

APPENDIX G: WATTS BRANCH CASE STUDY

Appendix G general note: The HEC-HMS and HEC-RAS models were developed in 2017 and were provided to the Project Team by the USACE in 2024. The Project Team built upon the provided models to perform the Watts Branch Case Study. Metrics were estimated for each proposed BGI practice and included in the HEC-HMS model to accurately depict each practice (i.e., volume, area).

Table G-1. HEC-HMS Model Component(s) by BGI Practice

BGI Practice Type	HEC-HMS Model Component
Multi-Purpose Floodable Recreational Space	Reservoir, Diversion, Sub-basin
Blue-Green Street	Reservoir, Diversion, Sub-basin
Pond Retrofit	Reservoir
Stream, Wetland, and Floodplain Restoration	Reach Routing, Diversion
Tree Planting	*N/A
Green Stormwater Infrastructure	*N/A

*Tree Planting and GSI opportunities are land use BGI practices, whereas Multi-Purpose Floodable Recreational Spaces; Blue-Green Streets; Pond Retrofits; and Stream, Wetland, and Floodplain Restoration are volume BGI practices. New/additional model components were not added to the HEC-HMS model for the land use practices. Instead, the existing curve number associated with the respective sub-basins was adjusted to account for each land use practice. Proposed land use BGI practices result in decreased curve number values.

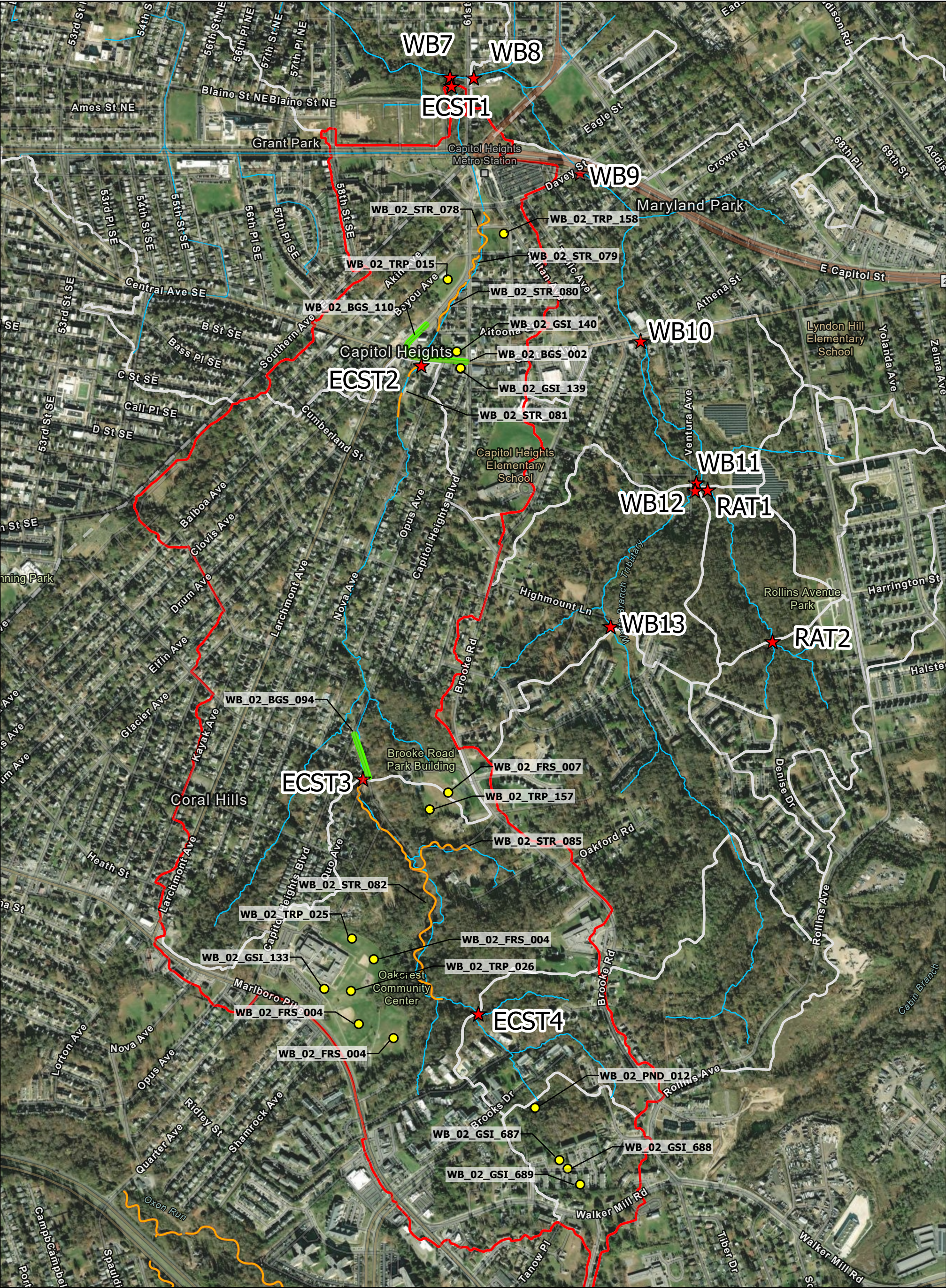
To represent Stream, Wetland, and Floodplain Restoration practices in the HEC-HMS model, the Project Team incorporated both reach routing and an inflow-diversion component. This dual approach reflects two key flood-reduction mechanisms commonly cited in restoration and stormwater guidance: (1) infiltration and storage within the floodplain, and (2) attenuation of peak flows due to increased travel time through rough, shallow floodplain areas.¹ The Inflow-Diversion Function was used to simulate infiltration and storage under a range of inflow and storm conditions, while reach routing was used to represent the slowing of flows through the restored stream-floodplain complex. Table G-2 below summarizes the assumptions and rationale used to define the Inflow-Diversion Function in the model.

Table G-2. Inflow-Diversion Function Assumptions Used in HEC-HMS Modeling

Inflow (cfs)	Diversion (cfs)	Notes
0	0	No inflow, no diversion.
1	0.01	Minimum constant diversion applied.
10	1.01	0.01 base + 10% of inflow.
100	11.01	0.01 base + 10% of inflow.
Existing 2-year discharge	11.01 + 10% of incoming 2-year discharge	Represents moderate effectiveness at low flow rates.
Existing 10-year discharge	Previous row + 5% of incoming 10-year discharge	Represents diminished effectiveness as flow rates increase.
Existing 100-year discharge	Previous row + 1% of incoming 100-year discharge	Further marginal increase for extreme events.
10,000	Previous row + 1% of inflow (10,000 cfs * 0.01) = 100	Used to cap model above maximum flow rates.

This table illustrates the staged assumptions used in the Inflow-Diversion Function to simulate infiltration and storage benefits for Stream, Wetland, and Floodplain Restoration in HEC-HMS. Diversion rates increase with inflow but taper as events become more extreme, consistent with diminishing infiltration effectiveness at higher flows.

¹For example, see Pennsylvania Department of Environmental Protection (PADEP) Pennsylvania Post-Construction Stormwater Management (PCSM) Manual. Document Number 386-0300-001. Draft dated January 28, 2023. See Section 3.4.3, Floodplain Restoration.



MAP LEGEND

GSI, FRS, TRP, PND Opportunity Locations

HEC-HMS Junction Points

Blue-Green Streets

Stream, Wetland, and Floodplain Restoration

Watts Branch Focus Area 2 Boundary

Existing Stream Centerline

HEC-HMS Subbasin Boundaries

Watts Branch
HEC-HMS
Modeling Map

June 2025

05001,0002,000

Feet

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Table G-3. HEC-HMS 2-YR Peak Flow Comparison Summary

HEC-HMS Junction	2-YR Peak Flow (cfs)					
	Existing	Concept	Difference	Existing 2080s	Concept 2080s	Difference
ECST4	57.3	35.2	-22.1	88.7	71.2	-17.5
ECST3	145.5	105.4	-40.1	228.0	192.4	-35.6
ECST2	280.6	178.0	-102.6	441.3	324.1	-117.2
ECST1	378.7	195.4	-183.3	584.3	347.0	-237.3
WB13	63.1	63.1	0.0	109.0	109.0	0.0
WB12	76.3	76.3	0.0	140.2	140.2	0.0
WB11	98.3	98.3	0.0	185.1	185.1	0.0
WB10	134.7	134.7	0.0	263.3	263.3	0.0
WB9	154.4	154.4	0.0	292.0	292.0	0.0
WB8	280.3	280.3	0.0	481.3	481.3	0.0
WB7	659.0	426.5	-232.5	1065.6	728.6	-337.0
WB6	725.4	484.6	-240.8	1171.1	833.7	-337.4
WB5	1001.8	770.5	-231.3	1548.8	1234.4	-314.4
WB4	1055.2	815.4	-239.8	1651.4	1314.3	-337.1
WB3	1061.4	847.8	-213.6	1659.2	1347.8	-311.4
WB2	1067.1	881.2	-185.9	1666.9	1410.2	-256.7
WB1	1051.2	888.8	-162.4	1640.4	1421.2	-219.2

Table G-4. HEC-HMS 10-YR Peak Flow Comparison Summary

HEC-HMS Junction	10-YR Peak Flow (cfs)		
	Existing	Concept	Difference
ECST4	139.5	119.4	-20.1
ECST3	354.6	313.7	-40.9
ECST2	686.9	562.3	-124.6
ECST1	896.1	604.3	-291.8
WB13	180.2	180.2	0.0
WB12	244.6	244.6	0.0
WB11	323.8	323.8	0.0
WB10	484.1	484.1	0.0
WB9	529.9	529.9	0.0
WB8	815.4	815.4	0.0
WB7	1711.5	1210.6	-500.9
WB6	1831.2	1378.1	-453.1
WB5	2375.0	1930.3	-444.7
WB4	2520.3	2068.3	-452.0
WB3	2555.6	2113.7	-441.9
WB2	2544.1	2195.1	-349.0
WB1	2513.1	2213.7	-299.4

Note: The 10-year storm event was not modeled in the USACE HEC-HMS model for the 2080s.

Table G-5. HEC-HMS 100-YR Peak Flow Comparison Summary

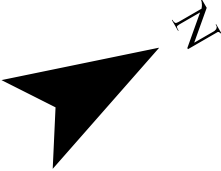
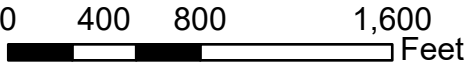
HEC-HMS Junction	100-YR Peak Flow (cfs)					
	Existing	Concept	Difference	Existing 2080s	Concept 2080s	Difference
ECST4	250.7	228.8	-21.9	397.9	379.0	-18.9
ECST3	648.0	588.0	-60.0	1147.7	1021.3	-126.4
ECST2	1260.6	1086.1	-174.5	2240.3	1967.6	-272.7
ECST1	1572.8	1214.0	-358.8	2682.8	2299.0	-383.8
WB13	420.7	420.7	0.0	737.8	737.8	0.0
WB12	579.8	579.8	0.0	1077.5	1077.5	0.0
WB11	746.3	746.3	0.0	1408.2	1408.2	0.0
WB10	1016.3	1016.3	0.0	1902.4	1902.4	0.0
WB9	1130.6	1130.6	0.0	2143.0	2143.0	0.0
WB8	1549.5	1549.5	0.0	2884.7	2884.7	0.0
WB7	3122.3	2603.6	-518.7	5532.0	5075.4	-456.6
WB6	3330.0	2778.9	-551.1	5920.7	5434.5	-486.2
WB5	4248.1	3735.9	-512.2	7507.2	7069.3	-437.9
WB4	4453.5	3903.5	-550.0	7892.0	7381.3	-510.7
WB3	4577.0	4010.8	-566.2	8181.3	7643.6	-537.7
WB2	4679.5	4223.1	-456.4	8453.6	7963.1	-490.5
WB1	4719.8	4303.5	-416.3	8654.6	8190.1	-464.5

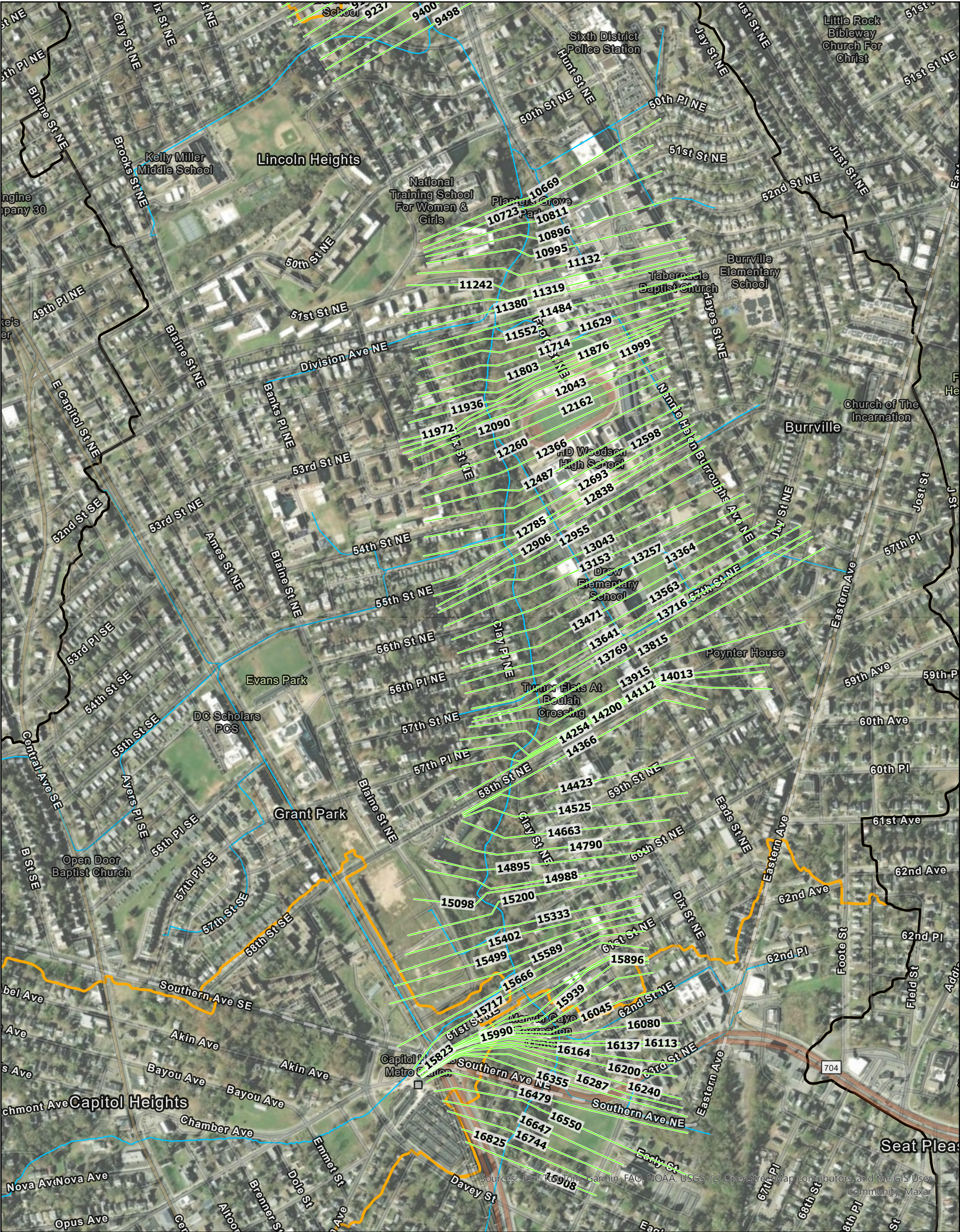


MAP LEGEND

- HEC-RAS Cross Sections
- ▣ Watts Branch Watershed Boundary
- ▣ Watts Branch Focus Area Boundaries
- Existing Stream Centerline

Watts Branch
HEC-RAS Map





MAP LEGEND

- HEC-RAS Cross Sections
- Existing Stream Centerline
- Watts Branch Focus Area Boundaries
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Watts Branch
HEC-RAS Map

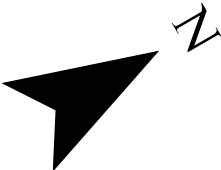
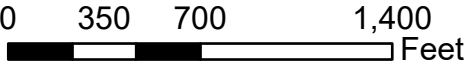


Table G-6. HEC-RAS 100-YR Water Surface Elevation Comparison Summary

River Station	100-YR Water Surface Elevation (ft)		
	Existing	Concept	Difference
16908	87.07	86.80	-0.27
16825	86.77	86.44	-0.33
16744	86.73	86.36	-0.37
16647	86.62	86.20	-0.42
16550	86.61	86.19	-0.42
16479	86.61	86.19	-0.42
16418	Southern Avenue Bridge		
16355	85.42	84.74	-0.68
16287	85.33	84.58	-0.75
16240	85.19	84.39	-0.80
16200	85.17	84.36	-0.81
16164	85.17	84.35	-0.82
16137	85.12	84.27	-0.85
16127	Footbridge		
16113	85.00	84.23	-0.77
16080	85.04	84.27	-0.77
16045	84.84	84.02	-0.82
15990	84.82	83.99	-0.83
15939	84.71	83.84	-0.87
15896	84.62	83.71	-0.91
15823	84.64	83.73	-0.91
15771	61 st Street Culvert		
15717	80.17	79.30	-0.87
15666	80.23	79.35	-0.88
15589	79.89	79.12	-0.77
15499	79.76	78.90	-0.86
15402	79.43	78.48	-0.95
15333	78.92	77.86	-1.06
15200	79.08	78.00	-1.08
15098	79.07	77.99	-1.08
14988	79.04	77.95	-1.09
14895	78.19	77.14	-1.05
14790	77.99	76.92	-1.07
14663	76.71	75.61	-1.10
14525	76.71	75.48	-1.23
14423	75.76	74.53	-1.23
14366	76.08	74.84	-1.24
14314	58 th Street NE Bridge		

14254	71.65	70.88	-0.77
14200	71.87	71.04	-0.83
14112	71.45	70.60	-0.85
14013	71.39	70.41	-0.98
13915	71.32	70.26	-1.06
13815	71.25	70.16	-1.09
13769	69.53	68.70	-0.83
13736	Footbridge		
13716	68.20	67.47	-0.73
13641	66.78	66.50	-0.28
13563	67.66	67.03	-0.63
13471	67.00	66.30	-0.70
13364	65.17	65.17	0.00
13257	65.27	65.20	-0.07
13153	65.37	65.27	-0.10
13043	65.26	65.19	-0.07
12955	65.18	65.13	-0.05
12906	65.04	65.03	-0.01
12872	55 th Street NE Bridge		
12838	64.03	64.57	0.54
12785	63.48	62.09	-1.39
12693	62.72	61.80	-0.92
12598	62.41	61.54	-0.87
12487	60.79	60.14	-0.65
12366	60.75	59.95	-0.80
12260	60.26	59.44	-0.82
12162	59.90	59.07	-0.83
12090	59.59	58.72	-0.87
12043	59.07	58.25	-0.82
11999	58.96	58.09	-0.87
11985	Footbridge		
11972	58.00	57.52	-0.48
11936	58.32	57.74	-0.58
11876	58.43	57.83	-0.60
11803	58.38	57.78	-0.60
11714	58.42	57.80	-0.62
11629	58.40	57.79	-0.61
11552	58.30	57.65	-0.65
11484	58.24	57.60	-0.64
11435	Division Avenue NE Bridge		

11380	57.18	56.74	-0.44
11319	55.08	54.66	-0.42
11242	55.23	54.66	-0.57
11132	54.93	54.37	-0.56
10995	54.83	54.20	-0.63
10896	54.77	54.15	-0.62
10811	54.62	53.99	-0.63
10723	54.31	53.63	-0.68
10669	53.04	52.68	-0.36
10412	Culvert		
9498	43.47	42.32	-1.15
9400	43.10	41.89	-1.21
9326	42.38	40.98	-1.40
9237	42.34	40.79	-1.55
9137	42.21	40.22	-1.99
9042	42.11	40.01	-2.10
8995	42.01	39.80	-2.21
8959	48 th Street NE Footbridge		
8926	38.97	38.32	-0.65
8880	38.89	38.14	-0.75
8806	36.64	36.40	-0.24
8719	37.21	36.81	-0.40
8631	37.45	36.97	-0.48
8526	37.31	36.84	-0.47
8429	37.15	36.68	-0.47
8334	36.52	36.07	-0.45
8243	36.53	36.03	-0.50
8165	36.50	35.95	-0.55
8090	36.50	35.93	-0.57
8055	36.49	35.91	-0.58
8037	Footbridge		
8018	35.44	34.96	-0.48
7966	35.18	34.79	-0.39
7885	35.13	34.71	-0.42
7777	34.92	34.50	-0.42
7680	34.84	34.42	-0.42
7570	34.79	34.36	-0.43
7482	34.73	34.29	-0.44
7432	34.66	34.22	-0.44
7396	44 th Street NE Bridge		

7357	33.72	33.21	-0.51
7319	33.69	33.17	-0.52
7264	33.55	33.01	-0.54
7181	33.25	32.68	-0.57
7141	33.24	32.68	-0.56
7098	Gault Place Bridge		
7038	31.64	31.33	-0.31
6990	31.63	31.29	-0.34
6924	31.21	30.88	-0.33
6837	31.06	30.75	-0.31
6774	31.28	30.95	-0.33
6722	30.92	30.62	-0.30
6676	30.88	30.58	-0.30
6663	Footbridge		
6648	30.58	30.30	-0.28
6604	30.53	30.26	-0.27
6538	30.62	30.34	-0.28
6465	30.32	30.05	-0.27
6371	30.30	30.03	-0.27
6325	30.30	30.03	-0.27
6286	Hunt Place Bridge		
6251	28.83	28.30	-0.53
6202	28.88	28.32	-0.56
6144	29.12	28.38	-0.74
6068	29.17	28.49	-0.68
6019	29.13	28.44	-0.69
5970	29.11	28.42	-0.69
5952	Footbridge		
5931	28.99	28.09	-0.90
5867	28.97	28.07	-0.90
5800	28.91	27.96	-0.95
5746	28.90	27.93	-0.97
5685	Minnesota Avenue Bridge		
5634	27.56	26.93	-0.63
5626	27.06	26.39	-0.67
5587	Railroad Bridge		
5565	26.56	26.02	-0.54
5561	26.56	26.02	-0.54
5533	Railroad Bridge		
5510	26.23	25.75	-0.48

5501	26.23	25.76	-0.47
5473	Railroad Bridge		
5411	25.65	25.39	-0.26
5390	25.86	25.58	-0.28
5364	US Route 295 Ramp Bridge		
5350	24.11	23.64	-0.47
5348	24.13	23.69	-0.44
5320	US Route 295 North Bridge		
5294	23.76	23.28	-0.48
5288	23.77	23.31	-0.46
5263	US Route 295 South Bridge		
5232	23.42	22.46	-0.96
5223	23.64	22.83	-0.81
5205	Kenilworth Avenue Bridge		
5162	23.71	22.71	-1.00
5105	23.69	22.66	-1.03
5053	23.70	22.68	-1.02
4988	23.57	22.59	-0.98
4948	Kenilworth Terrace Bridge		
4893	18.76	18.35	-0.41
4829	17.65	17.48	-0.17
4745	17.25	17.03	-0.22
4637	17.29	16.92	-0.37
4432	16.77	16.28	-0.49
4231	16.64	16.09	-0.55
4079	16.56	15.99	-0.57
3925	16.51	15.92	-0.59
3790	16.49	15.89	-0.60
3656	16.45	15.85	-0.60
3544	16.43	15.83	-0.60
3478	16.43	15.82	-0.61
3463	West Bank Trail Bridge		
3443	16.41	15.80	-0.61
3384	16.40	15.79	-0.61
3233	16.38	15.77	-0.61
3062	16.34	15.72	-0.62
2899	16.26	15.59	-0.67
2746	16.13	15.44	-0.69
2602	15.92	15.16	-0.76
2452	15.84	14.99	-0.85

2286	15.78	14.92	-0.86
2099	15.70	14.74	-0.96
1928	15.56	14.55	-1.01
1770	15.50	14.48	-1.02
1599	15.38	14.29	-1.09
1453	15.40	14.33	-1.07
1306	15.38	14.29	-1.09
1146	15.19	14.04	-1.15
1040	14.88	13.65	-1.23
971	14.64	13.42	-1.22
892	14.61	13.41	-1.20
836	Deane Drive Culvert		
769	10.34	9.94	-0.40
688	9.28	9.00	-0.28
552	9.10	8.81	-0.29
423	8.86	8.56	-0.30
284	7.29	7.03	-0.26
80	7.52	7.22	-0.30

