LID Application Review and FLO-2D Modeling

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Presentation Outline

- Introduction to LID
- LID Controls, Accessories, and Systems
- Review of LID Simulation Methods
- FLO-2D Modeling Methods of LID Controls
- FLO-2D Modeling Results of LID Controls
- Questions

Introduction to LID

Low Impact Development (LID) is an innovative stormwater management approach whose basic principle is modeled after nature: manage storm runoff at the source using distributed micro-scale controls. The goal of LID is to mimic and/or restore a site's predevelopment hydrology using design techniques that infiltrate, filter, store, evaporate, and detain runoff close to its source.

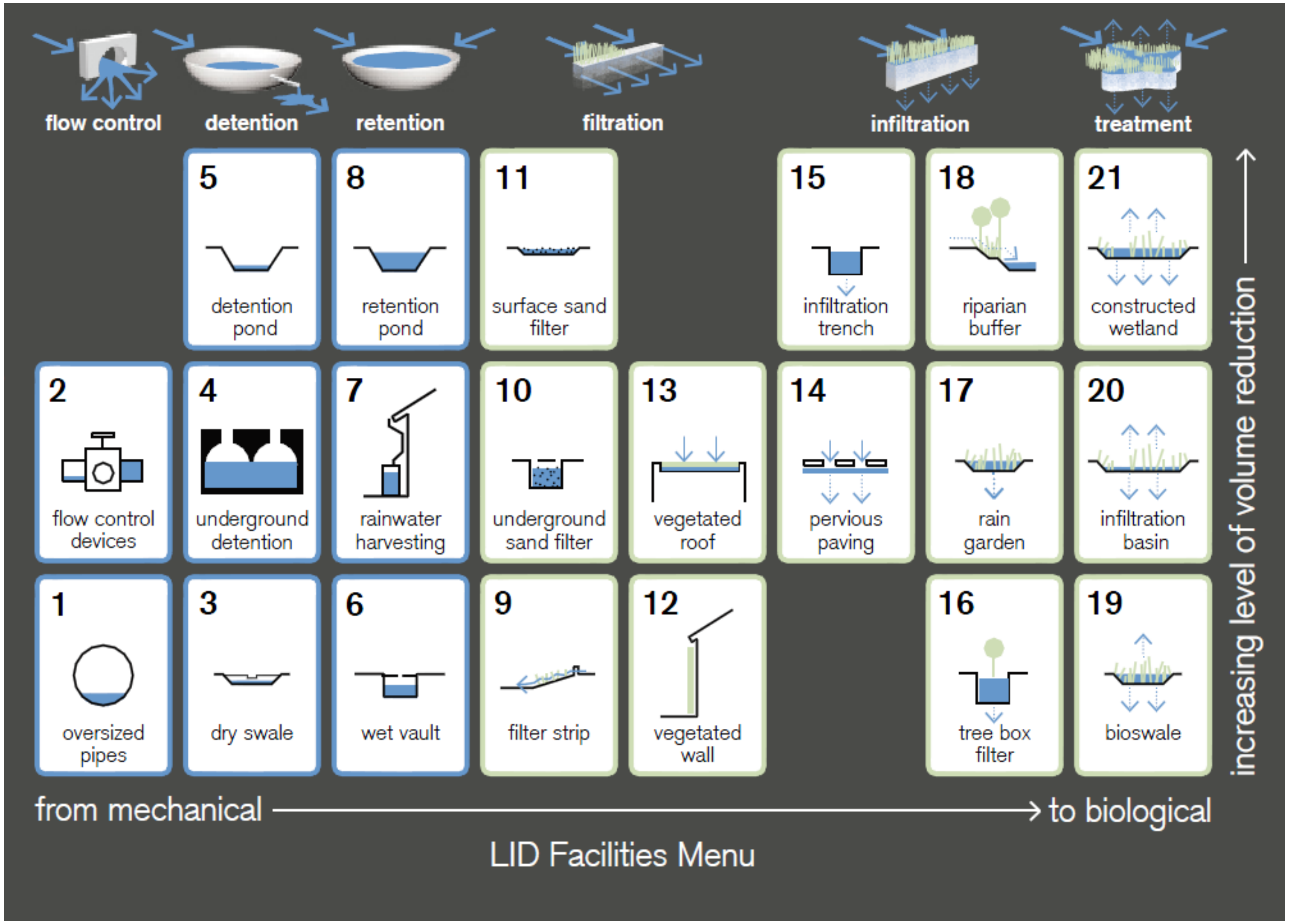
Typical LID Applications in Tempe

Benefits of LID

- LID is a more environmentally sound technology and a more economically sustainable approach to addressing the adverse impacts of urbanization.

- LID can enhance the local environment, protect public health, and improve community livability - all while saving developers and local governments money.

LID vs. Traditional Drainage Structures



LID Controls, Accessories, and Systems

- LID controls (tools, practices, techniques, methods, facility, concept, practice, application or similar names) have been developed and applied with similar hydrologic and hydraulic functions, but different shapes, materials, locations, and sometimes, with and or without add-ons (accessories).
- LID accessories are structures that are added or connected to LID basic controls to improve their hydrologic and hydraulic functions and capabilities.
- LID systems are combinations of one or more LID basic controls and accessories to improve and expand their hydrologic and hydraulic functions and capabilities.

LID Controls

LID Basic Controls and Their Similar Names				
Five LID Basic Controls				
Bio Retention	Bio Swale	Pervious Pavement	Rainwater Harvesting	Green Roof
Similar names	**Similar names**	**Similar names**	**Similar names**	**Similar names**
Bioretention cell	Downspout disconnection	Pervious concrete	Active rainwater harvesting	Vegetated roof
Chicane	Grass swale	Pervious paving	Above ground cistern	Rooftop garden
Flow-through planter box	Linear vegetated swale	Porous asphalt	Below ground cistern	
In-ground planter box	Meandering vegetated swale	Soft paving	Rain cistern	
On-site bioretention basin	Vegetated channel	Stabilized aggregate	Rain tank	
Planter box		Structural grid system		
Rain barrel		Permeable paver system		
Rain garden				
Raised planter box				
Regional bioretention basin				
Retention basin				

LID Controls and Hydrologic Functions

LID Basic Controls and Hydrologic Functions					
Basic LID Control Name	Hydrologic Functions				
	Retention	Detention	Infiltration/ Recharge	Storage & Reuse	Conveyance
Bio Retention	X	X	X		X
Bio Swale		X	X		X
Pervious Pavement	X	X	X		X
Rainwater Harvesting	X			X	
Green Roof	X	X		X	

LID Systems

LID Systems, Basic Controls, and Accessories				
Typical LID Systems	On-Lot Treatment System	Green Parking System	Green Street System	Active Rainwater Harvesting
Basic Controls	Bio Retention, Bio Swale, Pervious Pavement, Green Roof	Bio Retention, Bio Swale, Pervious Pavement	Bio Retention, Bio Swale, Pervious Pavement	Rainwater Harvesting, Green Roof
Accessories	Downspout, Roof drain, Paving blocks, Porous pavements, Curb cut, underdrain	Concrete flush curb, Curb cut with sediment capture, Curb cut with sidewing, Grated curb cut, Standard curb cut, Underdrain, Wheelstop curb	Concrete flush curb, Curb cut with sediment capture, Curb cut with sidewing, Grated curb cut, Standard curb cut, Underdrain	Downspout, Rain tank, Above ground cistern, Below ground cistern, Roof drain

On-Lot Treatment System Concept along Concorda Drive

Green Parking System Concept along Concorda Drive

Green Street System Concept along Concorda Drive

General Concepts of Basic LID Controls

- Bio Retention
- Bio Swale
- Pervious Pavement
- Rainwater Harvesting
- Green Roof

General Concepts of Basic LID Controls - Bio Retention

Bio Retentions are shallow, vegetated basins that collect and absorb runoff from rooftops, sidewalks, and streets.

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General Concepts of Basic LID Controls - Bio Retention


Bioretention cells fit into constrained urban site.

General Concepts of Basic LID Controls - Bio Retention

Bioretention planters provide stormwater storage and promote healthy growth of trees and plants.

General Concepts of Basic LID Controls - Bio Swale

Bioswales are vegetated, mulched, or "xeriscaped" channels that provide treatment and retention as they move stormwater from one place to another.

Vegetated swales accept stormwater for conveyance, storage and infiltration.

General Concepts of Basic LID Controls - Bio Swale

General Concepts of Basic LID Controls - Pervious Pavement

Pervious pavements are paved surfaces that infiltrate, treat, and/or store rainwater where it falls.

Permeable paving is an attractive way to provide runoff reduction in paving and pedestrian areas.

Structural grid paving reduces runoff in parking areas and firelanes.

General Concepts of Basic LID Controls - Pervious Pavement

Stabilized aggregate reduces storm runoff from low-traffic paving areas.

Porous asphalt paving is a runoff-reducing in paving areas and driveways.

General Concepts of Basic LID Controls - Rainwater Harvesting

Rainwater harvesting systems collect and store rainfall for later use. When designed appropriately, rainwater harvesting systems slow and reduce runoff and provide a source of water.

Cisterns can store rainwater to be re-used for future landscape irrigation.

Underground cisterns provide storage areas for rainwater reuse.

General Concepts of Basic LID Controls - Green Roof

Green roofs are covered with growing media and vegetation that enable rainfall infiltration and evapotranspiration of stored water.

Green roofs store and utilize stormwater to reduce runoff from building sites.

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General Concepts of Basic LID Accessories

- Standard Curb Cut
- Curb Cut with Sidewings
- Grated Curb Cut
- Curb Cut with Sediment Capture
- Concrete Flush Curb
- Wheelstop Curb
- Downspout
- Roof Drain
- Underdrain

General Concepts of Basic LID Accessories - Standard Curb Cut

Curb cuts are openings created in a curb to allow stormwater from an impervious surface, such as roads, parking lots, or hardscape areas, to flow into a lower landscaped storage and LID control area.

Curb cuts control stormwater flow from streets to LID facilities.

General Concepts of Basic LID Accessories - Curb Cut with Sidewings

The sidewing addition to curb cut conveys stormwater a greater distance, and can reduce the potential for erosion behind the curb or close to the paved surface.

Curb cuts direct stormwater from street to landscape areas.

General Concepts of Basic LID Accessories - Grated Curb Cut

Grated curb cuts allow stormwater to be conveyed into LID area under a pedestrian walkway.

Grates allow stormwater to pass through while proving an accrossing pedestrian route.

General Concepts of Basic LID Accessories - Curb Cut with Sediment Capture

Sediment catchments capture and collect sand and fine soils at the entrance to bio retention areas, removing them from stormwater and allowing periodic removal. Sediment removal can significantly extend the functional life of these features.

Sediment capture can be open or covered.

General Concepts of Basic LID Accessories - Concrete Flush Curb

Concrete flush curbs allow stormwater to runoff impervious surfaces directly into LID control areas and stormwater facilities.

Flush curbs allow stormwater to sheet drain to landscape areas.

General Concepts of Basic LID Accessories - Wheelstop Curb

Wheelstop Curbs are formed sections of curb with gaps between them. They allow stormwater from adjacent impervious surfaces, like parking lots, to flow into adjacent LID control areas.

Wheelstops allow sheet drainage to pass into landscape areas.

General Concepts of Basic LID Accessories - Downspout

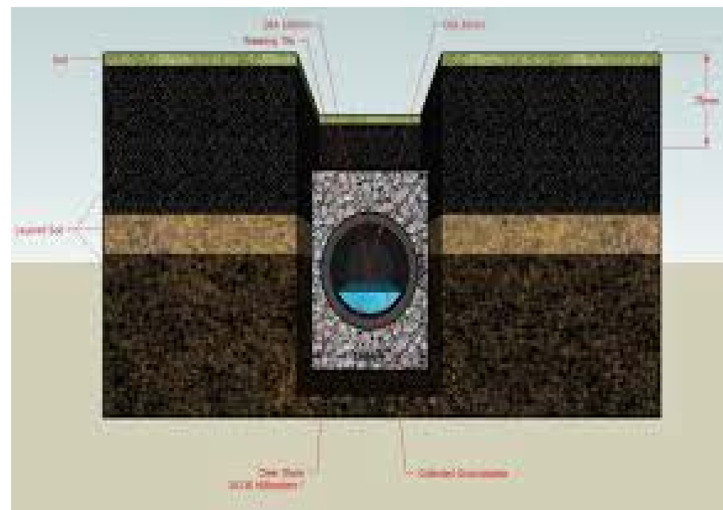
Downspout is used to direct rainwater from the rooftop into a LID control instead of into a piped system or into the street.

General Concepts of Basic LID Accessories - Roof Drain

Roof Drain is used to help collect and convey runoff from green roof LID control area into rain tanks, cisterns above/below ground or piped systems.

General Concepts of Basic LID Accessories - Underdrain

A perforated pipe, typically 4-6 inches in diameter placed longitudinally at the invert of a bio retention, bio swale, or pervious pavement LID control for the purposes of achieving a desired discharge rate or runoff volume reduction.



Review of LID Simulation Methods

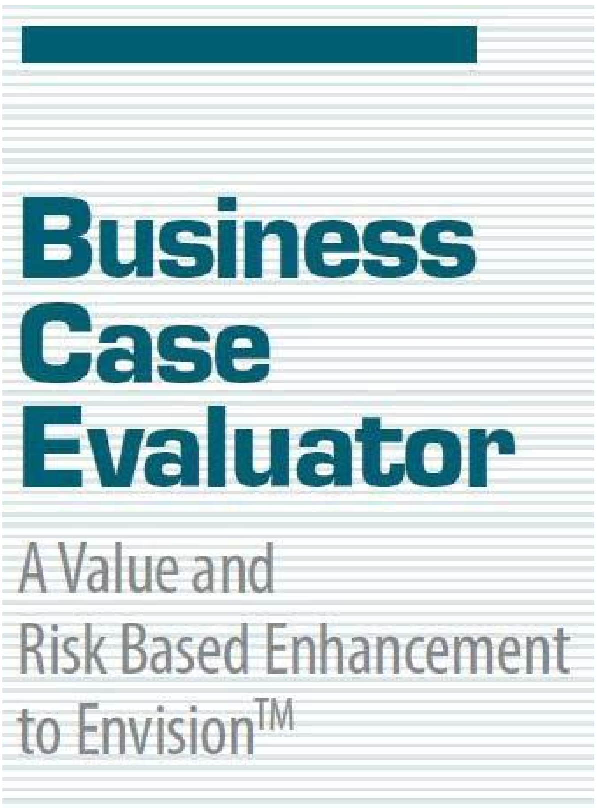
- Hydrologic and Hydraulic Modeling
- Benefit/Cost Estimation Programs
- General Help Tools

Review of LID Simulation Methods
- Hydrologic & Hydraulic Modeling

- NRCS Curve No. Method
- SWMM or PCSWMM
- HSPF (Hydrologic Simulation Program in FORTRAN) Model Function Tables
- EPA National Stormwater Calculator
- Statistical Method
- FLO-2D/SWMM

Review of LID Simulation Methods
- Benefit/Cost Estimation Programs

The Pima County Regional Flood Control District & Pima Association of Governments with the Cooperation of the City of Tucson



Review of LID Simulation Methods

- General Help Tools

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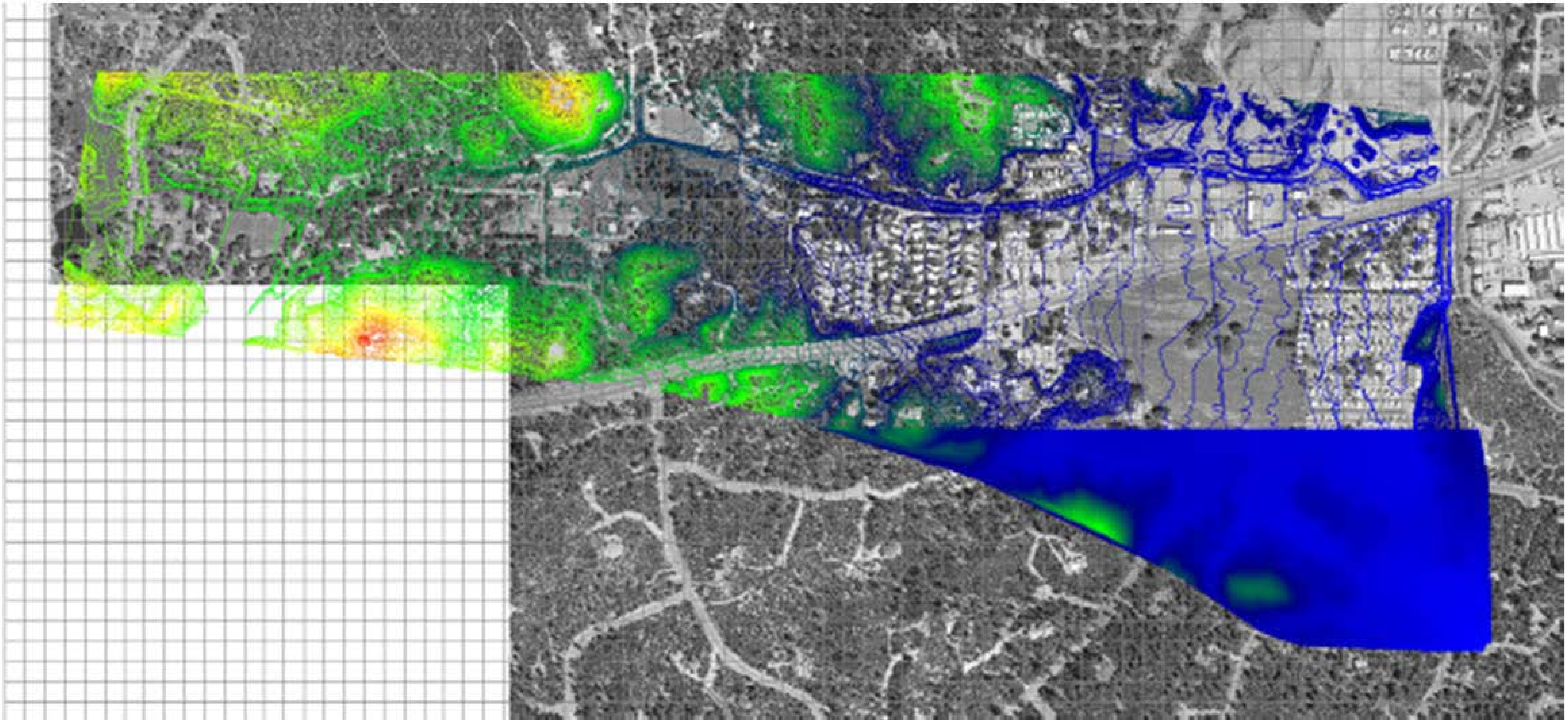
FLO-2D/SWMM Modeling of LID Controls
- Why FLO-2D/SWMM?

- LID practices are known to reduce area flooding, but quantification of LID flood impacts has been minimal to date;
- Grid-base (20’x20’ or smaller) provides necessary level of detail;
- Dynamic – accounts for spatial and temporal effects of distributed LID;
- Physical parameter modeling reduces dependence on assumptions;
- Model can track storm water volumes, peak flows, quality, and other parameters at the grid level;

FLO-2D/SWMM Modeling of LID Controls
- Why FLO-2D/SWMM?



How To Model LID with FLO-2D?

- Grid elevation adjustment-to mimic the volume storage of a specific LID application;
- Initial loss abstraction (IA) adjustment-to approximate rainfall depth/volume reduction;
- Infiltration rate & maximum soil depth adjustment;
- Diversion by a structure;
- Storm drain systems;
- Use artificial levees around the grids to control the flow locations and directions;
- Spatially variable rainfall data.

FLO-2D/SWMM Integration

Modeling of Storm Drain Systems

FLO-2D Modeling of LID Basic Controls

- Possible Modeling Parameters

FLO-2D Modeling Parameters for LID Basic Controls							
	Method No.	Parameter Name	LID Basic Control				
			Bio Retention	Bio Swale	Pervious Pavement	Rainwater Harvesting	Green Roof
			1	2	3	4	5
Potential Modeling Parameters	A	Grid elevation adjustment	X	X	X	X	
	B	Initial loss IA adjustment	X	X	X	X	X
	C	TOL value adjustment	X	X	X	X	X
	D	Infiltration rate adjustment	X	X	X	X	
	E	Limiting soil depth	X	X	X	X	
	F	Spatially variable rainfall	X	X	X	X	X
	G	Diversion by structure	X	X	X	X	X
	H	Boundary outflow grid	X	X	X	X	X
	I	Use of artificial WRF	X	X	X		X
	J	Use of artificial levee	X	X	X		
	K	Use of artificial storm drain	X	X	X	X	X
	L	Others/IRAIN-BUILDING				X	X

FLO-2D Modeling of LID Basic Controls

- Recommended Modeling Parameters

FLO-2D Modeling Methods for LID Basic Controls				
LID Basic Control	Possible Modeling Methods			
	Grid elevation adjustment	Initial loss IA adjustment	Infiltration rate/Soil depth adjustment	Use of artificial storm drain
Bio Retention	X	X	X	X
Bio Swale	X	X	X	X
Pervious Pavement	X	X	X	X
Rainwater Harvesting		X	X	X
Green Roof		X		X

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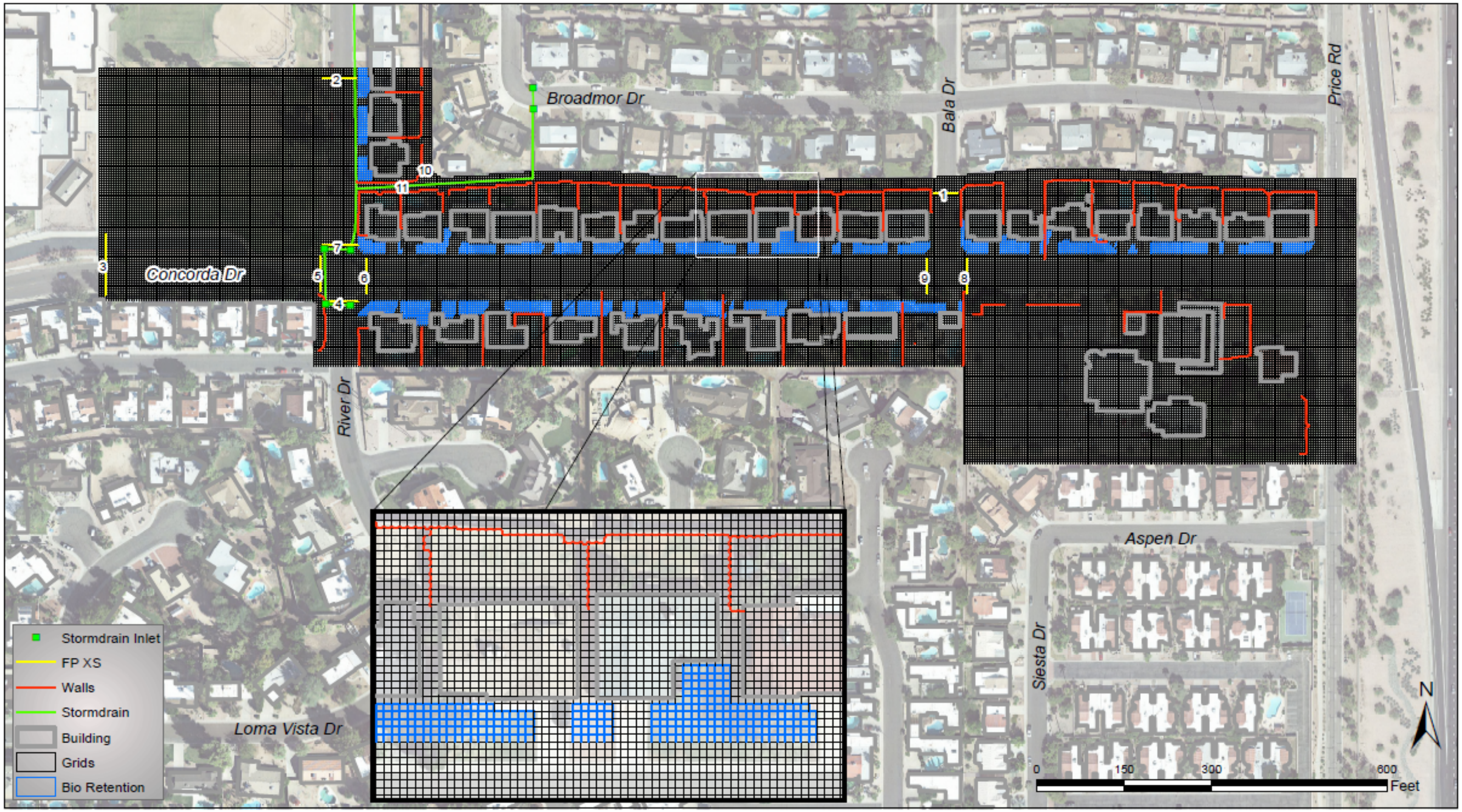
FLO-2D Modeling of LID Basic Controls

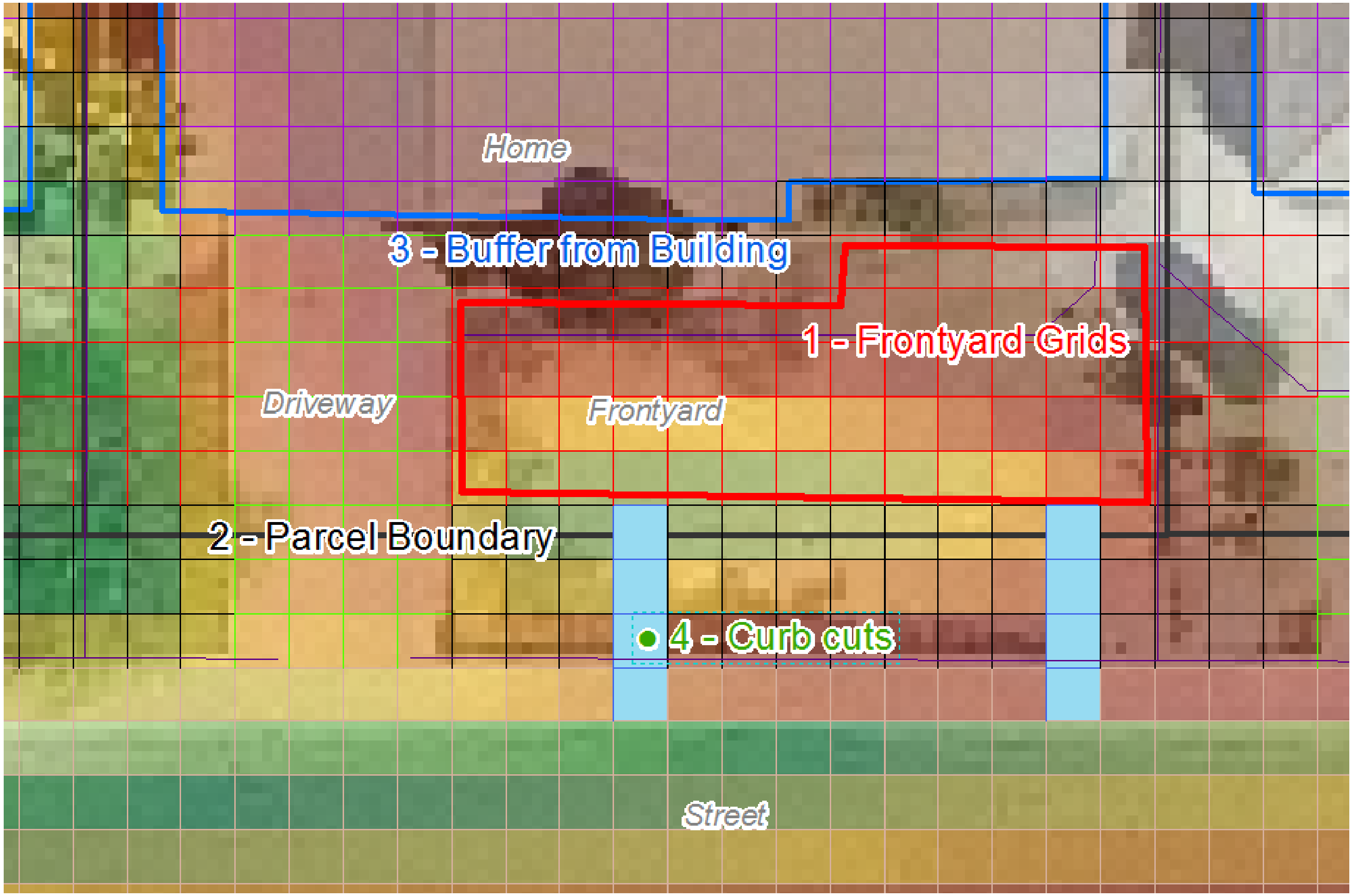
- Bio Retention

LID Focus Modeling Area - Bio Retention Control Grids



FLO-2D Modeling of LID Basic Controls

- Bio Retention



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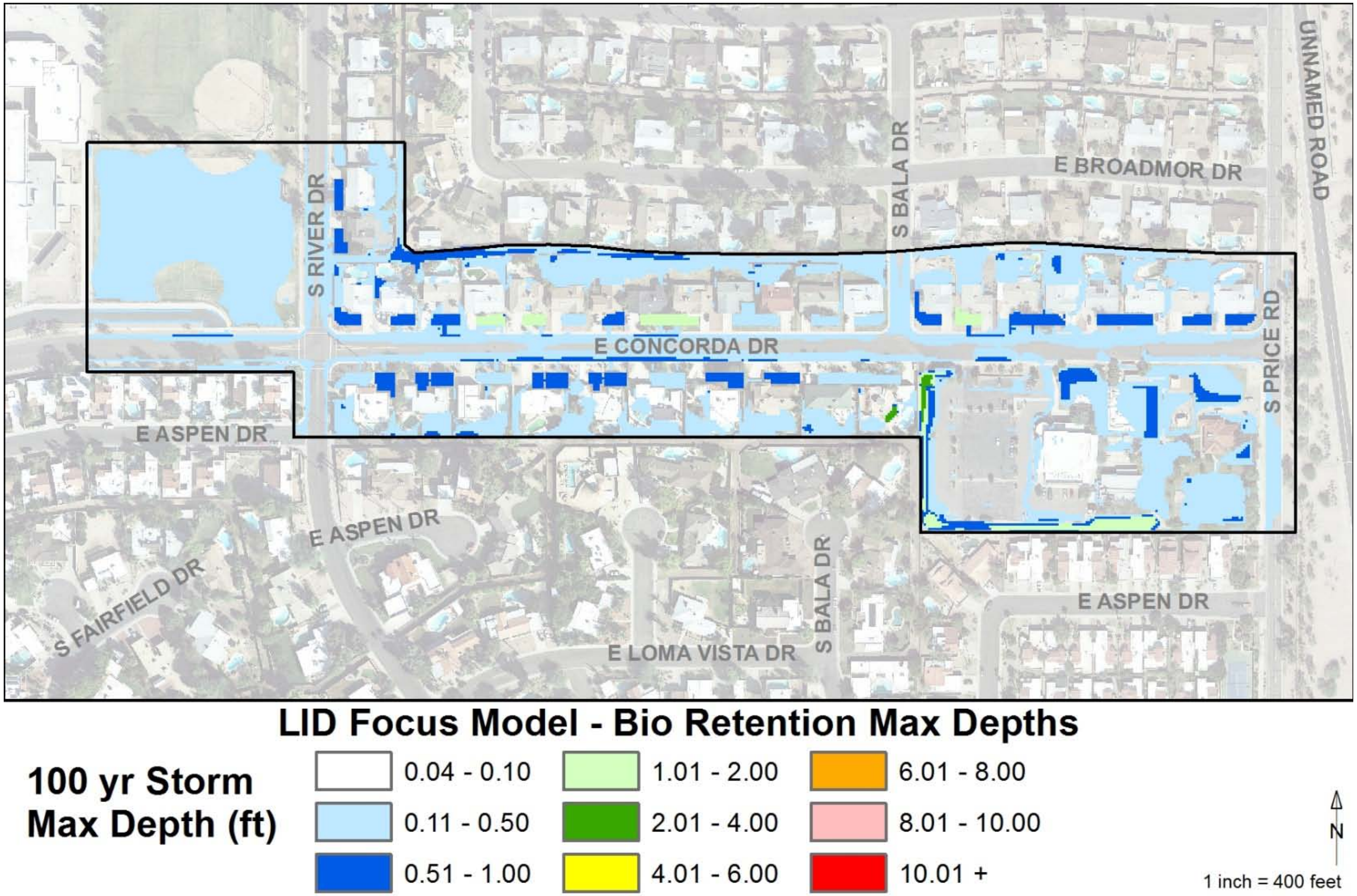

FLO-2D Modeling of LID Basic Controls

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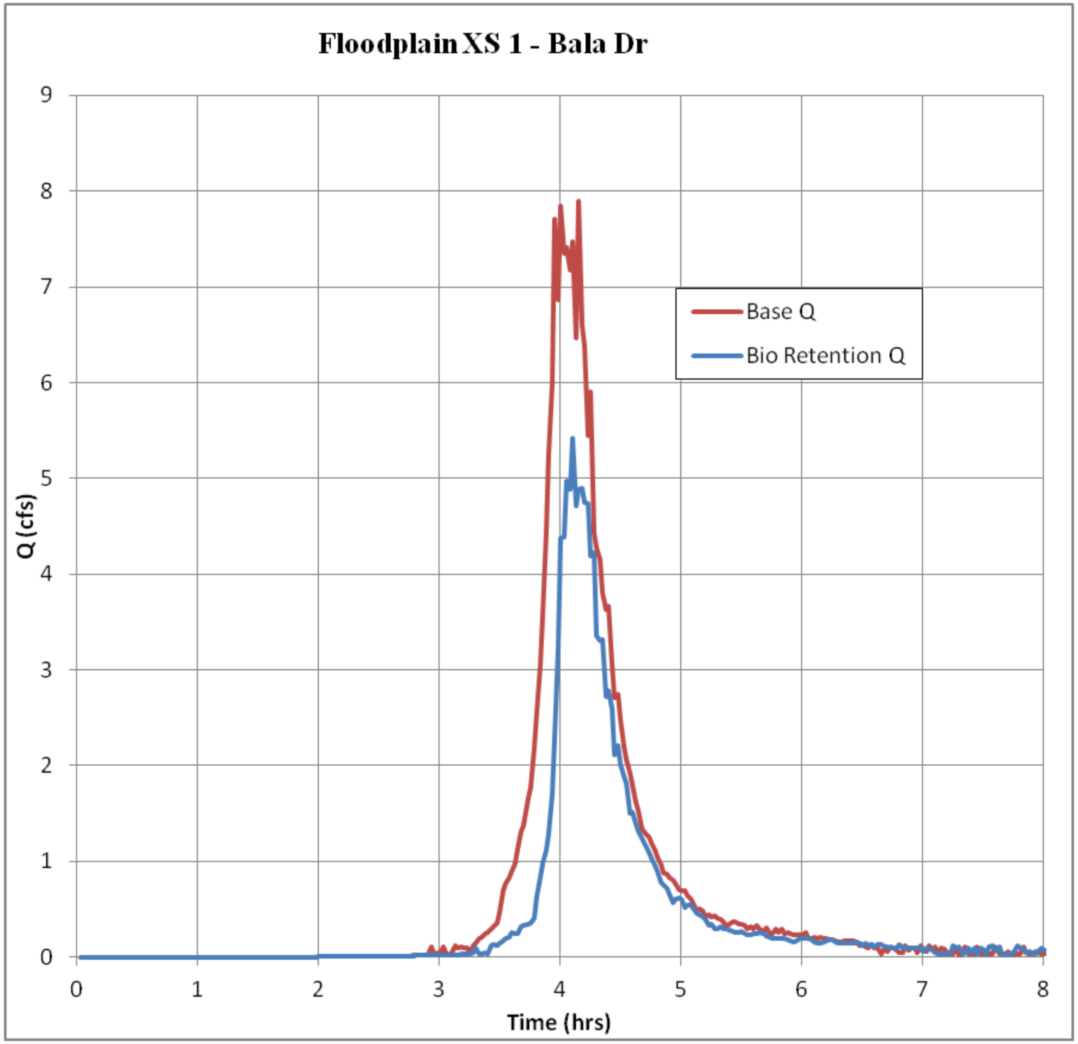
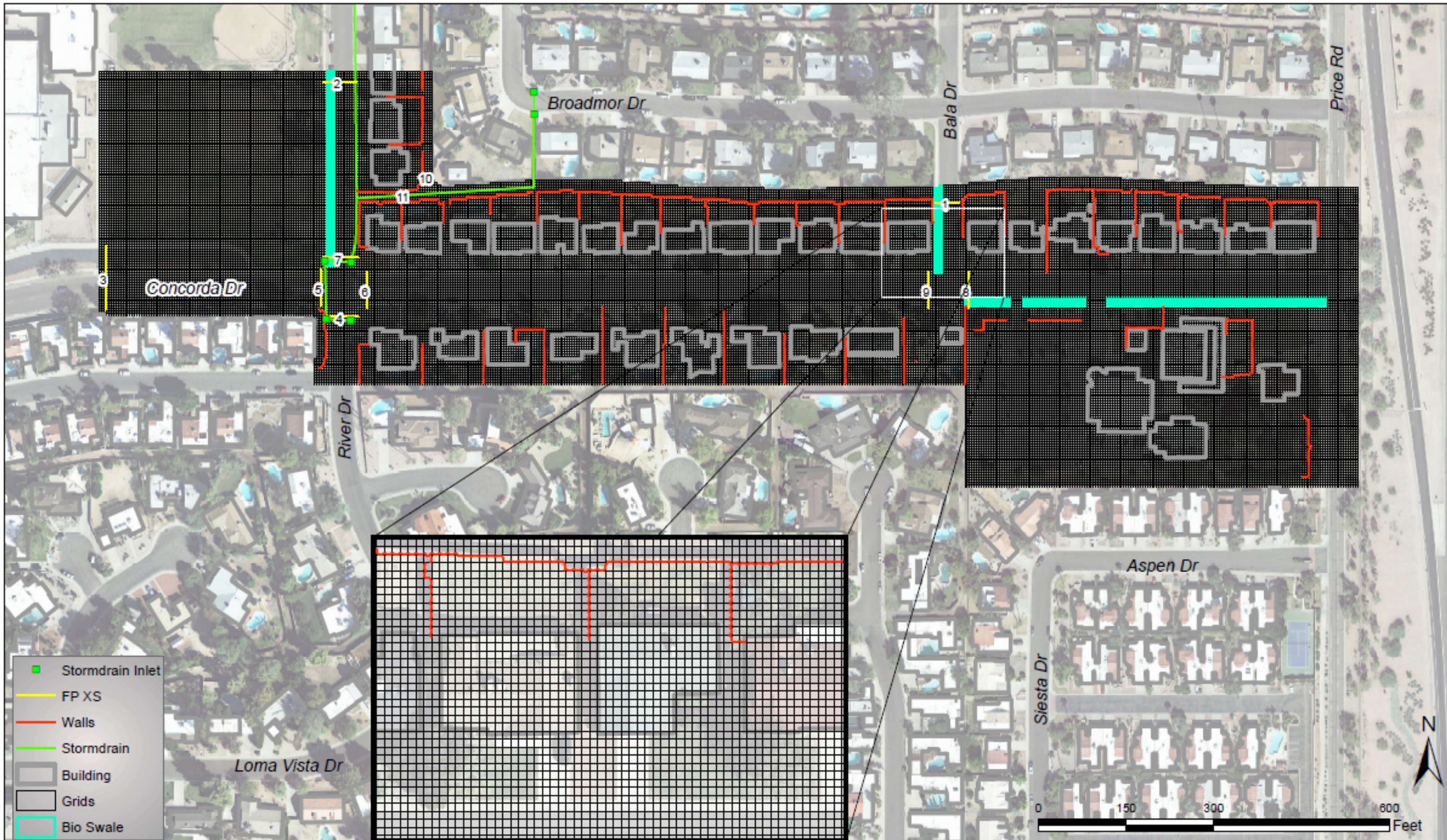


FLO-2D Modeling of LID Basic Controls

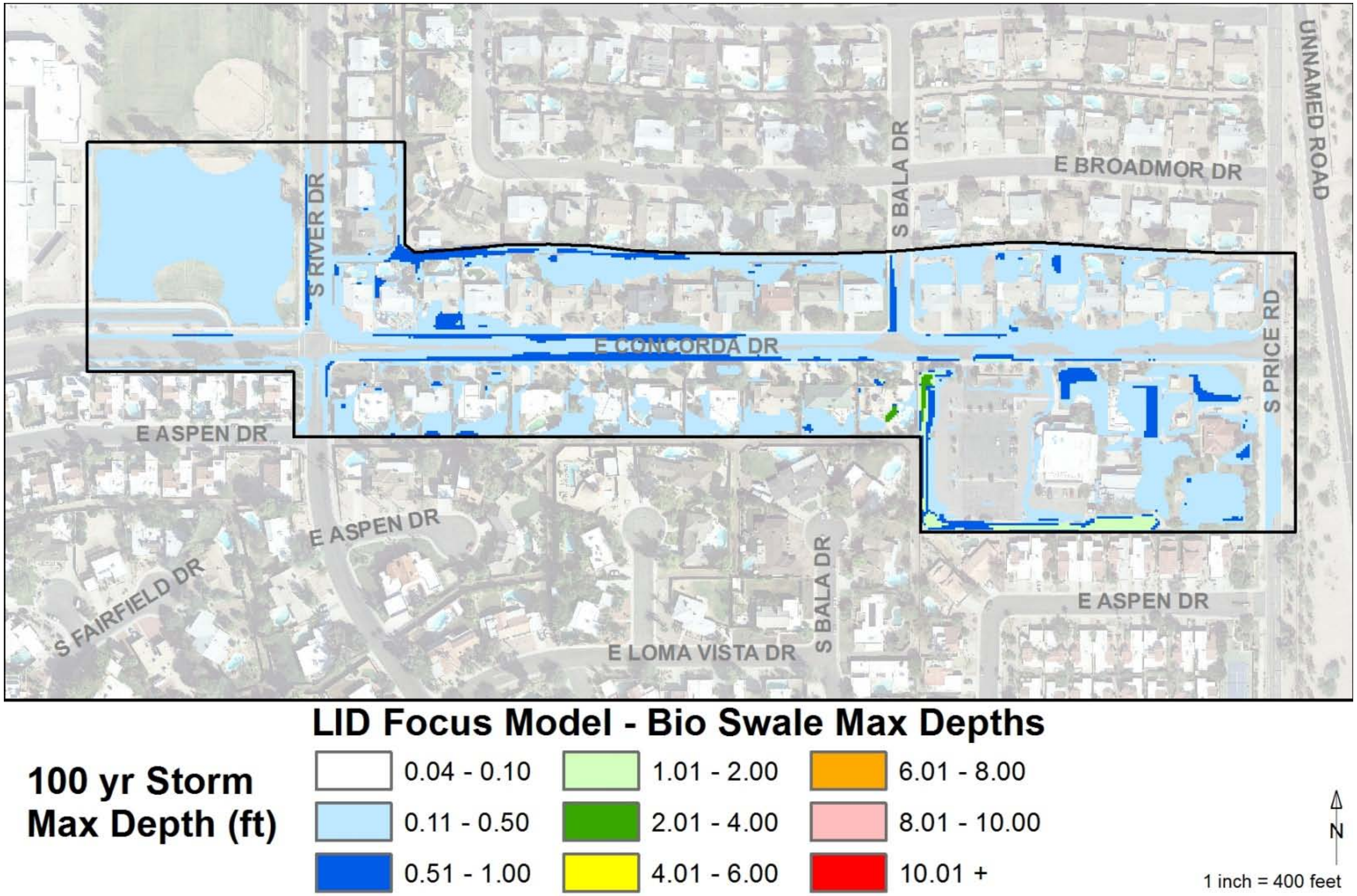
- Bio Swale

LID Focus Modeling Area - Bio Swale Control Grids



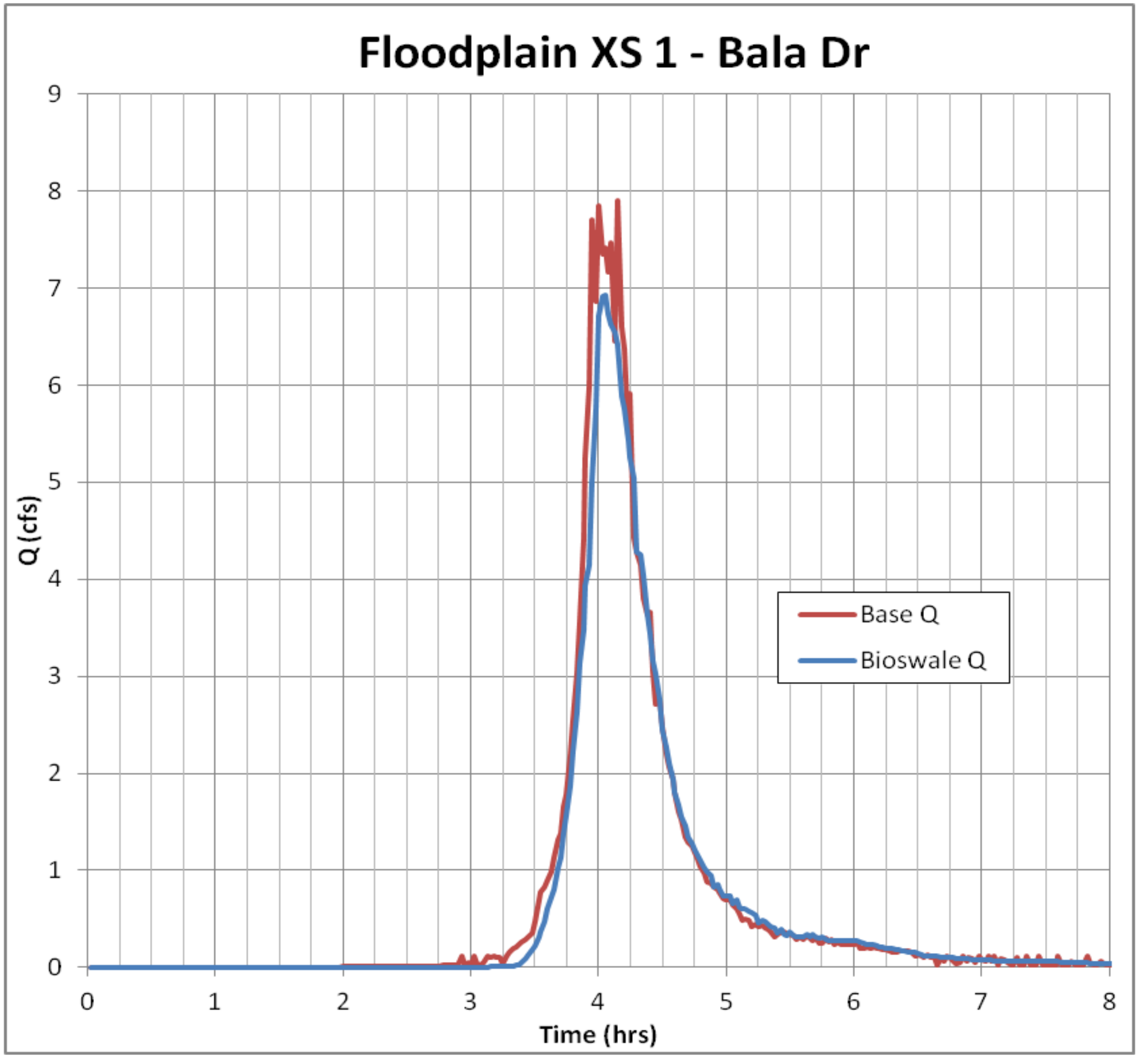
FLO-2D Modeling of LID Basic Controls

- Bio Swale



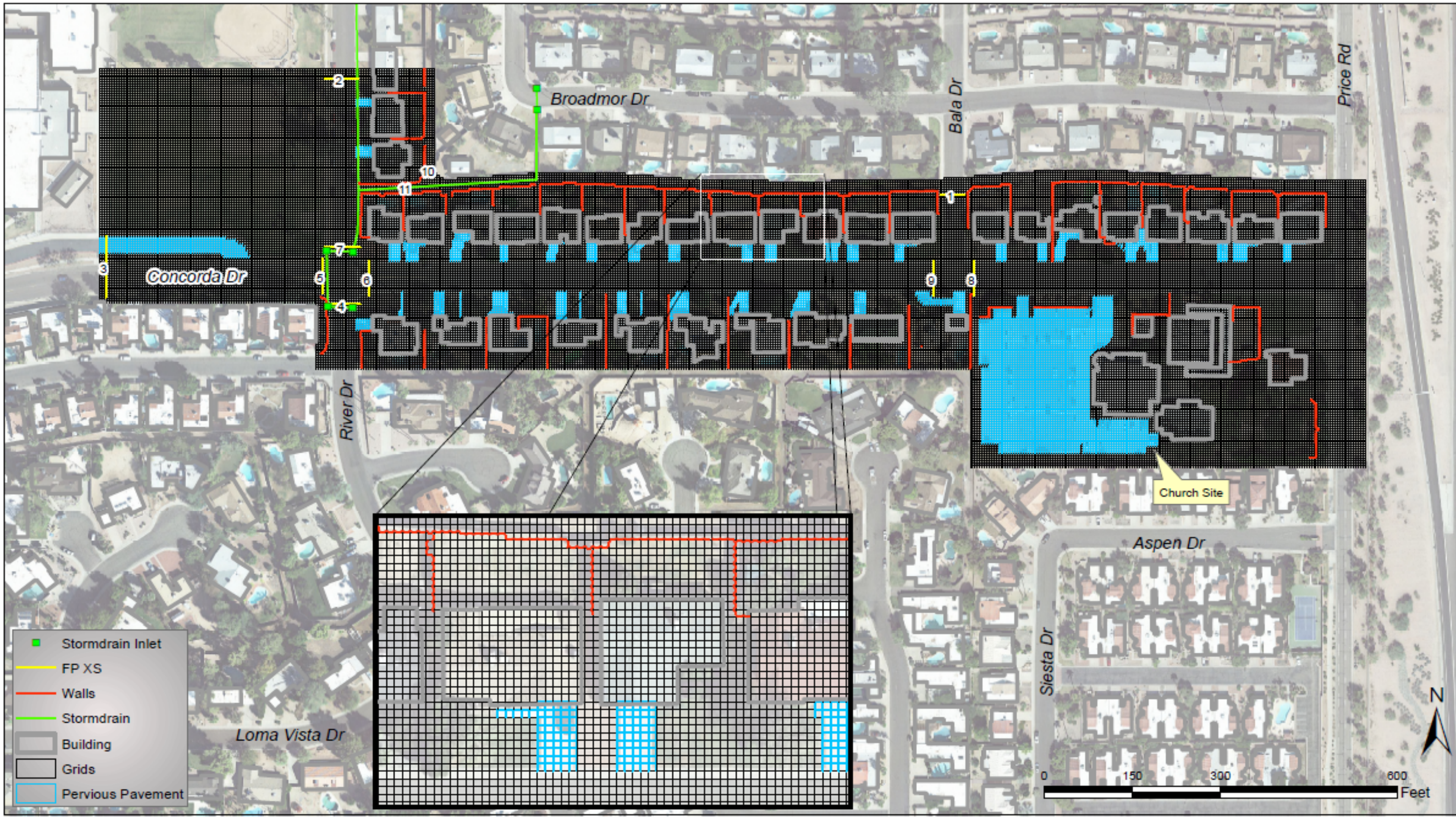
FLO-2D Modeling of LID Basic Controls

- Bio Swale



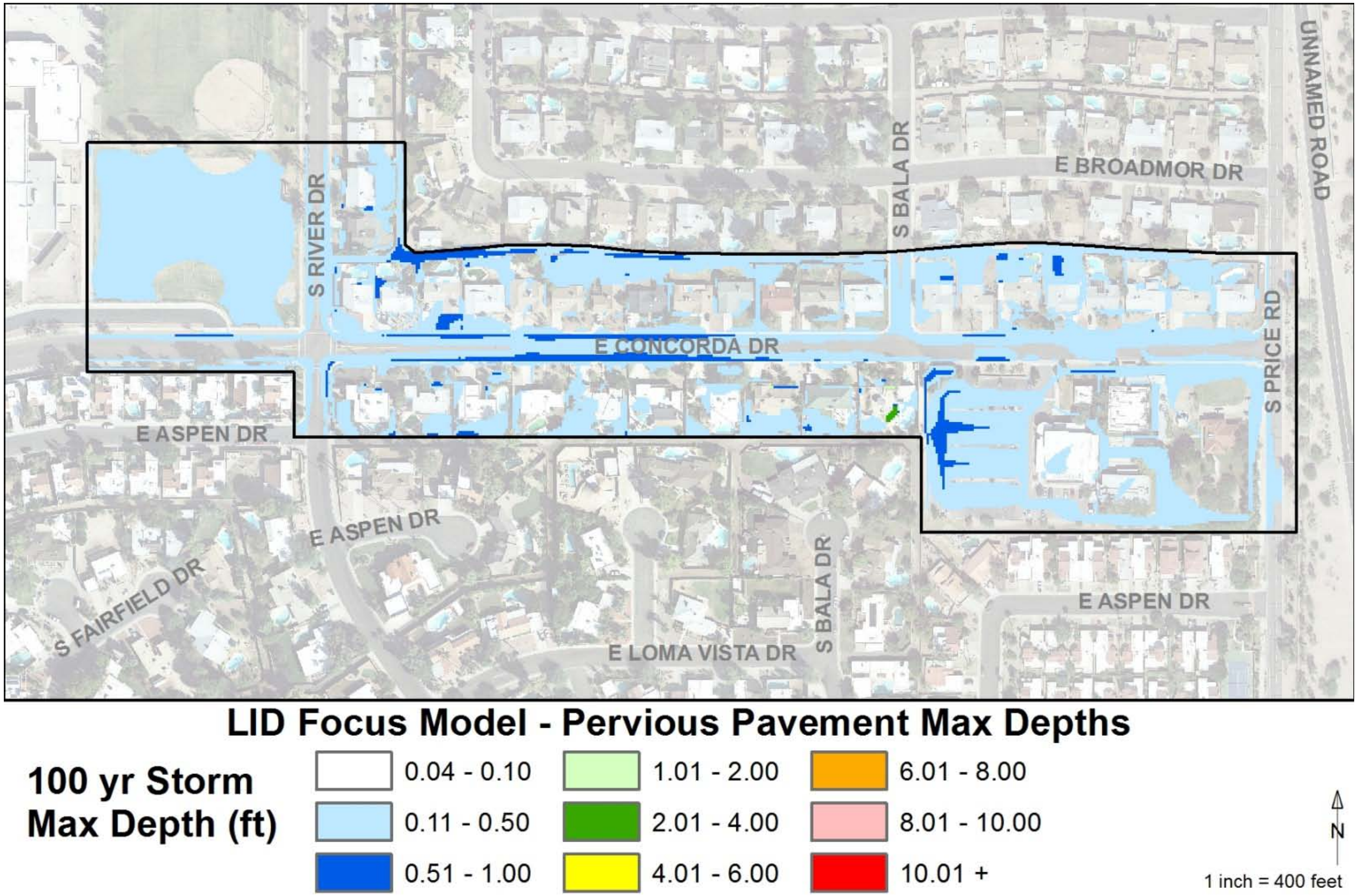
FLO-2D Modeling of LID Basic Controls - Pervious Pavement

LID Focus Modeling Area - Pervious Pavement Control Grids



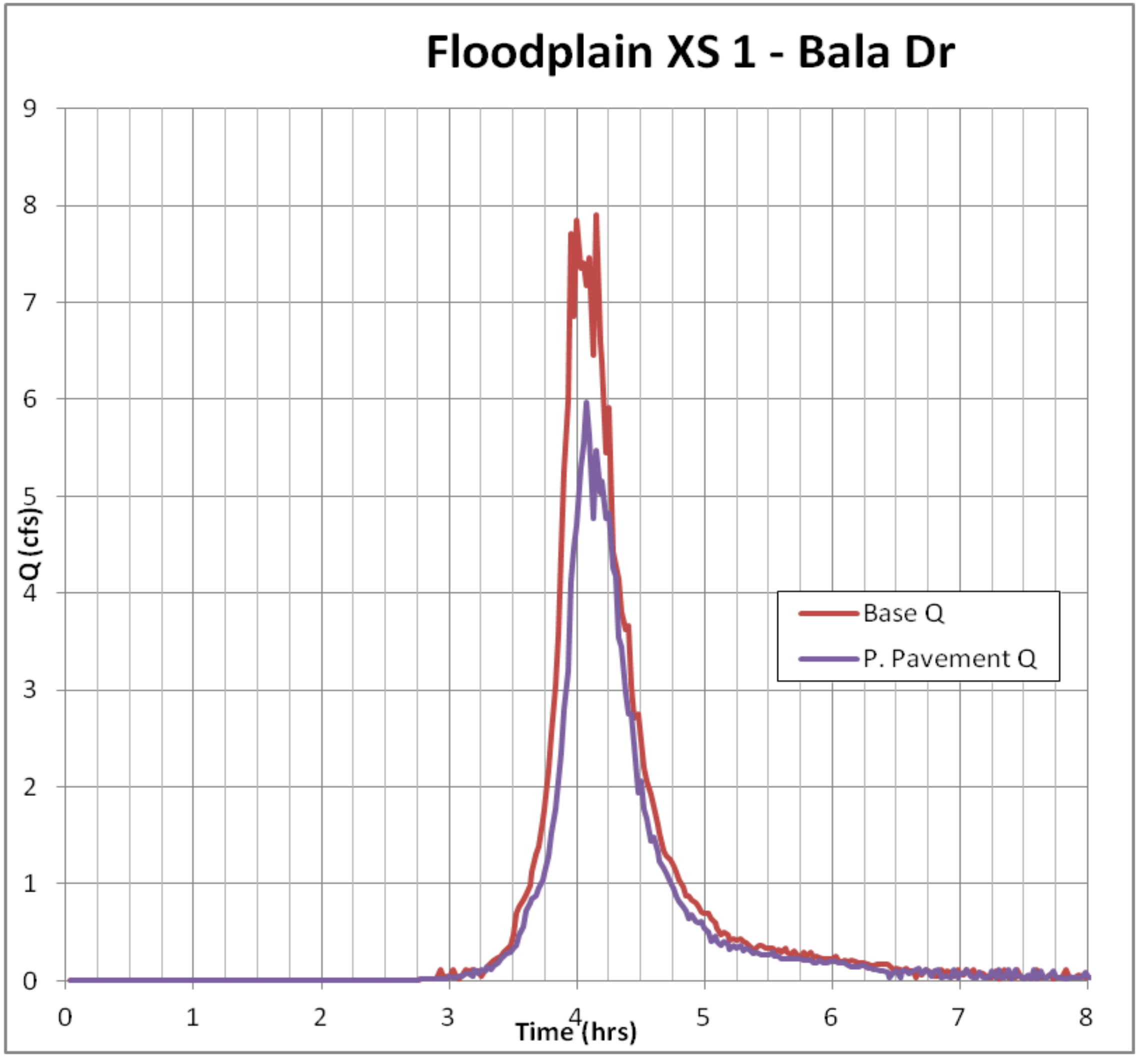
FLO-2D Modeling of LID Basic Controls

- Pervious Pavement



FLO-2D Modeling of LID Basic Controls

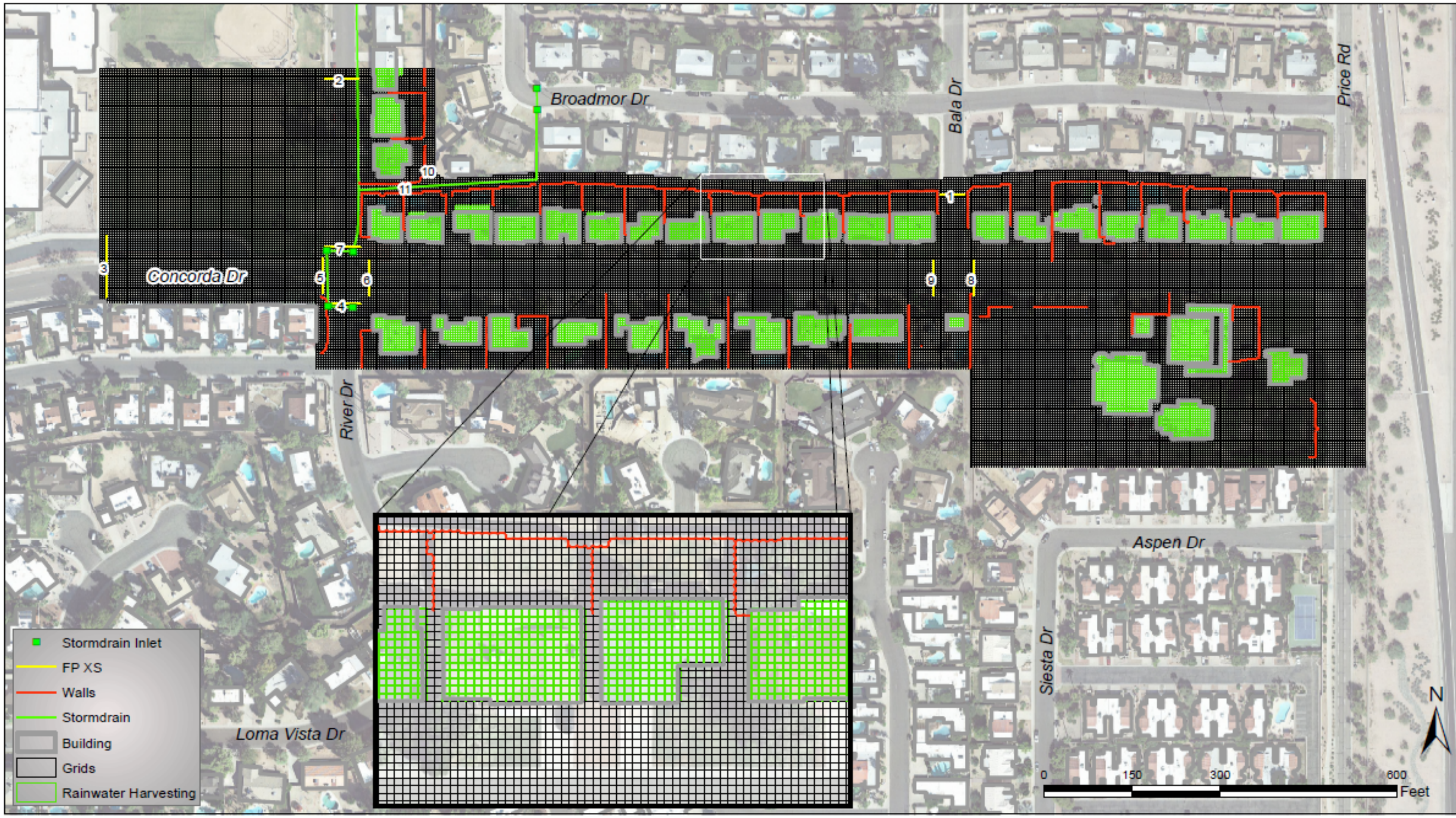
- Pervious Pavement



FLO-2D Modeling of LID Basic Controls

- Rainwater Harvesting

LID Focus Modeling Area - Rainwater Harvesting Control Grids



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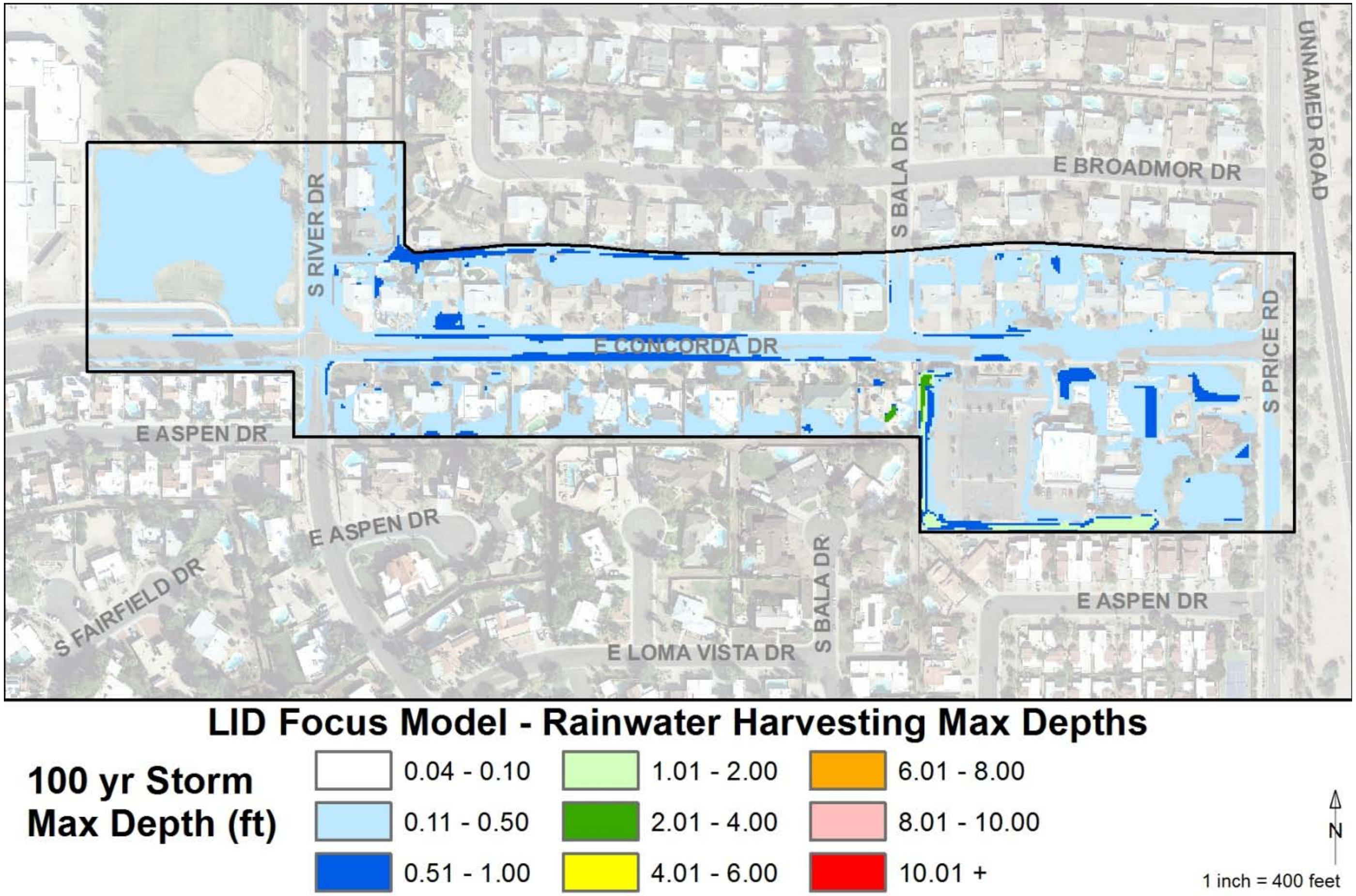

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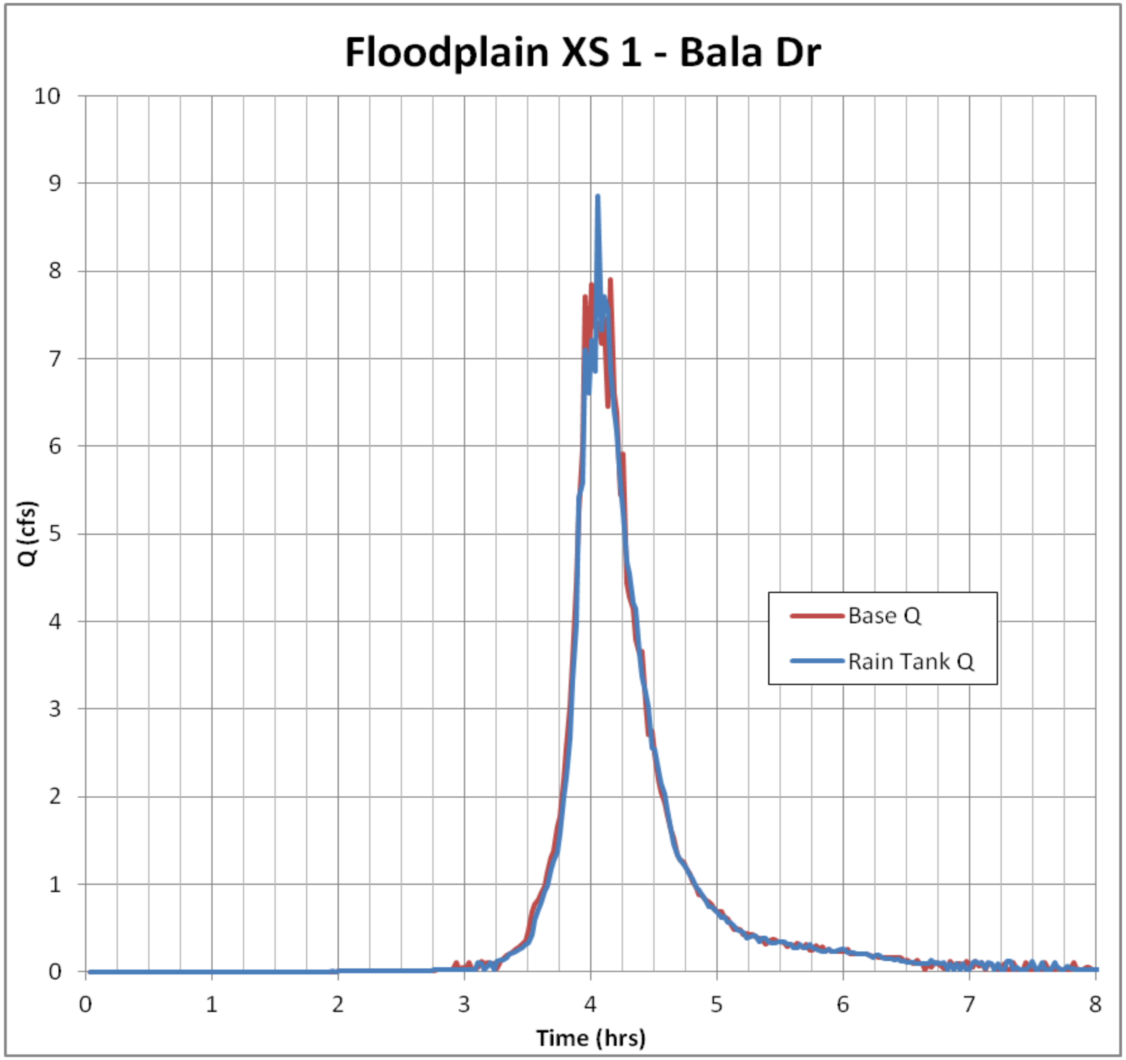
FLO-2D Modeling of LID Basic Controls

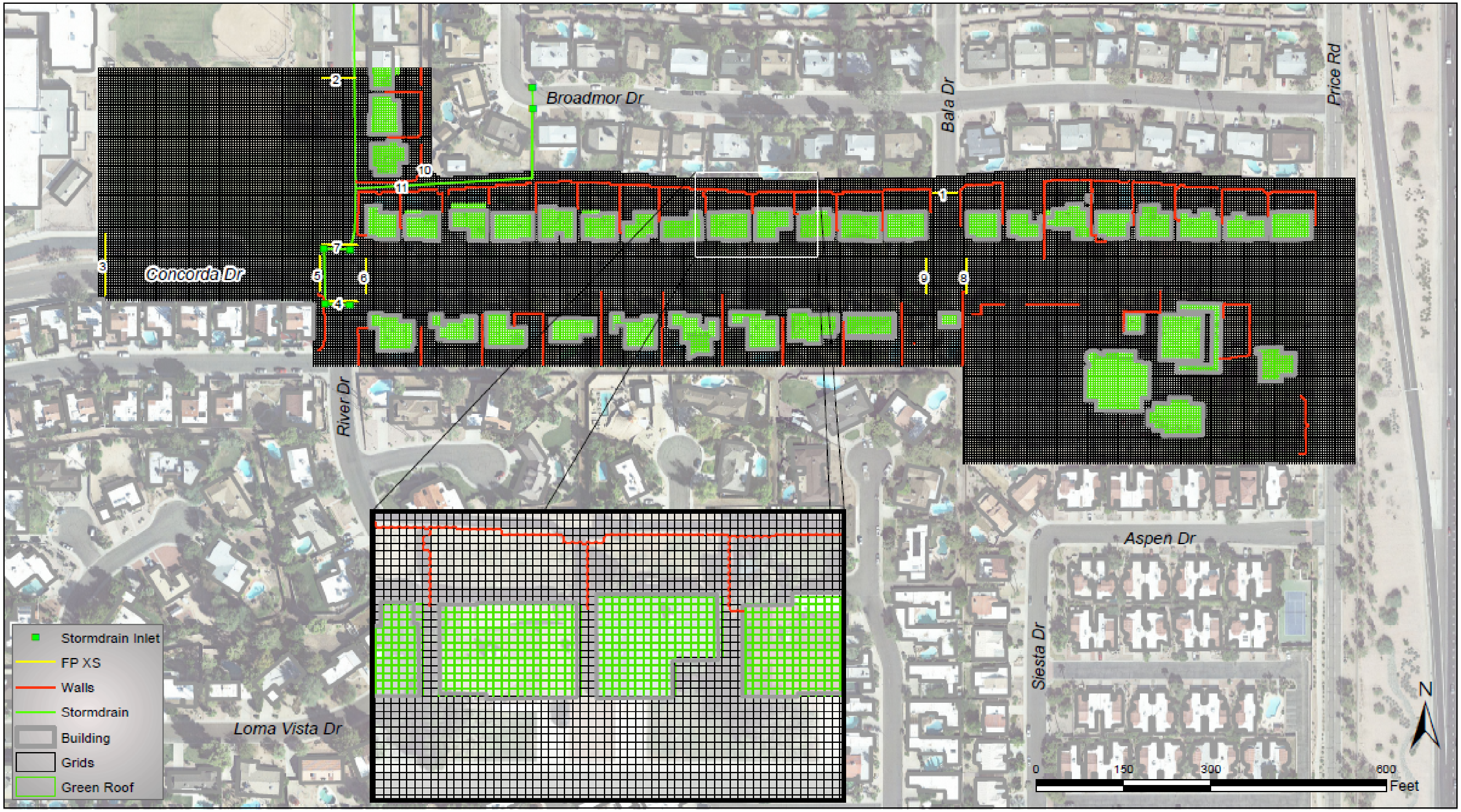
- Rainwater Harvesting



FLO-2D Modeling of LID Basic Controls

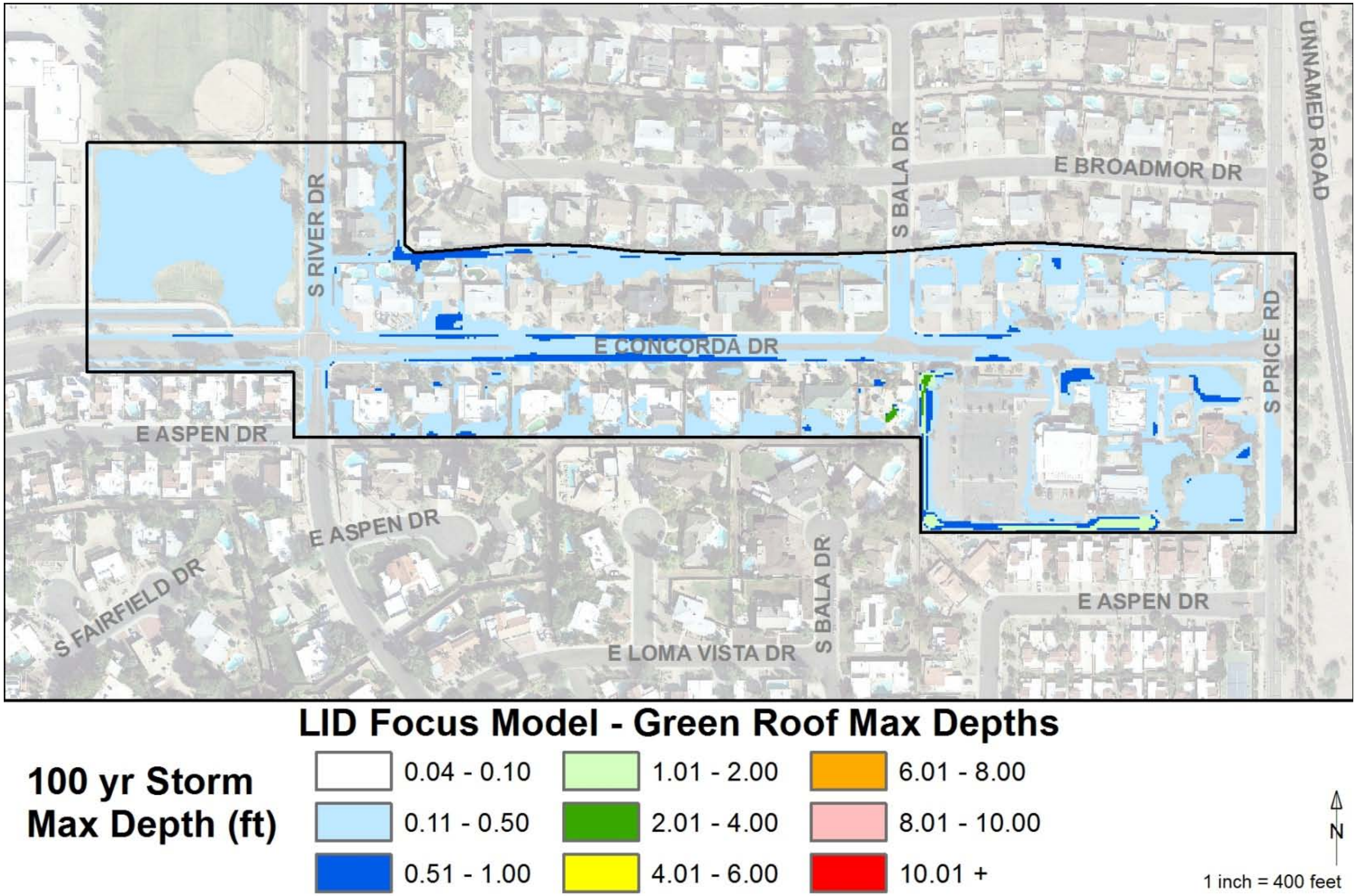
- Green Roof

LID Focus Modeling Area - Green Roof Control Grids



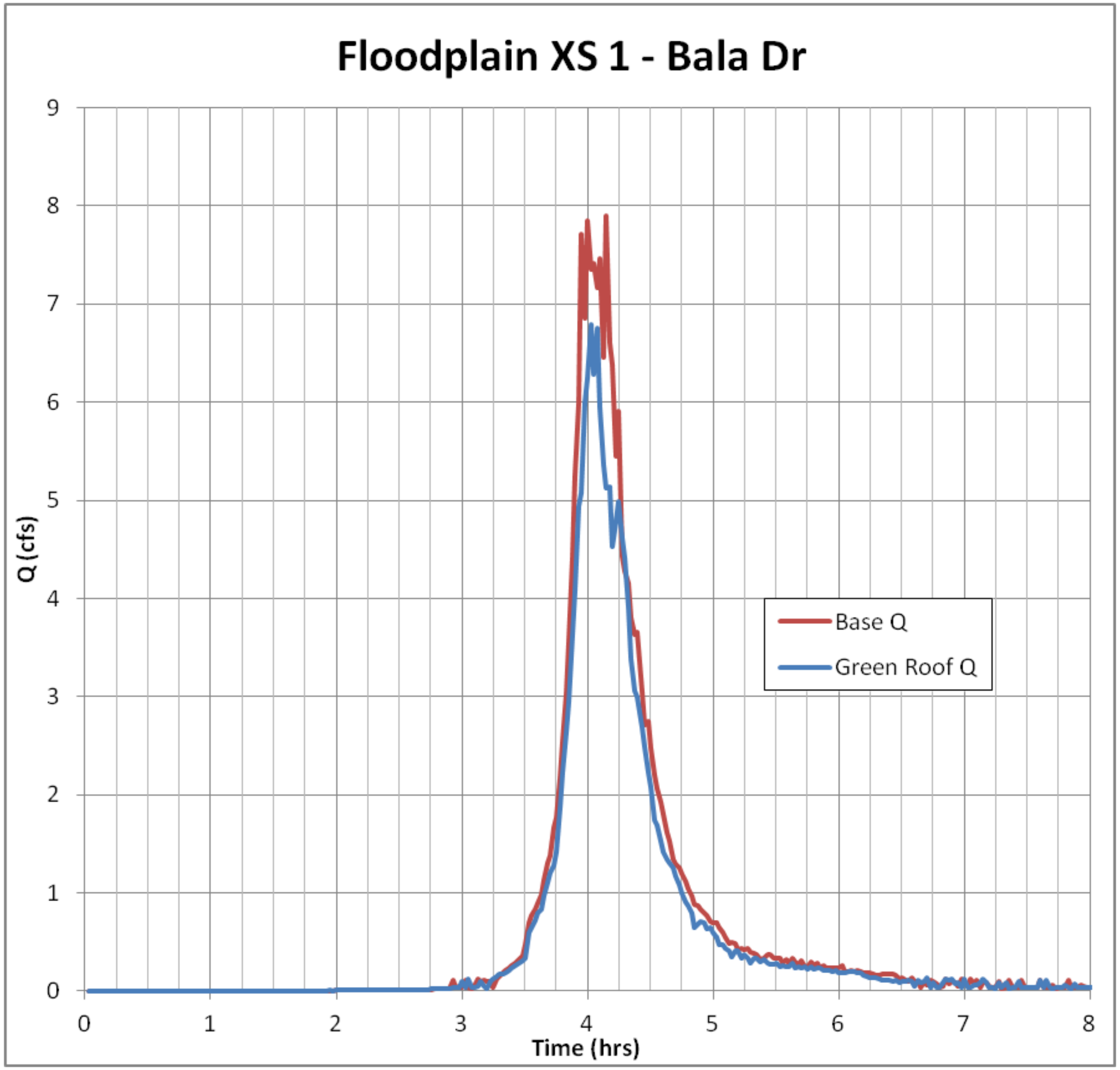
FLO-2D Modeling of LID Basic Controls

- Green Roof



FLO-2D Modeling of LID Basic Controls

- Green Roof



FLO-2D Modeling of LID Basic Controls

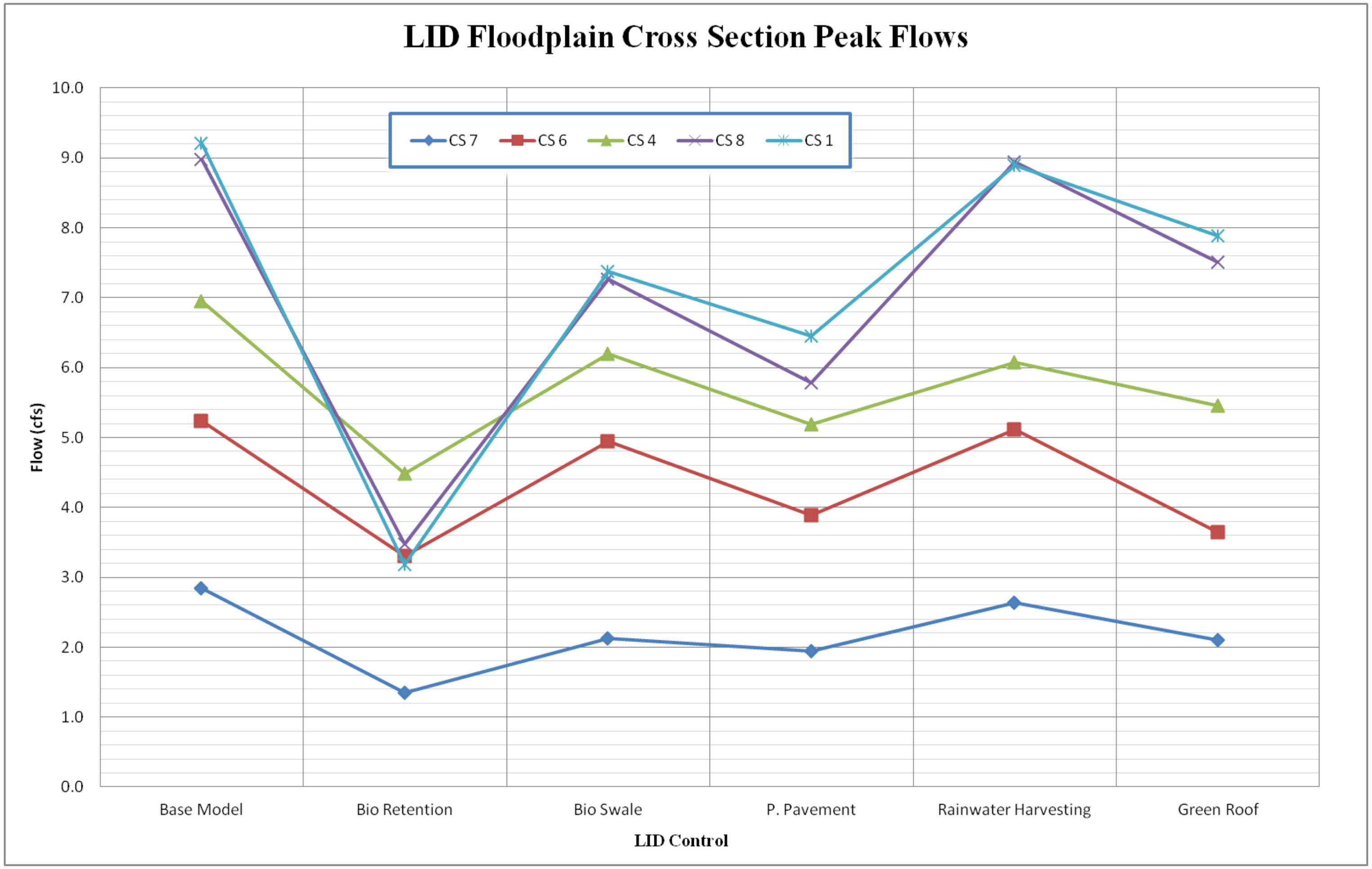
- Storm Water Volume Reduction

Summary Table for LID Basic Control Modeling Results

		Model	LID 2.1	LID 6.5	LID 13	LID 7.3	LID 9.3	LID 9.6
			Base	Bio Retention	Bio Swale	Pervious Pavement	Rainwater Harvesting	Green Roof
SWMM RPT	Outflow (Outfall node I338)	Qp (cfs)	8.58	4.70	8.45	7.52	8.62	7.85
	Wet weather inflow	V (acft)	1.19	0.64	1.11	1.02	1.15	0.93
	Return flow	V (acft)	0.04	0.00	0.03	0.02	0.04	0.02
SUMMARY OUT	Rainfall volume (2.52" depth)	V (acft)	4.37	4.37	4.37	4.37	4.37	4.37
	Infiltration & interception	V (acft)	0.93	1.32	0.99	1.67	1.05	1.54
		%	*21*	*30*	*23*	*38*	*24*	*35*
	Floodplain storage	V (acft)	1.47	1.83	1.5	1.09	1.44	1.27
		%	*34*	*42*	*34*	*25*	*33*	*29*
	TOL storage	V (acft)	0.07	0.07	0.07	0.07	0.07	0.07
		%	*2*	*2*	*2*	*2*	*2*	*2*
	Floodplain outflow	V (acft)	0.76	0.58	0.79	0.59	0.73	0.64
		%	*17*	*13*	*18*	*14*	*17*	*15*
	Stormdrain (FLO-2D to SWMM)	V (acft)	1.23	0.64	1.1	1.02	1.17	0.92
		%	*28*	*15*	*25*	*23*	*27*	*21*
	Return flow (SWMM to FLO-2D)	V (acft)	0.03	0.00	0.02	0.00	0.02	0.01
Vol Comparison	Sum of volumes	V (acft)	4.36	4.37	4.36	4.37	4.37	4.36
	LID volume captured	V (acft)	-	0.75	0.09	0.74	0.12	0.61
	LID design volume capacity	V (acft)	-	0.89	0.31	0.85	0.12	0.63
	Utilization of LID volume	%	-	84	29	87	98	96

FLO-2D Modeling of LID Basic Controls

- Peak Flow Reduction at CS




Questions?