

Recovery Potential Screening Example: Assessing Watershed Recovery Potential in Maryland's Piedmont Ecoregion

Preface: The following recovery potential screening example is based on a comparison of the watersheds of the Piedmont ecoregion in the State of Maryland. The example involves real data and analyses. It was conducted in 2010 as a demonstration study of recovery potential screening and thus had no direct relationship to EPA or State policies or decisions. This document follows the sequence of recovery potential screening steps (in blue) and step components (underlined subheads) presented in EPA's Recovery Potential Screening website. Some updates in steps and step components have been made in order to make this example consistent with 2015 website content revisions.

Step 1: **Define the project scope**

Define the geographic area of interest. The Eastern Piedmont ecoregion, State of Maryland.

Define the targeted units whose recovery potential will be assessed and compared. Although a statewide set of 94 watersheds was assessed (Figure 1), the Piedmont ecoregion's 27 watersheds are used in this screening example. The Maryland Department of Environment (MDE) assesses and lists its impaired waters on a watershed basis, using a medium-scale (MDE8) watershed delineation prepared at state level.

Identify the purpose for the screening. This screening was undertaken to compare watersheds in order to determine which of the impaired watersheds from the State's 303(d) list were the strongest candidates for restoration and re-attainment of water quality standards. The findings would help inform strategies for spending restoration funds where they would be more likely to result in successful restoration progress. Although the focus of the screening was on the 18 impaired watersheds, actually all the ecoregion's 27 watersheds were assessed. The 9 healthy watersheds were included as a set of reference sites of known condition in order to enable comparison of their recovery potential scores to those of the impaired watersheds.

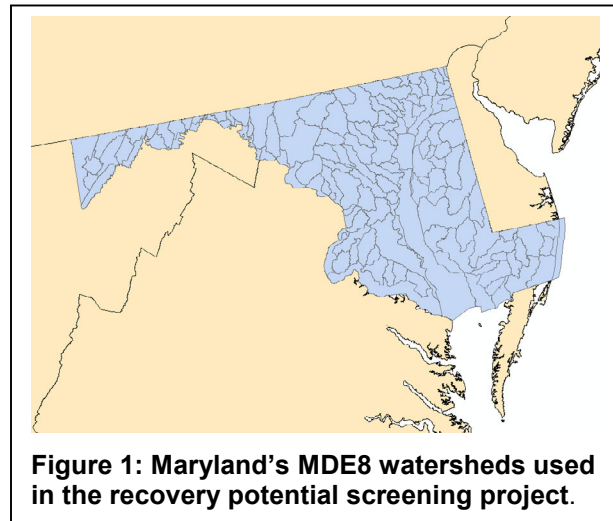


Figure 1: Maryland's MDE8 watersheds used in the recovery potential screening project.

Identify participants and their respective roles. The project workgroup included the MDE managers overseeing both TMDL development and TMDL and nonpoint source control (section 319) implementation; staff involved in impaired waters listing and TMDL implementation; and GIS staff. The scoping discussions were facilitated by EPA

recovery potential project members. Program managers identified the objectives and desired products for the screening assessment, and staff addressed technical details regarding data availability and factors potentially most relevant to recovery in the Piedmont region. Coordination with EPA Regional and Headquarters contacts was maintained throughout the project.

Identify desired findings and products. The effort was aimed at identifying a small (but not precisely defined) number of the ecoregion’s watersheds that scored more highly in recovery potential screening, and comparing these selections to other State efforts to identify promising watersheds for restoration.

**Step 2:
Design the project approach**

Establish IDs. Due to previous analyses, the watersheds of interest were already a mapped GIS dataset and a system of IDs (Table 1) had been assigned to all watersheds. These existing geospatial units would provide a basis for analyzing and compiling all the rest of the recovery potential indicator data tables, plots and maps.

Select and compile candidate indicators. The workgroup met multiple times and thoroughly discussed the characteristics of these watersheds relative to the goals of their program, and selected what they felt were the most important recovery indicator concepts for the ecoregion. In order to enable evaluation of recovery potential from different, complementary perspectives, they chose several indicators in each of three classes: ecological, stressor, and social context. The list of 60 candidate indicators was in part based on, but not restricted to, EPA recovery potential indicators information. Beyond these indicators, this study also had a “Pass” or “Fail” rating for every watershed based on MDE field assessment. This attribute would not be used in the scoring of any index. However, the “Pass” watersheds would play a crucial reference site role in validating the results from the screenings, and comparing scores among the “Fail” watersheds helped guide MDE toward the more restorable watersheds.

Both GIS and statewide monitoring data were available for measuring these indicators. Each candidate indicator’s data needs were considered in terms of availability, data quality, and relative importance to the assessment’s purpose. Data gaps and/or difficulties in working with some data

Table 1: IDs and names of Maryland Piedmont ecoregion watersheds	
MDE8DIGIT	MDE8NAME
02120201	L Susquehanna River
02120202	Deer Creek
02120203	Octoraro Creek
02120205	Broad Creek
02130608	Northeast River
02130609	Furnace Bay
02130701	Bush River
02130702	Lower Winters Run
02130703	Atkisson Reservoir
02130704	Bynum Run
02130706	Swan Creek
02130802	Lower Gunpowder Falls
02130804	Little Gunpowder Falls
02130805	Loch Raven Reservoir
02130806	Prettyboy Reservoir
02130904	Jones Falls
02130905	Gwynns Falls
02130906	Patapsco River L N Br
02130907	Liberty Reservoir
02130908	S Branch Patapsco
02131105	Little Patuxent River
02131106	Middle Patuxent River
02131107	Rocky Gorge Dam
02131108	Brighton Dam
02140205	Anacostia River
02140206	Rock Creek
02140207	Cabin John Creek

sets resulted in some reduction and modifications in the candidate indicators list. However, many candidate indicators were able to be retained and measured simply because it took very little effort (and increased later indicator use options) to measure additional attributes from datasets already being analyzed.

For indicators with available or easily obtainable data, measurement options were discussed at length. Often multiple alternatives for measuring the same indicator were evident, but a final measurement method was selected for each. Selections were based on how well the measurement technique appeared to relate to the properties described as recovery-relevant in literature and practice. Further refinements and reductions in numbers of candidate indicators occurred during this process.

Review and refine preferred indicators. After the iterative discussions, data considerations, and measurement considerations above, the workgroup reconvened and settled on 23 indicators with either 7 or 8 in each of the three classes as its selection for the initial round of screening (see Table 2). At a minimum, these 23 indicators would be measured for all the Piedmont watersheds and prepared for potential use in one or more planned recovery potential screening runs.

Table 2. Initial set of 23 recovery potential indicators for first screening run of MDE watersheds.		
Ecological (7)	Stressor (8)	Social Context (8)
Biotic condition: benthic IBI score	Proportion of degraded sites per watershed	Protected landownership % by watershed
Biotic condition: fish IBI score	Corridor % impervious cover per watershed	# of TMDLs approved per HUC
Recolonization: density of confluences	Watershed % urban	Proportion of stream length with stressor Attributed Risk
Recolonization: stream density	Watershed % cropland and pasture	Proportion of stream length with source Attributed Risk
Watershed condition: % forest	Corridor % cropland and pasture per watershed	Complexity: watershed # of local jurisdictions
Bank stability: MBSS buffer vegetation	Housing counts per corridor length in watershed	Sonoran index of economic stress
Natural channel form and condition	Corridor road length per corridor length in watershed	Community education level
	Road crossings per unit of corridor length in watershed	Tier 2 waters % per watershed

Step 3: Prepare your RPS Tool for screening

[NOTE: Significant advances in the RPS Tool since this 2010 study have now automated several steps that were performed manually at the time of the study. To serve as a current example of the RPS method and Tool efficiencies, steps 3 - 5 have been updated with reference to the original project as well as the new Tool.]

Verify geographic area of project and Verify watershed scale(s) of analysis. If using a pre-made RPS Tool, it is necessary to check on whether the project area chosen in Step 1 is completely covered in the Tool. Statewide RPS Tools contain every HUC12

watershed that is fully or partially within the state. At the time, this MDE project used state-delineated watersheds across the state but truncated at the state borders.

Make sure watershed units match. As all indicators in this project were originally measured directly on the MDE8 watersheds, this step was not an issue. However, RPS projects that combine existing watershed data measured by different groups or projects may have watershed inconsistencies, in number of watersheds or their boundaries.

Confirm all indicators data are available. MDE's need to gather all the data sources and compile all the indicators in this project was time-consuming, and also resulted in some proposed indicators being rejected due to insufficient data. This process has been made easier by pre-compiled indicator data available within each RPS Statewide Tool, where a user can review the available data for the indicators desired. If new indicators were calculated, this step ensures that they were properly added to the Tool.

Define watershed subsets of interest. Many RPS projects do not necessarily screen and compare all the watersheds contained in their Tool, especially if focusing on a subset of watersheds provides a chance to compare fewer watersheds of higher relevance to the purpose for the screening. For example, an RPS project may only be interested in comparing watersheds with impaired waters, or only watersheds with greater than 5% urban land, or coldwater fisheries, or other characteristic of interest. MDE's subsets of interest were:

- Ecoregions: the watersheds for each ecoregion were screened separately in addition to the statewide screenings. This gave MDE the opportunity to compare more similar watersheds (within each ecoregion) to one another, and hedged against any one ecoregion overshadowing the others in a statewide screening;
- Watersheds with non-tidal streams: tidally-influenced watersheds were not the primary interest in this project, and would have been more difficult to compare with non-tidal.
- Watersheds with impairments: the main purpose for the screening was essentially to focus on those impaired watersheds that had better recovery potential than others. Healthy watersheds were also screened with this subset, but used as reference.

QA/QC your customized RPS Tool before use. At the time of the MDE study, QA/QC necessary for indicator development and index measurement was extensive due to the numerous opportunities for human error in manual calculations. Now, Statewide RPS Tools have already been quality-assured before finalization as to basic functionality and quality of the indicator data already embedded. Nevertheless there are several QA/QC elements that remain appropriate before a screening, including checking file naming, data completeness and availability, and evaluating tool performance in a test run.

Step 4:
Run a Screening and Review the Results

Rename the Tool file. Because screening is an iterative process, several different screening runs are usually expected. Renaming the Tool file at the beginning of each run is necessary to keeping well organized records of the project.

Choose watersheds. The MDE’s project addressed different subsets, as described above. This example focused on the watersheds of the Piedmont Ecoregion.

Select indicators for the screening run. In the process of analyzing the preferred indicators selected in step 2, the workgroup compiled data on those 23 metrics and, at little additional effort, was able to add alternative measurements for several of them. The workgroup’s selected set of 23 indicators was used for the first screening run.

Assign weights if desired. Weights were not assigned in this study.

Run the screening. Once the above choices have been entered in the Tool’s SETUP page, running the screening does all calculations internally and generates tables of values for each watershed. These values per watershed include raw and normalized indicator values for each indicator, and four multimetric indices (Ecological, Stressor, Social, and Integrated).

Table 3 displays a partial dataset of raw, normalized and summary (EcolIndex) scores for the MDE Piedmont screening, as an example of what is now auto-calculated behind the scenes by the RPS Tool. Because different indicators in their raw state can be measured in vastly different quantities, normalization equally weights each indicator’s value range between 0 and 1. Weighting differences per indicator, if used, are applied after normalization. Each multi-metric index is calculated from the weighted and normalized indicators in each category, then transformed to a maximum-100 scale:

$$\text{Index scoring} = \frac{(V1 + V2 + V3...Vn)}{.01n}$$

The normalized values for each of the indicators in the ecological, stressor, and social categories were added along the rows to sum up three index sub-scores per watershed. Upon completion of the three index scores it was possible to calculate a single-value Recovery Potential Integrated (RPI) score for each watershed. Note that the Stressor Index component of the RPI is inverted to become directionally consistent (i.e. higher value is better) with the other indices, making the RPI Score also “higher is better” with a maximum value of 100.

$$\text{RPI Score} = \frac{\text{Ecological Index} + \text{Social Index} + (100 - \text{Stressor Index})}{3}$$

Review screening results and Perform a QA/QC check. The data quality for source datasets used in the indicator measurements was reviewed and considered before settling on indicator selection. GIS operations carried out to measure many of the indicators followed conventional standards of practice. Potential error sources were identified in the indicator measurement, data transfer, alignment, and normalization procedures. Each of these potential problem areas were either spot-checked through repeat calculations or repeated to verify identical results. Quality checks on index scores, although auto-calculated, should still be performed especially if they can be compared with reference watersheds such as the “Pass” watersheds in the MDE study.

Table 3. Example reduced dataset of three raw and normalized (renamed by adding an N) indicator values, with calculated ecological index. Although compiled manually in this 2010 project, all weighting, normalization and index calculation are automated in current RPS Tools.

MDE8DIGT	BIO A	XFIBI	NXFIBI	RFOR120	NRFOR120	CHANLNAT	NCHANLNAT	ECOINDEX
02120201	Fail	2.20	0.50	59.0575	0.60	0.9690	0.97	69.3
02120202	Pass	3.94	0.90	49.6109	0.51	1.0000	1.00	80.4
02120203	Pass	3.68	0.84	46.9329	0.48	0.9535	0.95	75.9
02120205	Pass	3.67	0.84	49.3248	0.51	0.9257	0.93	75.7
02130608	Pass	4.13	0.95	55.9161	0.57	0.9469	0.95	82.2
02130609	Pass	4.14	0.95	50.4246	0.52	1.0000	1.00	82.2
02130701	Fail	3.83	0.88	66.9792	0.69	0.8141	0.81	79.3
02130702	Fail	3.78	0.87	56.0208	0.57	0.9071	0.91	78.3
02130703	Fail	4.26	0.98	52.0353	0.53	0.8761	0.88	79.5
02130704	Fail	3.85	0.88	43.6476	0.45	0.7212	0.72	68.4
02130706	Fail	3.93	0.90	56.0521	0.57	0.8938	0.89	79.0
02130802	Fail	3.20	0.73	49.0271	0.50	0.5711	0.57	60.2
02130804	Pass	3.63	0.83	55.8416	0.57	0.9690	0.97	79.1
02130805	Fail	3.32	0.76	51.8082	0.53	0.8472	0.85	71.3
02130806	Pass	3.96	0.91	47.453	0.49	1.0000	1.00	79.8
02130904	Fail	2.68	0.61	45.5772	0.47	0.5438	0.54	54.2
02130905	Fail	2.94	0.67	33.7638	0.35	0.6083	0.61	54.3
02130906	Fail	2.88	0.66	49.8221	0.51	0.6341	0.63	60.2
02130907	Fail	4.22	0.97	44.1271	0.45	0.9185	0.92	77.9
02130908	Fail	4.36	1.00	32.8319	0.34	1.0000	1.00	77.9
02131105	Fail	3.27	0.75	41.2453	0.42	0.5525	0.55	57.5
02131106	Pass	3.49	0.80	34.9052	0.36	0.9009	0.90	68.6
02131107	Fail	3.52	0.81	49.9346	0.51	0.9563	0.96	75.8
02131108	Pass	3.61	0.83	43.3451	0.44	1.0000	1.00	75.7
02140205	Fail	3.28	0.75	38.4022	0.39	0.2565	0.26	46.7
02140206	Fail	3.40	0.78	42.9377	0.44	0.9174	0.92	71.2
02140207	Fail	2.50	0.57	46.9367	0.48	0.5586	0.56	53.8

Step 5: Compare your watersheds

Given the results of the first screening run, the MDE workgroup recognized that the watersheds could be compared using the data in a number of different ways. Further, it appeared that one way need not be selected to fit all purposes. For example, having all

three index scores available for each watershed through 3D plotting might be desirable for informal strategizing about restoration program options in which a variety of pluses and minuses about the watersheds could be considered. On the other hand, the ecological index alone might be of high interest in discussions of partnering possibilities with land trusts or natural resources agencies. Or, the stressor and social indices could be of elevated interest in discussions centered on how local restoration efforts could aid Chesapeake Bay recovery. At times, rank-ordering the watersheds might prove useful. In other situations, watershed comparisons could be better informed by seeing the ecological, stressor and social scores at the same time and determining whether a watershed's strengths were community-based, condition-based, or both. Although at the time these alternative formats had to be developed using three separate software packages, all three are now generated by the RPS Tool alone.

Rank-ordering. There are several options for rank-ordering by index score, based on the four indices. Table 4 contains the Piedmont ecoregion Ecological, Stressor, and Social Index and the RPI score for each of the 27 watersheds. Having included the "Pass" as well as the "Fail" watersheds in the assessment, it was possible to evaluate whether "Pass" watersheds as a group appeared to have higher recovery potential than "Fail" watersheds by comparing their mean sub-scores, scores and ranks. The results, in the bottom two rows of Table 4, point to consistently higher scores and ranks among the "Pass" watersheds in the comparisons. The weakest difference involved the social context mean score and rank. This may be explainable because social indicators for estimating future recovery are based much less on current environmental condition than are ecological and stressor recovery potential indicators. As such, social context-based recovery potential is fairly independent of ecological or stressor-oriented recovery potential indices. It was entirely plausible that in the Piedmont ecoregion a currently healthy watershed could have a poor social context for future restoration activities, and that an impaired watershed could have an excellent social setting favoring its recovery independent of its condition. These possible interpretations would be reconsidered when multiple screening runs with other alternative indicators became available.

Although rank-ordering the watersheds was of moderate interest, it was not considered sensitive enough in this project to consider watersheds adjacent in the rank order to be necessarily different in condition or restorability. Nevertheless, rank-ordering based on Index scores is generally appealing to communicate results to audiences even if not used as a basis for decisions or priorities.

Bubble plotting. RPS bubble plots are graphs that show a symbol (bubble) for each watershed plotted against X and Y axes that represent the Stressor and Eco Index scores, respectively. The Social Index score determines each bubble size. At a glance, each watershed's three indices can be viewed relative to all the other watersheds being screened. A fourth dimension of comparison is obtained by coloring the bubbles based on a single indicator or base attribute. By default, additional lines are also plotted at the median Eco and Stressor Index scores, creating quadrants in the plot that identify high-high, high-low, low-high, and low-low combinations of these Indices. For example, the upper left quadrant is where high Eco-low Stressor watersheds cluster; in this quadrant

one would expect to find the “Pass” MDE watersheds along with the “Fail” watersheds that might be least degraded and more recoverable.

Table 4. Using data from screening run one, a variety of summary score options calculated for the Piedmont ecoregion watersheds, including summary sub-scores for ecological, stressor, and social context indicators, and the RPI integrated score. Rank-ordering is also presented for each summary score type and as a summary of rank order. Note that in the rank ordering, 1 is consistently the top score in terms of recovery potential, including the rank-ordering based on stressor sub-scores. Watersheds have been sorted by FIELD-BASED bio-assessment Pass/Fail.

MDE8DIGT	BIO A	ECO INDEX	ECO RANK	STR INDEX	STR RANK	SOCIO INDEX	SOCIO RANK	RPI SCORE	RPI RANK	RANKADD (E+ST+SO)	RANK BY RANKADD
02130609	Pass	61.0	2	26.5	3	56.3	1	4.4	2	6	1
02120205	Pass	55.4	14	27.1	5	39.0	6	3.5	3	25	4
02130608	Pass	60.0	4	25.4	2	28.6	22	3.5	4	28	6
02120202	Pass	60.8	3	27.5	8	33.0	15	3.4	5	26	5
02130804	Pass	59.3	6	26.5	4	29.8	19	3.4	6	29	7
02130806	Pass	61.9	1	27.3	7	25.7	25	3.2	7	33	10
02120203	Pass	58.5	9	31.2	10	40.0	5	3.2	8	24	3
02131108	Pass	59.1	7	27.1	6	24.7	26	3.1	10	39	12
02131106	Pass	55.1	15	34.1	15	34.3	14	2.6	14	44	16
02130701	Fail	54.9	17	17.3	1	34.8	12	5.2	1	30	8
02130907	Fail	59.0	8	32.3	12	41.2	4	3.1	9	24	2
02131107	Fail	60.0	5	28.7	9	23.4	27	2.9	11	41	13
02130908	Fail	58.1	10	34.1	14	37.6	8	2.8	12	32	9
02130805	Fail	57.8	11	32.1	11	29.8	20	2.7	13	42	14
02130703	Fail	55.0	16	35.5	16	36.6	10	2.6	15	42	15
02130706	Fail	56.2	12	34.1	13	28.5	23	2.5	16	48	17
02130702	Fail	56.1	13	40.1	20	41.4	3	2.4	17	36	11
02120201	Fail	52.5	18	37.1	17	30.9	18	2.3	18	53	19
02130802	Fail	46.8	23	39.0	18	32.5	16	2.0	19	57	23
02140206	Fail	49.2	20	46.2	22	37.6	9	1.9	20	51	18
02130704	Fail	46.9	22	44.7	21	35.3	11	1.8	21	54	20
02130906	Fail	49.9	19	47.9	24	34.5	13	1.8	22	56	22
02140207	Fail	38.7	26	40.0	19	28.2	24	1.7	23	69	27
02131105	Fail	48.2	21	48.8	25	30.9	17	1.6	24	63	25
02130904	Fail	45.2	24	47.6	23	28.8	21	1.6	25	68	26
02140205	Fail	37.4	27	63.0	26	43.5	2	1.3	26	55	21
02130905	Fail	41.2	25	63.1	27	38.4	7	1.3	27	59	24
Mean pass scores		59.0	7	28.1	7	34.6	15	3.4	7	28.2	7
Mean fail scores		50.7	18	40.6	18	34.1	14	2.3	18	48.9	17

In the MDE project, the workgroup bubble-plotted the first run screening results (see Figure 2a). Color-coding enabled the output to easily separate the Pass (blue) from the Fail watersheds (black). Comparing watersheds on the basis of Ecological or Stressor Indices was evident in their X/Y position relative to the two main axes, and the median axes. The application of the Ecological and Stressor Indices medians divided the plot into four quadrants, and created a coarse sorting of the watersheds based on two of three Indices. As expected, “Pass” watersheds dominated the upper left quadrant, but

several “Fail” watersheds accompanied them, suggesting they might be worth further analysis as among the better prospects for restoration.

Use of statewide as compared to ecoregional median lines added a broader, state-level context to the consideration of relative recovery potential within the ecoregion. In fact, using the statewide medians revealed in other screenings that the three ecoregions differed significantly in the numbers of watersheds above or below statewide medians.

One method for selection of a high-ranking subset of watersheds using the 3D bubble plots is demonstrated here (Figure 2b). The initial assumption of this method is that the upper-left quadrant (i.e., higher eco with lower stressor scores, highlighted yellow) holds a subset of watersheds of likely higher restorability based on condition alone. This subset may be further reduced by targeting the watersheds with a better social context (larger bubble). Assuming that only the “Fail” watersheds would be considered priorities for restoration given the program’s purpose, three watersheds (black arrows) are selected by this technique. Because a decision process often has additional, case-specific information, additions or deletions based on special information and expert judgment (two brown arrows in upper right quadrant) are allowed to modify the initial set of watersheds. This hypothetical example results in identifying five watersheds of the 27 that were screened.

Mapping. RPS projects can choose from two basic approaches to mapping results: use the simple but limited mapping capability from within the RPS Tool, or use the Tool results in more versatile but complicated GIS software to create project maps. GIS of course can create the best-looking maps, and is capable of overlaying additional informative details (e.g., sampling sites, highway routes and their numbers) over the screening results per watershed. Both can display any of the watershed indices, and single indicator values per watershed, in a variety of user-controlled settings (e.g., colors, number of classes).

One advantage of the RPS Tool’s simplified mapping is that it is completed entirely within Excel and requires almost no training; in addition, its speed and simplicity enable a less-specialized user to create and change maps quickly as a manner of examining the data and considering options for making better maps elsewhere. Figure 3 displays six different statewide maps of Maryland watersheds (four indices and two single indicators) created in less than a half hour in Excel.

To use RPS project data in GIS, the data table from the RPS Tool simply needs to be exported to the GIS and transformed into the appropriate file type for the GIS to use it. Users may want to export only the table of Index scores after a screening. Or, it may be useful also to export some or all of the single indicator data as well. The GIS uses the data values as attribute information georeferenced to the watershed boundary shapefiles used in the RPS project.

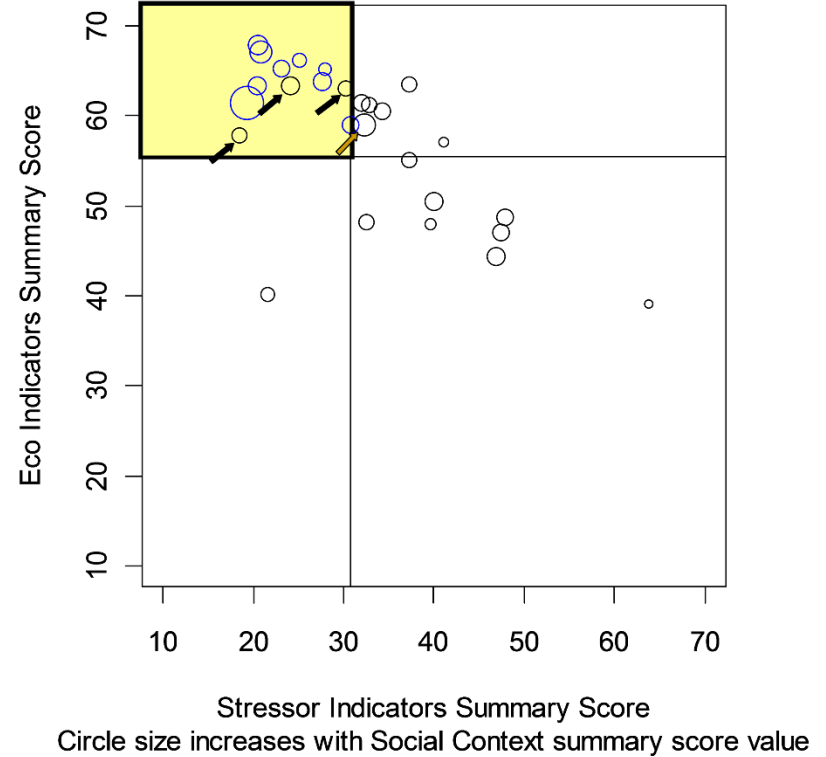
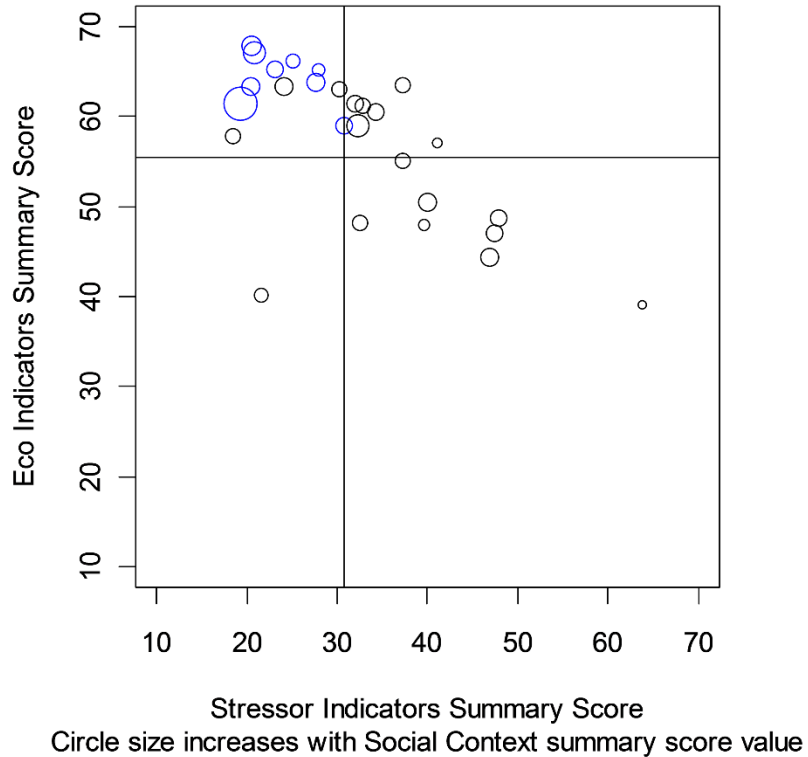


Figure 2A. A 3D bubble plot of Piedmont ecoregion watershed recovery potential from screening run 1. Watersheds that passed bioassessment are in blue, failing watersheds in black. Note that the healthy watersheds clustered in the upper left quadrant due to the combination of high eco/low stressor summary sub-scores. Larger dot size reflects higher social context score.

Figure 2B. The same bubble plot modified to demonstrate a simple decision support process for recognizing stronger candidates for restoration of impaired watersheds. First, the Fail watersheds in the upper left quadrant (black arrows in yellow shaded area) are identified. A better than average social context score (larger bubble) plus additional information and expert judgment support the addition (brown arrow) of another watershed from the upper right quadrant.

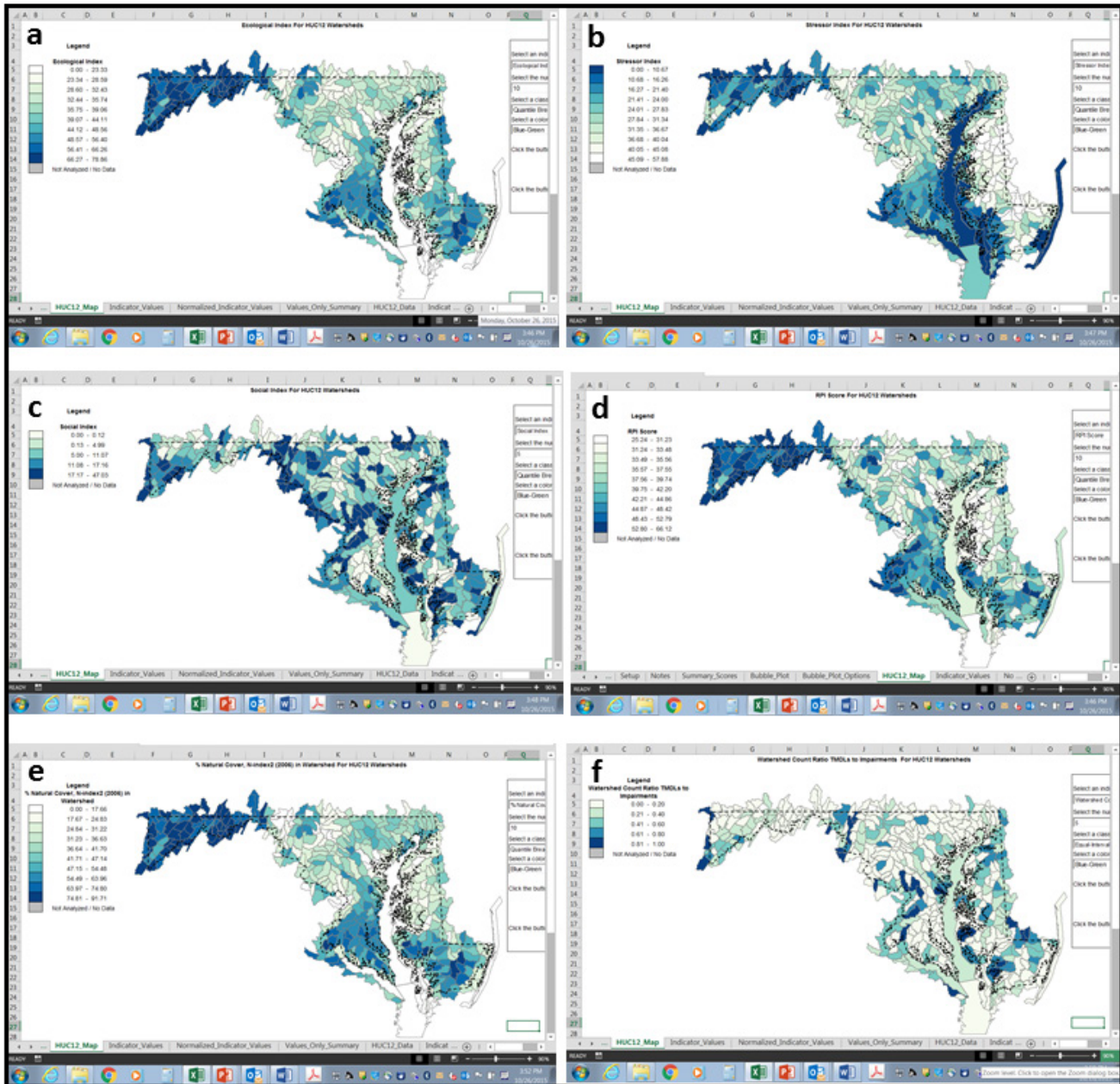


Figure 3. Six simplified watershed maps created with the RPS Tool. These include a) Ecological Index; b) Stressor Index; c) Social Index; d) RPI Score (integrates indices in a thru c); e) Percent natural cover in the watershed; and f) Ratio of completed TMDLs to water bodies needing TMDLs, per watershed. Although the RPS Tool's mapping capability is limited, the user can display all indices and all watershed indicators in the data table (not just those used in the screening) in a range of color types and interval breaks.

**Step 6:
Refine your assessment**

Revisit screening purpose and products. Based on the first screening run, testing for bivariate correlation among the indicators was carried out on the 23 indicators. The reduced set used in the second screening run (see Table 5) was in part informed by the correlation testing results. The workgroup decided to eliminate several indicators that appeared to be correlated and thus measuring similar characteristics. The workgroup selected what they considered the more relevant measure when faced with a choices between pairs of correlated indicators. The same correlations dataset and procedure remained available to inform alternative selections of indicators for additional screening runs. The reduced selection for run 2 identified 5 indicators in each of the 3 classes.

Discussions about the first and second screening run results noted that, although biotic community condition as represented by the Fish IBI and Invertebrate IBI indicators is arguably a strong factor influencing future recovery potential, these two indicators were probably highly correlated with the Pass/Fail information that was in part used to evaluate the results of the screening run (e.g., see Table 4). The group decided it would be worth testing the recovery potential screening without these two biotic indicators to observe whether or how the results might change. The new set of indicators for the third screening run appears in Table 6.

Table 5. Set of 15 recovery potential indicators selected for the second screening run. The primary difference from the first run was elimination of several correlated, duplicative metrics.

Ecological (5)	Stressor (5)	Social Context (5)
Biotic condition: benthic IBI score	Proportion of degraded sites per watershed	Protected landownership % by watershed
Biotic condition: fish IBI score	Corridor % impervious cover per watershed	Proportion of stream length with stressor Attributed Risk
Recolonization: density of confluences	Watershed % cropland and pasture	Complexity: watershed # of local jurisdictions
Bank stability: MBSS buffer vegetation	Housing counts per corridor length in watershed	Tier 2 waters % per watershed
Natural channel form and condition	Watershed 2006 reporting cycle # of impairment causes	Watershed % waters targeted by DNR for protection

Table 6. Set of 15 recovery potential indicators selected for the third screening run; the primary change from the second run was to replace both IBI metrics with alternative ecological measures.

Ecological (5)	Stressor (5)	Social Context (5)
Watershed % wetlands	Proportion of degraded sites per watershed	Protected landownership % by watershed
Watershed % forest cover	Corridor % impervious cover per watershed	Proportion of stream length with stressor Attributed Risk
Recolonization: density of confluences	Watershed % cropland and pasture	Complexity: watershed # of local jurisdictions
Bank stability: MBSS buffer vegetation	Housing counts per corridor length in watershed	Tier 2 waters % per watershed
Natural channel form and condition	Watershed 2006 reporting cycle # of impairment causes	Watershed % waters targeted by DNR for protection

Consolidate screening runs. Having performed multiple screening runs adds insight about how different watersheds measure up under different sets of indicators, but having many screening runs also complicates the process of finalizing one set of results. One way to proceed is to discard flawed or weaker screening runs, consider whether in the remaining runs some watersheds consistently rank well under different sets of indicators, and use a group process to select the run that best exemplifies the observed patterns.

The workgroup analyzed the three screening runs to identify a subset of impaired watersheds that scored well from each run, using the method illustrated in Figure 2b. The subsets of watersheds thus selected were compared with one another and to independent information available from MDE that had identified potentially strong candidates for restoration.

The same method for identifying a potentially more restorable subset of watersheds was applied to all three screening runs: identify all ‘high eco/low stressor’ but still failing watersheds in the upper left quadrant, then add all upper right quadrant failing watersheds (high eco/high stressor) with a better than average social context score. The results from all three runs are in Table 7.

Table 7. Summed frequency of watershed occurrence in upper left quadrant and/or upper right quadrant with better than average social context subscore. The ranking was made from 18 impaired watersheds.					
Watershed ID	Watershed name	Run 1 Priority	Run 2 Priority	Run 3 Priority	Total Priority
02130908	S Branch Patapsco River	X	X	X	3
02130702	Lower Winters Run	X	X	X	3
02130701	Bush River		X	X	2
02131107	Rocky Gorge Dam		X	X	2
02130704	Bynum Run	X		X	2
02130703	Atkisson Reservoir		X		1
02130706	Swan Creek		X		1
02130907	Liberty Reservoir	X			1

Match screening runs to specific actions and QA/QC the assessment results.

Comparison across screening runs does reveal five waters that were highly scored in two of three runs, and two waters highly scored in all three runs. As MDE had independently identified watersheds of potential priority for restoration separately from the screening project, the working group was able to compare screening selections to those selections. Watersheds flagged for high restorability in both venues appear **bolded** in Table 7.

Step 7:
Use your recovery potential screening results

As a demonstration study, this project produced a variety of outputs that could support a number of different types of trial applications. The State of Maryland had

been active in restoration planning and priority-setting before and throughout this demonstration, thus the recovery potential screening products are adding new lines of evidence and evaluation tools to their existing approaches. MDE activities that are integrating recovery potential data with other information include:

- Independent analysis of potential high-priority watersheds for TMDL implementation. On the statewide set of MDE8 watersheds that have been used for 303(d) listing, recovery potential screening targeted more restorable watersheds using a new method that could be crosswalked with the results of other priority-setting efforts.
- Subwatershed screening within high ranking MDE8 watersheds. The component subwatersheds of ten of the high-ranking MDE8 watersheds were also screened for recovery potential in a second-tier analysis at the single watershed level (see example in Figure 4). The subwatersheds were compared to identify where applying specific restoration practices would be most likely to achieve subwatershed recovery and thereby benefit the MDE8 watershed's overall condition.
- Support informal discussions with restoration partners. As input to identifying where MDE and MDNR might have opportunities to target restoration effort on sites of common interest, recovery potential screening data were used to identify high recovery potential subwatersheds co-occurring with MDNR-administered streams on public land (see example in Figure 5).
- Coordination with regional, multi-state restoration and protection efforts. The MD recovery potential screening data and methods will add to the dialogue among EPA Region 3 and the middle-Atlantic states, including the Healthy Waters Initiative, Healthy Watersheds Program, and the Water Resources Registry.
- Coordination with other state and local restoration efforts. The screening may add information to Maryland's state-level restoration activities such as the 2010 Bay Trust Fund restoration grants, the Biological Restoration Initiative, the BayStat framework's Stream Print program, and CWA Section 319 nonpoint source control grants. The screening methods may also present an opportunity for MDE to engage with local efforts such as Anne Arundel County's stream restoration program or Frederick County's Green Infrastructure project.

