

6 Benefits of Plan Implementation

In order to assess the benefits of the Belle Haven, Dogue Creek and Four Mile Run Watershed Management Plan, hydrologic, hydraulic and pollutant loading modeling was conducted for three separate scenarios:

- *Existing Conditions*: represented watershed conditions at the time the plan was prepared,
- *Future Conditions without Projects*: represented watershed conditions that included forecasts for changes in land use, and
- *Future Conditions with Projects*: added the proposed projects in this plan to the *Future Conditions without Projects* scenario.

All the proposed projects were modeled for pollutant loading reductions. Hydrologic and hydraulic benefits were calculated for the 34 10-year projects with significant storage, such as new stormwater ponds or pond retrofits. Additional information about the models used in this plan may be found in Section 2, while detailed results are discussed in Appendix B.

- Hydrologic modeling was conducted using SWMM. This model uses parameters for land cover, soils and stormwater management to estimate the amount and timing of runoff and stream flow that is generated from precipitation. Modeling was done for two precipitation events: the 2-year storm, with a 50 percent probability of occurrence in any one year, and the 10-year storm, which has a 10 percent probability of occurrence in any one year.
- HEC-RAS was used for hydraulic modeling. This model takes stream flow and estimates the speed and depth of the water. When the results are compared with elevations of buildings and structures, it is possible to determine whether or not they will be impacted.
- Pollutant loading is a type of water quality modeling that estimates how much of a particular pollutant (i.e. total suspended solids (TSS), total nitrogen (TN) or total phosphorus (TP) is being generated and delivered to streams and other water bodies through various land-use activities. The spreadsheet-based STEPL model was used to estimate stormwater runoff loads and assess the reductions of these pollutants through implementation of the proposed projects. Pollutant loads from stream erosion were estimated based on the length and severity of erosion identified in the SPA assessment. Stream restoration projects were assumed to reduce the TSS, TN, and TP loads to zero for the entire length of the restored reach.

6.1 Hydrology

The plan recommended eight stormwater pond projects: three in Belle Haven, two in Dogue Creek and three in Four Mile Run. Model results showed reduction of both peak flows (2- and 10-year) and surface runoff volumes for all three watersheds. Comparisons between the *Future Conditions without Projects* and *Future Conditions with Projects* scenarios showed a reduction in runoff volume from a low of 1.0 percent in for the 10-year event in Belle Haven to a high of 9.4 percent for the 2-year event in the Dogue Creek Barnyard Run WMA. Peak flow reductions varied from a low of 3.1 percent for the 2-year event in Belle Haven to a high of 7.4 percent for the 10-year event in Four Mile Run. There were no reductions in the Dogue Creek Piney Run or Potomac WMAs because no storage retrofits were proposed in these areas. A summary of the results is presented in Tables 6-1 and 6-2.

6.2 Hydraulics

Three projects were proposed in the plan to help alleviate roadway flooding problems identified through hydraulic modeling. Two were in Belle Haven (in areas outside of the Corps of Engineers study) and one was in the Dogue Creek North Fork WMA. Two projects are designed to reconstruct the road culvert to allow the 10- year and 100-year (1 percent annual probability of occurrence) flows to pass through the culvert unimpeded. The third project was a stream restoration project in the Belle Haven WMA downstream of Quander Road. The restoration will consist of daylighting a piped section of Quander Brook and restoring it to a natural stream system.

All proposed projects within VDOT right-of-way will be sent to VDOT for evaluation.

6.3 Pollutant Loading

The STEPL model showed slight increases in the modeled runoff pollutant loads between the *Existing Conditions* and *Future Conditions without Projects* scenarios for all watersheds.

- Belle Haven: There was a small increase in the pollutant loading, due to changes in land use from open space to residential.
- Dogue Creek: The Barnyard Run WMA had the smallest increase in loads, with less than one percent increase for TSS, TN and TP, while Piney Run had the highest increase of all the WMAs in Dogue Creek watershed, with TSS increasing by three percent, TN by six percent and TP by seven percent.
- Four Mile Run: Results were comparable to the Belle Haven watershed with a pollutant load increase less than three percent, primarily from forecast changes in residential density. The increase is small because almost 90 percent of the watershed has already been developed with commercial or residential land use.

All the structural projects were modeled for the *Future Conditions with Projects* scenario to determine the total pollutant removal of the proposed plan. .

- Belle Haven: There were notable reductions in TSS (53 percent), TN (8 percent) and TP (16 percent), largely from the reductions in stream erosion from the significant length of stream restoration projects proposed.
- Dogue Creek: The most significant reductions in pollutant loading were in the North Fork and Mainstem WMAs, with 16 percent and 14 percent reduction in TSS for the 25-year plan.
- Four Mile Run: Reductions in Four Mile Run were the lowest of the three watersheds overall, with about seven percent of TSS, three percent of TN, and four percent of TP removed as a result of the proposed projects.

6.4 Plan Cost and Benefits

The 60 priority projects in the 10-year plan will reduce total suspended solids by 744 tons per year, total nitrogen by 2,076 pounds per year and total phosphorus by 597 pounds per year. The full 25-year plan identifies an additional 29 structural projects for a total of 89, whose overall benefits include eliminating the overtopping of four road crossings and restoring almost five miles of streams and one half-mile of forested buffer. Full plan implementation will reduce pollutant loads by as much as 797 tons per year of total suspended solids, 2,544 pounds per

year of total nitrogen and 711 pounds per year of total phosphorus. These benefits will help meet the County's goals for water quality and stream improvements and provide a positive impact on the residents and conditions of the watersheds.

The total estimated cost for the structural projects for the 10-year plan is \$26.7 million. This includes all three watersheds; \$7.5 million for Belle Haven, \$13.7 million for Dogue Creek and \$5.5 million for Four Mile Run. Implementation of the 11-25 year structural projects adds \$7.5 million for a total of \$34.2 million; an additional \$7.1 million for Dogue Creek and \$0.4 million for Four Mile Run. Plan cost estimate include only structural projects and it should be noted that the 10-yr plan costs are more accurate as these projects were scoped in more detail.

Table 6-1: Pollutant Loading and Flow Reduction by Watershed

Watershed	Area (ac)	Scenario ³	Runoff Volume (in) ¹		Peak Flow (cfs/ac) ¹		TSS (lb/ac/yr) ²	TN (lb/ac/yr) ^{2,4}	TP (lb/ac/yr) ^{2,4}
			2 Year	10 Year	2 Year	10 Year			
Belle Haven	1,737.4	Existing	1.464	3.145	0.560	1.145	1,070.0	6.9169	1.2165
		Future without projects	1.515	3.208	0.576	1.181	1,076.0	7.1047	1.2381
		Future 10-yr projects	1.476	3.174	0.558	1.136	506.6	6.5143	1.0382
		Future 25-yr projects	N/A	N/A	N/A	N/A	506.6	6.5143	1.0382
		Reduction 10-year projects	0.039 (3%)	0.034 (1%)	0.018 (3%)	0.045 (4%)	569.4 (53%)	0.5904 (8%)	0.1999 (16%)
		Reduction 25-year projects	N/A	N/A	N/A	N/A	569.4 (53%)	0.5904 (8%)	0.1999 (16%)
Four Mile Run	1,953.0	Existing	1.592	3.287	0.816	1.604	245.7	5.4505	0.7964
		Future without projects	1.632	3.342	0.824	1.623	246.4	5.5786	0.8077
		Future 10-yr projects	1.583	3.264	0.766	1.503	230.3	5.3949	0.7764
		Future 25-yr projects	N/A	N/A	N/A	N/A	229.4	5.3934	0.7756
		Reduction 10-year projects	0.049 (3%)	0.078 (2%)	0.058 (7%)	0.12 (7%)	16.1 (7%)	0.1837 (3%)	0.0313 (4%)
		Reduction 25-year projects	N/A	N/A	N/A	N/A	17.0 (7%)	0.1852 (3%)	0.0321 (4%)
Dogue Creek	12,475.1	Existing	1.286	2.984	0.113	0.295	382.6	4.1327	0.6682
		Future without projects	1.325	3.031	0.127	0.343	390.6	4.3033	0.6932
		Future 10-yr projects	1.273	2.927	0.122	0.329	353.1	4.2479	0.6781
		Future 25-yr projects	N/A	N/A	N/A	N/A	344.8	4.2107	0.6690
		Reduction 10-year projects	0.052 (4%)	0.104 (3%)	0.005 (4%)	0.014 (4%)	37.5 (10%)	0.0554 (1%)	0.0151 (2%)
		Reduction 25-year projects	N/A	N/A	N/A	N/A	45.8 (11%)	0.0926 (2%)	0.0242 (4%)

¹Flow is cumulative

²Loads are representative of individual land area contributions

³25-year projects were not evaluated in the hydrologic model

⁴Due to rounding effects four decimals were needed to make the total loads from WMA and watershed coincide.

Table 6-2: Pollutant Loading and Flow Reduction by WMA

WMA	Area (ac)	Scenario ³	Runoff Volume (in) ¹		Peak Flow (cfs/ac) ¹		TSS (lb/ac/yr) ²	TN (lb/ac/yr) ^{2,4}	TP (lb/ac/yr) ^{2,4}
			2 Year	10 Year	2 Year	10 Year			
Belle Haven	1,737.4	Existing	1.464	3.145	0.560	1.145	1,070.0	6.9169	1.2165
		Future without projects	1.515	3.208	0.576	1.181	1,076.0	7.1047	1.2381
		Future 10-yr projects	1.476	3.174	0.558	1.136	506.6	6.5143	1.0382
		Future 25-yr projects	N/A	N/A	N/A	N/A	506.6	6.5143	1.0382
		Reduction 10-year projects	0.039 (3%)	0.034 (1%)	0.018 (3%)	0.045 (4%)	569.4 (53%)	0.5904 (8%)	0.1999 (16%)
		Reduction 25-year projects	N/A	N/A	N/A	N/A	569.4 (53%)	0.5904 (8%)	0.1999 (16%)
Four Mile Run	1,953.0	Existing	1.592	3.287	0.816	1.604	245.7	5.4505	0.7964
		Future without projects	1.632	3.342	0.824	1.623	246.4	5.5786	0.8077
		Future 10-yr projects	1.583	3.264	0.766	1.503	230.3	5.3949	0.7764
		Future 25-yr projects	N/A	N/A	N/A	N/A	229.4	5.3934	0.7756
		Reduction 10-year projects	0.049 (3%)	0.078 (2%)	0.058 (7%)	0.12 (7%)	16.1 (7%)	0.1837 (3%)	0.0313 (4%)
		Reduction 25-year projects	N/A	N/A	N/A	N/A	17.0 (7%)	0.1852 (3%)	0.0321 (4%)
Dogue Creek - Barnyard Run	1,528.7	Existing	1.328	3.025	0.125	0.181	197.7	3.2353	0.5020
		Future without projects	1.334	3.032	0.173	0.416	198.9	3.2630	0.5058
		Future 10-yr projects	1.208	2.766	0.162	0.391	197.0	3.2386	0.5016
		Future 25-yr projects	N/A	N/A	N/A	N/A	197.2	3.2446	0.5023
		Reduction 10-year projects	0.126 (9%)	0.266 (9%)	0.011 (6%)	0.025 (6%)	1.9 (1%)	0.0244 (1%)	0.0042 (1%)
		Reduction 25-year projects	N/A	N/A	N/A	N/A	1.7 (1%)	0.0184 (1%)	0.0035 (1%)
Dogue Creek - Mainstem	3,775.8	Existing	1.329	3.036	0.124	0.312	350.9	4.0837	0.6544
		Future without projects	1.367	3.082	0.138	0.371	359.8	4.2895	0.6823
		Future 10-yr projects	1.302	2.951	0.132	0.353	327.5	4.2047	0.6654
		Future 25-yr projects	N/A	N/A	N/A	N/A	308.9	4.2293	0.6600
		Reduction 10-year projects	0.065 (5%)	0.131 (4%)	0.006 (4%)	0.018 (5%)	32.3 (9%)	0.0848 (2%)	0.0169 (3%)
		Reduction 25-year projects	N/A	N/A	N/A	N/A	50.9 (14%)	0.0602 (1%)	0.0223 (3%)

WMA	Area (ac)	Scenario ³	Runoff Volume (in) ¹		Peak Flow (cfs/ac) ¹		TSS (lb/ac/yr) ²	TN (lb/ac/yr) ^{2,4}	TP (lb/ac/yr) ^{2,4}
			2 Year	10 Year	2 Year	10 Year			
Dogue Creek - North Fork	2,805.5	Existing	1.448	3.176	0.175	0.392	585.9	5.6584	0.9337
		Future without projects	1.509	3.252	0.240	0.508	592.5	5.8593	0.9582
		Future 10-yr projects	1.479	3.220	0.225	0.473	506.8	5.7795	0.9292
		Future 25-yr projects	N/A	N/A	N/A	N/A	500.6	5.7130	0.9153
		Reduction 10-year projects	0.03 (2%)	0.032 (1%)	0.015 (6%)	0.035 (7%)	85.7 (15%)	0.0798 (1%)	0.0290 (3%)
		Reduction 25-year projects	N/A	N/A	N/A	N/A	91.9 (16%)	0.1463 (3%)	0.0429 (5%)
Dogue Creek - Piney Run⁵	1,736.1	Existing	1.225	2.864	0.214	0.492	605.6	3.7192	0.6398
		Future without projects	1.240	2.879	0.221	0.499	625.6	3.9516	0.6855
		Future 10-yr projects	1.240	2.879	0.221	0.499	566.7	3.8883	0.6644
		Future 25-yr projects	N/A	N/A	N/A	N/A	557.5	3.6694	0.6329
		Reduction 10-year projects	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	58.9 (9%)	0.0633 (2%)	0.0211 (3%)
		Reduction 25-year projects	N/A	N/A	N/A	N/A	68.1 (11%)	0.2822 (7%)	0.0526 (8%)
Dogue Creek – Potomac⁶	2,629.0	Existing	0.405	1.005	0.446	0.945	171.3	3.3700	0.5200
		Future without projects	0.421	1.026	0.483	1.015	175.7	3.5000	0.5400
		Future 10-yr projects	0.421	1.026	0.483	1.015	175.7	3.5000	0.5400
		Future 25-yr projects	N/A	N/A	N/A	N/A	175.7	3.5000	0.5400
		Reduction 10-year projects	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0%)
		Reduction 25-year projects	N/A	N/A	N/A	N/A	0.0 (0%)	0.0 (0%)	0.0 (0%)

¹Flow is cumulative

²Loads are representative of individual land area contributions

³25-year projects were not evaluated in the hydrologic model

⁴Due to rounding effects four decimals were needed to make the total loads from WMA and watershed coincide.

⁵No storage projects were recommended in Piney Run, so there are no reductions in volume or flow from 10-year projects.

⁶No projects were recommended in the Potomac WMA as it lies within Fort Belvoir.

Table 6-3: Overall Pollutant Loading and Flow Reduction

	Area (ac)	Scenario ³	Runoff Volume (in) ¹		Peak Flow (cfs/ac) ¹		TSS (lb/ac/yr) ²	TN (lb/ac/yr) ^{2,4}	TP (lb/ac/yr) ^{2,4}
			2 Year	10 Year	2 Year	10 Year			
Full Plan	16,165.5	Existing	1.342	3.038	1.489	3.044	439.9	4.5911	0.7426
		Future without projects	1.383	3.088	1.527	3.147	446.8	4.7585	0.7656
		Future 10-yr projects	1.332	2.994	1.446	2.968	354.8	4.6301	0.7287
		Future 25-yr projects	N/A	N/A	N/A	N/A	348.3	4.6012	0.7216
		Reduction 10-year projects	0.051 (4%)	0.094 (3%)	0.081 (5%)	0.179 (6%)	92.0 (21%)	0.1284 (3%)	0.0369 (5%)
		Reduction 25-year projects	N/A	N/A	N/A	N/A	98.5 (22%)	0.1573 (3%)	0.0440 (6%)

¹Flow is cumulative

²Loads are representative of individual land area contributions

³25-year projects were not evaluated in the hydrologic model

⁴Due to rounding effects four decimals were needed to make the total loads from WMA and watershed coincide.

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