Gwynns Falls Water Quality Management Plan

Executive Summary

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STUDY OBJECTIVES & SITE DESCRIPTION

In partial fulfillment of the federally mandated National Pollutant Discharge Elimination System Permit (NPDES) – Municipal Stormwater Discharge Permit (99-DP-3317) for Baltimore County and (MC-BC-1999-013) for Baltimore City, and to provide watershed restoration framework for both jurisdictions, Parsons Brinckerhoff (PB), with support from Coastal Resources Inc. and Greenman-Pedesen Inc., has prepared the Gwynns Falls Watershed Water Quality Management Plan. This management plan represents a cooperative effort between Baltimore County and Baltimore City in addressing regional water quality issues and improving the health of the Cheaspeake Bay.

The 66 square mile Gwynns Falls watershed is located in western Baltimore County and the west side of Baltimore City (Figure E.1) The watershed begins at the headwaters in Glyndon, MD and ends at the Middle Branch of the Patapsco River in Baltimore City. This study was conducted by dividing the watershed into eleven (11) sub-watersheds: Red Run, Horsehead Branch, Scotts Level, Powder Mill Run, Dead Run, Gwynns Run North, Gwynns Run South, Maidens Choice, Upper Gwynns Falls, Middle Gwynns Falls and Lower Gwynns Falls. The Gwynns Falls Watershed Management Plan was prepared to meet the following objectives:

1. Identify and evaluate non-point source stormwater pollution,
2. Assess geomorphic condition of stream network and evaluate state of degradation,
3. Assess and determine management measures for the reduction of nonpoint source pollution and reestablishment of stream stability and
4. Provide a watershed restoration framework and capital improvement planning tool for Baltimore County Department of Environment Protection and Resource Management (DEPRM) and Baltimore City Department of Public Works (DPW).

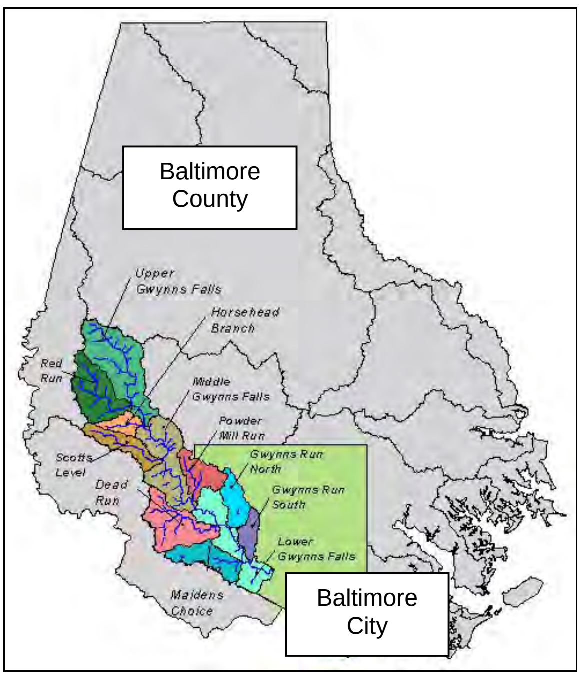


Figure E.1: Subwatershed map

STUDY TASKS

The following tasks were performed by the PB team to meet the study objectives.

I. ***Watershed Characterization***: PB assembled available GIS mapping from Baltimore City and County and identified the principle watershed characteristics.
II. ***SWMM Modeling***: Hydrologic and non-point source pollutant modeling was conducted using the EPA Stormwater Management Model (SWMM). The Gwynns Falls watershed was divided into 505 catchments with an average catchment size of 83 acres. The model simulation ran from 1980 through 2002, a 23-year period.
III. ***Stream Stability Assessment***: A rapid cruised reach assessment was conducted for all Baltimore City streams and Baltimore County streams not previously assessed by the Army Corps of Engineers. Information was collected on channel morphology, channel disturbances and habitat. A verification of the Army Corps of Engineers field data and photo documentation was provided for the Corps reaches in Baltimore County.
IV. ***Forest Assessment***: A "Level IV – Rapid Field Assessment" using the methodology and field data sheets from the report *A Geographic Information System Analysis of Forest Cover in the Gwynns Falls Watershed* prepared for Baltimore County DEPRM was conducted on 34 forest patches within the Gywnns Falls watershed. A GIS based forest assessment was also conducted in Baltimore City.
V. ***Stormwater Management Facility & Outfall Assessment***: PB assessed the condition of 39 SWM facilities and 73 major storm drain outfalls in the County and City. Based on the findings, PB recommended 81 sites in the County and City for water quality retrofit and improvement.
VI. ***Watershed Evaluation & Restoration Opportunities:*** Following the comprehensive watershed assessment, PB defined management and restoration goals for each subwatershed. PB identified more than 120 water quality improvement projects.
VII. ***Prioritization:*** PB developed a comprehensive ranking system incorporating environmental benefits and cost and ranked the improvement projects identified. Based on this ranking system, PB prioritized these projects and provided recommendations for implementation.

WATERSHED CHARACTERIZATION

The Gwynns Falls is an urbanized watershed. The lower City portion of the watershed has some of the oldest development and the upper County portion of the watershed has some of the newest development. Although many portions of the watershed are already completely built out, development continues in the central and upper portions of the watershed. Table E.1 summarizes the specific land use changes that occur between the existing land use condition and the ultimate development or full build out condition for the entire Gwynns Falls watershed. E.2 summarizes the existing and ultimate land use breakdown by subwatershed.

Baltimore City Subwatersheds

The Gwynns Run North and South and Lower Gwynns Falls subwatersheds lie wholly or mostly within Baltimore City, and are characterized by high imperviousness associated with dense residential (i.e. rowhouses), commercial and industrial development. Gwynns Run is completely built out and there is no significant change between the existing and ultimate development conditions. Gwynns Run was divided into two subwatersheds, Gwynns Run North and Gwynns Run South, because Gwynns Run North discharges directly into the Lower Gywnns Falls instead of flowing into Gwynns Run South. The Gwynns Run and Lower Gwynns Falls subwatersheds have been subject to significantly more SSO events than the other subwatersheds. Continuous sewage leaks were evident during the stream stability assessment. Leakin Park and Gwynns Falls Park, located along the Lower Gwynns Falls mainstem near the confluence with Dead Run, represent the only significant forested areas in the Baltimore City section of the watershed. Nearly all of the development in the lower three subwatersheds predates stormwater management regulations. Limited infill development is expected in these watersheds for the ultimate conditions, but parkland will remain forested even under ultimate build-out conditions.

Baltimore City and Baltimore County Subwatersheds

Powder Mill Run, Dead Run and Maidens Choice all straddle the City-County boundary. The Maidens Choice subwatershed lies predominantly within Baltimore City and consists of a mix of residential, commercial and industrial areas. The subwatershed is highly urbanized and has a high percentage of imperviousness. Large portions of the watershed were developed prior to current stormwater management regulations.

The Powder Mill Run subwatershed is located half in Baltimore City and half in Baltimore County. It contains a mix of commercial, institutional, industrial and medium-to-high density residential land. A large percentage of the development was constructed prior to formal stormwater management regulations. Several large stormwater management facilities have recently been constructed as a result of development and redevelopment within the Seton Industrial Park.

The Dead Run subwatershed lies mostly within Baltimore County, and features a mixture of commercial, institutional, industrial and residential land uses, along with the US-40, I-70 and Security Boulevard interchanges of the Baltimore Beltway (I-695). The newer developments in the Dead Run headwaters feature stormwater management ponds, but development in a large portion of this subwatershed predates stormwater management regulations.

Limited infill development is expected in these subwatersheds under ultimate conditions.

Water quality data shows that constant sewage leaks and SSO events are also a problem in the Dead Run subwatershed.

Baltimore County Subwatersheds

The Scotts Level Run subwatershed was almost entirely converted to medium-density residential development before the advent of stormwater management, though some woodland remains. The Middle Gwynns Falls subwatershed contains a majority of medium density residential development, woodland and major transportation corridors such as the Beltway and the I-795/Baltimore Metro route. The subwatershed generally lacks stormwater management.

The Upper Gwynns Falls watershed and portions of Red Run and Horsehead Branch have been designated as growth areas by Baltimore County, thus a large percentage of the remaining woodland and agricultural areas of these subwatersheds is expected to be converted to residential, commercial and industrial development. The Horsehead Branch and Red Run subwatersheds contain a mixture of commercial, low to medium density residential, agricultural, and wooded land uses and are the least-developed tributaries to the Gwynns Falls. The Soldier’s Delight Natural Environment Area in the Red Run subwatershed represents the largest contiguous wooded area in the Baltimore County section of the Gwynns Falls watershed. The Upper Gwynns Falls watershed still retains significant woodland and farmland, but the upper portion of this subwatershed has been largely converted to commercial, industrial and residential development. The highest concentration and density of development occurs along the Reisterstown Road corridor, with the lowest density occurring east of the Upper Gwynns Falls mainstem. Stormwater management ponds serve the newest developments in the upper three subwatersheds, however, these developments comprise less than half of the current total development in the upper subwatersheds.

Table E.1: Comparison between Existing and Ultimate land use for entire watershed

Land Use Category	% of Watershed		% Change from Existing
	Existing	Ultimate	
Low Density	5.2%	7.2%	2.0%
Medium Density	28.5%	34.1%	5.6%
High Density	18.2%	25.3%	7.1%
Commercial	9.2%	8.6%	-0.6%
Industrial	6.3%	3.4%	-2.9%
Institutional	7.5%	9.8%	2.3%
Barren	0.5%	0.0%	-0.5%
Open	4.4%	3.2%	-1.1%
Agricultural	3.4%	0.5%	-2.9%
Forest	16.7%	7.7%	-9.1%
Lake	0.1%	0.1%	0.0%

Table E.2: Subwatershed land use summary

Subshed	Condition	Percentage of Subshed										
		Low Density	Medium Density	High Density	Commer-cial	Industrial	Institutional	Barren	Open	Agricultural	Forest	Lake
Upper Gwynns Falls	Existing	11.2%	24.8%	12.5%	9.5%	7.5%	7.1%	0.7%	1.8%	7.4%	17.6%	0.0%
	Ultimate	15.1%	38.8%	18.1%	7.2%	12.8%	1.2%	0.0%	1.2%	1.2%	4.4%	0.0%
Red Run	Existing	16.0%	6.8%	11.7%	6.2%	5.4%	0.5%	1.9%	2.4%	11.0%	37.8%	0.3%
	Ultimate	22.5%	11.5%	23.6%	10.8%	11.6%	0.0%	0.0%	2.1%	2.0%	15.7%	0.3%
Horsehead Branch	Existing	1.2%	34.5%	8.0%	2.5%	0.0%	4.1%	0.0%	1.9%	20.7%	27.0%	0.0%
	Ultimate	14.3%	58.2%	17.3%	7.8%	0.0%	0.0%	0.0%	0.0%	0.0%	2.4%	0.0%
Scotts Level Branch	Existing	1.6%	60.0%	11.2%	7.2%	0.3%	5.5%	0.2%	1.0%	0.0%	13.0%	0.0%
	Ultimate	0.6%	67.6%	22.9%	5.6%	0.2%	0.0%	0.0%	0.1%	0.0%	2.9%	0.0%
Middle Gwynns Falls	Existing	5.3%	46.4%	9.3%	5.3%	3.3%	5.4%	0.4%	5.9%	0.7%	18.0%	0.0%
	Ultimate	9.4%	52.4%	21.8%	3.3%	2.9%	1.5%	0.0%	2.6%	0.0%	6.2%	0.0%
Powder Mill Run	Existing	0.7%	42.9%	15.1%	15.4%	7.3%	9.5%	0.0%	1.4%	0.0%	7.8%	0.0%
	Ultimate	0.7%	42.8%	19.9%	14.6%	9.5%	7.1%	0.0%	1.4%	0.0%	4.1%	0.0%
Gwynns Run North	Existing	0.0%	23.6%	38.7%	8.2%	9.8%	10.9%	0.0%	4.5%	0.0%	3.0%	1.4%
	Ultimate	0.0%	23.6%	38.7%	8.2%	9.8%	10.9%	0.0%	4.5%	0.0%	3.0%	1.4%
Gwynns Run South	Existing	0.0%	0.2%	58.7%	9.5%	15.3%	8.8%	0.0%	6.9%	0.0%	0.6%	0.0%
	Ultimate	0.0%	0.2%	58.7%	9.5%	15.3%	8.8%	0.0%	6.9%	0.0%	0.6%	0.0%
Dead Run	Existing	2.8%	24.3%	20.0%	18.1%	10.7%	4.3%	0.5%	4.5%	0.1%	14.6%	0.0%
	Ultimate	0.0%	27.7%	29.9%	15.0%	15.3%	0.6%	0.0%	2.2%	0.0%	9.3%	0.0%
Maidens Choice	Existing	0.7%	26.0%	28.9%	12.3%	5.2%	11.8%	0.0%	10.6%	0.0%	4.6%	0.0%
	Ultimate	0.0%	26.7%	33.4%	11.1%	6.0%	10.5%	0.0%	9.3%	0.0%	2.9%	0.0%
Lower Gwynns Falls	Existing	0.2%	23.2%	23.2%	5.6%	15.1%	7.0%	0.2%	7.4%	0.0%	18.0%	0.0%
	Ultimate	0.2%	23.1%	23.6%	5.8%	15.1%	7.0%	0.2%	7.4%	0.0%	17.7%	0.0%

WATER QUALITY MODELING

A water quality model using EPA SWMM was conducted to develop an understanding of the hydrologic characteristics of the Gwynns Falls Watershed and to estimate non-point source pollutant loadings. Rainfall-runoff modeling was performed for a 23-year period (Water Years 1980 through 2002) that represents a typical range of rainfall for Baltimore County. Modeling was performed of both existing and ultimate land use conditions and the results were used in this study to develop watershed management recommendations.

Subwatershed and Catchments

The Gwynns Falls watershed is divided into 11 subwatersheds, corresponding to the eight major tributaries plus upper, middle, and lower segments of the Gwynns Falls mainstem. At the request of Baltimore City, the 11 subwatersheds were to be divided into smaller modeling units called catchments, averaging approximately 90 acres each. The smaller modeling scale was required so that the pollutant loads from different types of land use, such as residential and commercial lands, could be quantified.

Directly Connected Impervious Area

The amount of Directly Connected Impervious Area (DCIA) is a key parameter that controls the amount of runoff generated. Precipitation that falls onto directly connected impervious area is assumed to immediately runoff and not to infiltrate. DCIA is related to the type of land use in a catchment. Heavily developed areas with storm sewers and many paved streets and roads possess large areas of imperviousness directly connected to streams. Residential areas, which have large areas covered by houses, can possess relatively low DCIA if roof drainage is not directly connected to storm sewers or street drainage. Rural, agricultural areas and forests have very little DCIA except for rock channels near streams. It is important to note that the DCIA refers to impervious areas that are directly connected to the watershed's drainage network. The total impervious area in the watershed can be significantly higher than the DCIA. Water falling on the DCIA is assumed to contribute almost instantaneously to the stormwater runoff. Table E.3 shows the DCIA for existing and ultimate land use conditions by subwatershed. Its important to note how much the DCIA increases between the existing and ultimate development condition.

Table E.3: Directly Connected Impervious Area by subwatershed

Subshed Name	% Directly Connected Impervious Area		
	Existing	Ultimate	Change
Upper Gwynns Falls	26.2%	31.9%	5.8%
Red Run	18.1%	31.3%	13.2%
Horsehead Branch	14.6%	25.9%	11.3%
Scotts Level Branch	23.7%	27.2%	3.5%
Middle Gwynns Falls	21.8%	25.4%	3.6%
Powder Mill Run	33.8%	36.2%	2.4%
Dead Run	36.2%	40.7%	4.5%
Gwynns Run North	36.2%	36.2%	0.0%
Gwynns Run South	44.2%	44.2%	0.0%
Maidens Choice	32.9%	34.2%	1.2%
Lower Gwynns Falls	31.6%	31.8%	0.2%
Entire Watershed	28.1%	32.5%	4.5%

Flow Modeling Results

Frequency Analysis

The SWMM model was used to perform flood frequency analyses for each of the subwatersheds. The frequency analysis was conducted for the 2-, 5-, 10-, 25- 50- and 100-year return periods. The return period is related to the probability that a discharge of that magnitude will occur in a given year.

A frequency analysis was conducted for the existing and ultimate development condition. The model enables us to determine the increase in discharge caused by the increase in imperviousness for each of the subwatersheds. Because individual stormwater management facilities were not modeled in SWMM, the actual increases in stream flows will be less than that shown in Table E.4. Table E.4 shows the percent increase in discharges between existing and ultimate development conditions.

Table E.4: Percent increase in Log Pearson III discharges between existing and ultimate development

Subshed	Return Period (yrs) Percent Increase					
	2	5	10	25	50	100
Upper Gwynns Falls	19.7%	22.3%	24.1%	26.5%	28.2%	29.9%
Red Run	29.3%	32.7%	35.3%	38.7%	41.2%	43.6%
Horsehead Branch	28.6%	32.2%	35.2%	39.2%	42.1%	44.9%
Scotts Level Run	9.5%	10.8%	11.9%	13.2%	14.2%	15.2%
Middle Gwynns Falls	16.0%	18.3%	20.0%	22.2%	23.8%	25.3%
Powder Mill Run	4.4%	5.1%	5.6%	6.2%	6.7%	7.2%
Dead Run	6.6%	7.7%	8.4%	9.3%	9.9%	10.5%
Gwynns Run North	0.0%	0.0%	-0.1%	-0.1%	-0.1%	-0.1%
Gwynns Run South	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Maidens Choice	2.1%	2.3%	2.4%	2.6%	2.7%	2.9%
Lower Gwynns Falls	8.3%	9.9%	11.0%	12.4%	13.4%	14.4%

Water Quality Modeling Results

Water quality modeling was conducted for the 12 pollutants listed below:

- Total suspended solids (TSS)
- Total phosphorus (TP)
- Orthophosphorus (OP)
- Total Kjeldahl Nitrogen (TKN)
- Nitrate/Nitrite (NO_3N)
- Biological oxygen demand (BOD)
- Chemical oxygen demand (COD)
- Copper (Cu)
- Zinc (Zn)
- Cadmium (Cd)
- Lead (Pb)
- Fecal Coliform (Fcol)

Figures E.2 through E.4 summarize the pollutant loading by subwatershed within the Gwynns Falls. Figure E.2 is a composite of the metal loadings (Cu, Zn, Cd, & Pb), E.3 is a composite of the nutrient loadings (TKN, NO_3N, TP & OP) and E.4 is an overall pollutant composite.

Top Metal Loadings:

- Gwynns Run South
- Dead Run
- Gwynns Run North

Top Nutrient Loading:

- Upper Gwynns Falls
- Maidens Choice
- Lower Gwynns Falls

Overall Pollutant Loading:

- Gwynns Run South
- Gwynns Falls Upper (Due to high nutrients)
- Gwynns Run North

Total annual pollutant loads in lbs./acre/year by subwatershed are presented in Tables E.5 to E.11. Results are presented for both existing and proposed conditions.

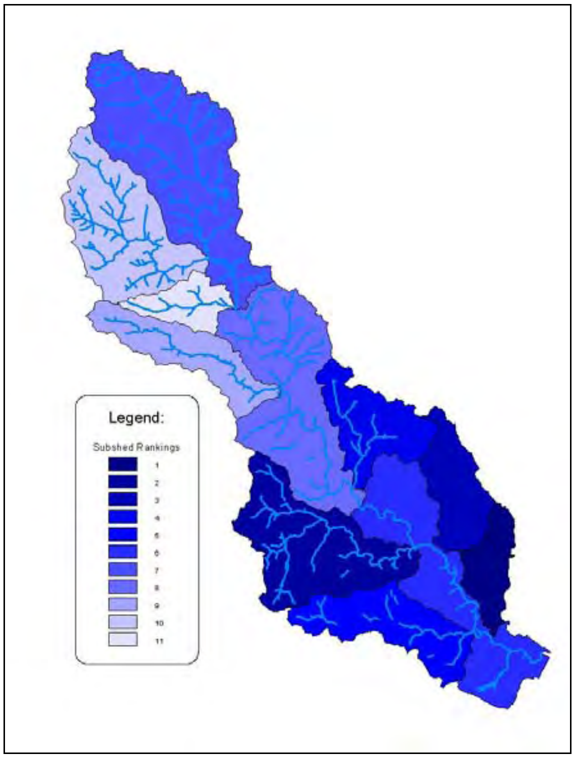


Figure E.2: Metal loadings (darkest subwatersheds have highest pollutant loading)

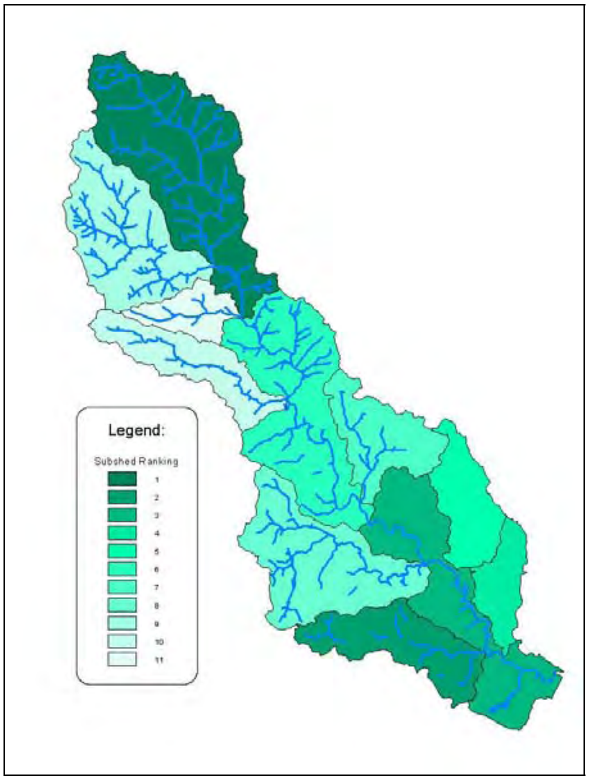


Figure E.3: Nutrient loading (darkest subwatersheds have highest pollutant loading)

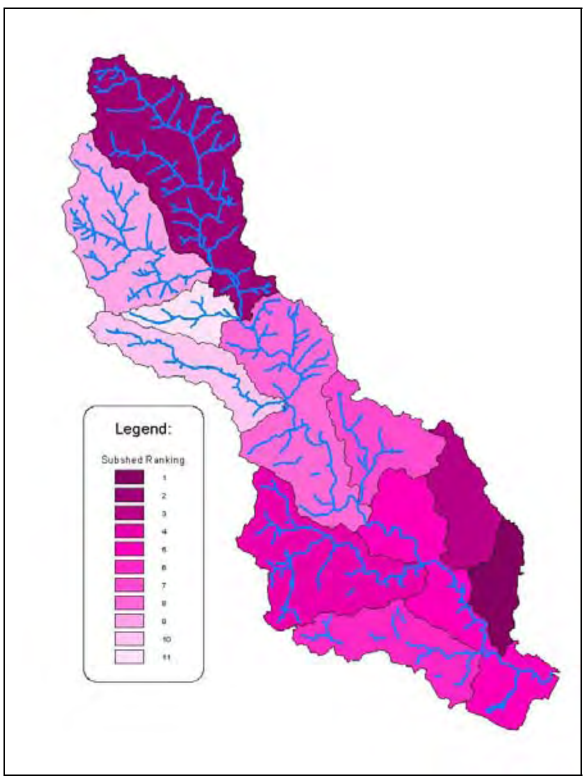


Figure E.4: Overall pollutant loading (darkest subwatersheds have highest pollutant loading)

Table E.5: Annual pollutant loadings by subwatershed

Subshed	Total Suspended Solids			Total Kjeldahl Nitrogen		
	Existing (lb/ac/yr)	Ultimate (lb/ac/yr)	% Increase	Existing (lb/ac/yr)	Ultimate (lb/ac/yr)	% Increase
Upper Gwynns Falls	51.15	54.79	7.1%	1.95	2.02	3.3%
Red Run	44.07	46.52	5.5%	1.58	1.78	12.7%
Horsehead Branch	37.26	38.05	2.1%	1.30	1.23	-5.7%
Scotts Level Run	43.76	45.89	4.9%	1.36	1.40	2.8%
Middle Gwynns Falls	50.93	52.51	3.1%	1.54	1.52	-1.9%
Powder Mill Run	46.06	46.97	2.0%	1.90	1.97	3.7%
Dead Run	46.95	44.25	-5.8%	2.07	2.14	3.0%
Gwynns Run North	49.33	49.32	0.0%	1.89	1.89	0.0%
Gwynns Run South	49.97	49.97	0.0%	2.18	2.18	0.0%
Maidens Choice	57.12	55.98	-2.0%	1.99	1.98	-0.6%
Lower Gwynns Falls	51.10	50.45	-1.3%	1.97	1.97	0.1%

Table E.6: Annual pollutant loadings by subwatershed

Subshed	Nitrate / Nitrite			Total Phosphorus		
	Existing (lb/ac/yr)	Ultimate (lb/ac/yr)	% Increase	Existing (lb/ac/yr)	Ultimate (lb/ac/yr)	% Increase
Upper Gwynns Falls	3.79	3.70	-2.2%	0.28	0.28	0.1%
Red Run	3.33	3.11	-6.9%	0.23	0.24	4.1%
Horsehead Branch	2.92	2.57	-11.8%	0.20	0.19	-4.9%
Scotts Level Run	3.01	3.04	1.0%	0.22	0.24	5.5%
Middle Gwynns Falls	3.19	3.20	0.4%	0.24	0.25	3.9%
Powder Mill Run	3.02	3.03	0.2%	0.26	0.26	2.3%
Dead Run	2.73	2.74	0.2%	0.25	0.26	4.5%
Gwynns Run North	3.01	3.01	0.0%	0.26	0.26	0.0%
Gwynns Run South	2.94	2.94	0.0%	0.27	0.27	0.0%
Maidens Choice	3.09	3.09	0.0%	0.26	0.26	0.9%
Lower Gwynns Falls	3.19	3.19	-0.1%	0.26	0.26	0.3%

Table E.7: Annual pollutant loadings by subwatershed

Subshed	Ortho Phosphorus			Biochemical Oxygen Demand		
	Existing (lb/ac/yr)	Ultimate (lb/ac/yr)	% Increase	Existing (lb/ac/yr)	Ultimate (lb/ac/yr)	% Increase
Upper Gwynns Falls	0.14	0.14	5.0%	9.38	8.74	-6.8%
Red Run	0.11	0.13	17.4%	8.06	8.18	1.6%
Horsehead Branch	0.08	0.09	9.7%	6.24	4.91	-21.3%
Scotts Level Run	0.10	0.10	6.7%	5.41	5.41	0.1%
Middle Gwynns Falls	0.11	0.11	5.5%	6.23	5.86	-5.9%
Powder Mill Run	0.13	0.13	4.2%	8.23	8.55	3.9%
Dead Run	0.13	0.14	6.8%	9.38	9.87	5.1%
Gwynns Run North	0.14	0.14	0.0%	8.14	8.14	0.0%
Gwynns Run South	0.16	0.16	0.0%	9.81	9.82	0.1%
Maidens Choice	0.13	0.13	1.8%	8.02	8.06	0.5%
Lower Gwynns Falls	0.13	0.13	0.7%	8.62	8.67	0.5%

Table E.8: Annual pollutant loadings by subwatershed

Subshed	Chemical Oxygen Demand			Fecal Coliform		
	Existing (lb/ac/yr)	Ultimate (lb/ac/yr)	% Increase	Existing (MPN/ac/yr)	Ultimate (MPN/ac/yr)	% Increase
Upper Gwynns Falls	88.02	91.06	3.4%	7.17E+04	6.73E+04	-6.2%
Red Run	71.18	81.16	14.0%	7.87E+04	7.62E+04	-3.2%
Horsehead Branch	58.65	56.42	-3.8%	5.22E+04	5.20E+04	-0.4%
Scotts Level Run	61.07	64.91	6.3%	6.12E+04	6.55E+04	7.1%
Middle Gwynns Falls	66.10	68.68	3.9%	6.56E+04	6.85E+04	4.5%
Powder Mill Run	84.10	88.05	4.7%	6.58E+04	6.74E+04	2.5%
Dead Run	90.06	96.08	6.7%	7.79E+04	8.11E+04	4.0%
Gwynns Run North	86.24	86.24	0.0%	7.54E+04	7.54E+04	0.0%
Gwynns Run South	100.62	100.62	0.0%	9.14E+04	9.14E+04	0.0%
Maidens Choice	84.14	85.31	1.4%	7.30E+04	7.47E+04	2.4%
Lower Gwynns Falls	84.36	84.93	0.7%	7.45E+04	7.53E+04	1.1%

Table E.9: Annual pollutant loadings by subwatershed

Subshed	Cadmium			Copper		
	Existing (lb/ac/yr)	Ultimate (lb/ac/yr)	% Increase	Existing (lb/ac/yr)	Ultimate (lb/ac/yr)	% Increase
Upper Gwynns Falls	0.008	0.010	26.5%	0.052	0.064	22.1%
Red Run	0.004	0.007	72.5%	0.036	0.059	63.3%
Horsehead Branch	0.005	0.007	55.6%	0.027	0.042	58.5%
Scotts Level Run	0.008	0.009	12.5%	0.041	0.050	20.9%
Middle Gwynns Falls	0.008	0.009	14.9%	0.043	0.052	21.0%
Powder Mill Run	0.010	0.011	4.4%	0.060	0.065	8.9%
Dead Run	0.010	0.011	11.5%	0.067	0.077	15.0%
Gwynns Run North	0.010	0.010	0.0%	0.072	0.072	-0.1%
Gwynns Run South	0.011	0.011	0.0%	0.092	0.092	0.0%
Maidens Choice	0.009	0.010	3.2%	0.066	0.070	5.3%
Lower Gwynns Falls	0.009	0.009	1.0%	0.063	0.064	1.5%

Table E.10: Annual pollutant loadings by subwatershed

Subshed	Zinc			Lead		
	Existing (lb/ac/yr)	Ultimate (lb/ac/yr)	% Increase	Existing (lb/ac/yr)	Ultimate (lb/ac/yr)	% Increase
Upper Gwynns Falls	0.079	0.089	12.2%	0.004	0.005	10.3%
Red Run	0.056	0.074	32.9%	0.003	0.004	32.0%
Horsehead Branch	0.046	0.057	25.3%	0.002	0.003	27.3%
Scotts Level Run	0.064	0.067	5.4%	0.003	0.003	3.2%
Middle Gwynns Falls	0.068	0.070	2.9%	0.003	0.003	-0.8%
Powder Mill Run	0.085	0.088	3.8%	0.004	0.005	4.2%
Dead Run	0.087	0.092	5.8%	0.005	0.005	5.6%
Gwynns Run North	0.084	0.084	0.0%	0.004	0.004	0.0%
Gwynns Run South	0.094	0.094	0.0%	0.005	0.005	0.0%
Maidens Choice	0.085	0.085	0.7%	0.004	0.004	0.6%
Lower Gwynns Falls	0.084	0.084	0.5%	0.005	0.005	0.5%

Table E.11: Annual pollutant loadings by subwatershed

Subshed	Total Nitrogen		
	Existing (lb/ac/yr)	Ultimate (lb/ac/yr)	% Increase
Upper Gwynns Falls	5.74	5.72	-0.3%
Red Run	4.91	4.88	-0.6%
Horsehead Branch	4.22	3.80	-9.9%
Scotts Level Run	4.37	4.44	1.6%
Middle Gwynns Falls	4.73	4.72	-0.3%
Powder Mill Run	4.92	4.99	1.5%
Dead Run	4.81	4.88	1.4%
Gwynns Run North	4.90	4.90	0.0%
Gwynns Run South	5.12	5.12	0.0%
Maidens Choice	5.08	5.07	-0.3%
Lower Gwynns Falls	5.16	5.16	0.0%

Table E.12 summarizes the top three subwatersheds with the highest annual pollutant load. The subwatershed with the lowest pollutant load is highlighted in yellow. As expected, the predominantly urban watersheds produced the highest loading per category. Gwynns Run South was ranked the highest pollutant load for 9 of the 12 constituents. Gwynns Run South is highly urbanized and almost entirely storm drain controlled. Upper Gwynns Falls ranked high in three categories including nitrate/nitrites (Rank #1), total phosphorus (Rank #1) and orthophosphorus (Rank #2). Red Run ranked high in fecal coliforms (Rank #2) and nitrate/nitrites (Rank #2). In contrast, Horsehead Branch was the cleanest subwatershed, ranking the lowest out of all subwatersheds for 9 of the 12 constituents. Over 47% of the existing watershed was comprised of agricultural or forested lands.

Although Gwynns Run South's land use composition did not change between the existing and ultimate development land use conditions, it did remain on the top of seven of the pollutant lists. Dead Run's ultimate development land use surpassed Gwynns Run South for biological oxygen demand (BOD) and Zinc (Zn). Horsehead Branch still remained the cleanest subwatershed for the ultimate condition land use, however, for the ultimate development conditions it was the lowest ranked subwatershed for all 12 constituents.

Table E.12: Top three pollutant loads by subshed for each constitutient, existing conditions

TSS	TKN	NO_3N	TP
1. Maidens Choice 2. Upper Gwynns 3. Lower Gywnns	1. Gwynns Run S 2. Dead Run 3. Lower Gwynns 3. Upper Gwynns 3. Maidens Choice	1. Upper Gwynns 2. Red Run 3. Lower Gwynns 3. Middle Gwynns	1. Upper Gwynns 2. Gwynns Run S 3. Lower Gwynns 3. Gwynns Run N 3. Maidens Choice 3. Powder Mill
Min = Horsehead	Min = Horsehead	Min = Dead Run	Min = Horsehead
OP	**BOD**	**COD**	**FCOL**
1. Gwynns Run S 2. Upper Gwynns 3. Gywnns Run N	1. Gwynns Run S 2. Dead Run 3. Upper Gwynns	1. Gwynns Run S 2. Dead Run 3. Upper Gwynns	1. Gwynns Run S 2. Red Run 3. Dead Run
Min = Horsehead	Min = Scotts Level	Min = Horsehead	Min = Horsehead
CD	**CU**	**ZN**	**PB**
1. Gwynns Run S 2. Gwynns Run N 2. Powder Mill	1. Gwynns Run S 2. Gwynns Run N 3. Dead Run	1. Gwynns Run S 2. Dead Run 3. Maidens Choice 3. Powder Mill	1. Gwynns Run S 2. Dead Run 3. Lower Gwynns
Min = Red Run	Min = Horsehead	Min = Horsehead	Min = Horsehead

Sewage Analysis

Sewage discharge into the Gwynns Falls is a major concern. The discharges provide safety risks to the public and wildlife. Many sections of the stream, particularly within Baltimore City are posted due to contaminated streamflow. Sewage in the stream system is easily identified by the general public.

Continuous sewer leaks are common occurrences in Baltimore City. The City's baseflow monitoring data and the stream assessment confirms this. The pollutant loading for Baltimore City's baseflow monitoring is much greater than for similar land uses in Baltimore County. Baltimore City has requested PB to quantify the loads that come from continuous sewer leaks and the reduction of loads if these leaks are repaired.

The original SWMM model for the existing and ultimate development comparison assumed that chronic sewage leaks would be repaired in the future. In order to determine the impact of repairing the City's chronic sewage leaks, the SWMM model was rerun and baseflow loads were adjusted to account for the high sewage discharges that are occurring in Baltimore City. Because SWMM can only model a single baseflow load, an area weighted average value between Baltimore County and City was used to determine the initial baseflow contaminant loading. This process will overestimate the pollutant loadings due to sewage in the County and underestimate the pollutant loads due to sewage in the City. By looking at the impacts of reducing the continuous sewage leaks in the overall watershed, these variances will be minimized. Figure E.5 shows examples of continuous sewage leaks found in the Gwynns Falls. These locations were reported to the City and County for repair. Table E.13 summarizes the reduction of pollutant loadings due to the repair of chronic sewer leaks.

Figure E.5: Sewage leaks found within the Gwynns Falls

Table E.13: Reduction in Pollutant Loading by Contaminant due to the repair of chronic sewage leaks.

Location	TKN	TP	BOD	COD	Fecal Coliform
Watershed Outlet	11%	8%	8%	9%	52%

STREAM STABILITY ASSESSMENT

The goal of the stream stability assessment was to document the geomorphic and riparian vegetative condition of the streams within the watershed and identify sites for possible protection, enhancement and restoration in order to improve the overall health and quality of the Gwynns Falls Watershed system. The study was divided into two primary components: Corps Reach Assessment and Cruised Reach Assessment.

Corps Reach Assessment

The U.S. Army Corps of Engineers, under a separate study, had assessment 41 miles of stream in Baltimore County. Baltimore County's Department of Environmental Protection had performed a quality review of the data and requested that PB walk these segments of stream verifying the existing data for use in the current watershed analysis. In addition, PB looked for restoration opportunities and photodocumented each of the stream reaches. Items examined by PB include:

- Rosgen Classification
- Habitat
- Bank Erosion
- Bed Stability
- Bank Stability

Cruised Reach Assessment

Cruised reach assessments were conducted on over 70 miles of Baltimore County and 22 miles of Baltimore City first, second and third order stream reaches that were not previously assessed by the U.S. Army Corps of Engineers. Cruising is defined as a team of two stream surveyors walking the entire length of each reach and performing rapid field assessments. Measurements using a stretched tape and surveyors rod were performed to assess bankfull width and depth. Detailed cross sections were not taken at each reach. A representative riffle section of the reach was selected for assessment. This section was photographed for future reference. The rapid assessment collected four major categories of stream information:

- Channel Morphology
- Channel Disturbances
- Channel Habitat
- Restoration Opportunities

Stream Stability Results

Five stream characterization categories were used to describe the streams within the Gwynns Falls: flow regime, entrenchment, channel slope, Rosgen stream classification and altered stream status.

Flow Regime: Streamflow exhibits a strong influence on channel morphology, aquatic habitat and riparian vegetation. Different restoration approaches are used on ephemeral and perennial channels.

Entrenchment describes the relationship of a river to its valley and landform features. The entrenchment ratio describes the vertical containment of a stream. It has been defined by Rosgen to be the ratio of the width of the floodprone area to the surface width of the bankfull channel. The entrenchment ratio was computed for each stream reach and then divided into three categories: slight entrenchment, moderate entrenchment and entrenched. Many urban streams do not have adequate access to their floodplain and are entrenched or vertically contained. Providing adequate floodplain access reduces shear stress, channel velocities and ultimately reduces the amount of bank erosion and channel degradation within a stream reach.

Channel Slope: The water surface slope is a major determinant of river channel morphology and of its related sediment, hydraulic and biological function. An average channel slope range was estimated for each stream reach. The channel slope is one of the characteristics that must be considered when assessing a stream's restoration potential.

Rosgen Stream Classification: One of the most widely used stream classification systems used by engineers and environmental specialists was developed by David Rosgen (1996). The classification system allows users to describe a stream's characteristics based on geomorphic measurements. The measurements are used to categorize the stream type. The cruised reaches were visually assessed and classified using Rosgen's methodology. The entrenchment ratio, width to depth ratio and sinuosity were used in stream type selection. The majority of the watershed's streams can be classified as B, E or G stream types. Figure E.6 shows the distribution of Rosgen stream types throughout the watershed.

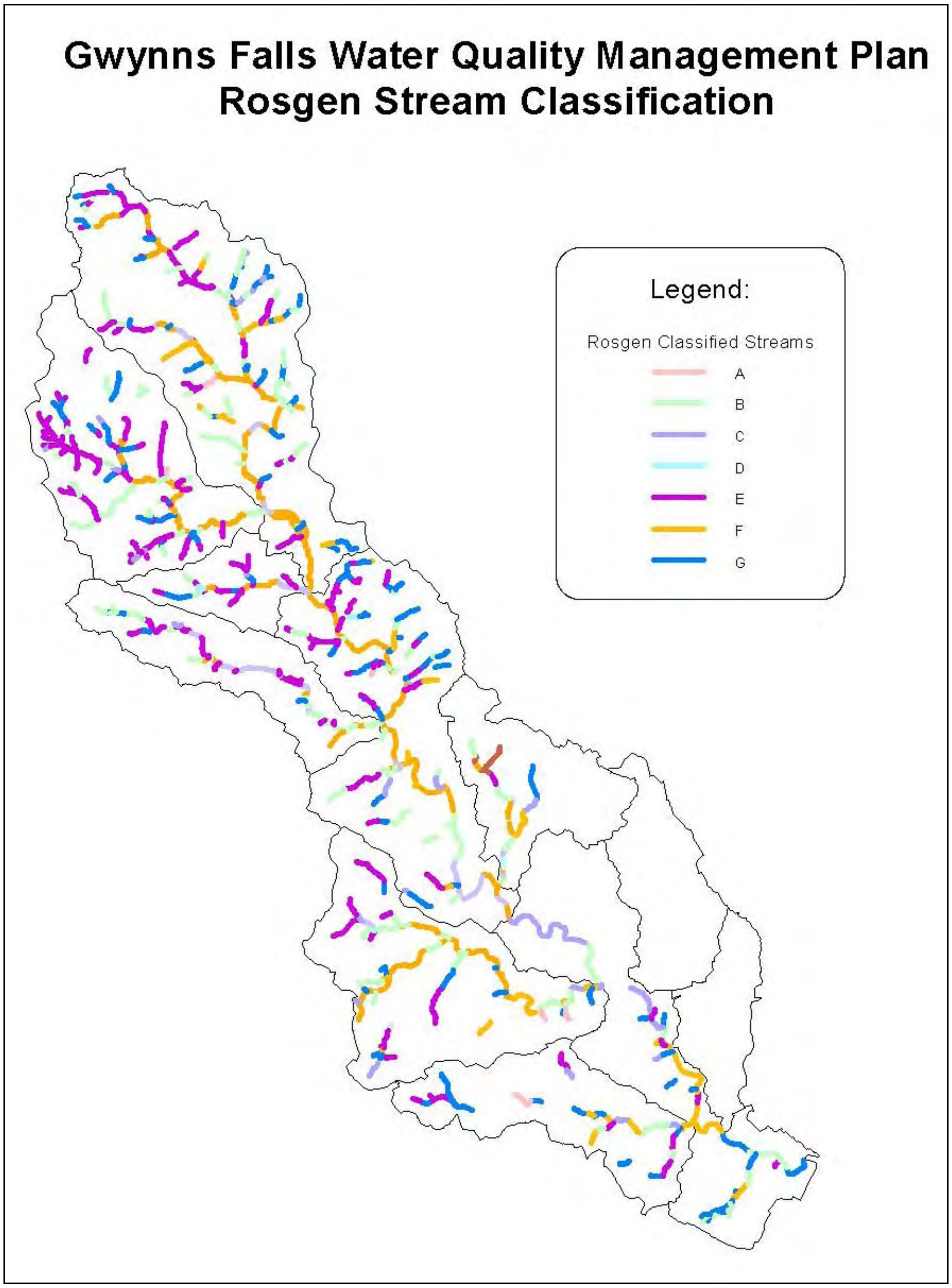


Figure E.6: Rosgen stream classification

Altered Channels: Due to the large amount of urbanization that has already occurred within the Gwynns Falls watershed, many stream channels have been altered from their natural state.

Table E.14 shows a summary of the stream assessment characteristics of the cruised reaches of the Gwynns Falls watershed.

Table E.14: Stream assessment summary

Flow Regime	Percent Cruised Reaches in Gwynns Falls Watershed
Ephemeral, flow only in response to precipitation	11%
Intermittent, flow exists seasonally or sporadically	14%
Perennial, flow exists year round	75%
Entrenchment	
Slight to No Entrenchment > 2.2	39%
Moderate Entrenchment (1.41 - 2.2)	33%
Entrenched (1.0 - 1.4)	28%
Channel Slope	
Low gradient, less than 2% slope	53%
Moderate gradient, 2 to 4% slope	43%
Steep gradient, greater than 4% slope	4%
Rosgen Stream Classification	
A - steep, entrenched, cascading streams	1%
B - moderately entrenched, riffle dominanted channel	24%
C - low gradient, meandering stream	7%
D - braided channel	1%
E - low gradient, meandering, very efficient & stable	32%
F - entrenched, meandering, overwidened channel	10%
G - entrenched "gully" type streams	25%
Altered Stream Channels	
Straighted	22%
Manmade lining such as concrete or gabion riprap	7%
Relocated channel (due to farming, buildings, roads, etc.)	6%
Piped	13%

Stream Summary

The results of the cruised reach assessment were combined with the data collected by the previous Army Corps of Engineers study. The current analysis verified and updated the Corps data collected within Baltimore County. Detailed stream assessment results appear in Chapter 3 for the overall watershed and are summarized below. Chapter 6 details the stream assessment results for each individual subwatershed.

Typical stream channel characteristics within the Gwynns Falls Watershed:

- Perennial
- Bankfull width is typically between 5-15 feet
- 25% of the streams are classified as Rosgen G stream types (gullies) and an additional 10% more Rosgen F stream types which are overwidened and entrenched
- Over 30% of the stream channel banks are classified as unstable (Figure E.7)
- More than 50% of the streams are moderately or severely entrenched
- Almost half of the stream reaches have been altered due to urbanization

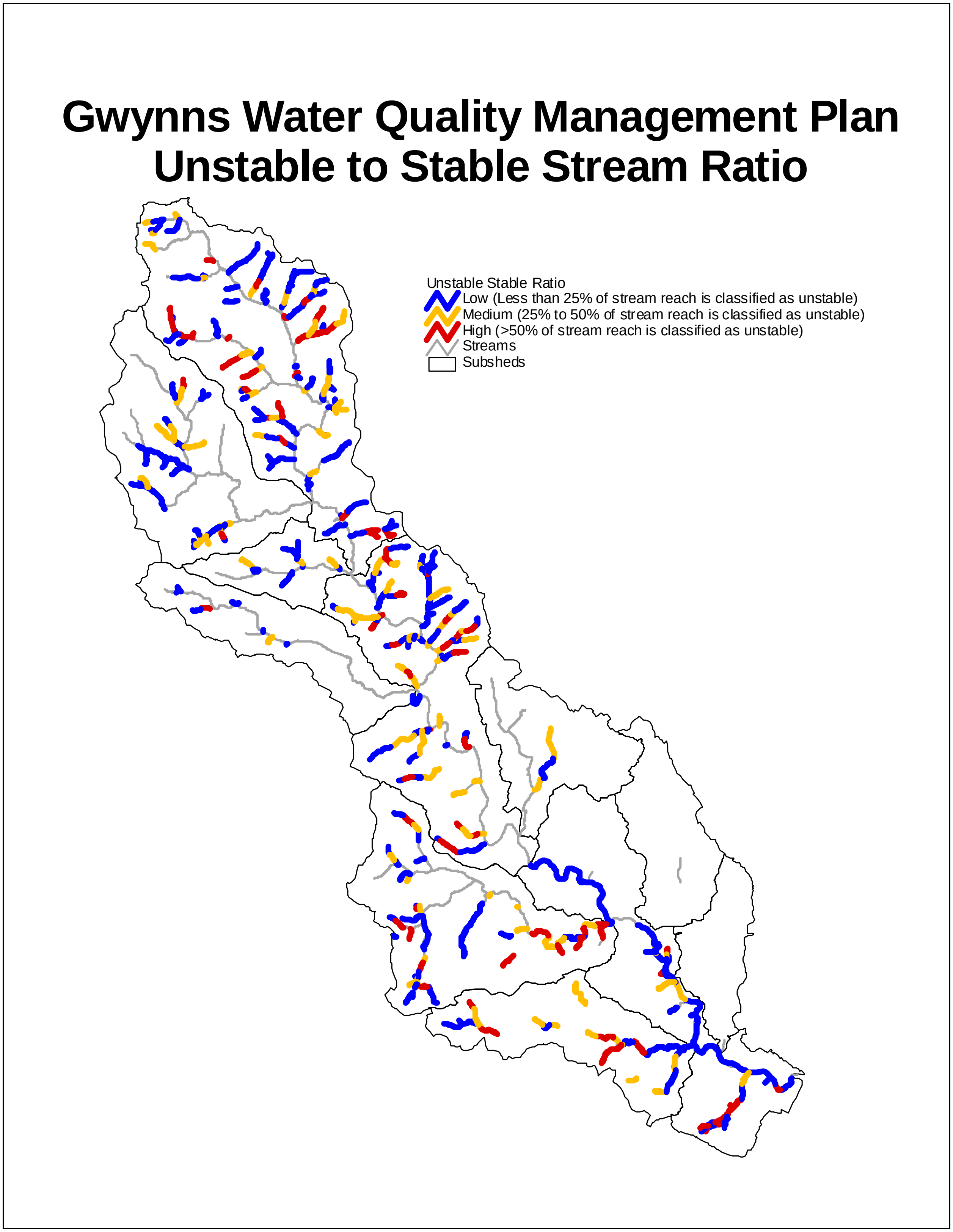


Figure E.7: Unstable streams (Red stream reaches have 50% or more unstable banks)

Typical stream buffer characteristics:

- Over half of the stream reaches have greater than 50% canopy cover
- 77% of the riparian buffers consist of deciduous overstory with brush understory
- Over half of the streams have greater than 50 feet of riparian buffer width on each side of the stream channel

FOREST ASSESSMENT

A forest patch assessment was conducted as part of the Gwynn's Falls Watershed Management Plan Study to investigate potential reforestation/conservation opportunities. Forested areas in the upland areas provides habitat and natural filtration of stormwater. Forested buffers improve the stability of the stream channel in addition to providing necessary habitat and connectivity. The primary goal of the GIS studies were to target forest parcels in low order tributaries with the greatest potential for restoration, enhancement and conservation.

17% of the Gwynns Falls is currently forested. Figure E.8 shows the areas of forested lands remaining within the Gwynns.

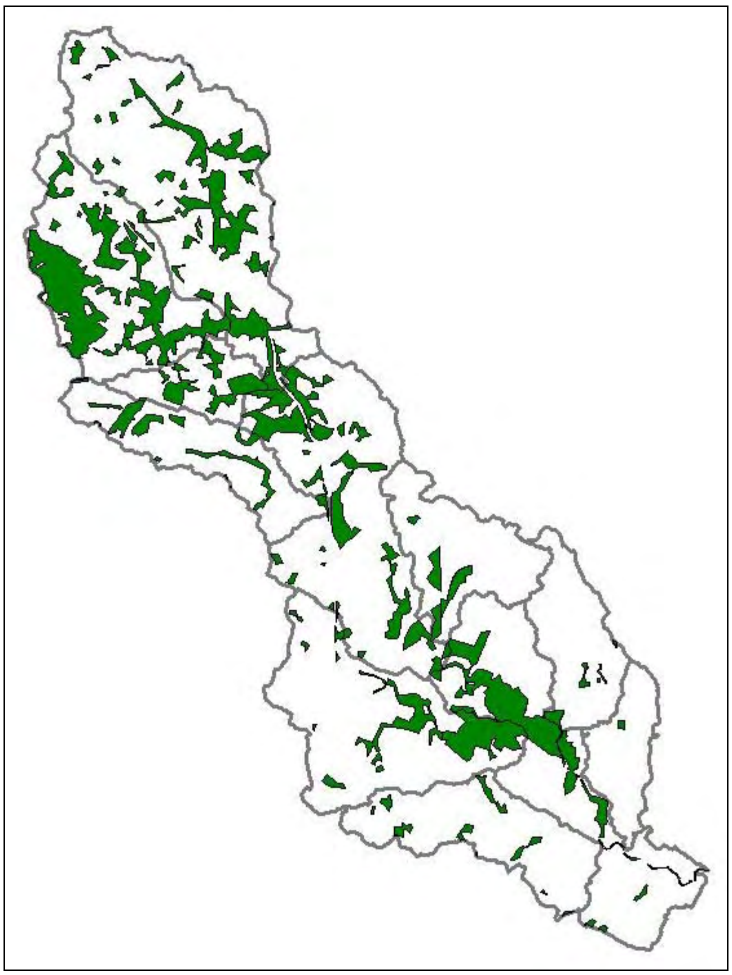


Figure E.8: Forest cover in the Gwynns Falls watershed

Baltimore County Rapid Field Assessment

29 small forested patches on primarily unforested, low order tributaries were assessed using Baltimore County's "Level IV" rapid assessment protocol. The patches ranged in size from 0.5 acres to 160 acres with an average patch size of 20.6 acres. The assessment provides an indication of forest patch quality and habitat suitability based on easily observed physical characteristics. Additionally, the assessment provides verification of the location and extent of stream and forest resources, as well as verification of adjacent land uses.

Baltimore City Forest Assessment

Five forest patch assessments were performed within Baltimore City using the same protocol as for those in the County. At Baltimore City DPW's request, investigators also documented riparian forest gaps, identified opportunities to divert runoff into forest areas, and recommended materials and supplies for reforestation of targeted patches.

Results

Table E.15 shows the recommended forest enhancement sites in Baltimore County. Dead Run and Middle Gwynns have the three highest scoring forest patches.

Table E.15: Baltimore County forest patch assessment results

FOREST PATCH ID	SCORE	SUB-WATERSHED	ACRES	JURISDICTION
168-23	499	DEAD RUN	7.1	COUNTY
72-178	485	MID GWYNNS	32.9	COUNTY
72-147	469	MID GWYNNS	113.8	COUNTY
72-80	457	UPPER GWYNNS	20.9	COUNTY
72-129	455	MID GWYNNS	4.2	COUNTY
168-29	451	DEAD RUN	2.6	COUNTY
72-10	451	UPPER GWYNNS	10.0	COUNTY
168-35	448	DEAD RUN	18.2	COUNTY
72-135	433	MID GWYNNS	1.1	COUNTY
72-49	433	UPPER GWYNNS	17.3	COUNTY
72-74	425	UPPER GWYNNS	160.2	COUNTY
72-11	420	UPPER GWYNNS	5.9	COUNTY
72-83	420	UPPER GWYNNS	3.9	COUNTY
168-11	419	DEAD RUN	2.5	COUNTY
72-187	417	MID GWYNNS	2.5	COUNTY
72-29	416	UPPER GWYNNS	7.1	COUNTY
72-48	412	UPPER GWYNNS	0.5	COUNTY
72-89	388	UPPER GWYNNS	67.1	COUNTY
72-62	383	UPPER GWYNNS	7.6	COUNTY
72-127	372	MID GWYNNS	7.3	COUNTY
86-54	371	RED RUN	1.1	COUNTY
72-45	348	UPPER GWYNNS	2.8	COUNTY
72-130	313	MID GWYNNS	2.2	COUNTY
72-78	276	UPPER GWYNNS	7.9	COUNTY
168-30	252	DEAD RUN	2.0	COUNTY
161-4	192	MAIDENS CHOICE	1.5	COUNTY
72-141	150	MID GWYNNS	64.7	COUNTY
86-24	0	RED RUN	10.7	COUNTY
86-29	0	RED RUN	11.4	COUNTY

Table E.16 shows the recommended forest enhancement sites in Baltimore City. Maidens Choice and the Lower Gwynns Falls are the highest ranking City parcels. The Lower Gwynns sites have additional enhancement opportunities to provide water quality treatment by instituting curb cuts or removing the curb in that area completely. Plantings near the southwestern end of patch 72-220 would help the woody plant succession that is beginning in this area.

Table E.16: Baltimore City forest patch assessment results

FOREST PATCH ID	SCORE	SUB-WATERSHED	ACRES	JURISDICTION
161-30	482	MAIDENS CHOICE	18.0	CITY
161-15	417	MAIDENS CHOICE	33.4	CITY
72-220	385	LOWER GWYNNS	6.9	CITY
72-195	384	LOWER GWYNNS	39.0	CITY
161-29	368	MAIDENS CHOICE	14.1	CITY

Each of the potential sites will require detailed investigation to determine the owner of the property and whether the current owner is willing to sell their parcels or allow conservation easements to be placed on the property. Property acquisition costs will determine the feasibility of enhancing these forested sections.

STORMWATER MANGEMENT ASSESSMENT

Much of the Gwynns Falls Watershed was developed prior to formal stormwater management policies, particularly those areas in Baltimore City and inside the Baltimore Beltway (I-695) in Baltimore County. Among existing facilities, the majority are designed for quantity control without water quality improvement features.

The goals of the stormwater management assessment were to:

1) Identify select existing stormwater management facilities that have the potential for conversion and water quality enhancement
2) Identify structural deficiencies and downstream channel instabilities in the selected existing stormwater management facilities
3) Identify opportunities for BMP creation at existing storm drain outfalls
4) Identify structural deficiencies at select storm drain outfalls.

Stormwater Management Facilities

48 stormwater management (SWM) facilities were selected by Baltimore City and Baltimore County for evaluation. Figure E.9 shows typical SWM facilities.

Figure E.9: Typical stormwater management facilities within the Gwynns Falls

Storm Drain Outfalls

Urban storm drain outfalls are often sources of channel instabilities and water quality problems. 82 storm drain outfalls in the Gwynns Falls watershed were selected for evaluation to improve the stream stability in the area downstream of the outfall and the water quality in the main stream. The outfalls were selected based on the following criteria:

- 36" diameter or larger pipe
- Must have at least 50 feet between the outfall and the stream channel

Figure E.10 shows typical outfalls in need of retrofit.

Figure E.10: Stormdrain outfalls in need of structural repair, energy dissipation and stream stabilization.

Results

Stormwater management (SWM) facilities are important because they slow down and treat surface runoff before it enters the stream network. Urbanization increases the amount of impervious area and increases the runoff from storm events. This was shown in the frequency analysis conducted as part of the water quality modeling. Converting standard detention SWM facilities to extended detention facilities provides water quality treatment as well as reducing the peak discharges that enter the stream channel. Lower discharges and velocities reduce stream power and consequently channel erosion.

Thirteen sites were rated as high priority retrofits within the Gwynns Falls watershed. Three of these sites were in Baltimore County and the remainder in Baltimore City. Eleven storm drains (9 City and 2 County) and two stormwater facility retrofits (1 City and 1 County) were rated as high. Refer to Chapter 7 for detailed project recommendations. Chapter 6 details the results of the remaining sites evaluated and the recommendations for SWM facility and outfall retrofits for Baltimore City and County. Figure E.11 shows the locations of the proposed outfall and facility retrofits. Typical stormwater management facility retrofits include conversion to extended detention, addition of forebays or other pretreatment options and the creation of shallow marshes. Typical storm drain outfall retrofits include energy dissipation devices, creation of shallow floodplain marshes, creation of bioretention facilities, channel daylighting and downstream stabilization.

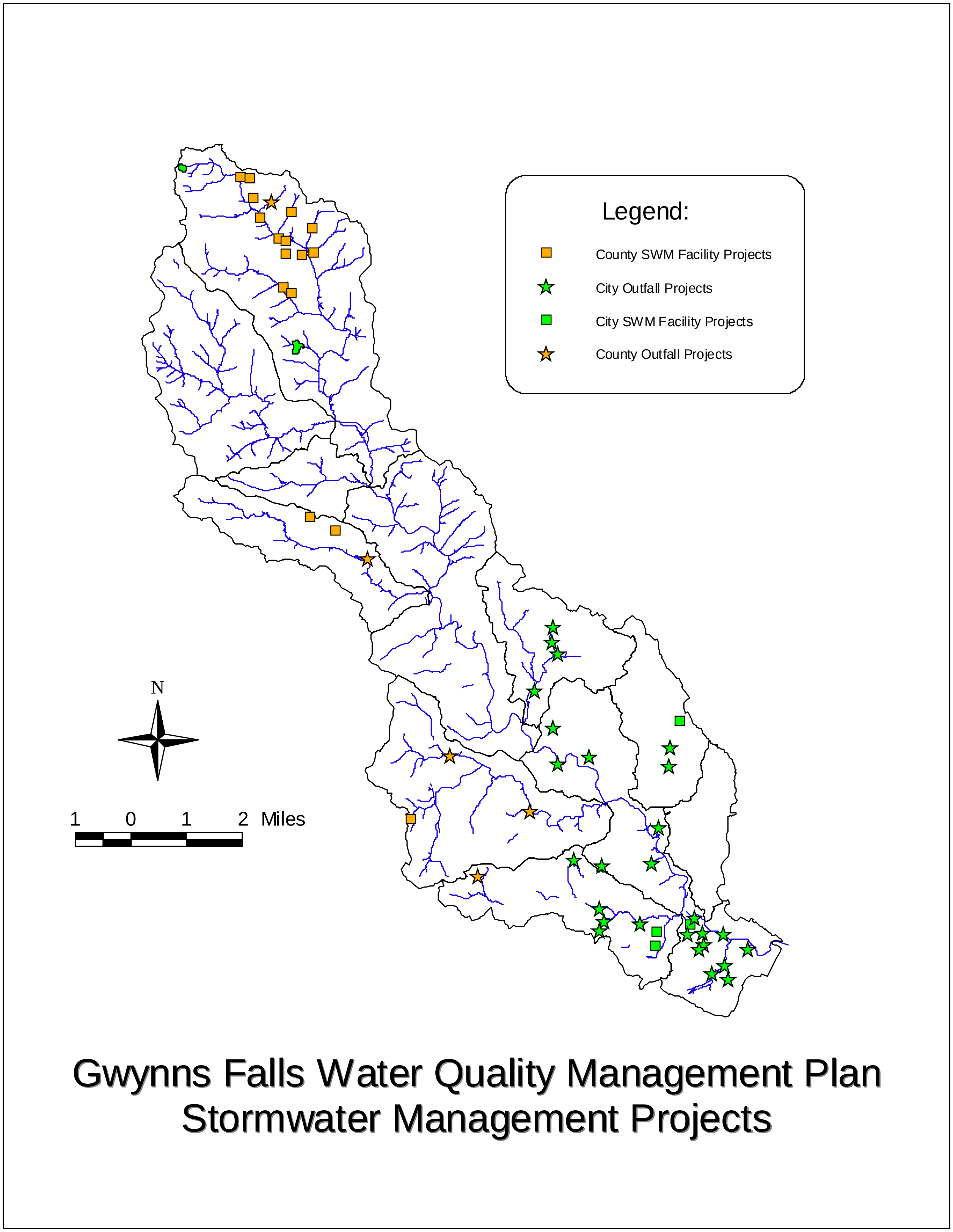


Figure E.11: Proposed stormwater management facility and outfall projects

RESTORATION GOALS & MANAGEMENT MEASURES

The Gwynns Falls subwatersheds were divided into four major groups based on the amount of development (imperviousness), stream channel stability and stormwater management potential, in each subwatershed. These grouping were used to define the subwatershed goals and objectives. Table E.17 shows the breakdown among the watersheds.

Table E.17: Classification of Gwynns Falls Subwatersheds

Group 1 – Sensitive (% Impervious)	Group 2 – Impacted (% Impervious)	Group 3 –Urbanized (% Impervious)	Group 4 – Highly Urbanized (% Impervious)
Red Run (18%)	Upper Gwynns Falls (26%)	Powder Mill (34%)	Gwynns Run North (36%)
Horsehead Branch (15%)	Scotts Level (24%)	Dead Run (36%)	Gwynns Run South (44%)
	Middle Gwynns Falls (22%)	Maidens Choice (33%)	
		Lower Gwynns Falls (32%)	

Group 1 – Sensitive Subwatersheds

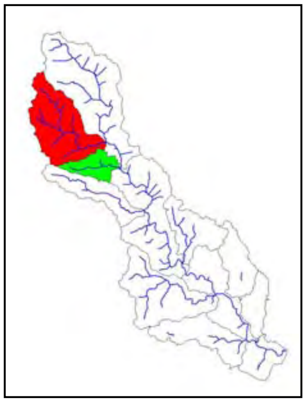
The Sensitive subwatersheds are the least developed subwatersheds within the Gwynns Falls. Both Red Run and Horsehead Branch have less than 20 percent impervious area. The majority of the development in these watersheds has taken place with some stormwater management in place. More than 25% of existing land use of these subwatersheds are comprised of forested areas.

The current land use zoning was used to evaluate the impacts of the ultimate development condition on each of the subwatersheds. Both subwatersheds are expected to experience significant increases in impervious area when comparing existing conditions versus ultimate development. In fact, these subwatersheds experience the largest increase in imperviousness out of any of the Gwynns Falls subwatersheds. Red Run's imperviousness will increase from 18% to 31% while Horsehead Branch's imperviousness will increase from 15% to 26%. These subwatersheds are just beginning to see the impacts of development on their stream networks. The future of these stream networks will depend largely on future land use conditions.

Both of the subwatersheds in this category have a large percentage of existing forested land. Protecting forested buffers will be critical in maintaining the quality of the streams within each subwatersheds.

Consequently, the primary goals for these two subwatersheds will focus on land management measures to protect the quality of the stream network during this future development period.

Some existing streams in this subwatershed are trout streams and high water quality must be maintained. The primary goals for the Group 1, Sensitive subwatersheds are:



- Land management strategies
  - Focus on stream buffer preservation
  - Forest preservation and enhancement
  - Continue to pursue opportunities to provide water quality treatment
  - Apply current stormwater management regulations to the highest standard possible. Waivers and variances should not be considered without evaluating the cumulative effect of the waiver/variance on the watershed.

Figure E.12: Sensitive subwatersheds

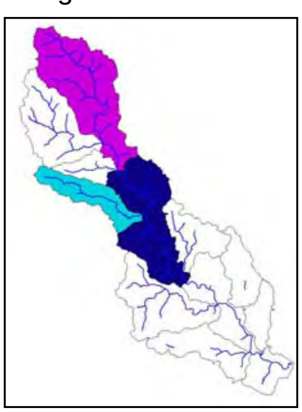
Land management strategies are critical to maintaining the health of Group 1 streams. Future zoning and land use changes will have a significant effect on the future stability and habitat of the streams within these subwatersheds. Figure E.12 shows the location of the sensitive subwatersheds within the Gwynns Falls. Red Run is shaded red and Horsehead Branch is shaded green.

Group 2 – Impacted Subwatersheds

The Impacted subwatersheds are already feeling the effects of urbanization and are between 22 and 26% imperviousness. The streams are affected by urbanization but have the potential for recovery with habitat oriented stream improvements.

Large portions of the subwatersheds were developed with stormwater management, however, the majority of these occurred before water quality requirements. All stormwater management facilities should be evaluated for potential expansion and/or conversion to extended detention. Baltimore County DEPRM selected over 23 stormwater management ponds within these three subwatersheds for evaluation.

Many of the streams within these subwatersheds have nearly vertical stream banks and poor ecological habitat. Because a significant amount of development has already occurred in these subwatersheds, the focus switches from land management (as in Group 1 – Sensitive streams) to retrofit opportunities. Retrofit opportunities considered in these watersheds should enhance stream stability and improve the habitat quality of the existing stream network. Figure E.13 shows the impacted subwatersheds. Upper Gwynns Falls is colored purple, Middle Gwynns Falls is navy blue and Scotts Level is turquoise.



The primary goals for the Group 2, Impaired subwatersheds are:

- Stream channel improvements with habitat enhancement focus
- Identify stormwater management retrofit opportunities

Figure E.13: Impacted subwatersheds

- Continue to enforce current stormwater management regulations

Group 3 – Urbanized Subwatersheds

The Urbanized subwatersheds contain between 30 and 36% impervious area and experience significant stream channel instabilities and habitat impairment. Although the percentage of impervious development within these subwatersheds is high, there are a significant number of open stream channels. ***This key difference between the Urbanized subwatersheds and the Highly Urbanized subwatersheds is that the Urbanized subwatersheds still have a significant stream network while the Highly Urbanized subwatersheds are primarily piped.***

Many of the Urbanized subwatersheds were developed prior to mandatory stormwater management regulations, both quantity and quality control. BMP creation and/or expansion are considered high priorities in these subwatersheds.

The high amount of urbanization has caused widespread stream stability issues within these subwatersheds. Land use and space constraints are common problems in the these urbanized areas. Because many of the subwatersheds in this category are completely built out, water quality enhancement efforts should be focused on redevelopment projects. Figure E.19 shows the urbanized subwatersheds. Powder Mill is orange, Dead Run is red, Maidens Choice is blue and the Lower Gwynns Falls is shaded green in Figure E.14.

The primary goals for the Group 3, Urbanized subwatersheds are:

- Design stream channel improvements with a focus on geomorphic adjustment to achieve stream stability
- Identify new opportunities for stormwater management BMPs
- Proactive relocation and/or protection of non-leaking sewer/utility lines and manholes in stream channel
- Seek opportunities for water quality improvement in evaluating redevelopment projects

Figure E.14: Urbanized subwatersheds

Group 4 – Highly Urbanized Subwatersheds

The Highly Urbanized subwatersheds contain 36% or more imperviousness. The primary difference between the Urbanized (Group 3) and Highly Urbanized (Group 4) categories is that Group 3 subwatersheds have a significant amount of open stream channel and that Group 4 subwatersheds have primarily piped channels. Once contaminants enter the stormdrain system, they are transported straight into the mainstem of the Gwynns Falls. Figure E.20 shows the highly urbanized subwatersheds. Gwynns Run North is shown in navy blue and Gwynns Run South is shown in red in Figure E.15.

The primary goals for the Group 4, Highly Urbanized subwatersheds are:

- Focus on prevention and reduction of pollutant loads before they enter the stormdrain system
- Focus on installing *structural* BMP devices at proper locations in the storm drain systems
- Identification and correction of existing sewage leaks from sewer lines and manholes
- Continue to look for opportunities to create SWM facilities where space is available

Figure E.15: Highly urbanized subwatersheds

WATER QUALITY ENHANCEMENT PROJECTS

Potential projects were identified using the results of the field assessments and the management goals for each subwatershed established above. Because of the complexity of data collected during this study, a two-tiered approach was developed to aid in project identification:

1) Stream based assessment – incorporates the results of the cruised reach and Corps reach assessments
2) Source based assessment – incorporates the results of the stormwater management facility and outfall assessment, Forest assessment and SWMM modeling assessment.

WATER QUALITY RANKING

Ranking is performed for potential restoration and stabilization projects in order to determine recommended City and County actions. A well defined and balanced ranking system allows direct comparison of competing projects. This mitigates for inherent subjectivity.

Five criteria were used to form a ranking of water quality enhancement projects. Details of the criteria are explained below and in Table E.18.

1. Water Quality Benefit – This represents an assessment of a project's benefit to reducing pollutant and sediment loads and improving water quality within the watershed.

2. Habitat enhancement – This criteria looks specifically at improvements to habitat within the watershed and the stream channel itself.

3. Land availability & Construction Access – This category rates the ability for a project to be constructed and includes both land availability and construction access.

4. Public Acceptance and educational opportunities – This category rates the public's willingness to support a project, its benefit to community aesthetics and potential for public education.

5. Reduction of Risk to Public Safety or Infrastructure – This includes the threat of localized flooding, culvert failure and unstable stream banks along improved properties.

Table E.18: Water quality enhancement project ranking scheme

Ranking Category	Numeric Ranking			
	0	1	2	3
1) Water Quality Benefit	None	Low	Moderate	High
2) Habitat Enhancement	None	Low	Moderate	High
3) Land Availability & Construction Access	Private land w/ no access	Private land w/ good access	Public land w/ fair access	Public land w/ good access
4) Public Acceptance & Educational Opportunity	Strong objections & no educational opportunity	Some objections & minimal educational opportunity	Some desire & good educational opportunity	Strong desire & strong educational opportunity
5) Reduction of Risk to Public Safety or Infrastructure	No Impact	Low	Moderate	High

Priority Projects

The priority projects were chosen using the prioritization scheme described above. Projects were broken into three size categories based on total cost for comparison purposes. Projects were broken into three categories:

- Large (Present worth of project is > $300,000)
- Medium ($100,000< Present worth of project<= $300,000)
- Small (Present worth of project <= $100,000)

Projects were ranked in two steps. First, the projects were sorted by project score and then based on the project's annual cost. In order to provide a uniform cost benefit comparison, the project score was divided by the annual project cost (in thousands). The cost benefit analysis did not assign a cost associated with each benefit, however, it allowed for a reasonable cost comparison among proposed projects. When two projects had the same project score and annual cost, they were ranked as a tie.

PROJECT SUMMARY

The data collection and analysis conducted as part of this comprehensive effort have led to the identification of 120 proposed capital projects at a cost of approximately $30 million. Table E.19 summarizes the variety of projects that have been recommended as part of this water quality plan. These projects include over 10 miles of stream restoration, 8 miles of riparian buffer enhancements and 67 stormwater retrofits. The proposed stream restoration and riparian enhancement projects restore 25% of the watersheds most unstable streams. Stabilizing these streams reduces sediment loads within the watershed by approximately 26%. Figure E.16 shows the location of the priority projects throughout the watershed.

Table E.19: Summary of proposed projects within the Gwynns Falls Watershed

Project Type	Number of Proposed Projects
SWM Facility Retrofit	29
SWM Facility Maintenance	1
SWM Storm Drain Outfall Retrofit	37
New BMP Creation	17
Floodplain Wetland Creation	12
Forest Enhancement	4
Riparian Buffer Enhancement	25
Stream Restoration & Stabilization	42
Sediment Reduction due to Proposed Projects	26%
Utility Protection and/or Relocation	1
Debris Removal	3

To estimate the pollutant reductions that would be achieved by constructing these projects, average pollutant loading reductions for BMP and stream restoration projects based on past Baltimore County monitoring projects were used. The values in table E.20 show the pollutant removal efficiency of many types of BMP's. Table E.21 shows the average pollutant reduction in pounds per linear foot of stream restoration.

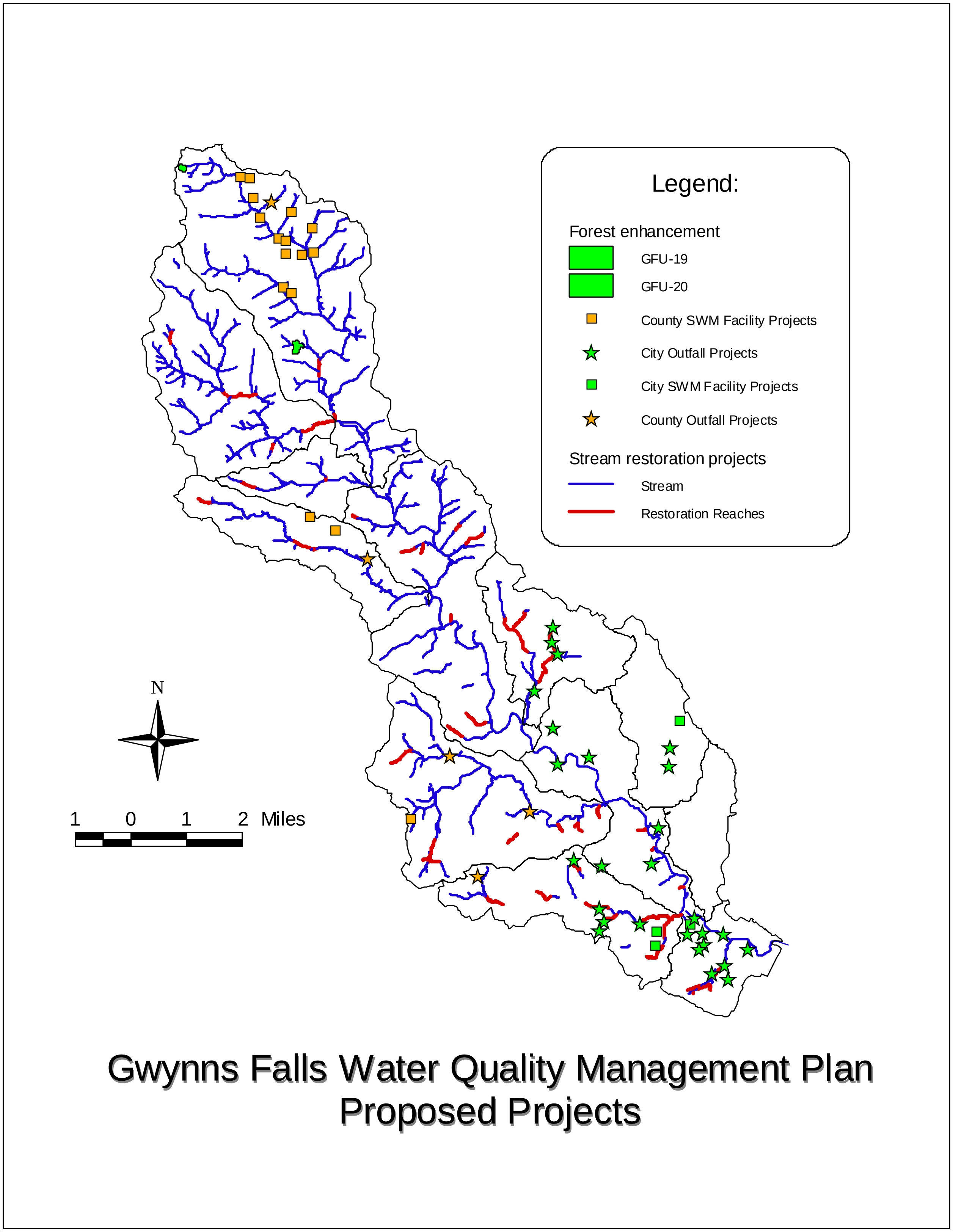


Figure E.16: Proposed Priority Projects

Table E.20: Percent removal efficiency for select BMP's

Facility Type	TSS	TP	TN	Pb	Zn
Detention Facility	10%	10%	5%	43%	26%
Extended Detention Facility	60%	20%	30%	43%	26%
Wet Ponds/Shallow Marshes	80%	50%	50%	73%	51%
Infiltration Practices	90%	70%	50%	71%	80%
Filtration Practices	85%	60%		-	-
Stormceptors	80%	35%	35%	40%	40%

Table E.21: Pollutant reductions for stream restoration projects

Stream Reductions	TSS	TP	TN	Pb	Zn
Lbs of reduction per linear foot	2.55	0.0035	0.024	0.00007	0.0007

Table E.22 shows the estimated percent reduction in annual pollutant loading by subwatershed.

Table E.22: Percent pollutant reduction for proposed projects

Subwatershed	Miles of stream restored	TSS	TP	TN	Pb	Zn
Upper Gwynns Falls	0.8	15%	4%	1%	7%	3%
Red Run	0.6	3%	1%	0%	2%	1%
Horsehead Branch	0.0	10%	3%	1%	19%	5%
Scotts Level	1.5	30%	9%	3%	17%	7%
Middle Gwynns Falls	0.9	10%	3%	1%	9%	3%
Powder Mill	0.9	17%	5%	2%	10%	4%
Gwynns Run North	0.0	1%	1%	0%	6%	1%
Gwynns Run South	0.0	-	-	-	-	-
Dead Run	1.6	19%	6%	3%	37%	8%
Maiden Choice	2.0	20%	7%	3%	21%	6%
Lower Gywnns Falls	1.6	12%	4%	2%	21%	5%
Overall reduction in Gwynns Falls Pollutant Loading		**13.5%**	**4.0%**	**1.5%**	**15.1%**	**4.0%**

Because no stream or stormwater retrofit projects are recommended for Gwynns Run South, there is no pollutant load reduction associated with this watershed. In highly urbanized subwatersheds like Gwynns Run North and South, there is often limited space available for the construction of new stormwater management facilities and other restoration measures. Treating runoff before it enters the storm drain system is critical. One potential treatment option is through the use of structural BMP devices such as Stormceptors®, ,Baysavers® and other filtration devices. These devices capture the “first flush” of flow entering a storm drain and separate the sediments and oils from the discharge. Regular maintenance of these facilities is necessary to keep these systems working efficiently. These structures should also be considered when performing any maintenance in an urbanized area and during redevelopment projects. The reductions that can be obtained from these types of technology are summarized in table E.23. It is assumed that these devices will treat a percentage of the runoff generated from each of the subwatersheds. Since Powder Mill, Dead Run and Maidens Choice have the potential for water quality projects such as stormwater management retrofits and stream restoration, the structural BMP's can be used to supplement the water quality treatment network. In Gwynns Run North and South, the structural BMP's will be the primary source of water quality treatment.

The last line of table E.23 shows the potential reduction in pollutant loading for the entire Gwynns Falls watershed. By installing these devices in the highly urbanized subwatersheds which are typically high pollutant generators, a significant reduction in overall watershed loading can be obtained.

Table E.23: Pollutant loading reductions due to the installation of structural BMPs

Subwatershed	% of watershed runoff treated	Cost per acre of treatment	TSS	TP	TN	Pb	Zn
Powder Mill	15	$7,200	12%	5%	5%	6%	6%
Gwynns Run North	75	$8,200	60%	26%	26%	30%	30%
Gwynns Run South	75	$7,200	60%	26%	26%	30%	30%
Dead Run	20	$8,800	16%	7%	7%	8%	8%
Maiden Choice	15	$6,800	60%	26%	26%	30%	30%
Lower Gywnns Falls	50	$6,400	40%	18%	18%	20%	20%
Overall reduction in Gwynns Falls Pollutant Loading			**18.1%**	**7.7%**	**7.5%**	**9.8%**	**9.6%**

Table E.24 shows the overall pollutant reduction that can be achieved by the construction of the non-structural projects and the installation of the structural BMP devices in the urban areas.

Table E.24: Overall pollutant loading reduction in the Gwynns Falls

Subwatershed	TSS	TP	TN	Pb	Zn
Reduction due to proposed projects	**13.5%**	**4.0%**	**1.5%**	**15.1%**	**4.0%**
Reduction due to structural BMPs	**18.2%**	**7.7%**	**7.4%**	**39.5%**	**37.7%**
Total reduction for the Gwynns Falls	**31.8%**	**11.8%**	**8.9%**	**54.6%**	**41.7%**

One additional area that will provide significant water quality benefit to the watershed is to clean-up the continuous sewage leaks that are occurring within the watershed. Although these leaks occur throughout the watershed, the largest concentrations can be found in Dead Run, Maidens Choice and the Lower Gywnns Falls subwatersheds. Table E.30 summarizes the pollutant load reductions that can be achieved as the City and County continue to address these problems.

Table E.25: Pollutant load reductions due to the repair of continuous sewer leaks

Location	TKN	TP	BOD	COD	Fecal Coliform
Watershed Outlet	11%	8%	8%	9%	52%

With the completion of the Gwynns Falls Water Quality Management Plan, the City and County now have a comprehensive water quality plan that will allow them to make the most efficient use of the limited funds available. The plan serves as a framework and provides multiple tools for the agencies to select the best project based on cost, subwatershed area or overall pollutant reductions. By combining capital projects with community education and outreach, the City and County can work towards achieving their water quality goals.

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