TETRA TECH

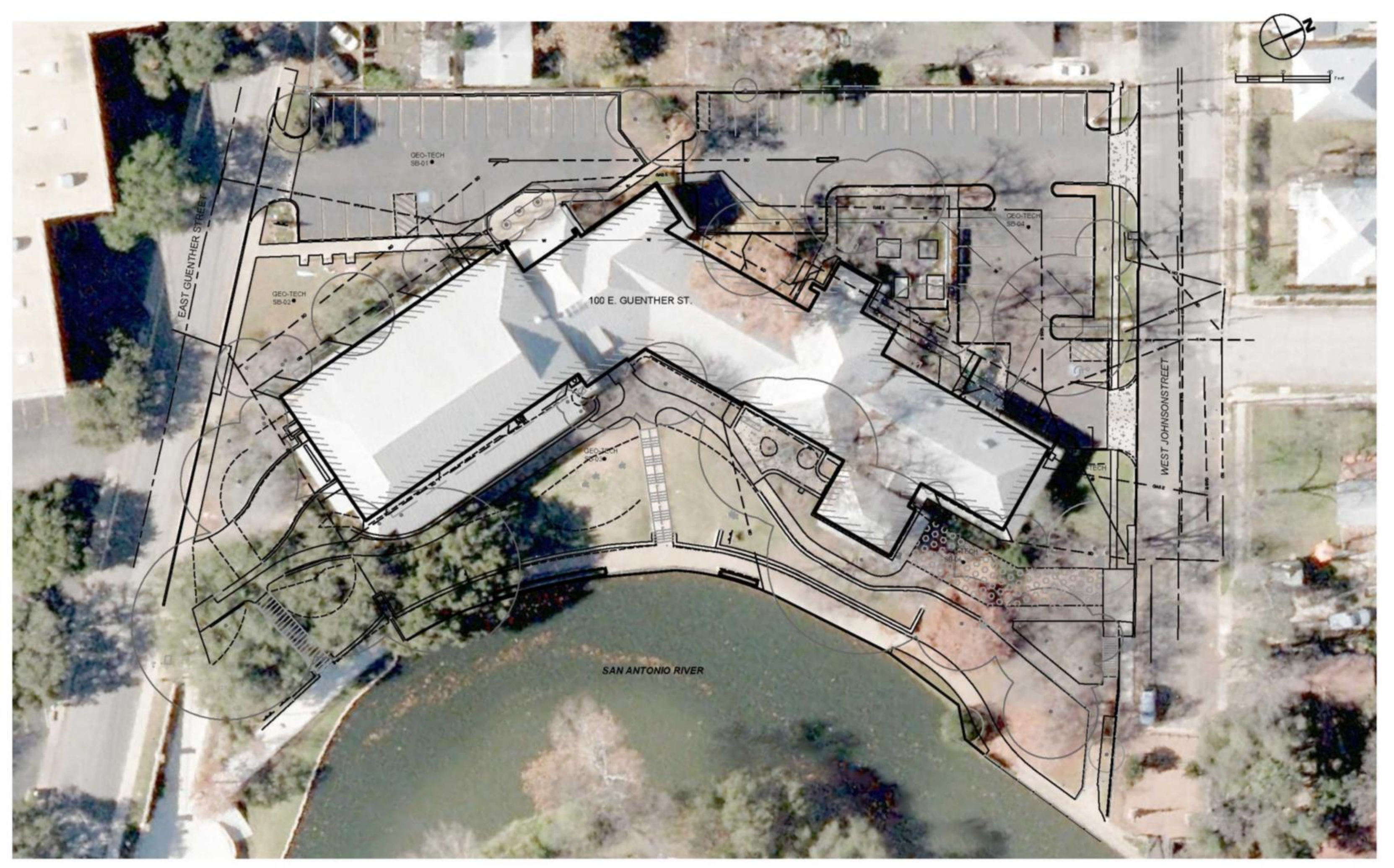
Modeling, Design, and Construction of a Commercial Low Impact Development Retrofit

Troy Dorman, Ph.D, PE, CFM

Overview

- The Site
- Triple Bottom Line Approach
- SUSTAIN Modeling and Optimization
- Concept Design
- Final Design
- Construction

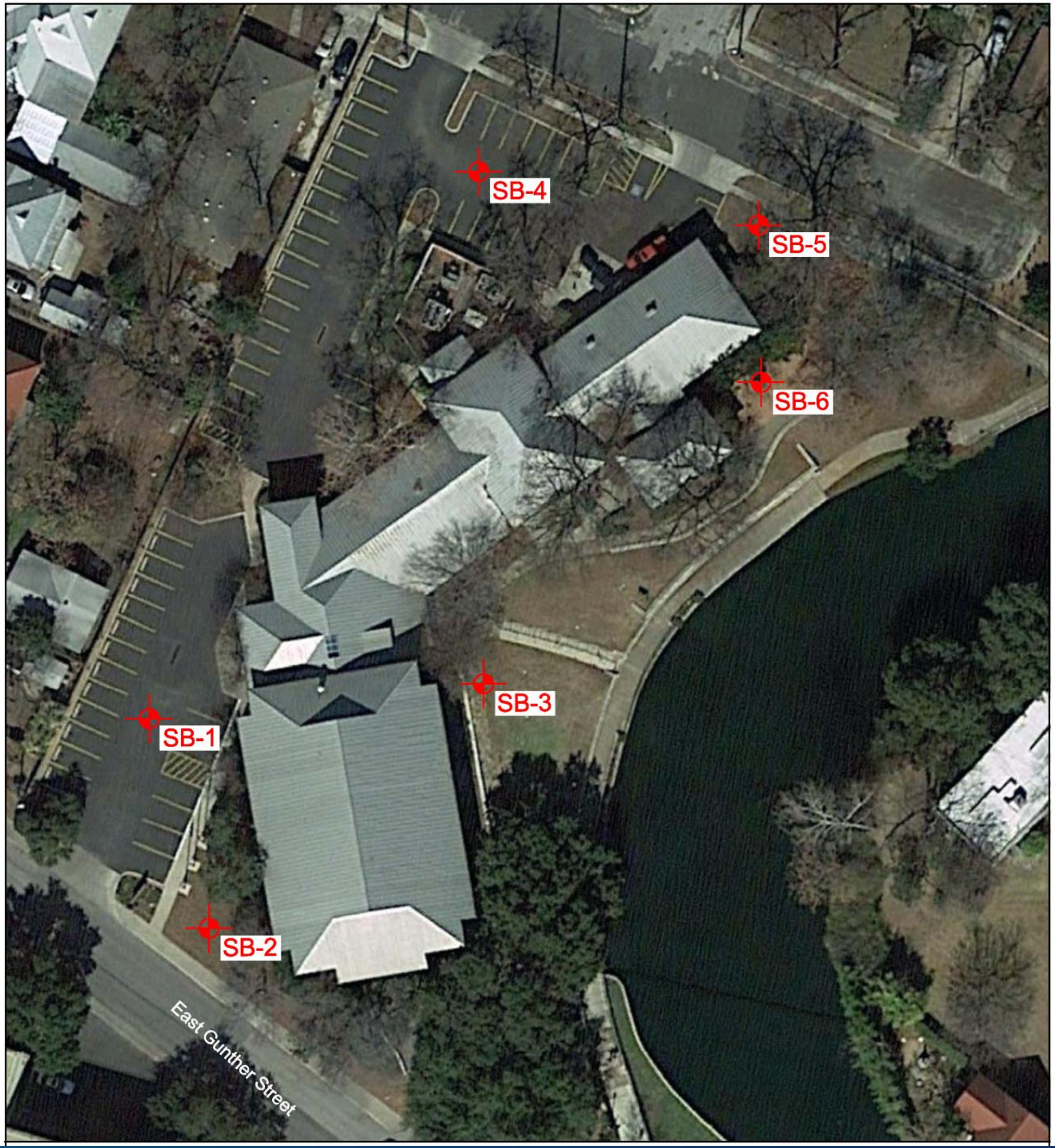
Existing Site Layout



Existing Site C

Grading
Landscaping
Downspouts
Utilities
Parking
Maintenance

Soil Borings



SB-2

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BORING LOG NO. SB-02 Page 1 of 1

PROJECT: SARA Guenther LID Retrofit	CLIENT: Tetra Tech, Inc. San Antonio, Texas
SITE: 100 E. Guenther Street San Antonio, Texas	

LOCATION See Exhibit A-2 Latitude: 29.412747° Longitude: -98.496821° ATTERBERG LIMITS

GRAPHIC LOG	LOCATION See Exhibit A-2 Latitude: 29.412747° Longitude: -98.496821° DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
	FILL-SANDY LEAN CLAY with GRAVEL (CL); dark brown, brown and tan				4.5 (HP)	6	41-16-25	59
					29-14-33 N=47	7		
	4.0 **FILL-CLAYEY GRAVEL (GC)**; tan	5			7-12-10 N=22	9	42-18-24	49
					8-13-18 N=31	10		
		10			4-3-3 N=6	8		30
	13.0 **SANDY FAT CLAY (CH)**; dark brown, with roots and organics				4-2-4 N=6	18		

Triple Bottom Line Analysis Factors - Economic

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- Life cycle costs
- Traditional Cost = Replacement Cost + Maintenance Cost
- LID Cost = BMP Construction Cost + Maintenance Cost
  - Use SUSTAIN output for LID planning-level costs
  - Verify that maintenance costs seem reasonable for future maintenance needs, including vegetation
- Property values
- GI Value = Property Value X 4% + Tree Mitigation Cost/iTree Value X 2%
- Based on the studies in the table below, we would recommend assuming a 4 percent increase in property value when adding trees.

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Triple Bottom Line Analysis – Economic Cont.

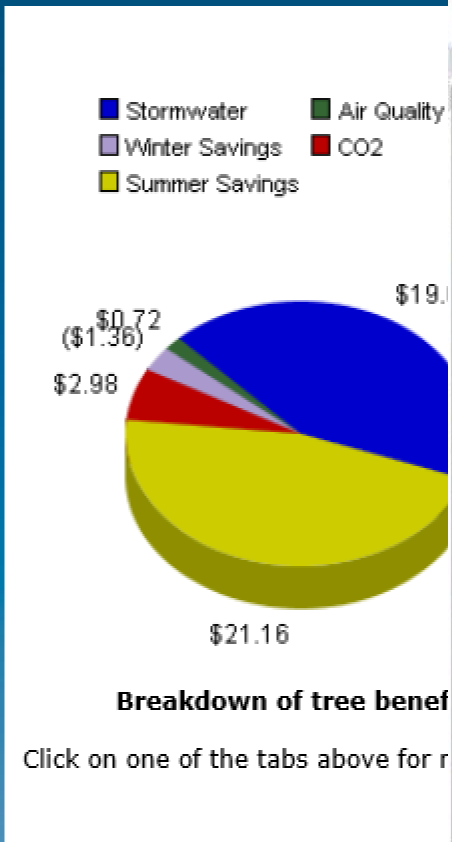
Source	Percent increase in Property Value	Notes
Ward et al. (2008)	3.5 to 5%	Estimated effect of LID on adjacent properties relative to those farther away in King County (Seattle), WA.
Shultz and Schmitz (2008)	0.7 to 2.7%	Referred to effect of clustered open spaces, greenways and similar practices in Omaha, NE.
Wachter and Wong (2008)	2%	Estimated the effect of tree plantings on property values for select neighborhoods in Philadelphia.
Anderson and Cordell (1988)	3.5 to 4.5%	Estimated value of trees on residential property (differences between houses with five or more front yard trees and those that have fewer), Athens-Clarke County (GA).
Voicu and Been (2008)	9.4%	Refers to property within 1,000 feet of a park or garden and within 5 years of park opening; effect increases over time
Espey and Owasu-Edusei (2001)	11%	Refers to small, attractive parks with playgrounds within 600 feet of houses
Pincetl et al. (2003)	1.5%	Refers to the effect of an 11% increase in the amount of greenery (equivalent to a one-third acre garden or park) within a radius of 200 to 500 feet from the house
Hobden, Laughton and Morgan (2004)	6.9%	Refers to greenway adjacent to property
New Yorkers for Parks and Ernst & Young (2003)	8 to 30%	Refers to homes within a general proximity to parks

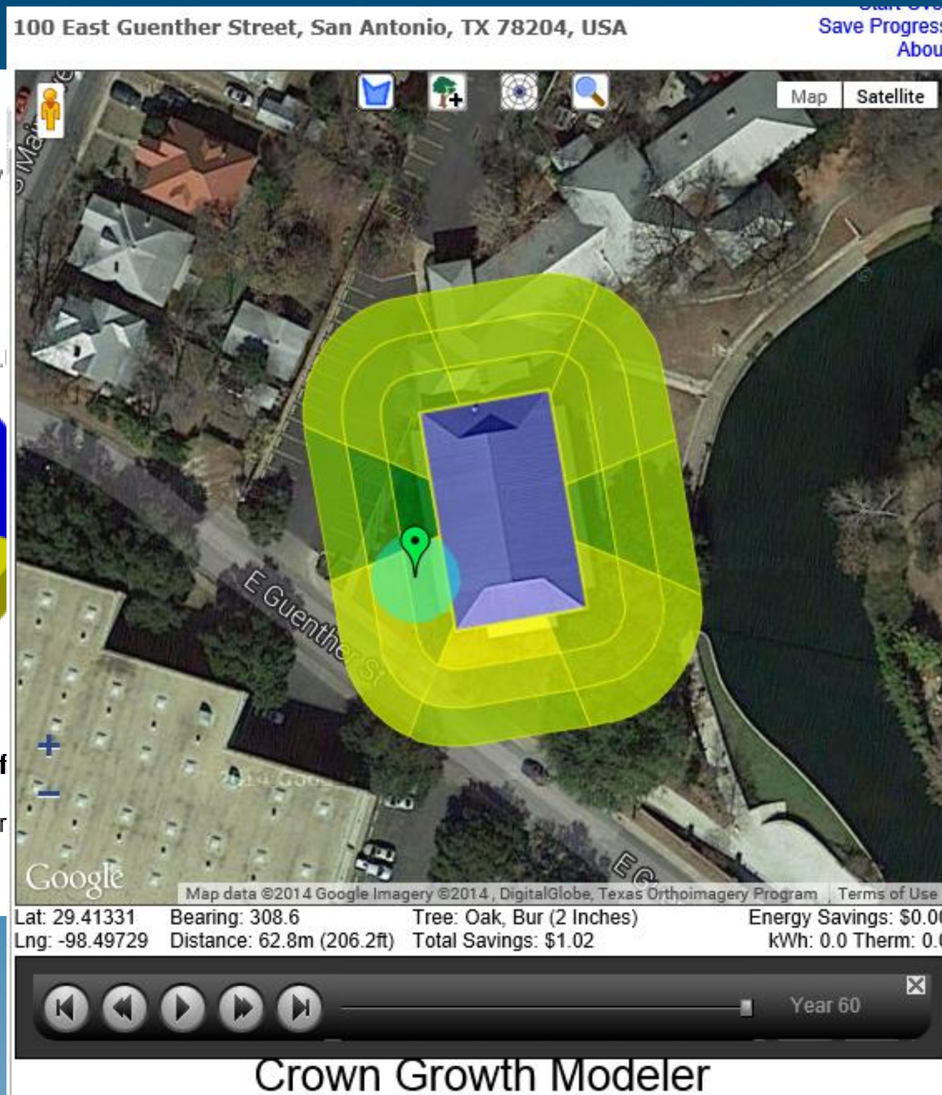
Studies Estimating Percent Increase in Property Value from Tree Planting, Low Impact Design with Vegetation, or Community Gardens.

Triple Bottom Line Analysis – Economic Cont.

- Reduced cost of irrigation
- Base on irrigation and how it will change with new plantings
- Averted Irrigation = Water Cost * Irrigation Area * Annual Irrigation Depth + Irrigation System Maintenance Cost
- Estimate future irrigation use and cost (Calculate difference between future and current)
- Energy savings
- Heat Reduction from shading of existing and new trees (large trees preserved
- Use i-Tree design (https://www.itreetools.org/design.php) or other i-Tree tool.

Triple Bottom Line Analysis – Economic Cont.





Bur oak
Quercus macrocarpa

Triple Bottom Line Analysis Factors - Quality of Life

- Improved air quality (amount of pollutant reduced)
- Air Quality Value = Increased Canopy Area * Removal Value per Area
- Use values from the City of San Antonio's Tree Canopy study
- Approximately 50,000 square feet of existing tree canopy.
- Around $410 per year of air pollution removal value

Triple Bottom Line Analysis Factors - Environmental

- Pounds of sediment and nutrient removed (modeling analysis)
  - Use SUSTAIN output
  - Capacity costs for sediment in stormwater infrastructure
- Annual volume of increased groundwater recharge
  - Value = Volume of water recharged * Utilities current water rates
  - Use SUSTAIN output
- Stormwater Infrastructure
  - Use SUSTAIN Output
  - Average cost ($/cf) of stormwater infrastructure

Building Site Impacts and Runoff

- Parking Areas – 23,750 square ft.
- Building Footprint – 24,350 square ft.
- Sidewalks, Driveways, Fire lane – 7,625 square feet
- Flows – 6.5 – 7.5 cfs for 2 – 5 Year storms
- Constituents – Bacteria, Sediment, PAHs
- Volumes – Annual volume of ~1 Million Gallons
- Soils – Fill Clayey Gravels/Sands underlain by Fat Clay

Tree Value

- **Summary of Existing Trees on Site**
  - 62 Trees subject to Tree Ordinance
  - Largest 39" Diameter Pecan with Estimated Replacement Cost of $23,400
- **Total Replacement Value of Trees**
  - Approximately $300,000 based on $200 per inch tree mitigation cost
  - Does not include cost of landscaping plants which have significant value to site aesthetics and habitat for pollinators

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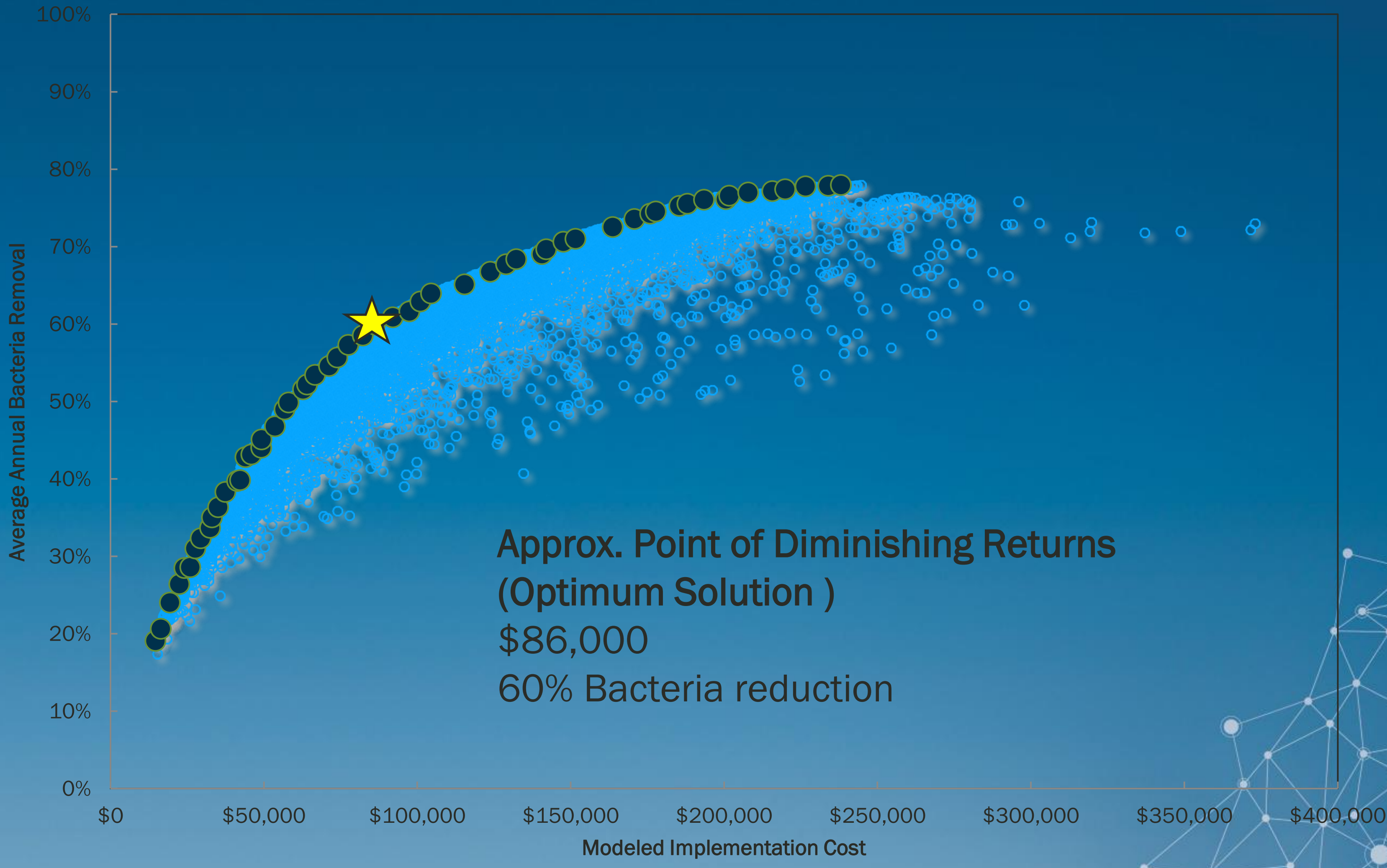
Modeling

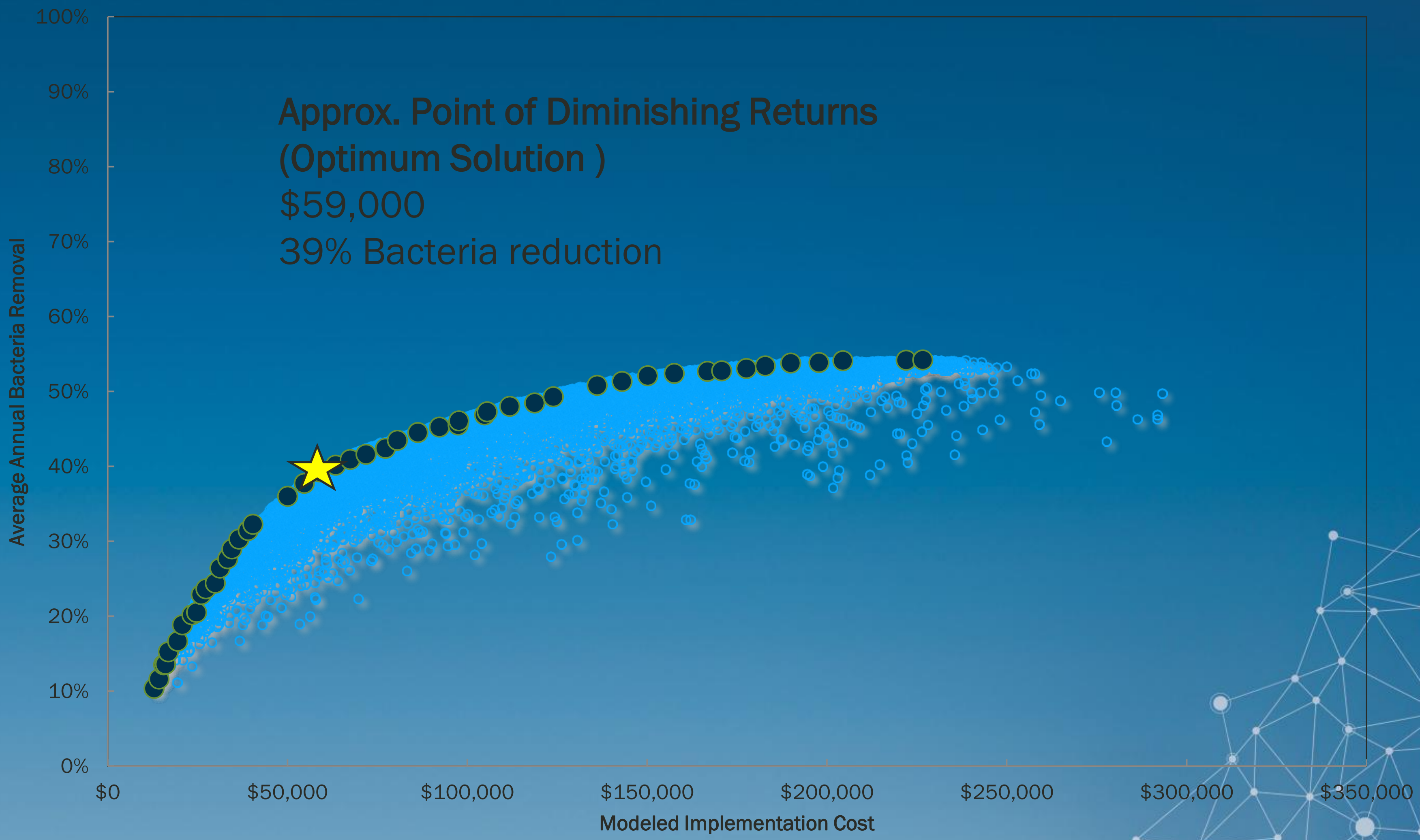
- **SUSTAIN Evaluation**
- **Potential BMPs**
  - Vegetated Swales/Filter Strips
  - Storage
  - Stormwater Wetlands
  - Permeable Pavement
  - Sand Filter
  - Bioretention/Bioswale
  - Green Roofs
  - Planter Boxes

Permeable Pavement Option

Sand Filter Option



Two Largest Parking Lots Untreated

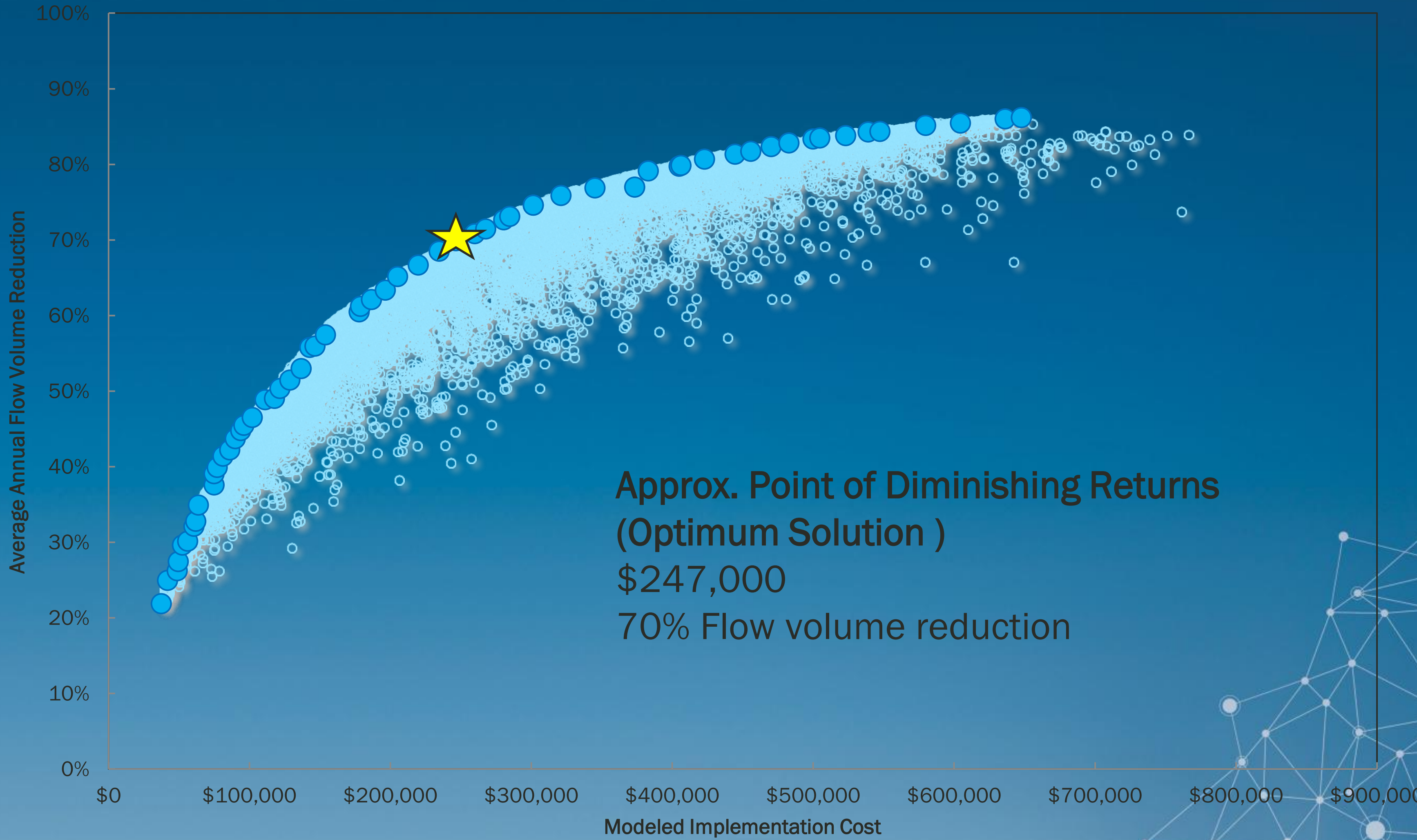


Permeable Pavement Option

Sand Filter Option

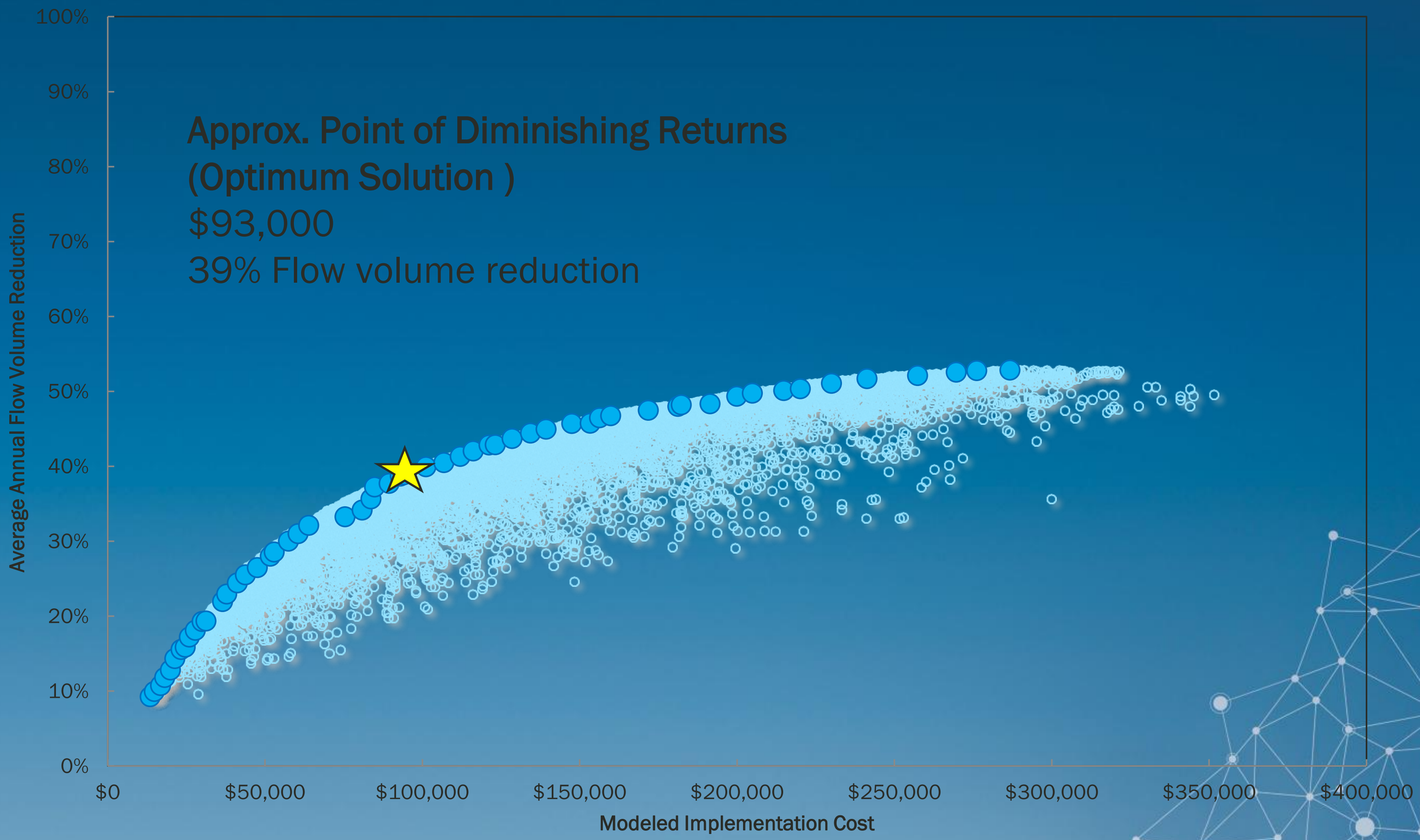
Two Largest Parking Lots Untreated

Permeable Pavement Option



Approx. Point of Diminishing Returns
(Optimum Solution)
$247,000
70% Flow volume reduction

Sand Filter Option



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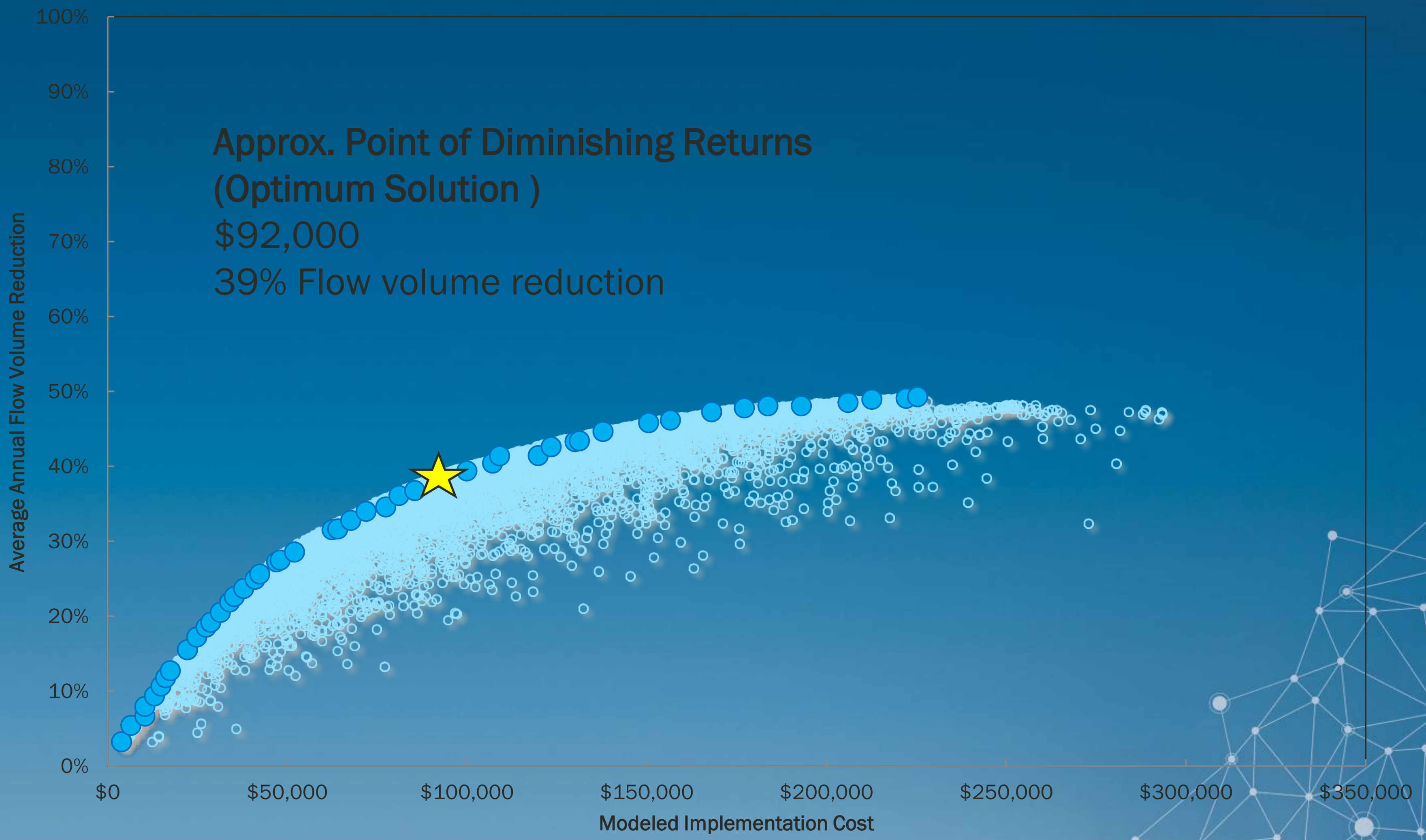

Scenario 1 - Optimized for Bacteria using Permeable Paving

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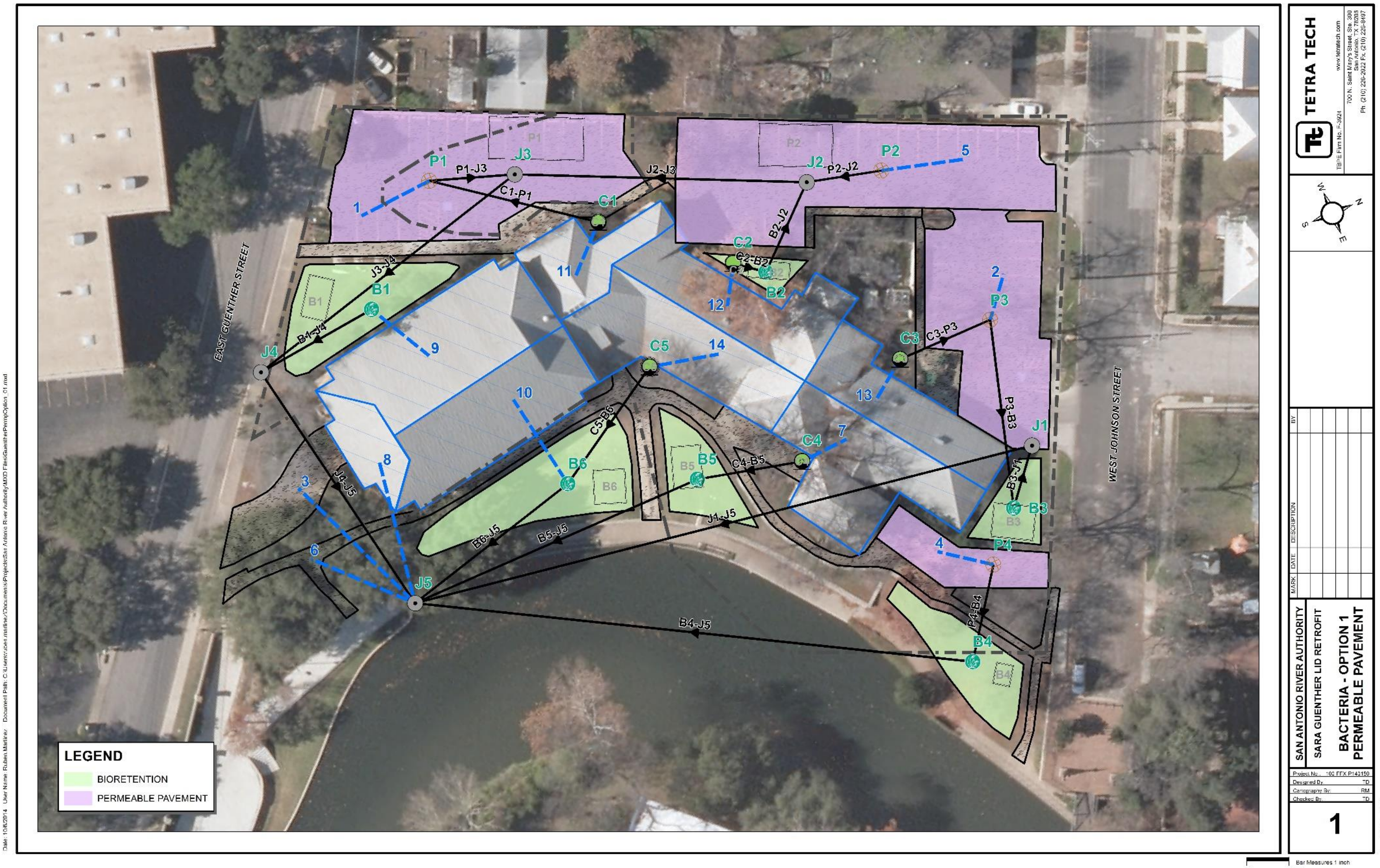

Scenario 2 – Optimized for PAHs using Sand Filters

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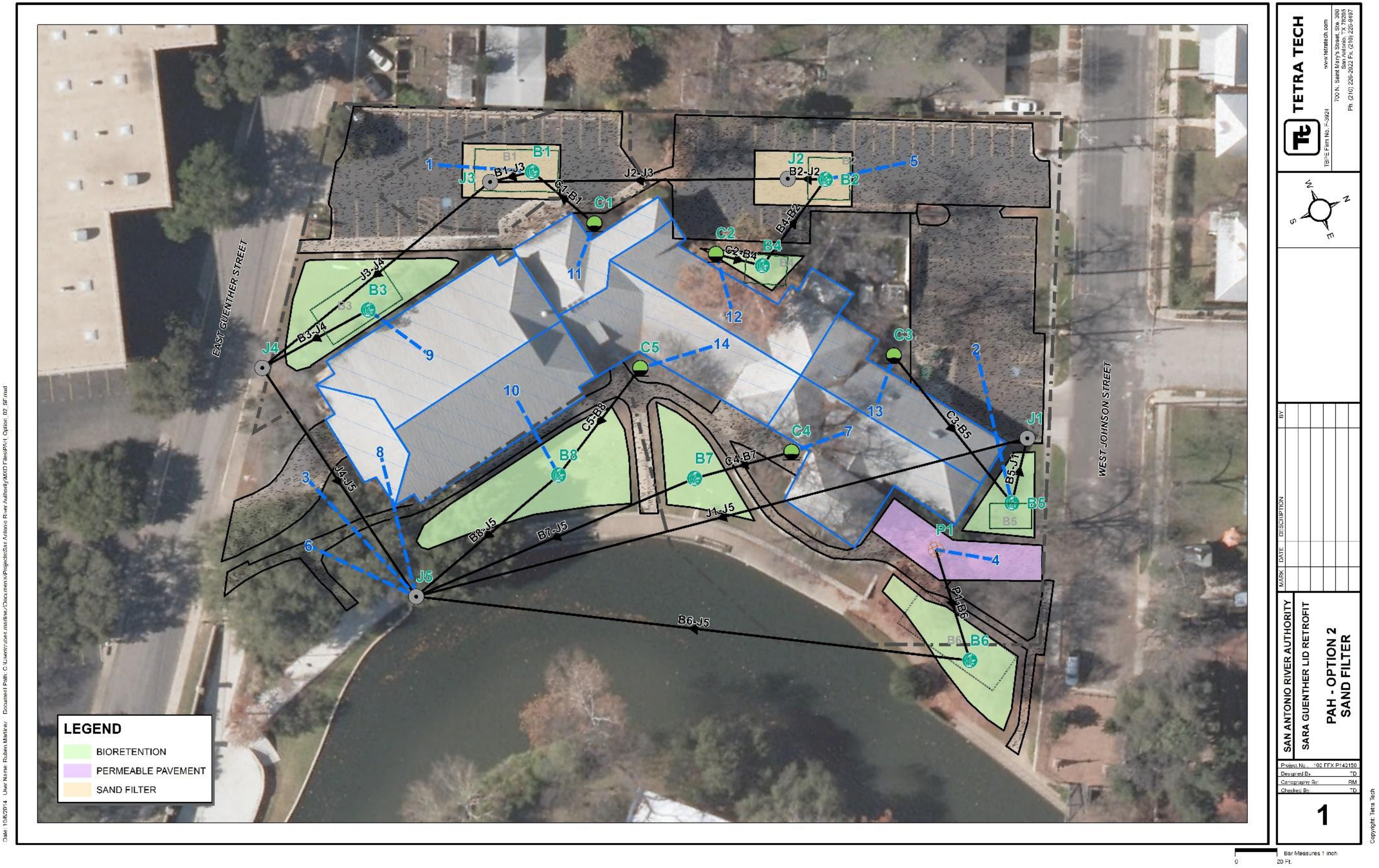

Scenario 3 – Optimized for PAHs using Permeable Pavement

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Scenario 4 – Optimized for Volume – No Treatment of Parking Areas 1 and 2

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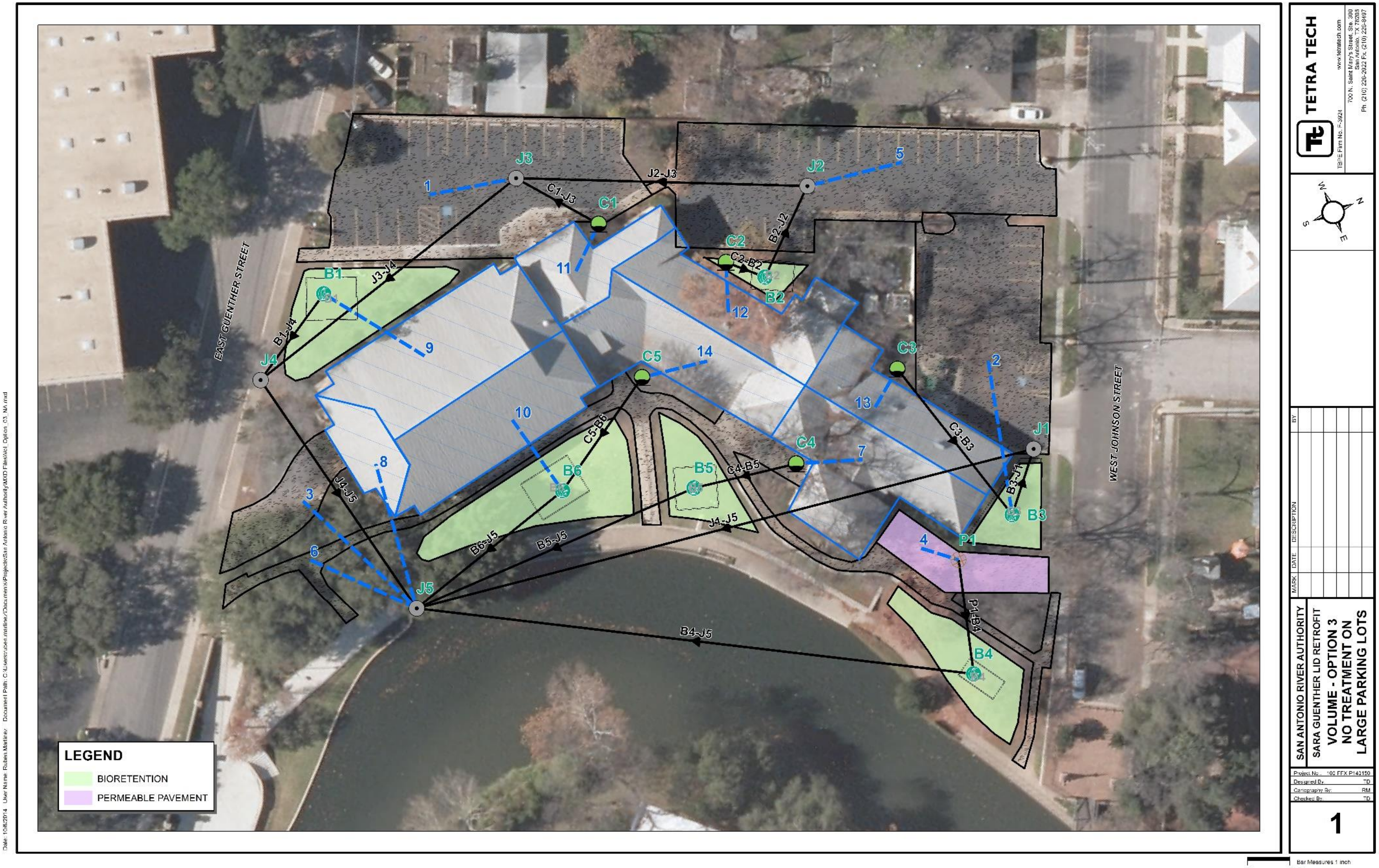
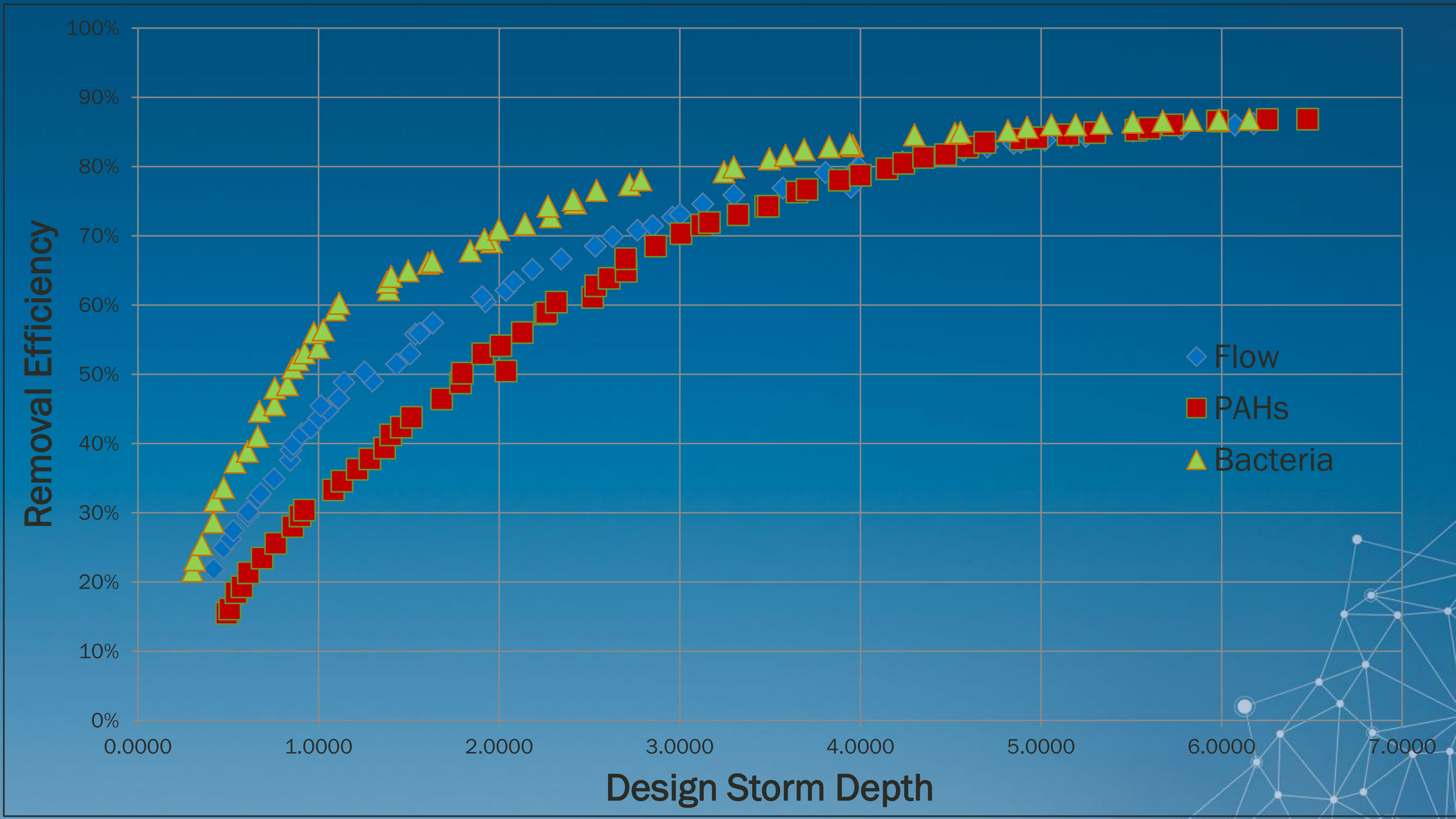


Removal Efficiency vs. Capture Depth



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Comparison of Optimum Scenarios

	Bacteria	PAH	Volume
Permeable Pavement	$114,000 60% 1.11 in.	$295,000 70% 3.01 in	$247,000 70% 2.62 in.
Sand Filter	$86,000 60% 1.09 in	$201,000 71% 2.54 in.	$93,000 39% 1.18 in
Untreated Parking	$59,000 39% 0.71 in	$141,000 46% 1.65 in	$92,000 39% 1.18 in

Landscaping Schematic

TREES	
COMMON NAME	SCIENTIFIC NAME
Eve's Necklace	*Sophora affinis*
Mexican Buckeye	*Ungnadia speciosa*
Possumhaw Holly	*Ilex decidua*
Yaupon Holly	*Ilex vomitoria*
Red Mulberry	*Morus rubra*
Redbud (Texas or Mexican)	*Cercis canadensis*
SHRUBS / PERRENIALS / GRASSES	
Cardinal Flower	*Lobelia cardinalis*
Dwarf Waxmyrtle	*Myrica cerifera*
Gulf Muhly	*Muhlenbergia capilaris*
Hill Country Penstemon	*Penstemon triflorls*
Horsetail	*Equisetum hyemale*
Inland Sea Oats	*Chasmanthium latifolium*
Liriope	*Liriope muscari 'Big Blue'*
Mexican Buckeye	*Ungnadia speciosa*
Morea Iris	*Morea bicolor*
Obedient Plant	*Phystostegia intermedia*
Rock Rose	*Pavonia lasiopetala*
Texas Columbine	*Aquilegia chrysantha var. hinckleyana*
Turk's Cap	*Malvaviscus arboreus var drummondii*
GROUNDCOVERS	
Daylily	*Hemerocalis spp.*
Blue Shade Ruellia	*Ruellia squarrosa 'Blue Shade'*
Lanceleaf Coreopsis	*Coreopsis lanceolata*
River Fern	*Thelypteris kunthii*
Wood Sorrel	*Oxalis spp.*
Zexmenia	*Wedelia texana*

- AREAS FOR RE-PLANTING
- EXISTING TURF/PLANTING
- GROUNDCOVER
- MEDIUM, SHRUBS/GRASSES
- LARGE SHRUBS
- SMALL TREE

Visualizing the Plan

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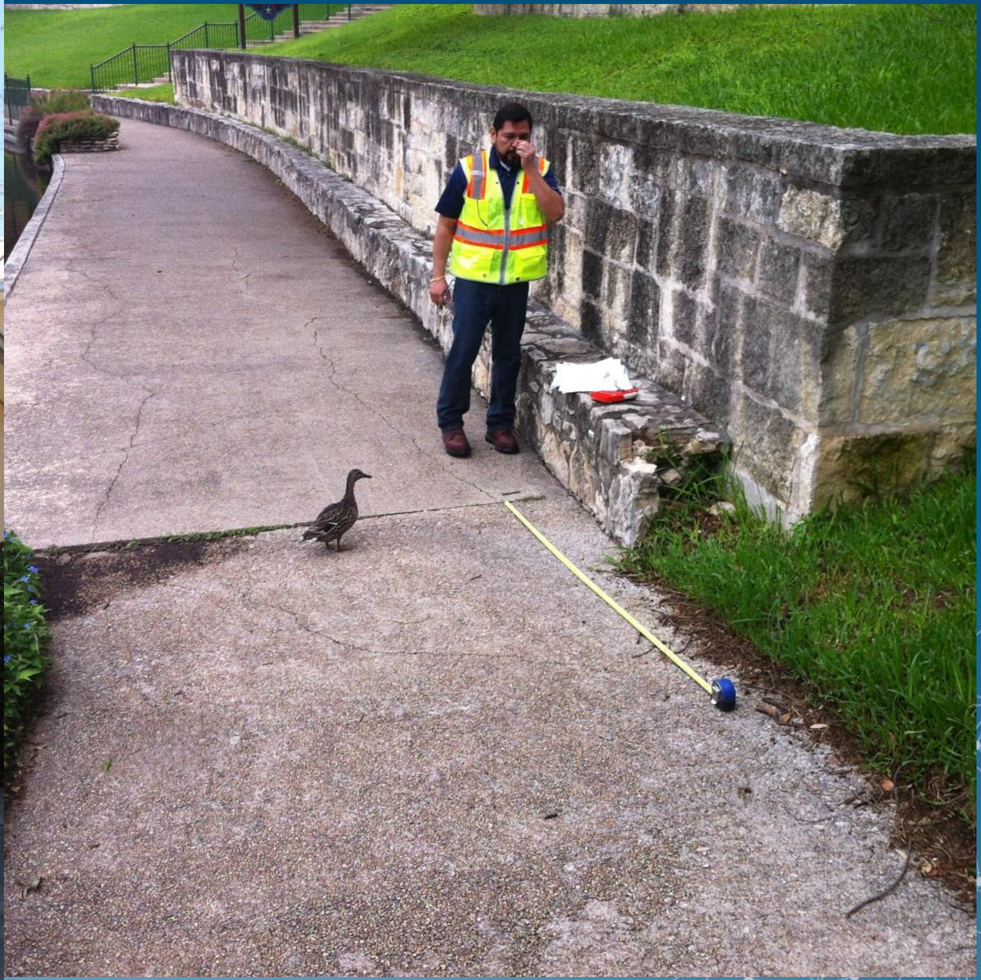
Visualizing the Plan

Time Value of Money

Project today will be less expensive than in the future.
Parking lots will need rebuilding in the next few years?
Trees will decline and need removal and replacement
Maintenance program will require modification of existing drainage patterns

Design Phase – Site Visit



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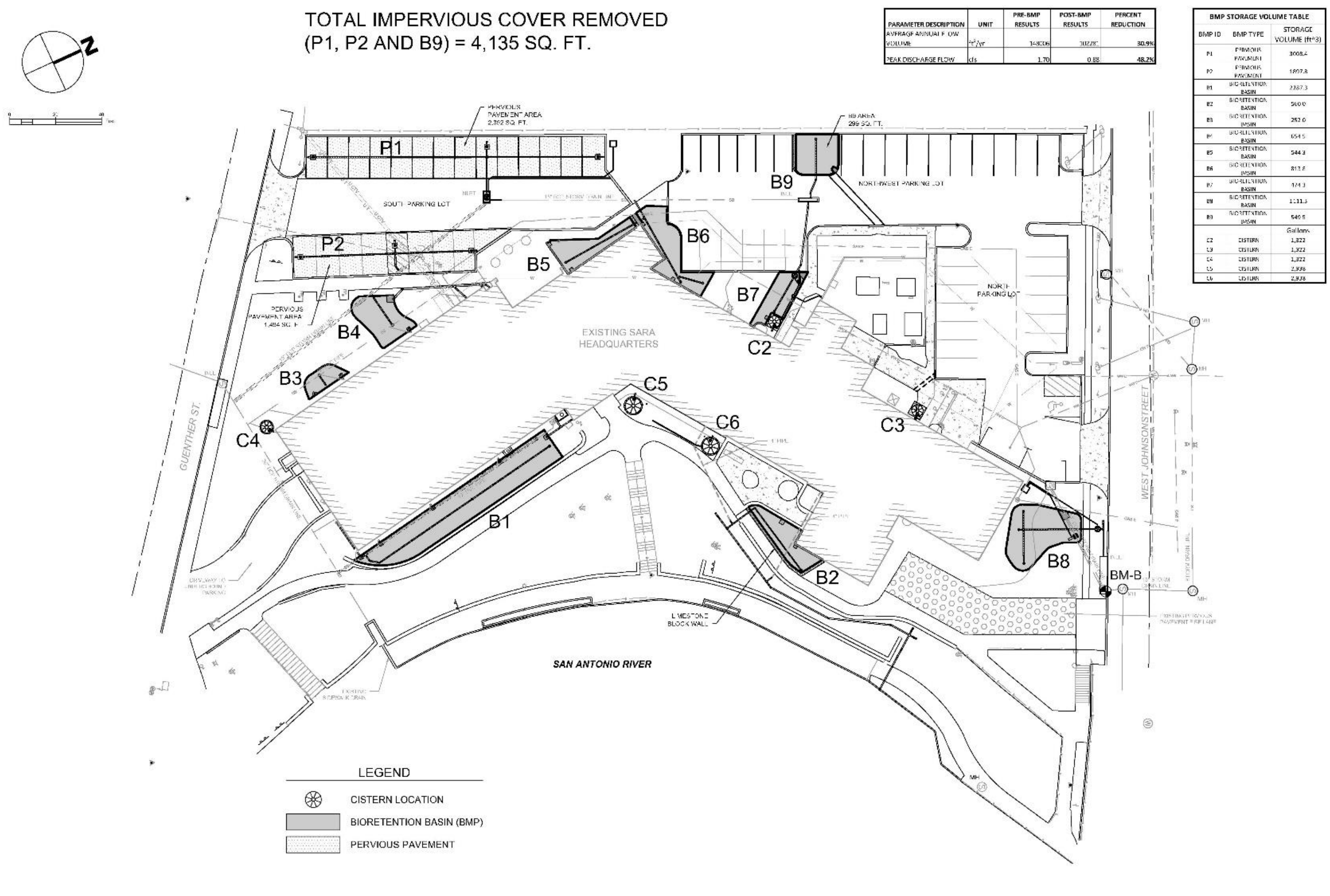
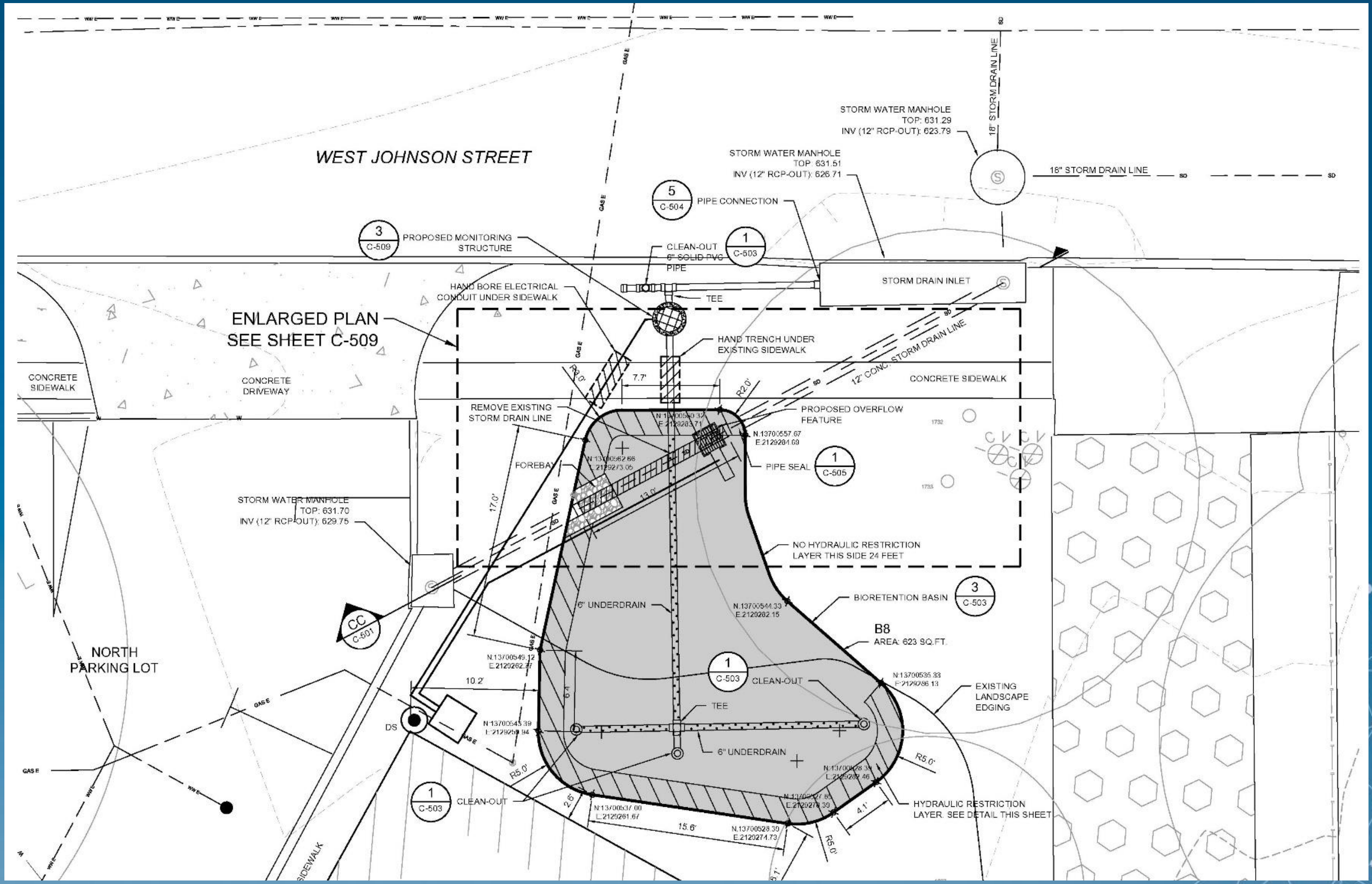
Design Phase – Selected Option



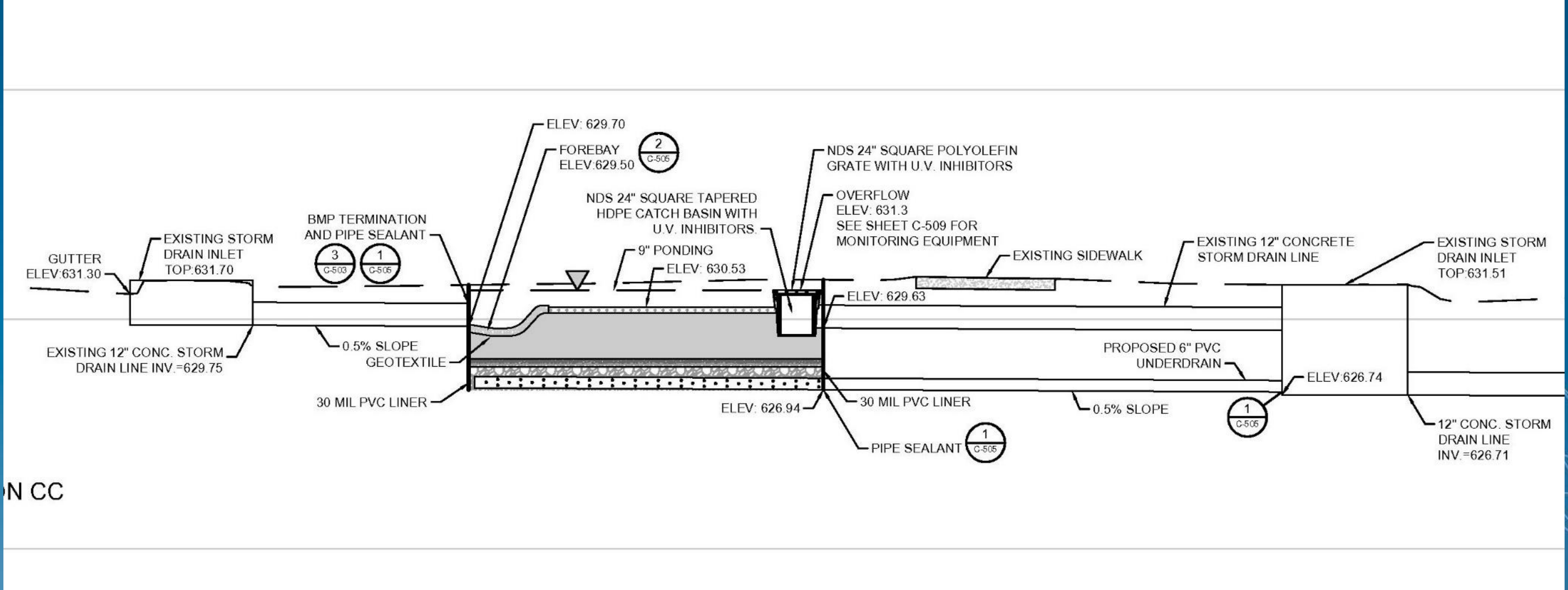
PARAMETER DESCRIPTION	UNIT	PRE-BMP RESULTS	POST-BMP RESULTS	PERCENT REDUCTION
AVERAGE ANNUAL FLOW VOLUME	ft^3/yr	148006	102281	30.9%
PEAK DISCHARGE FLOW	cfs	1.70	0.88	48.2%

BMP STORAGE VOLUME TABLE		
BMP ID	BMP TYPE	STORAGE VOLUME (ft^3)
P1	PERVIOUS PAVEMENT	3008.4
P2	PERVIOUS PAVEMENT	1807.8
B1	BIORETENTION BASIN	2287.3
B2	BIORETENTION BASIN	560.0
B3	BIORETENTION BASIN	252.0
B4	BIORETENTION BASIN	654.5
B5	BIORETENTION BASIN	544.3
B6	BIORETENTION BASIN	813.8
B7	BIORETENTION BASIN	474.3
B8	BIORETENTION BASIN	1111.3
B9	BIORETENTION BASIN	549.5
		Gallons
C2	CISTERN	1,322
C3	CISTERN	1,322
C4	CISTERN	1,322
C5	CISTERN	2,998
C6	CISTERN	2,998

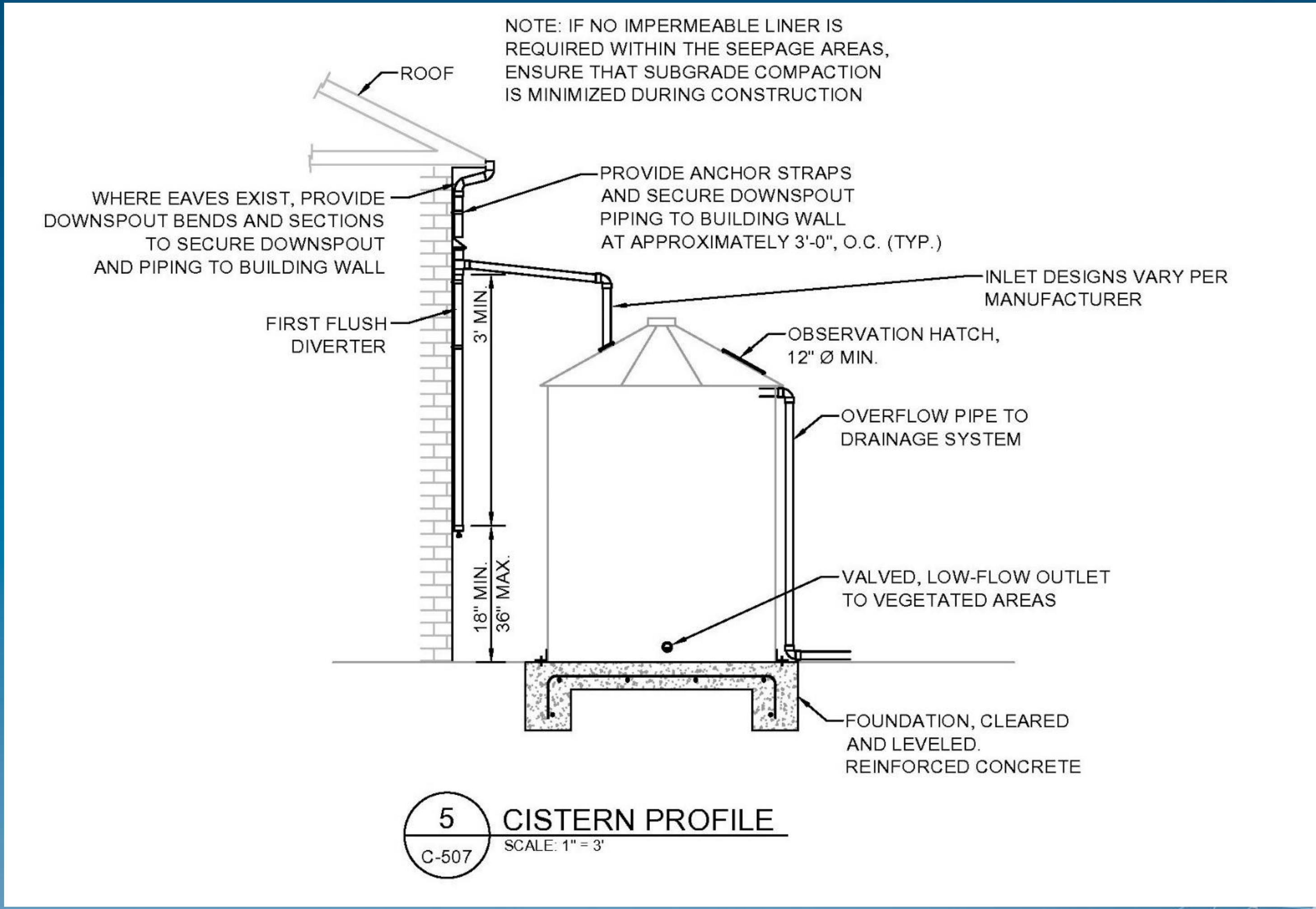
Design Phase



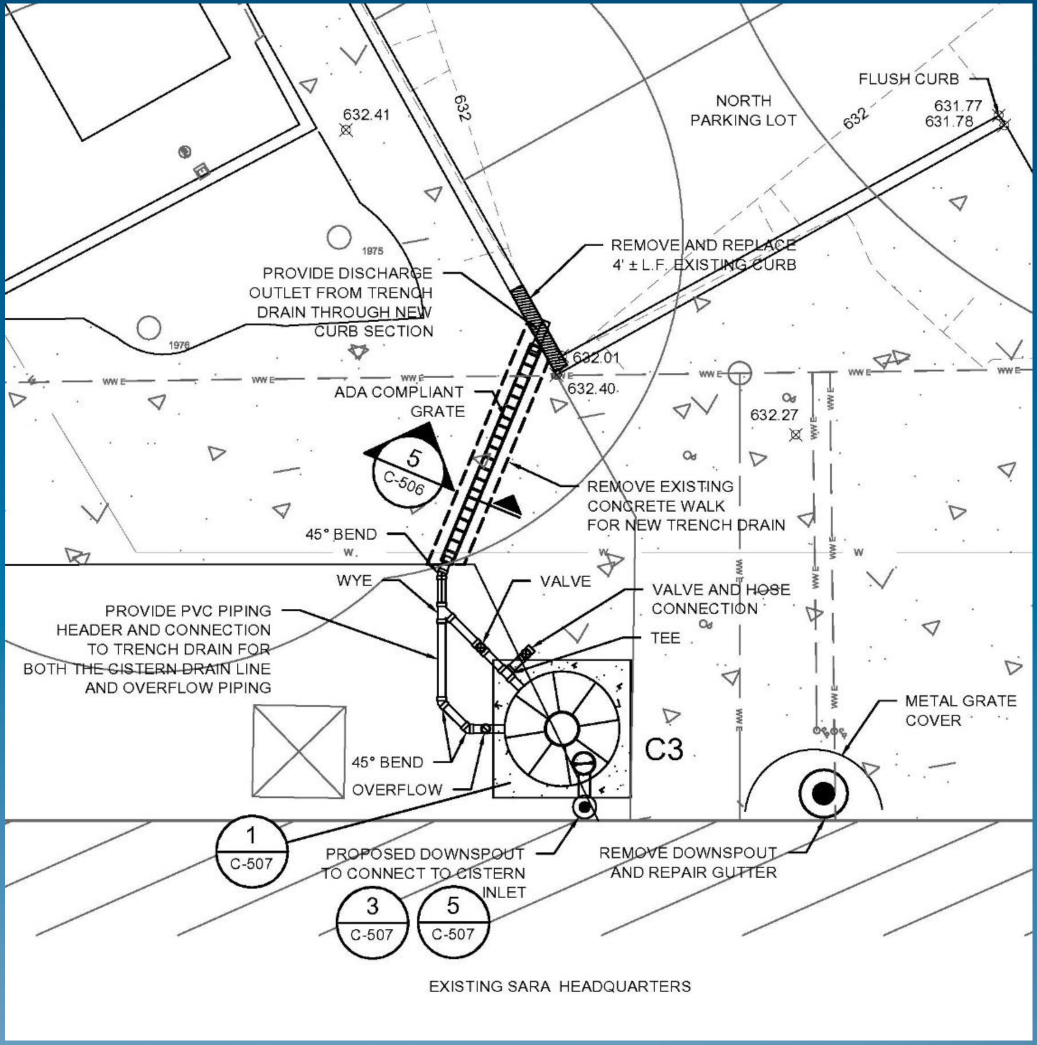
Design Phase



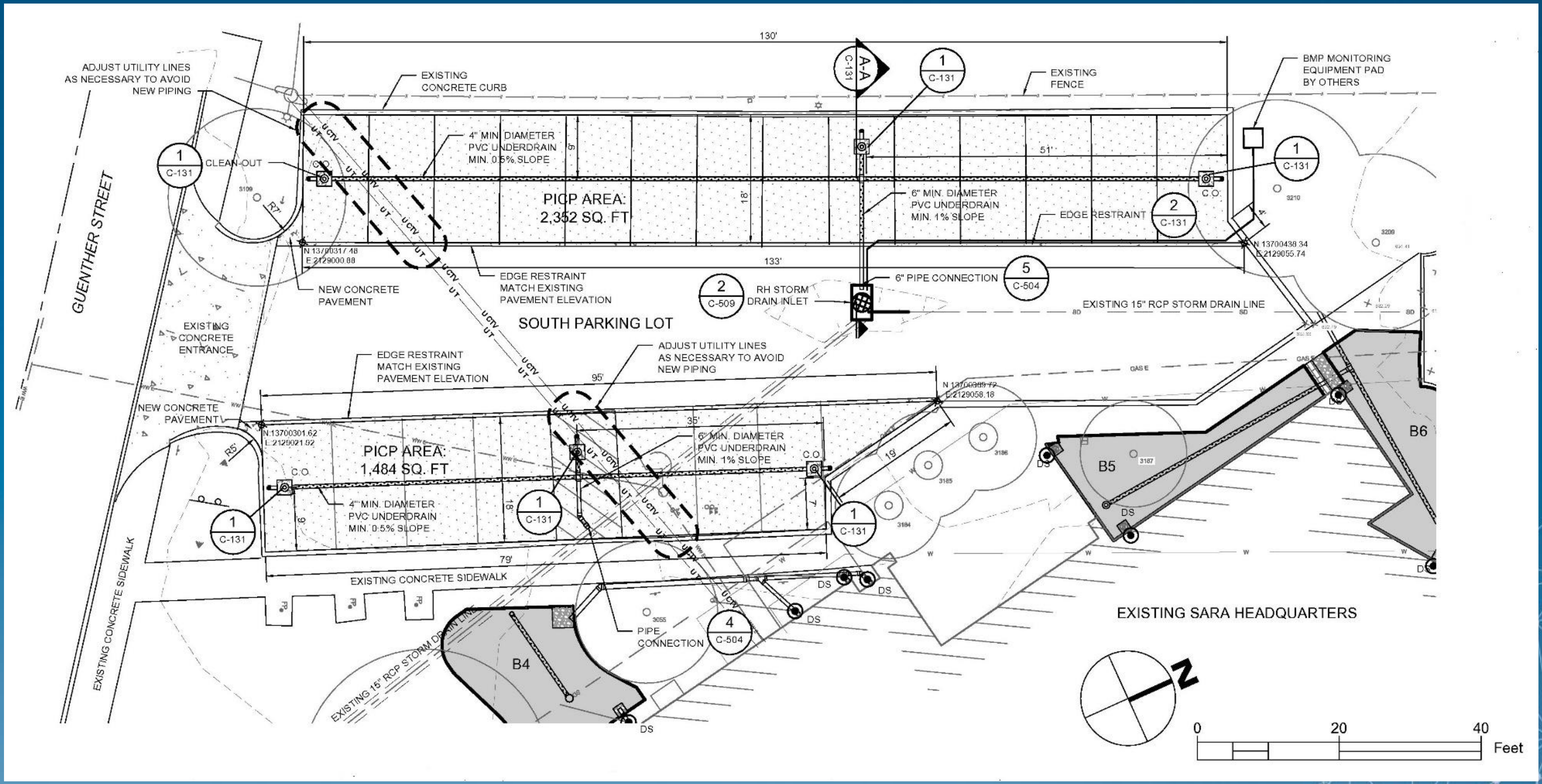
Design Phase



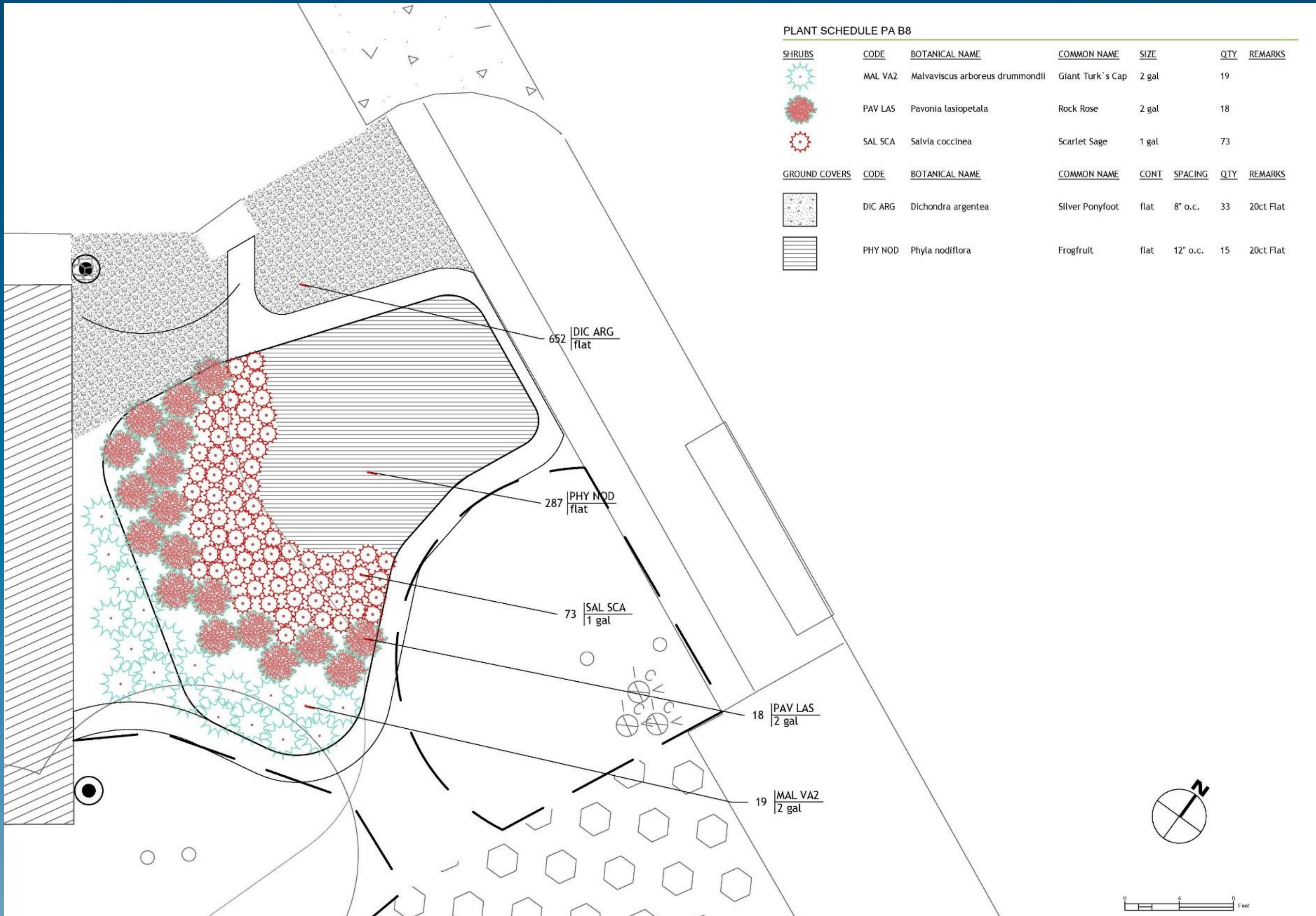
Design Phase



Design Phase – Interlocking Concrete Pavers



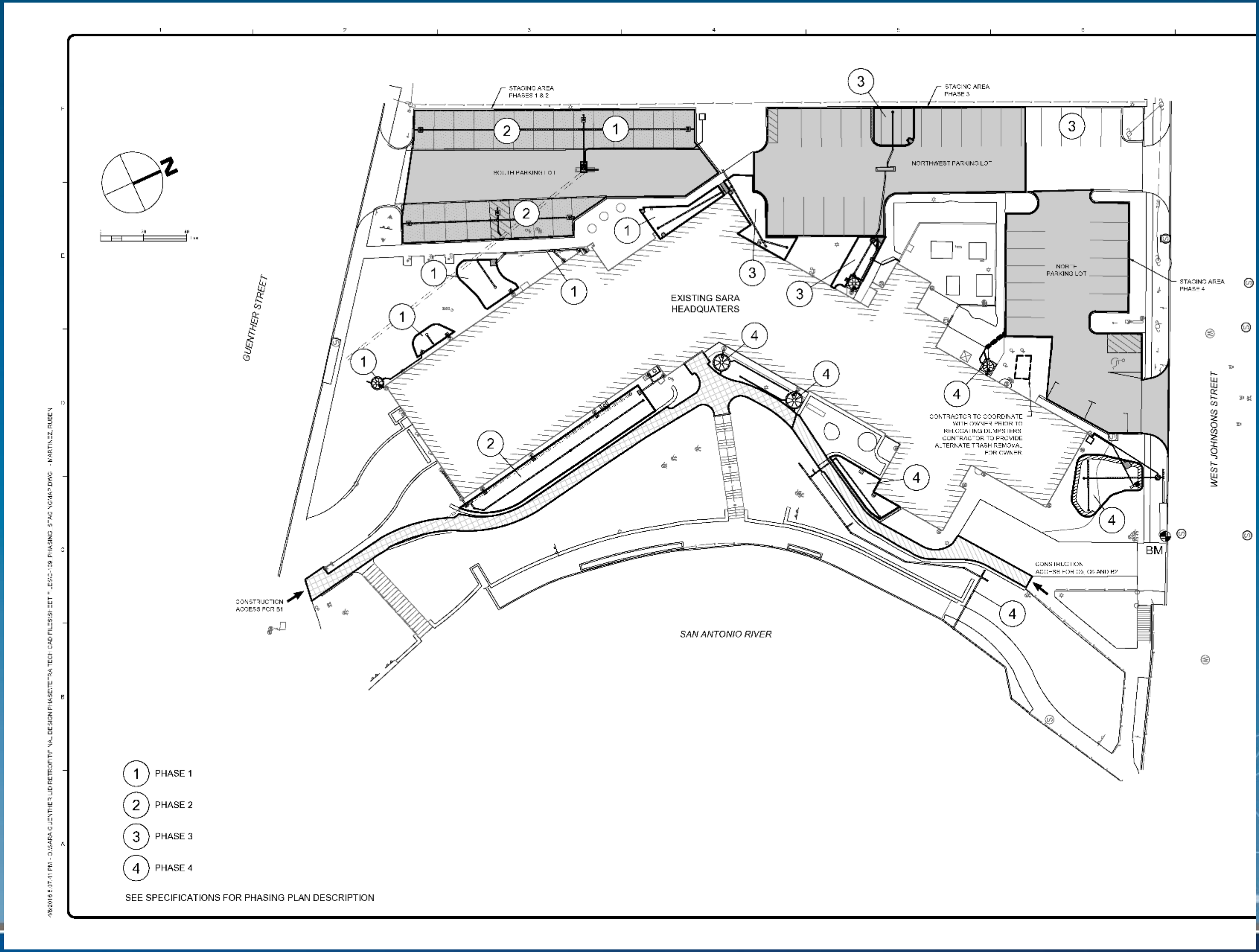
Landscaping



PLANT SCHEDULE PA B8

SHRUBS	CODE	BOTANICAL NAME	COMMON NAME	SIZE		QTY	REMARKS
	MAL VA2	Malvaviscus arboreus drummondii	Giant Turk`s Cap	2 gal		19	
	PAV LAS	Pavonia lasiopetala	Rock Rose	2 gal		18	
	SAL SCA	Salvia coccinea	Scarlet Sage	1 gal		73	
GROUND COVERS	**CODE**	**BOTANICAL NAME**	**COMMON NAME**	**CONT**	**SPACING**	**QTY**	**REMARKS**
	DIC ARG	Dichondra argentea	Silver Ponyfoot	flat	8" o.c.	33	20ct Flat
	PHY NOD	Phyla nodiflora	Frogfruit	flat	12" o.c.	15	20ct Flat

Phasing Plan

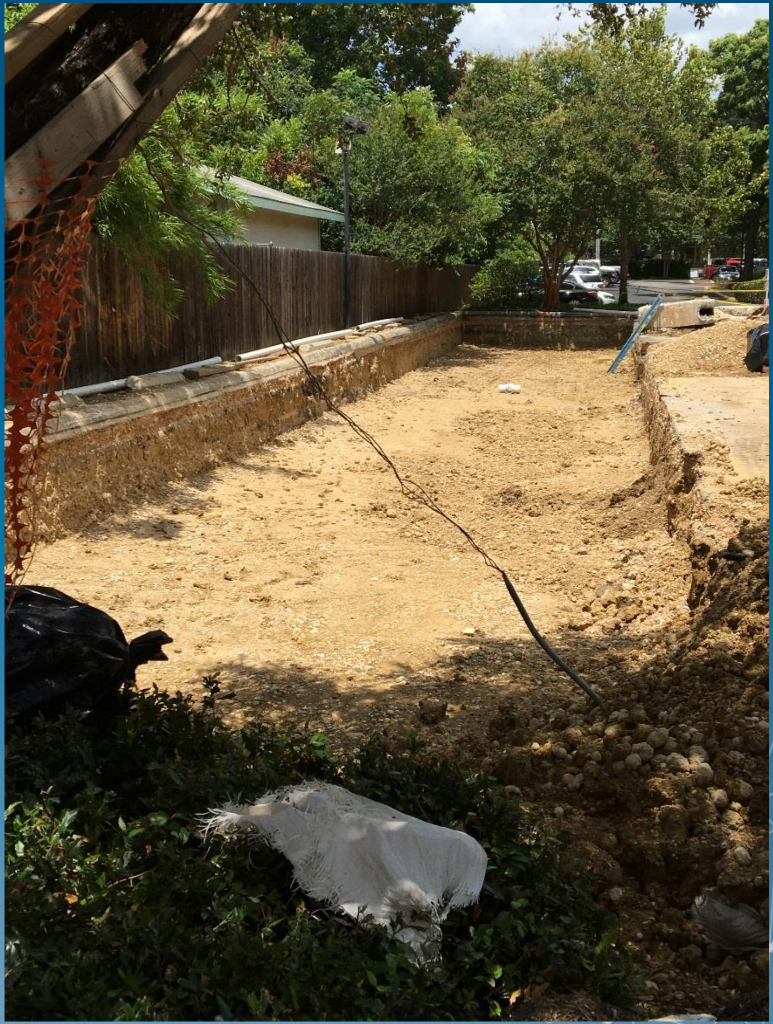


Construction Phase - Utility Conflicts

Construction Phase – Excavating for Tie In to Existing Storm Drains

Bioretention Liner

Interlocking Concrete Pavers



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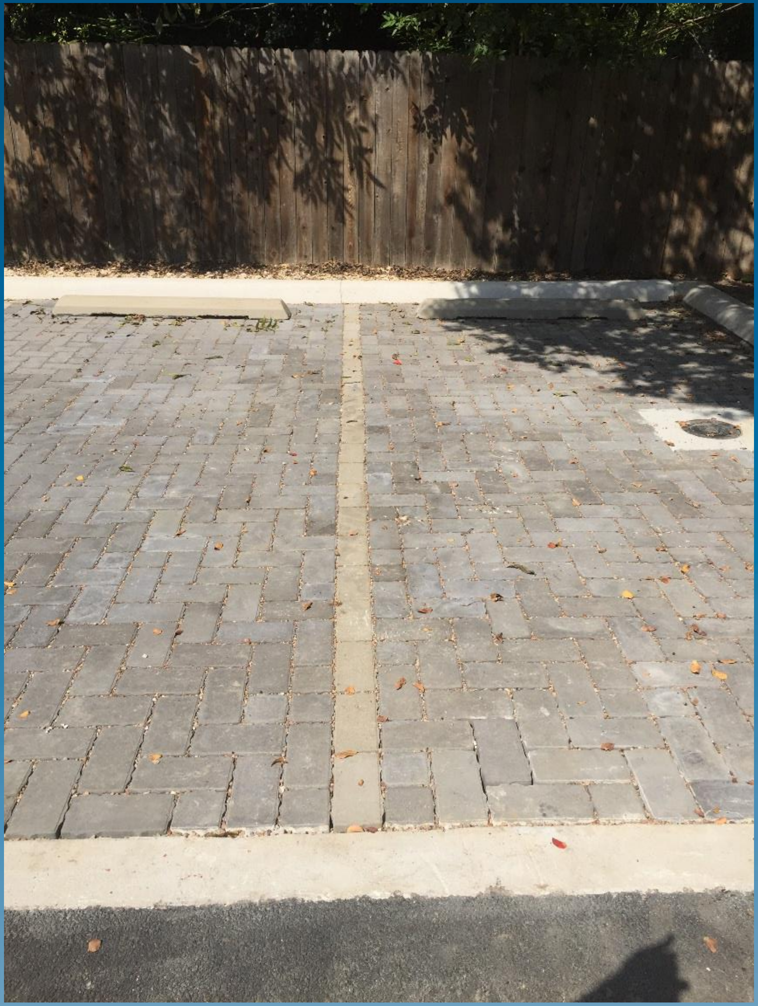
Paver Installation Details



Ongoing Construction

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Questions

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