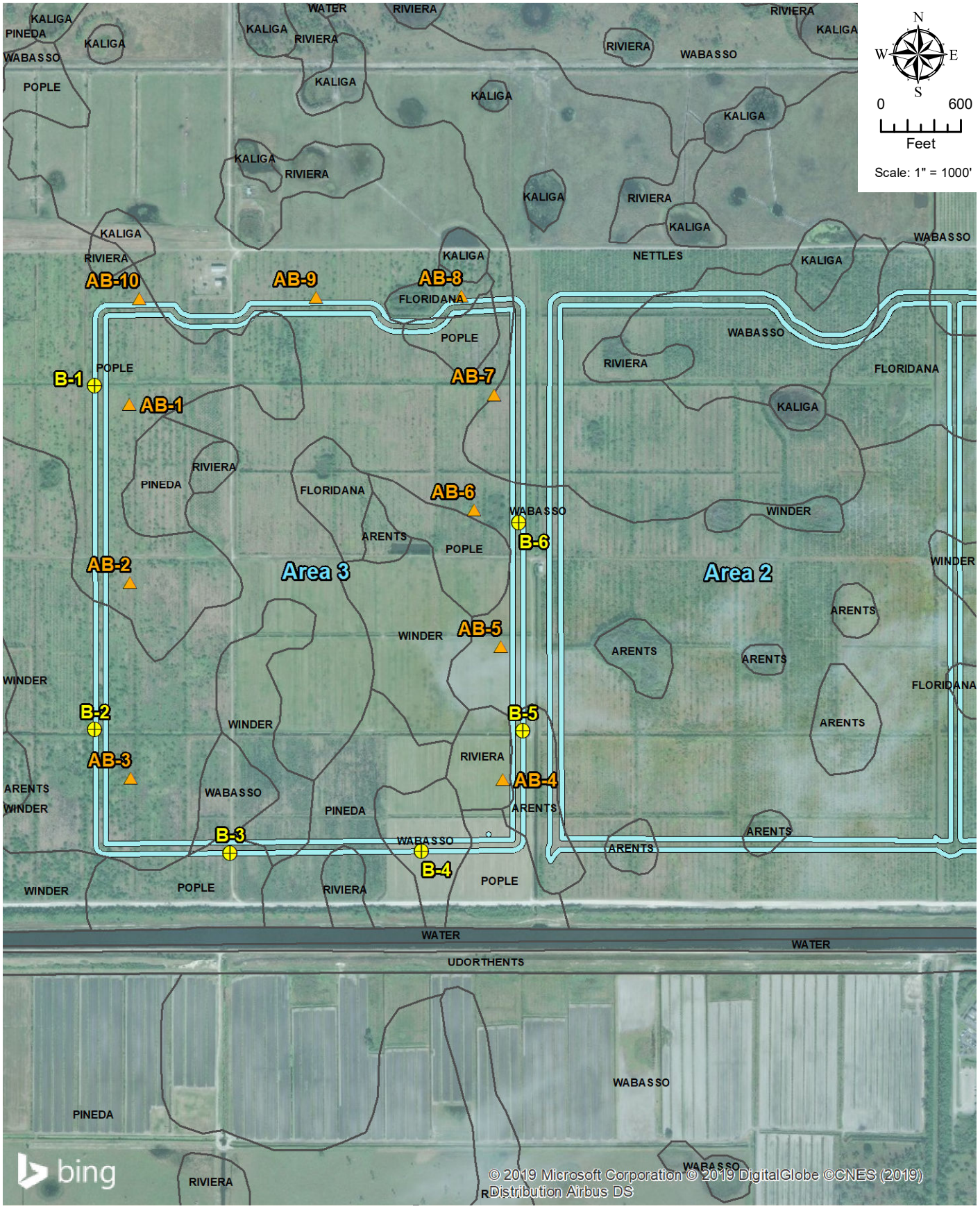
TABLE 1
McCARTY RANCH EXTENSION WATER FARM AREA 3
SLUG TEST RESULTS

Boring and Well No.	Soil Description	Well Depth (ft bls)	Screened Interval (ft bls)	Depth to Water Table (ft bls)	Hydraulic Conductivity (feet/day)
B-1	Shelly fine sand	20	15 to 20	4.4	10
B-2	Shelly fine sand	25	20 to 25	6.5	17
B-3	Fine sand to fine sand with clay - Mostly Shell	15	10 to 15	5.7	15
B-4	Shelly fine sand	20	15 to 20	5.6	37
B-5	Clayey fine sand with limestone fragments	20	15 to 20	6.0	35
B-6	Fine sand to fine sand with silt - Mostly Shell	20	15 to 20	5.3	36
B-7	Fine sand with clay - Mostly Shell	15	10 to 15	4.3	32
B-8	Fine sand to shelly fine sand	25	20 to 25	5.1	39
			Averages	**5.4**	**27.6**

TABLE 2
PRECIPITATION DISTRIBUTION AND
THORNTHWAITE POTENTIAL ET CALCULATION
CLIMATE DATA FROM FORT PIERCE NOAA STATION (1981-2010)

MONTH	Precipitation (in)	Precipitation (ft)	80% Precipitation (ft/day)		DAILY AVG. TEMP.(F)	DAILY AVG. TEMP.(C)	HEAT INDEX Im	Unadj. Potential ETmonth (in)	30 degree Latitude Daylight Factor	Adjusted Potential ETmonth (in)	Adjusted Potential ET Day (ft/day)
January	2.35	0.19583	0.00505	0.00632	62.00	16.67	6.19	1.52	0.90	1.37	0.00368
February	3.09	0.25750	0.00736	0.00920	64.10	17.83	6.86	1.83	0.87	1.59	0.00473
March	3.68	0.30667	0.00791	0.00989	67.20	19.56	7.88	2.35	1.03	2.42	0.00651
April	2.87	0.23917	0.00638	0.00797	71.20	21.78	9.28	3.16	1.08	3.41	0.00947
May	3.78	0.31500	0.00813	0.01016	76.80	24.89	11.36	4.55	1.18	5.37	0.01443
June	5.72	0.47667	0.01271	0.01589	80.50	26.94	12.81	5.65	1.17	6.61	0.01837
July	6.04	0.50333	0.01299	0.01624	81.90	27.72	13.37	6.11	1.20	7.33	0.01971
August	7.49	0.62417	0.01611	0.02013	81.90	27.72	13.37	6.11	1.14	6.96	0.01872
September	7.69	0.64083	0.01709	0.02136	80.90	27.17	12.97	5.78	1.03	5.95	0.01654
October	5.42	0.45167	0.01166	0.01457	76.70	24.83	11.32	4.52	0.98	4.43	0.01191
November	3.58	0.29833	0.00796	0.00994	70.10	21.17	8.89	2.92	0.89	2.60	0.00722
December	2.13	0.17750	0.00458	0.00573	64.70	18.17	7.05	1.92	0.88	1.69	0.00455
TOTALS	**53.84**		**0.00983**							**49.74**	**0.01136**



▲ Auger Boring Locations ⊕ SPT and Piezometer Locations ☐ Soil Boundary ☐ Water Farm

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BORING AND SOIL LOCATION MAP
McCARTY RANCH EXTENSION
WATER FARM AREA 3
CITY OF PORT ST. LUCIE

FIGURE 1

grid2 PropBound

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WATER FARM AREA MODEL GRID
McCARTY RANCH EXTENSION
WATER FARM AREA 3
CITY OF PORT ST. LUCIE

FIGURE 2

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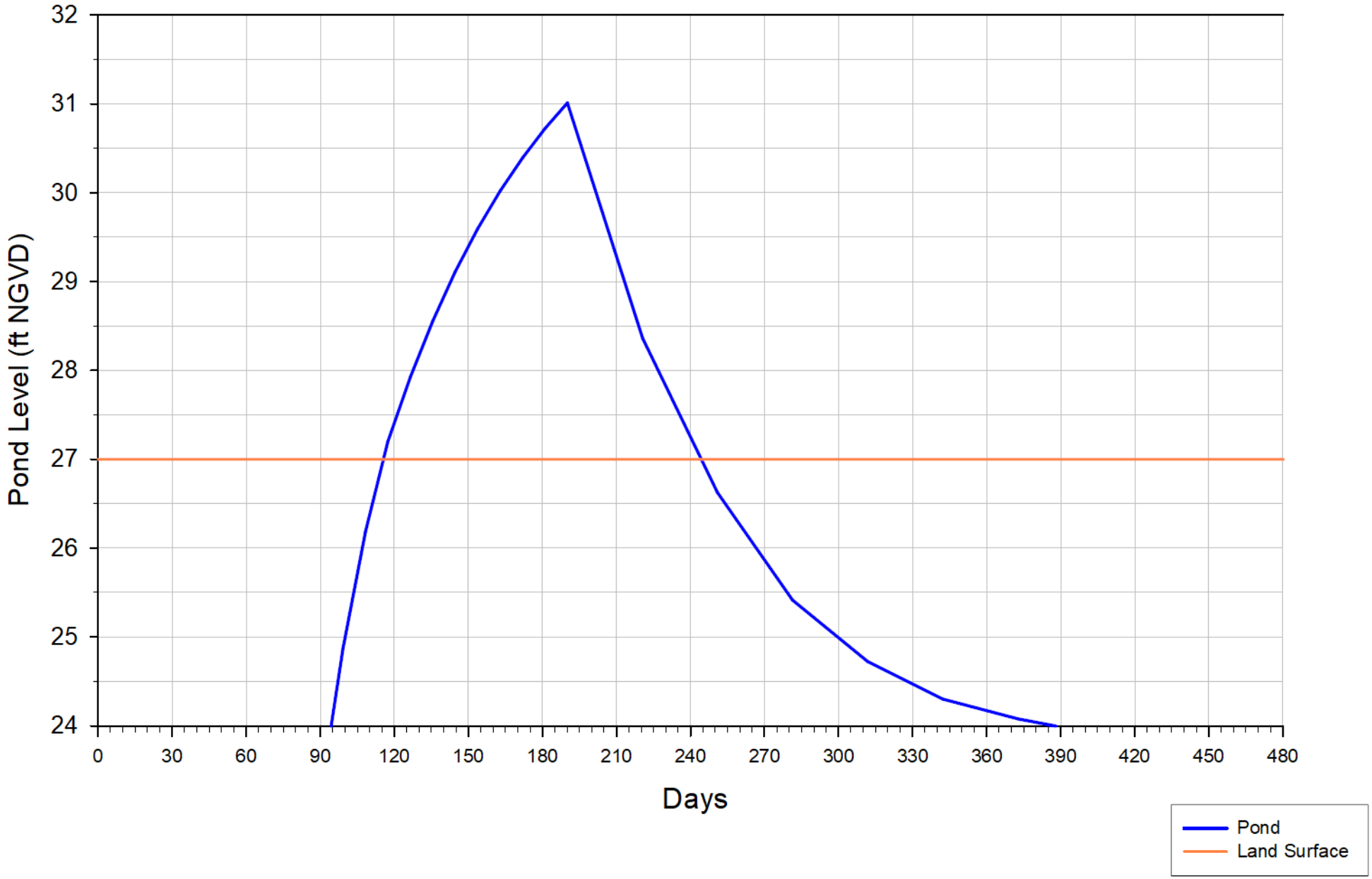

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POND LEVEL RECESSION FROM 31 FT NGVD
McCARTY RANCH EXTENSION WATER FARM AREA 3
CITY OF PORT ST. LUCIE, FLORIDA

Figure 3

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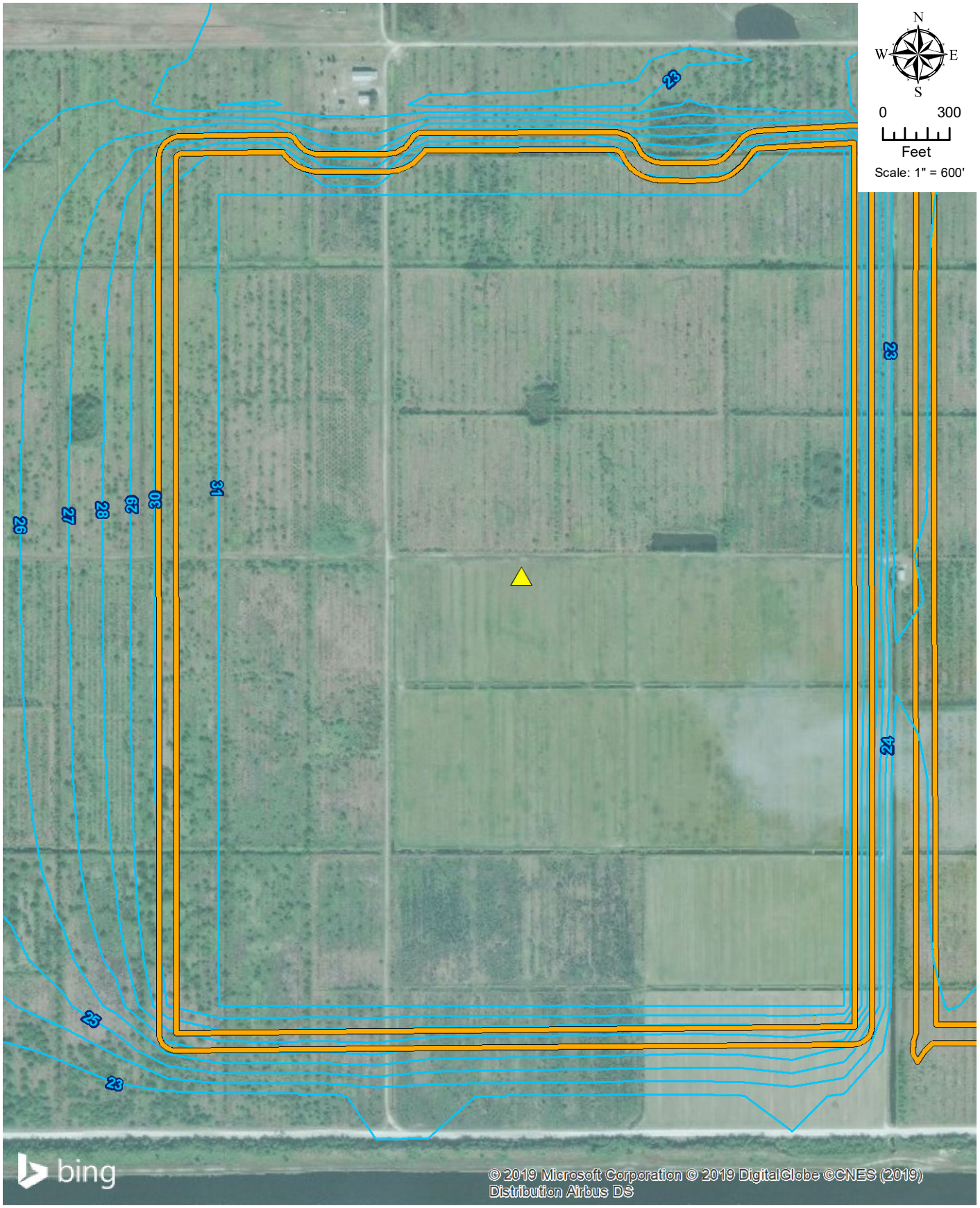

△ Hydrograph Location — Water Table Contour (Interval = 1 ft NGVD) ▭ Water Farm

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FULL POND WATER TABLE CONTOURS
McCARTY RANCH EXTENSION
WATER FARM AREA 3
CITY OF PORT ST. LUCIE

FIGURE 4

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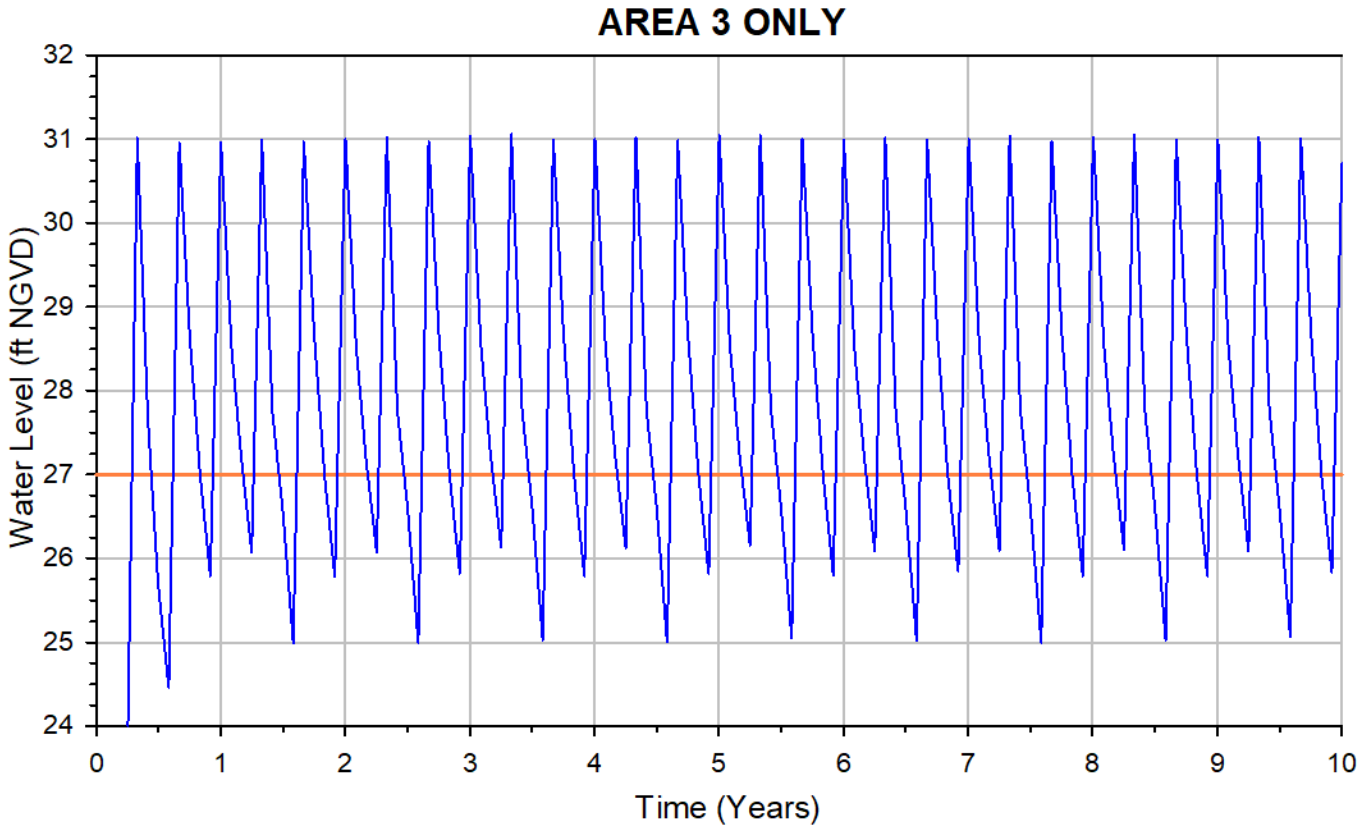

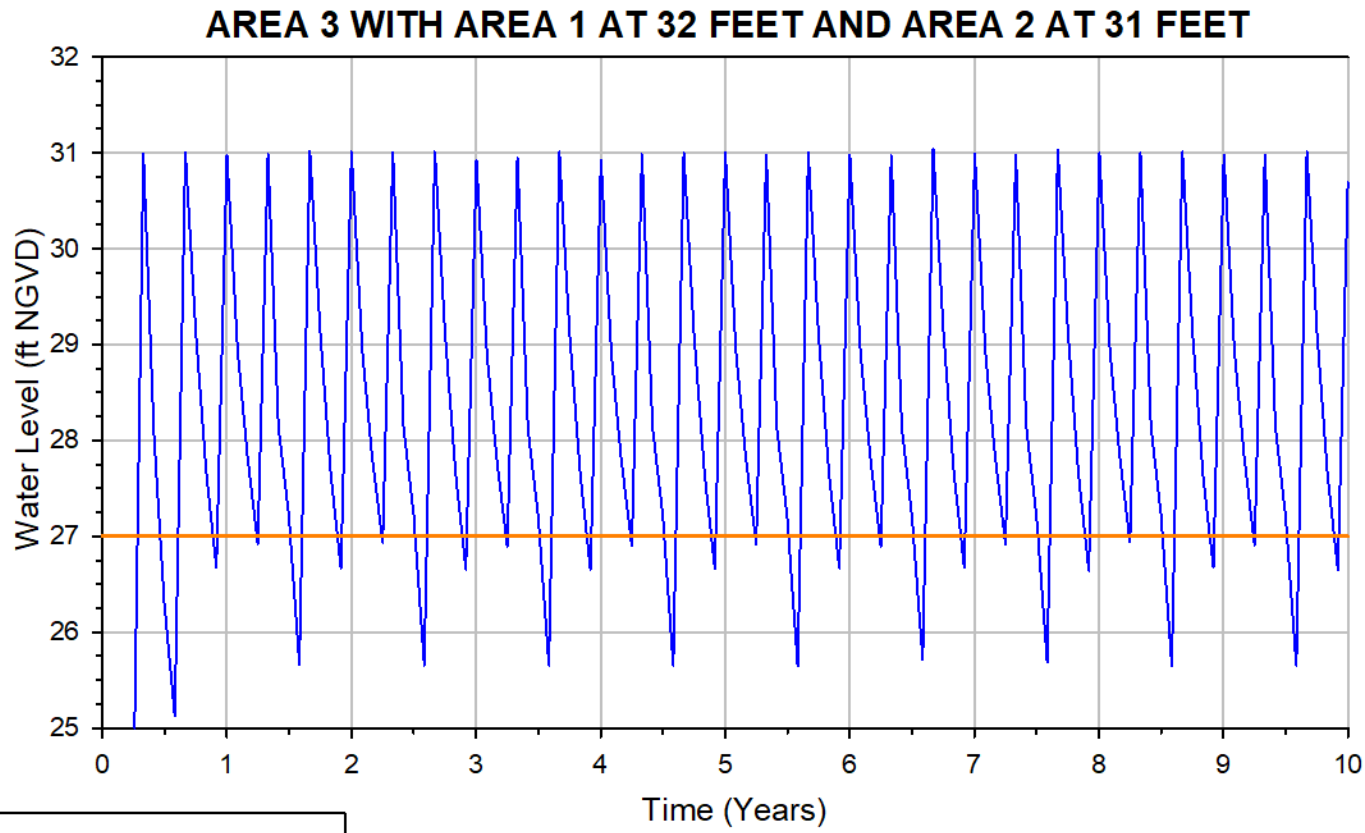

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10 YEAR SIMULATED WATER LEVELS
McCARTY RANCH EXTENSION WATER FARM AREA 3
CITY OF PORT ST. LUCIE, FLORIDA

FIGURE 5

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