WATER BUREAU COMPLIANCE ASSISTANCE

Michigan Municipal Separate Storm Sewer System (MS4) Permit
Total Maximum Daily Load (TMDL) Elective Option

Introduction

The National Pollutant Discharge Elimination System (NPDES), Municipal Separate Storm Sewer System (MS4) permits require regulated public entities located within urbanized areas that discharge storm water from an MS4 to a water body designated with a TMDL to demonstrate progress toward meeting Water Quality Standards (WQS). If the TMDL was written for *E. coli* or total phosphorus, the MS4 permits further require permittees to collect representative samples of storm water discharges from their regulated MS4s to those water bodies.

However, the Watershed General Permit allows permittees to choose an "Elective Option," whereby the permittee develops a monitoring program, in conjunction with other watershed partners. The permit states:

"Permittees subject to monitoring… may elect to meet these requirements by working collaboratively with their watershed partners to implement a monitoring program within three years of COC issuance to evaluate the effectiveness of the overall activities in meeting water quality standards and determine priority areas for future implementation activities. The monitoring program shall be detailed in the SWPPI and assess the portion of the TMDL watershed in the urbanized area…"

Further, the permit continues with requirements regarding the design of the program.

"The design of the monitoring program shall be based on such factors as:

- Applicable approved TMDLs listed in the COC
- 303(d) listed waters
- TMDL findings
- Priorities in the watershed plan
- Results from the Illicit Discharge Elimination Program (IDEP)
- The availability of existing monitoring data"

This type of monitoring program may include ambient (surrounding water) monitoring instead of discharge (storm water pipe/outfall) monitoring; however, the goals must be preserved. The goals are to 1) assess the areas where there are approved TMDLs, 2) evaluate current implementation strategies for existing TMDLs, and 3) develop and prioritize actions to reduce the pollutants of concern.

The data collected during monitoring are used to understand what areas most likely contribute the pollutants of concern. After the initial study, additional monitoring may be necessary to further identify sources, or there may be enough information to effectively develop an implementation strategy to eliminate sources and continue to find additional sources.

The Department of Natural Resources and Environment (Department) recommends that permittees who opt to pursue the Elective Option use Part One of the Storm Water Sampling Guidance for Total Phosphorus & *E. coli* document to help develop the program, as there is more information regarding first flush, sampling equipment, safety, quality assurance, etc. A detailed study design carefully considers sample site location, sample collection numbers, collection methods, quality control procedures, and data interpretation

to ensure the success of a monitoring program. While more time consuming and costly up front, investing in a comprehensive monitoring plan will result in a more accurate, representative, and confident characterization of water quality, upon which future decisions can be based. The monitoring results will help permittees make sound storm water management and land use decisions and prioritize potentially expensive and intensive actions necessary to make progress towards meeting WQS.

Group Approach

Watershed permittees, required to monitor TMDL areas, are also required to work collaboratively if selecting the Elective Option. Moreover, permittees would benefit greatly by working together toward common goals. For instance, cost savings of a group approach may be significant if there are enough partners involved to pool resources, purchase supplies in bulk, and utilize appropriate staff expertise for the benefit of the whole. In addition, if there is no existing umbrella organization, developing such a group may provide a more structured, cohesive approach to the monitoring program.

An existing local organization, watershed group, or council could be used as the lead, or umbrella, for the monitoring program. Well developed watershed councils may already have the expertise in reviewing existing data, locating the appropriate sites for sampling, and designing a monitoring plan while at the same time having a vested interest in sustaining the program due to the mission of most councils.

Whether there are existing local organizations or watershed groups, permittees should start organizing through their storm water advisory committees developed under the last permit cycle. The committees can provide the direction for collaboration when developing a monitoring plan.

> One example of an existing organizational support program is through the Huron River Watershed Council (HRWC). This council has been providing MS4 permittees a menu of services for many years. The permittees working with the HRWC have benefitted through collaboration, branding, bulk savings, as well as through a successful grass roots effort in many areas of water quality, specifically phosphorus. For more information on the HRWC phosphorus program, go to www.hrwc.org/, click on Our Work > Middle Huron.

IDEP Results and Staff Involvement

In addition to permittee collaboration, the permit requires the basis of the monitoring program design include IDEP information. Under the IDEP, permittees should have finished dry-weather screening all discharge points/outfalls at least once during the last permit cycle, and the screening shall continue during the current permit cycle. Data collected during this process may be useful in developing the monitoring program. Collaboration with field staff involved in IDEP work will be invaluable with regard to potential monitoring site locations, hot spots, and catchments (sub-watersheds).

Existing Data

Existing data may help groups make better informed decisions and assist in developing the monitoring plan under the Elective Option. If appropriate, existing data may be used as a baseline to help find sources of problems. Ideally, baseline data includes a broad spectrum of constituents, as necessary, and is an evaluation of water quality over space and time. Data such as these can be used to analyze the basic water quality or help understand trends over time as well as evaluating the effectiveness of TMDL implementation actions or the storm water program in general. The documents and sources listed below are a starting point to gathering existing data. If there are no baseline data available, this is the time to consider a broader based monitoring program for such purposes.

1. Illicit Discharge Data – Results from the IDEP may help in narrowing down sources or hot spots for further investigation.
2. TMDL Report – These can be downloaded from the Department's Web site at www.michigan.gov/dnre, click on Water > Water Quality Monitoring > Assessment of Michigan Waters, then total Maximum Daily Loads. Most approved TMDLs identify and estimate the contributing land area percentages from municipalities as well as hot spots and potential sources.
3. Watershed Management Plans – If available, these plans may contain information such as pollutants, their causes and sources, as well as implementation actions.
4. Additional data from other agencies – Data from other sources should be investigated to determine usefulness. Staff familiar with the data should be consulted. Potential sources include:
   - Local health departments –Septic system programs and other surface water monitoring programs may have information regarding potential hot spots for E. coli discharges due to failing septic systems, direct hook-ups, or other sources.
   - DNRE – Various reports, data, or even upcoming monitoring plans may be available from the Department. The Department's Surface Water Assessment Section is one resource for historic data or plans for future monitoring. For more information on various monitoring programs, and online data, go to http://www.michigan.gov/dnre, click on Water > Water Quality Monitoring.
   - Watershed groups/councils – Watershed plans, as discussed above, are important documents that can help inform monitoring programs; however, additional data may be available. Involvement by local watershed groups/councils will help determine the data and background information available.
   - Volunteer monitoring – Additional available volunteer monitoring data should also be reviewed. Data may be through other monitoring groups, local school science classes, or colleges and universities. Watershed groups/councils may already have the contacts for these groups or a call to the local high schools, colleges, and universities may be necessary to find out if there is any monitoring done at that level. The Department has contact information for most volunteer monitoring programs, and the Michigan Clean Water Corps (MiCorps) has a directory of programs on their website at www.micorps.net.

The following questions should be considered when reviewing the various documents, data, and other information pertinent to developing a monitoring program.

- Where was monitoring conducted?
- What types of data were collected?
- Where might monitoring be needed?
- What areas exceeded WQS?
- What are the identified potential sources?
- Which sources are located within the MS4 regulated area?
- What implementation actions are identified to address the problem?

Design

The first critical step in designing an effective monitoring study is to produce a well-defined question related to the problem. Defining the question requires consideration of the spatial and temporal scope of the wet weather discharge(s) and the potentially impacted area. Spatial and temporal scale will drive the statistical rigor necessary, sampling techniques used, level of effort employed, and analysis and interpretation of the data.

Spatially, monitoring studies can be designed to assess conditions at a reach (a segment of a stream with identified start and end points), a sub-watershed (catchment), or a watershed scale. By way of example, a "reach" scale design is often used to assess the effectiveness of a Best Management Practice (BMP) or the environmental impacts of a specific discharge. A "sub-watershed" scale design is needed to evaluate the effectiveness of BMPs strategically placed throughout a portion of the watershed. Finally, a "watershed" scale design is required to evaluate the environmental impacts of a catastrophic storm event, the broad application of BMPs, or broad land use changes.

Given the variability of all storms, data from a single runoff event are of very limited use. For many wet weather study purposes it is desirable to sample at least five to ten runoff events of varying intensities and durations, spread over the seasons, which can equate to at least one or two years of sampling effort. In addition, some pollutants exhibit roughly predictable season patterns (e.g., chloride inputs in the late spring, or coliform bacteria during the summer and fall), which should be accounted for.

Pollutant concentrations are sometimes highest at the beginning of runoff (first flush). This is often true for small catchment areas of less then 400 acres and especially in smaller, paved areas (Law et. al., 2008) as well as for commercial and industrial land uses (National Research Council, 2008), but not in larger catchments where the highest pollutant loads are normally observed during peak flow. If first flush data are desired, collect samples within the first 30 minutes to one hour of the start of runoff.

If the interest lies in monitoring discharges of wet weather, the Department recommends utilizing the Storm Water Sampling Guidance for Total Phosphorus & *E. coli*. In addition, the Center for Watershed Protection (www.cwp.org) developed monitoring guidance specifically for storm water studies. The guidance is called *Monitoring to Demonstrate Environmental Results: Guidance to Develop Local Stormwater Monitoring Studies Using Six Example Study Designs*. The guidance has two example studies (Study Design 1 and 2) which would be especially useful in regard to developing a monitoring program through the elective option as they are geared toward "communities that are just starting up their storm water programs and need to determine the quality of runoff in the community and identify the land use types and source areas that contribute the most pollutants to receiving waters."

A monitoring program may also focus on ambient sampling to help identify and prioritize reaches, tributaries, outfalls, etc. for additional characterization of water quality parameters of concern. Monitoring of ambient waters can be designed to 'bracket' possible source tributaries, major outfalls or groups of outfalls, or other sources (e.g., known or suspected sites of contamination). This may be an especially appropriate approach if the TMDL catchment is large and more resolute sampling therefore too costly or otherwise logistically difficult. Adequate frequency, and concurrent sampling, upstream and downstream of these kinds of potential sources helps to identify reaches needing additional effort and follow-up monitoring and, similarly, may help remove reaches that do not appear to be sources.

Some monitoring studies aimed at evaluating implementation must be capable of assessing pre- and post-conditions, or comparing conditions at impacted and un-impacted (or less impacted) sites. This can be done either by using upstream/downstream sites or finding a representative paired site from a nearby watershed. The strongest study design to test the impact from a change in a watershed is a Before-After/Control-Impact (BACI), in which conditions are assessed both before and after a change has occurred, at both the potentially impacted site and at a control or reference site. Less rigorous, but still potentially useful, designs are either half of the BACI, a Before-After survey of the potentially impacted site, or a Control-Impact study of impacted and control sites after a potential impact. A BACI design provides the strongest data for BMP effectiveness studies, while a Before-After design can be adequate for trend and some BMP effectiveness studies.

If discharge point monitoring is selected as the preferred strategy, a focus on wet weather sampling is necessary. If ambient monitoring is used for initial assessment, monitoring across a range of flow conditions can yield an understanding of pollutant concentration dynamics.

It cannot be stressed enough that a well-designed study may require input from statistics and environmental sampling design experts. Input from these professionals from the start will lead to a more valid, defensible study and more meaningful analyses and interpretation of the data.

Permittees that wish to develop their own monitoring program should take these issues into consideration when designing it, whether for discharge or ambient monitoring. In addition, Department staff may be consulted for further design advice.

What to Monitor

The constituents to be monitored need to be based on the TMDL(s), whether *E. coli* or total phosphorus. It will be necessary to work with a professional laboratory to analyze water samples for the parameters. Review the Storm Water Sampling Guidance for Total Phosphorus & *E. coli* document for details on proper analytical procedures and sample collection techniques. It may also be useful to measure dissolved phosphorus. Measuring differences between or proportions of dissolved phosphorus and it's opposite – particulate phosphorus – can provide insight into sources. Erosive processes will tend to generate phosphorus concentrations in particulate form, as phosphorus binds to soil particles. Runoff from areas with excessive fertilizer is likely to yield higher dissolved phosphorus concentrations. Dissolved phosphorus concentrations can be obtained by filtering a standard water sample to remove suspended particulate matter. Soluble and particulate phosphorus are differentiated by whether or not they pass through a 0.45 micron membrane filter (Carlson and Simpson, 1996).

Flow should be measured or estimated at each sampling location. Similar to water sample collection, flow measurements can be performed manually or with automated equipment. Flow measurements can be made at the time of water sample collection or estimated from water level after establishing a water level-discharge rating curve. Water level can be determined by visual measurement in-stream using a staff gage or utilizing a water level data logger. If auto-samplers are used for water sampling during storm events, automated water level/discharge estimation will be necessary to allow for calculation of event mean concentrations (EMC). Flow is also used to calculate pollutant loadings and helps with interpretation of collected data.

Selecting Monitoring/Sampling Points

The size of the drainage area to be monitored, the number of tributaries in the area of interest, and critical areas or sources will influence the number and location of sampling sites. As mentioned in the design section, the ability to 'bracket' possible sources including tributaries, major outfalls or groups of outfalls, or other potential sources will help identify reaches needing further monitoring or attention.

The selection of sampling points is a multi-step process that involves desktop analysis and site visits. Utilization of land use maps, topographic maps, watershed plans, high-resolution aerial photographs, and storm water sewer system maps -- aided by GIS -- can greatly reduce the amount of field work necessary for the site selection process, as discussed further.

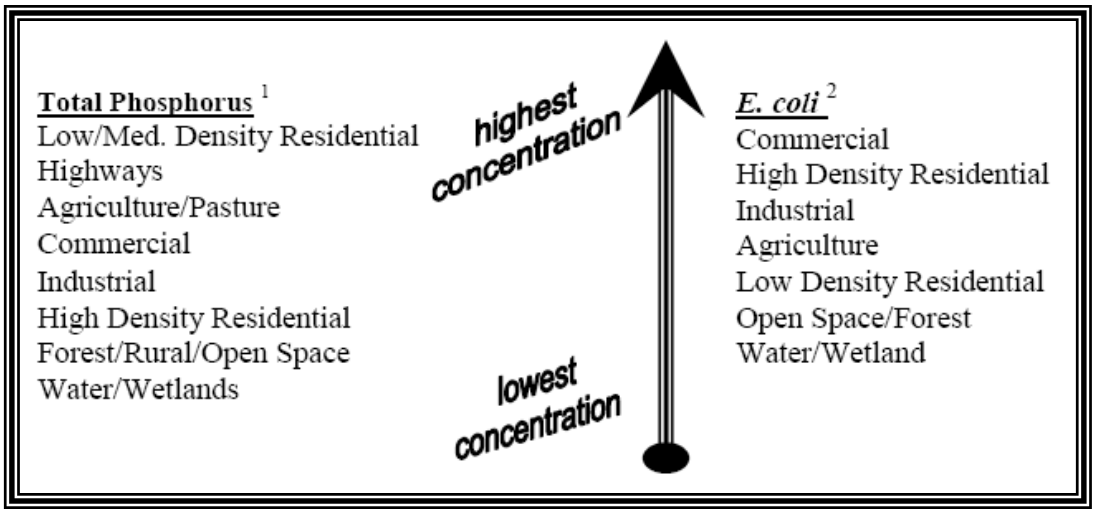
1. **Determine scope of the monitoring area** -- Certificates of Coverage (COC), issued under the Watershed General Permit, will identify the specific TMDLs the permittee shall address. At a minimum, the monitoring area shall include the TMDL reach and contributing watershed within the urbanized area. However, sections of the TMDL reach and contributing watershed that are outside the urbanized area should also be included in a comprehensive monitoring plan. Such monitoring is important for understanding the mix of potential sources.

2. **Determine catchment characteristics of the identified TMDL reach** -- Characteristics to identify include (in part from Law, 2008):
   - Catchment size and boundaries
   - Predominant land use type and distribution across catchment(s)
   - Land cover distribution (e.g., percent impervious cover, forest, wetland)
   - Type of conveyances (open or enclosed channel; curbs and gutters or swales)
   - Development characteristics (e.g., age, traditional versus low impact)
   - Presence and type of BMPs
   - Age and maintenance of BMPs

3. **Develop a prioritized list of catchments to target for monitoring** or to bracket during ambient monitoring --
   - Catchments with higher potential to generate pollutants of concern based on land use. Figure 1 shows a ranking of urban land uses with regard to potential total phosphorus or *E. coli* discharge concentrations[1, 2].
   - Age of development (older areas have a higher potential for illicit discharges and system failures) and age/maintenance of BMPs.
   - Previous IDEP data.
   - Existing ambient monitoring data suggesting source catchments
   - Specific local information. For example, golf courses may discharge high phosphorus, areas with failing septic systems and older systems with prevalent wildlife access may contribute *E. coli*.
   - Site conditions that may affect sampling include adequate safe access for sampling and housing equipment with a minimum potential for vandalism.

   Ultimately, the prioritized list should be based upon the likelihood of the area to contribute the pollutant of concern and its dominance in the monitoring area.

Figure 1 Ranking of urban land use potential to discharge total phosphorus and *E. coli*.



1. TP from research by the Rouge River National Wet Weather Demonstration Project, Technical Memorandum RPO MOD TM34.00.
2. *E. coli* from Purdue University's L-THIA Basic Model for relative fecal coliform loadings based on land use; cobweb.ecn.purdue.edu/runoff.

An ambient monitoring program aimed at systematically sampling relevant portions of the TMDL watershed or upstream drainages may help to inform and further focus the monitoring. Reaches or tributaries for which ambient data have demonstrated elevated levels of the parameter of concern can be given a higher prioritization when developing a monitoring program. Ambient monitoring should also proceed on a systematic basis to narrow in on likely pollutant sources.

4. **Fixed vs. Variable locations** -- For long-term monitoring, used for trend analysis and an overall understanding of the water body, fixed locations are important. These locations may or may not include monitoring sites specific to TMDLs. However, for a TMDL investigation, the locations for monitoring will most likely need to change over time.

   Possible rationale for changing the sampling locations will vary and may include:

   - Sampling data consistently shows little to no pollutants of concern.
   - Site selection poor due to safety, flashiness, poor collection ability.
   - Illicit discharges have been removed and sampling is no longer finding the pollutant, indicating success in that area.
   - Sampling data indicates pollutant of concern, but concentrations are weak and moving further upstream may be more valuable.

   A reasonable strategy may be to select a set of long-term monitoring sites that are monitored consistently year to year to establish a baseline for comparison and add a set of investigative sites that get moved based on results. Results from upstream investigative sites can be compared to downstream long-term sites to determine differences in concentrations or loadings that may suggest likely pollutant sources and future investigative sites.

Quality Control Procedures
Preparation of a Quality Assurance Project Plan (QAPP) is always a good idea prior to sample collection, and may be required depending on the monitoring program funding source. A QAPP provides a detailed framework for deciding how data will be collected to achieve specific objectives, and describes the procedures that will be implemented to obtain data of known and adequate quality. The U.S. EPA provides a guidance on preparing QAPPs, which is available at www.epa.gov/QUALITY/qapps.html.

Several important aspects of quality assurance are outlined in Part One, section 5, of the Storm Water Sampling Guidance for Total Phosphorus & *E. coli*.

Meaningful Plan
A permittee that designs a monitoring study for the sole purpose of "just meeting the permit requirements" may result in misused time and effort. In choosing the Elective Option, permittees are expected to represent a good faith effort toward obtaining the best information reasonably possible to further understand the problem and make the effort to abate those problems.

Ultimately, the monitoring program must be sufficient, realistic, and provide the permittees with quality information in order to begin prioritizing and implementing appropriate actions to meet WQS.

References

1. Carlson, R.E. and J. Simpson. 1996. *A Coordinator's Guide to Volunteer Lake Monitoring Methods*. North American Lake Management Society. 96 pp.

2. Law, Neely L; Fraley-McNeal, Lisa; Cappiella, Karen; Pitt, Robert. 2008 *Monitoring to Demonstrate Environmental Results: Guidance to Develop Local Stormwater Monitoring Studies Using Six Example Study Designs*. Center for Watershed Protection Ellicott City, MD. Available at www.cwp.org.

3. National Research Council (NRC), 2008 *Urban Stormwater Management in the United States*. The National Academies Press, Washington, D.C.

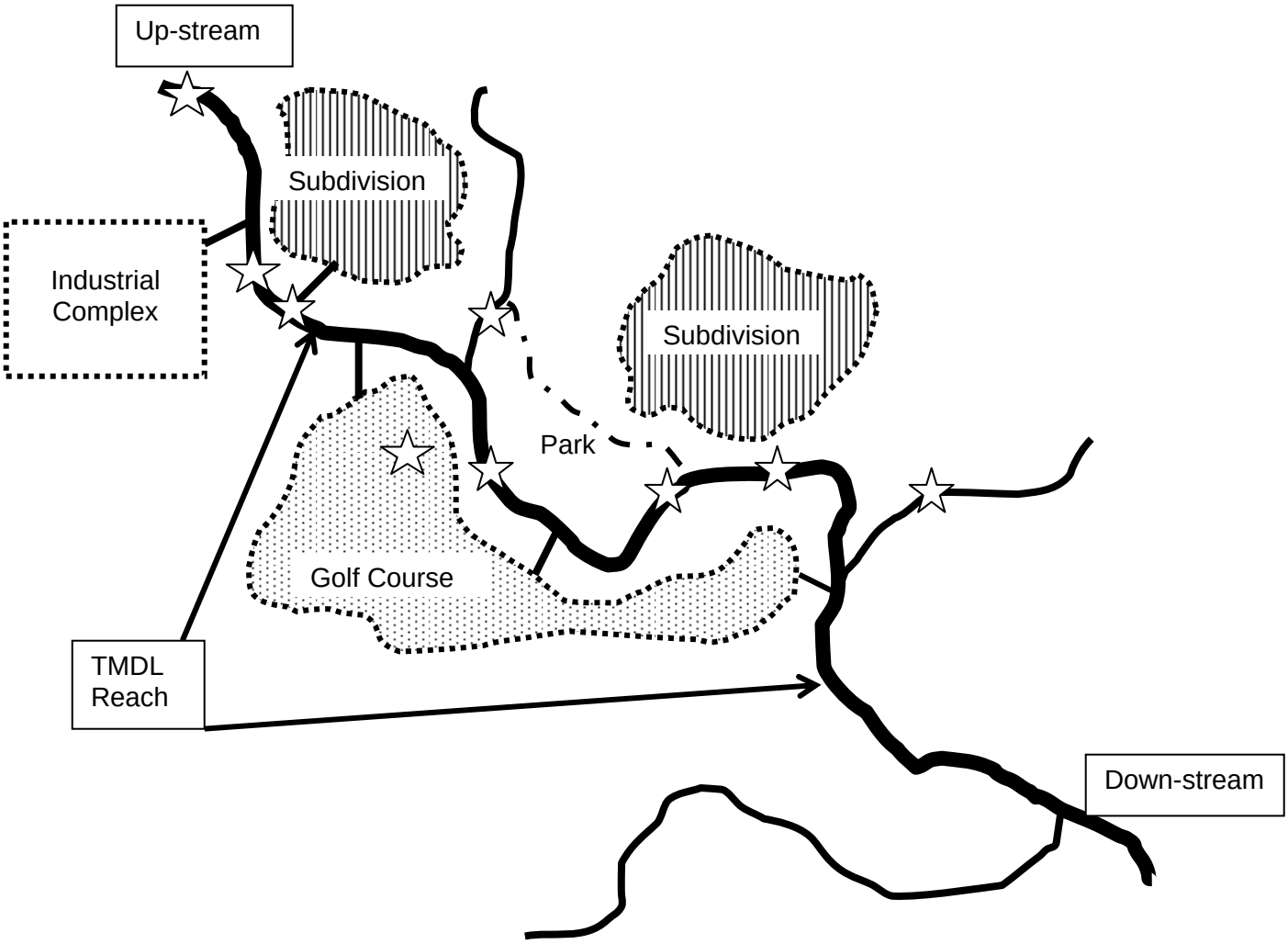
4. United States Environmental Protection Agency (USEPA). 1997. *Volunteer Stream Monitoring: A Methods Manual*. EPA-Office of Water. EPA 841-B-97-003.

Examples

While both examples show sampling at discharge points, permittees may chose to focus on only ambient monitoring in order to help narrow down possible hot spots. Keep in mind; these are examples, not requirements.

Example 1 – *E. coli* TMDL: Initial Monitoring includes both ambient and discharge points. The ambient monitoring will include upstream, downstream, and two tributaries located within the TMDL reach. The discharge points will only include the two subdivision outfalls. This example shows nine initial monitoring sites to be sampled six times. Three samples will be collected during wet weather events, during first flush, and three samples collected during dry weather.

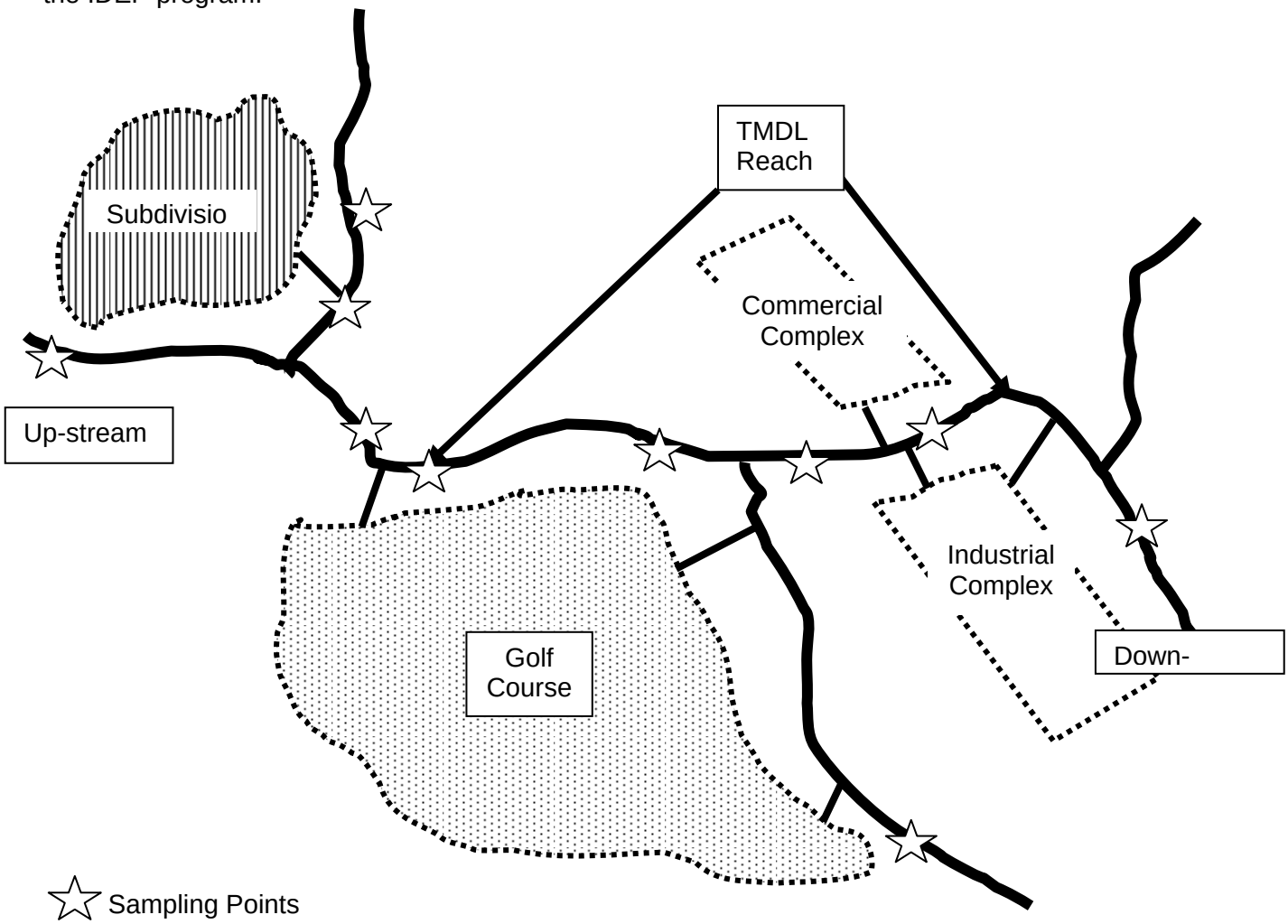
The initial sampling is expected to occur over four months. Follow-up sampling will occur as soon as possible if high *E. coli* counts (over 5000 cfu) are found. If high counts are found in ambient waters, samples will be collected upstream. If high counts are found in the discharge points for the subdivisions, further investigation will commence through the IDEP program.



☆ Sampling Points

Example 2 – Phosphorous TMDL: Initial Monitoring includes ten ambient sites and one discharge point. Samples will be taken during wet weather and dry weather. The ambient monitoring will include upstream, downstream, and three tributaries, with one tributary upstream of the TMDL reach. The discharge point will only include the subdivision outfall. This example shows ten initial monitoring sites to be sampled five times. Three samples will be collected during wet weather events, during first flush, and two samples collected during dry weather.

The initial sampling is expected to occur over five months. Sampling will include total phosphorus as well as dissolved phosphorus. Follow-up sampling will occur as soon as possible if high phosphorus levels are found. If high levels are found in ambient waters, samples will be collected upstream. If high levels are found in the discharge point of the subdivision, further investigation will commence through the IDEP program.



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