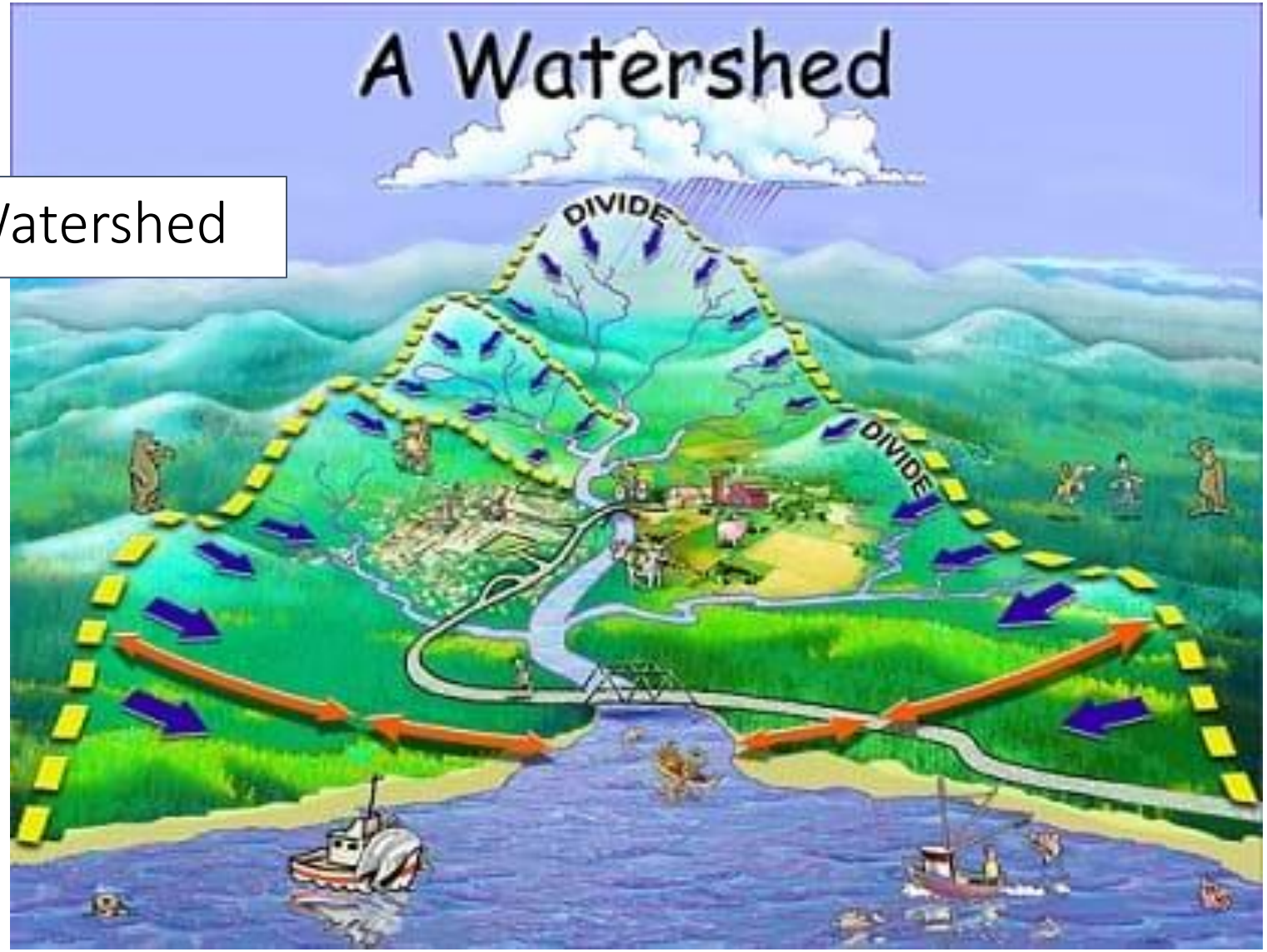
Taylor Run BMPs In the Watershed

Taylor Run Consensus Building Group Meeting

February 13, 2023

HYDROLOGY & HYDRAULICS

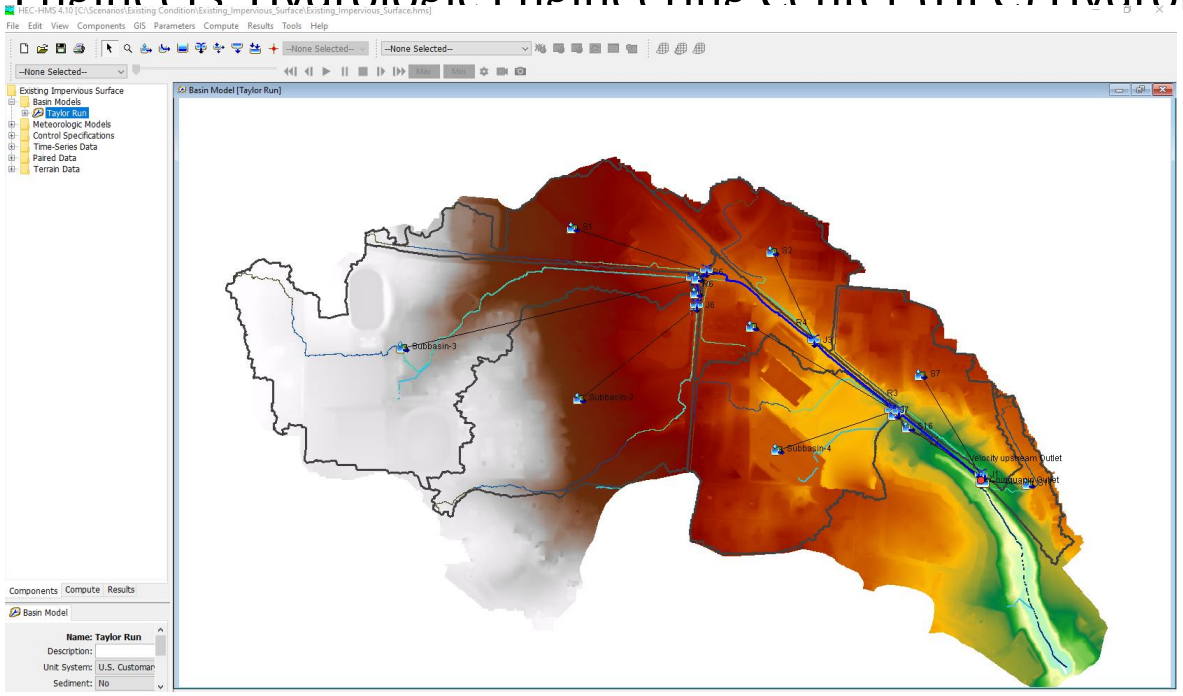
- Modeling a Watershed



MODELING THE RUNOFF

THE DRAINING AWAY OF WATER FROM THE SURFACE OF AN AREA OF LAND, A BUILDING OR STRUCTURE, ETC.

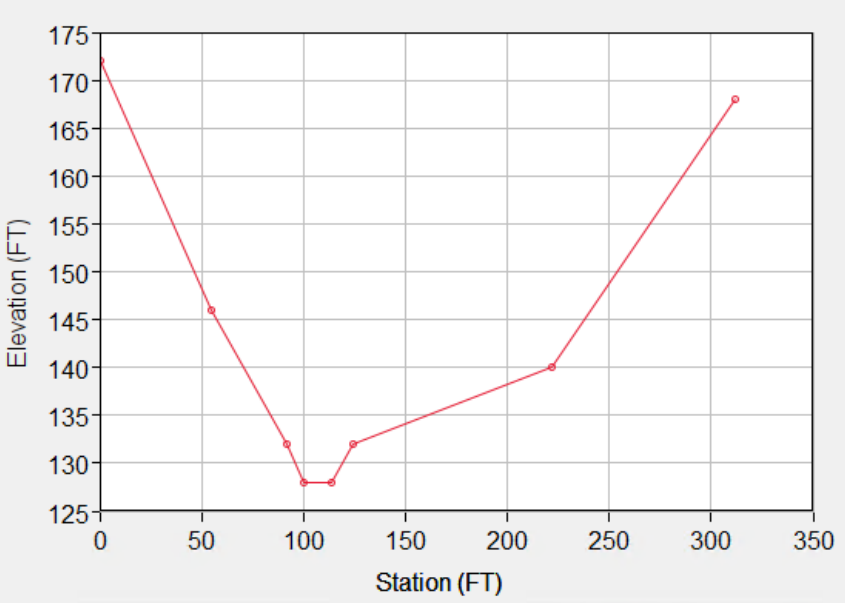
- Model Setup - Hydrology & Hydraulics
  - Hydrology
    - Models that approximate the runoff potential of specific rain events over specific land types
    - US Army Corps of Engineers' Hydrologic Engineering Center (HEC) Hydrologic Modeling System (HMS)

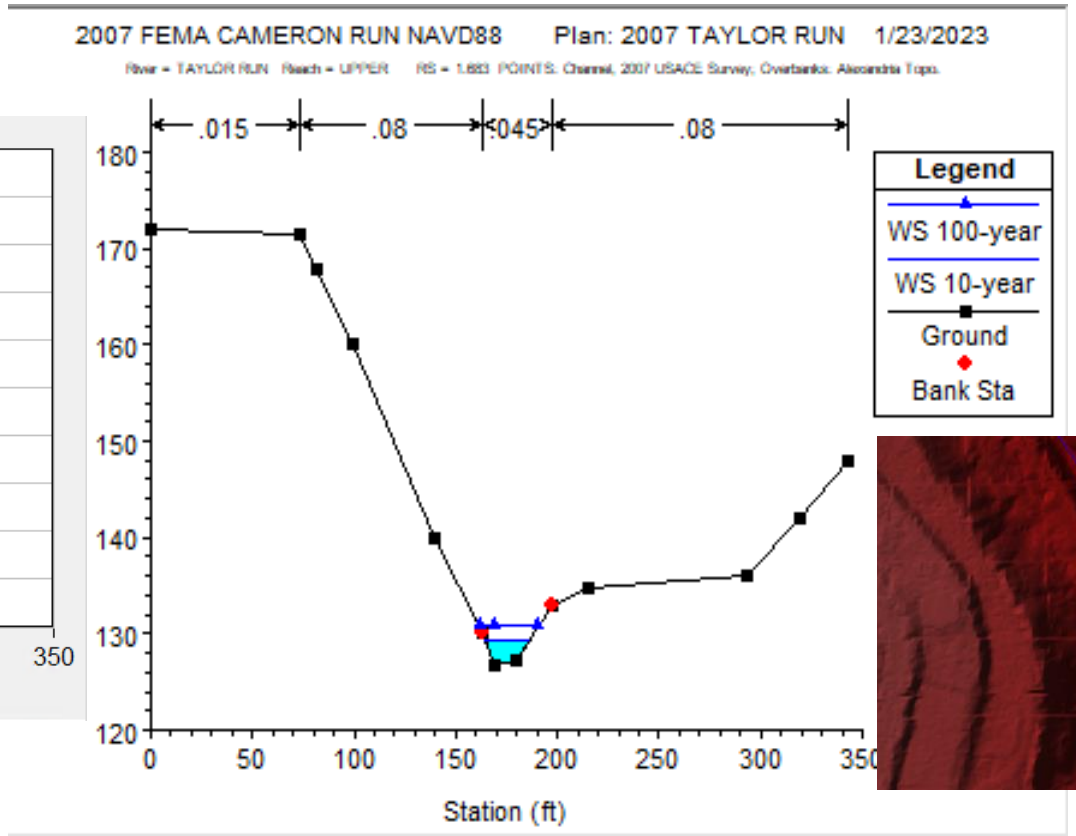


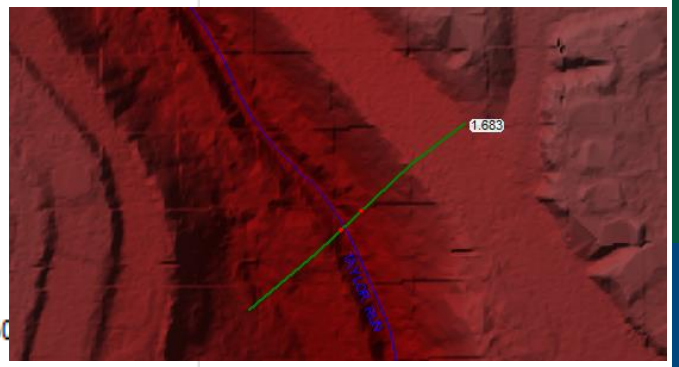
MODELING THE RUNOFF

THE DRAINING AWAY OF WATER FROM THE SURFACE OF AN AREA OF LAND, A BUILDING OR STRUCTURE, ETC.

- Model Setup - Hydrology & Hydraulics
  - Hydraulics - Models flow in a channel
    - US Army Corps of Engineers Hydrologic Engineering Center (HEC) Hydrologic Modeling System (HMS)







Storm Events

10-Year, 24-Hour Storm Event

Rainfall Duration	Rainfall Depth (in)
5 Minutes	0.57
15 Minutes	1.16
1 Hour	2.18
2 Hours	2.57
3 Hours	2.57
6 Hours	3.34
12 Hours	4.09
24 Hours	4.84

100-Year, 24-Hour Storm Event

Rainfall Duration	Rainfall Depth (in)
5 Minutes	0.76
15 Minutes	1.53
1 Hour	3.23
2 Hours	3.93
3 Hours	4.27
6 Hours	5.34
12 Hours	6.82
24 Hours	8.37

PART 1 & PART 2

- Goal is to reduce runoff enough to reduce erosive velocities in Taylor Run
- Given the onsite soils, target velocities are between 4-feet/sec to a Maximum of 6-feet/sec

US Department of Agriculture's Natural Resources Conservation Service's Stream Restoration Design National Engineering Handbook, Chapter 8 "Threshold Channel Design"

Table 8–4 Allowable velocities

Channel material	Mean channel velocity (ft/s)	(m/s)
Fine sand	2.0	0.61
Coarse sand	4.0	1.22
Fine gravel	6.0	1.83
Earth		
Sandy silt	2.0	0.61
Silt clay	3.5	1.07
Clay	6.0	1.83
Grass-lined earth (slopes <5%)		
Bermudagrass		
Sandy silt	6.0	1.83
Silt clay	8.0	2.44
Kentucky bluegrass		
Sandy silt	5.0	1.52
Silt clay	7.0	2.13
Poor rock (usually sedimentary)	10.0	3.05
Soft sandstone	8.0	2.44
Soft shale	3.5	1.07
Good rock (usually igneous or hard metamorphic)	20.0	6.08

PART 1: SIMULATING MORE BMPS IN THE WATERSHED

- Adding BMPs = Reduction in Impervious Surface
- Reduction in impervious surface scenarios
  1. Existing Conditions – 37%
  2. Reduction to – 30%
  3. Reduction to – 27%
  4. Reduction to – 17%
  5. Reduction to – 7%
  6. Reduction to – 0% (Natural Conditions)

Scenario	Total Sub-Watershed Area (Acre)	Impervious Surface (Acre)	Impervious Surface (%)	Impervious Surface Reduction (%)
1	244.44	90.94	37	0
2	244.44	73.68	30	7
3	244.44	66.53	27	10
4	244.44	42.61	17	20
5	244.44	17.54	7	30
6	244.44	0.00	0	37

PART 1: RESULTS

- 10-YR 24-HR

Rainfall Duration	Rainfall Depth (in)
5 Minutes	0.57
15 Minutes	1.16
1 Hour	2.18
2 Hours	2.57
3 Hours	2.57
6 Hours	3.34
12 Hours	4.09
24 Hours	4.84

Scenario	Hydrologic Element	Percent Impervious	Peak Discharge (cfs)	Peak Velocity (fps)
1	Watershed Runoff to Taylor Run	37	579.10	7.41
2	Watershed Runoff to Taylor Run	30	554.80	7.28
3	Watershed Runoff to Taylor Run	27	544.60	7.24
4	Watershed Runoff to Taylor Run	17	511.60	7.11
5	Watershed Runoff to Taylor Run	7	480.40	6.99
6	Watershed Runoff to Taylor Run	0	238.00	5.71

PART 1: RESULTS

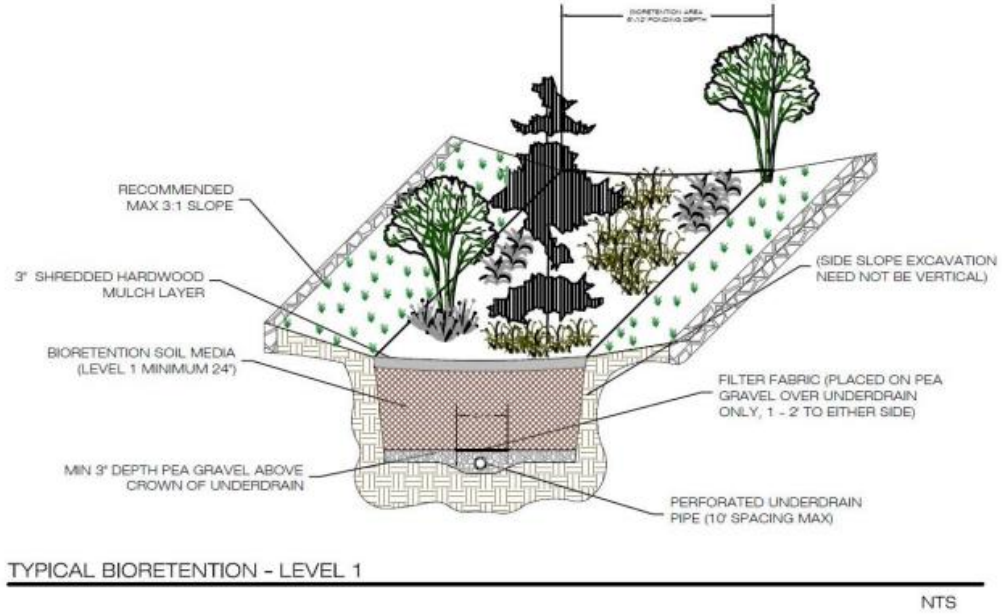
- 100-YR 24-HR

Rainfall Duration	Rainfall Depth (in)
5 Minutes	0.76
15 Minutes	1.53
1 Hour	3.23
2 Hours	3.93
3 Hours	4.27
6 Hours	5.34
12 Hours	6.82
24 Hours	8.37

Scenario	Hydrologic Element	Percent Impervious	Peak Discharge (cfs)	Peak Velocity (fps)
1	Watershed Runoff to Taylor Run	37	954.10	8.66
2	Watershed Runoff to Taylor Run	30	932.80	8.55
3	Watershed Runoff to Taylor Run	27	924.20	8.52
4	Watershed Runoff to Taylor Run	17	897.40	8.45
5	Watershed Runoff to Taylor Run	7	871.50	8.37
6	Watershed Runoff to Taylor Run	0	596.60	7.47

PART 1: RESULTS

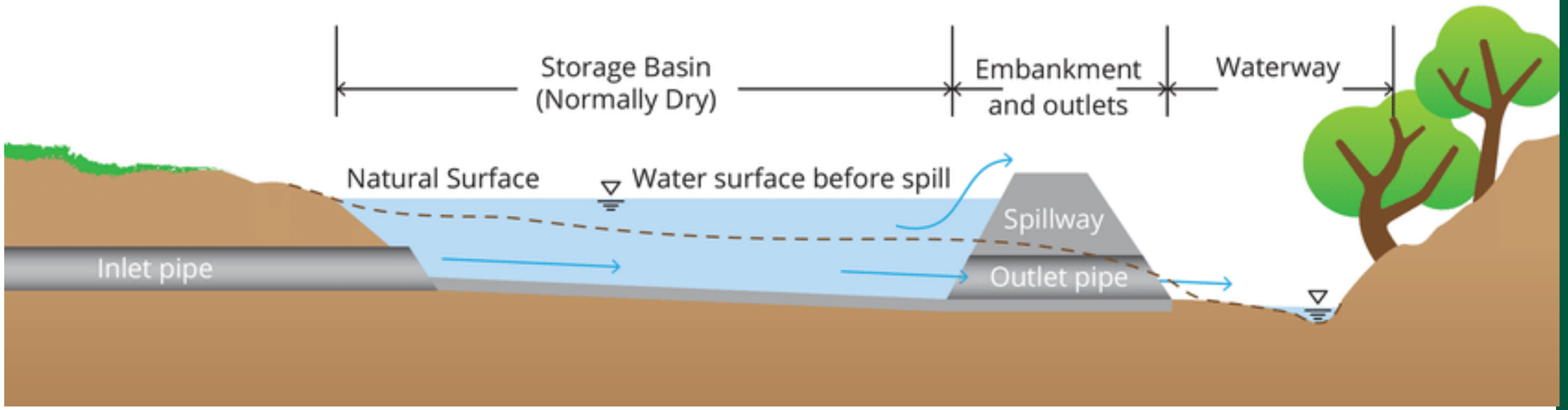
- Impervious area captured in BMPs is as surrogate for reduced impervious area in the model
- BMPs are designed for first 1” of rainfall; occurs in the first 15 minutes for 10-yr and 100-yr (slide 5)
- BMP capturing original 40 acres (51 BMPs) plus 50 additional acres (100 GI BMPs treating 0.5 acre impervious each)
- $25 million dollars to retrofit watershed



Credit: VDEQ

	Currently Captured (38.68 impervious acres)	Additional to be Captured (50 impervious acres)
Runoff Volume Reduced	0.8 acre-ft	1.58 acre-ft
Total Nitrogen (TN)	307.09 lbs./year	495.44 lbs./year
Total Phosphorus (TP)	51.09 lbs./year	59.52 lbs./year
Total Suspended Solids (TSS)	23,971.43 lbs./year	27,926.78 lbs./year

PART 2: ADDING DETENTION STORAGE



Detention input into the model has a footprint of 2-acres

- Maximum depth:12-feet
- Maximum storage: 24-acre-ft
- 48” Outlet Pipe
- 30-ft long, 20-ft wide spillway
- Spillway set at 8-ft of depth
- MODEL RUN USING EXISTING CONDITIONS

Pond Outlet Rating Table

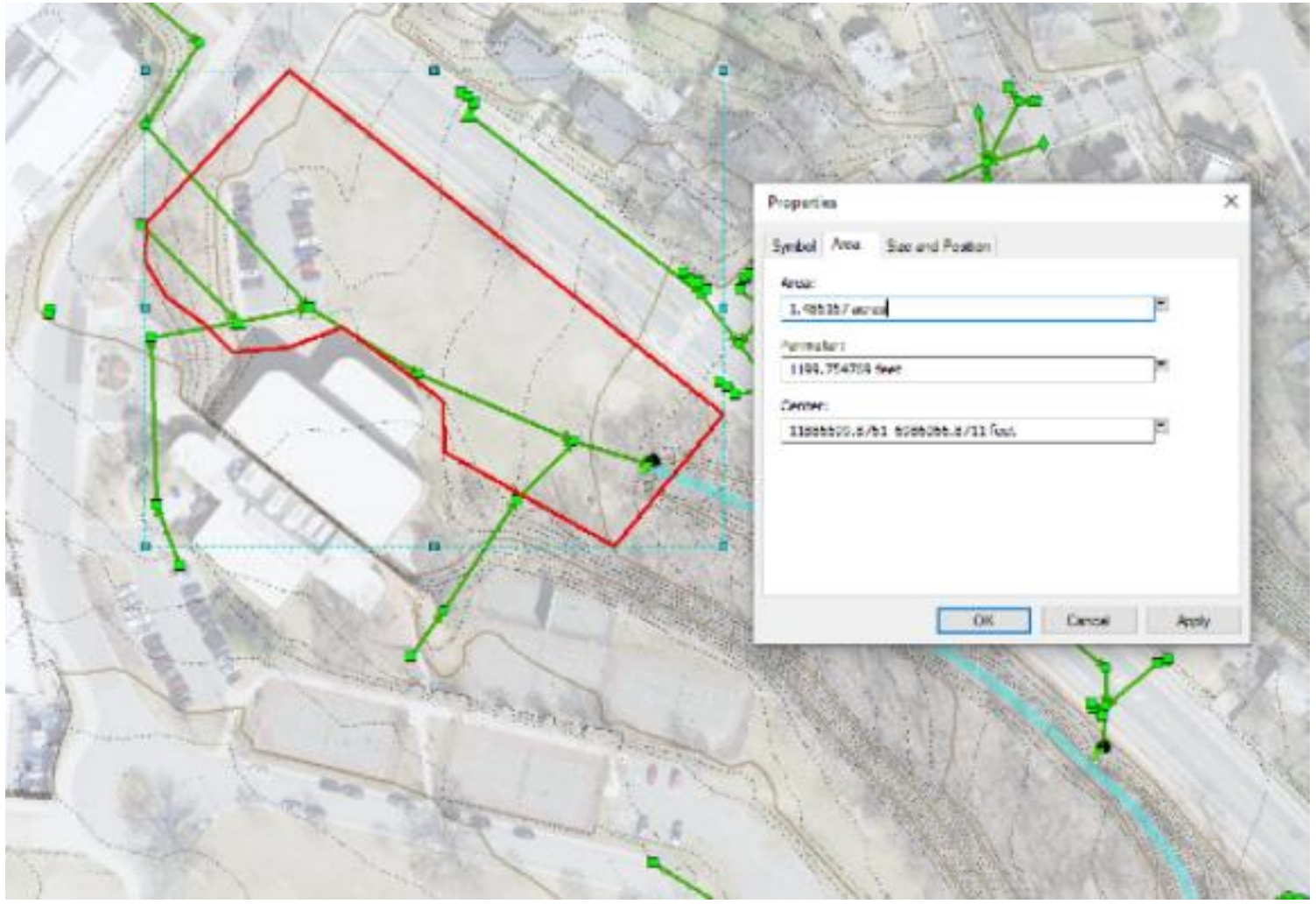
ELEV	ACRE-FT	Qt
0	0	0
4	8	90
8	16	180
9	18	250
10	18	450
11	22	720
12	24	900

PART 2: RESULTS

DETENTION STORAGE					
10-YR	Storage (acre-ft)	Peak Flow into Storage (cfs)	Peak Flow to Taylor (cfs)	Velocity in TR (fps)	Existing V (fps)
	19	562	315	6.1	7.2
100-YR	Storage (acre-ft)	Peak Flow into Storage (cfs)	Peak Flow to Taylor (cfs)	Velocity in TR (fps)	Existing V (fps)
	23	925	799	8.1	8.5

PART 2: ADDING DETENTION STORAGE

Available footprint at Chinquapin Park is approximately 1.5-acres



10-YR
- 19-acre-feet storage
- About 13 feet deep

100-YR
- 23-acre-feet storage
- About 15 feet deep

Considerations
- Feasibility, competing uses, pumping

CONCLUSIONS

PART 1

- Reducing impervious surface (adding water quality BMPs) slightly reduced runoff to Taylor Run
- However, due to the soils type and the shape of the existing Taylor Run channel, erosive velocities were only incrementally reduced and did not get below 6-feet/sec except for the 10-YR storm under Scenario 6
- BMPs reduce velocities for the 1” runoff event; first 15 minutes of the 10-yr and 100-yr storms; provide good nutrient and sediment reductions

CONCLUSIONS

PART 2

- Detention Storage reduced runoff to Taylor Run; and velocities reduced to the target range for only the 10-YR storm, using 19-acre-ft.
- Water quality BMPs provide limited runoff reduction of 2.38-acre-ft. (0.8 existing, 1.58 new); provide good nutrient and sediment reductions.

CONCLUSIONS: COSTS

- Costs to add an equivalent number of water quality BMPs to reduce the impervious (does not reduce flow to target)
  - BMPs cost about $250k per .5 acre of impervious area
  - $25 million in BMPs to retrofit the watershed
- Costs to adding Detention Storage
  - Arlington County spent $18.4M in 2021-2022 to install 12.3-acre-ft of underground storage to a depth of 13-feet. That's $1.5M/acre-foot
  - To build 19-acre-feet needed to reduce the would be approximately $1.5M x 19 = $28.5M

QUESTIONS

- More Information
  - TECHNICAL MEMORANDUM
    - Taylor Run Watershed Analysis: The Effects of Implementing Stormwater Facility Best Management Practices (BMPs) in the Watershed on the Stream Channel

  - https://www.alexandriava.gov/stormwater-management/stream-health-improvement-community-collaboration