Infiltration BMP Design Exercise

Applications to a Site Development

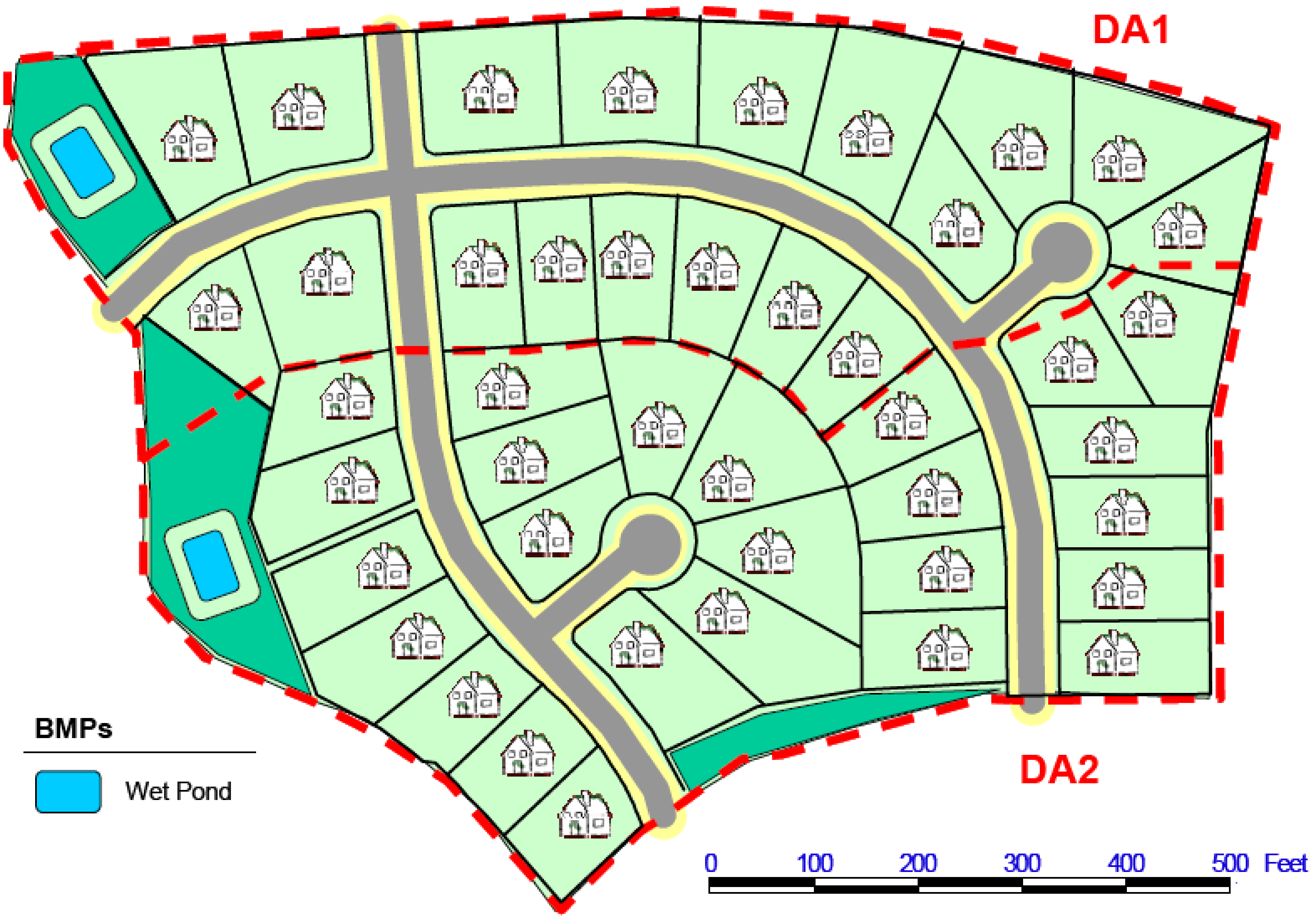
IAFSM

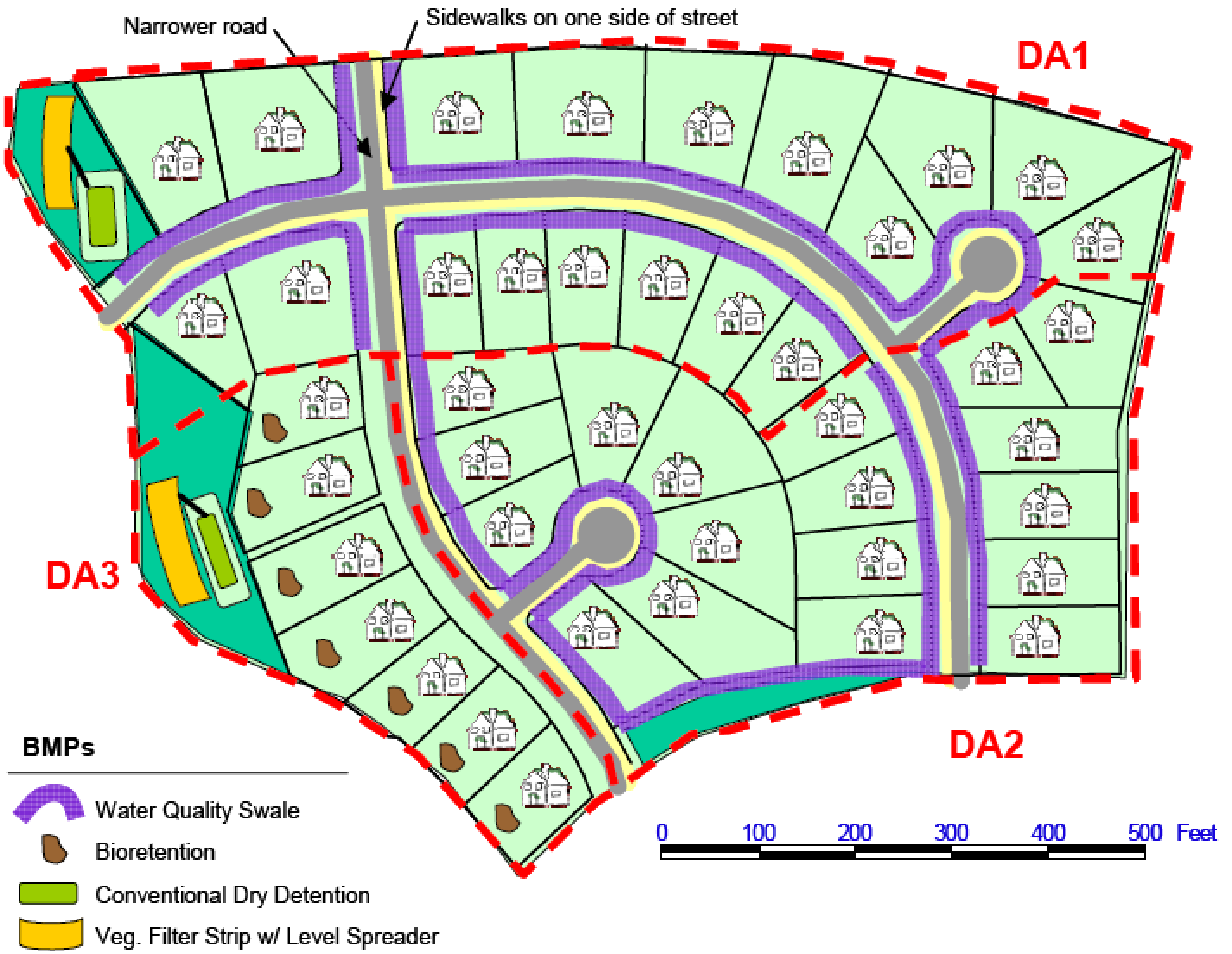
Illinois Association for Floodplain and Stormwater Management

Introduction –
Robert Murdock (Michael Baker Jr., Inc.)

- Site Plan Example
- Intent of Design Exercise

Example





Narrower road
Sidewalks on one side of street
DA1
DA2
DA3
BMPs
Water Quality Swale
Bioretention
Conventional Dry Detention
Veg. Filter Strip w/ Level Spreader
0 100 200 300 400 500 Feet

Existing Site and Land Use Intent –
Gregory Kacvinsky (Foth Infrastructure & Environment, LLC)

- Developer's goals
  - 10-acre parcel (660 feet square)
  - Minimum density of 2.8 units/acre (28 units minimum)
  - Residential
  - Single entrance from road along north side
  - Must include street stubs to south and west to serve future planned developments *(commercial properties planned west and south of development, along south bank of channel)*

Existing Site and Land Use Intent – Continued

- Local Rules
  - Standard R.O.W. width is 60 feet for local roads
  - Standard street width is 30 feet (face-face)
  - Minimum residential lot size is 8,000 sq. ft.
  - Low Impact Development Ordinance (allows variance from street/R.O.W./lot size minimums):
    - 50-foot R.O.W.
    - 24-foot edge-edge (pavement without curb)
    - Minimum 6,000 sq. ft. lots (minimum 50’ frontage)

Existing Site and Land Use Intent – Continued

- Other considerations
  - Pedestrian/bicycle pathway desired to connect developments
  - Offsite drainage (from areas east and south)
  - Existing wetland
  - Existing drainage channel
    - 1.5:1 (horiz:vert) sideslopes
    - Local Greenway Ordinance requires flatter sideslopes and linear amenities

Design Standard Overview –

Robert Murdock (Michael Baker Jr., Inc.)

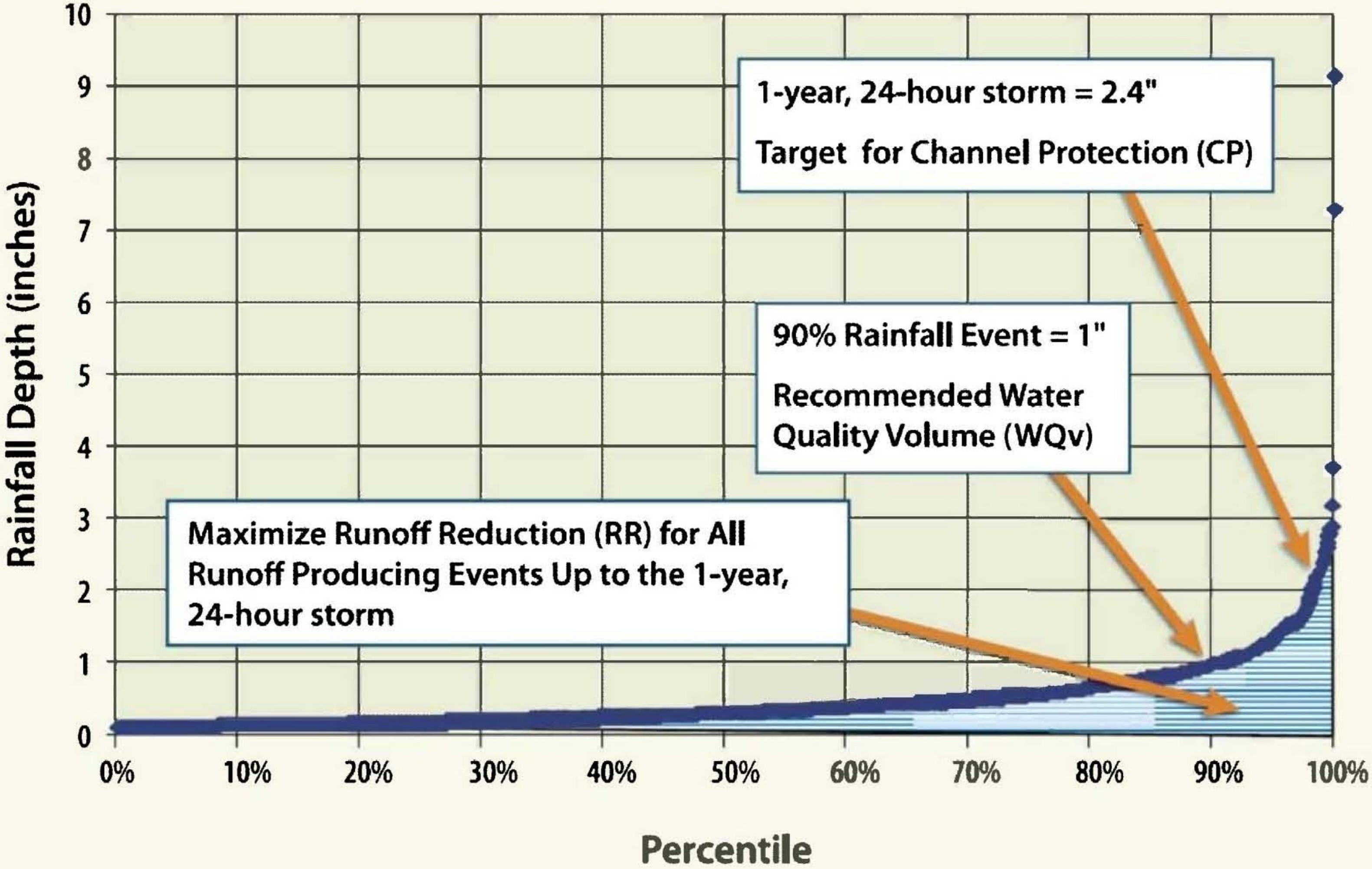
- What are the local design standards that will impact the development?

Design Standard Overview – Continued

Basic Options for Water Quality

- 90 % Rainfall Event:
  - The water quality volume is equal to the storage required to capture and treat approximately 90% of the average annual stormwater runoff volume.
  - The specific rainfall event captured is the 90% storm event, or the storm event that is greater than or equal to 90% of all 24-hour storms on an annual basis.
  - This value varies regionally, based on local rainfall patterns.

2. Water quality hydrology is for smaller events



See Chapter 4: Figure 4.2

Design Standards for Sizing BMPs

Table 1. 90% Rainfall Event for Select U.S. Cities	
City	**Rainfall (Inches)**
Columbus, OH	1.0
Albany, NY	0.9
New York, NY	1.2
Frederick, MD	1.1
Washington, D.C.	1.2
Boise, ID	0.5
Phoenix, AZ	0.8
Denver, CO	0.7
Austin, TX	1.4
Savannah, GA	1.5
Montpelier, VT	0.9
Los Angeles, CA	1.3

http://www.stormwatercenter.net/- Stormwater manager’s resource center

Design Standard Overview – Continued

Annual Volume Reduction

- For residential developments one of the following shall be met:
  - Infiltrate sufficient runoff volume so that the post–development infiltration volume shall be at least 90% of the pre–development infiltration volume, based on an average annual rainfall.
  - Infiltrate 25% of the post–development runoff volume from the 2–year, 24–hour design storm with a type II distribution.

Design Standard Overview – Continued

- Local Design Standards
  - Stormwater Quantity:
    - 0.15 cfs/acre (100-year storm)
  - Stormwater Quality:
    - 100% infiltration for 1 inch, 1-hour duration storm, AND
    - Maintain 90% of pre-development infiltration under proposed conditions (8-month rainfall series)

Design Standard Overview – Continued

- Local Design Standards
  - Detention in floodplains
    - Assume zero discharge during design (100-year) storm

Site Fingerprinting –

Erin Pande (Engineering Resource Associates, Inc.)

- What is “site fingerprinting”?

Site Fingerprinting – Continued

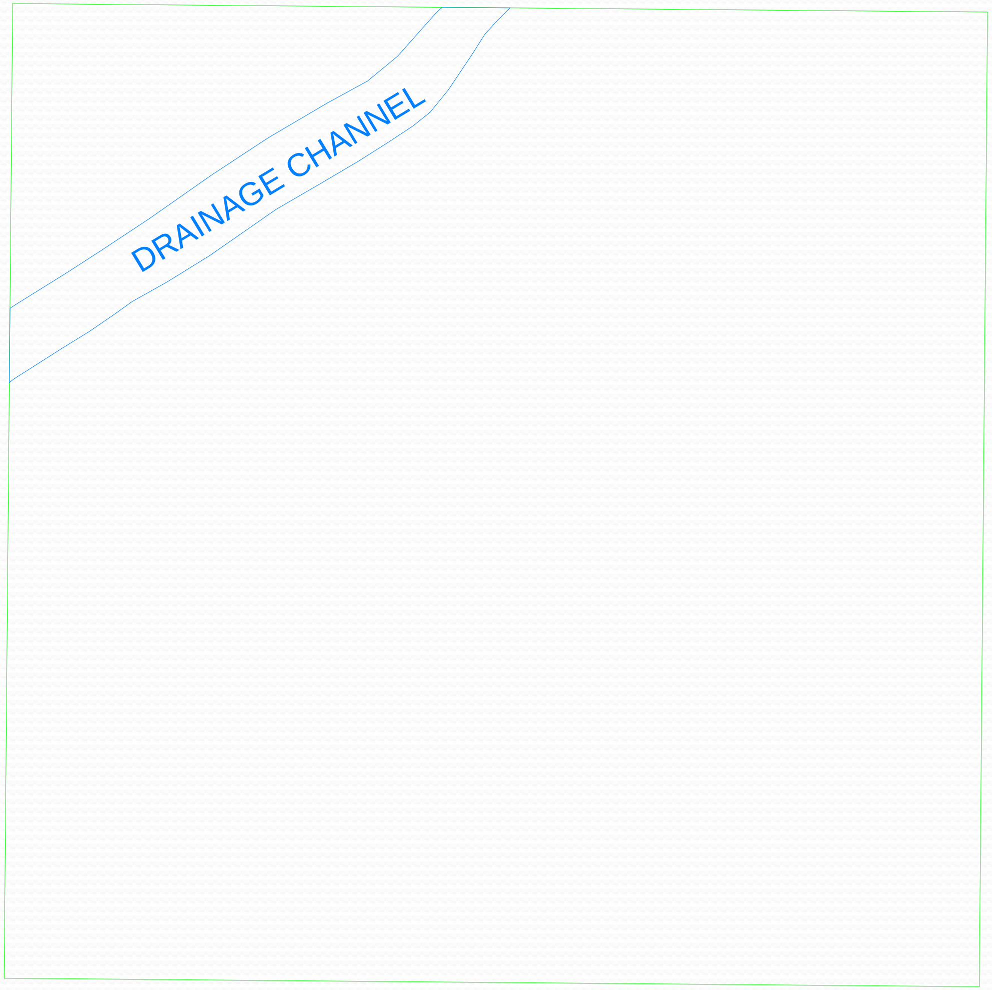
- Identify on-site and nearby environmental features and issues
  - Floodplain
  - Wetlands
  - Woodlands
  - Endangered Species
  - Archeological
  - Contamination

Site Fingerprinting –

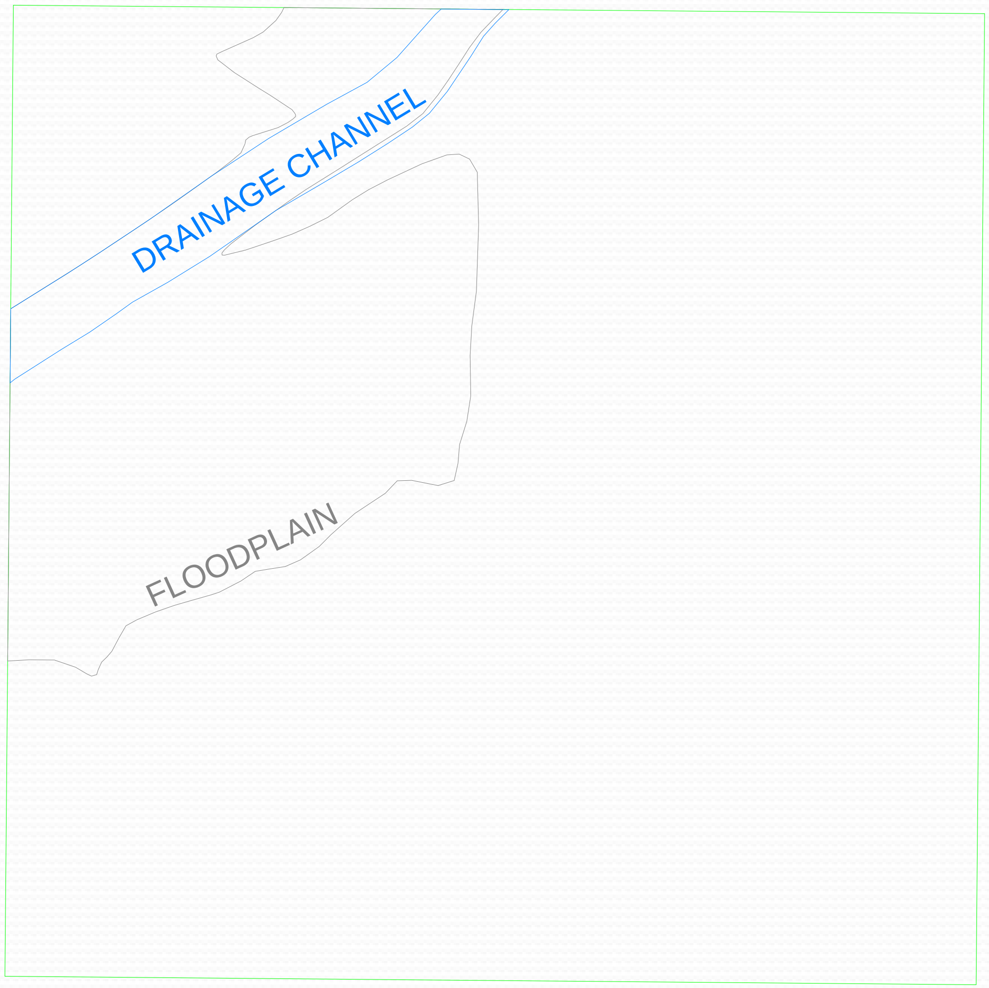
Continued

Site Fingerprinting –

Continued

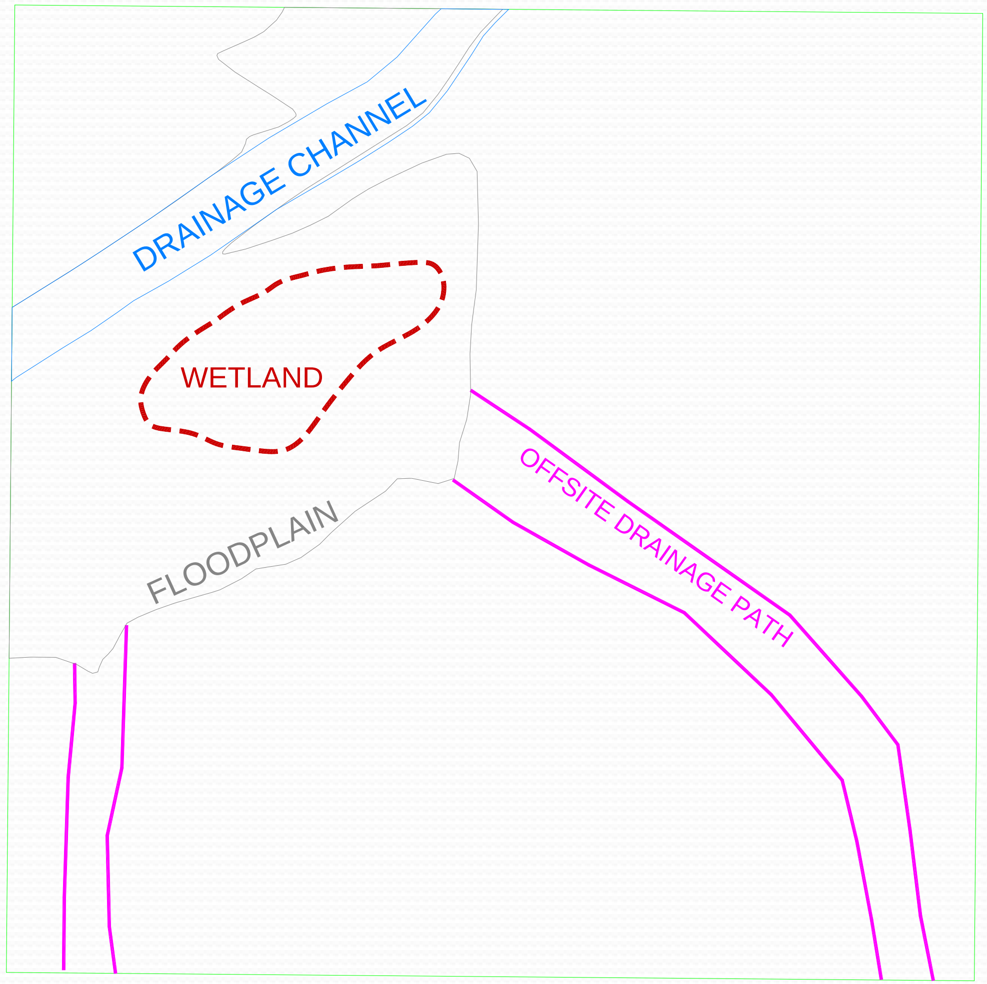


Site Fingerprinting –
Continued



Site Fingerprinting –
Continued

Site Fingerprinting – Continued



Site Fingerprinting –

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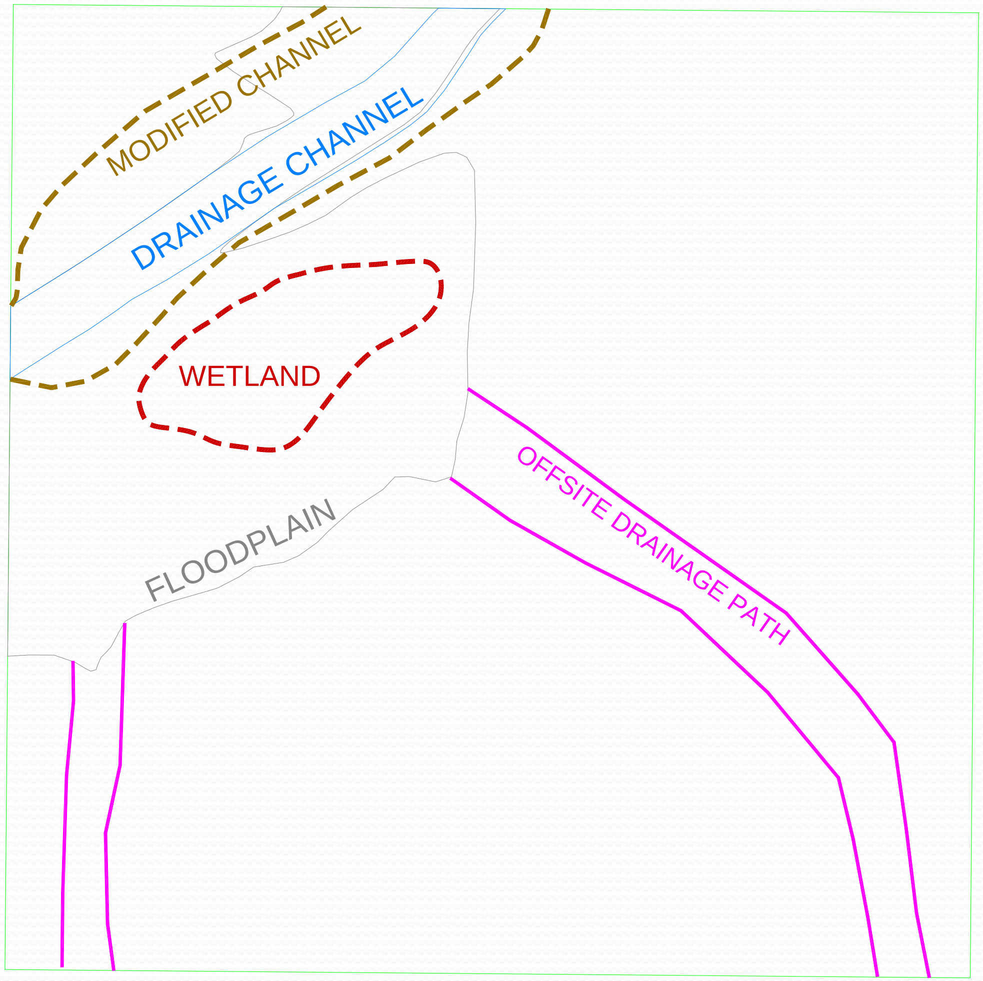
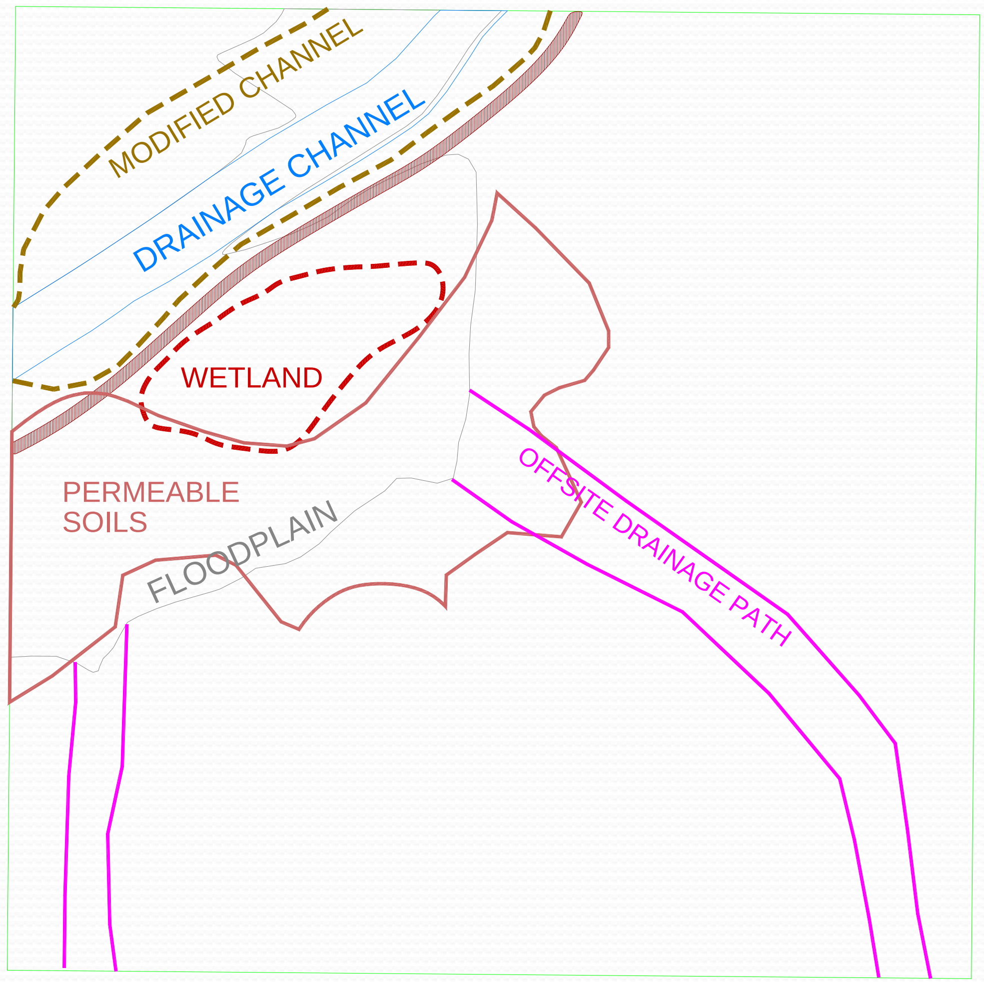


Site Fingerprinting – Continued



Site Fingerprinting – Continued

- Identify permeable soils
  - USDA/NRCS Soils Maps (available online)
    - A first step only
  - Geotechnical investigation
    - Soil borings (soil type and groundwater level)
    - Permeability tests

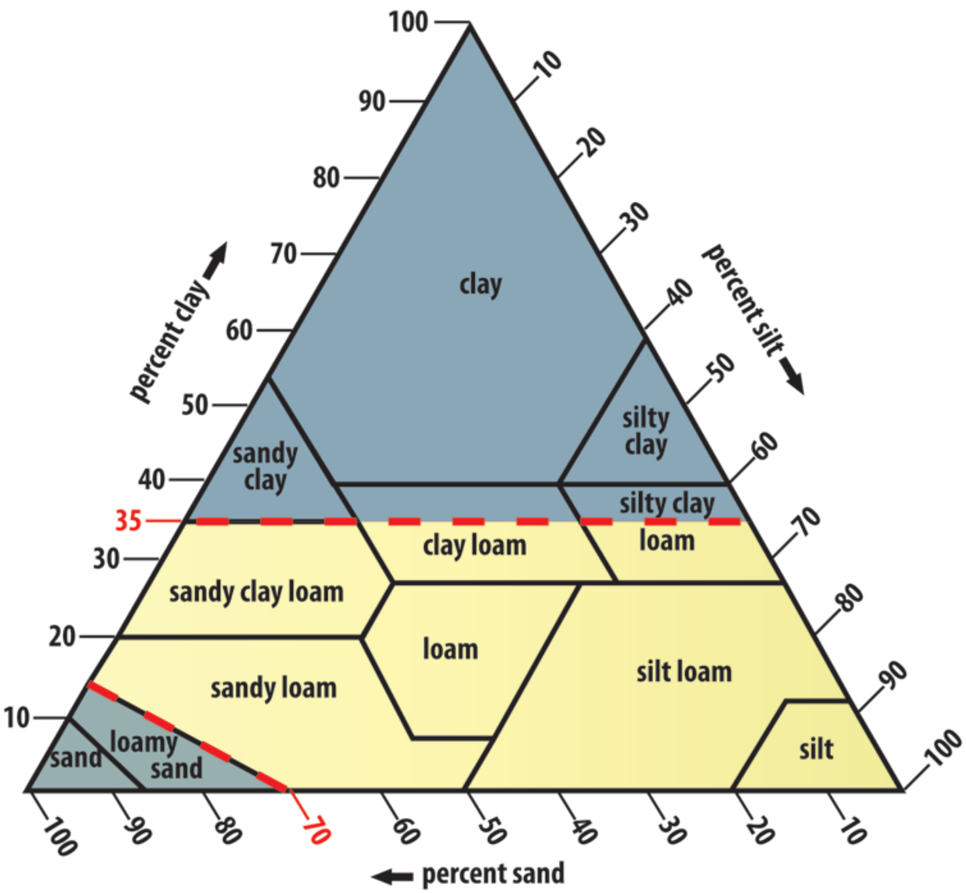
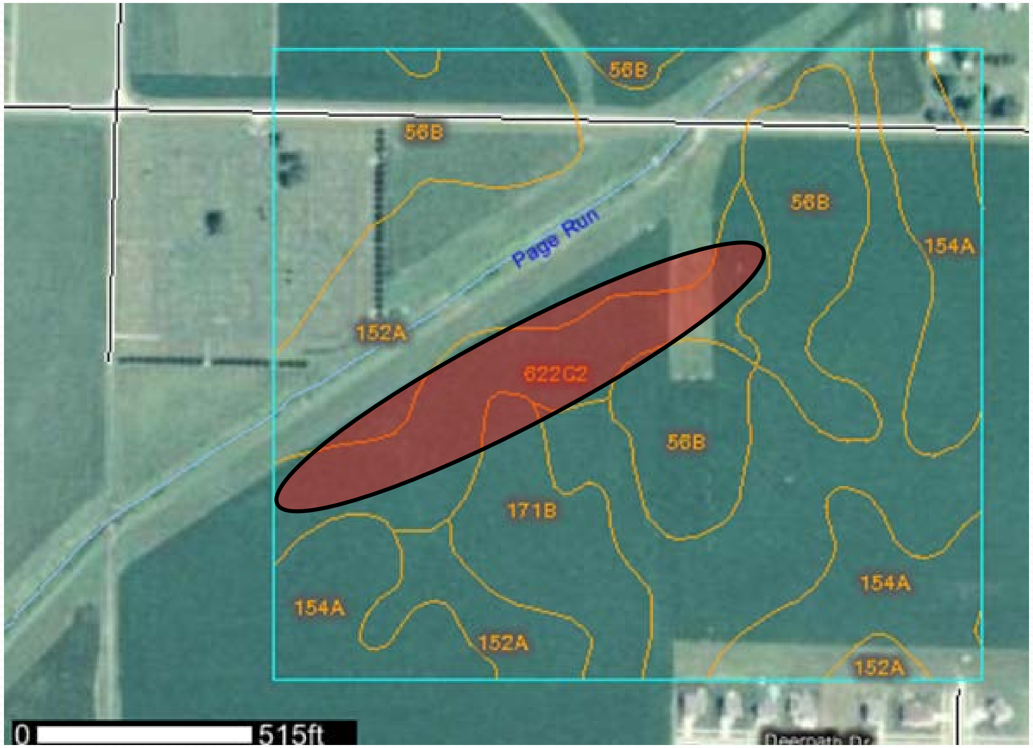


Chart showing the percentages of clay, silt and sand in the basic textural classes.

Site Fingerprinting – Continued

- USDA-NRCS Soils Map
  - 622G2 is of interest (more permeable)
  - Remaining soil types consist of SILTY CLAYS, poorly- to moderately-drained



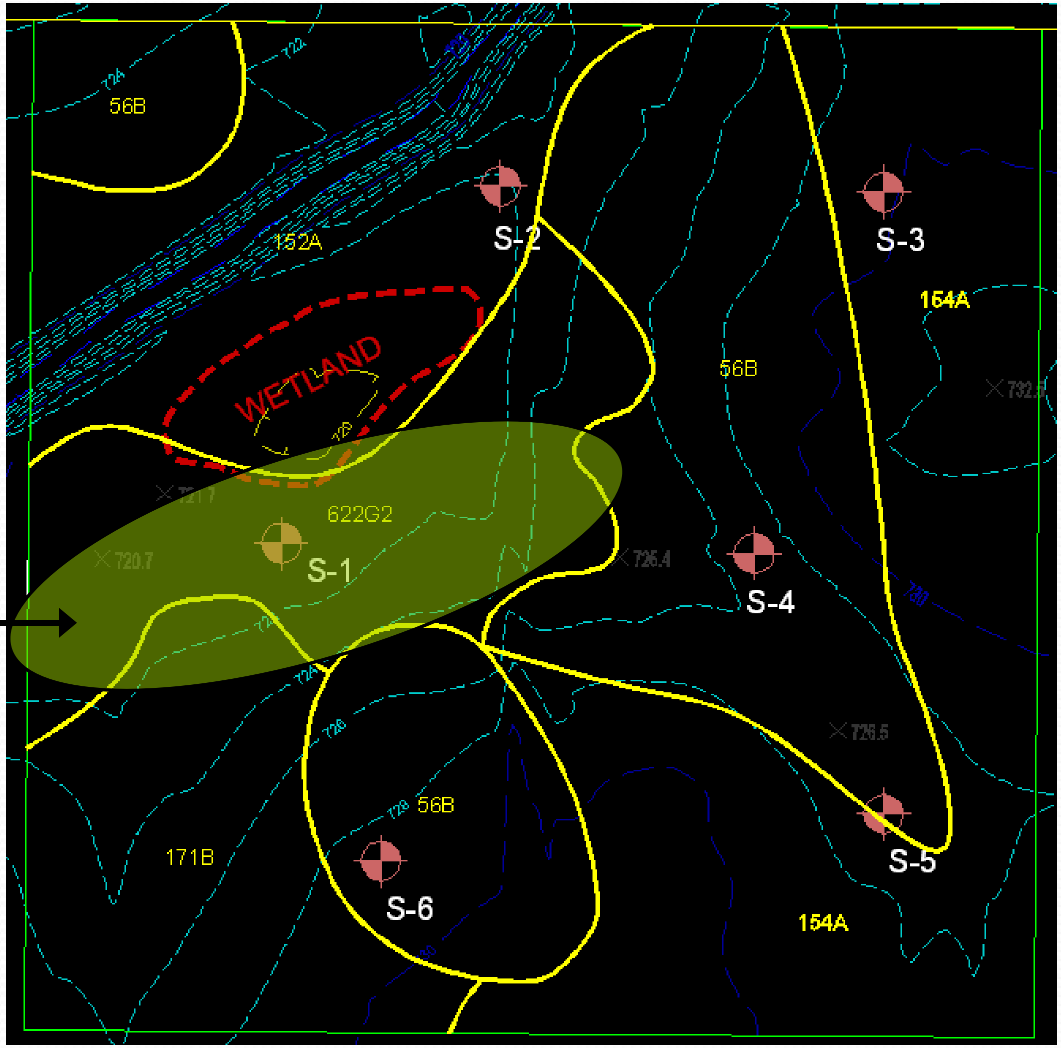
Site Fingerprinting – Continued

- USDA-NRCS Soils Data
  - 622G2
    - Wyanet silt loam
    - Depth to restrictive feature: 80 inches
    - Drainage class: well-drained
    - Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.40 to 0.60 in/hr)
    - Depth to water table: >80 inches
  - Typical Profile:
    - 0-8 inches: silt loam
    - 8-26 inches: clay loam
    - 26-34 inches: loam
    - 34-60 inches: loam

Site Fingerprinting –

Continued

Ideal location for infiltration BMPs



Site Fingerprinting –
Continued

- Geotechnical data
  - S-1: Silty loam, Ksat <0.50 in/hr
  - S-2: Clayey Silt, Ksat <0.10 in/hr
  - S-3: Clayey Silt, Ksat <0.20 in/hr
  - S-4: Silty Clay, Ksat <0.05 in/hr
  - S-5: Silty Clay, Ksat <0.1 in/hr
  - Water table for all samples generally between 12 -20 feet below the surface

S-4

VISUAL SOIL CLASSIFICATION	FT.	SAMPLE NO.	N	Q_p (tsf)	Q_u (tsf)	MC (%)	Dd (pcf)	REMARKS
7" Topsoil		1-AU	-	-	-	27	-	
Brown silty CLAY (CL)		2-SS	7	2.0	2.2	31	96	
	5	3-SS	5	1.0	1.4	17	95	
Brown silty CLAY with sand and small gravel (ML-CL) Till		4-SS	14	2.5	5.2	15	105	
	10	5-SS	15	2.3	4.2	13	120	
Gray silty CLAY with sand and small gravel (CL) Till		6-SS	18	4.5+	7.4	11	128	
	15	7-SS	18	4.0	5.9	12	128	Completion: 15 ft.
	20	8-SS	16	4.0	4.2	12	109	Drilling: 20 ft.
END OF BORING AT 21.5 FEET								

Preliminary Site Layout –

Erin Pande (Engineering Resource Associates, Inc.)

- Identify appropriate area(s) for stormwater flood storage (8%)
- Identify appropriate area(s) for stormwater infiltration (4%)
- Identify other natural areas for preservation and open space management
- Lay out site development areas and roadway configuration
- Verify developer's needs are met (28 units, min 6000 sf)
- LID Considerations (24' road width, 50' R.O.W.)

GROUP SITE LAYOUT EXERCISE

- Select one person as the “drafter”
- Work with each other to determine appropriate lot and roadway layout
- Spend first 15 minutes discussing desired layout, then put pen to paper
- Don’t worry about precision-drafting…a rough layout is fine
- Be open-minded: push aside your knowledge of traditional site layout and be creative

Stormwater Modeling –

Gregory Kacvinsky (Foth Infrastructure & Environment, LLC)

- Why EPA-SWMM?
  - Basis for most of the comprehensive urban stormwater modeling programs
  - Able to model infiltration in storage nodes (bioretention)
  - Able to model single event (“design”) storms AND continuous simulation
  - Most accessible to design engineers (public domain)

Stormwater Modeling –

Gregory Kacvinsky (Foth Infrastructure & Environment, LLC)

- What we'll cover today
  - Establish hydrologic components
    - Subbasins and hydrologic variables
  - Establish storage components
    - Detention pond and bioretention storage
  - Establish bioretention characteristics
    - Infiltration variables
  - Establish hydraulic components
    - Pipes, outlet structures

Stormwater Modeling –
Continued

- What we'll cover today
  - Running the XP-SWMM model
    - Single "design" event
    - Continuous simulation (8 months of rainfall data)
  - Common model pitfalls and debugging strategies
  - Interpreting results
  - Creating figures and processing output data (if time permits)

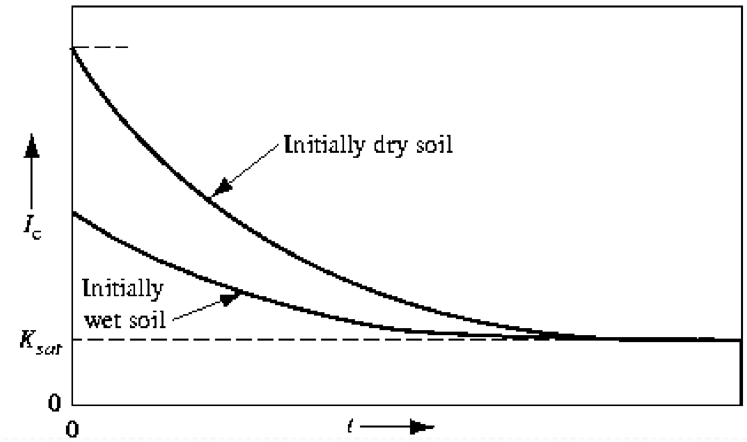
Stormwater Modeling –
Continued

- Runoff modeling in SWMM
  - Not the same as TR-20/TR-55/HEC-HMS
  - Pervious and impervious areas treated separately
  - Curve Number in SWMM is NOT the same as in traditional methods
  - No time of concentration
    - Instead, subbasin length/width, slope, and n values
  - More knobs to turn, but more realistic model
  - Water quality modeling

Stormwater Modeling – Continued

- Divide development into two primary subbasins
  - Each draining to a bioretention cell
- Assume offsite flow will bypass bioretention system
- Key assumptions:
  - Impervious surface percentage = 50%
    - Higher because of high density lot layout

Stormwater Modeling –
Continued



- Bioretention modeling:
  - Establishing infiltration criteria
    - Green-Ampt method
      - **Conductivity (in/hr): Ksat (saturated soil conductivity)**
        - MOST IMPORTANT VARIABLE
        - Should be at least 0.3-0.4 in/hr for effective infiltration
      - Suction Head (ft): capillary suction
        - Higher for fine-grained soils
      - Initial deficit (fraction): lower for saturated soils
        - Typically 0.2 – 0.5 (lower for wet soils)

Stormwater Modeling – Continued

- Bioretention modeling:
  - Bioretention overflow hydraulic connections

Stormwater Modeling – Continued

- Bioretention modeling:
  - Flood storage (detention pond)

Stormwater Modeling – Continued

- Bioretention modeling:
  - Event-based analysis
    - Meet local flood control criteria?
    - Meet infiltration criteria?

Stormwater Modeling – Continued

- Bioretention modeling:
  - Extended Period Simulation
    - Site runoff characteristics for one growing season (7 months)

Stormwater Modeling –
Continued

- Bioretention modeling:
  - Quantify infiltration volume using EPA-SWMM output data:
    - Existing infiltration volume (from separate analysis)
      - 4.87 MG
    - Total bioretention/pond infiltration
      - = Total developed runoff – total pond discharge volume
      - = 2.58 MG – 0.41 MG = 2.17 MG (6.7 ac-ft)
    - Define catchment infiltration (from runoff results)
      - Area 1 + Area 2 + Pond Area = 2.53 MG
    - Total Developed Infiltration = 2.53 MG + 2.17 MG = 4.7 MG
      - 96% of existing infiltration

Stormwater Modeling – Continued

- Infiltration Calculations:
  - Existing conditions infiltration…many ways to calculate
    - What infiltration method do you use?
      - CN?
      - Horton?
      - Green-Ampt?
    - CN = 75, Infiltration = 5.00 MG (we score 94%)
    - CN = 78, Infiltration = 4.87 MG* (we scored 96%)
    - CN = 80, Infiltration = 4.69 MG (we score 100%)
    - Horton, Infiltration = 4.76 MG (we score 99%)
    - Green-Ampt, Infiltration = 5.71 MG (we score 80%)

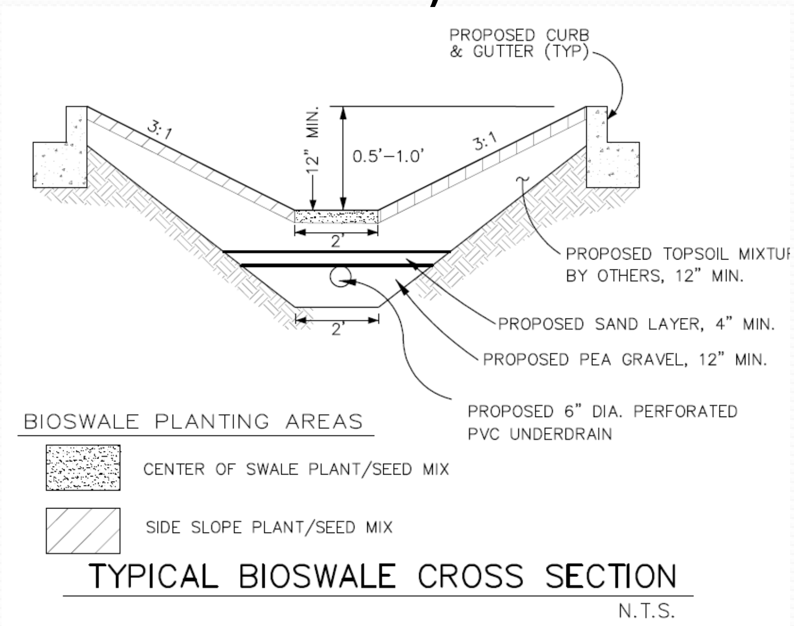
Stormwater Modeling – Continued

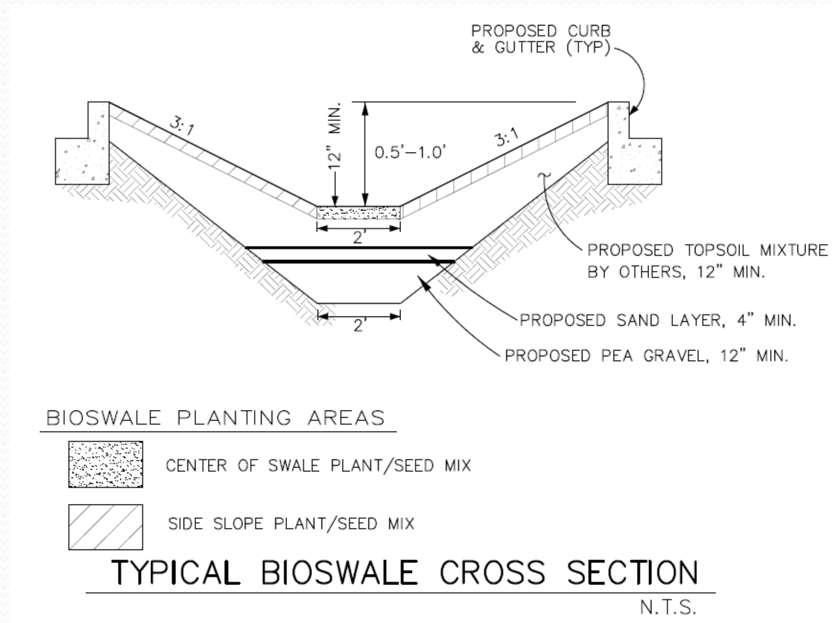
- Not meeting water quality (infiltration) criteria?
  - Consider the following:
    - Overestimating existing infiltration? Is your curve number high enough?
    - Increase % of “disconnected” impervious areas (25% in our model)
    - Design (and model) the main detention pond to accept infiltration (requires dry pond)
    - Increase size (footprint) of bioretention areas to reduce overtopping frequency

Plans, Specifications & Long-Term Maintenance

Gregory Kacvinsky (Foth Infrastructure & Environment, LLC)

- Key design considerations for final plan development
  - Bioretention plans and cross sections (underdrain or no underdrain?)

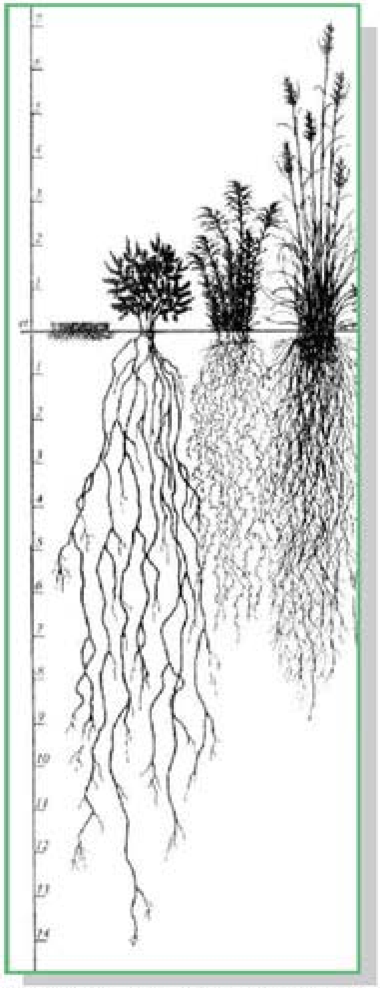




Plans, Specifications & Long-Term Maintenance

Continued

- Key design considerations for final plan development
  - Specifications for excavation, backfill, and plant schedule
  - Upon excavation disc sub-soil
  - Do not compact backfill
  - Backfill to consist of combination sand, peat and mulch
  - Use deep rooted vegetation to increase permeability and evapotranspiration
  - Construct bioretention AFTER establishment of permanent vegetation on site



Root length of conventional turf grass (left)as compared to native plant roots (right).

Plans, Specifications & Long-Term Maintenance

Erin Pande (Engineering Resource Associates, Inc.)

- Key design considerations for final plan development
  - Choose plants that will tolerate the proposed hydrology.
  - Choose salt tolerant plants.
  - Provide an alternate area to plow snow. Don't plow snow on top of bioretention areas.

Table 1
Plant/Seed Mix

Scientific Name	**Common Name**	**Lbs/Ac**	**Plugs/Ac**
Cover Crop:			
Avena sativa	Oats	32.000	
Lolium multiflorum	Annual	10.000	
	TOTAL w/ Cover Crop:	**42.000**	
Permanent Matrix:			
Aster novae-angliae	Aster	0.250	
Bidens cernua	Nodding Bur Marigold	0.250	
Carex hystericina	Porcupine Sedge	0.063	600
Carex scoparia	Lanced Fruited Oval Sedge	0.125	600
Carex stipata	Awl-friuted Sedge	0.125	600
Carex vulpinoidea	Brown Fox Sedge	0.500	1500
Helenium autumnale	Sneezeweed	0.125	
Iris virginica shrevei	Blue Flag Iris		500
Juncus balticus littoralis	Rush		500
Juncus torreyi	Torrey's Rush	0.063	250
Panicum virgatum	Switch Grass	2.000	1000
Physostegia virginiana	Obedient Plant	0.125	
Scirpus atrovirens	Dark Green Rush	0.250	807
Scirpus pendulus	Red Bulrush	0.125	675
Solidago riddelli	Riddell's Goldenrod		600
Verbena hastata	Blue Vervain	0.250	250

Plans, Specifications & Long-Term Maintenance

Continued

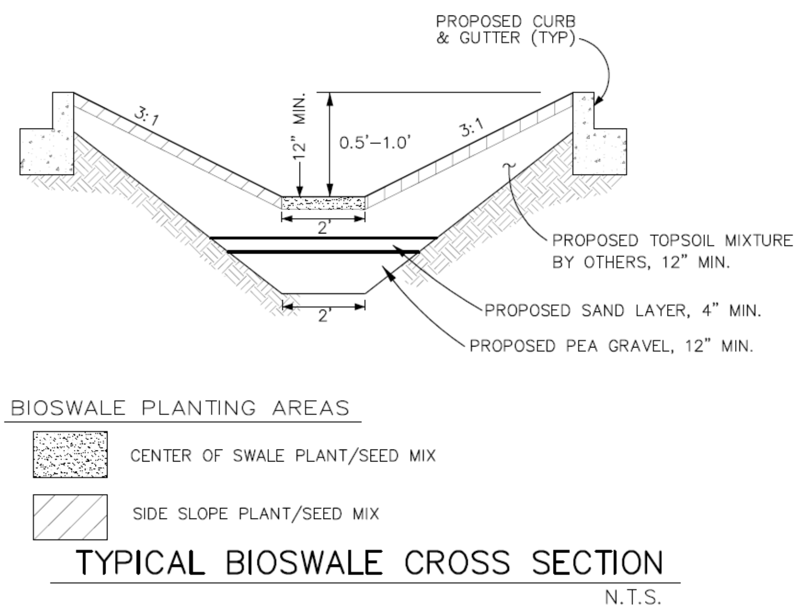


Table 2
Bioswale Side-Slope Plant/Seed Mix

Scientific Name	**Common Name**	**Lbs/Ac**	**Plugs/Ac**
Cover Crop:			
Avena sativa	Seed Oats	32	
Lolium multiflorum	Annual	10	
	TOTAL w/ Cover Crop:	**42**	
Permanent Matrix:			
Andropogon scoparius	Little Bluestem	3.500	500
Aster laevis	Sky Blue Aster	0.125	
Aster nova-angliae	Aster	0.125	500
Baptisia leucantha	Wild White Indigo	0.063	500
Coreopsis tripteris	Tall Coreopsis	0.125	
Echinacea pallida	Pale Purple Coneflower	0.250	500
Elymus canadensis	Wild Rye	2.500	500
Eryngium yuccifolium	Rattlesnake Master	0.125	250
Juncus dudleyi	’s Rush	0.125	
Liatris spicata	Marsh Blazing Star	0.125	500
Monarda fistulosa	Wild Bergamot	0.250	500
Panicum virgatum	Switch Grass	2.000	1000
Penstemon digitalis	Foxglove Beardstongue	0.125	500
Petalostemum purpureum	Purple Prairie Clover	0.250	
Ratibida pinnata	Yellow Coneflower	0.125	
Rudbeckia hirta	Black-eyed Susan	0.500	
Solidago rigida	Stiff Goldenrod	0.250	
Sporobolis heterolepis	Prairie Dropseed	2.000	1000
Tradescantia ohiensis	Spiderwort	0.125	500

Plans, Specifications & Long-Term Maintenance

Continued

- Key design considerations for final plan development
  - Performance specifications for bioretention plantings.

Sample Performance Standards (3-growing season monitoring period)

1. By the end of the third growing season, at least 50% of the vegetative coverage (as measured by aerial coverage) will consist of seeded/planted species. The planted area shall exhibit at least the following at the end of each growing season: Year 1- 10% and Year 2- 25%
2. By the end of the third growing season, at least 75% of the planted areas must contain native, non-invasive perennial species as measured by aerial coverage. The planted area shall exhibit at least the following at the end of each growing season: Year 1- 10% and Year 2- 25%.
3. None of the three most dominant species within the planted areas shall be nonnative or invasive species, including but not limited to: Cattail *(Typha spp.), Reed* Canary Grass *(Phalaris arundinacea), Purple Loosestrife (Lythrum salicaria),* Common Reed *(Phragmites australis), Canada Thistle (Cirsium arvense),* Sandbar Willow *(Salix exigua), Kentucky Blue Grass (Poa pratensis), and White* Sweet Clover *(Melilotus alba).*
4. No more than 0.5 square meters in size shall be devoid of vegetation at any time.
5. 100% of the planted trees and shrubs shall be alive, in healthy condition, and representative of the individual species at the end of each growing season.

Plans, Specifications & Long-Term Maintenance

Continued

- Maintenance Plan
  - Frequency and type of maintenance
  - Treat non-native invasive species yearly
  - Remove/replace mulch every 4-5 years (residential)
  - Potentially more frequent removal in high density developments
  - Installing bioretention does not reduce the need for other non-structural BMPs such as street sweeping

Recap and Close – Q&A