Subwatershed Analysis Protocol

Urban Subwatersheds

Metro Conservation Districts' Urban Subwatershed Analysis (SWA) Program

The Subwatershed Analysis (SWA) Program is a collaborative effort between the Metro Conservation Districts (MCD), a joint powers governmental entity consisting of eleven Soil and Water Conservation Districts in Minnesota's Twin Cities metropolitan area. The SWA Program is implemented by Conservation Districts working with local cities, watershed districts, watershed management organizations, and other partners to complete SWAs for subwatersheds of priority or impaired surface waters. The goal of these studies is to identify the most cost-effective stormwater retrofit opportunities to improve water quality, reduce storm runoff volumes, and manage stormwater rates of discharge within priority subwatersheds. This report will explain the process used to meet this goal which includes identifying subwatersheds for analysis, finding locations for retrofit projects, modeling potential retrofit projects for pollution reduction estimates, and developing a cost estimate for each potential retrofit project. The final product is a ranked list of retrofit projects that provide the greatest pollutant reduction per dollar spent over the life of the project. The reports can also be amended at a later date to incorporate new projects as they are discovered, so long as the new projects are evaluated and ranked using the same model and cost criteria that the report had used. Final reports that adhere to this basic protocol and structure can then be used to justify and prioritize one project over another when applying for local, state, and/or federal grant funding.

Project Area and Scope Selection

Many factors are considered when choosing which subwatershed to analyze for stormwater retrofits. The most common drivers include TMDL studies, negative trends in water quality monitoring data, non-degradation report modeling, local reports and studies, and public pressure. SWAs that can be performed or supported by a Local Government Unit with sufficient capacity (staff, funding, available GIS data, etc.) to greater facilitate the assessment also rank highly. For some communities, a SWA would complement their BMP implementation efforts required within their MS4 stormwater permit. The focus is always on a high priority waterbody. To receive funds from the Clean Water Fund SWA Accelerated Implementation Grant, justification as to how the subwatershed was selected must be documented.

Subwatershed Analysis Process

The process used for a typical SWA is outlined below and was modified from the Center for Watershed Protection's Urban Stormwater Retrofit Practices, Manuals 2 and 3 (Schueler, 2005, 2007). Locally relevant design considerations were also incorporated into the process (Minnesota Stormwater Manual). The urban subwatershed analysis process includes these five steps:

1. **Project Scoping** – Determine project objectives, meet with local experts, define preferred treatment options and criteria, and refine subwatershed focus area.

2. **Desktop Analysis** – Computer-based evaluation of catchments within the subwatershed.
3. **Field Investigation** – Evaluate focus areas and specific sites identified during Desktop Analysis.
4. **Treatment/Cost Analysis** – Estimate potential benefits of projects, prepare cost estimates, and rank projects in terms of cost-benefit.
5. **Reporting** – Summarize methods and findings. Use a report table to list projects with the best cost-benefit.

Step 1 - PROJECT SCOPING

Be sure to include at least one meeting with partners/stakeholders into your SWA workplan. You will want to determine the extent of your SWA, the types of retrofits you will potentially target, and uncover any other issues that were not considered in the initial scoping of the project. There are potentially many items to cover during a scoping meeting (or series of conversations). Below is a checklist of typical items to discuss before committing to any desktop or fieldwork.

PROJECT SCOPING MEETING CHECKLIST:

1. **Review SWA process** with stakeholders and provide estimated timeline for SWA process
    a. *(Also see Sample Scoping Meeting Document in the Appendix)*
2. TYPICAL **SWA TIMELINE**
    a. TAC scoping meeting
    b. Desktop analysis
    c. Field investigation
    d. TAC review meeting 1
        i. Review identified retrofit opportunities prior to modeling
        ii. Fill missing gaps
        iii. Revise practices as needed
    e. Treatment/cost analysis
    f. TAC review of draft report
        i. Make final edits and
    g. Final report
3. Review target area and discuss **high priority areas** or **areas of concern**
4. Review **preliminary focus area**
    a. Discuss stakeholder planned and potential future projects – should any be included in the SWA?
5. Discuss **treatment goals**
6. Identify **target pollutant**(s) and **reduction goal**(s)
7. Discuss **preferred retrofit types** (e.g. public vs. private property, pond retrofits to increase storage or enhance treatment, reuse, underground storage, hydrodynamic separators, bioretention, permeable pavement, etc.)
8. Discuss preferred **catchment naming convention**(s) to align with previous studies or other stakeholder naming and clarify consistent terminology depending on scale (e.g. subwatershed > drainage network > catchment > subcatchment > microcatchment)
9. Discuss **data currently available** for the analysis and identify any **data gaps** (e.g. land use, soils, scale of catchment delineations, etc.)

10. Establish **contacts for additional data requests** necessary for desktop review (e.g. GIS files for storm sewer networks and drainage area delineations, as-built plan sets for storm sewers and existing BMPs, and questions that may arise throughout the process)

By this point, you should have a clear idea of which water body you are analyzing, as well as a rough idea of the extent of the watershed you will want to model and analyze. In some cases, the drainage area to your priority waterbody may be exceptionally large and will need to be reduced in size. You will want to work with relevant stakeholders (typically watershed district staff and/or city staff) to determine the area to be analyzed. Landlocked catchments, or those flowing through pre-existing stormwater pond networks may be considered for exclusion from analysis (especially those installed after local stormwater permit rules were enacted). Another tactic to reduce project size would be to look at only the direct-draining catchments to a waterbody. That is, catchments that receive no pollutant pre-treatment prior to discharging into the waterbody. But, the decision to rule out certain catchments before the modelling phase should be left to the primary stakeholder in the SWA. The goal is to get to a manageable study size that will fit within budget constraints while still delivering the majority of the benefits of such a study (e.g., achieving meaningful pollutant reductions to the priority waterbody).

During the Project Scoping process, you will also want to consider the types of retrofits that are best suited to the landscape. Retrofit scoping includes determining the primary goals of the retrofits (volume reduction, TP and/or TSS reductions, etc.) and the level of treatment desired. It involves meeting with local stormwater managers, city staff, and watershed management staff to determine the issues in the subwatershed. This step will help to define preferred retrofit treatment options and retrofit performance criteria. For instance, areas with shallow bedrock, drinking water protection areas, or heavy clay soils may not be suitable for infiltration. In some cases, city public works staff may have had good success with one type of BMP and terrible success with another. It is helpful to determine the best alternatives that will suit the needs and skills of those who will be maintaining a proposed BMP.

Step 2 - DESKTOP ANALYSIS

Desktop analysis involves computer-based evaluation of the subwatersheds in the target project area. The overall goal of the desktop analysis is to flag sites (using a GIS software) within the project area that may be suitable for the installation of water quality BMPs. GIS data is used to visually look for clues in the landscape that may suggest appropriateness for certain forms of stormwater BMP's. See the following tables for examples of useful data to use in the desktop analysis and appropriate BMPs that would fit with certain landscape features.

Datasets to Gather for Desktop Analysis and their Typical Usage

Data Description	Typical Use or Components
GIS Basemap	Base data for all report imagery: LiDAR (hillshade maps), 2' contour topography, roads, parcel boundaries, municipal boundaries, etc.
Hydrology	National Wetland Inventory (NWI), State or county level Lake and River/Stream boundaries, perennial stream flow lines (when avail.)

Soils Maps	County Soil maps in GIS. For model inputs, use Hydrologic Soil Group (HSG) and notes on general infiltration capacity of soils.
Stormwater Routing	Municipal and/or county drainage networks. Catchbasins, storm ponds, pipes. The finer the detail the better. Driveway culverts are not typically marked. Field ID will have to verify these if necessary.
Stormwater Catchments	Catchment and Subcatchment boundaries (from previous partner studies or models). HUC-12 boundaries are helpful, but smaller subdivisions will ultimately be needed. Catchment connectivity and outlets to waterbodies are critical. May have to be generated from scratch using other tools such as ArcSWAT or NRCS Engineering Tools. Manual catchment delineation is also an option.
Landuse and Land Cover Data	Minnesota Land Cover Classification System (MLCCS) will be used for pollutant modelling. Land cover types will govern model inputs. Metropolitan Area Land Use and Land Cover maps will also fill this role.
Modelling Software for Pollutant Loading	WinSLAMM or P8 are most typical for urban stormwater pollutant delivery models. MIDS calculator can be used for individual BMPs but is not good for catchment-scale network modelling.
Data Processing and Report Delivery Software	Microsoft Office suite. Excel will be used heavily for data processing, sorting, and creation of final tables for the report. Use of Pivot Table function will help easily sort soils and land cover data needed for model inputs. The report can be constructed using software such as Microsoft Word or Adobe InDesign. Word is easiest to share across agencies.
Existing BMP data	Existing BMP locations and pollutant load reductions are helpful for existing condition models (check Watershed Districts and SWCDs). As-built plans for BMPs are helpful as well (from municipalities and watershed districts).

Landscape Features and their Potential Stormwater Retrofit Opportunities.

Landscape Feature	Potential Retrofit Project
Existing Ponds	Add storage by excavating pond bottom or expanding pond surface area, modifying riser, raising embankment, adding an Iron-enhanced Sand Filter (IESF), stormwater reuse, adding pretreatment bay, and/or modifying flow routing, dredge sediment
Existing Wetlands	**Dredge of legacy-load sediment to improve pollutant export, expand storage, expand buffers. ID wetlands that may need further targeted monitoring.**
Open Space (public or private)	New regional treatment (pond, bioretention). Irrigation reuse.
Roadway Culverts	Add wetland, infiltration, or extended detention upstream of culvert.
Outfalls	Split flows or add storage below outfalls if open space is available.
Catchbasins	Curb-Cut raingardens with underdrains to catchbasins, any BMP that requires an underdrain connection, swirl separators and proprietary filtration devices.
Conveyance system	Add or improve performance of existing swales, ditches, and non-perennial streams.
Large Impervious Areas (campuses, commercial, parking)	Stormwater treatment on site or in nearby open spaces; stormwater reuse; tree pits; impervious reduction; underground storage facilities; swirl separators; Proprietary underground treatment units
Neighborhoods	Utilize right of way, roadside ditches, curb-cut rain gardens, or filter systems before water enters storm drain network.

The desktop portion of the analysis must also involve at least one of the following approaches before proceeding to step 3 – Field Investigation:

Model Approach	Typical Reasons for Selection
1. **Model subwatershed existing conditions (using P8 or WinSLAMM)** and select highest ranking catchments for further investigation – based on potential loading/contribution	• *Base models already exist for subwatershed (provided by other partners)* • *Highly complex subwatershed (number of landuse types, existing stormwater infrastructure)* • *Available budget* • *User preference*

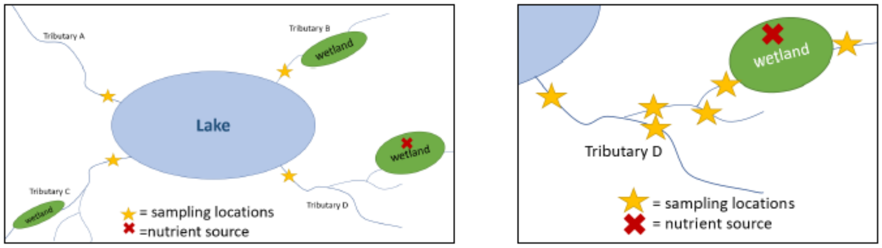
2. **Prioritize catchments based on proximity and estimated delivery to receiving water body** (i.e., directly connected, landlocked catchments, etc.)	• *Medium to large subwatersheds* • *Land morphology/stormwater infrastructure characterized by Isolated catchment areas* • *Available budget* • *User preference*
3. **Select all catchments within selected subwatershed** for further analysis	• *Monolithic landuse types* • *Small to medium subwatersheds* • *Available budget* • *User preference*

***Special Consideration*: Wetland Investigation for Retrofits and Diagnostic Monitoring**

If there is a single wetland in a subcatchment, one could easily model this in WinSLAMM or P8 if its inlet and outlet elevations, and live and dead storage depths are known. But, in this model you will only capture particulate and dissolved phosphorus that migrate through the wetland, based on a series of flow calculations. The model cannot account for real world issues such as internal loads of sediment within the water body. If a wetland is modelled in this way, understand that there are limits to the model and that the outputs are only good when used as relative values to the other catchments modelled in the same way (using WinSLAMM or P8).

In some instances, a watershed may be dominated by networks of wetlands and inter-connected channels, and determining which wetlands are important pollution sources and which are not can be extremely difficult. Within these networks, there will be wetlands that you may suspect would be exporting more phosphorus than they are receiving. This could be due to historic presence of feedlots and grazing, or where known activities in the past may have contributed to unusually high sediment loading to the wetland. Historic aerial photo comparisons will allow you to see basic trends over time on the landscape that may have impacted the wetland. But, this will only tell half the story. Since there are not many software models that can replicate the pollutant delivery of a wetland (without some real-world monitoring data to calibrate your model to), then you may have to rely on a system of targeted pollutant and flow monitoring.

To help solve the problem of accurately representing wetland contributions to a watershed, one could use the Sequential Diagnostic Monitoring (SDM) Protocol (see Appendix XXXX). This protocol is a step-by-step manual on how to identify wetlands for targeted diagnostic monitoring, how to perform the tasks in the field, and how to quantify and analyze the results. If this SDM protocol is used for a portion of an Urban SWA, the resultant wetland report could be integrated into the same final SWA report if it is declared that two different modelling methods were used, and an explanation of methods and assumptions are documented. Otherwise, it is recommended that the areas of wetland focus become a standalone report; but mention of the diagnostic effort or report within the SWA is still recommended. This way, the SWA can still be used to support grant applications that may target the wetlands in question.



Figures 1 and 2. Schematic drawing of Phase 1 - whole watershed sequential diagnostic monitoring (left panel) and Phase 2 – focused subwatershed sequential diagnostic monitoring (right panel).

Figures 9 and 10. 1964 aerial photography indicating an active dairy near Bone Lake in Washington County (left panel) and a 2019 Google Earth image of the same area. No evidence of the dairy remains in 2019. The 1964 image indicates the barnyard right down to the wetland boundary. Soil samples taken from the wetland found phosphorus levels three to ten times normal background levels – likely from manure laden runoff entering into the wetland over several decades.

Top: *Example of potential monitoring locations provided in the Sequential Diagnostic Monitoring Protocol*
Bottom: *Comparison of historic aerials to verify potential sources of wetland degradation*

***Special Consideration**: Street Sweeping*

Another BMP for modelling consideration is Street Sweeping. It has been demonstrated that increased and targeted street sweeping is by far the most cost-effective tool for managing TSS if a municipality already has a street sweeping program in place. General increases in street sweeping frequency can be modelled in WinSLAMM and those results can be considered as their own BMP for consideration in the report.

Alternatively, a targeted street sweeping analysis can be performed using the XXX TOOL provided by XXX organization. This method looks at tree canopy cover of your target area and prioritizes the streets with the densest canopy covers and highest runoff loads in which to increase street sweeping. This method can be used as a standalone tool, or the results can be integrated into the report. If the results are integrated, make sure to document the assumptions and model methods in the final report.

FL01-N2: Increased Street Sweeping

Rank 1/64

Drainage Area – 1.224 curb miles (0.94 curb miles plus 30,000sf of parking lots)
Location – All major roads and parking lots in the catchment
Property Ownership – Mostly Public, some Private Lots
Description – It is assumed that most major roads in Forest Lake are swept 2x yearly (Spring and Fall). This cost/benefit analysis factors in existing equipment and staffing and proposes increasing the sweeping regime to 4x yearly. This will typically result in about a 50% increase in TP/TSS removal rates over the current twice-yearly regime. This load reduction assumes the sweepings are equally spread throughout the season between the first Spring sweeping and the final Fall sweeping. A large amount of sediment can be captured if the parking lots that are adjacent to Lake St S and 1st St SE are included in the street sweeping (factored into the modelling).

Cost/Removal Analysis		Project ID: Increased Street Sweeping to 4x per year	
		New trtmt	Net %
Treatment	TP (lb/yr)	1.0	7%
	TSS (lb/yr)	522.5	7%
	Volume (acre-feet/yr)	0.0	0%
	Number of BMP's	1	
	BMP Size/Description	1.224	curb miles
	BMP Type	Street Sweeping	
Cost	Materials/Labor/Design	$419.30	
	Promotion & Admin Costs	$50	
	Probable Project Cost	$469	
	Annual O&M	$0	
	10-yr Cost/lb-TP/yr	$46	
	10-yr Cost/2,000lb-TSS/yr	$180	

Above: *Example of Street Sweeping BMP Profile Page. Treatment Summary and Load Reductions included.*

Special Consideration: Shoreline Restoration

Shoreline restoration can also be included in SWAs. Historically, modelling shorelines alone will only show results for the upland runoff contributions flowing to a shoreline buffer or water body. Traditional runoff models do not account for the erosion that occurs on the immediate shore, as a result of mass-wasting, calving, and wave action. On an average sized lake lot, the pollution from overland runoff does not amount to much, pushing the cost-benefit ranking of a shoreline restoration to the bottom of the list. But, if you are able to capture the near-shore erosion contributions, many shoreline restorations will fare better in the overall cost-benefit rankings. This way, especially problematic shorelines will benefit from a better ranking which more accurately accounts for their TSS and TP contributions to a lake.

To capture near-shore contributions, use the "BWSR Water Erosion Pollution Reduction Estimator Spreadsheet" (https://bwsr.state.mn.us/water-quality-tools-and-models). Using the appropriate tab, you can generate a pollution reduction estimate for near-shore losses. This TSS and TP value can be manually added to the overland runoff estimates generated by P8 or WinSLAMM. If using this approach, include the methodology and assumptions in the SWA report. See example below for how the data could be organized in the report.

FL01-N11 – MAP of Priority Shoreline Catchment 105

Overall Rank (incl. Street Sweeping and Typ. Shorelines): **19/64**
BMP Only Rank (Priority Shorelines and Non-Shoreline BMPs *only*): **2/30**

Notes: Densely arranged, 65-100' wide lots with signs of erosion and some ice heave. All Shore Segments of Priority Shoreline Catchment 100 are showing some signs of bank failure. Shore Segment 16 and 17 exhibit losses of 6" lateral recession and 6" vertical loss. Shore Segment 18 shows losses of 12" lateral recession and 12" vertical loss. Shore Segment 19 shows the heaviest losses of 24" lateral recession and 24" vertical loss. Losses likely occurred over a shorter duration than the typical assumption of 10 years, but actual duration of losses cannot be determined without consultation with landowner (modelled at 10yrs). ***Shore Segment 19 should be one of the highest priority individual shorelines in the study area.***

PRIORITY CATCHMENT 102 to 105 - SUMMARY										
			WinSLAMM Reductions			BWSR Erosion		TOTAL LOAD REDUCTION		
SubCatch ID	# lots	Subcatch Area (acres)	WQV	TSS	TP	TSS	TP	WQV	TSS	TP
102	3	0.393	7003	46	0.14	1260	0.630	7003	1306	0.77
103	5	0.565	8753	64	0.21	9520	4.760	8753	9584	4.97
104	3	2.467	19658	261	0.61	1800	0.900	19658	2061	1.51
105	4	0.524	6174	58	0.22	2440	1.220	6174	2498	1.44
	TOTAL	3.949					TOTAL	41588	15449	8.686

Above: *Example of shoreline catchment that includes both WinSLAMM and BWSR Spreadsheet data.*

Desktop Preparations for Field Work

After desktop analysis is completed, field maps must be prepared for field work. Depending on the size of the subwatershed area and available budget; fieldwork and maps should be focused on the prioritized catchments. Prioritize field work by identifying catchments that need the most field verification, that have the most potential for retrofitting, that are direct drainage to priority waterbody, etc.

Field maps should include base data layers such as: air photos, topographic contour lines, catchment lines, parcel lines (differentiate between public and private ownership), public right-of-way, political divisions, storm sewer infrastructure, and land use. Have at least two pages per catchment – having all the data needed for field navigation and analysis and another page with basic information (parcel lines, storm sewer infrastructure, roads, etc.) to write down field codes/notes. Often one map set will have contours for visual verification, then the other set will be without contours so it is cleaner to write notes on.

Experienced BMP designers should scan the GIS data looking for clues in the landscape that may suggest certain BMP practice locations (see table 1 in Step 2 above). Potential BMPs should be noted on the maps for field verification. It is common to mark these points in GIS so that the point can carry over if the BMP is in fact retained as a viable practice. If potential projects are identified within the Right of Way, utility maps can help further vet potential project locations.

An alternative to field collection on printed maps includes working with Arc Collector and Survey 123. This way, if you have a mobile device that has cellular data and GIS location capabilities then you can create a field-form with standardized presets based on each BMP type and size. This allows for streamlining of critical modelling and design information that will be used in WinSLAMM or P8, later in the process. Entering data via a mobile device can save some time on the back-end and eliminate the need to transcribe handwritten field notes. Having mobile data entry also allows for immediate entry of critical information that may be lost or forgotten, since it is common that you may not be able to transcribe your field notes into GIS until a week or two after your field visits.

Finally, before entering the field, you may need to send out mailings to inform landowners and residents that your organization will be conducting site visits for water quality improvements. State the reason for the study, alert them to the dates, and give relevant contact info for questions. This is especially important if there are multiple sites that are deep within private property boundaries and likely cannot be seen from the road (you need to walk onto the property to see the site). Giving ample time for landowners to respond is critical and these mailers should be sent at least 3-4 weeks in advance of your anticipated field visits.

Step 3: FIELD INVESTIGATION

After identifying potential retrofit sites through the desktop search, a field investigation is conducted to evaluate each site. In the field, you will test design assumptions and identify factors that can negatively impact the BMP design. Site constraints are assessed to determine the most feasible BMP retrofit options as well as eliminate sites from consideration. Issues with micro-grading, incorrect catchment boundary delineation, conflicts with utilities, or catchbasins that are too shallow to plug an underdrain into are all items that can be verified in the field and used to eliminate projects from contention. During the investigation, the drainage area and stormwater infrastructure mapping data are verified. The field investigation may also reveal additional retrofit opportunities that could have gone unnoticed during the desktop search.

Public right-of-way and public land within priority catchments are often used as a starting point for visual assessment. There may be a need for a second and third visit into the field. There are often new BMP locations that were identified during the Desktop or Field Analysis steps, but they could not be seen from the road or from adjacent public areas. These landowners should be contacted via mailers to alert them to your desire to visit the site at a specified later date. You can also give the landowner the option of meeting with you personally if you determine the project is important enough to garner some early buy-in from the landowner.

Field Work Procedures

Materials Needed: Base maps with required data, field codes (optional), colored pens, camera, GPS (optional), 100' tape, 25' tape, catchbasin grate lifter, flashlight, credentials and business cards, construction-colored field vest, marked vehicle

Minimum Data for Field Maps: Air photos, topographic contour lines, catchment lines, parcel lines (differentiate between public and private ownership), public right-of-way, political divisions, storm sewer infrastructure, land use, soils information (can be on a subwatershed overview page), areas of interest for field checks.

Field Map Size: 11" x 17" field maps work best for use in the field.

Procedure:

1. Create hardcopy base maps. Base maps are needed for all land area within each priority catchment. Map scale should be no greater than 1 inch = 300 feet for proper interpretation of site features (smaller scale may be used). Each printed map should display the following: aerial photo, parcels, contours, and roads – this map is to be used for taking field notes. An overall large-scale location map is needed, showing the area covered by each base map.

2. Identify all potential viewing areas to visit for each base map (typically public roadways and public property). Is it a drive-by of all locations? Or, are there opportune spots on adjacent lands where you can view certain sites that are too far from the road to be seen from a vehicle? Are there locations that you had a question about before you could determine if a BMP is feasible. Mark those as a location to visit.

3. Take legible field notes (using a dark-colored pen); record site characteristics, potential BMP locations, stormwater infrastructure locations, pour points, and any other pertinent information. Record critical locations using GPS (approximate locations by sketching on base maps).

4. Scan field notes and create a digital file for all field-checked areas.

5. Maintain a list of probable high-priority project areas not observable from public roadways or public property for individual follow-up site visits. Create a standardized packet of information for landowners that includes a description of the project, a map of the site, information about potential BMPs and cost-share grants available, and other pertinent information. Conduct follow-up site visits with landowners.

6. For all potential BMP locations, evaluate cost-benefit potential. Using simple evaluation methods, staff will determine the expected P reduction due to BMP installations.

7. Critical Inputs for BMPs: BMP Location, BMP Type; BMP footprint area; BMP depth; BMP drainage area;

8. Potential Inputs for BMPs: Underdrain needed for raingardens? Nearby catchbasin depth acceptable for connecting underdrains? Is a wall needed? Utility conflicts requiring relocation? Other site-specific notes that will impact the design?
    a. Many items will determine BMP feasibility and can have a dramatic increase on the cost. Not all raingardens are equal and it will create a more accurate cost-benefit ranking if you consider these costs while in the field, before the modelling and ranking phase.

Step 4 - TREATMENT/COST ANALYSIS

It must be decided (prior to this phase) which method of comparison will be most useful for the report structure:

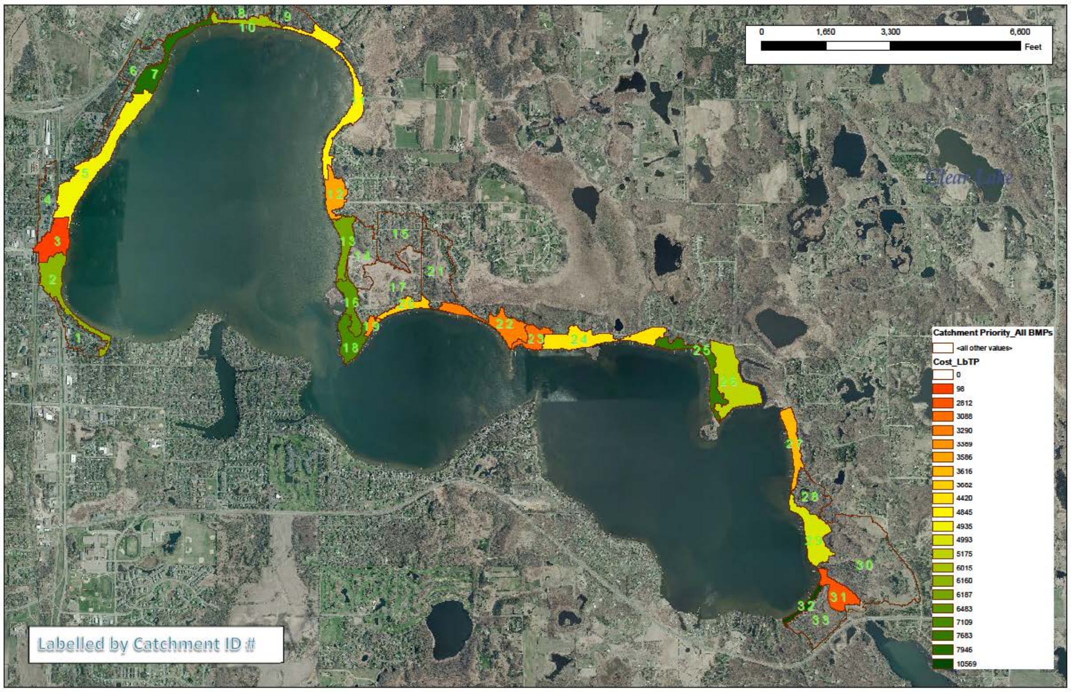
- Option 1: Compare individual BMPs against each other, regardless of catchment location
- Option 2: Compare overall catchments and their collective load reductions.

Option 1: This is the preferred strategy overall, regardless of TMDL status of the waterbody. Often, there is no specific load reduction target other than the goal of overall, measurable improvement in the waterbody. This method is also useful for areas that are extremely limited in good locations for BMPs. Downtown Stillwater, Minnesota would be a great example of an area with limited BMP opportunities. There are tight lots, odd ROW boundaries, poor soils, steep slopes, DWSMA and wellhead protections areas, and karst geology. There are not many opportunities to implement BMPs so you essentially take what you can get; and then compare them against each other to see which BMPs rank as the best cost for the most pollution reduction.

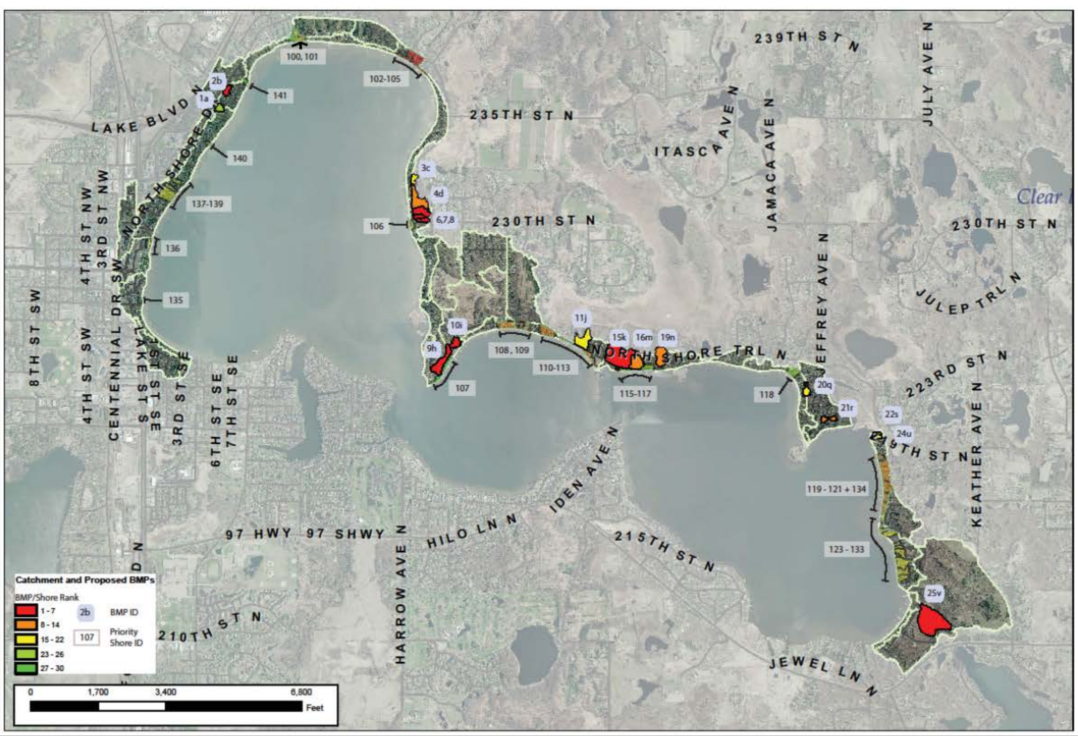
Option 2: This option is most beneficial if a TMDL has been assigned to the waterbody and multiple cities are involved; where each city has been assigned their own individual wasteload allocations. If the TMDL states that the individual community needs 100lbs of TP reduction to the waterbody, then the goal should be to find the largest offending catchments, and then model scenarios of alternative levels of BMP implementation that allow you to achieve 100lbs of TP reduction. Then you would rank the overall cost/benefit of implementing those BMPs in each catchment collectively. Using this approach does not rule out the need to compare the benefits of individual BMPs. Even though the report will be structured in response to the TMDL and catchment wide goals, the accompanying table of ranked individual BMPs will still be vital. There may be a situation where a great BMP is located in a catchment that may not be ranked very high itself. Nevertheless, the BMP would still be of a great cost-benefit to the waterbody. For this type of report, the individual BMP ranking table can reside in the Appendix. See examples below:

Prioritized Rankings by Catchment - rank of stormwater catchments referred to in this report

(prioritized by overall $Cost/Lb of TP removed over 10 years, if all proposed BMPs are implemented in each catchment).



Ranking map of locations of standalone projects referred to in this report. This map only includes BMP locations and Priority Shoreline Catchment Locations (ranking table on preceding pages 5-7). Street Sweeping and Typical Shoreline Restorations are excluded. The 'Catchment Profiles' section provides additional detail on these projects. See Appendix C for concept designs of all identified standalone projects.



Top: *Example of Catchments ranked against each other if ALL BMPs were to be implemented in each catchment.*
Bottom: *Example of BMPs (and their associated drainage areas) ranked by BMP cost-benefit. Here the color of each BMP catchment matches the ranked list, where groupings of BMPs are further categorized in groups ranging from High to Low priority.*
Below: *Ranked list of BMPs that supports the map in the Bottom Image (above)*

Stormwater Retrofit Ranking by BMP Cost Effectiveness

Project Rank	Catchment ID FL01-Nx	Retrofit Type (refer to catchment profile pages for additional detail)	# Projects Identified	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Total Project Cost	$Cost/ lb-TP/year (10-year)
21	N18	BMP 9h - BioInfiltration Simple	1	0.42	185	0.29	$4,567	$2,409
22	N19	BMP 10i - BioInfiltration Mod Complex	1	0.69	279	0.46	$15,026	$2,451
23	N31	BMP 25v - IESF Bench Retrofit	1	0.83	15	0.00	$18,339	$2,812
24	N12	BMP 6g,7f,8e - Retention Swales and BioInfiltration Mod Complex	3	1.14	455	0.61	$21,022	$2,831
25	N20	Priority Shoreline 108, 109	7	2.49	2588	0.86	$47,479	$3,094
26	N24	BMP 19n - BioInfiltration Simple	1	0.32	105	0.23	$5,432	$3,153
27	N12	BMP 4d- BioInfiltration Simple	1	0.45	182	0.33	$9,049	$3,322
28	N22	Priority Shoreline 110, 111, 112, 113	18	8.21	10892	1.65	$167,549	$3,334
29	N26	BMP 21r- BioInfiltration Simple	1	0.31	137	0.18	$7,026	$3,454
30	N24	BMP 16m - BioInfiltration Simple	1	0.27	109	0.23	$5,346	$3,620
31	N27	Priority Shoreline 119, 120,121,122,134	22	7.03	6914	2.00	$159,016	$3,683
32	N26	BMP 20q - BioInfiltration Simple	1	0.17	77	0.11	$4,481	$3,739
33	N27	BMP 24u - Swale Inlet and Raingarden Outfall Modification	1	0.07	46	0.05	$2,620	$3,743
34	N10	Priority Shoreline 101	3	1.12	1543	0.42	$29,489	$4,296
35	N5	Priority Shoreline 136-140	10	2.15	2735	1.05	$61,600	$4,655
36	N12	Priority Shoreline 106	3	0.97	1535	0.10	$27,704	$4,674
37	N22	BMP 11j - BioInfiltration Mod Complex	1	0.66	247	0.38	$18,113	$4,790
38	N29	Priority Shoreline 123 to 133	12	5.13	6106	1.75	$150,705	$4,822
39	N11	BMP 3c - BioInfiltration Mod Complex	1	0.36	152	0.16	$14,305	$4,951
40	N27	Shoreline Restorations-Typ Participation Rates	3	0.60	240	0.27	$16,698	$5,051
41	N7	Priority Shoreline 100 & 141	3	0.87	1243	0.33	$27,403	$5,138
42	N24	Priority Shoreline 115, 116, 117	11	2.04	1078	0.63	$70,523	$5,612
43	N25	Priority Shoreline 118	3	0.80	993	0.33	$27,704	$5,623
44	N7	BMP 1a - Parking Lot Retrofit	1	0.44	53	0.77	$22,506	$6,082

The cost/benefit analysis and modelling must be based on a comparison of pre-BMP installation versus post-BMP installation scenarios (choose P8 or WinSLAMM). There will be an Existing Conditions model with existing BMPs and waterbodies included. Then there will be a Proposed Conditions model that integrates all of the proposed BMPs you have identified.

Rank catchments or BMPs using cost/benefit analysis (cost table provided; can be modified to use local cost data). Estimated costs should include design, installation, and maintenance - annualized across a 10 or 30-year period (chosen by the most common BMP). Estimated benefits can be pounds of phosphorus removed, total suspended solids removed, volume removed, or another pollutant of concern. Most commonly it is TSS or TP. Also, even if the primary target is perhaps TSS, it is good to include alternative rankings by TP or volume in the Appendices. This decision is left to the primary partner on which cost-benefit rankings they would like to see in the final report.

Treatment analysis

Each proposed project's pollutant removal estimates must be estimated using a water quality stormwater model such as P8 or WinSLAMM. Both models are useful for determining the effectiveness of proposed stormwater control practices, but they are slightly different in how they are built and operate. WinSLAMM has been preferred by Twin Cities SWCD's because it uses an abundance of stormwater data from the upper Midwest and elsewhere to quantify runoff volumes and pollutant loads from urban areas. It has detailed accounting of pollutant loading from various land uses and allows the user to build a model "landscape" that reflects the actual landscape being considered. The user is allowed to place a variety of stormwater treatment practices that treat water from various parts of this landscape. It also uses rainfall and temperature data from a typical year, routing stormwater through the user's model for each storm.

An *Existing Conditions model* should be constructed to estimate pollutant loading from each catchment in its present-day state, considering existing stormwater treatment. To accurately model runoff volumes and pollutant loading and runoff, you have to consider the impervious and pervious makeup of each catchment. WinSLAMM utilizes different Standard Land Uses to model these different impervious to pervious ratios. P8 utilizes Curve Numbers to help define these ratios. In both situations, assigning either a Land Cover classification or delineating impervious and pervious cover across your entire project area in GIS will be a necessary step in order to construct your stormwater model.

If the project area is in Minnesota, making use of the Minnesota Land Cover Classification System (provided by the MN Dept of Natural Resources) can assist in assigning Land Cover Classifications to your project area. The dataset has predefined CN values that you can use for inputs into P8. The MCD also has an amended MLCCS GIS dataset (available through the Washington Conservation District) where portions of the metro area have been reassigned to reflect WinSLAMM's Standard Land Use codes. This makes modelling much easier since the land uses have already been recategorized for use in WinSLAMM.

The *Proposed Conditions model* should use the Existing Conditions model as its base. Then there are two ways in which you can enter proposed BMPs into your Existing Conditions model. 1) Insert BMPs directly into the Existing Conditions model, where the proposed BMP catchments have already been considered in the construction of the Existing Conditions model. This means that either you have anticipated all of your proposed BMPs and catchment areas ahead of this step, or you will have to rebuild the Existing Conditions model to reflect your new proposed BMP catchments and locations. This can be time consuming in a large model, but it is a viable method. 2) If the proposed BMP catchments have not been considered and previously built into in the Existing Conditions model, then it would be appropriate to model the BMPs individually (in separate WinSLAMM models). Then, the pollutant load reductions can be deducted from the Existing Conditions model in Excel. This way you do not have to rearrange your Existing Conditions model in order to accommodate your proposed BMPs and their respective catchment areas. Rearranging the model can easily over-complicate and corrupt your model, especially in WinSLAMM. If using this approach, ensure that both the BMP and the Existing Conditions models are equally constructed so that they both accurately reflect the real-world conditions of the proposed BMP catchment area (percent impervious area cover and soil types are the most critical).

Cost Estimates

Cost estimates should be based on annualized costs that incorporated design, installation, installation oversight, and maintenance over a 10 or 30-year period (depending on lifecycle of BMPs proposed). In cases where promotion to landowners is important, such as rain gardens, those costs should be included as well. In cases where multiple, similar projects are proposed in the same locality, promotion and administration costs can be estimated using a non-linear relationship that accounts for savings with scale. Design assistance from an engineer is assumed for practices in-line with the stormwater conveyance system, involving complex stormwater treatment interactions, or posing a risk for upstream flooding. Cost estimates should reflect the level of design that is being considered, and assumptions should be documented in the report. For instance, you can choose to model cost on a conceptual design level; where costs may not consider the intricacies of a specific site. While this is not the best option for evaluating BMPs, it is often the budget-conscious choice for the SWA if there are large project areas or where hundreds of BMPs are being considered. The other option is to model costs based on construction feasibility; where essential design parameters have already been considered and it is possible to know whether an underdrain is technically feasible, a utility needs to be relocated, or wall is needed due to steep grades. This allows for more accurate cost estimation and becomes a much more helpful tool for making implementation decisions down the road. In general, if a more detailed design and cost estimate for each BMP can be attained within the SWA scope and budget then it should be pursued.

Evaluation and Ranking

A table that ranks each BMP based on its cost benefit value is a required component of the SWA report. For instance, you have determined that the cost per pound of phosphorus treated is the most important for your report. Your table will include a ranked list of BMPs, their ID number or name, the BMP type, the total project cost (including design, O+M annualized costs), and the cost/lb of TP removed per year. See table below for an example of what information should be included, as well as what optional data could be included depending on what deliverables your partners would like to see. Notice that this table ranks by cost per pound of TP removed, but also includes the cost per ton of TSS removal (which is not ranked).

Project Rank	Catchment ID FL01-Nx	Retrofit Type (refer to catchment profile pages for additional detail)	Projects Identified	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Total Project Cost	Estimated Annual Operations & Maintenance (2012 Dollar	Estimated cost/ lb-TP/year (10-year)	Estimated cost/ ton-TSS/year (10-year)
1	N23	BMP 15k - BioInfiltration Simple	1	0.7	102.0	0.2	$6,728	$315	$1,399.15	$19,369
2	N11	Priority Shoreline 102,103,104,105	15	8.69	15,449	1.0	$96,850	$6,037	$1,810.07	$2,035
3	N7	BMP 2b - Vegetated Swale	1	0.14	53	0.0	$1,620	$132	$2,084.96	$11,094
4	N18	BMP 9h - BioInfiltration Simple	1	0.42	185	0.3	$4,567	$563	$2,409.46	$11,018
5	N19	BMP 10i - BioInfiltration Mod Complex	1	0.69	279	0.5	$15,026	$200	$2,451.00	$12,205
6	N31	BMP 25v - IESF Bench Retrofit	1	0.83	15	0.0	$18,339	$500	$2,811.96	$311,190
7	N12	BMP 6g,7f,8e - Retention Swales and BioInfiltration Mod Complex	3	1.14	455.0	0.6	$21,022	$1,125	$2,830.85	$14,185
8	N20	Priority Shoreline 108, 109	7	2.49	2,588	0.9	$47,479	$2,960	$3,094.32	$5,957
9	N24	BMP 19n - BioInfiltration Simple	1	0.32	105	0.2	$5,432	$450	$3,153.02	$18,918

Above: *Table ranked by total cost per pound of TP removed annually over 10 years. Highlighted fields are minimally required fields to include in the ranking table of a SWA report.*

Step 5 - SUBWATERSHED ANALYSIS – FINAL REPORT

The SWA Final Report is a physical document that is assembled to act as a stand-alone report including all pertinent information to conduct the analysis and install prioritized BMPs. The report must have a structure containing the following information:

1. **Executive summary -** Include Map of BMPs and Catchments and the Ranking Table as part of the executive summary. Briefly describe existing conditions of watershed, what pollutants are being targeted, mention any TMDLs or LGU planning documents that are driving the process for improving the waterbody. Describe brief summary of findings such as number of BMPs, difficulties in locating BMPs, unique features that drove key decisions.

2. **Required maps –** Project Area Map showing all subcatchments and catchment connectivity (one map or diagram showing flow routing between all catchments and receiving water). Can be separate maps or one single map. Include in the Executive summary as well as in the Appendix or body of report (as appropriate).

3. **Catchment and associated BMP descriptions**- One Catchment Profile for each priority catchment must include pertinent catchment characteristics, written description of existing conditions, catchment overview map showing potential BMP locations, and description of potential BMPs. Include a short description of each BMP and pollution reduction benefit. Table of key model outputs should be included in catchment summary, and each BMP profile should have a table describing the BMP's individual cost, cost-benefit value (rank is optional), and pollutant reductions.

4. **Appendix**
    a. **Local cost assumptions and documentation** – Provide a description of costs used for each BMP in the appendix. Any other cost assumptions should be documented as well, especially those that may be useful to a user who reads the report years later.

    b. **Protocol for analysis (field and desktop)** - Modelling methodology and basic design assumptions of each BMP described in the report, and references.

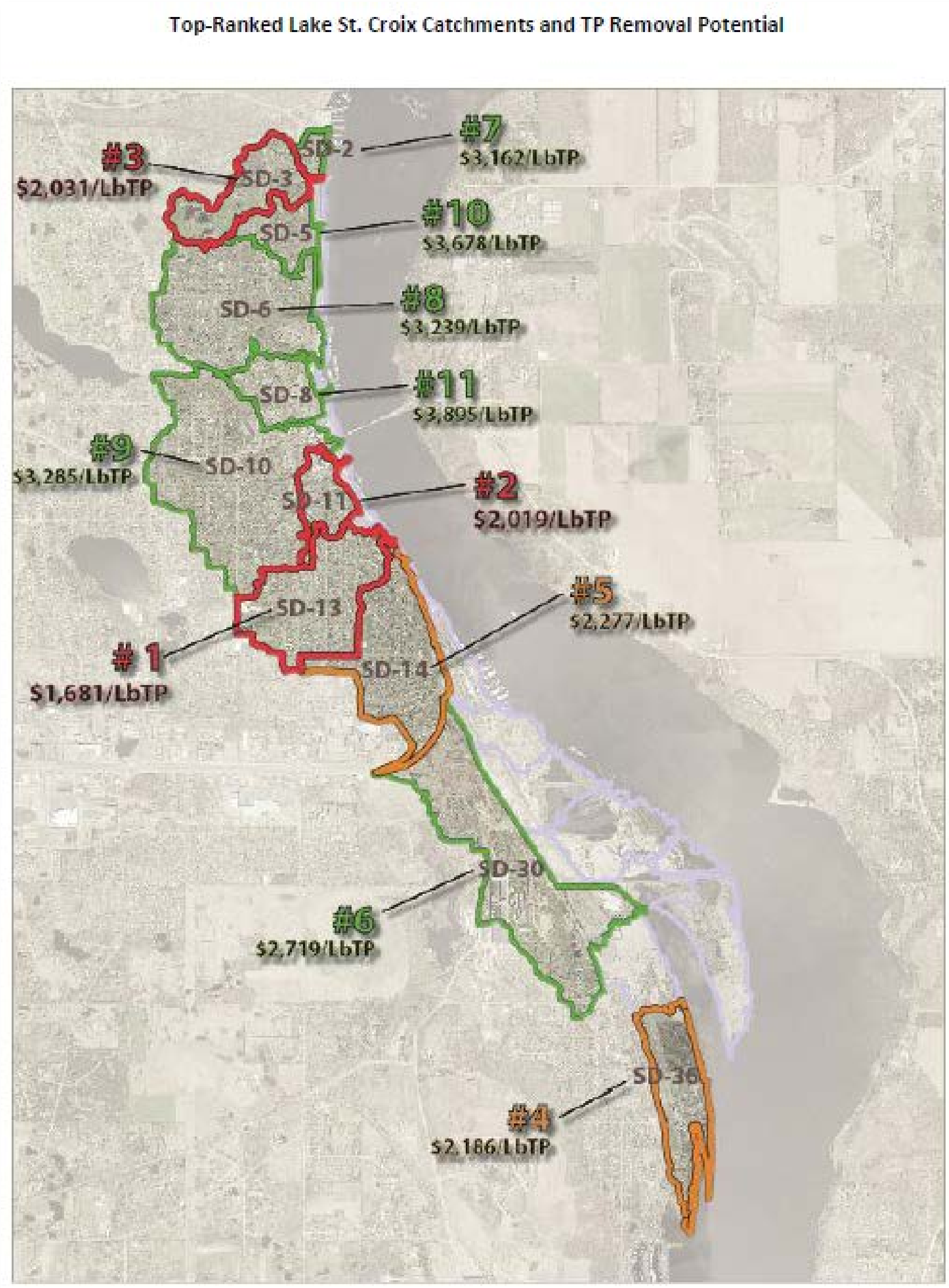
<u>SEE BELOW FOR GRAPHIC EXAMPLES OF KEY REPORT REQUIREMENTS</u>

1. **Executive summary -** Include Map of BMPs and Catchments and the Ranking Table as part of the executive summary (SEE "2. Required Maps"). Briefly describe existing conditions of watershed, what pollutants are being targeted, mention any TMDLs or LGU planning documents that are driving the process for improving the waterbody. Describe brief summary of findings such as number of BMPs, difficulties in locating BMPs, unique features that drove key decisions.

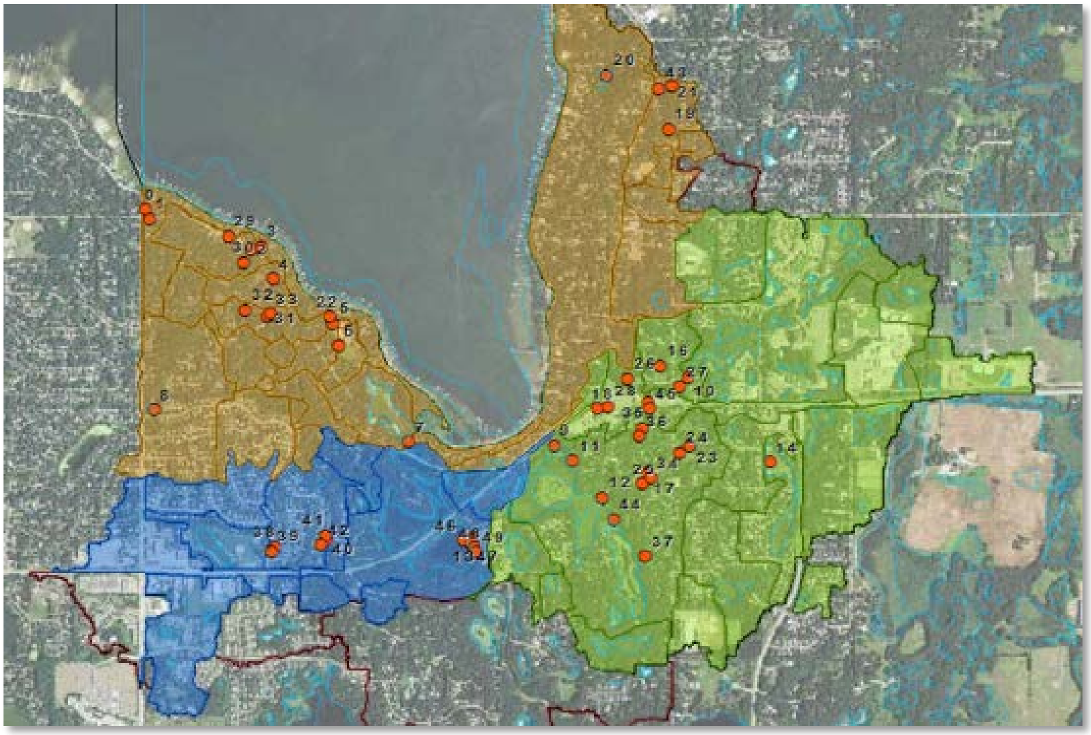
2. **Required maps –** Project Area Map showing all subcatchments and catchment connectivity (one map or diagram showing flow routing between all catchments and receiving water). Can be separate maps or one single map. Include in the Executive summary as well as in the Appendix or body of report (as appropriate). See examples below.

Catchment Map - Required: Show each catchment boundary analyzed in the study.

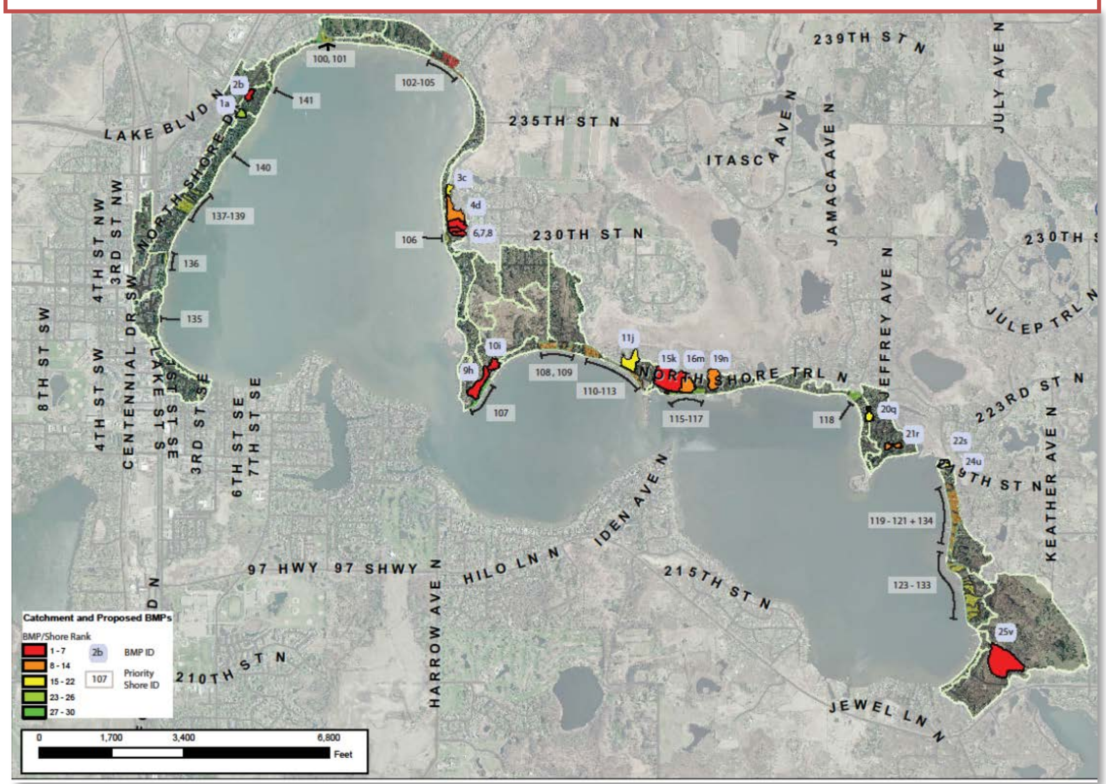
Optional: Rank each catchment by pollutant capture potential if all proposed BMPs were to be installed (shown here), Rank each catchment by existing pollutant loading (which catchments were most important for pollutant load reduction and BMP consideration), etc.



BMP Location Map - Required: BMP point with BMP Name at approximate location



BMP Location Map – Optional: ranking of BMP which is color coded by rank -or- BMP point is replaced with BMP catchment boundary (shown below, to better illustrate rank and location of each BMP)



BMP Ranking Table - Required: BMP Name, Catchment in which it resides, BMP Cost-Benefit Rank, Pollutant being ranked, Project Cost used for ranking,

Optional: Additional pollutants of concern (for reader reference), maintenance costs, # of projects identified (if multiples of same BMP type), page number where BMP is located in the report, etc.

Stormwater Retrofit Ranking by BMP Cost Effectiveness

Project Rank	Catchment ID FL01-Nx	Retrofit Type (refer to catchment profile pages for additional detail)	# Projects Identified	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Total Project Cost	$Cost/ lb-TP/year (10-year)
21	N18	BMP 9h - Bioinfiltration Simple	1	0.42	185	0.29	$4,567	$2,409
22	N19	BMP 10i - Bioinfiltration Mod Complex	1	0.69	279	0.46	$15,026	$2,451
23	N31	BMP 25v - IESF Bench Retrofit	1	0.83	15	0.00	$18,339	$2,812
24	N12	BMP 6g,7f,8e - Retention Swales and Bioinfiltration Mod Complex	3	1.14	455	0.61	$21,022	$2,831
25	N20	Priority Shoreline 108, 109	7	2.49	2588	0.86	$47,479	$3,094
26	N24	BMP 19n - Bioinfiltration Simple	1	0.32	105	0.23	$5,432	$3,153
27	N12	BMP 4d- Bioinfiltration Simple	1	0.45	182	0.33	$9,049	$3,322
28	N22	Priority Shoreline 110, 111, 112, 113	18	8.21	10892	1.65	$167,549	$3,334
29	N26	BMP 21r- Bioinfiltration Simple	1	0.31	137	0.18	$7,026	$3,454
30	N24	BMP 16m - Bioinfiltration Simple	1	0.27	109	0.23	$5,346	$3,620
31	N27	Priority Shoreline 119, 120,121,122,134	22	7.03	6914	2.00	$159,016	$3,683
32	N26	BMP 20q Bioinfiltration Simple	1	0.17	77	0.11	$4,481	$3,739
33	N27	BMP 24u - Swale Inlet and Raingarden Outfall Modification	1	0.07	46	0.05	$2,620	$3,743
34	N10	Priority Shoreline 101	3	1.12	1543	0.42	$29,489	$4,296
35	N5	Priority Shoreline 136-140	10	2.15	2735	1.05	$61,600	$4,655
36	N12	Priority Shoreline 106	3	0.97	1535	0.10	$27,704	$4,674
37	N22	BMP 11j - Bioinfiltration Mod Complex	1	0.66	247	0.38	$18,113	$4,790
38	N29	Priority Shoreline 123 to 133	12	5.13	6106	1.75	$150,705	$4,822
39	N11	BMP 3c - Bioinfiltration Mod Complex	1	0.36	152	0.16	$14,305	$4,951
40	N27	Shoreline Restorations-Typ Participation Rates	3	0.60	240	0.27	$16,698	$5,051
41	N7	Priority Shoreline 100 & 141	3	0.87	1243	0.33	$27,403	$5,138
42	N24	Priority Shoreline 115, 116, 117	11	2.04	1078	0.63	$70,523	$5,612
43	N25	Priority Shoreline 118	3	0.80	993	0.33	$27,704	$5,623
44	N7	BMP 1a - Parking Lot Retrofit	1	0.44	53	0.77	$22,506	$6,082

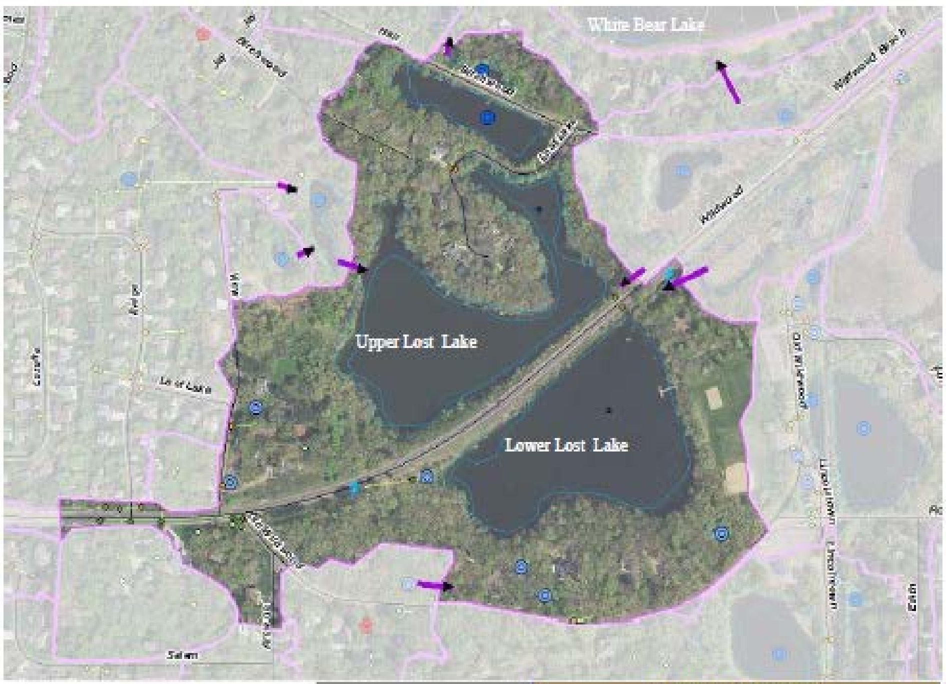
3. **Catchment descriptions**- One Catchment Profile for each priority catchment must include pertinent catchment characteristics, written description of existing conditions, catchment overview map showing potential BMP locations, and description of potential BMPs. Include a short description of each BMP and pollution reduction benefit. Table of key model outputs should be included in catchment summary,

and each BMP profile should have a table describing the BMP's individual cost, cost-benefit value (rank is optional), and pollutant reductions.

Catchment Summary Page (below) - Required: Catchment Map (w/Flow Arrows connecting adjacent catchments), Catchment Existing BMPs and existing load summaries, brief description of catchment cover, conditions, and existing BMP treatment.

Optional: Describe unique features that would impact design of BMPs such as DWSMA and groundwater protection rules, karst features, bedrock outcrops, excessive slopes, poor soils, etc.

Catchment LOST-01



Existing Catchment Summary	
Acres	82.59
Dominant Land Cover	MDRNA
Volume (acre-feet/yr)	20.97
TP (lb/yr)	31.16
TSS (lb/yr)	10,315

	Existing Conditions	EXISTING CONDITIONS			
		Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	31.7	3.5	11%	**28.3**
	TSS (lb/yr)	13,408	1,247.0	9%	**12,161**
	Volume (acre-feet/yr)	20.97	0.0	0%	**21.0**
	Number of BMP's				
	BMP Size/Description				
	BMP Type	Street Sweep 2x annually, wooded storage			

CATCHMENT DESCRIPTION

Catchment LOST-01 is the direct drainage area contributing to Lost Lake. It is comprised of primarily medium to low density, single-family residential land use and has large tracts of wooded areas and steep slopes. There is much erosion around the slopes of the Lower Lost Lake, especially near the DNR fishing dock at Wildwood Park. The lake itself is typically connected via surface water to Lake Washington in normal to wet years.

EXISTING STORMWATER TREATMENT

Street sweeping of city streets and parking lots occur approximately twice annually. There are multiple natural depressions that add significant volume storage for smaller rain events. There are two recently repaired gully areas along the SW corner of the Lower Lost Lake at Wildwood.

BMP Summary Page (below) - Required: BMP Name and BMP Type, brief description of BMP

Optional: BMP rank that correlates with BMP ranking table (for ease of report navigation)

LOST-01: RETROFIT RECOMMENDATIONS

RANK 1/46 - **Increased Street Sweeping:** Increase Street Sweeping from 2x/year to 4x/year. This includes sweeping the parking lots that are adjacent to the main roads.

RANK 27/46 - **BMP 46: Irrigation Reuse:** Draw water from Lost Lake to irrigate fields at Wildwood Park.

RANK 28/46 - **BMP 47, 48, 49: Erosion Restoration on Lost Lake:** Repair severely eroded slopes and rethink pedestrian circulation and near-shore fishing opportunities near DNR fishing dock and along SE shoreline.

RANK 31/46 - **BMP 13: Infiltration Basin Above DNR Dock:** Repair shoreline headcut and install infiltration basin near wooded edge to minimize future shoreline erosion.

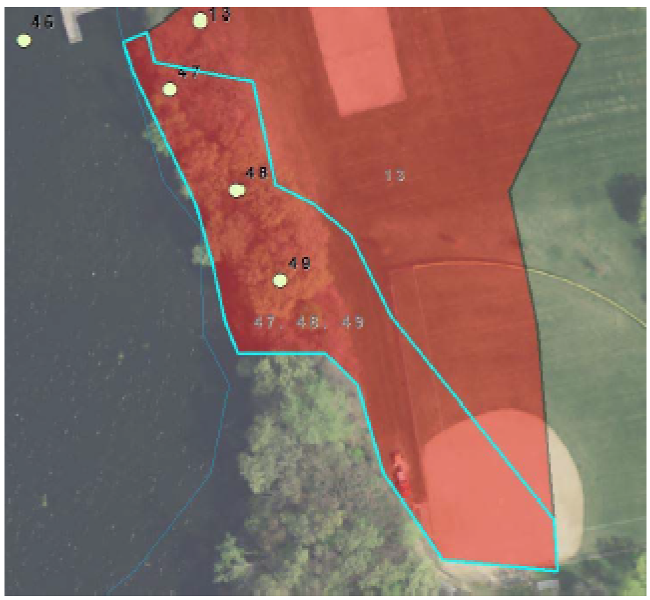
		RETROFIT OPTIONS									
		Catchment LOST-01									
Cost/Removal Analysis		Increased Street Sweeping to 4x per year		BMP 46: Irrigation Reuse; draw from Lost Lake		BMP 47, 48, 49: Erosion Restoration Lost Lake		BMP 13: Infiltration Basin Above DNR Dock		Total Reductions (all implemented)	
		New trtmt	Net %	New trtmt	Net %	New trtmt	Net %	New trtmt	Net %	New trtmt	Net %
Treatment	TP (lb/yr)	2.8	12%	2.5	11%	3.5	15%	0.8	3%	6.0	26%
	TSS (lb/yr)	1209	12%	0	0%	7400	n/a	155	2%	1364.0	13%
	Volume (acre-feet/yr)	0.0	0%	3.0	15%	0.0	0%	0.2	1%	3.2	16%
	Number of BMP's	1		1		1		1		1	
	BMP Size/Description	1.016	curb miles	2.930	acre	2,000	sf	1,000	sf	All Practices	
	BMP Type	Street Sweeping		Irrigation Reuse		Priority Lakeshore Restoration		Filtration Basin (Turf)			
Cost	Materials/Labor/Design	$383.74		$22,525.00		$28,000.00		$8,320.00		$59,228.74	
	Promotion & Admin Costs	$400		$400		$400		$400		$1,600.00	
	Probable Project Cost	$784		$22,925		$28,400		$8,720		$60,828.74	
	Annual O&M	$0		$300		$900		$20		$1,220.00	
	10-yr Cost/lb-TP/yr	$28		$1,052		$1,069		$1,189		$835	
	10-yr Cost/2,000lb-TSS/yr	$130		n/a		$1,011		$11,510		$4,217	

BMP Profile Page (below) - Optional: Individual BMP profile pages describing BMP design and site conditions in detail (budget permitting), BMP rank that correlates with BMP ranking table (for ease of report navigation), design assumptions and issues that may affect participation or cost, items for additional consideration to increase BMP effectiveness that may need additional feasibility studies or soil borings, etc.

LOST-01: BMP 47, 48, 49 – Erosion Restoration

Rank 28/46

Drainage Area – 0.74 acres
Location – Lost Lake shorelines near DNR dock at Wildwood Park
Property Ownership – Public
Description – This site has heavily eroding slopes that need to be stabilized as soon as possible. Site circulation should be redesigned to limit traffic in areas of bank failure and promote safe and efficient access to designated on-shore fishing spots south of the dock area. This project should be designed and installed in conjunction with the other proposed BMP projects at the park to maximize cost efficiencies and minimize further pedestrian impacts.



Cost/Removal Analysis		RETROFIT OPTIONS Catchment LOST-01 BMP 47, 48, 49: Erosion Restoration Lost Lake	
		New trtmt	Net %
Treatment	TP (lb/yr)	3.5	15%
	TSS (lb/yr)	7400	n/a
	Volume (acre-feet/yr)	0.0	0%
	Number of BMP's	1	
	BMP Size/Description	2,000	sf
	BMP Type	Priority Lakeshore Restoration	
Cost	Materials/Labor/Design	$28,000.00	
	Promotion & Admin Costs	$400	
	Probable Project Cost	$28,400	
	Annual O&M	$900	
	10-yr Cost/lb-TP/yr	$1,069	
	10-yr Cost/2,000lb-TSS/yr	$1,011	

4. **Local cost assumptions and documentation** – Provide a description of costs used for each BMP in the appendix. Any other cost assumptions should be documented as well, especially those that may be useful to a user who reads the report 10 years later. Also, it will be helpful to reference a recently completed SWA in your region for the most up to date cost projections. These can then be edited to fit your particular regional construction market or local cost assumptions.

BMP	Materials/Labor (Installation)	Unit	Description	Design	Promotion & Administrat	Annual Maintenance Cost	O&M Term	Inst. Cost ($/ft^2)
No Treatment								
Rain Leader Disconnect Rain Garden	$7.56	Square Foot						$4.00
24" RCP								
Filtration Basin (Turf)	$16.31	Square Foot						$15.00
Simple BioInfiltration	$20.00	Square Foot	(no engineered soils or under-drains, but w/curb cuts and forebays)					$20.00
Moderately Complex BioInfiltration	$28.00	Square Foot	(incl. engineered soils, no under-drains, curb cuts, forebays but no retaining walls)					$23.00
Complex BioInfiltration	$32.00	Square Foot	(as MCBI but with 1.5-2.5 ft partial perimeter walls)	$840	1470	$75 Each	30	$27.50
Moderately Complex BioFiltration	$40.00	Square Foot	(incl. engineered soils, under-drains, curb cuts, forebays but no retaining walls)					$40.00
Complex BioFiltration	$48.00	Square Foot	(as MCBF but with 1.5-2.5 ft partial perimeter walls)					$48.00
Highly Complex BioFiltration	$52.00	Square Foot	(as CBF but with partial perimeter 2.5-4 ft walls or shorter, complete perimeter walls)					$52.00
Impervious Cover Conversion	$21.71	Square Foot						$20.00
Curb-Cut	$80.00	Linear Foot						
Grass/Gravel Permeable Pavement	$18.95	Square Foot	(sand base)					$12.00
Permeable Asphalt	$10.80	Square Foot	(granite base)		$70*24	.023*SQFT	30	$10.00

Excerpt from a cost table used for a SWA. There are many more columns included that are not shown (admin cost/design cost/other lifecycle costs as necessary).

5. **Appendix -** Protocol for analysis (field and desktop), modelling methodology and basic design assumptions of each BMP described in the report, and references.

Appendix

1. *Example Project Scoping Document*

Subwatershed Assessment Stakeholder Meeting 1

Sample Subwatershed – EWD

I. Partners	
3.10.2011	1:00 - 3:00
Meeting called by	Washington Conservation District (WCD)
Type of meeting	Planning and Scoping
Facilitator	Pete Young (WCD)
Note taker	Jay Riggs (WCD)
Other Attendees	Amy Carolan (Example Watershed District), Andy Schilling (WCD), City of Stillwater

II. Needs and Capabilities Assessment	
1 hour	
Discussion	
Establish LGU interest level and regulatory drivers that will shape watershed goals and evaluate existing local retrofit capa city and needs.	
Conclusions	

1. Regulatory drivers
2. Data availability (GIS layers, monitoring info, reports, plans, etc.)
3. EWD, community capabilities: BMP Program, maintenance of stormwater infrastructure
4. Government and non-government partnerships
5. Residents' knowledge of water quality issues; common concerns (algae, water clarity, etc.)
6. Key community contacts: media, politicians, local groups/associations, local outreach opportunities
7. Funding resources (for assessment, outreach, and future projects)
8. Listed species of concern in subwatershed

Action Items	Person Responsible	Deadline
ITEM 1	WCD	ASAP
ITEM 2	WCD	ASAP
ITEM 3	EWD	DATE
ITEM 4	EWD	DATE
ITEM 5	CITY	DATE
ITEM 6	WCD	DATE

III. Existing Data Analysis	
20 minutes	
Discussion	
Define key problems and impairments in the watershed; target retrofit efforts to assist in shaping goals and objectives through analysis of historical data; identify quantity, quality and resolution of existing data and additional resources required.	

Data Needed or Revision	Task	Partner	Deadline
DATA NEEDED 1	OBTAIN	CITY	ASAP
DATA NEEDED 2	OBTAIN	EWD	ASAP
DATA NEEDED 3	OBTAIN	EWD	ASAP

Pollutant/WQ Problem of Concern	Partner
1. TP	EWD
2. Volume	CITY, EWD
3. TSS	CITY, EWD
4. Non-native/invasive vegetation	CITY, EWD
5. POLLUTANT 5	EWD

Action Items	Person Responsible	Deadline
Talk to City/Watershed to obtain shapefiles	WCD STAFF 1	ASAP
ACTION ITEM 2	MCD STAFF 1	ASAP
ACTION ITEM 3	WCD STAFF 2	ASAP

2: WinSLAMM and P8 Screenshots:

Example WinSLAMM 10 Catchment Routing View:

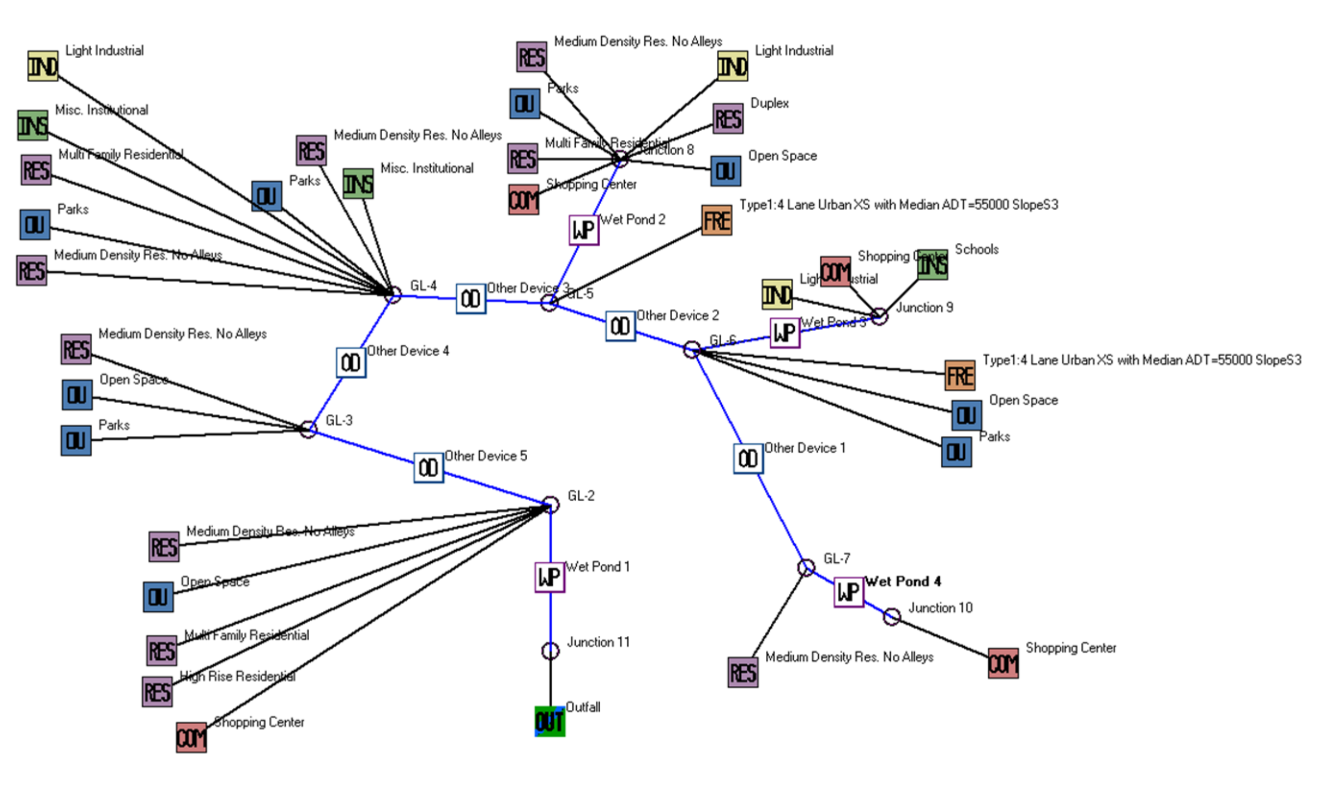


Image from Golden Lake Subwatershed Analysis – Anoka Conservation District

P8 Mass Balance Terms:

P8 online help guide

3. Example Field Investigation Codes

RRI SITE / PARCEL CODE SHEET

CODE	BMP
PND	Pond Retrofits
EXD	Extended Detention
WTP	Wet Pond
WET	Stormwater Wetland
INB	Infiltration Basin (regional treatment - e.g., recreational field with stormwater drained to it for infiltration)
SDC	Stormwater disconnect to pervious area
ICC	Impervious Cover Conversion
RBR	Rain Barrels
CIS	Cisterns
DWL	French Drain/Dry Well
WTS	Wet Swale (vegetated swale with no underdrain)
WQS	Water Quality Swale (Dry Swale (swale with filtration media and drain tile)
USF	Underground Sand Filter
SSF	Structural Sand Filter (a surface filter including peat, compost, iron amendments, or similar)
RDG	Rain Leader Disconnect Raingardens
BRA	Simple Bioretention (no engineered soils or under-drains, but w/curb cuts and forebays)
BRB	Moderate Bioretention (engineered soils, under-drains, curb cuts, forebays but no retaining walls)
BRC	Complex Bioretention (as BRB but with partial, or 1-3 ft retaining walls)
BRD	Highly Complex Bioretention (as BRB but with perimeter or 3-5 ft retaining walls)
STP	Stormwater Tree Pits
SP	Stormwater Planter
PPG	Grass/Gravel Permeable Pavement (sand base)
PPA	Permeable Asphalt (granite base)
PPC	Permeable Concrete (granite base)
PPP	Permeable Pavers (granite base)
EGR	Extensive Green Roof
IGR	Intensive Green Roof

CODE	SITE APROPRIATENESS BY FIELD INDICATOR
1	Prime: ideally situated within catchment, few physical constraints, little to no grading required, easy maint.
2	Alternate: a possible substitute for Prime location with oderate indicators
3	Poor: not suitable; porrly situated in catchment, too many constraints, extensive grading, difficult maint.

Example Site Code for RRI	
CODE	DESCRIPTION
1WQS	A perfect site/parcel for a Water Quality Swale
2BRB	An alternate site/parcel, after all Prime sitess have been pursued, for Moderate Bioretention
3	Do not pursue BMP placement of any type on this site/parcel