May 7, 2024

Ms. Karen Bain.
Angleton Drainage District.
1123 County Road 428
Angleton TX 77515.

Re: Serenity Oaks – Single Family Development in Angleton, Texas.
Detention Plan Revised Land Plan *4SPN 1221-29*

Dear Ms. Bain,

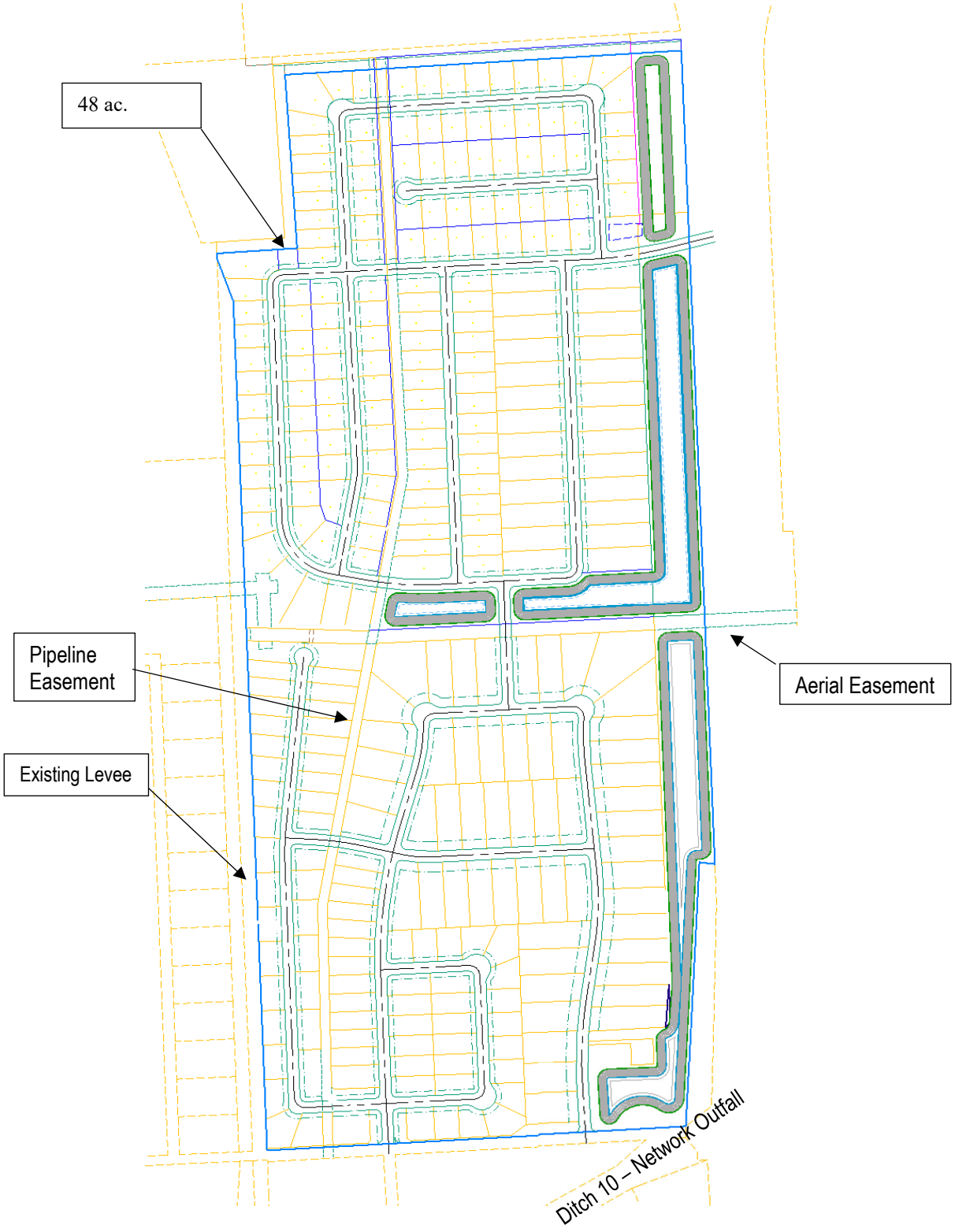
We are writing to submit this letter report for the captioned project. We have coordinated this project with the district engineer to gather initial instruction relative to criteria and the goals of the district. We have applied those rules and have defined an appropriate detention plan for the development. Herein we discuss details that support our conclusions found on page 14.

The project includes a large lot single family development upon a number of tracts totaling approximately 300 acres. It is located north of CR 28 and Jimmy Phillips Blvd between US 288 and the levee as noted below in **Figure 1.**

Above the subject 300-ac property is shown with an offsite 48-ac drainage area to the northwest.

Proposed are 0.50 to 1.5 acre lots with open ditch drainage. Those open ditches (to be defined during final design by others) will be sized for the 5yr event per criteria and will drain the property to the detention network shown below.

The detention system however, will be sized to handle the 100-yr event and includes any offsite tracts that drain through the project area. **Figure 2** below is the general land plan.



The tract includes a north and south region each with wet detention ponds interconnected with culverts. The northernmost channel is dry and includes a 70-foot setback from the roadway. That area will be reserved for landscape or additional source fill as needed.

The **General plan** is to construct these 4 interconnected detention ponds to drain the properties into Ditch 10. The ponds and connecting culverts will be sized to comply with the requirements set forth by the City of Angleton. These rely partly upon Brazoria County Drainage Criteria Manual.

The plan also includes a **Phase One** construction. Herein the limits thereof and the required detention facilities are identified. See also page 13 and 14 and Exhibit 7.

One primary criterion includes an **allowable discharge rate** derived from a Master Drainage Plan developed for the area. We have been advised we are in drainage basin OC-025 (Oyster Creek) and are allowed a discharge rate of 0.45cfs per acre.

Accordingly, the total area draining to the network is 344acres. Thus, the maximum allowable peak discharge into Ditch 10 is 155cfs. This applies to ATLAS-14 100yr event.

The 344acres includes a 48-acre offsite tract located northwest of the property. Coincidently, the allowable 0.45cfs/acre matches the existing runoff from that tract for the 100-yr storm event. Thus, the site may drain freely as is into the network.

However, any future development therein would require onsite detention with a controlled release rate of 0.45cfs/acre. That detention outfall pipe would be subject to the depth of the channel provided at the edge of the property. See page 13 and 14.

Allowable peak discharges for lesser storm events are not specified, however target max allowable discharges can be reasonably deciphered from peak runoff computations and correlation to the specified allowable 100-yr event.

In summary, upon factoring the peak flows for the 100yr, 10yr, and 5yr storm events (Rational Method Computation), reasonable peak outflows are 0.29cfs/acre for the 10yr event, and 0.25cfs/acre for the 5yr event. This is discussed further on page 13 below.

Ditch 10 is also shown above on Figure 2. It drains The City of Angleton across US-288, then south and southwest toward the Levee and into the Brazoria River. 100yr storm event flood flows are contained within its banks.

The southern third of the east property line has a taper along Ditch 10. However, Ditch 10 just cuts across the SE corner of the property as can be seen above. The recommended facilities will preserve the existing alignment of Ditch 10.

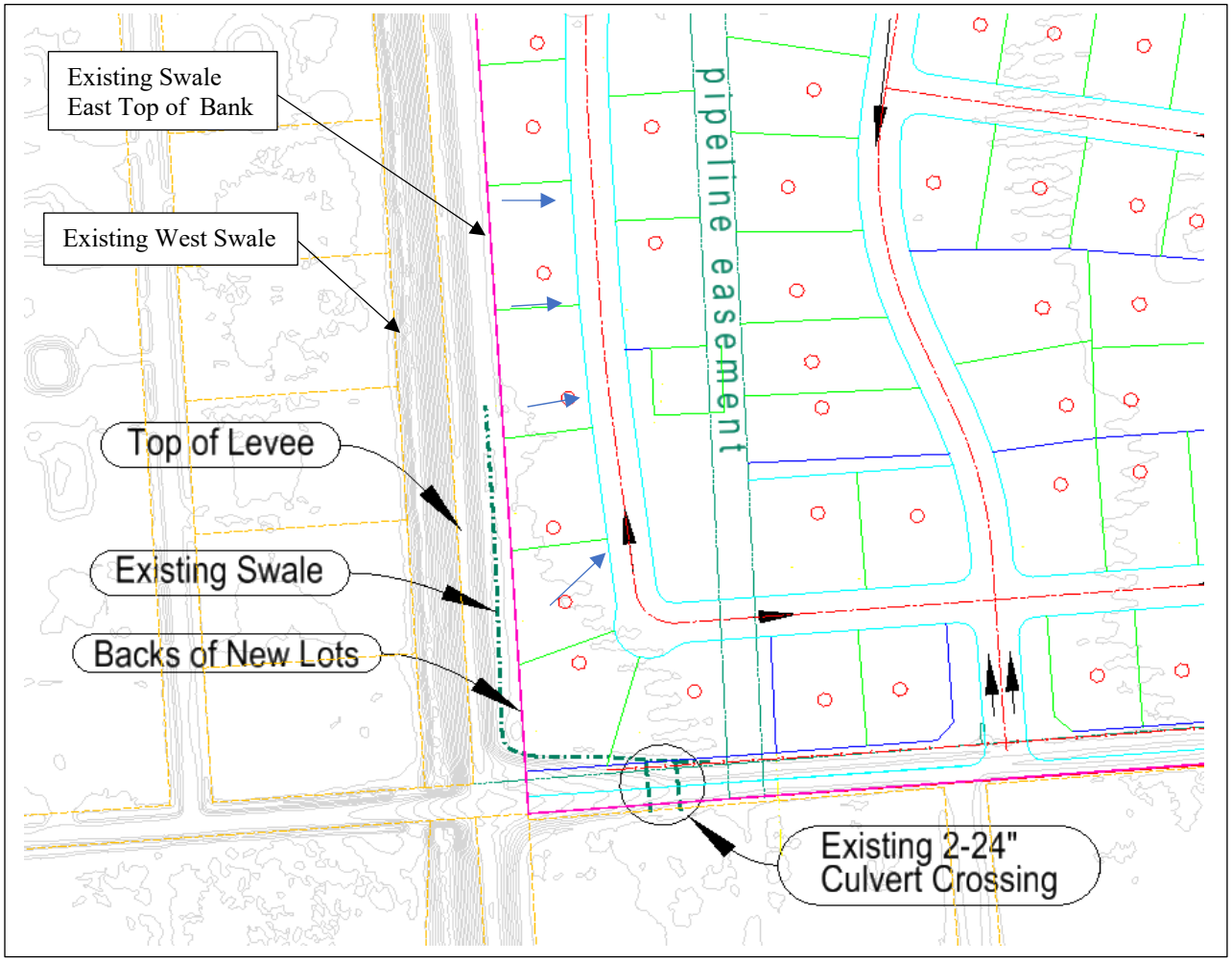
The outfall from the proposed detention network will tie into Ditch 10 at that SE corner of the property. In that area, there are a few Oaks that will include no fill, no development, and thus, will be preserved.

Also shown above, is the **existing levee** that protects the city and the subject property from Brazoria River Floodplain as shown on effective FIRM Panel 48039C0440K dated 12-30-2020.

Notably, as-built drawings of the Levee provided by the district indicate its east toe includes a southerly drainage swale. That swale drains the area between the levee and the pipeline easement noted above. It leads south to 2-24” culverts which cross under CR28 and on into Ditch 10.

It should be noted the back of lots along that levee do no encroach into that swale as can be seen below . The new lots will be graded east to the road; however, the swale will be preserved.

Figure 3 below is the southwest corner of the proposed land plan.



Likely, the lots along the levee will need to include one to two feet of fill and graded east to drain to the new roadside ditch and then to the detention network.

Notably, the owner has rejected FHA-HUD Type B Lot grading whereby the back of lot would drain west to the swale. Thus, the levee swale will be regraded and resized as dictated by the final grading plan (by others).

This design will be based on the residual acreage west of the lots up to and including the levee. The very backs of lot may include a fill easement that may become part of the drainage boundary for the swale. If so, no changes to these analyses will be necessary.

The new swale may be elevated but will still convey design flows toward the south toward the 2-24" pipes which will not be modified. Nor will the flow rates be adversely impacted by the swale redesign.

It should be noted that depending upon final design, an additional drainage easement may be needed for District access to the reconfigured channel

Design Model/Methodology

The proposed network has been modeled using StormWise (formerly ICPR). The model is used to define the components of the proposed detention network. It will indicate the maximum expected discharges and the resultant Peak Stage (PS) in each pond.

The program is developed by Streamline Technologies out of Winter Park Florida and has widespread use locally.

It uses "Nodes" to model detention ponds. The ponds are defined with an elevation verses acreage data table. The model uses that data table to interpret the storage volume available in the pond at various elevations. Included in that table is the area at the normal pool elevation and then at 1-ft increments (+/-) up to the top of bank.

The top of bank is set exactly 1 foot over the resultant peak flood stage un each pond. This provides **1 foot freeboard** as required by the district.

The Ponds are connected by "Links" which are pipes, channels, weirs, and such. Links can vary in size, shape, material, and barrel count. Included are entrance and exit loss coefficients.

Entrance losses are dependent on the type of headwall, wingwalls, and type of installation (pipe mitered to slope or pipe projecting from fill and the like).

Exit losses are dependent on the ratio of the link velocity and the downstream node velocity. When a pipe is connected to a detention pond, the ratio is infinity since the velocity in a detention pond is effectively zero. The exit loss is then maximized at 1.0.

When connected to a ditch or manhole with a pipe where the expected velocities are relatively even, the ratio of link velocity to downstream node velocity is minimized at 1.0. The corresponding exit loss coefficient is then zero. When the ratio is about 2, the value is 0.75. The model includes a schedule of coefficients for various velocity ratios. This and the entrance loss coefficients are often used to fine tune results.

The StormWise model includes a "boundary flow" option whereby predetermined runoff hydrographs can be assigned at various ponds/nodes. This introduces storm water into the detention work.

Those hydrographs will be prepared using the Rational Method to define a peak. Then the Small Watershed Method will be used to define the full hydrographs as per criteria.

These methods employ **criteria found in the BCDCM**. including Section 2.2.1 for Rational Method parameters and Section 2.3.1 for Malcolm's Method. This includes table 2.4 which indicates the excess runoff in inches as it relates to impervious cover.

Further, the StormWise model uses a data table to define storm water conditions in the receiving stream (aka tailwater conditions). In a complex situation with a large project with shallow outfall streams and floodplain issues, a detailed stage-time curve developed from combining data derived from HECHMS and HECRAS models of the receiving stream is sometimes warranted.

However, in smaller to medium projects with deep outfalls and no floodplains, such as this, and as recommended by the district engineer, the **tailwater** can be maximized at the top of pipe. Thus, around peak conditions and points thereafter during a typical 24-hour storm event, the tailwater is set at the top of pipe.

However, during the initial stages of a given storm event, the defined tailwater ascends from the flow line of the outfall pipe to the top of the outfall pipe. This is done to prevent back flow from the outfall ditch into the network and to maintain positive outflows during the ascending portion of the storm event.

However, given the depth of outfall and top of pipe being some 5 to 6 feet below channel top of bank, we are recommending a backflow preventer for the final pipe.

Notably, Ditch 10 upstream of the proposed outfall location services some 1,200 acres along 2.35 miles (12,400 ft) of ditch. When runoff from this area peaks and drains to the outfall location, flood stages in Ditch 10 will be near to the top of bank which is about 25 feet.

When this occurs, Ditch 10 will substantially lessen outflows from the detention network. Thus, internal flood stages would increase, possibly overtop the banks, and discharge more than allowed. Consequently, an overflow weir should be added to control release rates and peak stages during high tailwater conditions. A review to address that issue is found below on page 11.

One last model setup issue is the **flowline of the final outflow**. The upstream end of the last pipe governs the minimum normal pool elevation for all wet ponds within the network.

The district provided cross sections of ditch 10 which reveal the top of bank and channel bottom. However, they indicate a water surface at elevation 19.0', which suggests there is some 4 to 5 foot of standing water in Ditch 10. This seems excessive.

This water surface appears to be consequent to some recent storm event at the time of the survey. Current and historical photos suggest there is some, but normally minimal standing water in Ditch 10.

To examine this further, we developed a new cross section of Ditch 10 near the outfall using HGAC 2018 Lidar.

A digital elevation model was imported into 2D HECRAS and a new **cross-section** was cut at the outfall location using 0.20ft contours developed from the DEM.

The aerial photos were then used to measure the **cross-section** station that corresponds to the standing water visible in the latest aerial photo. This appears to be at station 95' in the **cross-section** as can be seen on **Figure 4** below. Historical aerial photos show that to be relatively constant.

Thus, the normal water surface in Ditch 10 corresponds to station 95' in the **cross-section** as seen on **Figure 4** below.

The cross-section elevation at that station was then taken as the elevation of the normal water surface. The outfall was then set one half foot higher. See graphics below.

Note:

- The district cross-section elevations are based on USGS BM A-693, NGVD 1929.
- The HGAC Datum is NAVD88 2001 adj.
- The Ditch 10 top of bank in the area closely matches that of the district cross sections. Thus, little subsidence occurred over those datums.

Figure 4 below is the HGAC cross section with notes regarding the standing water surface.

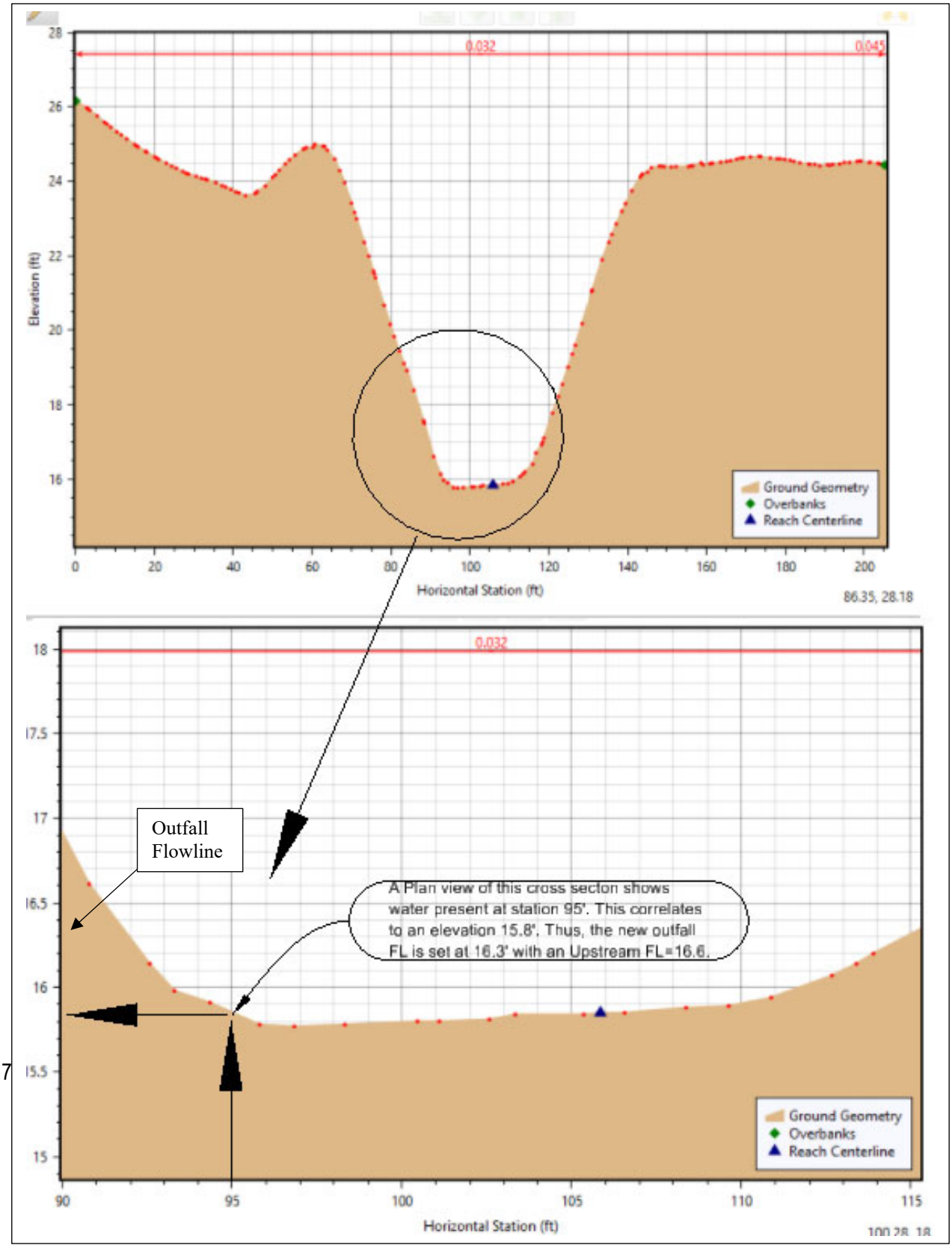
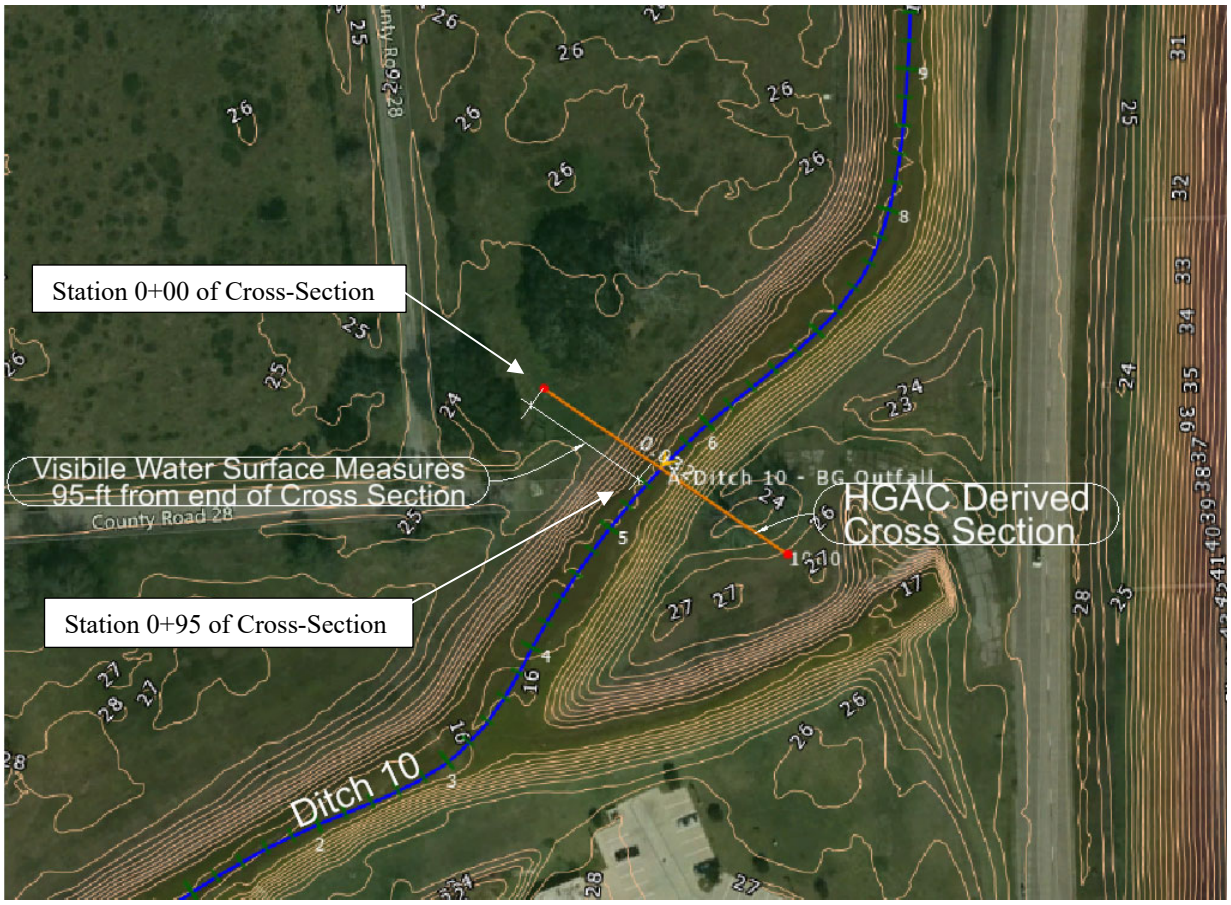


Figure 4 continued: A plan view of the cross section and measure to water edge



Based on the above, the existing standing water surface in the stream is 95 feet from the cross section starting point and its elevation is estimated at 15.8 feet. The outfall flowline is then set at elevation 16.3 to offer clearance and buffer for variances in the standing water surface.

The upstream flowline of the outfall pipe (which sets the static water surface elevation in the network) is 16.6'.

Proposed is a 48" outfall pipe. Thus, the max tailwater is defined as 16.3'+4' = 20.3'.

Notably, Lidar imaging used for terrain data does not penetrate standing water. Thus, channel bottom data typically represent the elevation of any standing water at the time of the survey. However, it is prudent to review aerial photos and other data sources to verify if that claim is reasonable.

Proposed Conditions

A land plan has been provided by the developer. It shows the street and lot layout and preserves any existing easements. Therein is a north-south pipeline easement and an east-west aerial utility easement. See figure 2 above.

The land plan also includes tracts reserved for detention ponds, channels, easements, significant Oaks, and other drainage facilities.

Exhibit 1 is a proposed conditions drainage area map. Included is the 48-acre offsite tract to the northwest. Its boundaries were deciphered from aerial photos and HGAC Lidar based contours.

The Drainage Area Map includes Basin ID and the Acreage. Also shown is the Time of Concentration.

The Rational Method was used to compute the peak runoff for each basin. This was done for the 100-yr, 10-yr and 5-yr storm events. Parameters for which were derived from BC-DCM.

The travel path for time of concentration represents the longest water course for storm water runoff to reach the downstream end of the basin. Typically, the travel time across lakes and or detention pond is zero minutes.

The Rational Method requires a composite C value. Detention ponds, large lots, and non-developable easements were all accounted in determining an average C value.

The open pasture classification was used for the easements. The manual assigned 5% impervious and C = 0.15 for this class. Details of the computations are on the full table shown on Exhibit 2.

Shown on Exhibit 2 are the prescribed equations for Time of Concentration. This includes Kerby Method for overland flow and L/V method for ditch and pipe runs. A normal depth routine was used to estimate ditch velocity at 1.5fps. For pipe runs, a typical velocity of 2fps was used.

Shown under the headings are design parameters taken from BC-DCM. The bottom of the page shows the ATLAS 14 e-b-d values also taken from the manual. See Exhibit 2.

Below is a Summary of those computations;

Peak Runoff Summary					
ID	Basin	Percent Impervious	Peak Runoff (cfs)		
	Acreage		100-yr	10-yr	5-yr
OS-A1	48.78	5.5	22.1	12.7	10.6
NS-A1	15.03	22.0	30.3	19.8	17.0
NS-A2	38.67	21.0	75.4	49.5	42.4
NS-A3	38.67	26.0	75.7	49.2	42.0
NS-A4	19.28	29.5	45.3	29.8	28.0
NS-A5	18.28	26.6	41.9	27.7	23.8
NS-A6	32.72	40.3	88.2	57.9	49.6
SS-A1	76.46	26.3	142.1	91.4	78.0
SS-A2	30.30	21.3	64.0	42.3	36.3
SS-A3	26.02	27.6	52.9	34.5	29.5

Exhibit 2 shows the Rational Method Peak Flow computation for the 100-yr, 10-yr and 5-yr storm events. These computations define hydrograph peaks.

Exhibits 3 and 4 include the Small Watershed Method Hydrographs. Included are the excess runoff amounts in inches taken from the BC-DCM. These are used to interpolate the excess runoff in inches which in turn defines the volume of the hydrograph.

The ascending and descending limbs of the hydrographs are then computed using equations found in the BC-DCM. These are standard for Malcolm's Small Watershed Method Hydrographs. The computation interval is 10-minutes.

Exhibits 3 and 4 also include plots of the hydrographs. The peaks of those hydrographs match the Rational Method computations.

These hydrographs are assigned to various StormWise model nodes as can be seen on Exhibit 6.

Each detention pond in the model is defined with a stage-area data set. The data set is derived from the land plan and the detention ponds drawn in to fit.

Design of the ponds include;

- 20-foot maintenance berms w/backslope swales around the top of bank
- 4 to 1 side slopes above normal pool
- 3 to 1 side slopes below normal pool
- Dry Channel Slopes are 0.1%
- Dry Channels have 6' minimum bottom width per criteria

Exhibit 5 shows the data set for each pond. Included is the computed storage volume for each pond.

Exhibit 6 shows the **ICPR Model Setup**. Each Pond is identified and the assigned hydrograph(s) are shown.

The model includes a few extra components besides the detention ponds. This includes a channel across basin SS-A3 on the south end.

This conveys runoff from basin SS A2 east to the street where runoff from basin SS A3 will be added. Then a 54"rcp ties to pond SS-1. Exhibit 7 calls the proposed channel and inlet to drain basins SS-A2 and SS-A3 to pond SS-1.

A second offline component is a pipeline crossing North of pond NS-1. A model dummy node (JUNC-1) has been added west of the roadway leading to from pond NS-3. This allows the pipeline crossing to be properly sized.

Runoff from Basins OS-A1 and NS-A1 will commingle in that manhole west of the pipeline easement on the south side of the street. An 80-foot x 48"-rcp will then siphon that manhole to anther manhole on the east side of the pipeline easement. There, a Type E inlet will be used to allow flows to rise high enough to continue east along the road side ditch.

Along that run, up to 8 cross culverts should be used to equalize flows on both sides of the ditch. Then at the downstream end, a 60"-rcp will be needed to tie into pond NS-3. This is a general plan, that may be revised if final design conditions warrant. Unless, the siphon is relocated, no amendment to this report would be needed.

Pond NS-3 will be tie to Pond SS-1 with a 36"-rcp. This is smaller than the upstream connecting culvert, but is needed to fully utilize the detention volume in the upper levels of the north detention ponds where the majority of site fill will occur.

High Tailwater Review

After defining a viable detention plan, the models were then reconfigured to reflect a high tailwater condition in Ditch 10. This is done to determine peak flow conditions when Ditch 10 is near full. Previously, we found the design peak flood stage in Ditch 10 is elevation 25.0 feet during a 100-yr event.

The plan includes adding an emergency overflow weir at the most downstream detention pond. The weir crest will be set just above the computed 100-yr event peak flood stage in the final pond. It will be grassed lined and drivable for maintenance

The weir width is then set to limit discharges to the allowed rate (155cfs) at a maximum depth of 1.0 feet (the design freeboard). Thus, network outflows will be limited to the allowed rate while fully containing the storm water runoff. Notably, during normal operation weir flow will not be used.

To model this scenario, the tailwater was revised to peak at elevation 25.0 feet after the ascending limb reaches top of pipe (at elevation 20.3').

Thus, after elevation 20.3 feet, network outflows through the outfall pipe are significantly reduced. When the flood stage in the pond rises high enough, it will drive additional flows through the overflow weir starting at elevation 26.01'. Notably, the combined pipe and weir flow reaching Ditch 10 should still be limited to 155cfs.

A 34ft wide weir was selected as an initial estimate. It will include 6 to 1 side slopes and a 0.1% grade toward Ditch 10. Thus, it can be driven over by maintenance vehicles.

Upon adding this weir to the model (crest elevation 26.01'), flood stages in the final pond govern the driving head and thus governs discharges through the weir and outfall pipe.

Upon doing so, the model indicates the peak outflow will be 154.5cfs and the peak flood stage will be 26.77 feet. Thus, peak storm flows are compliant and remain confined within the ponds.

Results

Exhibit 7 shows the recommended components of the detention network. Connecting culverts and flow lines are identified.

Also shown is a detention summary. It shows the proposed network will provide 262 ac-ft of detention storage to serve 297 acres. This results in a detention storage rate of 0.88 acre-feet per acre.

For a project that averages 25% new impervious cover, 0.88 ac-ft per acre is a relatively high rate of storage. However, this is attributable to the relatively low allowable outflow rate (0.45cfs per ac). As desired, the maximum flow rate provided ensures the project will help advance the goals of the Master Drainage Plan.

Excavation totals 481,000 cubic yards. This includes 375,000 cubic yards of Storage Volume and 106,000 cubic yards of wet volume not used for detention.

The results on Exhibit 7 also show the maximum peak outflow. The 100-yr event is just below the maximum allowed at 155cfs. The 10yr event is 97cfs and the 5yr event is 77cfs.

Allowable rates for the 10-yr and 5-yr are not specified however the results are reasonable based on factoring the computed peak flows.

Below, allowable discharge rates are factored from the 100-yr specified rate (0.45cfs/ac) and the average peak flows for each storm event.

Peak Discharge Review	100yr	10yr	5yr
Average Peak Flow Rate (cfs/ac)	2.1	1.4	1.2
(1) Peak low Ratio to 100-yr	-	0.65	0.56
(2) Allowable Discharge cfs/ac	0.45	not specified	
Factored Allowable Discharge (1) x (2), (cfs/ac)	-	0.29	0.25
Total Area (ac)	344.2	344.2	344.2
Peak Allowable Discharge (cfs)	155	100	86
Peak Discharge Provided (cfs)	155	97	77

Above, the allowable peak discharges are shown relative to the prescribed 100-yr storm event. The proposed peaks do not exceed those maximum flow rates.

Included on Exhibit 6 are the model results for the 100-yr event. Below is a Summary;

POND VOLUME SUMMARY							
Pond ID	Type	Flow Line ft	Normal Pool ft	Peak Stage ft	Storage ac-ft	Top of Bank ft	Freeboard ft
NS-1	WET	16.60	16.60	28.64	16.84	29.64	1.00
NS-2	DRY	16.80	-	28.55	27.88	29.55	1.00
NS-3	WET	16.60	16.60	28.48	117.51	29.48	1.00
SS-1	WET	16.60	16.60	26.01	100.20	27.01	1.00

Phase 1 includes some 112 acres to the south and east as noted on Exhibit 7. The perimeter pipeline easement is discounted as developed property.

All drainage components defined herein which are located south of the arial easement should accompany that first phase of development.

The south ponds yield 100 ac-ft of storage which results in a detention storage rate of 0.88 ac-ft per acre. This well exceeds the design rate discussed above. Thus, the south pond alone can accommodate up to 113 acres of the planned development.

Notably, the north bank of pond SS-1 must not be filled prior to installing Pond NS-3 and its connecting culvert. Exhibit 7 includes appropriate notes.

This completes the detention analysis.

An additional review item includes the depth of outfall for the 48-acre offsite tract. The project should not incumber offsite flows in any way. To achieve this, the depth of outfall should mirror that found in the field.

Existing minimum flowline is at elevation 27.8 feet. This is located at the southwest corner of the tract next to the levee where flows historically drain.

Since the project will relocate that lowest outfall some 500 feet to the east, the flow line there must accommodate drainage from the SW corner.

Thus, the maximum flowline of the channel or pipe installed for the offsite channel should be 27.8' minus 500'@ 0.1% or 27.3 feet. See Exhibit 7.

Since the allowable rate of runoff matches the existing rate of runoff, no restrictor or pipe is required. Also, future development may add a deeper outfall pipe tying directly to the nearest manhole or detention pond with approval and coordination with the developer and the district.

Conclusions

- The detention network should provide 262-acre feet of detention storage.
- The final outfall should be a 48"CMP with a D/S FL = 16.3' and U/S FL=16.6'
- The final pond should include an emergency overflow grassed weir with a crest of 26.01 feet, a bottom width of 34 feet, 6 to 1 sideslopes, and a 0.1% driving slope.
- The maximum allowable discharge is 155cfs for a 100yr event. Provided is 155cfs.
- The elevation of normal standing water is Ditch 10 is approximated at 15.8'
- The interior detention network should match that shown on Exhibit 7.
- The detention ponds should provide storage as shown on Exhibit 5.
- There are 48 acres to the northwest that will drain through the new network.
    - The conveyance capacity for that offsite area provided by the network matches the existing runoff (0.45cfs/ac 100yr event or 22cfs)
    - The elevation of the receiving channel or pipe at the edge of property must be no higher than 27.3 feet.
- The west property line skirts a swale along an existing levee.
    - The backs of lot along that levee lie east of that swale top of bank.
    - The swale must be redesigned based on the final grading plan.
    - The swale redesign should prevent adverse impacts to the existing culvert crossings under CR 28 to the south.
    - A drainage easement may be needed to accommodate access to that swale.
- The recommended facilities herein are compliant with the criteria.
- The first 112 acres built south of the aerial easement should include Pond SS-1 and its outfall to Ditch 10. However, no bank fill on the north side of Pond SS-1should occur prior to installing Pond NS-3.
- Post Construction there will be no adverse impacts to perimeter tracts that drain through the project area.
- Post Construction, there will be no adverse impacts to receiving water bodies for storm events up to and including the ATLAS-14 100-yr event.

I trust you will find this information adequate for your review and acceptance. However, if you need additional information or have further instruction, contact me anytime.

Regards,

May 7, 2024
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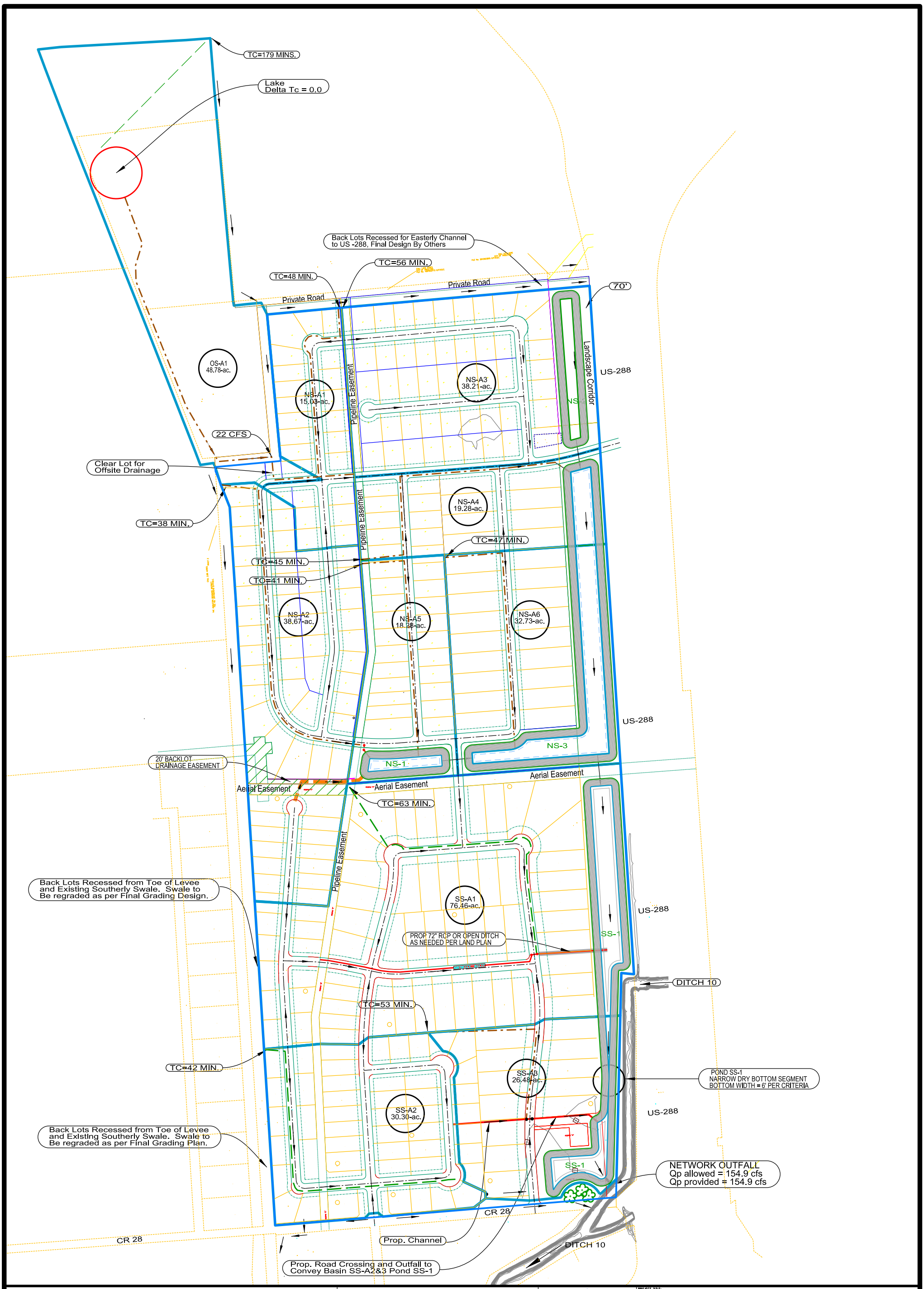

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PROJECT TITLE:	Serenity Oaks - Detention Plan	
DRAWN BY:	SHEET DESCRIPTION: EXHIBIT 1	JOB NO:
CK'D BY:	PROPOSED DRAINAGE AREA MAP	FILE NAME:
SCALE:	REVISED LAND PLAN	FILE NO:
DATE: May 2024	APPROVED BY:	SHT NO:

SERENITY OAKS DETENTION PLAN

ULTIMATE CONDITIONS - RATIONAL METHOD PEAK RUNOFF COMPUTATIONS

100-yr Sub-Area	Basin Area (ac.)	Time of Concentration Tc (min.)													I 100-yr (in/hr)	"C" & % Imp.					Q 100-yr (cfs)
		Total Path (ft)	Overland/Lots					Roadside Ditches			Pipe Outfalls			Total Tc			Open Pasture	Lots > 1 ac. Avg.	Detention Ponds	Composite "C"	Composite "% Imp"	
			L	N	Delta	S	Tc (mins)	Length	Vel (fps)	Tc (mins)	Length	Vel (fps)	Tc (mins)	(mins.)	(hrs.)							
	Overland Vel. Eq. from BDD5 Criteria		Kerby Equation, Tov=0.828*LN$^{(0.476)}$*S$^{(-0.235)}$					Average Design Velocity along Streets. V=f(Normal Depth)			Avg. Design Velocity along Outfall Pipes and Crossings						*Braz. Co. "C" Value*	*0.15*	*0.35*	*0.75*	Result		
			N=	0.4	Pasture/Avg. Grass												*Braz. Co. %Imp*	*5*	*22*	*85*			
ULTIMATE																						
OS-A1	48.78	3800	3000	0.4	0.6	0.0002	171.5	400	1.5	4.4	400	2.0	3.3	179	2.987	2.902	47.35	1.43		0.16	5.5	22.1
NS-A1	15.03	2740	180	0.4	1.0	0.006	20.7	2330	1.5	25.9	230	2.0	1.9	48	0.808	5.755		15.03		0.35	22.0	30.3
NS-A2	38.67	3730	240	0.4	1.0	0.004	25.3	1940	1.5	21.6	180	2.0	1.5	48	0.806	5.762	2.21	36.45		0.34	21.0	75.4
NS-A3	38.67	1350	350	0.4	1.0	0.003	33.0	1805	1.5	20.1	320	2.0	2.7	56	0.928	5.356	4.17	30.89	3.61	0.37	26.0	75.7
NS-A4	19.28	1489	270	0.4	1.0	0.004	27.5	1470	1.5	16.3	120	2.0	1.0	45	0.747	5.993	1.21	15.45	2.62	0.39	29.5	45.3
NS-A5	18.28	1330	270	0.4	1.0	0.004	27.5	1200	1.5	13.3	70	2.0	0.6	41	0.690	6.242	2.37	13.94	1.97	0.37	26.6	41.9
NS-A6	32.72	3050	350	0.4	1.0	0.003	33.0	1200	1.5	13.3	70	2.0	0.6	47	0.781	5.855	2.05	20.63	10.04	0.46	40.3	88.2
SS-A1	76.46	1562	480	0.4	1.0	0.002	41.2	1630	1.5	18.1	450	2.0	3.8	63	1.050	5.023	6.10	63.47	6.89	0.37	26.3	142.1
SS-A2	30.30	3240	130	0.4	1.0	0.008	16.5	2200	1.5	24.4	150	2.0	1.3	42	0.702	6.185	1.31	28.99		0.34	21.3	64.0
SS-A3	26.02	1240	680	0.4	1.7	0.003	46.4	560	1.5	6.2	0	2.0	0.0	53	0.877	5.516	4.71	17.73	3.58	0.37	27.6	52.9
Total Area	*344.20*	*344.20* *pproved area*															*71.48*	*244.00*	*28.72*	344.20	0.00	check

10-yr Sub-Area	Basin Area (ac.)	Time of Concentration Tc (min.)													I 10-yr (in/hr)	"C" & % Imp.					Q 10-yr (cfs)
		Total Path (ft)	Lawn					Streets			Pipe Outfalls			Total Tc			Lots	Residential (1 ac.)	Detention	Composite "C"	Composite "% Imp"	
			Length	Vel (fps)	Delta	S	Tc (mins)	Length	Vel (fps)	Tc (mins)	Length	Vel (fps)	Tc (mins)	(mins.)	(hrs.)							
ULTIMATE																						
OS-A1	48.78	3800	3000	0.4	0.6	0.0002	171	400	2	4	400	2	3	179	2.987	1.675	47.35	1.43		0.16	5.5	12.7
NS-A1	15.03	2740	180	0.4	1.0	0.006	20.7	2330	1.5	25.9	230	2.0	1.9	48	0.808	3.773		15.03		0.35	22.0	19.8
NS-A2	38.67	3730	240	0.4	1.0	0.004	25.3	1940	1.5	21.6	180	2.0	1.5	48	0.806	3.778	2.21	36.45		0.34	21.0	49.5
NS-A3	38.67	1350	350	0.4	1.0	0.003	33.0	1805	1.5	20.1	320	2.0	2.7	56	0.928	3.477	4.17	30.89	3.61	0.37	26.0	49.2
NS-A4	19.28	1489	270	0.4	1.0	0.004	27.5	1470	1.5	16.3	120	2.0	1.0	45	0.747	3.949	1.21	15.45	2.62	0.39	29.5	29.8
NS-A5	18.28	1330	270	0.4	1.0	0.004	27.5	1200	1.5	13.3	70	2.0	0.6	41	0.690	4.132	2.37	13.94	1.97	0.37	26.6	27.7
NS-A6	32.72	3050	350	0.4	1.0	0.003	33.0	1200	1.5	13.3	70	2.0	0.6	47	0.781	3.847	2.05	20.63	10.04	0.46	40.3	57.9
SS-A1	76.46	1562	480	0.4	1.0	0.002	41.2	1630	1.5	18.1	450	2.0	3.8	63	1.050	3.230	6.10	63.47	6.89	0.37	26.3	91.4
SS-A2	30.30	3240	130	0.4	1.0	0.008	16.5	2200	1.5	24.4	150	2.0	1.3	42	0.702	4.090	1.31	28.99		0.34	21.3	42.3
SS-A3	26.02	1240	680	0.4	1.7	0.003	46.4	560	1.5	6.2		2.0		53	0.877	3.596	4.71	17.73	3.58	0.37	27.6	34.5
Total Area	*344.20*																*71.48*	*244.00*	*28.72*	344.20	0.00	check

5-yr Sub-Area	Basin Area (ac.)	Time of Concentration Tc (min.)													I 5-yr (in/hr)	"C" & % Imp.					Q 5-yr (cfs)
		Total Path (ft)	Lawn					Streets			Pipe Outfalls			Total Tc			Open Pastureland	Residential (1 ac.)	Detention	Composite "C"	Composite "% Imp"	
			Length	Vel (fps)			Tc (mins)	Length	Vel (fps)	Tc (mins)	Length	Vel (fps)	Tc (mins)	(mins.)	(hrs.)							
ULTIMATE																						
OS-A1	48.78	3800	3000	0.4	0.6	0.0002	171	400	2	4	400	2	3	179	2.987	1.392	47.35	1.43		0.16	5.5	10.6
NS-A1	15.03	2740	180	0.4	1.0	0.006	20.7	2330	1.5	25.9	230	2.0	1.9	48	0.808	3.232		15.03		0.35	22.0	17.0
NS-A2	38.67	3730	240	0.4	1.0	0.004	25.3	1940	1.5	21.6	180	2.0	1.5	48	0.806	3.237	2.21	36.45		0.34	21.0	42.4
NS-A3	38.67	1350	350	0.4	1.0	0.003	33.0	1805	1.5	20.1	320	2.0	2.7	56	0.928	2.972	4.17	30.89	3.61	0.37	26.0	42.0
NS-A4	19.28	1489	230	0.4	1.0	0.004	24.6	1169	1.5	13.0	90	2.0	0.8	38	0.638	3.712	1.21	15.45	2.62	0.39	29.5	28.0
NS-A5	18.28	1330	270	0.4	1.0	0.004	27.5	1200	1.5	13.3	70	2.0	0.6	41	0.690	3.548	2.37	13.94	1.97	0.37	26.6	23.8
NS-A6	32.72	3050	350	0.4	1.0	0.003	33.0	1200	1.5	13.3	70	2.0	0.6	47	0.781	3.297	2.05	20.63	10.04	0.46	40.3	49.6
SS-A1	76.46	1562	480	0.4	1.0	0.002	41.2	1630	1.5	18.1	450	2.0	3.8	63	1.050	2.755	6.10	63.47	6.89	0.37	26.3	78.0
SS-A2	30.30	3240	130	0.4	1.0	0.008	16.5	2200	1.5	24.4	150	2.0	1.3	42	0.702	3.511	1.31	28.99		0.34	21.3	36.3
SS-A3	26.02	1240	680	0.4	1.7	0.003	46.4	560	1.5	6.2		2.0		53	0.877	3.077	4.71	17.73	3.58	0.37	27.6	29.5
Total Area	*344.20*																*71.48*	*244.00*	*28.72*	344.20	0.00	check

Rainfall Intensity-Duration-Frequency Coefficients

Brazoria County Drainage Criteria Manual / Region 1

Coeff	2-year	10-year	25-year	100-year	500-yr
e	0.754	0.676	0.618	0.533	0.474
b (in)	57.440	57.515	52.780	46.316	47.179
d (mins)	11.511	7.777	5.022	1.555	0.322

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FIRM F-5076

STATE OF TEXAS — LAWRENCE B. LOPEZ — 78660 — LICENSED — PROFESSIONAL ENGINEER

PROJECT TITLE: Serenity Oaks - Detention Plan
DRAWN BY:
CK'D BY:
SCALE:
DATE: May 2024
SHEET DESCRIPTION: EXHIBIT 2 / RATIONAL METHOD / PEAK RUNOFF COMPUTATION
APPROVED BY:
JOB NO:
FILE NAME:
FILE NO:
SHT NO: /

MALCOLM'S SMALL WATERSHED METHOD
100YR EVENT

Table 1 (cont.)
SERENTIY LAKES
Small Watershed Hydrographs (100yr Event)

Subarea	Area(ac)	% Imp	in*	ft	Vol(ft³)	Tp(sec)	Qp	1.25*Tp
OS-A1	48.78	5	**14.44**	1.204	2557603	83387	**22.1**	**28.95**
NS-A1	15.03	22	**14.87**	1.239	811335	19283	**30.3**	**6.70**
NS-A2	38.67	21	**14.85**	1.237	2083901	19874	**75.4**	**6.90**
NS-A3	38.67	26	**14.98**	1.248	2102206	19967	**75.7**	**6.93**
NS-A4	19.28	29	**15.07**	1.256	1054537	16757	**45.3**	**5.82**
NS-A5	18.28	27	**14.99**	1.249	994774	17076	**41.9**	**5.93**
NS-A6	32.72	40	**15.35**	1.279	1822739	14876	**88.2**	**5.17**
SS-A1	76.46	26	**14.98**	1.249	4158692	21048	**142.1**	**7.31**
SS-A2	30.30	21	**14.85**	1.238	1633671	18373	**64.0**	**6.38**
SS-A3	26.02	28	**15.02**	1.251	1418375	19273	**52.9**	**6.69**

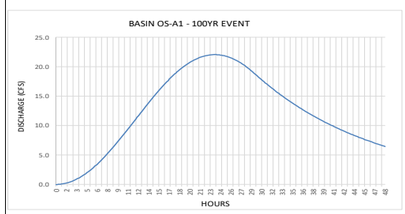
**Rainfall Excess Runoff (in.) 100-yr Event Taken from BCDCM Table 2-4 Region 1*

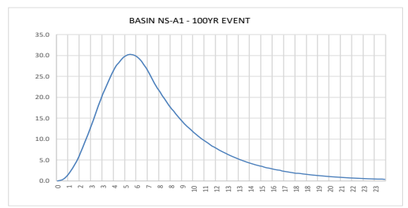
% Impervious	*0*	*20*	*40*	*60%*	*80*	***Total Runoff***
Runoff	*14.30*	*14.82*	*15.34*	*15.86*	*16.38*	*17.00*

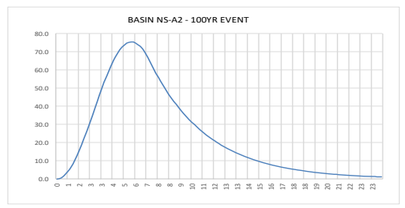
EXCESS RUNOFF FROM Bz. Co. DCM TABLE 2.4

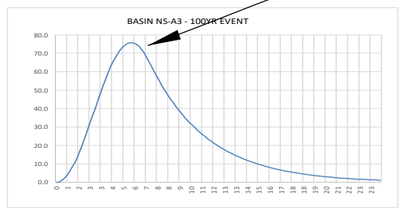
427.87

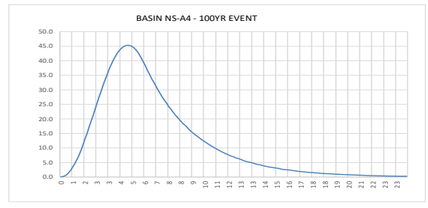
HYDROGRAPH PEAKS MATCH RATIONAL METHOD COMPUTATIONS

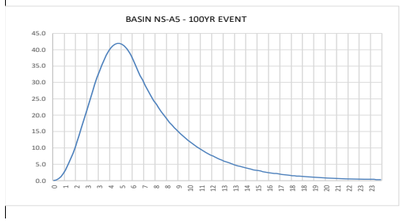


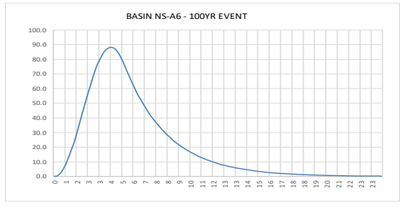


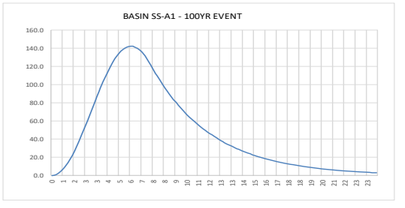


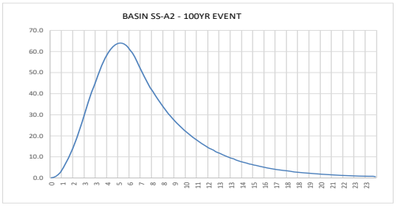












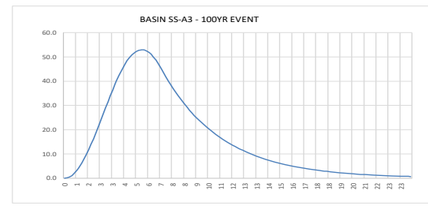
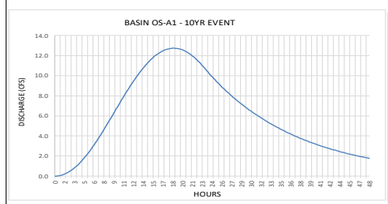


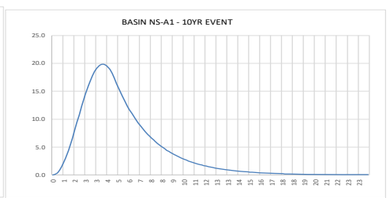
Table 1 (cont.)
SERENTIY LAKES
Small Watershed Hydrographs (10yr Event)

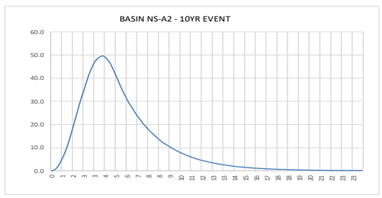
Subarea	Area(ac)	% Imp	in*	ft	Vol(ft³)	Tp(sec)	Qp	1.25*Tp
OS-A1	48.78	5	**6.53**	0.544	1156216	65308	**12.7**	**22.68**
NS-A1	15.03	22	**6.92**	0.576	377299	13678	**19.8**	**4.75**
NS-A2	38.67	21	**6.89**	0.574	967597	14073	**49.5**	**4.89**
NS-A3	38.67	26	**7.01**	0.584	983790	14392	**49.2**	**5.00**
NS-A4	19.28	29	**7.09**	0.591	496122	11965	**29.8**	**4.15**
NS-A5	18.28	27	**7.02**	0.585	465935	12083	**27.7**	**4.20**
NS-A6	32.72	40	**7.34**	0.611	871300	10823	**57.9**	**3.76**
SS-A1	76.46	26	**7.02**	0.585	1947032	15326	**91.4**	**5.32**
SS-A2	30.30	21	**6.90**	0.575	758830	12905	**42.3**	**4.48**
SS-A3	26.02	28	**7.04**	0.587	665366	13868	**34.5**	**4.82**

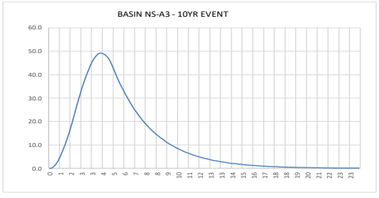
**Rainfall Excess Runoff (in.) 10-yr Event Taken from BCDCM Table 2- -Region 1*

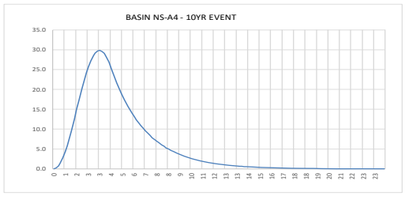
% Impervious	*0*	*20*	*40*	*60%*	*80*	***Total Runoff***
Runoff	*6.40*	*6.87*	*7.33*	*7.80*	*8.26*	*8.83*

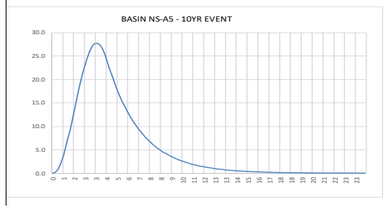


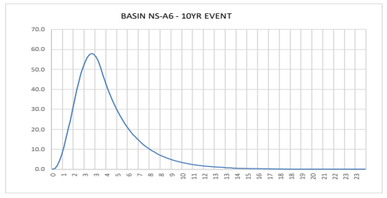


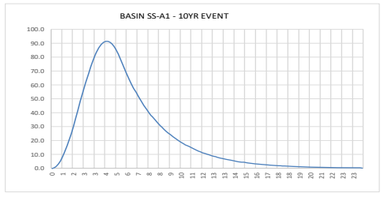


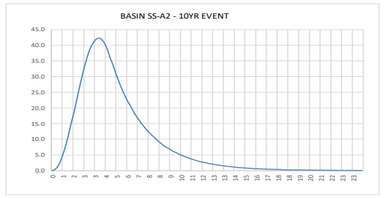


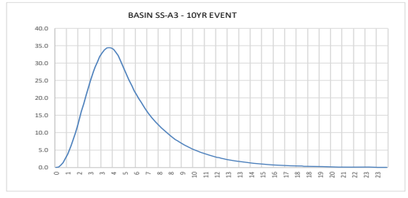












NO.	REVISIONS	DATE	NAME

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FIRM F-5076

STATE OF TEXAS
LAWRENCE S. LOPEZ
103635
LICENSED
PROFESSIONAL ENGINEER

PROJECT TITLE: Serenity Oaks - Detention Plan
DRAWN BY:
CK'D BY:
SCALE:
DATE: MAY, 2024
SHEET DESCRIPTION: EXHIBIT 3 SMALL WATERSHED METHOD HYDROGRAPHS
APPROVED BY:
JOB NO:
FILE NAME:
FILE NO:
SHT NO: /

MALCOLM'S SMALL WATERSHED METHOD
5YR EVENT

Table 1 (cont.)
SERENTIY LAKES
Small Watershed Hydrographs (5yr Event)

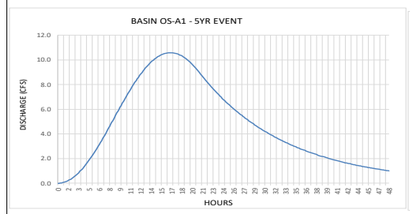
Subarea	Area(ac)	% Imp	in*	ft	Vol(ft³)	Tp(sec)	Qp	1.25*Tp
OS-A1	48.78	5	**4.88**	0.407	864339	58750	**10.6**	**20.40**
NS-A1	15.03	22	**5.24**	0.437	286084	12105	**17.0**	**4.20**
NS-A2	38.67	21	**5.22**	0.435	733050	12444	**42.4**	**4.32**
NS-A3	38.67	26	**5.33**	0.444	748538	12811	**42.0**	**4.45**
NS-A4	19.28	29	**5.41**	0.451	378574	9713	**28.0**	**3.37**
NS-A5	18.28	27	**5.35**	0.445	354684	10711	**23.8**	**3.72**
NS-A6	32.72	40	**5.65**	0.470	670549	9716	**49.6**	**3.37**
SS-A1	76.46	26	**5.34**	0.445	1481795	13676	**78.0**	**4.75**
SS-A2	30.30	21	**5.23**	0.436	575007	11391	**36.3**	**3.96**
SS-A3	26.02	28	**5.37**	0.447	506921	12348	**29.5**	**4.29**

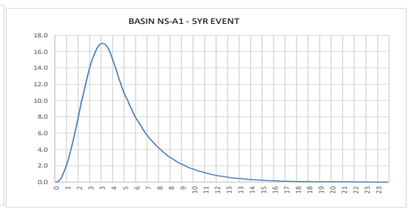
**Rainfall Excess Runoff (in.) 10-yr Event Taken from BCDCM Table 2- -Region 1*

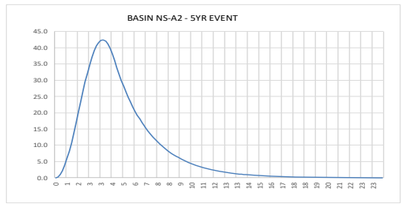
% Impervious	*0*	*20*	*40*	*60%*	*80*	***Total Runoff***
Runoff	*4.76*	*5.20*	*5.64*	*6.07*	*6.51*	*7.05*

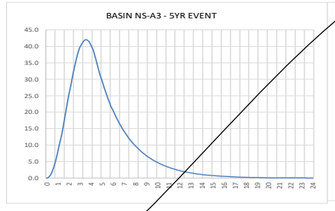
EXCESS RUNOFF FROM BzCo. DCM TABLE 2.4

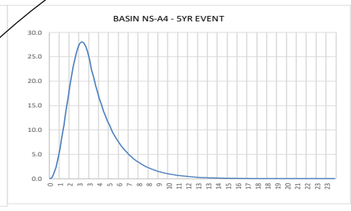
HYDROGRAPH PLOTS
PEAKS MATCH RATIONAL

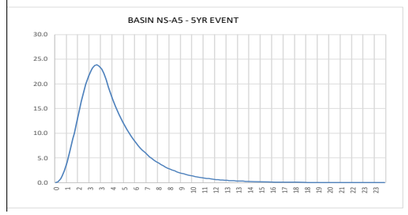


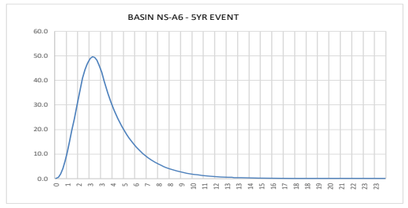


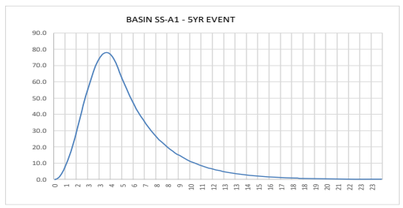


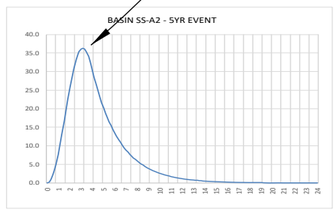


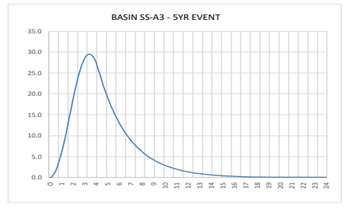












NO.	REVISIONS	DATE	NAME

BEHRENS LAND GROUP, INC

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FIRM F-5076

STATE OF TEXAS
LAWRENCE S. LOPEZ
103615
LICENSED
PROFESSIONAL ENGINEER

PROJECT TITLE: Serenity Oaks - Detention Plan

DRAWN BY:
CK'D BY:
SCALE:
DATE: **MAY, 2024**
APPROVED BY:

SHEET DESCRIPTION: EXHIBIT 4
SMALL WATERSHED
METHOD HYDROGRAPHS

JOB NO.
FILE NAME:
FILE NO.
SHT NO. /

Table 2
SERENITY OAKS DRAINAGE PLAN
Proposed Detention Pond Geometry

SERENITY OAKS - POND NS-1		**WET POND**		
Elevation	Area	Area	Inc. Volume	Total Volume
ft	sq.ft.	ac.	ac-ft	ac-ft
10.60	18690	0.4291		0.00
16.60	32925	0.7558	3.51	3.51
16.60	32925	0.7558	0.00	0.00
17.60	37245	0.8550	0.80	0.80
18.60	41667	0.9565	0.91	1.71
19.60	46188	1.0603	1.01	2.72
20.60	50811	1.1664	1.11	3.83
21.60	55533	1.2749	1.22	5.05
22.60	60357	1.3856	1.33	6.38
23.60	65281	1.4986	1.44	7.82
24.60	70305	1.6140	1.56	9.38
25.60	75430	1.7316	1.67	11.05
26.60	80655	1.8516	1.79	12.84
27.60	85981	1.9739	1.91	14.76
29.64	88682	2.0359	4.09	18.84
			Interpolated Volume	
28.64			Total Volume	**16.84**
29.64	**T/B ELEV.**		10-yr Peak Stage	23.39
			5-yr Peak Stage	22.09

SERENITY OAKS - POND NS-3		**WET POND**		
Elevation	Area	Area	Inc. Volume	Total Volume
ft	sq.ft.	ac.	ac-ft	ac-ft
10.60	231850	5.3225		0.00
16.60	304426	6.9887	36.82	36.82
16.60	304426	6.9887	0.00	0.00
17.60	325422	7.4707	7.23	7.23
18.60	346518	7.9550	7.71	14.94
19.60	367714	8.4416	8.20	23.14
20.60	389011	8.9305	8.68	31.82
21.60	410409	9.4217	9.17	41.00
22.60	431907	9.9152	9.67	50.66
23.60	453506	10.4111	10.16	60.83
24.60	475205	10.9092	10.66	71.49
25.60	497005	11.4097	11.16	82.64
26.60	518905	11.9124	11.66	94.30
27.60	540906	12.4175	12.16	106.47
29.47	551944	12.6709	23.46	129.93
Model Result			Interpolated Volume	
28.48			Total Volume	**117.51**
29.48	**T/B ELEV.**		10-yr Peak Stage	23.33
			5-yr Peak Stage	22.05

SERENITY OAKS - POND NS-2		**DRY POND**		
Elevation	Area	Area	Inc. Volume	Total Volume
ft	sq.ft.	ac.	ac-ft	ac-ft
16.60	0	0.0000	0.00	0.00
17.40	62836	1.4425	0.38	0.38
18.40	**70507**	1.6186	1.53	1.91
19.40	78279	1.7970	1.71	3.62
20.40	86152	1.9778	1.89	5.51
21.40	94125	2.1608	2.07	7.58
22.40	102199	2.3462	2.25	9.83
23.40	110374	2.5338	2.44	12.27
24.40	118648	2.7238	2.63	14.90
25.40	127024	2.9161	2.82	17.72
26.40	135500	3.1106	3.01	20.73
27.40	144076	3.3075	3.21	23.94
28.40	152753	3.5067	3.41	27.34
29.57	157129	3.6072	4.16	31.51
Model Result			Interpolated Volume	
28.55			Total Volume	**27.88**
29.55	**T/B ELEV.**		10-yr Peak Stage	23.37
			5-yr Peak Stage	22.08

SERENITY OAKS - POND SS-1		**WET POND**		
Elevation	Area	Area	Inc. Volume	Total Volume
ft	sq.ft.	ac.	ac-ft	ac-ft
10.60	136435	3.1321		0.00
16.60	235050	5.3960	25.28	25.28
16.60	235050	5.3960	0.00	25.28
17.60	258485	5.9340	5.66	30.94
18.60	282022	6.4743	6.20	37.14
19.60	305658	7.0170	6.74	43.89
20.60	329396	7.5619	7.29	51.17
21.60	353234	8.1091	7.83	59.01
22.60	377172	8.6587	8.38	67.39
23.60	401211	9.2105	8.93	76.32
24.60	425351	9.7647	9.49	85.81
25.60	449591	10.3212	10.04	95.85
26.60	473931	10.8800	10.60	106.45
27.00	486139	11.1602	4.41	110.86
Model Result			Interpolated Volume	
26.01			Total Volume	**100.20**
27.01	**T/B ELEV.**		10-yr Peak Stage	22.27
			5-yr Peak Stage	21.33

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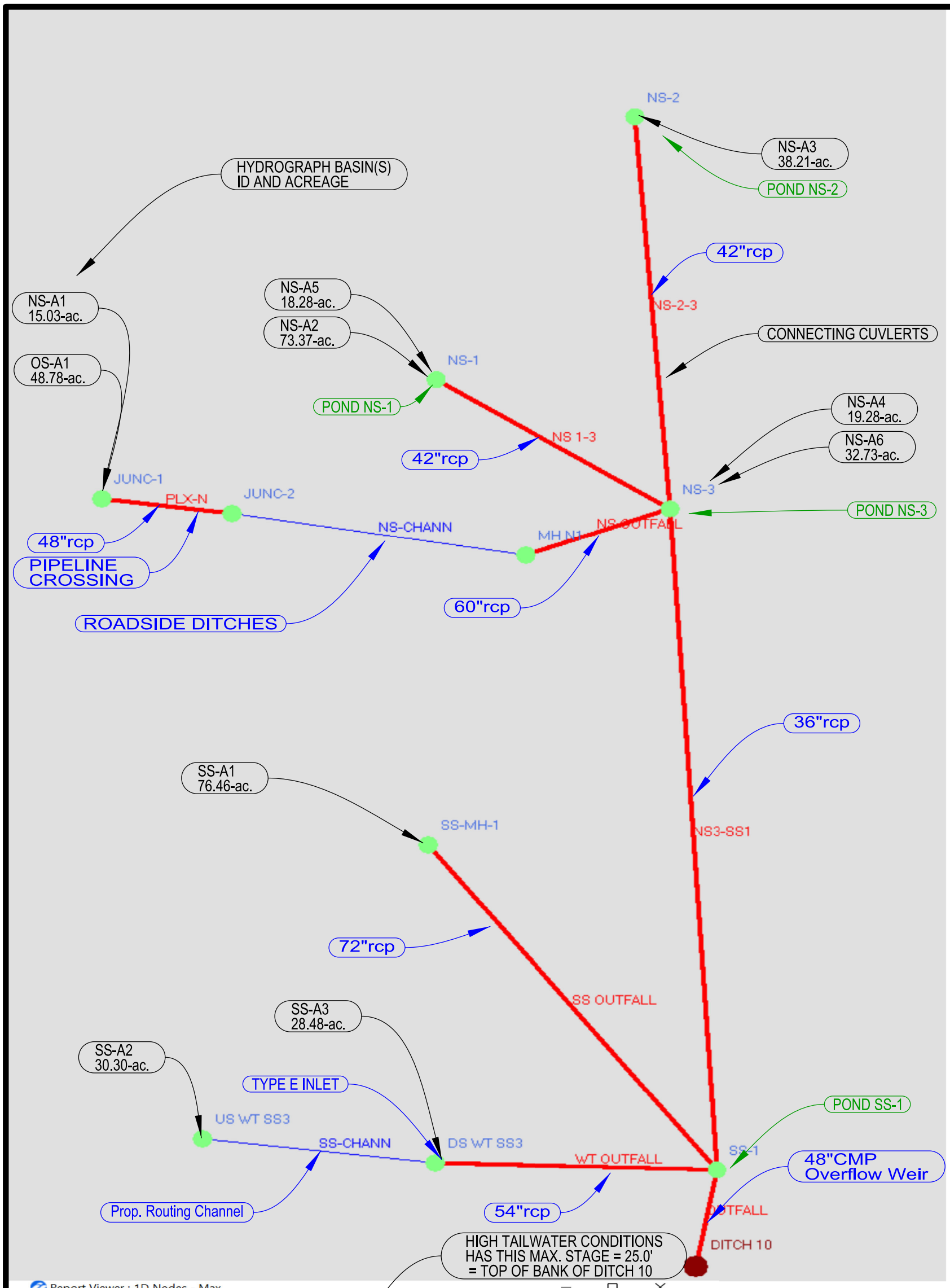
LAWRENCE S. LOPEZ

PROJECT TITLE:	Serenity Oaks - Detention Plan	
DRAWN BY:	SHEET DESCRIPTION:	JOB NO:
CK'D BY:	EXHIBIT 5	FILE NAME:
SCALE:	BASIN GEOMETRY	FILE NO:
DATE: May 2024	APPROVED BY:	SHT NO:



Report Viewer : 1D Nodes - Max

Menu

PEAK FLOOD STAGES

Node Name	Maximum Stage [ft]	num Total Inflow Rate [cfs]	num Total Outflow Rate [cfs]
DITCH 10	20.30	154.88	0.00
DS WT SS3	26.29	116.75	116.69
JUNC-1	29.19	33.15	33.16
JUNC-2	28.99	77.04	76.90
MH N1	28.52	76.90	76.90
NS-1	28.64	115.76	74.87
NS-2	28.55	75.73	22.20
NS-3	28.48	245.34	71.17
SS-1	26.01	277.56	154.88
SS-MH-1	26.29	142.14	142.09
US WT SS3	27.93	63.95	63.94

100yr Event:

155-cfs peak outflow to Ditch 10 under Normal Tailwater Conditons

154-cfs peak outflow to Ditch 10 under High Tailwater Conditions

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STATE OF TEXAS LAWRENCE S. LOPES 106466 ENGINEER

PROJECT TITLE: Serenity Oaks - Detention Plan

DRAWN BY:

CK'D BY:

SCALE:

DATE: May 2024

SHEET DESCRIPTION: EXHIBIT 6 ICPR MODEL LAYOUT

APPROVED BY:

JOB NO:

FILE NAME:

FILE NO:

SHT NO:

STORAGE VOLUME (ac-ft)

North Vol	162
South Vol	100
Tot. Vol.	262
Project Developed Area	297
Cs (ac-ft/ac)	**0.88**

DRY EXCAVATION VOLUME

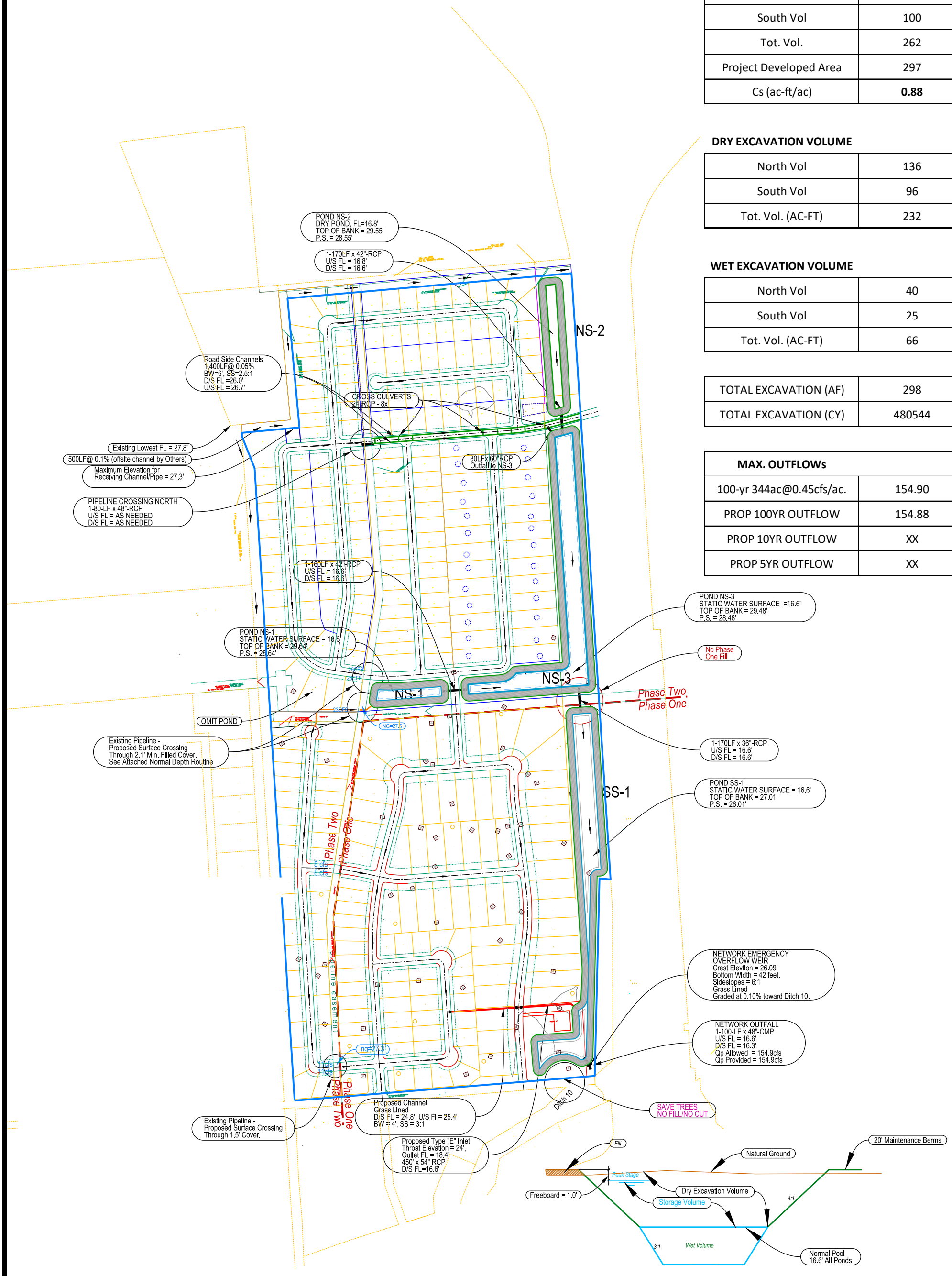
North Vol	136
South Vol	96
Tot. Vol. (AC-FT)	232

WET EXCAVATION VOLUME

North Vol	40
South Vol	25
Tot. Vol. (AC-FT)	66

TOTAL EXCAVATION (AF)	298
TOTAL EXCAVATION (CY)	480544

MAX. OUTFLOWs	
100-yr 344ac@0.45cfs/ac.	154.90
PROP 100YR OUTFLOW	154.88
PROP 10YR OUTFLOW	XX
PROP 5YR OUTFLOW	XX



Typical Section Wet Ponds

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PROJECT TITLE:	Serenity Oaks - Detention Plan	
DRAWN BY:	SHEET DESCRIPTION: EXHIBIT 7 PROPOSED DETENTION NETWORK REVISED LAND PLAN	JOB NO:
CK'D BY:		FILE NAME:
SCALE:		FILE NO:
DATE: May 2024	APPROVED BY:	SHT NO: