Meeting Outline

- Introduction
  - Overview
  - Source data and datum

- Methodology
  - Hydrology
  - Hydraulics
  - Boundary conditions
  - Model validation

- Master plan model application
  - Master plan model application
  - Master plan model limitations
  - Examples
City Watersheds and Model Status
City Watersheds and Model Status
Model Software

Storm Water Management Model (SWMM)

Computational Hydraulics International
Model Resolution

Primary stormwater management system (PSMS):
- Open channels and pipes 24-inch diameter and larger
- Stormwater Management Facilities (SWMF)
- Overland flow paths
- 2-D modeling where applicable
- Based on Public Works Stormwater Infrastructure GIS
- Models continue downstream to MS4 outfall and/or tidal boundary condition
- North American Vertical Datum of 1988 (NAVD 88)
  - Included conversions from NGVD 1929 and NGVD 1929 with 1972 adjustment
Methodology
Hydrology

- **Subbasin Geometry**
  - Boundaries (DEM/contour lines/sewer network)
  - Flow width (Area weighted)
  - Slope
  - Area
  - Outlet

![Subcatchment Boundary and Outlet](image)
Hydrology

Flow Width (three-path approach)

Lx: Flow path length
Sx: Flow path slope
Wx: Flow path width
Hydrology

- Subbasin Runoff Parameters (Landuse)
  - Impervious area
  - Surface runoff roughness (Manning’s Roughness Coefficient)
  - Initial abstraction (Depression storage)
  - Subarea routing (Impervious → pervious OR pervious → impervious)
  - Percent routed between subareas
  - Flow routing method (Kinematic/Dynamic Wave)
Hydrology (Rainfall Patterns and Inputs)

- Historical rainfall (Rain gauge data) for model calibration
- Design storm rainfall for master plan simulations
  - NOAA Atlas 14 Type C
  - One set of rainfall hyetographs for the entire City
- Rainfall depth
  - Based on values at the Centroid of the City (Watershed 6)
- Temporal pattern
  - Based on shape of 25-year rainfall hyetograph
Hydrology (Rainfall Patterns and Inputs)

NOAA Atlas 14 Type C Hyetograph
Hydrology (Rainfall Patterns and Inputs)

![Image of a software interface for choosing time series data for a raingage universal system, with a graph showing rainfall data over time, and a table listing dates, times, and corresponding rainfall values.]
Hydrology

- Infiltration (Soil)
  - Modified Green-Ampt infiltration
    - Suction Head
    - Conductivity
    - Initial Deficit

\[
Q = \frac{W}{n} \left( \frac{d}{d - d_p} \right) \frac{5/3}{s} \frac{1/2}{s}
\]

\( d \) (Rainfall depth)
\( d_p \) (Depression storage)

EVAPORATION, RAINFALL, SNOWMELT

INITIAL ABSTRACTION (DEPRESSION STORAGE)

INfiltration (Modified Green-Ampt)
Hydraulics (View in PCSWMM)
Hydraulics (2-D Area)
Hydraulics (2-D Area)

Dense 2D Grid along roads
Hydraulics (Lake and SMF Example)

Lake Trashmore (storage)

Pipe Length: 147 ft

Model Schematic Length: 660 ft
Hydraulics – Stage Area Relationships

- Conveyance system storage: Stage-area-storage in open (irregular) conduits
- Surface storage at storage nodes: stage-storage area relationships computed from topography (LiDAR and GIS)
- Approach foundation: No double-counting surface area and conveyance system storage
Irregular links used to equalize flood depths between neighboring subbasins
Hydraulics – Overflow links

- Link transect computed from topography (LiDAR and GIS)
Model Representation of Rim

- Ground Elevation at 04520-460: 7.1 ft NAVD 88
- Model rim: 17.1 ft
Model Validation

- Historical rainfall events based on flood call history
- Observed and field surveyed high water elevations from 2016
- 10-year event profile compared with VDOT hydraulic grade line calculation
Coordination and References

Section 2 Model Approach

NEEDED: Pictures to Update the City’s Master Drainage Plans

- [https://www.vbgov.com/government/departments/public-works/storm-water/Pages/storm-pics-master-drain-plan-6-8-17.aspx](https://www.vbgov.com/government/departments/public-works/storm-water/Pages/storm-pics-master-drain-plan-6-8-17.aspx)

Comprehensive Sea Level Rise

Master Plan Model Application
Master Plan Model Application

- Flows and water surface elevations in the PSMS
- Locations with surcharging in the PSMS
- Performance of storage facilities
- Overland flow between subbasins
- Surface flooding (storage node water surface elevations)
- Influence of downstream tidal conditions
Additional Master Plan Model Applications

1. Site specific evaluations
   a. Tailwater to support site design
   b. System flow-routing understanding, “what-if” scenarios for downstream impacts and improvements

2. Starting Point for refined site-specific evaluations
   a. Site specific topography and critical elevations
   b. Site specific drainage features
   c. System flow-routing refinements

3. Intent: Provide information and tools to assist with engineering evaluations and compliance with DPW Standards
Model Application – Tailwater Conditions

- Profile view through Thalia Creek

![Diagram showing Thalia Creek and its tailwater conditions during a 100-year event, including overflow conduits, Bonney Road, Constitution Drive Tributary, VB Blvd, and Thalia Creek Outfall.]
Peak overland flow: 72.7 cfs

Peak storage junction HGL: 11.46 ft NAVD

Peak manhole HGL: 11.37 ft NAVD

Peak pipe flow: 16.8 cfs

Subbasin
Master Plan Model Limitations

- Results based on available data:
  - GIS stormwater infrastructure
  - GIS invert elevations
  - LiDAR topography data
  - City impervious area
  - City land use
  - City soils data (from NRCS)

- Areas upstream of the modeled PSMS

- Overland flow within a single subbasin located upstream of the subbasin storage node
Example Application for Site of Interest

Project Location: Virginia Beach Boulevard and N Budding Drive
Example Application for Site of Interest
Desired boundary conditions: 10-year and 100-year HGL

- Ground elevation 8 feet
- 10-year HGL = 9.3 feet and 100-year HGL = 10.1 feet
Application for Site of Interest

Overflow at ground level added from node of concern (04520-494) to the storage node downstream in subbasin 34.
Additional Overland Flow Path
Refined Model Results

Model 1 – no overflow link
Model 2 – overflow link added
Refined Model Results

- Desired boundary conditions: 10-year and 100-year HGL
  - Ground elevation 8 feet
  - 10-year HGL = 8.5 feet and 100-year HGL = 8.7 feet
Example Model Refinement

Master Plan Model

Watershed 10
Veteran Care Center

Master Plan Model Refinement to Reflect Existing Conditions

Site Specific Refinement
Example Model Refinement

Step 1:
- Delete all the nodes and links that will be updated/replaced with refined data
Example Model Refinement

Step 2:
- Update the delineation and runoff parameters of the subbasins to represent the new development.
- In this example, it involves splitting two subbasins into six subbasins.
Example Model Refinement

Step 3:

- Add storage nodes to represent surface storage and detention facilities.
- Storage nodes for surface storage are assigned to the subbasin “Outlet”
- Add junctions along the hydraulic system
Example Model Refinement

Step 4:
- Add links to represent the hydraulic system:
  - Open channels
  - Stormwater pipes
Example Model Refinement

Step 5:
- Add overland flow paths connecting adjacent subbasins and the hydraulic system
Example Model Refinement

Step 6a:
- Build and assign a stage-storage curve for each storage node
Example Model Refinement

Step 6b:
- Assign a transect for each open channel, ditch and overland flow path
Example Model Refinement: Storage Assignment
Example Model Refinement: Storage Assignment

- Critical to not double count storage
- Define ditch storage and overbank storage separately
Example Model Refinement: Storage Assignment

Ditch Storage: Transect
Example Model Refinement: Storage Assignment

Subbasin (Overbank) Storage Node
Example Model Refinement

Overview of model refinement elements

- Design drawings or “As-Built” drawings
- GIS refinements (additional pipes and nodes)
- Additional control structures (not in GIS)
- Import new GIS
- Refine subbasins and process parameters
- Storage curves
- New open channels
- New overland flow links
- Initial depths